University of the Philippines, Diliman
Electrical and Electronics Engineering Institute

EEE 33 – Electric Circuit Theory
AY 2011-2012 Semester 1

Problem Set 1

Problem 1

(a) An infinite network. A network of resistances R_1 and R_2 extends to infinity toward the right as shown in Fig. 1.

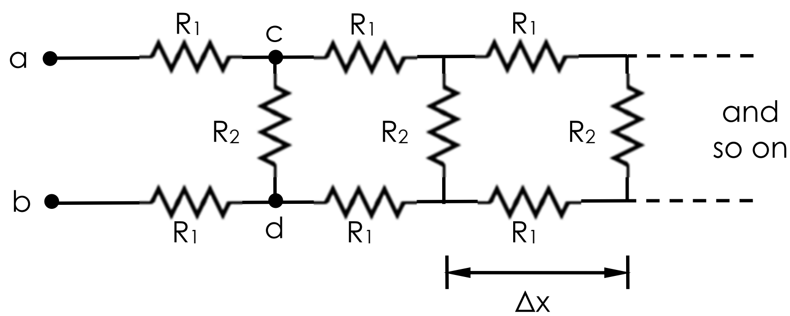

FIGURE 1

Prove that the total resistance R_T of the infinite network is equal to

$$R_T = R_1 + \sqrt{R_1^{\,2} + 2R_1R_2}$$

(Hint: Since the network is infinite, the resistance of the network to the right of points c and d is also equal to R_T*.)*

(b) Attenuator Chains and Axons. The infinite network of resistors shown in Fig. 1 is known as an attenuator chain, since this chain of resistors causes the potential difference between the upper and lower wires to decrease, or attenuate, along the length of the chain. Show that if the potential difference between the points a and b in Fig. 1 is V_{ab}, then the potential difference between points c and d is $V_{cd} = V_{ab}/(1+\beta)$, where $\beta = 2R_1 (R_T+R_2)/R_TR_2$ and R_T is given in (a).

(c) If the potential difference between terminals a and b at the left end of the infinite network is V_0 show that the potential difference between the upper and lower wires *n* segments from the left end is $V_n = V_0 / (1+\beta)^n$. If $R_1 = R_2$, how many segments are needed to decrease the potential difference V_n to less than 1.0% of V_0?

(d) An infinite attenuator chain provides a model of the propagation of a voltage pulse along a nerve fiber, or axon. Each segment of the network in Fig. 1 represents a short segment of the axon of length Δx. The resistor R_1 represent the resistance of the fluid inside and outside the membrane wall of the axon. The resistance of the membrane to current flowing through the wall is represented by R_2. For an axon segment of length $\Delta x = 1.0\ \mu m$, $R_1 = 6.4 \times 10^3\ \Omega$ and $R_2 = 8.0 \times 10^8\ \Omega$ (the membrane wall is a good insulator). Calculate the total resistance R_T and β for an infinitely long axon. (This is a good approximation, since the length of an axon is much greater than its width; the largest axons in the human nervous system are longer than 1 m but only about 10^{-7} m in radius.)

Problem 2

Two networks, N1 and N2, are described graphically in terms of their i-v relations and connected together through a single resistor, as shown below.

(a) Find the Thevenin and Norton equivalents of N1 and N2.
(b) Find the currents i_1 and i_2 that result from the interconnection of N1 and N2 by replacing N1 and N2 with their respective Thevenin equivalent circuits.
(c) Find the currents i_1 and i_2 that result from the interconnection of N1 and N2 by replacing N1 and N2 with their respective Norton equivalent circuits.

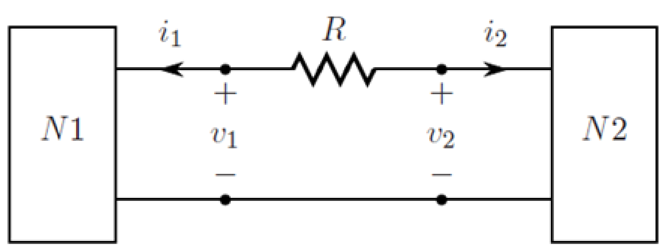

FIGURE 2

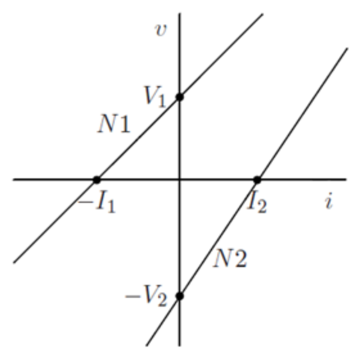

FIGURE 3

Problem 3

A transistor amplifier circuit has the equivalent circuit below.

(a) Write the KVL equations describing each loop to determine V_o/V_s.
(b) Find the Thevenin equivalent circuit seen across terminals a and b. Verify your answer in (a) using the Thevenin equivalent circuit..
(c) If V_s is 20mV, what would be the power supplied by the dependent current source?

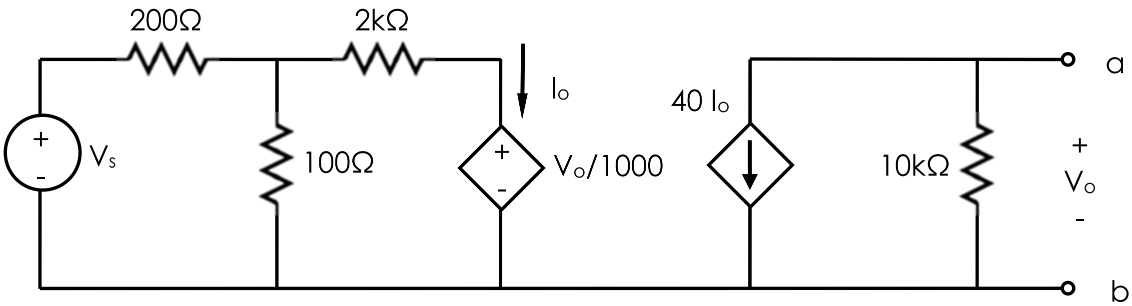

FIGURE 4

Problem 4

(a) Using superposition, find the voltage across terminals a and b, V_{ab}.
(b) Using superposition (again!), find the current flowing from terminal a to terminal b, I_{ab} when terminals a and b are short circuited.

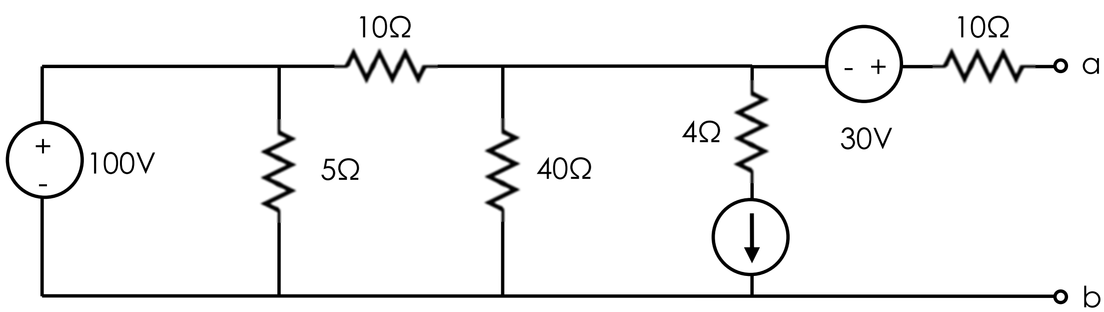

FIGURE 5

Problem 5

Express the output voltage v_o in terms of v_1, v_2, and v_3. Assume that the op-amp is ideal.

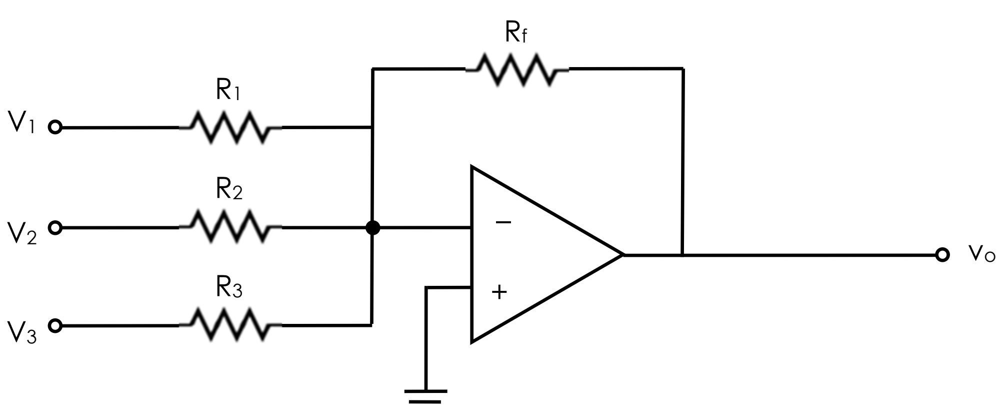

FIGURE 6

Problem 6

Solve for the voltage v_a using nodal analysis.

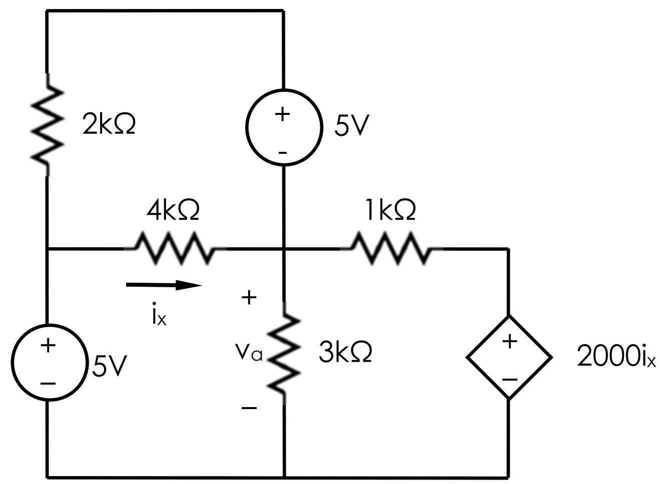

FIGURE 7

Sources:

(1) University Physics
(2) MIT OpenCourseWare
(3)–(6) Previous EEE 33 Exam and Problem Set Problems (modified)