General Instructions:

- The exam is closed book, closed notes, no calculators.
- Do not open the exam until you are told to begin.
- Put your name, student identification number, and instructor name in the blanks above. Fill in your name, student identification number, and section number in the appropriate places on the computer scan forms.

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<tr>
<th>Time</th>
<th>Instructor</th>
<th>Section Number</th>
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<tr>
<td>7:30 am</td>
<td>Bagwell</td>
<td>0001</td>
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<tr>
<td>4:30 pm</td>
<td>Balakrishnan</td>
<td>0002</td>
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<tr>
<td>12:30 pm</td>
<td>Krogmeier</td>
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<td>3:30 pm</td>
<td>Chong</td>
<td>0004</td>
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- The exam consists of 8 multiple choice questions (5 points each), 2 short-answer problem (20 points), and 1 workout problem (40 points). No partial credit is given on multiple choice questions, partial credit will be given on short-answer and workout problems though points will be more coarsely quantized on the short-answer problem.

- In both the short-answer and workout problems you must put your final answer in the box provided in order to qualify for full credit. If the answer to a question requires that you specify a unit (e.g., Amps, Ohms, Watts, etc.), then you must write it down in the box along with the numerical value (e.g., I = 2.3 A).

- On short-answer and workout problems show your work in the white space provided with the problem. (Only the final answer should be placed in the box.)

- Keep your computer scan form (for multiple choice answers) hidden when you are not marking an answer.
Problem MC-1. [0 or 5 points] In the circuit shown below, all resistors have a resistance of one ohm. Find the value of the current $I$.

(1) 0.5 A  (2) -0.5 A  (3) 1 A  (4) -1 A  
(5) 2 A  (6) -2 A  (7) 5 A

Problem MC-2. [0 or 5 points] In the circuit shown below, 20 watts is dissipated in the 5 ohm resistor. Find $V_{DC}$.

(1) 4 V  (2) 5 V  (3) 9 V  (4) 10 V  
(5) 18 V  (6) 20 V  (7) 22 V

Problem MC-3. [0 or 5 points] Find the current $i_x$ in the circuit shown below.

(1) 50 A  (2) 40 A  (3) 10 A  (4) 400/19 A  
(5) 500/19 A  (6) 1000/19 A  (7) 1 A
Problem MC-4. [0 or 5 points] In the circuit shown below, all resistors have a resistance of one ohm. Find the effective resistance $R_{AB}$ seen between terminals $A$ and $B$.

(1) 5 $\Omega$  (2) 4 $\Omega$  (3) 3 $\Omega$  (4) 2 $\Omega$
(5) 1 $\Omega$  (6) 1/2 $\Omega$  (7) 1/4 $\Omega$

Problem MC-5. [0 or 5 points] In the circuit shown below, when the switch $S$ is open, a current of $i = 1$ A flows through the 5 $\Omega$ resistor. Find $i$ when the switch $S$ is closed.

(1) 2 A  (2) 1 A  (3) -1 A  (4) 0 A
(5) 1/2 A  (6) -1/2 A  (7) -2 A

Problem MC-6. [0 or 5 points] In the circuit shown below, all resistors have a resistance of one ohm. Find the value of the current $I$.

(1) 0 A  (2) 1/4 A  (3) 1/2 A  (4) 1 A
(5) 2 A  (6) -1 A  (7) -2 A
Problem MC-7. [0 or 5 points] Find the current $I$ in the circuit shown below.

(1) 3 A  (2) 6 A  (3) -1 A  (4) 9 A  
(5) -9 A  (6) -3 A  (7) -6 A

Problem MC-8. [0 or 5 points] Find the energy absorbed by element B in the figure below over the time interval $0 \leq t \leq 3$ sec.

(1) 1/2 J  (2) 1 J  (3) 3/2 J  (4) 2 J  
(5) 1 W  (6) 3/2 W  (7) 2 C
Problem SA-1. [0, 5, or 10 points] In the circuit shown below, all resistors have a resistance of one ohm. Find the current \( i \), and the total power dissipated in all the resistors.

\[
i = \quad \text{Power} =
\]

\[
\text{\begin{tabular}{c}
\end{tabular}}
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\[
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\]
Problem SA-2. [0, 5, or 10 points] Find the voltage $V_x$ in the circuit shown below using nodal analysis.
Problem WO-1. In this problem we investigate the behavior of a practical model for a “real voltage source.” The model, consisting of an ideal voltage source of value $V_s$ volts in series with a resistance of value 1000Ω, is shown inside the dashed box in the figure below.

(a) [0, 5, or 10 points] The figure above also shows a load resistor $R_L$ connected to the terminals of the “real voltage source.” Find an expression for $V_L$ as a function of $V_s$ and $R_L$. Also, plot $V_L$ as a function of $R_L$ on the axes given.

\[ V_L = \frac{V_s \times R_L}{1000 \Omega} \]

(b) [0 or 5 points] From your expression and the plot of (a) you should notice that the load voltage $V_L$ “droops” significantly if we attempt to drive a load resistance $R_L$ which is too small. Find the smallest load resistance that we can tolerate and still keep the load voltage above 90% of its nominal value.

\[ R_{L,\text{min}} = \]
(c) [0 or 5 points] In an attempt to improve the performance of the weak “real voltage source from parts (a) and (b) we insert a unity gain buffer between the source and the load as shown in the figure below. If we assume the ideal operational amplifier model (i.e., the “virtual short”), find an expression for $V_L$ in terms of $V_s$.

$V_L = \ldots$

(d) [0, 5, or 10 points] Consider a more accurate model for the unity gain buffer. Now replace the operational amplifier, in the circuit of part (c), with the standard linear active region model consisting of an input resistance $R_i$, an output resistance $R_0$, and a linear voltage controlled voltage source of value $Av_d$. Redraw the circuit of part (c) with this model inserted for the operational amplifier. Indicate all relevant voltages on your circuit diagram.

Circuit of (c) with OP AMP model:
(e) [0, 5, or 10 points] For the circuit you found in part (d), solve for the load voltage $V_L$ as a function of the remaining circuit parameters, assuming that $R_i = \infty \, \Omega$. Next, assuming that $A$ is reasonably large and $R_0$ is reasonably small, indicate roughly on the axes of part (a) where the curve of $V_L$ vs. $R_L$ would lie. Label the curve “load voltage of (e)” to distinguish it from the curve of (a).