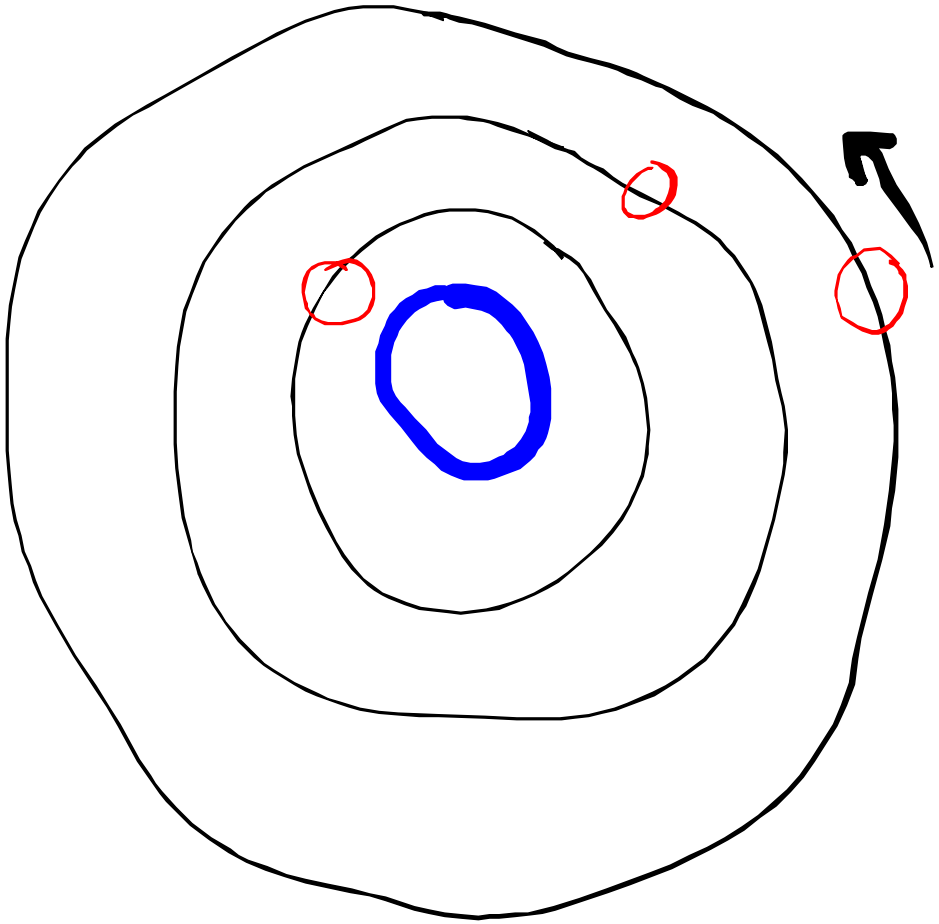
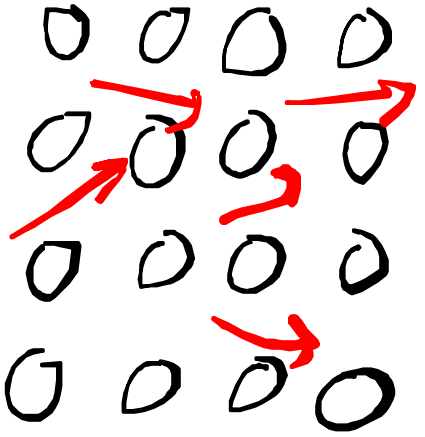
Atoms and Electrons

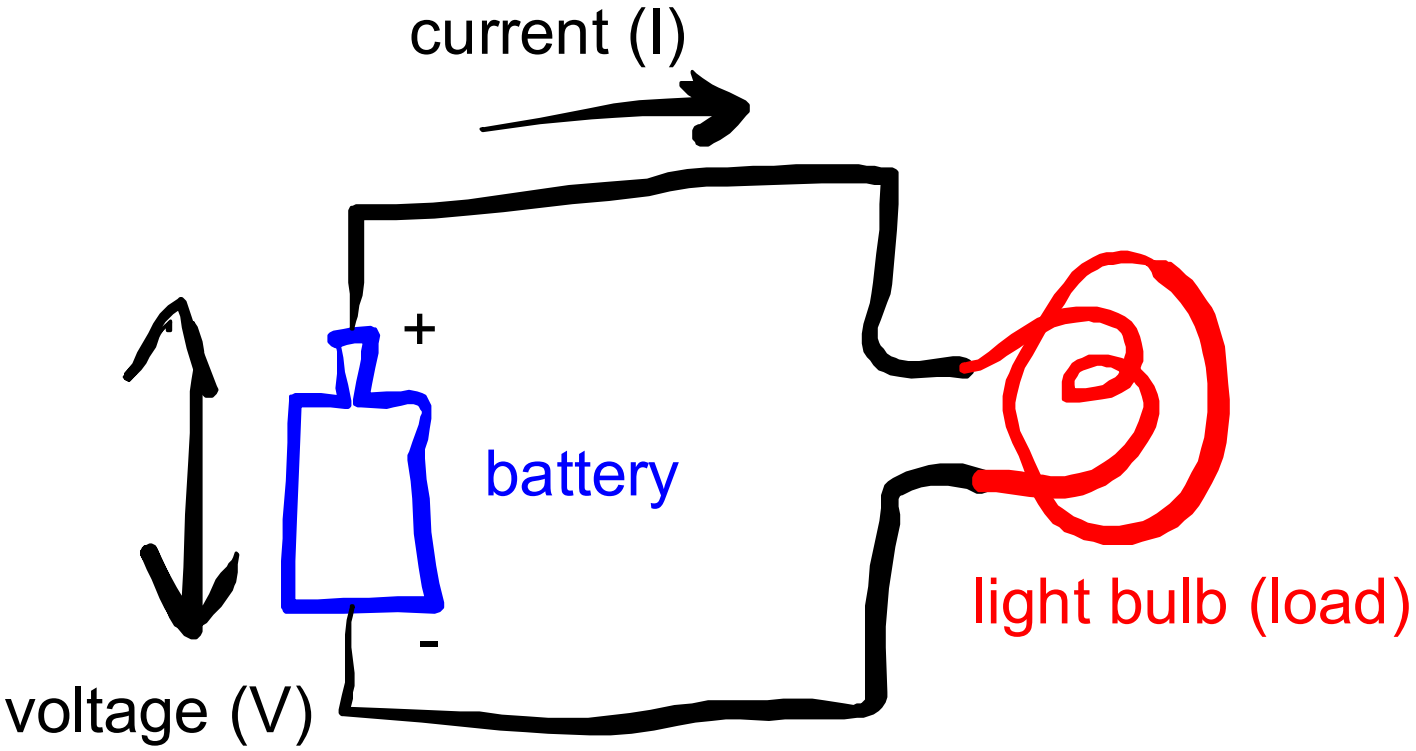




Electrons orbit the nucleus

Some electrons break free of the nucleus and can move freely through the metal. Conduction electrons

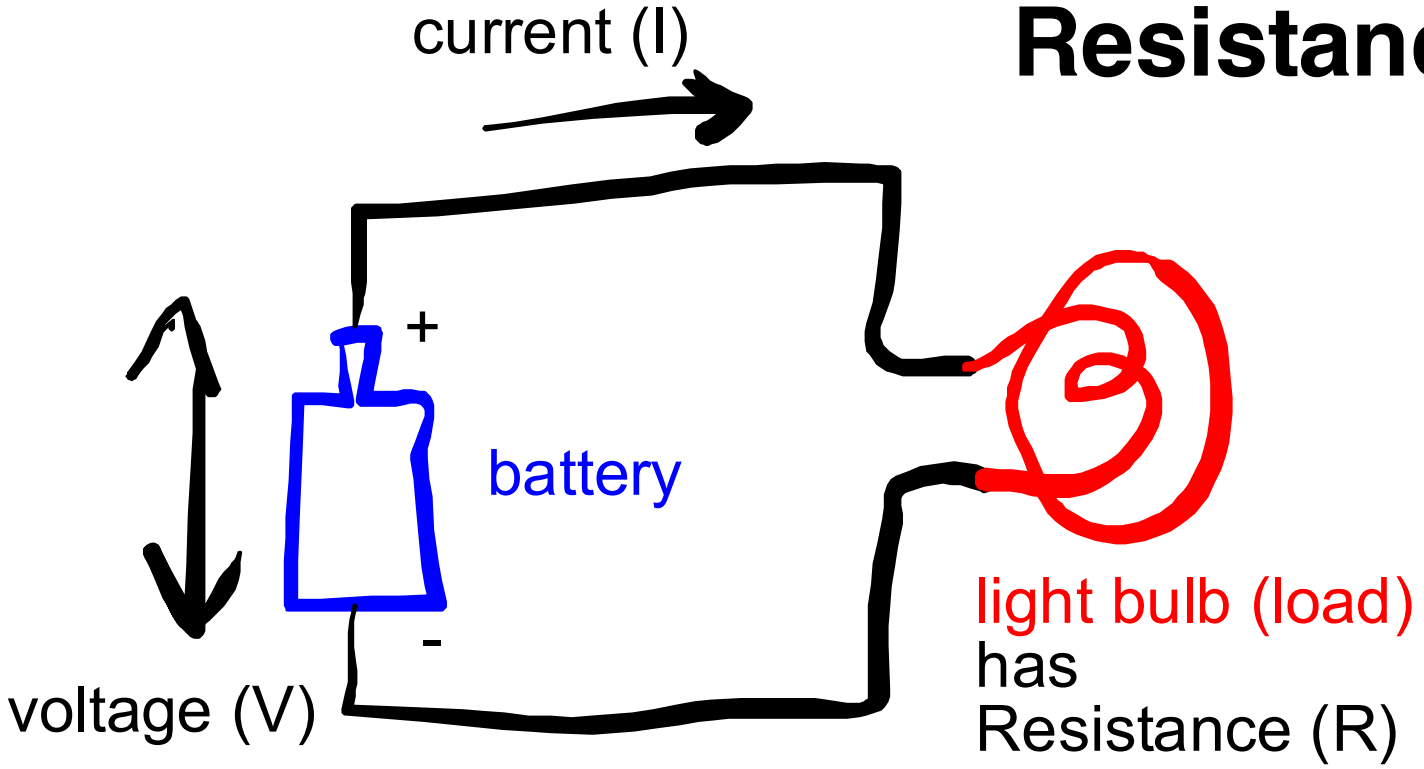
Electric Circuits



Current moves from + to -
(positive to negative)

Actually, electrons travel from - to +

Electric Circuits
Resistance



Ohm's Law: V = I R
voltage = current times resistance

If you have constant voltage:
small resistance gives big current
big resistance gives small current

Power

Power is energy released per time

Big power, lots of energy released per second
Small power, little energy released per second

$P = V I$
power = voltage times current

remember
$V = I R$
so
$P = I R I$

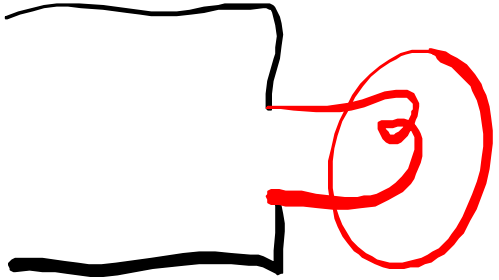
$P = I^2 R$
power = current squared times resistance

Units of power are watts (W), 1 watt is 1 volt times 1 amp

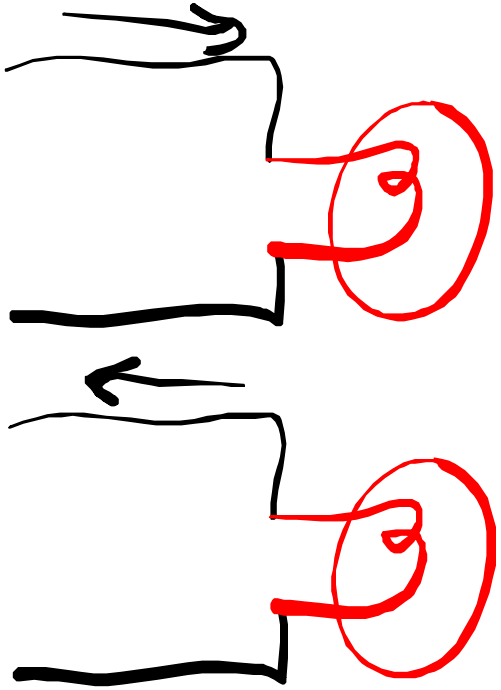
lower temperatures in materials mean less electron movement
which means less likely charges collide -> lower resistance
EXCEPT in semi-conductors. If no electrons are able to move, then resistance increases as well

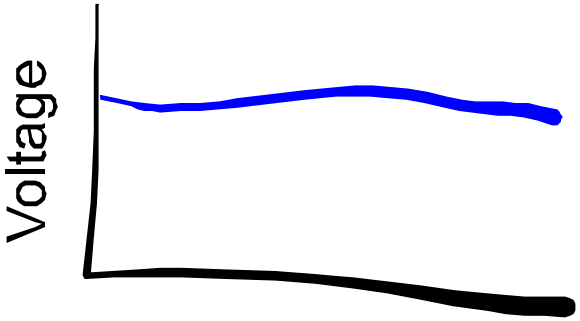
Direct / Alternate Current

Current direction is constant

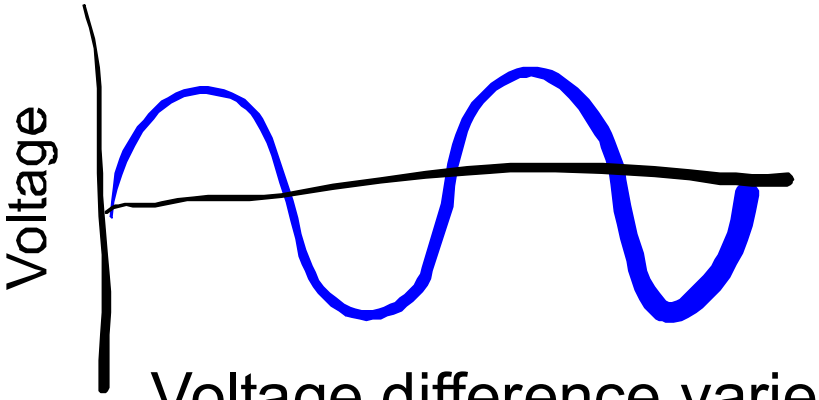


Current direction changes





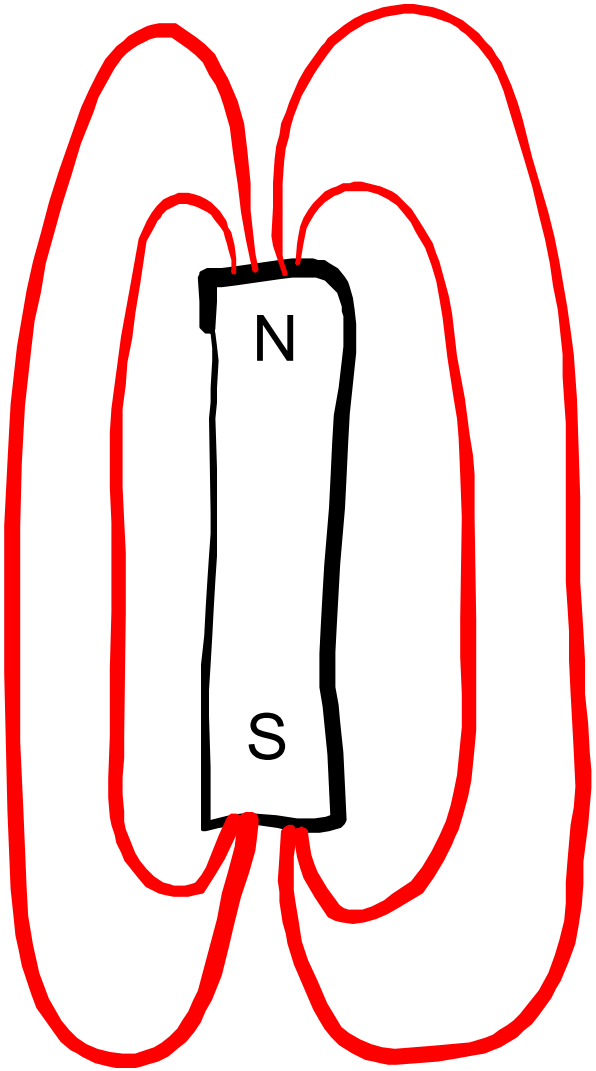
Voltage difference is constant



Voltage difference varies

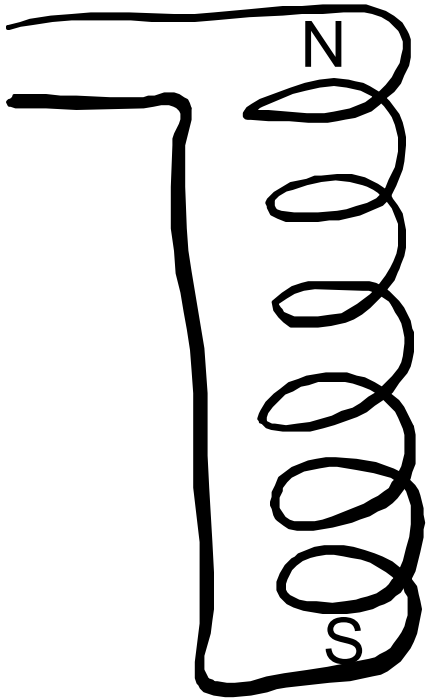
Magnets

Magnetic field lines



Permanent Magnet

Current in a coil

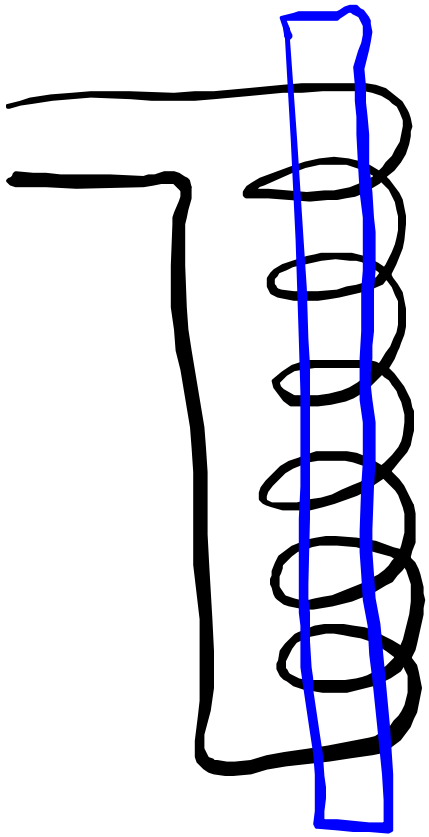


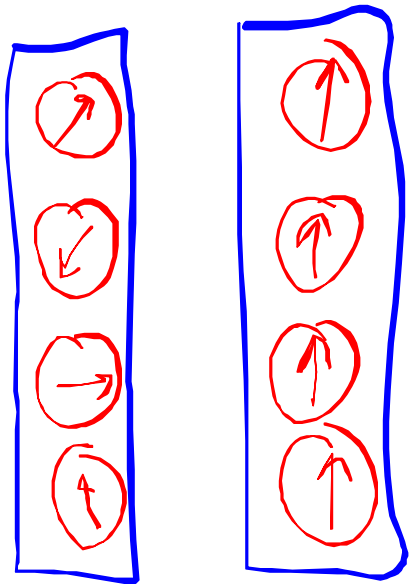
Electromagnet

Magnets and Electricity

Electric current makes a magnetic field

Strength of field
depends on current
and number of windings





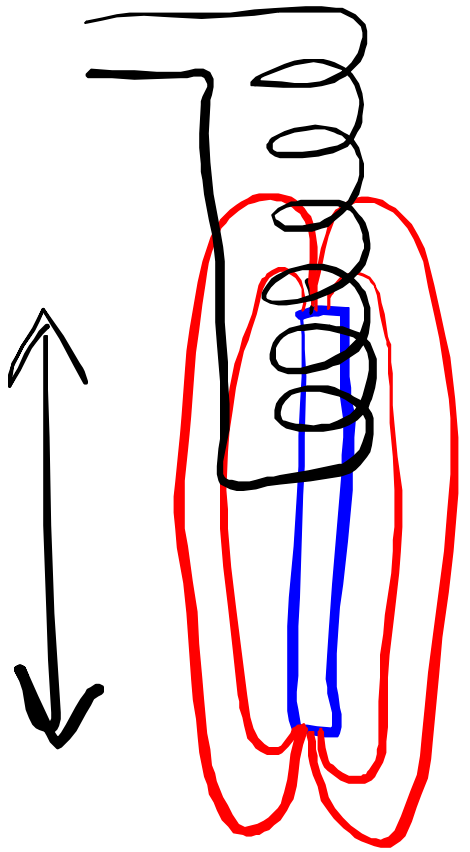
Iron bar has magnetic domains
that are normally randomly oriented.
They can be oriented by an external
magnetic field.

This amplifies the total magnetic strength
of the electromagnet

Magnets and Electricity

Changing magnetic field induces an electric field.

Move permanent magnet in and out of coil to change magnetic field inside coil



Changing magnetic field inside coil induces voltage across the coil. This voltage (and current) can power an electrical load (light bulb)

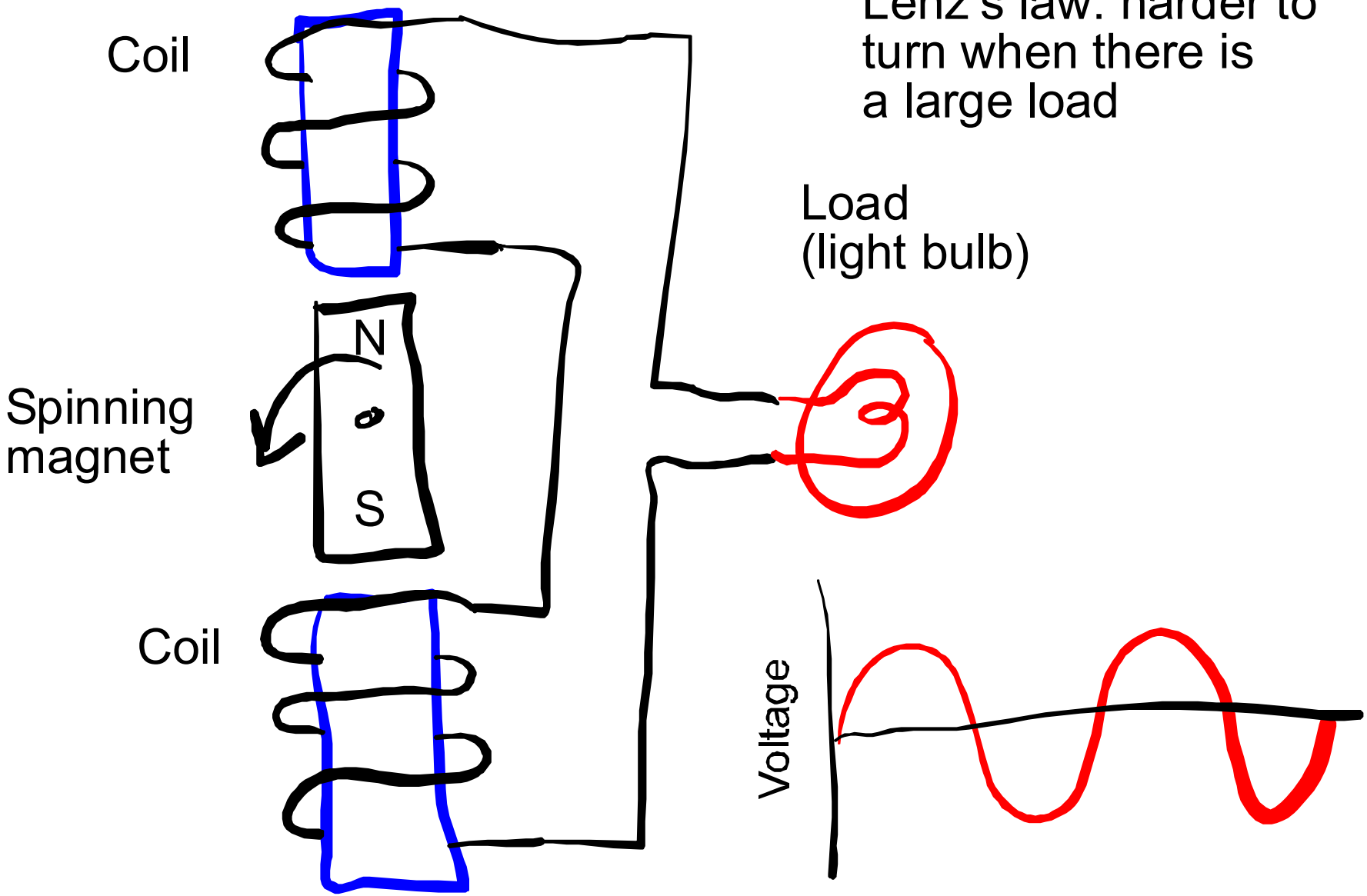
Lenz's Law

Lenz's Law: Current induced by a changing magnetic field always produces a magnetic field that opposes the change.

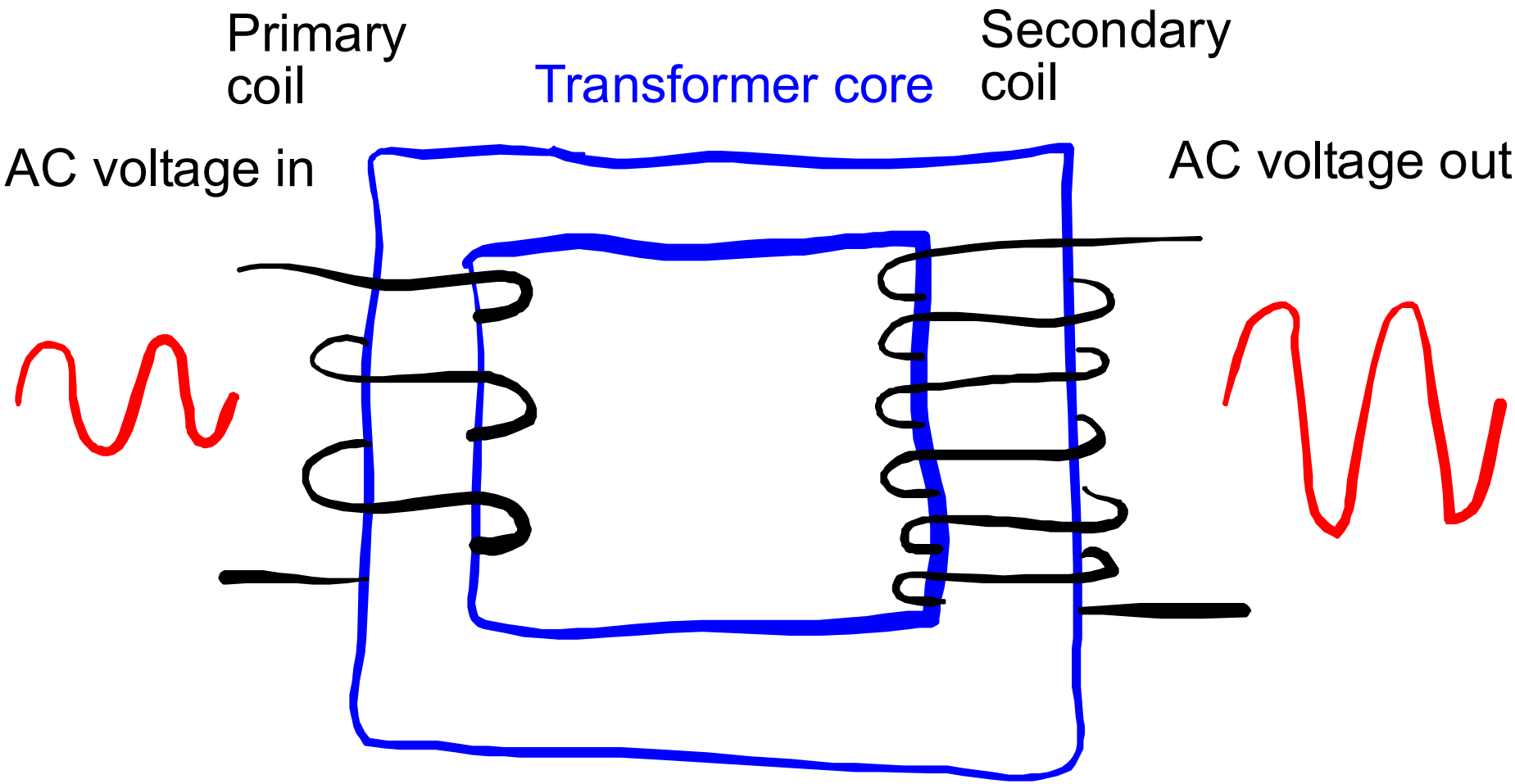
If I push the magnet into the coil, the coil will try to push back.
I need to do work on the magnet, this work gets transferred into electrical energy.

Use this to make a generator

Generator


Coil
Lenz's law: harder to turn when there is a large load
Load (light bulb)
N
S
Spinning magnet
Coil
Voltage

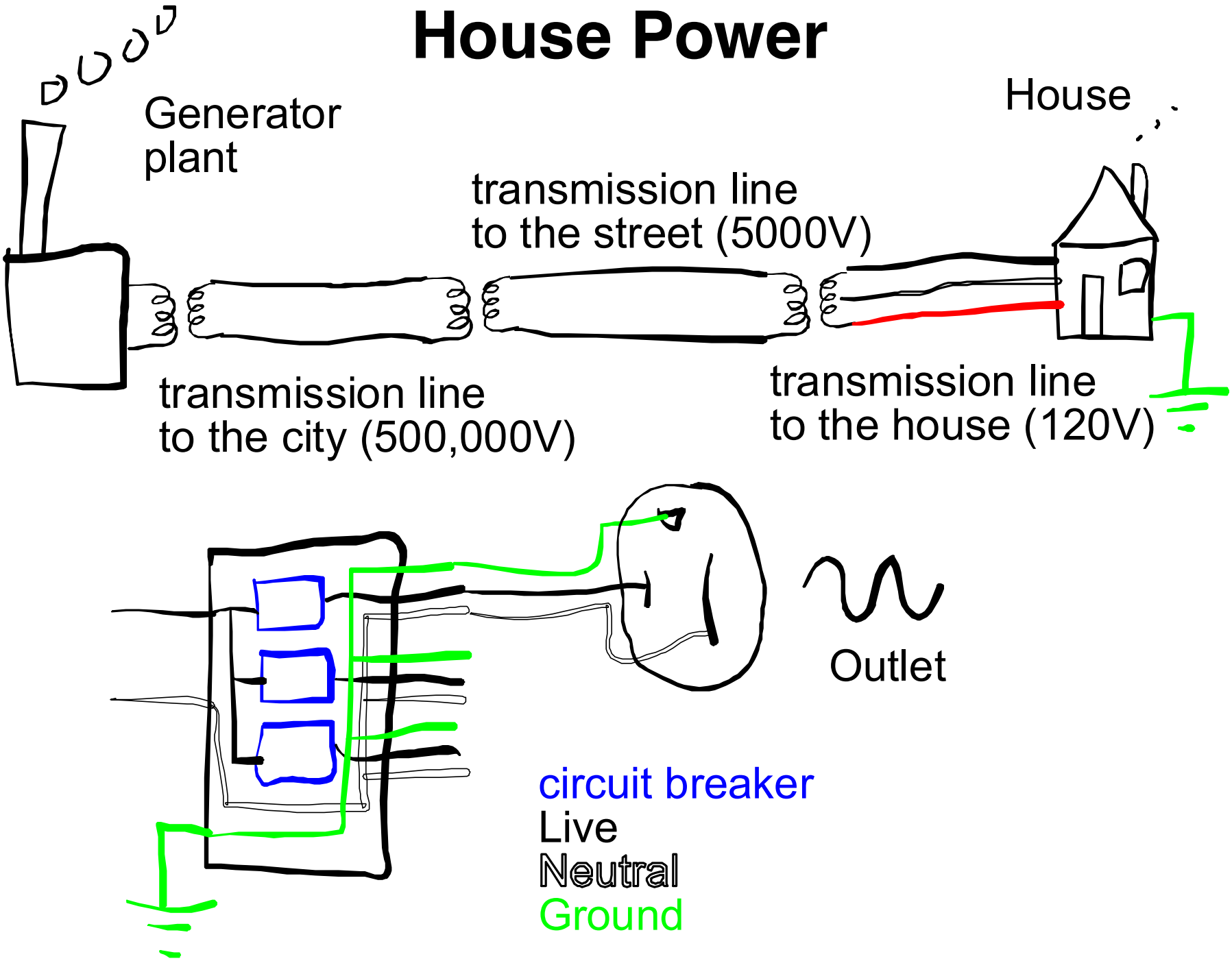
Transformer



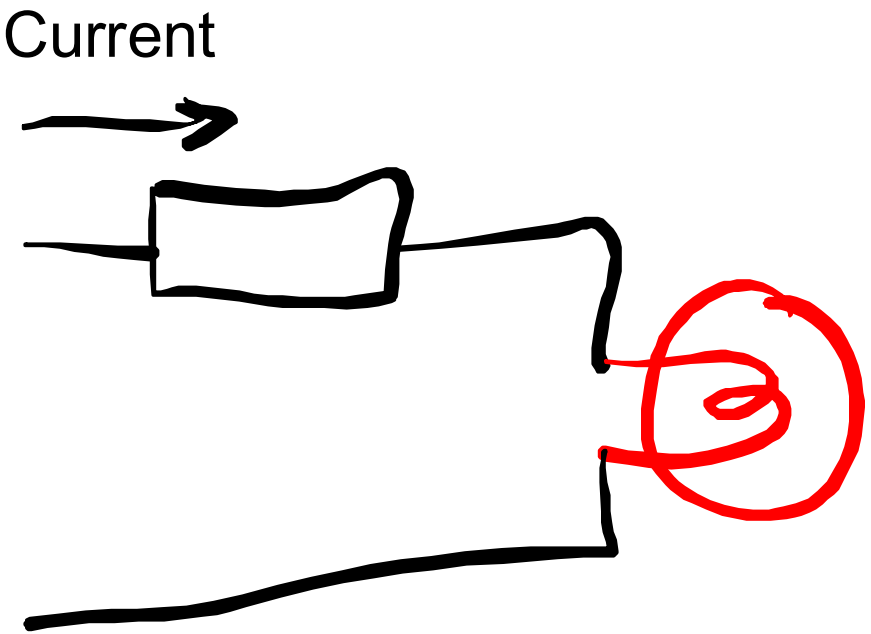
The ratio of the two voltages is the same as the ratio of the number of turns on the coils

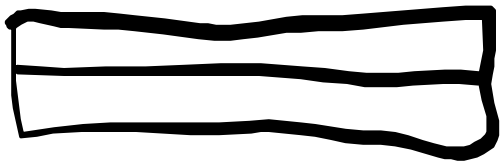
$$\text{Vin / Vout} = \frac{\text{Number of turns in primary}}{\text{Number of turns in secondary}}$$

House Power


Generator
plant
House
transmission line
to the street (5000V)
transmission line
to the city (500,000V)
transmission line
to the house (120V)
Outlet
circuit breaker
Live
Neutral
Ground

Fuses

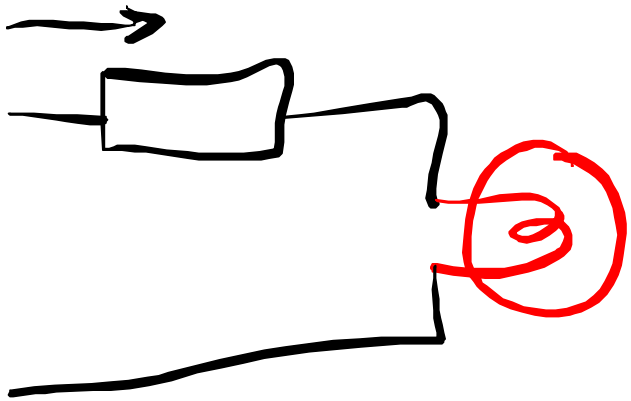




Fuse wire heats (I^2R)
eventually melts and breaks
the circuit--protects the light bulb

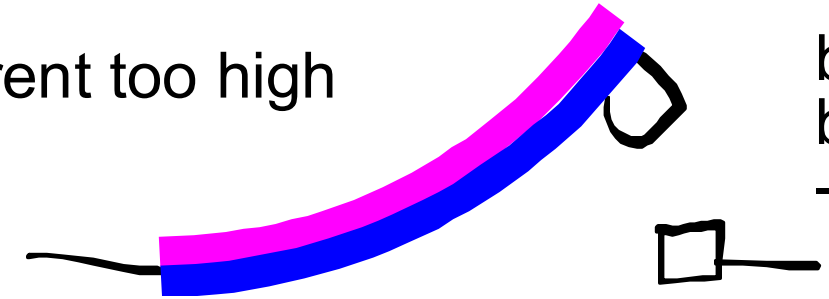
Circuit Breaker

bimetallic strip: two strips of metal that thermally expand at different rates



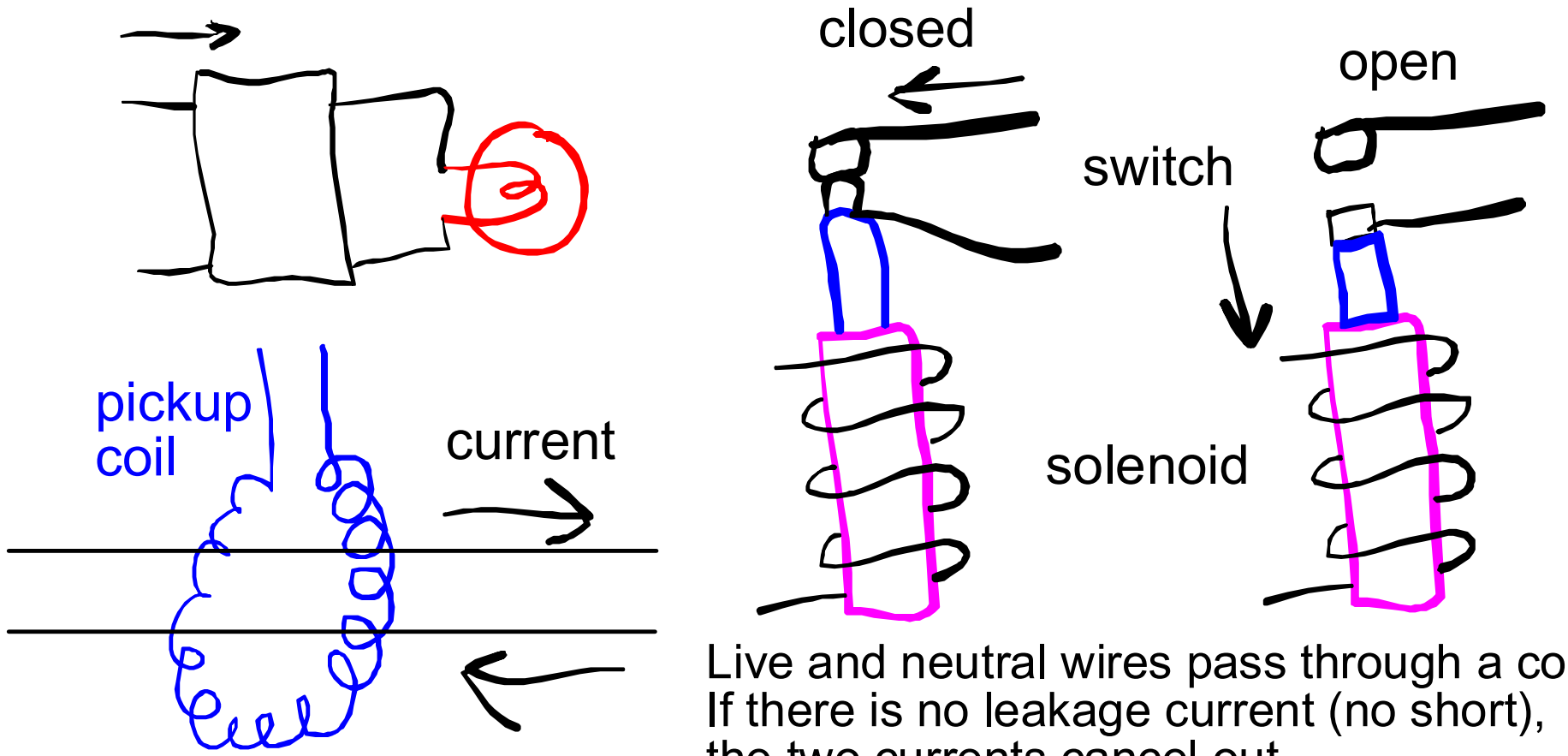
Low current

Current too high



bimetallic strip heats (I^2R), bends and pulls the contacts apart --protects the light bulb

Ground Fault Circuit Interrupter (GFCI)



Live and neutral wires pass through a coil.
If there is no leakage current (no short),
the two currents cancel out
and no magnetic field is induced in the coil.

If the currents are not perfectly balanced (5mA difference), the coil will sense the difference and activate the solenoid, opening the switch and turning off the power. There are also mechanical pieces that make certain the power can not turn on again unless the reset button has been pushed.