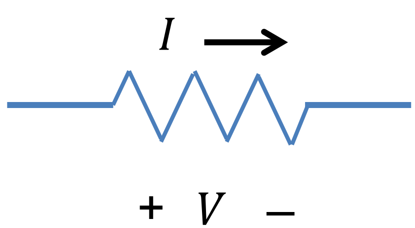
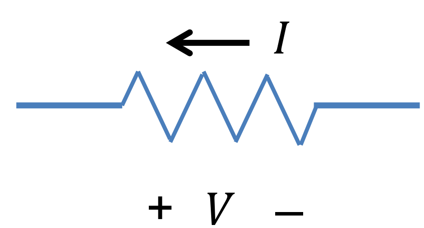
Passive Sign Convention

Consider a situation where there is a voltage drop across a resistor. We know from our physics course that voltage and current are related by Ohm's Law (V=I*R), but which way will the current flow?



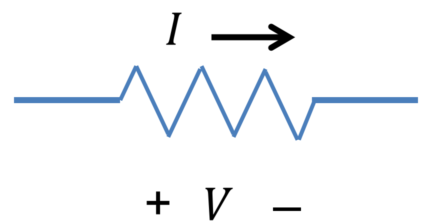
or



If you are not sure, consider a mechanical analogy with water flowing through pipes. Would water flow from high pressure to low or from low pressure to high?

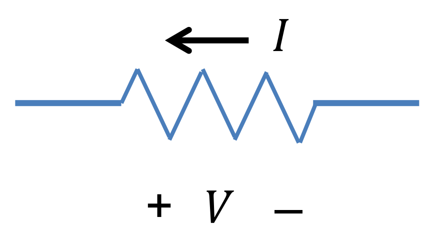
Passive Sign Convention

Positive current will flow from high voltage to low voltage. That is, current should flow into the positive voltage terminal.



$$V = IR$$

But what if we (or somebody else) labelled (defined) the current and voltage in a way that is backwards with regard to this physical reality?

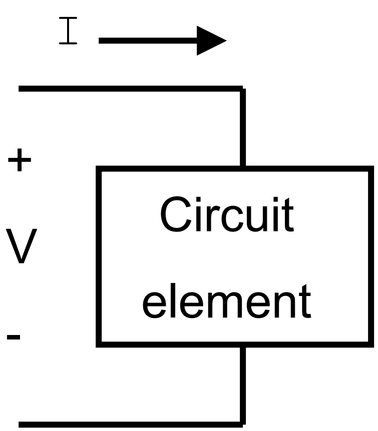


$$V = -IR$$

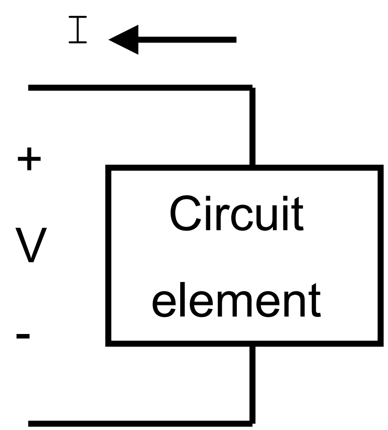
Actually, it's not a problem as long as we know to adjust Ohm's Law with an appropriate negative sign.

Passive Sign Convention

Passive Sign Convention - For a two terminal element, whenever the reference direction for the current is in the direction of the voltage drop, use a positive sign in any expression that relates voltage to the current. Otherwise use a negative sign.



$$V = +IR$$
$$V = +L\frac{dI}{dt}$$
$$I = +C\frac{dV}{dt}$$
$$P = +IV$$



$$V = -IR$$
$$V = -L\frac{dI}{dt}$$
$$I = -C\frac{dV}{dt}$$
$$P = -IV$$

Passive Sign Convention

- Often, in order to analyze a circuit, we need to define the voltage polarity or the direction of current flow at a certain point in a circuit. → We can do this arbitrarily.

- If we guess wrong, the quantity of interest will turn out to be negative (telling us our original definition was backwards).

- The passive sign convention will allow us to correctly evaluate other related quantities.

- If we had started out with an opposite polarity definition, everything should still work out the same in the end, as long as we stick to the passive sign convention.

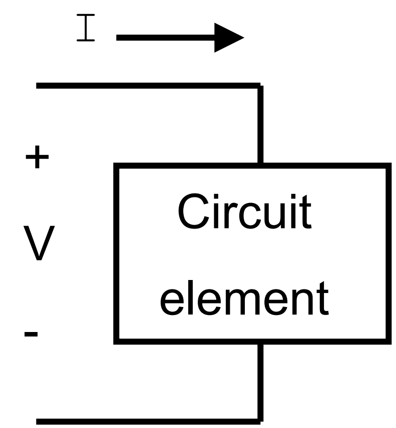
Passive Sign Convention

•Suppose we define the current, I, flowing through the circuit element from top to bottom as shown and the voltage, V, with a higher potential at the top terminal of the element.

•Suppose also that after analyzing the circuit (or measuring these quantities in the lab) we determine that V=6 volts and I=-2mA.

•The negative sign in the current measurement means that the current is actually flowing from the bottom terminal to the top terminal.

•The lack of a negative sign in the voltage measurement means that the voltage drop is in fact in the direction we defined it.



P = + I V

= (-2mA)(6V)

= -12mW

•The negative sign in the power calculation shown means that the circuit element is generating power (delivering power to other elements it may be connected to). If the power was positive then the element would be absorbing power.

- ✓ - ➔ generating, producing, providing, delivering
- ✓ + ➔ absorbing, dissipating, consuming, using

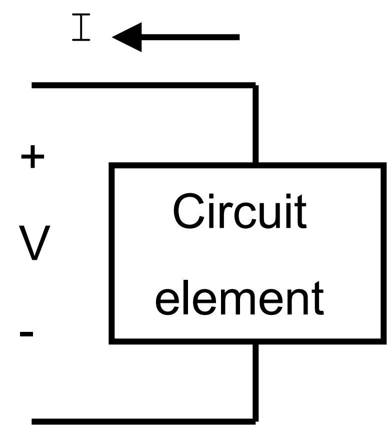
Passive Sign Convention

•In the example from the previous slide, suppose we had defined the current to be flowing in the opposite direction as shown in the drawing at right.

•Now we would measure the current to be $I=2mA$ and the voltage would still be $V=6volts$ as before.

•Now, when calculating the power (using $P=IV$), the passive sign convention tells us to use a negative sign since the reference current direction is opposite of the reference voltage drop.

•Note that even though we defined the reference current differently, the element is still found to be *generating* 12mW of power.



$$\mathbf{P = - I\ V}$$

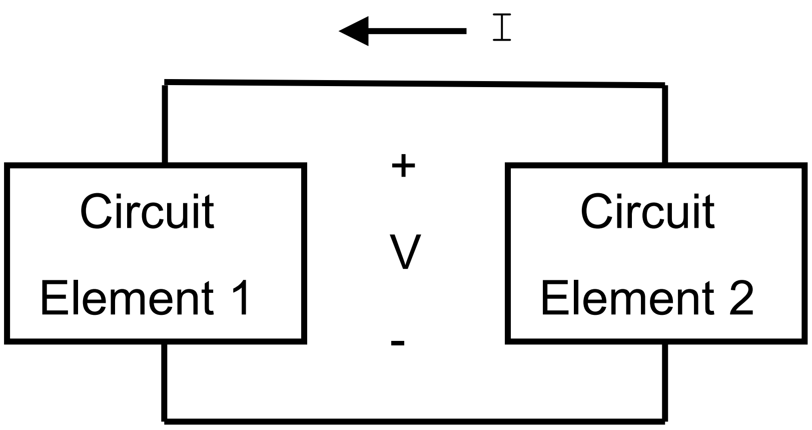
$$= -(2mA)(6V)$$

$$= -12mW$$

Try this: Change the reference polarity of the voltage drop and convince yourself that the power still turns out to be -12mW.

Test Your Understanding

In this example two circuit elements are connected together. With the voltage polarity and the direction of current defined in the drawing, for each case below determine if Element 1 is delivering power to element 2 or vice versa.



a) $V = 3 \text{ volts}, I = -20mA,$

b) $V = -3 \text{ volts}, I = 20mA,$

c) $V = -3 \text{ volts}, I = -20mA,$