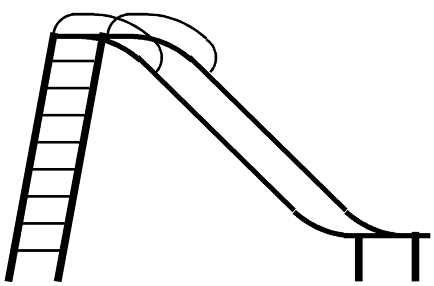
PhyzGuide: The Slider Circuit

Understanding electric circuits is critical for anyone hoping for full participation in our increasingly technological society (as well as anyone hoping to pass the next physics test). But all this talk of voltage, resistance, current, and the transformation of potential energy in a circuit is enough to short circuit a person's medulla oblongata! One way to better comprehend a seemingly nebulous concept is through the use of an **analogy.** Analogies are helpful to the extent that they help us understand a process, but we must always keep in mind that no analogy is perfect and some important details of a process are often lost or misrepresented in an analogy. With that in mind, let's consider the slide analogy for electric circuits; we'll present the slide and the circuit side-by-side for comparison.

SLIDE



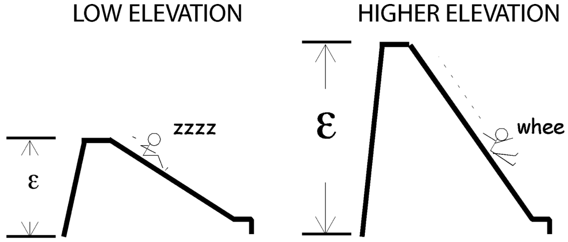
Overview

Riders raise themselves to a specific height by climbing the ladder—each rider gains gravitational potential energy. Gravitational force pulls each rider down the slide, where they lose their energy (the gravitational potential energy of each rider is converted to heat—the slide heats up, as do the riders' buns). Finally, the riders reach the bottom of the slide—the end of their journey.

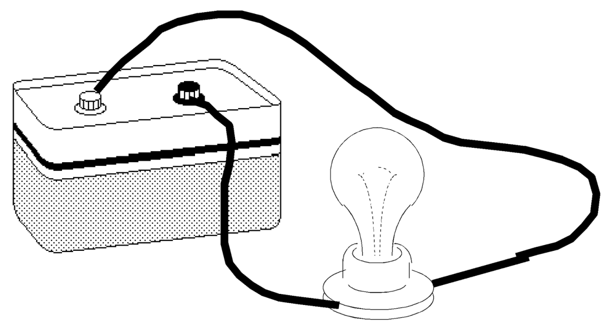
The Ladder: Source of Height

Riders won't slide if both ends of the slider are at the same elevation; they'll slide from one point to another only if there is a difference between the elevation of those two points. Greater elevation difference results in greater rate of slide. Rate of rider flow has no other name. *Hey, this is only an analogy—what do you want?*

LOW ELEVATION HIGHER ELEVATION



ELECTRIC



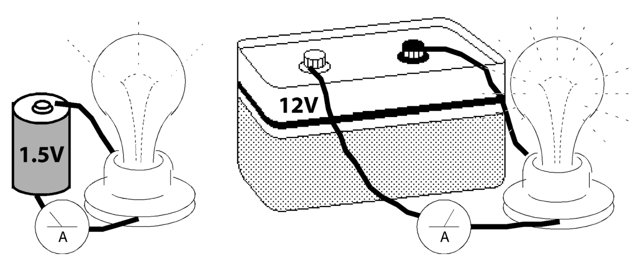
Overview

Electrons are raised to a specific electric potential through a chemical reaction in the battery—each electron gains electric potential energy. Electric force pushes each electron through the wire and filament of the bulb, where they lose their energy (the electric potential energy of each electron is converted to heat and light). Finally, the electrons reach the positive terminal—the end of their journey.

The Battery: Source of Voltage

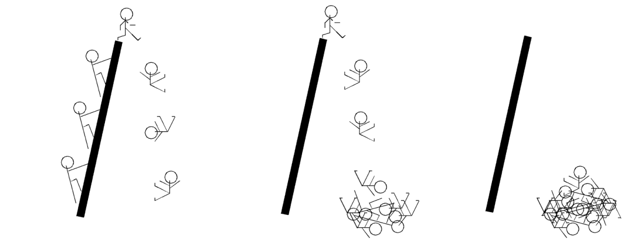
Electrons won't flow if both terminals of the battery have the same potential; they'll flow from one point to another only if there is a potential difference (voltage) between those two points. Higher voltage results in a greater rate of electron flow. Rate of charge flow is called "current" or "amperage," and can be measured by an ammeter.

LOW VOLTAGE HIGHER VOLTAGE



The Slide: Run Length

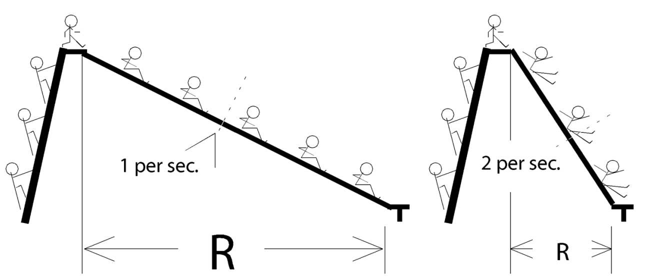
If the slide were not part of the slider and riders went straight from the top of the ladder to the ground, we would have a "short ride." Riders would suffer physical damage and would soon stop using the defective slide.



INITIALLY the riders fall at a high rate

LATER all of the riders have traversed the "slide." GAME OVER.

The slide provides "gravitational resistance" that prevents such a stampede of riders and instead allows a steady stream of riders on the slide. The longer the slide is (greater resistance), the slower the riders will slide, resulting in a low rate of flow. A shorter slide (small resistance) results in a faster ride and a high flow rate.



GREAT RUN LENGTH results in slower ride—lower flow rate

SMALL RUN LENGTH results in faster ride—higher flow rate

Slippery-Sam's Ratio Rule

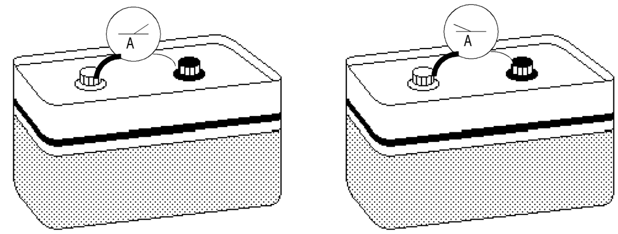
The relation between rider flow, height and length is called Sam's Ratio Rule and is just a summary of what we've learned so far. Rider flow is directly proportional to the elevation of the slide (greater drop = faster fall) and inversely proportional to the run length of the slide (longer slide = slower ride). Simply put: *Rider flow = Elevation/Run Length or Rider flow = Slope of the slide*.

Betty's Bun-Burning Principle

Each rider loses most of his/her gravitational potential energy as he/she slips down the slide. The rate at which the slide is given energy (which is turned into heat) is the "bun-warming" power associated with the slide. Greater power results in warmer buns. Power is directly proportional to how much energy is given by each rider (elevation factor) and how fast the riders are flowing (rider flow). In words: *Power = rider flow x the elevation.*

The Bulb: Resistance

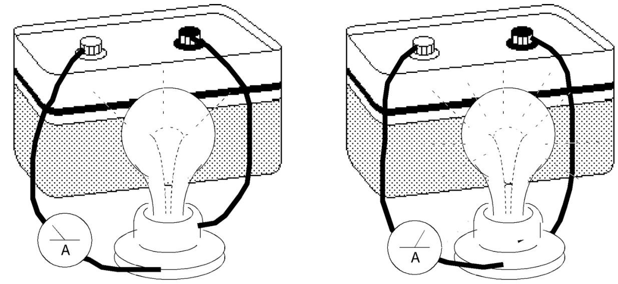
If the bulb were not part of the circuit and electrons could go straight from the negative terminal to the positive one, we would have a "short circuit." The chemical reaction in the battery would run its course very quickly and we'd be left with a dead battery.



INITIALLY the ammeter reads high current

LATER the ammeter reads no current: the battery is dead

The bulb provides electrical resistance that prevents such a stampede of electrons and instead allows a steady stream of electrons through the circuit. The greater the resistance of the bulb is, the greater difficulty electrons have traveling through it, resulting in low current. Smaller resistance results in higher current.



HIGH RESISTANCE results in LOW CURRENT

LOW RESISTANCE results in HIGH CURRENT

Ohm's Law

The relation between current, voltage, and resistance in a circuit is called Ohm's law. Ohm's law is just a summary of what we've learned so far. Current is directly proportional to the voltage provided by the battery (bigger voltage = more current) and inversely proportional to the resistance of the resistor (bigger resistance = less current). In symbols: $I = V/R$.

Joule's Law

Each electron loses most of its electric potential energy as it passes through the filament of the bulb. The rate at which the filament is given energy (which is converted to heat and light) is the power associated with the circuit. Greater power results in brighter light. Power is directly proportional to how much energy is given by each unit of charge (i.e., potential) and how fast the charge is flowing (current). In symbols: $P=IV$.