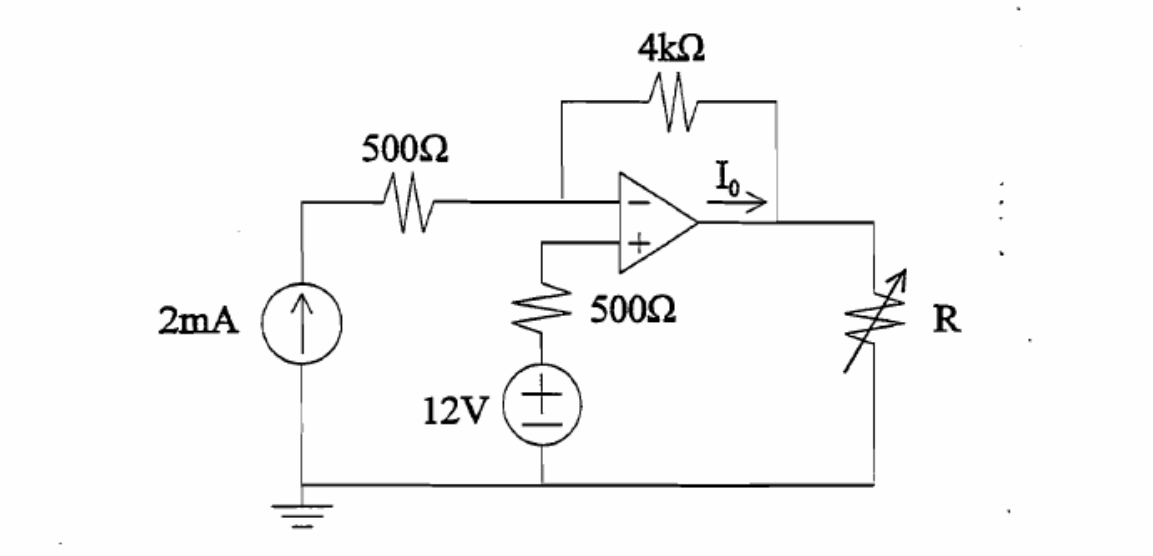
ECSE 200: Fundamentals of Electrical Engineering

Assignment 3

Winter 2006

Question 1

Consider the linear ideal op-amp circuit below. Find the value of R that yields $I_0 = 0$.
Also: calculate the value of the power absorbed by the op-amp in the limit as $R \to \infty$.



Question 2

You are given an unspecified practical battery, an unknown ohmic resistor and an ideal multimeter, that can be used to measure either voltage or current. The battery is known to exhibit negligible loss under open-circuit conditions. Explain how you can correctly determine the values of the open-circuit voltage and internal resistance(s) which model the battery, together with the value of the unknown resistor, and the power delivered to this resistor when it is connected across the battery – if you are only permitted to make a total of three measurements. Express your answers clearly and concisely in terms of specific voltage and/or current measurements, involving the battery and/or the resistor. You are not permitted to use any other equipment or data, except for that stated above.

Note: Please feel free to use circuit diagrams to illustrate and clarify your explanation.

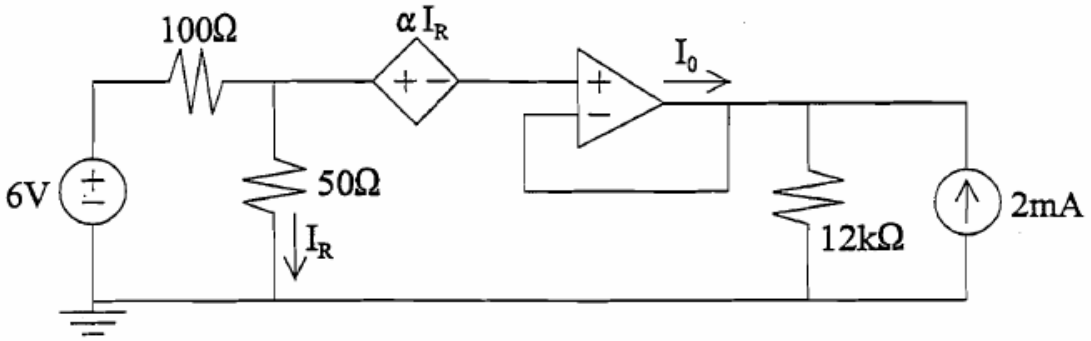
Question 3

Consider the circuit provided. Use the ideal op-amp model, and answer the following:

(a) For $\alpha = 80$, find the value of the current I_0, and the power supplied by each source.

(b) Find the value of α which minimizes the power absorbed by the 12kΩ resistor.

(c) Suppose that the short-circuited op-amp feedback branch is replaced by a small, but nonzero, resistance branch. Explain the effect this would have on the value of I_0.

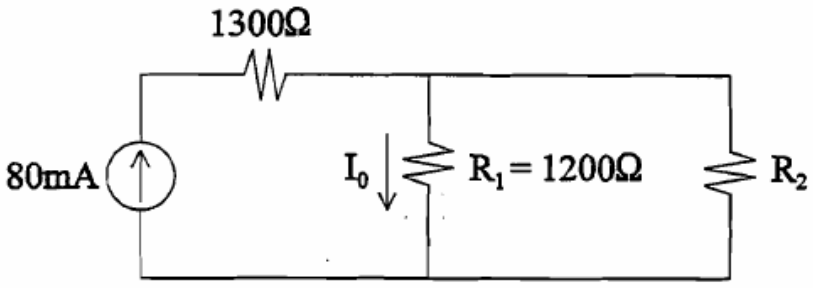


Question 4

Consider a practical battery that exhibits negligible loss under open-circuit conditions. Explain how to accurately determine the values of the open-circuit voltage and internal resistance(s) which model this battery, using only an ideal ammeter and a 10kΩ resistor. Express your answers clearly and concisely in terms of specific current measurements. You are not permitted to use any other equipment or data, except for that given above.

Question 5

Consider the circuit provided below and answer each of the following questions:



(a) Find the value of the resistance R_2 which yields 120V across the source.

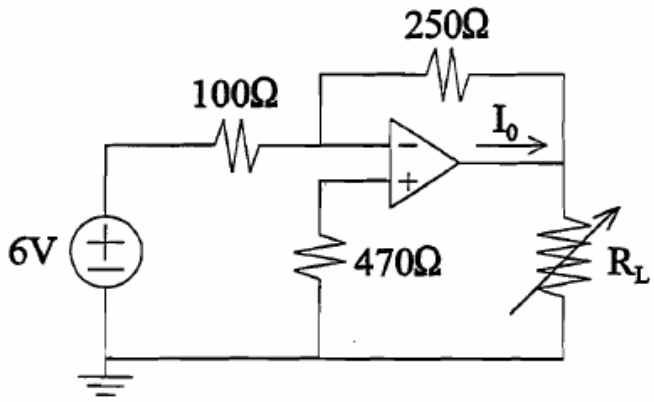
(b) Find the value of the current labelled I_0 if the resistance $R_2 = 400\Omega$.

(c) Suppose the current I_0 in part (b) is measured with a passive non-ideal ammeter. State how the measured value will differ (larger/smaller/same) from the calculated value in (b), and briefly explain the fundamental reasoning behind your response.

(d) Assume that R_1 and R_2 represent 'metallic wire' resistors which become thermally nonlinear when operated above 1W. Describe how the physical value of I_0 would differ (larger/smaller/same) from the calculated value in part (b). Briefly explain the fundamental reasoning behind your response.

Question 6

Consider the circuit provided below and answer each of the following questions: (Assume that the ideal op-amp model is valid for each part.)



(a) Find the powers absorbed by each of the three fixed resistances, if $R_L = 4700\Omega$.

(b) Find the op-amp output current labelled I_0 if R_L is set to infinite resistance.

(c) Assume that the op-amp supplies are fused to shutdown if the total op-amp output power demand exceeds 1W. Find the smallest value of R_L that can be used in this circuit without causing the op-amp power supplies to fail. Finally, find the power absorbed by this minimal load resistance.

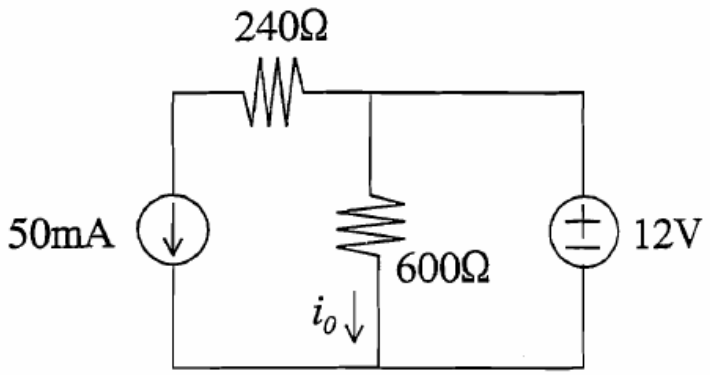
Question 7

Consider the circuit provided below:

a) Calculate the power *supplied* by each of the sources.

b) Calculate the value of the current i_0 that would be measured with a *passive* ammeter which has an internal resistance of 30Ω. Define your ammeter model and show how it should be connected to the circuit to make this measurement.

c) Calculate the power that would be *supplied* by each of the sources while making the current measurement proposed in part (b) above.



Question 8

Consider the circuit provided below. Use the ideal op-amp model for all calculations.

a) Calculate the value of the current i_0 if R = 4kΩ.

b) Find the value of resistor R that causes the 12V source to supply exactly half of the total power dissipated as heat within the circuit.