University of California, Berkeley | *Spring 2010*
EE 42/100 | *Prof. A. Niknejad*

Midterm Exam (closed book/notes)
Tuesday, February 23, 2010

Guidelines: Closed book. You may use a calculator. Do not unstaple the exam. In order to maximize your score, write clearly and indicate each step of your calculations. We cannot give you partial credit if we do not understand your reasoning. Feel free to use scratch paper.

Electron charge $q = 1.60217646 \times 10^{-19}$ C.

KCL: Kirchhoff's Current Law states that the net current flow into a node (or super-node or any closed surface) is zero.

$$\sum I_k = 0$$

KVL: Kirchhoff's Voltage Law states that the net voltage drop around any loop is zero.

$$\sum V_k = 0$$

Power flow into a component: (positive means power is absorbed or dissipated.

$$P = I \cdot V$$

Ohm's Law:

$$V = I \cdot R$$

or

$$I = G \cdot V$$

where $G = R^{-1}$.
Power dissipated in a resistor:

$$P = I^2 R = V^2 G$$

Resistors in series add:

$$R = R_1 + R_2 + \cdots$$

Conductances in parallel add:

$$G = G_1 + G_2 + \cdots$$

For two resistors in parallel, this implies

$$R_{||} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

When a chain of resistors are in series and connected to a voltage source, the voltage across the kth resistor is given by the voltage divider forma

$$V_k = \frac{R_k}{R_1 + R_2 + \cdots}$$

When a chain of conductors are in parallel and connected to a current source, the current through the kth conductor is given by the current divider formula

$$V_k = \frac{G_k}{G_1 + G_2 + \cdots}$$

Any black box can be modeled using Thevenin or Norton's Equivalent networks: Voltage source V_{th} in series with R_{th} or a current source I_N in parallel with R_N. You can find the values using open-circuit voltages and short-circuit currents

$$V_{th} = V_{oc}$$

$$I_N = I_{sc}$$

$$R_{th} = R_N = \frac{V_{oc}}{I_{sc}}$$

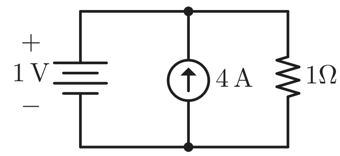
If there are no sources in the black box, then there is only R_{th} in the model. You can calculate R_{th} by calculating the resistance of the black box: Connect a current (or voltage) source and monitor the resulting voltage (or current).

When an ideal op-amp is operated with negative feedback, the following "Golden Rules" apply:

$$V^+ = V^-$$

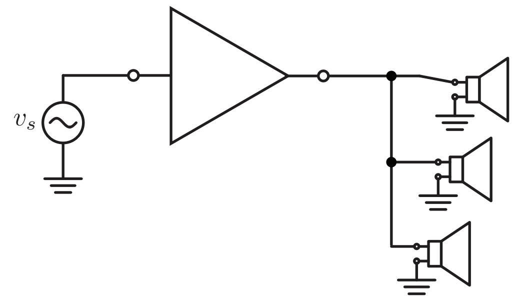
$$I^+ = I^- = 0$$

1. (16 points) Answer the following questions succinctly.

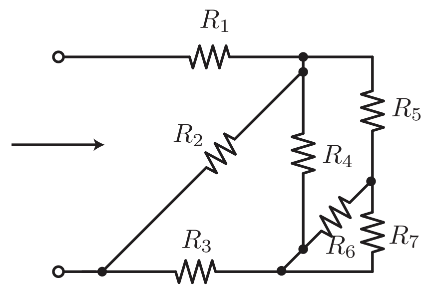


(a) (*4 points*) What is the power delivered or absorbed by the battery? Clearly state if the battery is delivering or absorbing power and find the numerical value.

(b) (*4 points*) A current of 15fA (f= 10^{-15}) flows through a resistor. On average, how many electrons flow into negative terminal of the resistor per second?

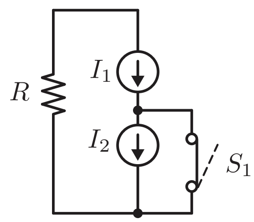


(c) (*4 points*) Calculate the voltage at the output driving the load speakers. Each speaker alone has an effective resistance of $R_L = 9\Omega$. The amplifier has an open-circuit voltage gain of 40dB ($A_v = 100$) and an input resistance of 10Ω and an output impedance of 3Ω. Assume the source has a voltage of $1V$.

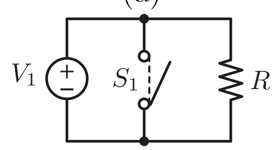


(d) (*4 points*) Find the equivalent resistance seen by looking into the terminals shown. Do not do any math but simply state the answer using the "||" and "+" operators. Use parenthesis to clarify your answer.

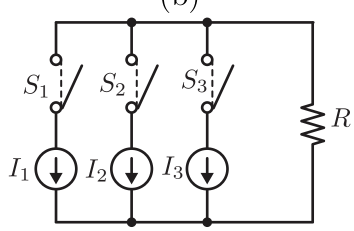
2. (*17 points*) For each schematic, describe any issues (if any) when combinations of switches are opened and closed. State which principals are violated in each case.



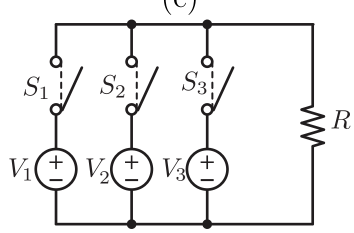
(a)



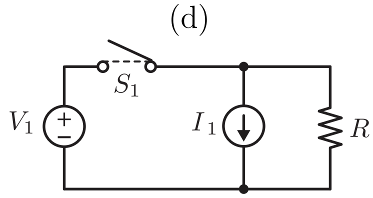
(b)



(c)

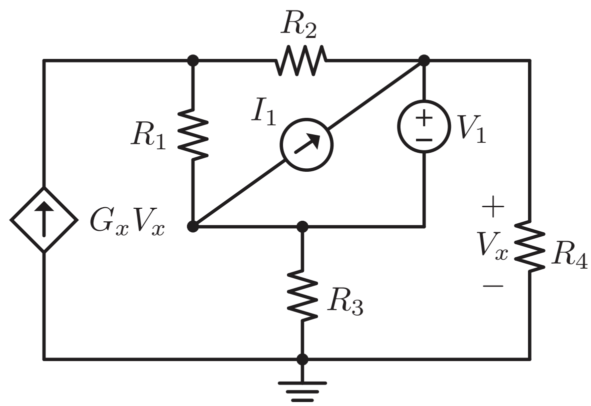


(d)

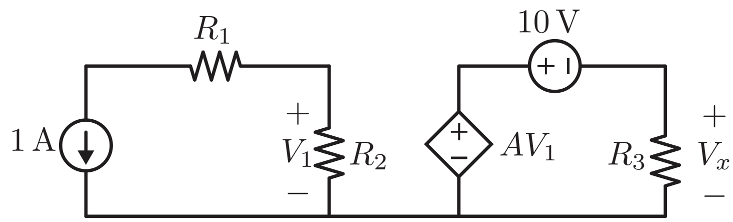


(e)

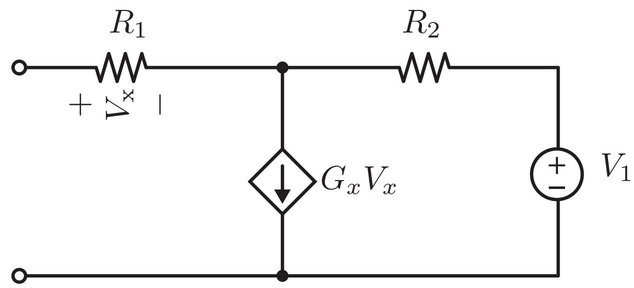
3. (*17 points*) For the following circuit, write nodal equations and put them into standard format, $Ax = b$. Assume the reference voltage is chosen as shown by the ground symbol.



4. (*16 points*) Use superposition to find V_x in the following circuit. $A = 10$, $R_1 = 1\,\mathrm{k}\Omega$, $R_2 = 3\,\mathrm{k}\Omega$, and $R_3 = 500\,\Omega$.



5. (*17 points*) Find the Norton Equivalent for the following circuit.



6. (*17 points*) Calculate the output voltage v_o as a function of v_1 and v_2. (*Hint:* Partition the circuit into stages.)