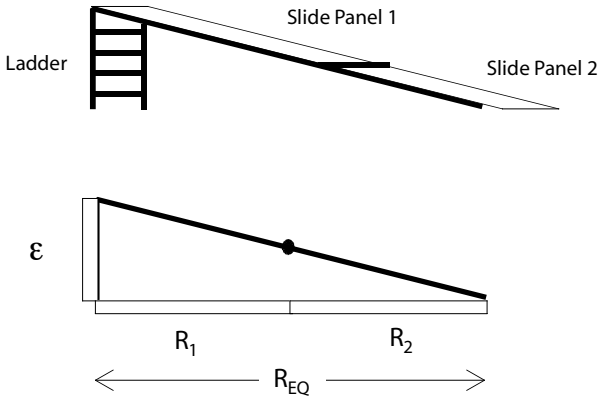
PhyzGuide: Series Circuits

TWO EQUAL RESISTORS IN SERIES

SLIDER CIRCUIT



CONFIGURATION • One ladder, two equal slide panels —one after the other (in *series*).

ELEVATION • The elevation is "provided" by the ladder. This is the same ladder as in the "**Simple Circuit**" guide.

RUN LENGTH • The run length is the slide's horizontal distance. Having two panels in a row makes a slide that would be the same as one made with a single slide panel that was simply twice as long as the original.*

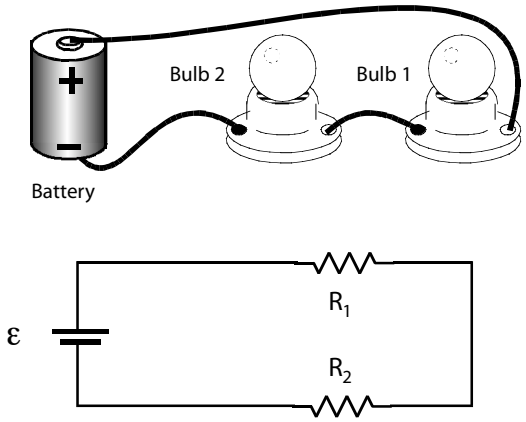
INCLINE (FLOW RATE) • Incline of the circuit is determined by the relation: $I = \mathcal{E}/R_{EQ}$ (incline = elevation / equivalent run length). Since we have the same elevation and twice the run length of the **simple circuit**, the flow is half of what the **simple circuit** flow is.

BUN-BURNING • The bun-burning factor is determined by $BB = I\mathcal{E}$ (bun-burning = flow rate x drop distance; drop distance is equal to elevation). Since the incline (flow rate) is only half of what it was in the **simple circuit**, the power delivered in this circuit is only half of the power output in the **simple circuit**.

NOTICE • Each rider must travel across both slide panels to get to the bottom. No rider can go down the first panel without also going down the second panel.

Also, each rider drops through only half the elevation as he or she traverses the first slide panel. In other words, the rider loses half of his or her potential energy while sliding down one panel. The remaining energy is lost sliding down the second panel.

ELECTRIC CIRCUIT



CONFIGURATION • One battery, two equal light bulbs—one after the other (in *series*).

EMF • Electric potential (voltage) is provided by the battery. This is the same battery as in the **"Simple Circuit"** guide.

RESISTANCE • Resistance is due to the devices in the circuit; in this case the light bulbs. Having two bulbs in a row makes the same circuit as one with a single bulb with twice the resistance.

CURRENT • Current in the circuit is determined by the relation: $I = \mathcal{E}/R_{EQ}$ (current = emf / equivalent resistance). Since we have the same emf and twice the resistance of the **simple circuit**, the current is half of what the **simple circuit** current is.

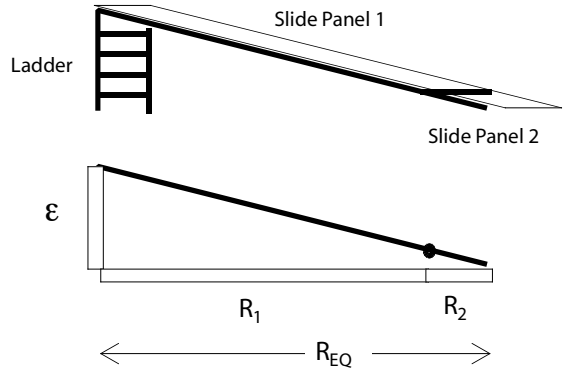
POWER • Power dissipation in the circuit is determined by $P = I\mathcal{E}$ (power = current x voltage drop across the resistor; voltage drop in this case is equal to the battery's emf). Since the current is only half of what it used to be, the power delivered in this circuit is only half of the power output in the **simple circuit**.

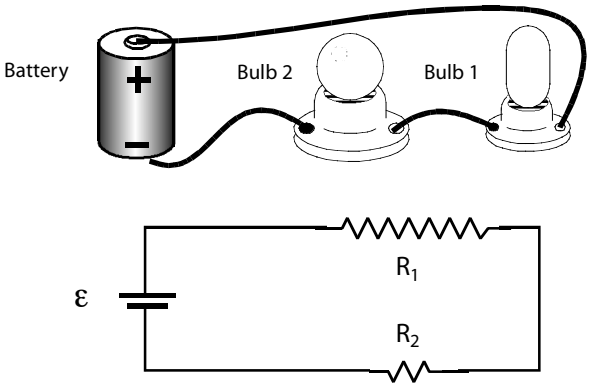
NOTICE • Each electron must travel through both resistors to get to the positive terminal. No electron can go through the first resistor without also going through the second resistor.

Also, each electron drops through only half the potential difference as it traverses resistor l. In other words, the electron loses half of its potential energy while passing through one resistor. The remaining energy is lost while passing through resistor 2.

*OK, maybe not exactly twice as long; for the purposes of our analogy, the difference is negligible.

TWO UNEQUAL RESISTORS IN SERIES





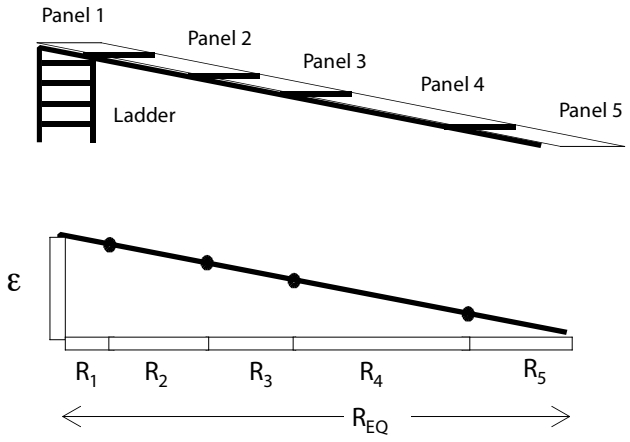
CONFIGURATION • Two unequal panels in series.

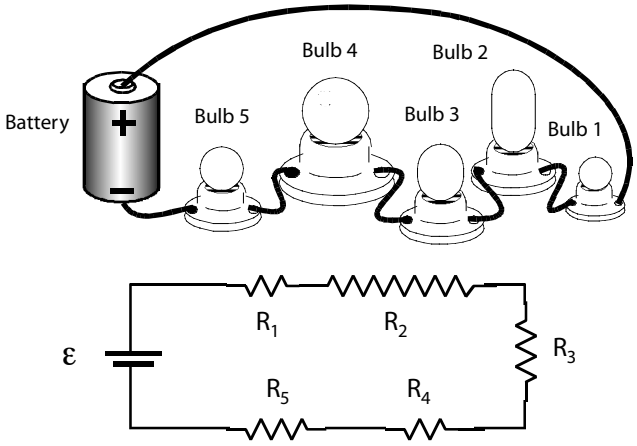
NOTICE • The flow rate (indicated by the incline) is smaller than if the slide consisted of either panel individually. Again, the flow rate must be the same along both panels.
• Riders lose most of their potential energy as they traverse the longer panel. There is a larger drop in elevation between the beginning and end of the longer panel than there is across the short panel.
• More bun-burning occurs on the longer panel simply because riders lose more potential energy on that panel.

CONFIGURATION • Two unequal bulbs in series.

NOTICE • The current is smaller than if the circuit consisted of either resistor individually. Again, the current must be the same through both resistors.
• Charge loses most of its potential energy as it traverses the resistor with the higher resistance. There is a larger drop in potential across the higher resistance bulb than there is across the low resistance bulb.
• More power is dissipated in the higher resistance bulb simply because electrons lose more potential energy going through that resistor.

MANY RESISTORS IN SERIES





CONFIGURATION • Several panels connected in series.

NOTICE • As more slide panels are added, the flow rate (as determined by the incline) decreases. The flow rate along each panel must be the same.
• Riders lose a fraction of their potential energy as they traverse each panel. The energy loss is proportional to the run length of the panel.
• The overall bun-burning ability of the slide decreases since the elevation drop remains constant and the flow decreases (recall that $BB = I\varepsilon$).

CONFIGURATION • Several bulbs connected in series.

NOTICE • As more bulbs are added, the current decreases. The current through each bulb must be the same.
• Charge loses a fraction of its potential energy as it passes through each bulb. The energy loss is proportional to the resistance of the bulb.
• The overall power dissipation in the circuit decreases since the total voltage drop remains constant and the current decreases (recall that $P = I\varepsilon$).