Homework 2

Due Friday (5pm), Feb. 8, 2013

Please turn the homework in to the drop box located next to 125 Cory Hall (labeled EE 42/100). Make sure to clearly label your Name, Student ID, Class, and Discussion sections on the homework.

1) In the following three circuits everything is the same except the location of the ground node has been changed. For each circuit find the following:
   
i) \( I_x \)
   
ii) \( V_A \)
   
iii) \( V_{AB} \)

![Circuit Diagrams]

2) You are given a 10V source, a resistor \( R_0 = 10k \), and a digital voltmeter that gives 4 digits of resolution from 0 to 10V (0.000 to 9.999). You use a voltage divider to measure the resistance of an unknown resistor \( R_x = R_0 + \Delta R \) which is approximately 10k. Draw the circuit, write down the equation for the output voltage as a function of the change in resistance, \( \Delta R \), and the equation for the resistance as a function of the measured voltage. How accurately can you measure the resistance of \( R_x \)?

3) In addition to the previous equipment, you are given another pair of 10k resistors, and an instrumentation amplifier with a gain of exactly 10,000. Draw an amplified Wheatstone bridge circuit, write the equation for the output of the amplifier as a function of the fractional change in resistance, \( \varepsilon = \Delta R / R_0 \), and an equation for the resistance as a function of output voltage. How accurately can you measure the resistance of \( R_x \)?
4) For the following resistor network find the equivalent resistance between the following nodes:

a) $R_{eq}(a,b)$

b) $R_{eq}(g,h)$

c) $R_{eq}(c,d)$

d) $R_{eq}(g,b)$ assuming nodes $c$ and $d$ are shorted together.

![Resistor Network Diagram](image)

5) You want to use a 9V battery as a power source to turn on a light emitting diode which has the same I-V equation as a normal diode. The saturation current is $I_S = 10^{-32}$ A. LEDs emit light when there is a positive current flowing through them.

a) You first hook up the battery and LED as shown in figure a) below. For this configuration calculate the current through the LED. You can assume that the LED follows the equation, $I_d = I_s(e^{V_d/V_{th}} - 1)$. Where $V_{th}=26$ mV. Will the LED light up?

b) You then hook-up the circuit as shown in figure b) below. Now calculate the current through the LED. You notice your LED lights up brightly but it is getting very hot. Why? Will the 9V battery continue to source 9V?

c) You then remember hearing something about current limiting resistors from Professor Pister, so you find a resistor and hook it up as below in figure c). Now what is the current through the LED? Will the LED light up brightly? Why or why not? Note: You should get a transcendental equation which you can solve iteratively.
d) You then decide to read the packaging for the LED, and it says the safe operating current is 10mA. What voltage do you need on the diode to get this current? What value of R in figure d) should you choose to meet this operating point?

6) For each circuit schematic, indicate whether the voltage source is absorbing power or supplying power to the circuit. Justify your answers.
7) For the following circuit:
   a) Apply nodal analysis to find node voltages $V_1$ and $V_2$.
   b) Determine the voltage $V_R$ and current $I$.

![Circuit Image]

8) Apply nodal analysis to find node voltages $V_1$ to $V_3$ in the circuit and then determine $I_x$.

![Circuit Image]

9) (a) Find the Thevenin and Norton equivalents of the circuit below for terminal $V_{ab}$
   (b) Suppose we attach a voltage source $V$ across the terminal $ab$, with the positive reference at $a$.
   What is the relationship between $V$ and the resultant current $I$ flowing from $b$ to $a$?

![Circuit Image]

10) Find the Thevenin equivalent circuit at terminals $a,b$:

![Circuit Image]