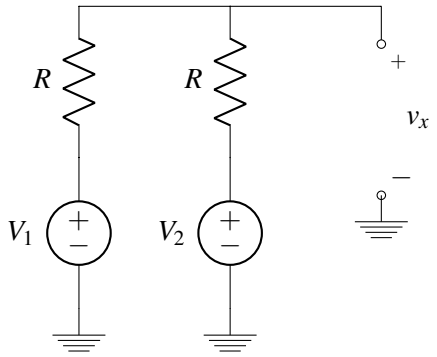
EECS 16A Designing Information Devices and Systems I
Summer 2017 D. Aranki, F. Maksimovic, V. Swamy Discussion 6A

1. Dividers for Days

(a) Solve the following circuit for v_x.



(b) You have access to two voltage sources, V_1 and V_2. You can use two resistors (as long as $0 \leq R < \infty$). How would you design a circuit that produces a voltage $v_x = \frac{1}{3}V_1 + \frac{2}{3}V_2$?

(c) You have two current sources I_1 and I_2. You also have a load resistor $R_L = 6\,\text{k}\Omega$. Similar to the first part, you can use whatever resistors you want (as long as they are finite integer values). How would you design a circuit such that the current running through R_L is $I_L = \frac{2}{5}(I_1 + I_2)$?

2. Baking

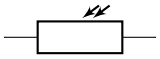
You decide to make a little oven (from scratch) for a party so the kids can bake things. In order to do this you will need a filament to radiate heat inside the oven. A filament can be modeled as a resistor with all the power dissipated by the resistor being converted into heat.
You find a 1 m-long strip of some filament material that has a resistance of $20\,\Omega$ and you want to cut a length of it to connect it directly to your 20 V battery (which has internal resistance of $1\,\Omega$) to heat the play oven. Assume that the resistance of the strip of filament is proportional to its length.

(a) How long should you cut the strip to maximize the amount of heat generated in the oven?

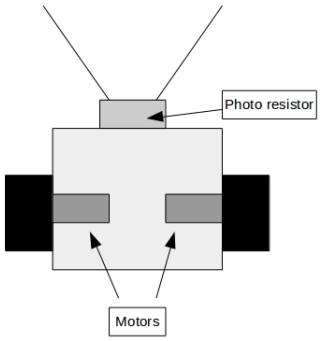
(b) How much heat (in units of W) is available in the oven?

3. PetBot Design (Fall 2016 Final)

In this problem, you will design circuits to control PetBot, a simple robot designed to follow light. PetBot measures light using photoresistors. **A photoresistor is a light-sensitive resistor. As it is exposed to more light, its resistance decreases.** Given below is the circuit symbol for a photoresistor.



Below is the basic layout of the PetBot. It has one motor on each wheel. We will model each motor as a $1\,\Omega$ resistor. When motors have positive voltage across them, they drive forward; when they have negative voltage across them, they drive backward. At zero voltage across the motors, the PetBot stops. The speed of the motor is directly proportional to the magnitude of the motor voltage. The light sensor is mounted to the front of the robot.



(a) **Speed control –** Let us begin by first having PetBot decrease its speed as it drives toward the flashlight. **Design a motor driver circuit that outputs a decreasing positive motor voltage as the PetBot drives toward the flashlight. The motor voltage should be at least** $5\,\text{V}$ **far away from the flashlight. When far away from the flashlight, the photoresistor value will be** $10\,\text{k}\Omega$ **and dropping toward** $100\,\Omega$ **as it gets closer to the flashlight.**

In your design, you may use any number of resistors and op-amps. You also have access to voltage sources of $10\,\text{V}$ and $-10\,\text{V}$. Based on your circuit, derive an expression for the motor voltage as a function of the circuit components that you used.

(b) **Distance control –** Let us now have PetBot drive up to a flashlight (or away from the flashlight) and stop at distance of $1\,\text{m}$ away from the light. At the distance of $1\,\text{m}$ from the flashlight, the photoresistor has a value $1\,\text{k}\Omega$.

Design a circuit to output a motor voltage that is positive when the PetBot is at a distance greater than $1\,\text{m}$ **from the flashlight (making the PetBot move toward it), zero at** $1\,\text{m}$ **from the flashlight (making the PetBot stop), and negative at a distance of less than** $1\,\text{m}$ **from the flashlight (making the PetBot back away from the flashlight.**

In your design, you may use any number of resisitors and op-amps. You also have access to voltage sources of $10\,\text{V}$ and $-10\,\text{V}$. Based on your circuit, derive an expression for the motor voltage as a function of the values of circuit components that you used.