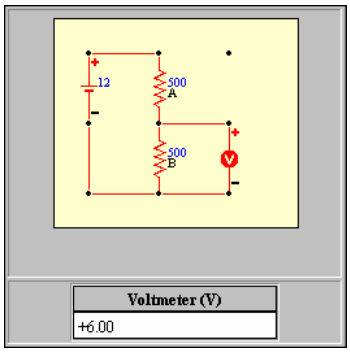
Worksheet for Exploration 30.3: Designing a Voltage Divider



Often with circuits, not only do you want to be able to figure out what a circuit that is already built is doing, you may want to design a circuit for a specific task. In this case, our task is to design a circuit that is a voltage divider with a particular output voltage **(voltage is given in volts and resistance is given in ohms)**. You have a 12-V supply that can give you 1 W of power and you need a 4-V output with as much power as possible. The resistors that you have can dissipate 1 W of power.

To divide the voltage we can put the power supply in series with two resistors and then use the voltage across one of the resistors to be our 4-V output.

a. What ratio of resistors do you need to divide the supply voltage by 1/3? In other words, how many times bigger (or smaller) should resistor A be than resistor B to get an output of 4 V? Try it.

i. Using V = IR, develop an expression for V as a function of R_A, R_B and the power supply voltage (12 V).

ii. For an output voltage of 4 V, what is the equation that relates R_A and R_B.

iii. Try it: R_A = _____ R_B = _____.

b. Once the ratio is set up, do you have the maximum available power? To determine this, figure out the power used from the voltage source (P = V I). To get the maximum power (at a fixed voltage), should you increase or decrease the resistance in the circuit?

P from the power supply = _____.

i. If you increase the total resistance in the circuit, will the power dissipated by the circuit increase or decrease? Explain.

c. What is the limit on the total resistance ($R_A + R_B$) and, therefore, the limit on each resistor. Try it.

i. What is the value of the current, I, for the maximum power from the power supply?

ii. What then, is the limit on the total resistance and the total resistance for each resistor?

d. Try using a smaller value of resistance. Does the power supply burn up? (Fortunately, you can simply restart the animation and try again).

e. Double the values of R_A and R_B. How much power does this circuit now draw from the battery?

Now that you have determined convenient values of R_A and R_B that produce a 4-Volt output, replace the voltmeter with a light bulb. (Adding a power consuming circuit element is sometimes referred to as adding a "load.")

f. When this light bulb is added, what is the voltage across the light bulb?

g. Why is it less than 4 V?

(Hint: Think about the current going through the light bulb.)

h. If you increase R_A and R_B more, what happens to the voltage across the light bulb? Why? This is the reason voltage dividers like this are made from resistors that are as small as possible.