EE 42
Midterm Exam No. 1
27 February 2002

Put your name (printed, signed), your student identification number, and the number of the Discussion Section that you attend here:

Print Name (last, first) __________________________ Sign Name __________________________
S. I. D. __________________________ Discussion Section No. __________________________

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NOTE: THERE ARE SEVERAL DIFFERENT VERSIONS OF THIS EXAM IN THE ROOM. Your responses will be different from those of your neighbors. Keep your eyes on your own paper.

PLEASE DON'T OPEN THE TEST UNTIL THE PROCTOR SAYS YOU MAY BEGIN

Table 1:

<table>
<thead>
<tr>
<th>Page</th>
<th>Points/ Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>/15</td>
</tr>
<tr>
<td>3</td>
<td>/15</td>
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<td>4</td>
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<td>TOTAL</td>
<td>/100</td>
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</tbody>
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1 (15 points). Write enough nodal equations to solve for all unknown currents and voltages in the circuit shown below. (IT IS NOT NECESSARY TO SOLVE THESE EQUATIONS.)

Node X and Y

We have a supernode:
\[
\begin{align*}
V_X - V_Y &= V_0 \quad (1) \\
\frac{V_X}{R_1} - I_0 + \frac{V_Y - V_Z}{R_2} &= 0 \quad (2)
\end{align*}
\]

Node Z

\[
\begin{align*}
\frac{V_2 - V_0}{R_2} + \frac{V_Z}{R_3} &= 0 \quad (3)
\end{align*}
\]

3 Unknown voltages: \(V_X, V_Y, V_Z\)
3 Equations.
2. (15 points). Draw the Norton equivalent circuit and find its $I_N$ and $R_N$, that is equivalent to the circuit to the left of the terminals A-B shown below. The values of the elements are: $V_0 = 6V$, $R_1 = 100 \, \Omega$, $R_2 = 200 \, \Omega$, $R_3 = 300 \, \Omega$.

![Circuit Diagram](image)

a. Draw Norton equivalent circuit here -->
b. $I_N = \frac{6V}{100 \, \Omega} \, A$
c. $R_N = 54.5 \, \Omega$

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1st way: Node Analysis

\[
\begin{align*}
V_A - V_0 + \frac{V_A - V_B}{R_3} + \frac{V_A - V_B}{R_3} + I_N = 0 \\
V_A = 0 \text{ (connected to ground through wire)} \\
\Rightarrow \frac{V_0}{R_1} = I_N = 60mA
\end{align*}
\]

2nd way: The wire takes out $R_2, R_3$

\[
\begin{align*}
V_A - V_0 + \frac{V_A}{R_1} + \frac{V_A}{R_1} = 0 \\
\Rightarrow \frac{V_0}{R_1} = I_N = 60mA \\
\text{So, } I_N = 60mA
\end{align*}
\]

---

2) Deactivate sources

\[
\begin{align*}
\begin{array}{c}
R_1 \\
R_2 \\
R_3
\end{array}
\end{align*}
\]

which is the same as

\[
\begin{align*}
\frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{600 \, \Omega}{11}
\Rightarrow R_N = \frac{54.5 \, \Omega}{11}
\end{align*}
\]
True-False Questions:

3. (5 points) The equivalent resistance of six resistors connected in parallel is larger than the value of any of the individual resistors. True ☐ False ☐

4. (5 points) The equivalent resistance of six resistors connected in series is smaller than the value of any of the individual resistors. True ☐ False ☐

5. (5 points) The prefixes used to represent 1000, 1/1000, and 10^-9, respectively, are mezzo, milli, and nano, respectively. True ☐ False ☐

6. (5 points) To measure current flowing in a circuit element you connect an ammeter across the circuit element. True ☐ False ☐

7. (5 points) An ideal voltmeter is electrically equivalent to a short circuit (zero resistance). True ☐ False ☐

8. (5 points) The electrical units for capacitance, inductance and voltage are henries, farads and volts. True ☐ False ☐

9. (5 points) If a 4-volt supply delivers current through a switch, resistor, and inductor connected in series, the voltage generated when the switch is operated cannot exceed 4 V. True ☐ False ☐

3. It should have been smaller than
4. It should have been larger than
5. Kilo, milli and nano
6. The ammeter is connected in series
7. It is electrically equivalent to an open circuit
8. Farads, Henries, Volts
9. If the inductor had some initial current of 1A stored in it then: At t=0 the inductor looks like, as the inductor holds on to its current value of 1A temporarily. Then ad t=0, V=1(1/100Ω)×105V>4V
10. (5 points) Redraw the circuit below to show its electrical equivalent after you have “turned off” the independent sources (which you might do in order to find the Thevenin equivalent resistance, $R_T$, or in order to use superposition to analyze the circuit).

11. (5 points) An uncharged 60 $\mu$F capacitor is suddenly connected to a 9V battery in series with a 100 $\Omega$ resistor, at time $t = 0$.
   a. The maximum current that flows is $\frac{90}{100}$ (give units $mA$) and it occurs at time $t = 0$.
   b. The minimum current that flows is $0$ (give units $mA$) and it occurs at time $t = \infty$.

   After switching, $v_C$ will go from $0V$ to $9V$ like so:

   The current $i$ flowing through is $\frac{9 - V_C(t)}{100}$ (by applying Ohm's law on the $100\,\Omega$ resistor).

   $\max i$ when $V_C(t) = 0$ which happens at $t = 0$ (initially uncharged capacitor).
   $\min i$ when $V_C(t) = 9$ which happens at $t = \infty$ (capacitor behaves like an open circuit).

12. (5 points) When analyzing a first-order transient circuit problem, which of these quantities cannot change instantaneously (check all that apply):.
   a. Voltage across a resistor
   b. Current flowing through a capacitor
   c. Voltage across a capacitor
   d. Energy stored in an inductor
   e. Current flowing in an inductor
   f. Charge in a capacitor
   g. None of those
13. (6 points) A 120V supply is connected to a 500 Ω and a 700 Ω resistor connected in series.
What is the rate of energy dissipation in
a. The 500 Ω resistor: \( \frac{120V}{500 \text{Ω} + 700 \text{Ω}} = 0.1 \text{ A} \)
\[ \text{Power}_{500} = I^2 \times (500 \text{Ω}) = (0.1 \text{ A})^2 \times (500 \text{Ω}) = 5 \text{ W} \]
\[ \text{Power}_{700} = I^2 \times (700 \text{Ω}) = (0.1 \text{ A})^2 \times (700 \text{Ω}) = 7 \text{ W} \]
\[ \text{Power}_{\text{source}} = (\text{Voltage across source}) \times (\text{Current from straight to the supply}) = 120V \times (-0.1 \text{ A}) = -12 \text{ W} \]

A quick check: The sum of all power has to be zero. \(-5 + 7 - 12 = 0\)

14. (4 points) Write an equation for the voltage \( V_{XY} \) across resistor \( R_3 \) in terms of the loop (mesh) currents indicated in this circuit:

Apply Kirchhoff's Law at \( E \): \( I_2 = I_3 + I_1 \) \( \Rightarrow I_3 = I_2 - I_1 \)
\[ V_{XY} = R_3 \times \text{(current flowing through)} = R_3 \times (I_2 - I_1) \]

\[ \Rightarrow V_{XY} = R_3 \times (I_2 - I_1) \]
5. (10 points) The circuit below shows a number of resistors and capacitors, in addition to an independent ideal voltage source. Combine the resistors into a single resistor \( R_{eq} \) that is in series with the voltage source and an equivalent capacitor \( C_{eq} \) (so that you could apply transient analysis to the circuit whose time constant would be \( R_{eq}C_{eq} \)). Note: all resistors are 1 kΩ and all capacitors are 2 μF.

\[
\begin{align*}
\text{a. } R_{eq} &= 600 \ \Omega \\
\text{b. } C_{eq} &= 5 \ \mu F
\end{align*}
\]