NAME: _____________________________

STUDENT NUMBER: _________________

LAB DAY: __________________________

ENGI 1040 – Electric Circuits
Winter 2012

Midterm 1A

Total Marks: 40

Only basic scientific (i.e., not programmable) calculators are permitted.

Clarity: Answer all of the following questions in the space provided. Marks will reflect the clarity of the presentation of your solution. When defining and calculating voltages and currents from a circuit diagram, label voltage and current notation directly on the circuit diagram if they are not already there. If you do not, you may lose marks for lack of clarity in your solution.

Units: State the units for all answers. Up to 1 mark will be deducted when an answer is presented without an appropriate unit.

Methods: When requested to use a specific method, this method must be used in order to obtain full marks for the question. If no specific method is requested, any appropriate method may be used.
Question 1  [15 MARKS – 3 marks per part]

(a) Electrons flow from left to right at a rate of $10^{20}$ electrons per minute in the following partial circuit. Recall that $-1 \text{ C} \equiv 6.25 \times 10^{18}$ electrons.

Determine $i_0$ and $v_0$.

(b) As shown below, 2 charges are placed along a straight line: $+8\text{ C}$ is fixed in place at position 0m and $+8\text{ C}$ is fixed in place at position 6m. These charges are fixed and cannot move.

Consider 3 different scenarios for the placement of a third charge of $-4\text{ C}$ which is placed and then released. For each scenario, determine what happens to the charge after it is released and indicate by circling the appropriate phrase.

(1) The third charge is placed at the 8m position on the line:

(i) it moves to the right        (ii) it moves to the left   (iii) it does not move

(2) The third charge is placed at the 3m position on the line:

(i) it moves to the right        (ii) it moves to the left   (iii) it does not move

(3) The third charge is placed at the 2m position on the line:

(i) it moves to the right        (ii) it moves to the left   (iii) it does not move
(c) Two 9V batteries are connected in parallel and then this parallel combination is connected across a resistive load. It is known that each battery sources 20 μA of current. How much power is provided by the batteries? How much energy is consumed by the load in 10 minutes?

\[
\text{power delivered is} \quad P = \ldots
\]

\[
\text{energy consumed is} \quad E = \ldots
\]

(d) Consider the following partial circuit which contains an ammeter that uses a galvanometer. In the circuit below, the ammeter is at full scale deflection and measures 10 mA. The voltage \(v_0\) is known to be 10.01 V.

\[
R_{\text{am}} = \ldots
\]

Given the full scale deflection of the galvanometer is 1 mA, what is the current through the shunt resistor used in the ammeter?

\[
i_{\text{shunt}} = \ldots
\]

(e) A heater is plugged into 120V\(_{\text{rms}}\) power outlet drawing 8 A\(_{\text{rms}}\) of current when it is on. Given that the heater has a duty cycle of 50% on Feb. 2, 2012 and the cost of energy is 10 cents/kW·h, what does it cost to operate the heater on this day?

\[
\text{cost} = \ldots
\]
Question 2  [10 MARKS – (a) 3 marks, (b) 4 marks, (c) 3 marks]

Consider the circuit to the right. The series dropping dropping resistor, $R_S$, is represented by a variable resistor which can be adjusted from $1 \, \text{k}\Omega$ to $25 \, \text{k}\Omega$. The load is represented by resistor $R_L$ on the lower right.

For convenience, voltages and currents are labeled. You may not need to calculate all labeled values.

(a) For $R_S$ set to $10 \, \text{k}\Omega$, using voltage divider, determine the voltage delivered across the load, $v_L$, and, subsequently, the current delivered to the load, $i_L$.

\[ v_L = \]  
\[ i_L = \]

(b) Now assume that $R_S$ is adjusted so that the current delivered to the load, $i_L$, is minimized. Determine $i_S$ and, using current divider, determine the value of $i_L$.

\[ i_S = \]  
\[ i_L = \]

(c) Now assume that $R_S$ is adjusted so that the voltage across the load, $v_L$, is maximized. What is the power absorbed by the load?

\[ P_L = \]
Question 3  [8 MARKS – (a) 3 marks, (b) 2 mark, (c) 3 marks]

Consider the following circuit.

(a) What is the equivalent resistance, $R_{eq}$, of the entire circuit, as seen by the voltage source?

(b) Determine the current coming from the source, $i_s$, and the power delivered by the source, $P_s$.

(c) Now the 6 Ω resistor is replaced by an unknown resistance $R$ as shown below. If the source current, $i_s$, is measured to be 40 A, determine the value of $R$. 

$$R =$$
Question 4  [7 MARKS – (a) 5 marks, (b) 2 marks]

Consider the following circuit. For convenience, voltages and currents are labeled. You may not need to calculate all labeled values.

(a) Assume that the voltmeter is ideal (i.e., has an infinite internal resistance) and measures a voltage of $v_0 = 9V$. Determine the voltage source voltage, $v_S$.

\[
v_S = \text{[Expression]}\]

(b) Assume now that the voltmeter is not ideal but has an internal resistance of 180 kΩ (that is, it adds 180 kΩ to the circuit). If the voltmeter measures a voltage of $v_0 = 9V$, determine current $i_2$.

\[
i_2 = \text{[Expression]}\]