PHYSICS 106 - Principles of Physics II

Electricity / waves / optics/ nature of light

Relative weight will be assigned as follow:

tests (3)	45%
Laboratory	20%
virtual labs	20%
final	15%

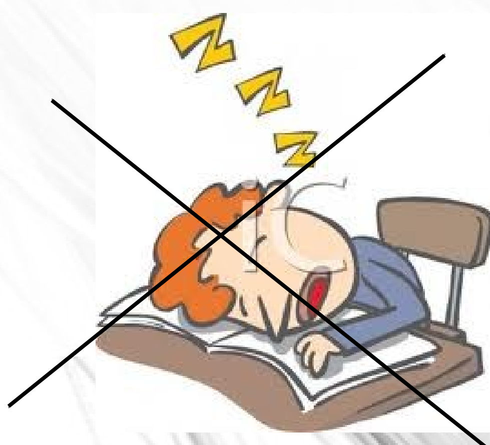
Participation bumps your grade 1 letter up. Except if you have a A-.

Participation bumps final grade 1 up
Low Attendance = 1 or 2 grade down

Missing lab = 10 points down from lab grade
Texting, facebooking, sleeping... = 1 grade down

Strong positive correlation between assignments, virtual labs and tests

If it bites or scratches,
it's biology.
If it stinks or pops,
its chemistry.
If it doesn't work,
it's physics



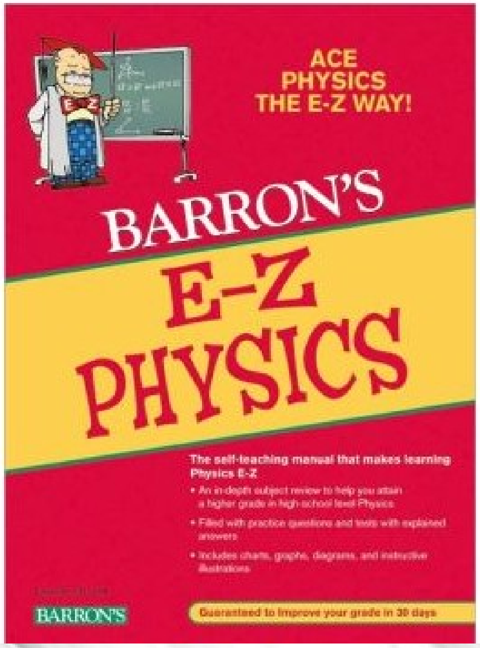
- I shared the slides in my dropbox

- I communicate through email.
Check your emails every day.

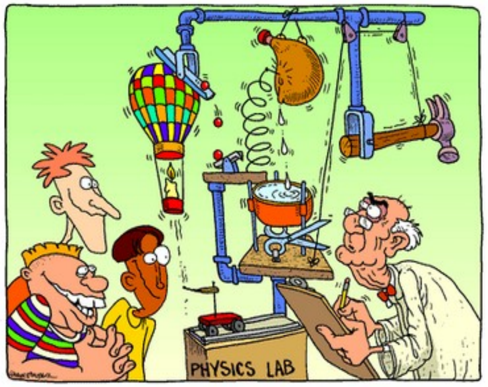
- test after unit: electricity, waves,
  Nuclear Physics.

E-Z Physics (Barron's E-Z Series)
Paperback

by Robert L. Lehrman
ISBN 9780764141263



Hands-on LAB runs for at least 2 hours.



I share the labs with you in the shared folder.

- Download the lab in your computer and bring it in class.
- or print out the lab.

20%

One virtual lab to complete every week.

20%

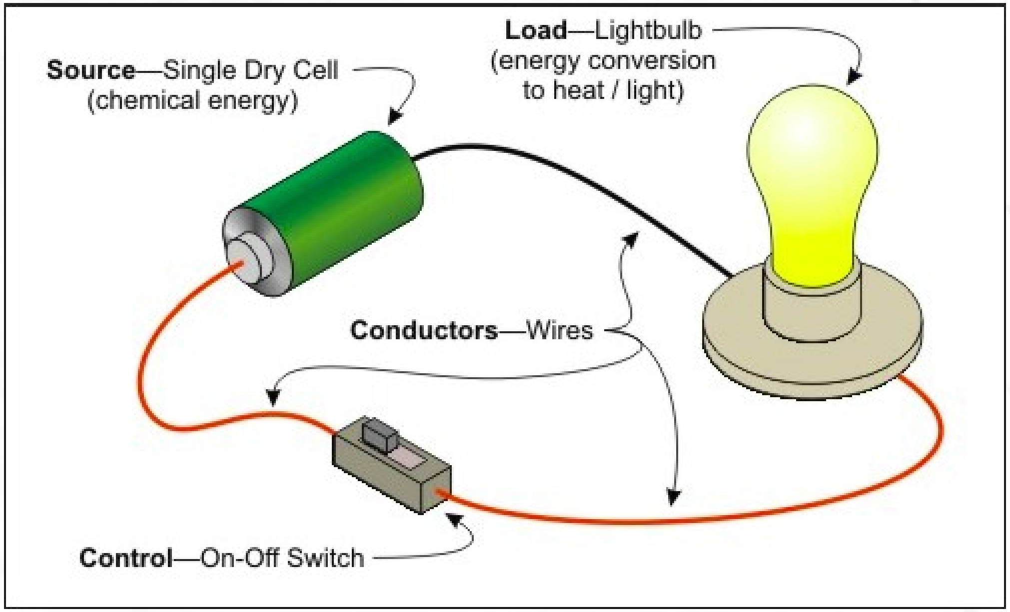
Use the library's computers and print out the lab report. Some of the questions will be in the tests. I don't accept late work. I don't accept attachments.

Virtual labs are from this website:

https://phet.colorado.edu/en/simulations/category/physics

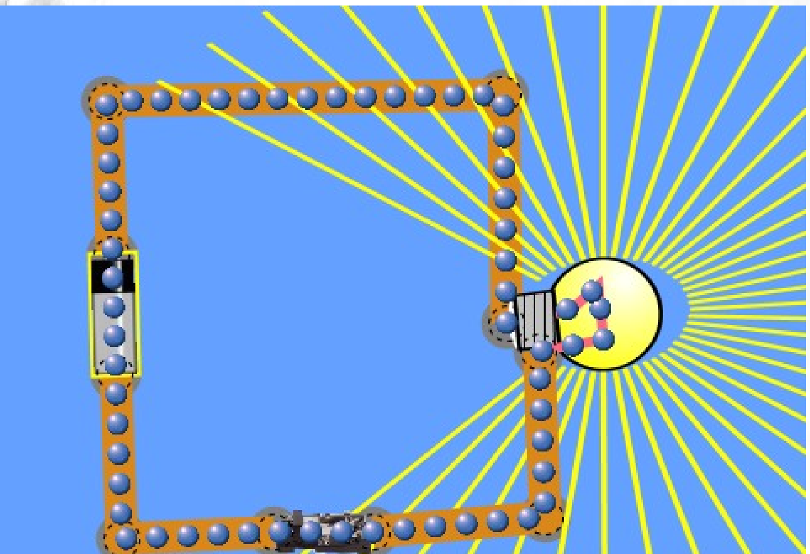
Virtual lab is due every Friday (usually)

UNIT 1: Electric circuits

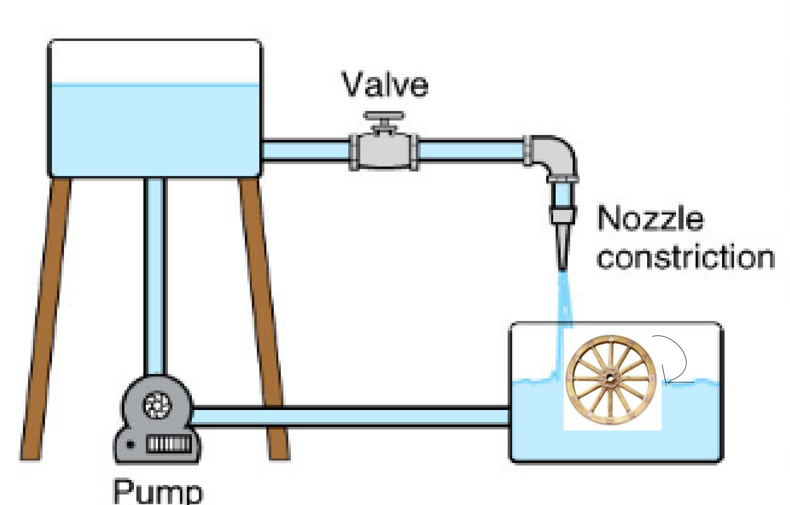


https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-ac

Open the app and build your first electric. Measure voltage and current. Use a snipping tool (PC) to save your circuit. Demo: a real circuit.



Electric circuit: power supply + load + Resistance to limit the current.



The water can flow only if there is a closed loop
And so does electric current.

The light bulb or load is similar to spinning wheel. It consumes energy per unit time (power).

The power supply turns chemical energy to Electric energy.

Voltage is to charges what altitude is to the water here. Voltage is potential energy per unit charge. Altitude is Potential energy per unit mass .

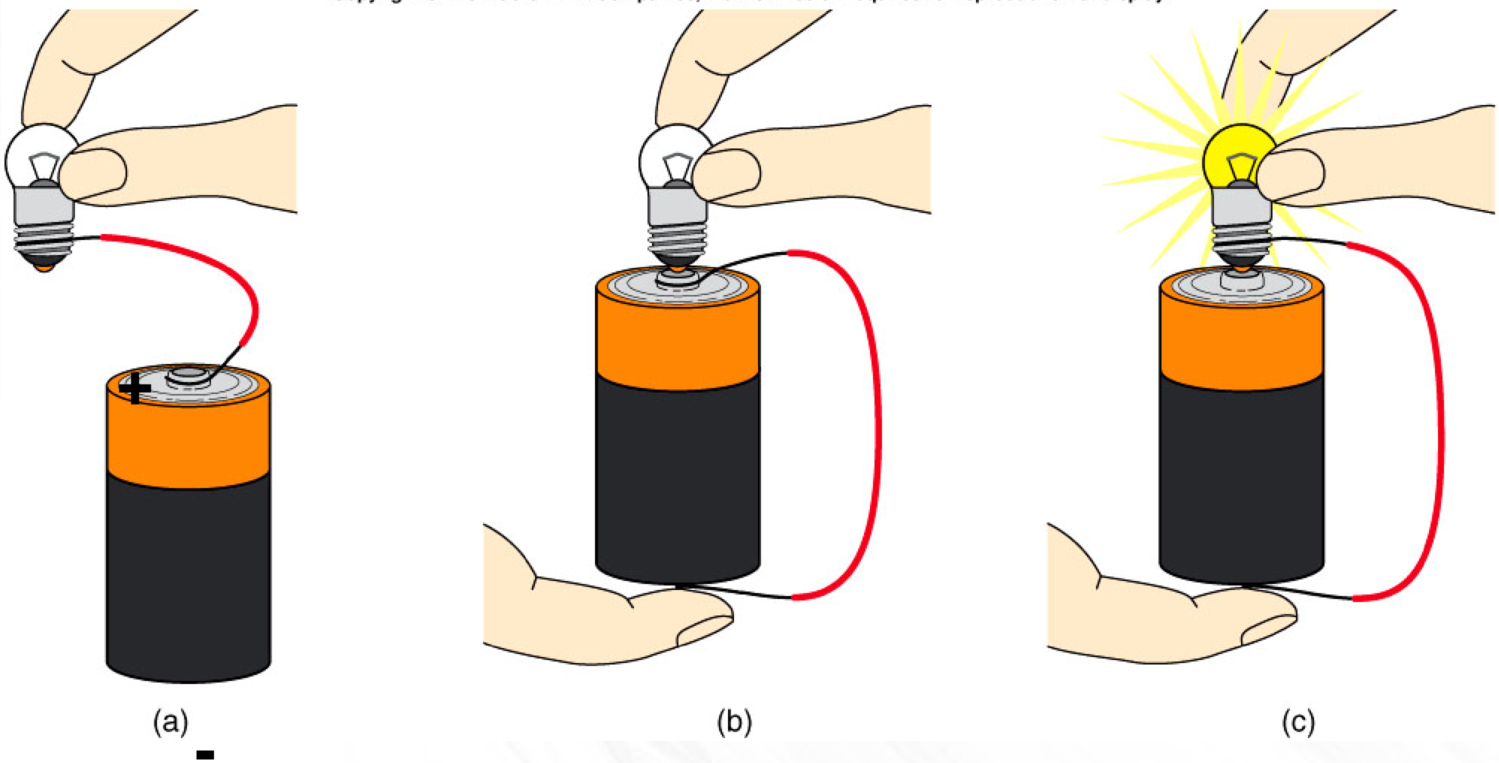
Current is similar to the quantities of gallons flowing per second. Its the amount of charges produced per Unit second.

Power supply (battery) is similar to the pump. Bring each charge/gallon to a higher level of energy (PE)

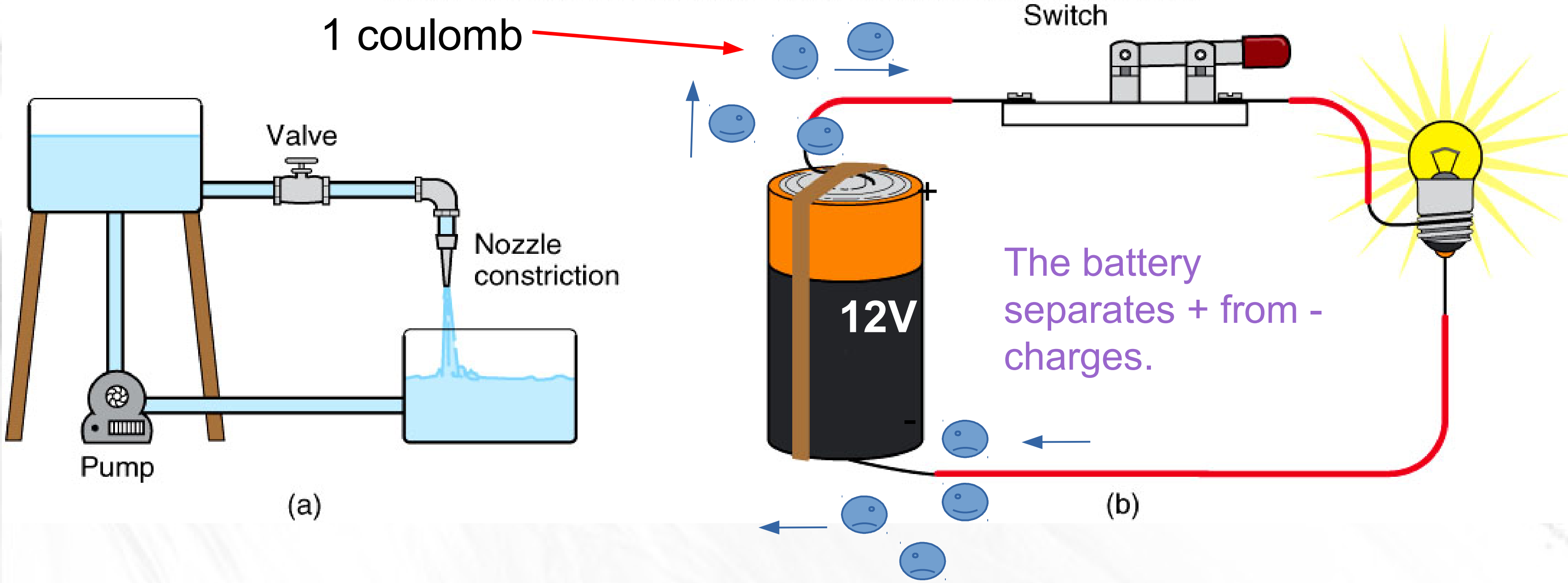
A **resistor** similar to the valve that limits the amount of water flowing. A resistor limits the electricity. Resistance is a number that measures how the device reduces the electric current flow through it.

Electric circuit = closed loop
From power supply, through load, back to power supply.

Source: the Physics of everyday phenomena (Griffith)



In lab, you will build such simple circuit.



If every second 4 charges (4 coulombs)
are provided by the battery : it means the current is 4 amperes or 4A.
(every second 4 charges flow through any cross-section of the wires)

If the battery has a tension of 12V (or voltage or difference of potential of 12V)
that means each coulomb of charge is "given " 12 joules of potential energy by
the battery.

Total energy available per second = 4 x 12 joules/second = power.
This power is consumed by the load (some is lost to heat too)

Some definitions

Voltage or electric potential tension (denoted Δ**V** or ΔU) is the energy per unit charge.
The SI unit for measuring voltage : **volts (V)** , or joules per coulomb (J/s).
A **voltmeter** is used to measure voltage.

An electric current (denoted **I**) is a flow of electric charge. It is the number of charges per second. In electric circuits this charge is often carried by moving electrons in a wire. It can also be carried by ions in an electrolyte, or by both ions and electrons such as in a plasma.
The SI unit for measuring an electric current is the **ampere (A)**, which is the flow of electric charge across a surface at the rate of one coulomb per second. An **ammeter** measures current.

The **electrical resistance** (denoted **R**) of an electrical conductor is the opposition to the passage of an electric current through that conductor. The SI unit of electrical resistance is the **ohm (Ω)**,
An **ohmmeter** measures resistance.

Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field. There are two types of electric charges: **positive and negative**. Positively charged substances are repelled from other positively charged substances, but attracted to negatively charged substances; negatively charged substances are repelled from negative and attracted to positive. An object is negatively charged if it has an excess of electrons, and is otherwise positively charged or uncharged. The SI derived unit of electric charge is the **coulomb (C)**

Introduction

Reference tables

Electricity

$F_e = \frac{kq_1q_2}{r^2}$

$E = \frac{F_e}{q}$

$V = \frac{W}{q}$

$I = \frac{\Delta q}{t}$

$R = \frac{V}{I}$

$R = \frac{\rho L}{A}$

$P = VI = I^2R = \frac{V^2}{R}$

$W = Pt = VIt = I^2Rt = \frac{V^2t}{R}$

A = cross-sectional area
E = electric field strength
F_e = electrostatic force
I = current
k = electrostatic constant
L = length of conductor
P = electrical power
q = charge
R = resistance
R_{eq} = equivalent resistance
r = distance between centers
t = time
V = potential difference
W = work (electrical energy)
Δ = change
ρ = resistivity

Series Circuits

$I = I_1 = I_2 = I_3 = \ldots$

$V = V_1 + V_2 + V_3 + \ldots$

$R_{eq} = R_1 + R_2 + R_3 + \ldots$

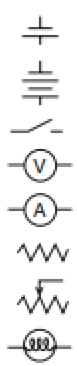
Parallel Circuits

$I = I_1 + I_2 + I_3 + \ldots$

$V = V_1 = V_2 = V_3 = \ldots$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

Circuit Symbols



cell
battery
switch
voltmeter
ammeter
resistor
variable resistor
lamp

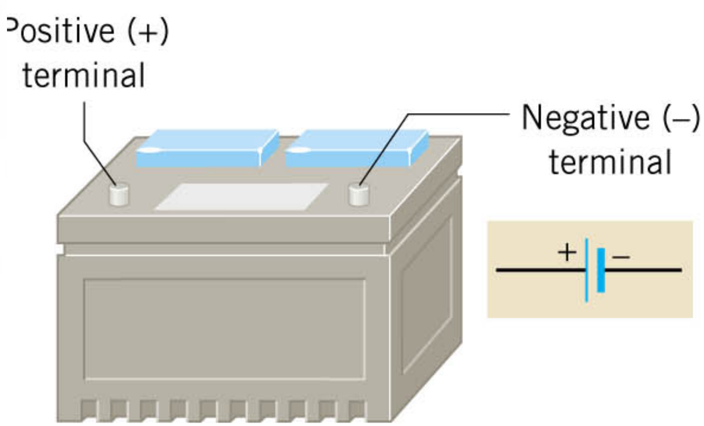
Resistivities at 20°C	
Material	**Resistivity (Ω•m)**
Aluminum	2.82×10^{-8}
Copper	1.72×10^{-8}
Gold	2.44×10^{-8}
Nichrome	$150. \times 10^{-8}$
Silver	1.59×10^{-8}
Tungsten	5.60×10^{-8}

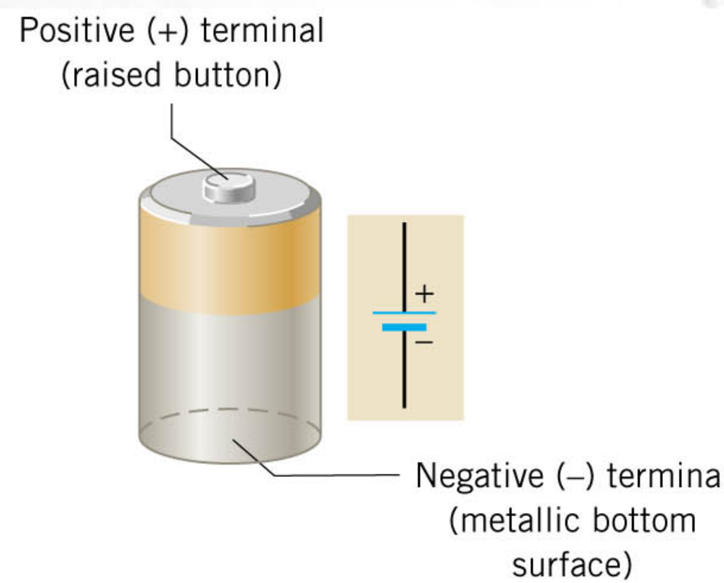
http://newyorkscienceteacher.com/sci/pages/reftables/prt.php

voltage

Within a battery, a chemical reaction occurs that transfers electrons from one terminal to another terminal.

The maximum potential difference across the terminals is called the ***electromotive force (emf) or voltage of the battery.***





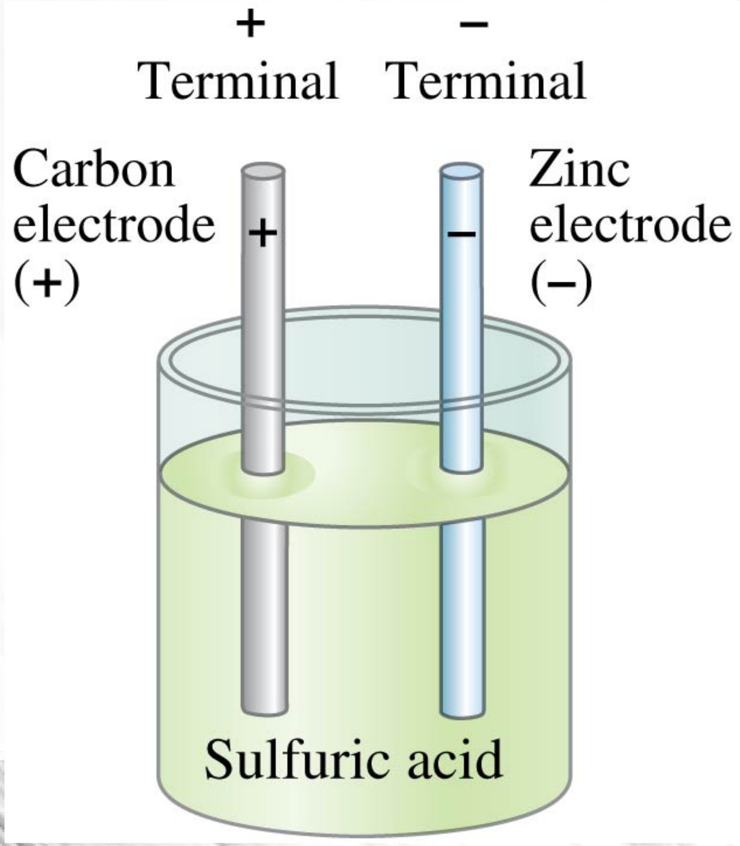
voltage

The Electric Battery

Volta discovered that electricity could be created if dissimilar metals were connected by a conductive solution called an electrolyte.

This is a simple electric cell.

demo



(Electromotive force)

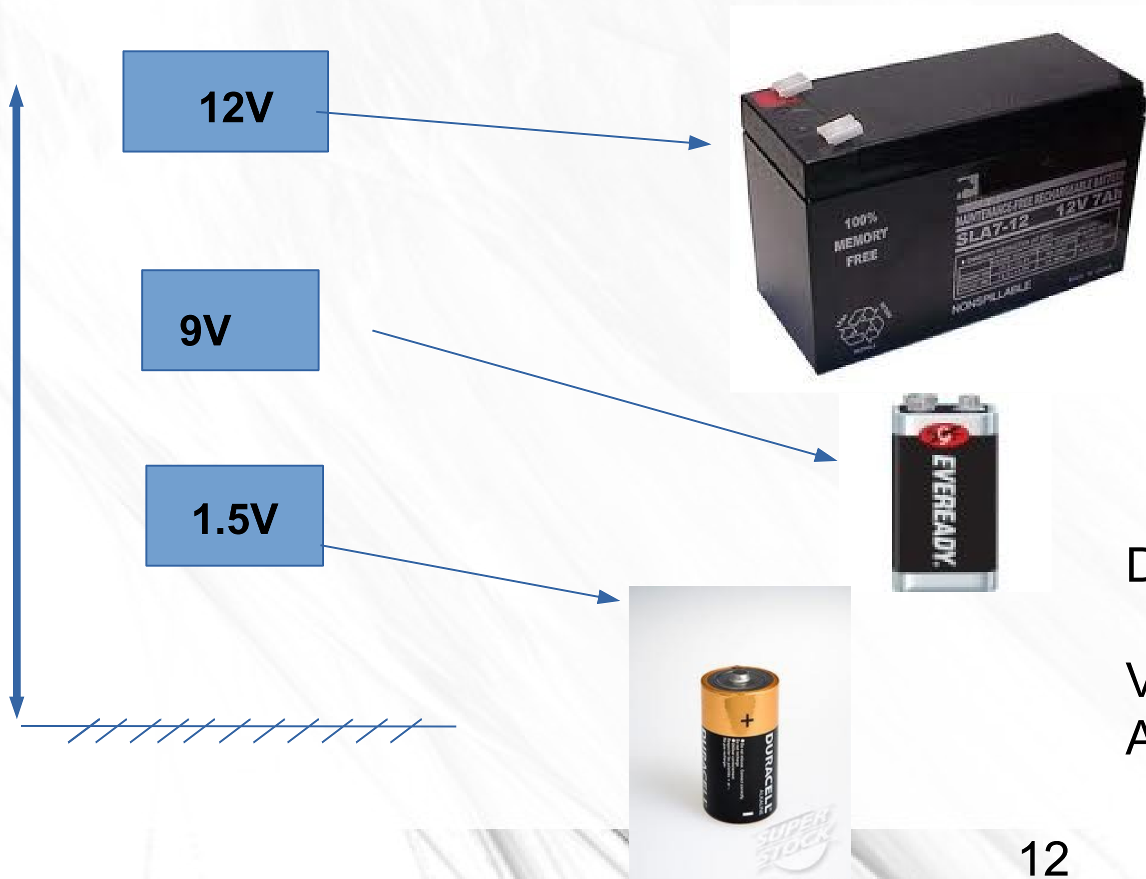
Emf of battery

=Voltage = (potential) energy per unit charge

SI unit is joules / coulomb = volts (V) .

Voltage is to a charge what height is to a mass

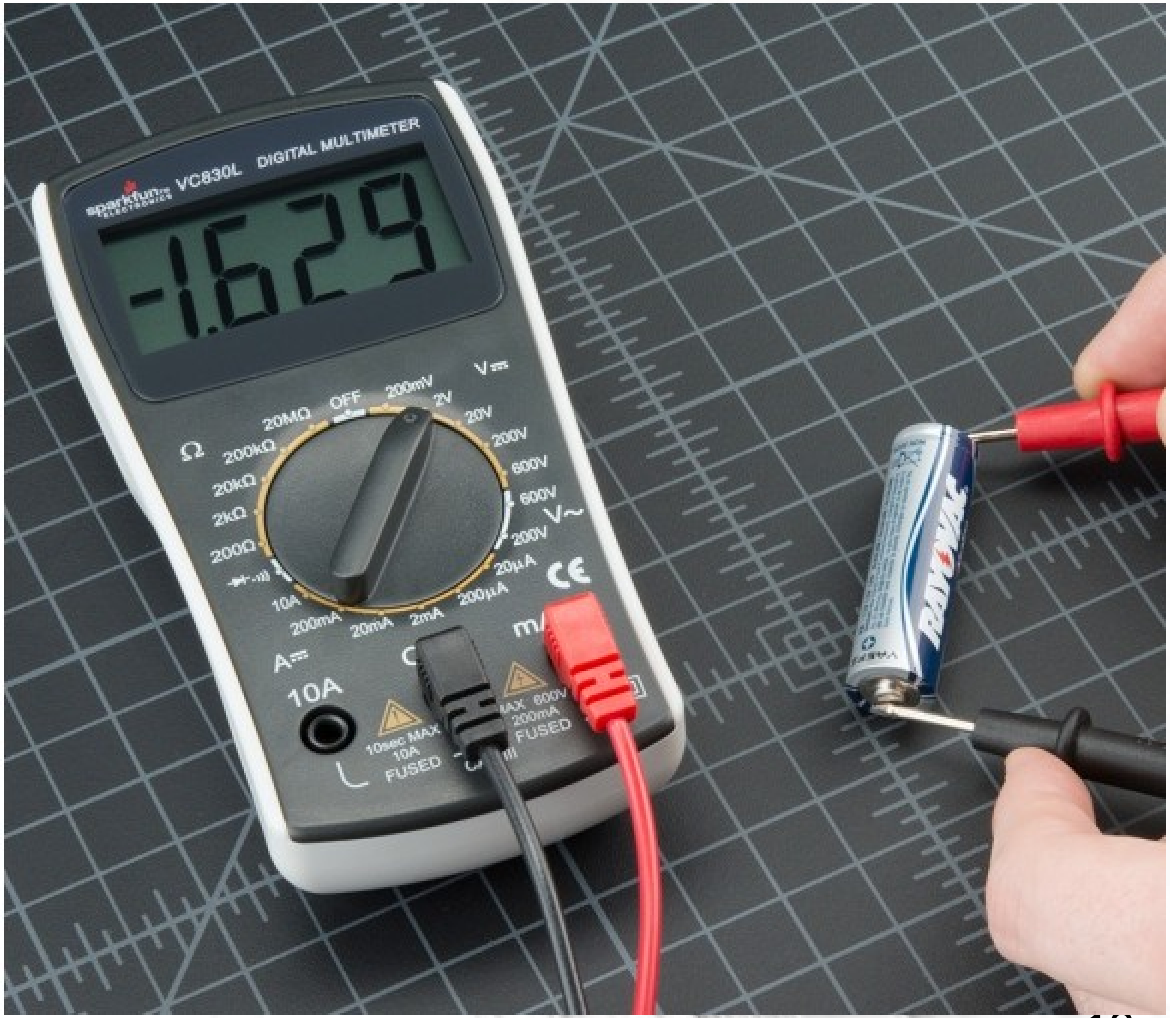
Increase the height = increase the Energy per charge



Demo:

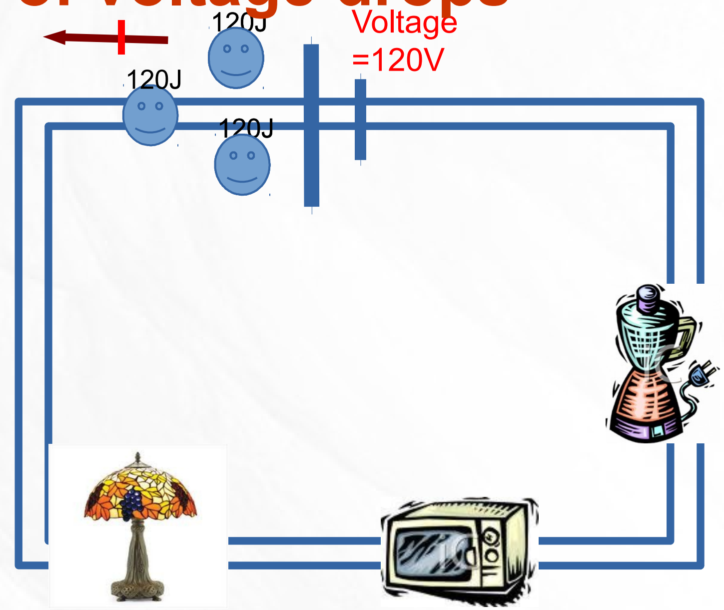
Voltmeter
And batteries

How to measure voltage across a battery
. The connection COM (common ground) has to connects
To the negative terminal of the battery. Otherwise you get a negative number.

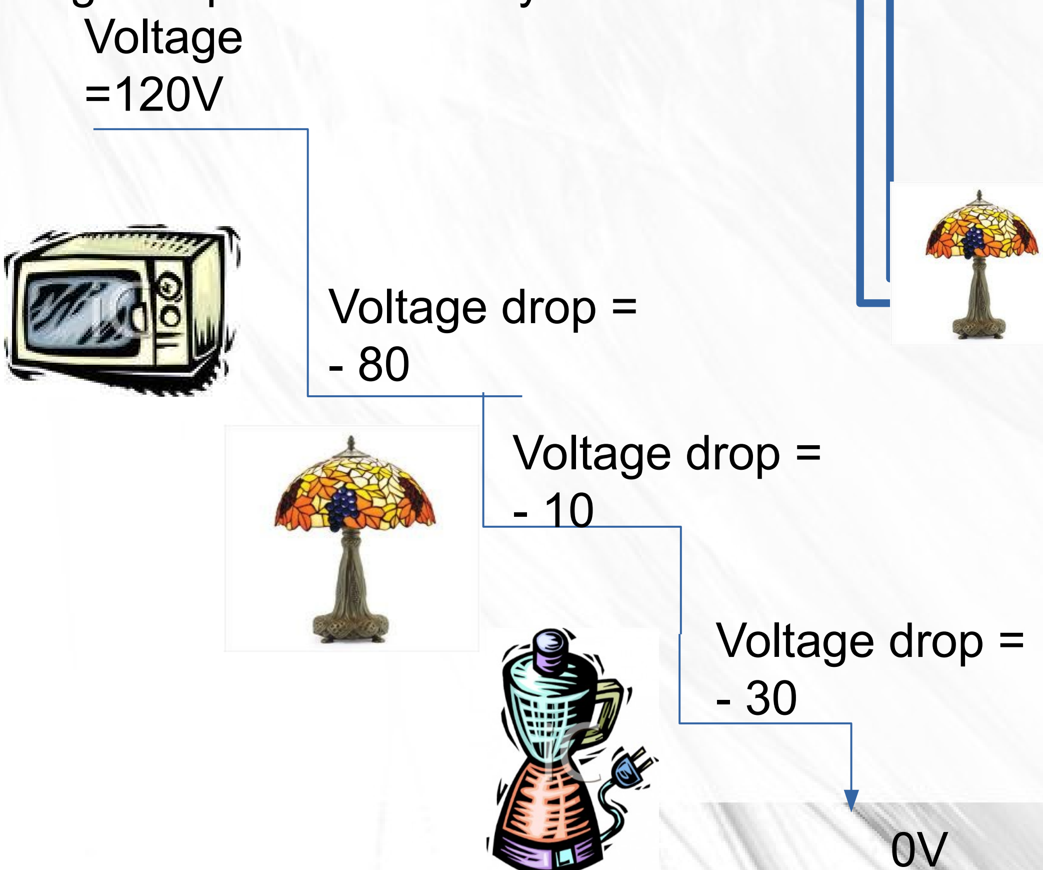


Voltage is to charge what altitude is to mass.
The voltage drops across each load
Voltage of power supply = sum of voltage drops

Every unit of charge has a potential energy of 120V if the power source provides 120V.

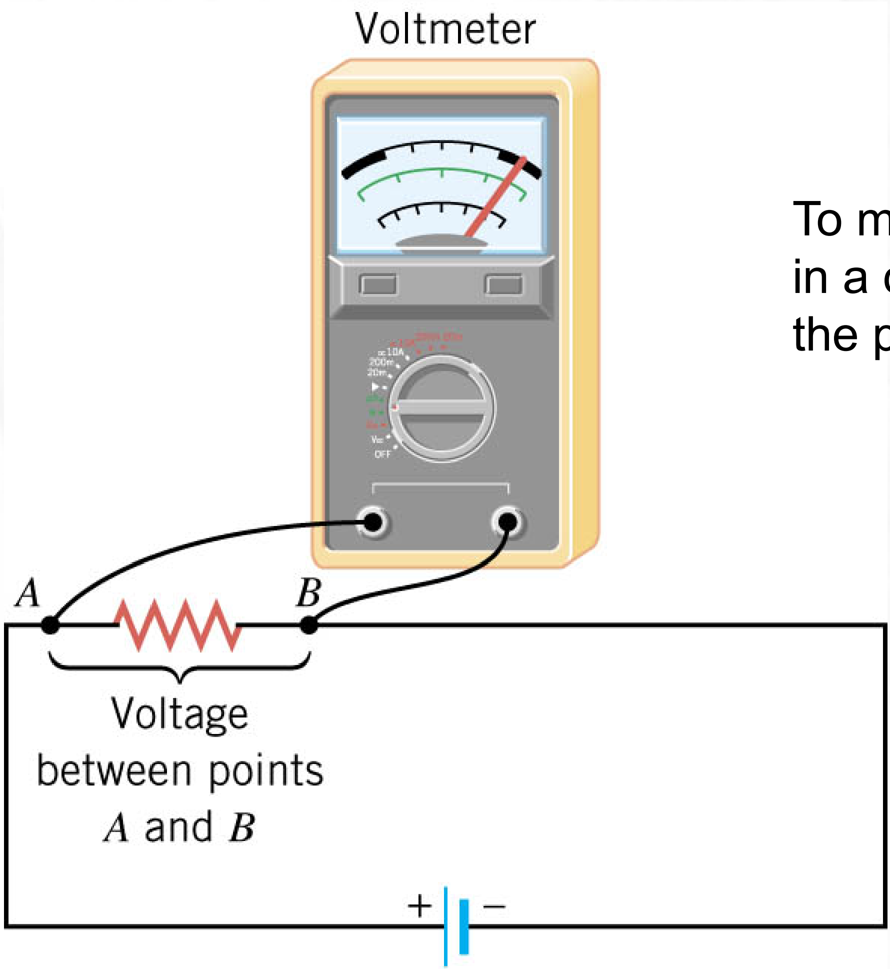


The voltage drops across every load.



Think of voltage as altitude

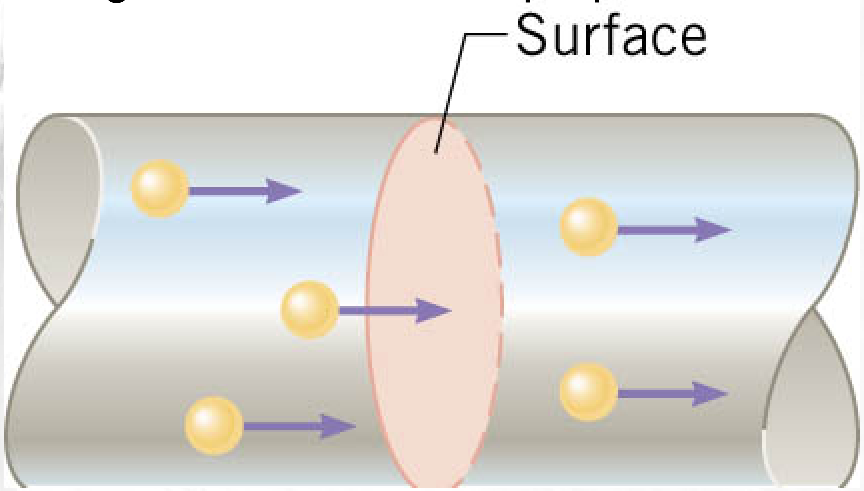
Current and Voltage

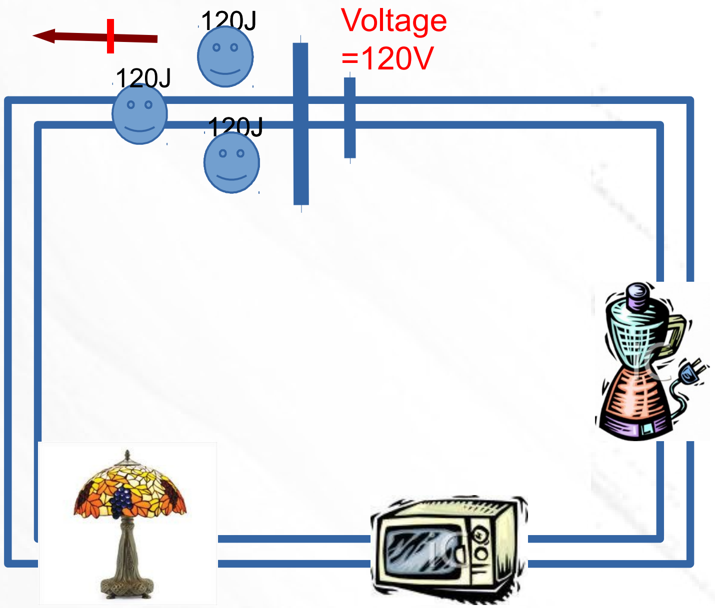


To measure the voltage between two points in a circuit, a voltmeter is connected between the points.

Electric current

The ***electric current*** is the amount of charge (or coulomb) per unit time that passes through a surface that is perpendicular to the motion of the charges.





Current = charge / time

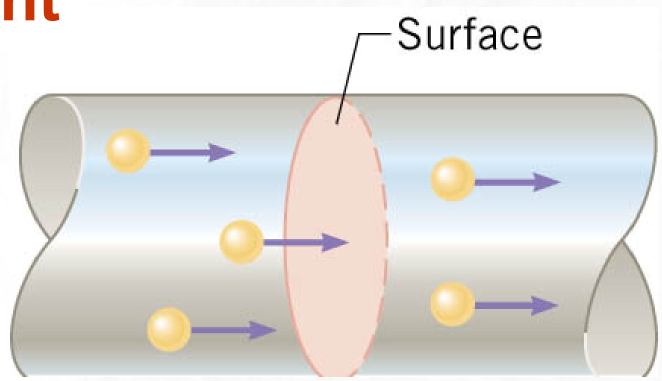
.amps= coulombs/second

One coulomb per second equals one ***ampere*** (A).

- Current is the amount of flow of charge past a given point
- We use the symbol **i** to represent current
- The unit of current is charge per unit time [C/sec], or Amperes [A]

$$\mathbf{i} = \frac{dq}{dt}$$

Electric current

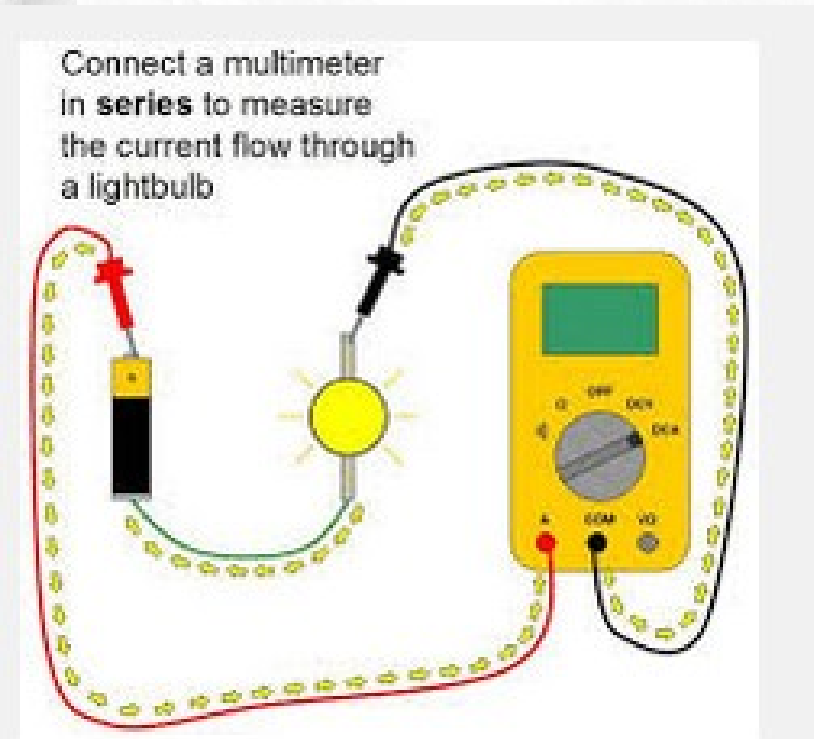


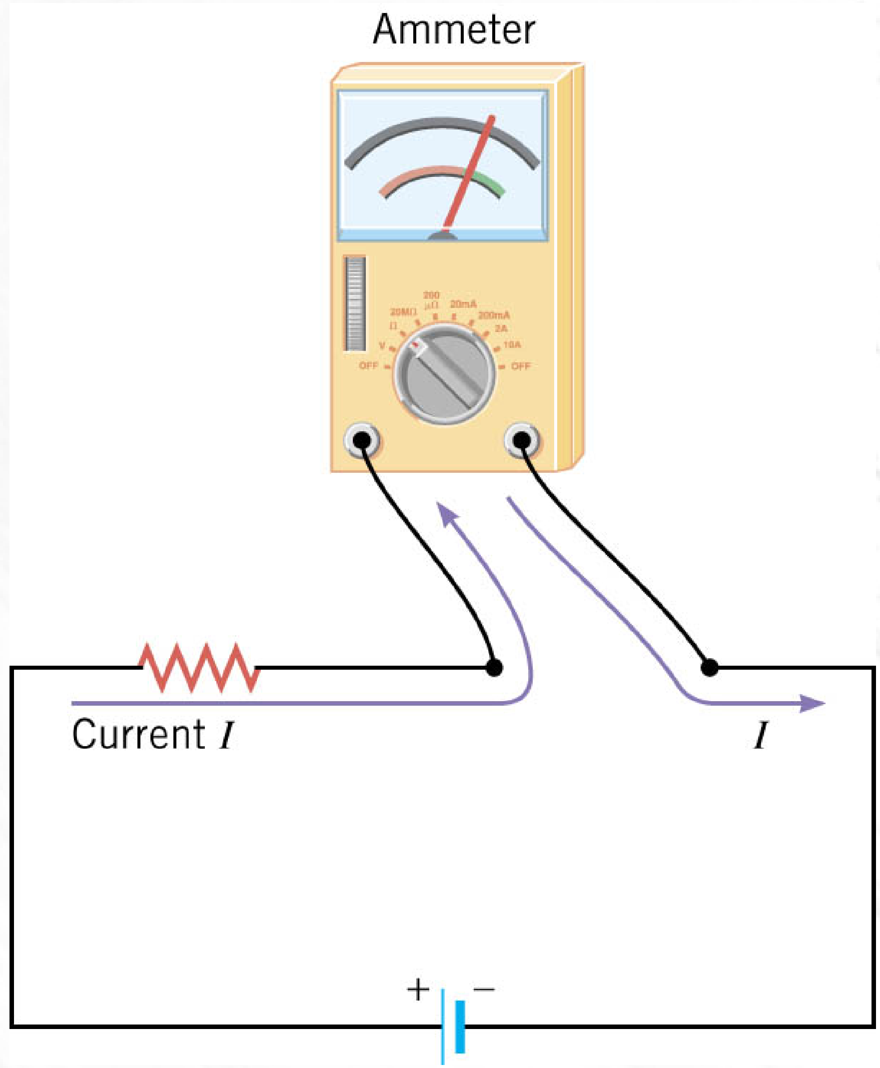
If the charges move around the circuit in the same direction at all times, the current is said to be ***direct current*** (***dc***).

If the charges move first one way and then the opposite way, the current is said to be ***alternating current*** (***ac***).

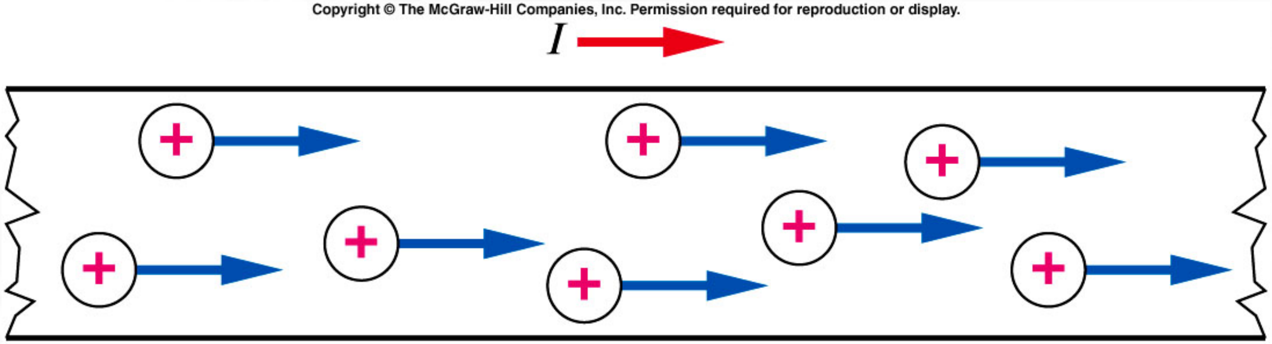
Measuring current with an ammeter. The device is Part of the circuit. The charges go through the ammeter. The ammeter counts the charges per unit second = current.

An ammeter must be inserted into a circuit so that the current passes directly through it.

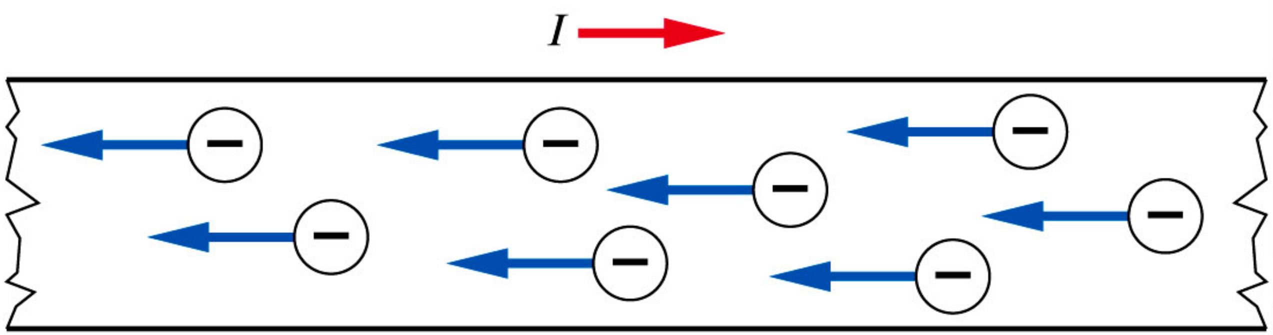




Electric current



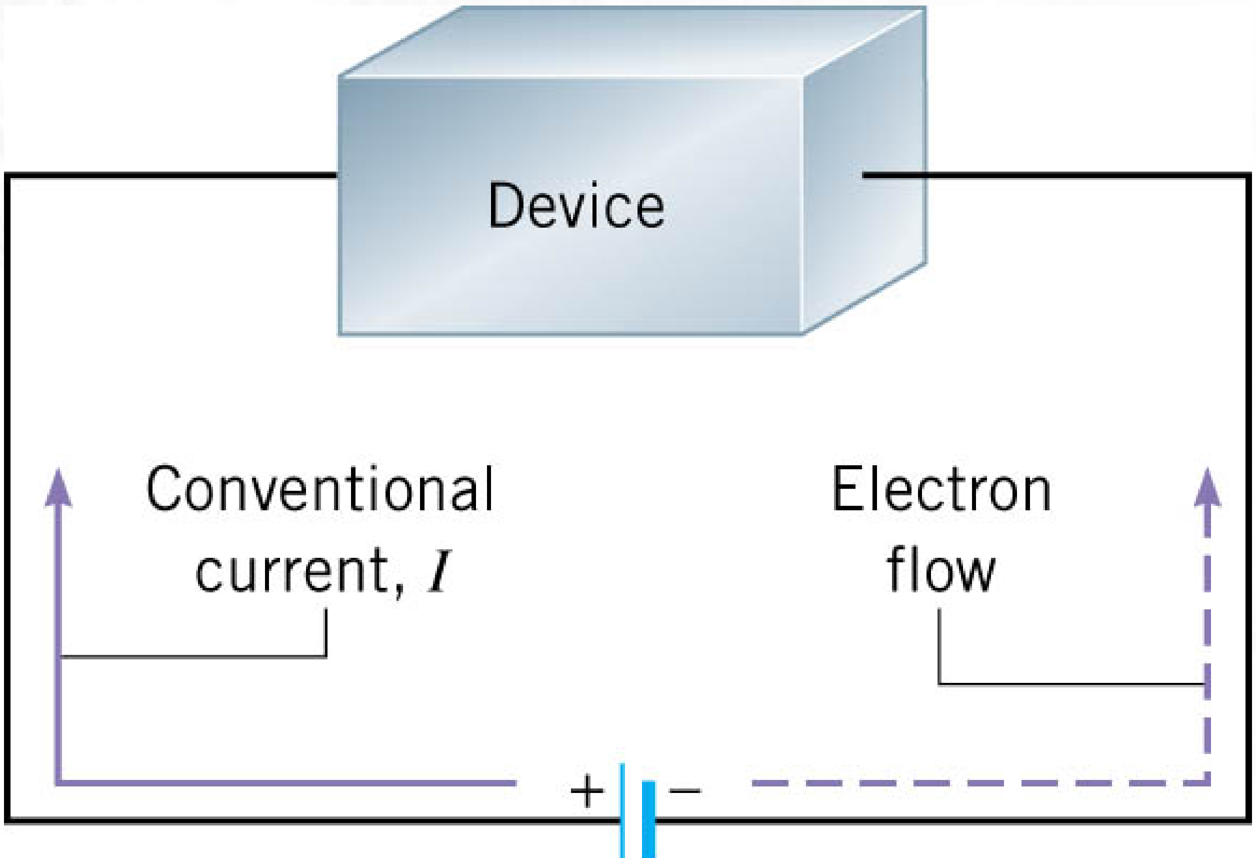
(a)



(b)

Electric current

Conventional current is the hypothetical flow of positive charges that would have the same effect in the circuit as the movement of negative charges that actually does occur.



Equations so far/units

t is the time elapsed Units = seconds (s)

E = total energy consumed/produced. Units = joules(J)

Q = amount of charge . Units = coulombs (C)

I = current or amount of charge per unit second =number of charge/ time = Q/ t
Units: Amps(A) or equivalent to coulombs/second (C/s)

V or ΔV = difference of potential or voltage or tension
= Energy per unit charge = E/Q
Units = volts (V) equivalent to joules/coulomb (J/C)

P = power = energy consumed/produced per unit second = E / t
Units = watts(W) or joules/second(J/s)

R = resistance units= ohms (Ω)

P= V I E = P t or P=E/t V = E / Q I = Q/t

Voltage across an ohmic conductor with resistance R **V = RI**

1. The current (measured in Amperes) in a circuit is
A. the amount of charge (measured in Coulombs) that passes a point (in the circuit) in 1 second.
B. the amount of the total energy carried by 1 Coulomb of charge.
C. the total number of electrons in the circuit.
D. never lethal if the current is due to positive charges.

2. volt is the unit for :
A. current
B. voltage
C. power
D. resistance

3. ohm is the unit for
A. resistance
B. current
C. voltage
D. Power

4. Power (watts) is:
A. energy per charge
B. number of charge per second
C. energy per seconds

4.voltage is:
A. energy per charge
B. number of charge per second
C. energy per seconds

5.One ampere is equivalent to:
A. 1 V/m.
B. 1 N/C.
C. 1 J/s.
D. 1 C/s.
E. 1 ohm/volt.

6. One volt is equivalent to:
A. 1 V/m.
B. 1 N/C.
C. 1 J/C
D. 1 C/s.
E. 1 ohm/volt

7. A coulomb of charge that passes through a 6V battery is given :
A. 6 joules
B. 6 amperes
C. 6 ohms
D. 6 watts
E. 6 newtons

8) which state is correct
A) current flows through a circuit
B) voltage flows through a circuit
C) resistance is established across a circuit
D) current causes voltage

9) when a battery does 24J of work on 10C, the voltage it supplies is:
A) 2.4V
B) 4.2V
C) 24V
D) 240V

10) If there are 10C for 10s the current is _____________

11) the resistance is similar to a:
A) pump
B) wheel spinning
C) valve
D) pipes

Electric Power

Power, as in kinematics, is the energy transformed by a device per unit time:

$$P = \frac{\text{energy transformed}}{\text{time}} = \frac{QV}{t}.$$

Unit of power is Watt (W)

P = V I

Power = current x voltage

Unit of energy is joule (J)

E = Q V

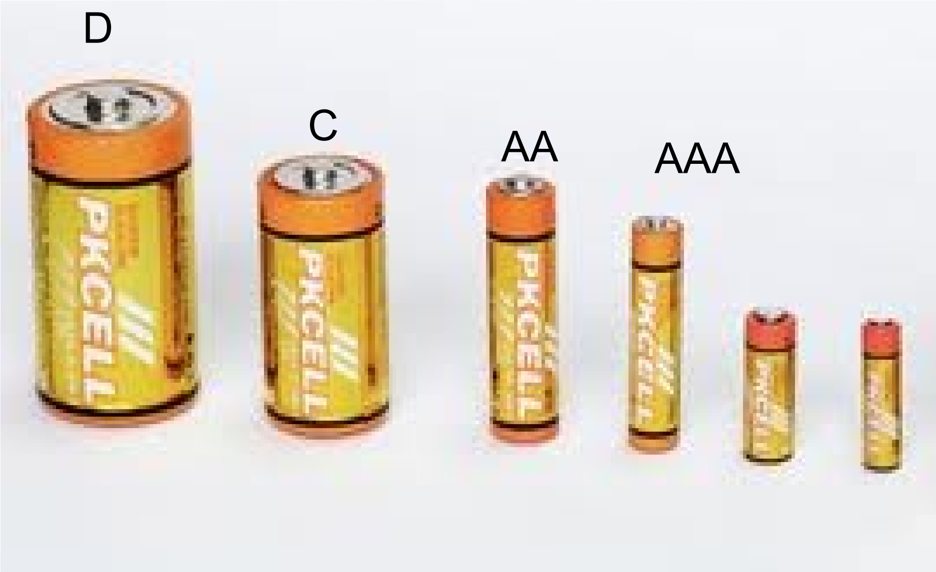
Energy = charge x voltage

P = E / t

Power = energy / time

Unit of current is ampere (A)

Unit of time is second (S)



All these batteries deliver the same voltage 1.5V
(1.5 joule per charge). So why some devices (or toys) require
the large one and some the small ones ?
Hint: some devices need more energy that other.

ENERGY DELIVERED PER SECOND = VOLTAGE x CURRENT
voltage is energy per charge and current is number of charge per second.
So If voltage = 1.5V and I = 0.2 A then POWER = _______ watts

Electric current

Example 1 **A Pocket Calculator**

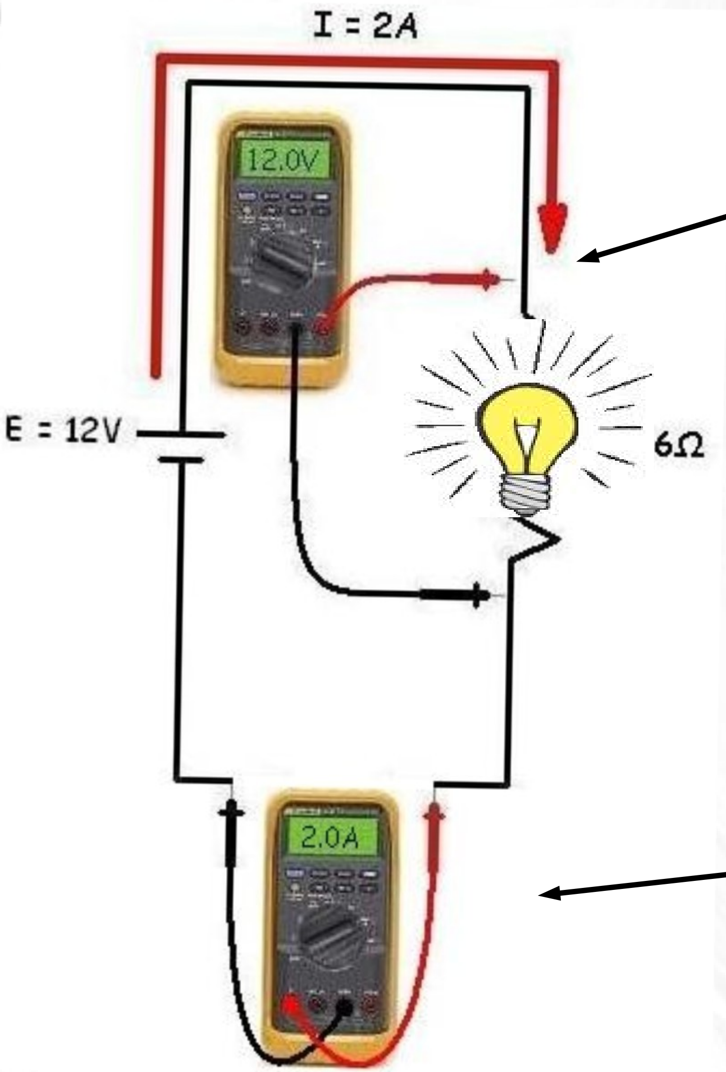
The current in a 3.0 V battery of a pocket calculator is 0.17 mA. In one hour of operation, (a) how much charge flows in the circuit and (b) how much energy does the battery deliver to the calculator circuit?

(a) Hint: current is the number of charges per second. (proportion)

(b) Hint: voltage is the energy per charge

Ex2. My laptop has a voltage of 20V and a current of 1.5A (according to the charger).
A) what is power consumes by my laptop ? (in watts and in kWatt)
B) what is the energy consumed in 24 hours
C) The amount of charge (coulomb) flowing in 1 hour.

How to measure voltage vs current/



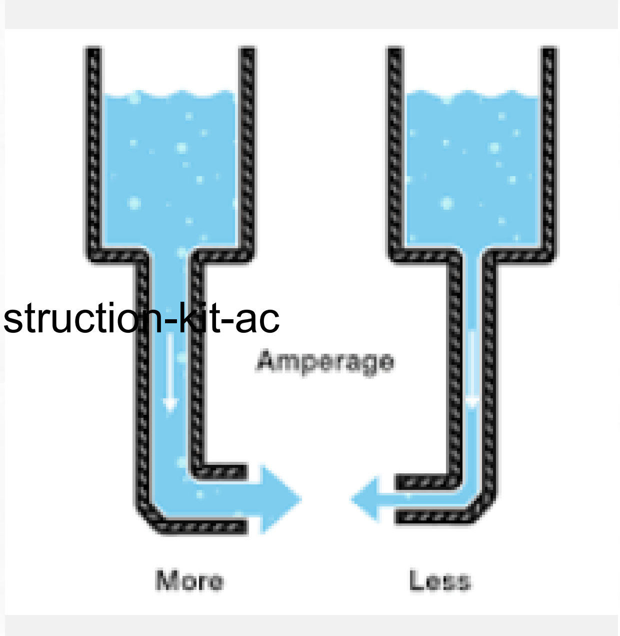
voltag
e

current

Electric resistance

Water flows through pipes. Larger the pipe less
Resistance to water flowing.

Likewise. Conductors (wires, loads, power supply,
Resistors) have resistance. Large resistance:
The “ pipe” network get smaller. See app.
https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-ac



The electrical resistance R of an electrical conductor is a measure of the difficulty to pass an electric current through that conductor.
Conductor: wires, loads, resistors
Any component that let the current
Flow.

$$V = IR.$$

This is Ohm's law.
Voltage across load = resistance x current
Also applies to the whole circuit.

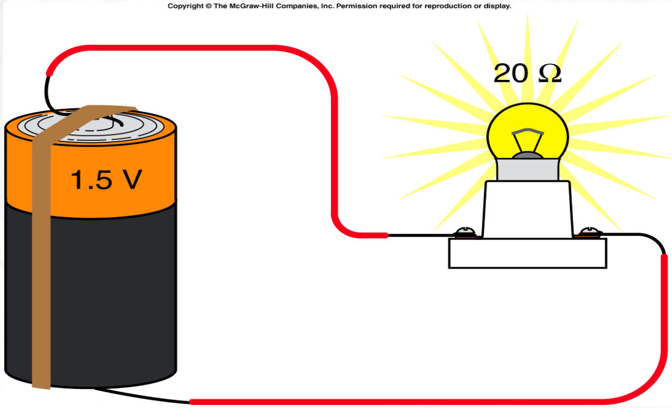
Each time you add a load (wire, light bulb, resistor) , the current decreases.
Each load has a resistance R . Unit is ohms (Ω)

Ohm's Law: Resistance and Resistors

The ratio of voltage to current is called the resistance:

$$V = IR.$$

So V/I = constant for that Component. = resistance.



Experimentally, it is found that the current in a load (ohmic conductor) is proportional to the voltage across is.

Draw the schematic and find the current.

Find the current.

The voltage drop across a resistor is 3.0 V for a current of 1 A in the resistor. What is the current that will produce a voltage drop of 9.0 V across the resistor?

A. 1 A

B. 3 A

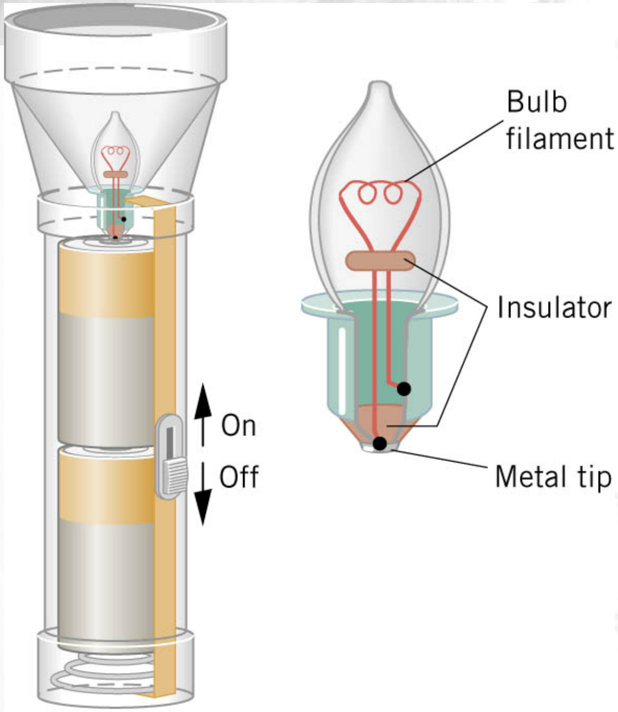
C. 0.33A

D. 27 A

Ohm's Law

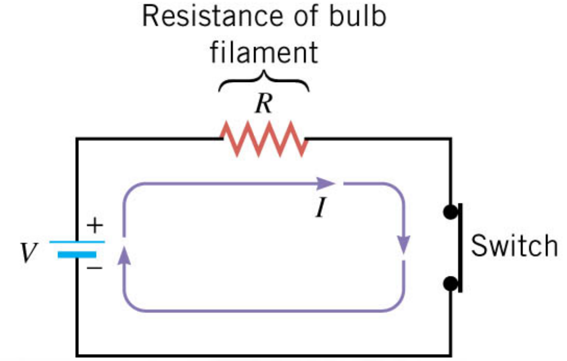
OHM'S LAW

The ratio *V/I* is a constant, where *V* is the voltage applied across a piece of material and *I* is the current through the material:

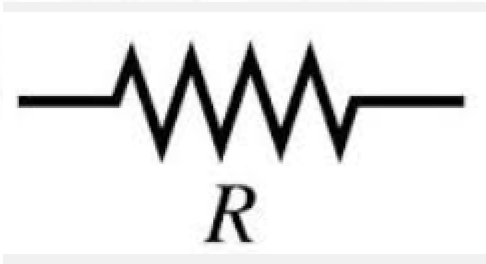


Source: Physics / Cutnell

SI Unit of Resistance: volt/ampere (V/A) = ohm (Ω)



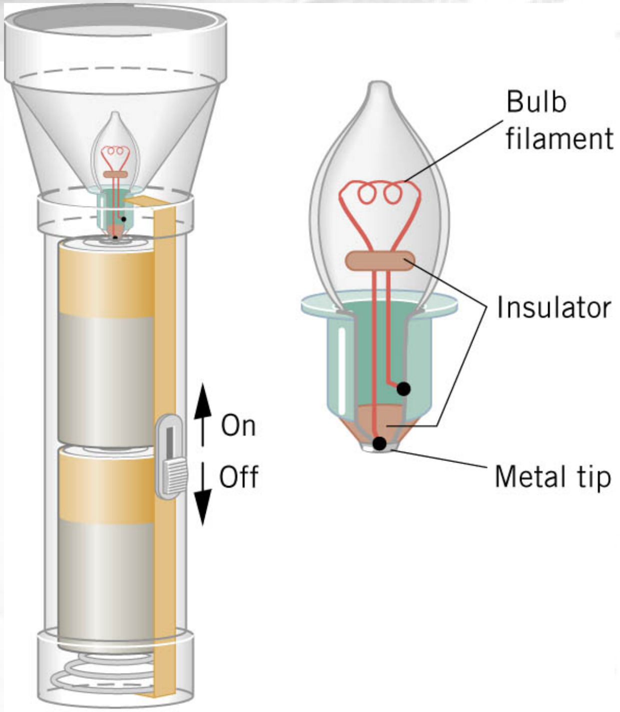
Symbol of a load with resistance R
Or symbol of a resistor

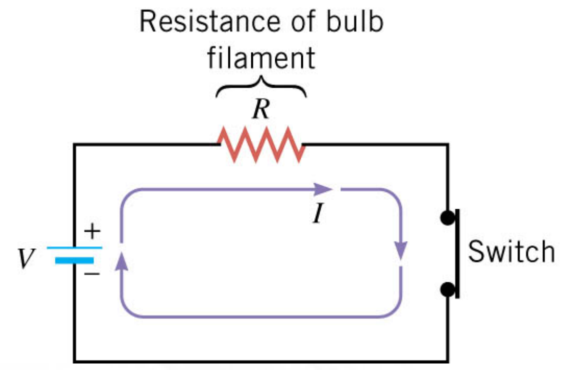


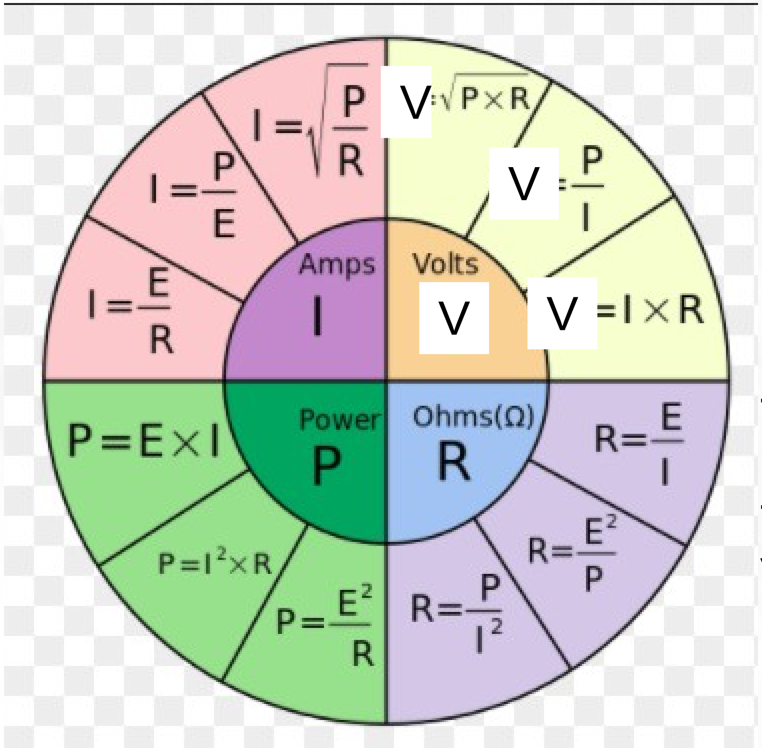
Example 2 A Flashlight

Ohm's Law

The filament in a light bulb is a resistor in the form of a thin piece of wire. The wire becomes hot enough to emit light because of the current in it. The flashlight uses two 1.5-V batteries to provide a current of 0.40 A in the filament. Determine the resistance of the glowing filament.







Useful “ cheat sheet”

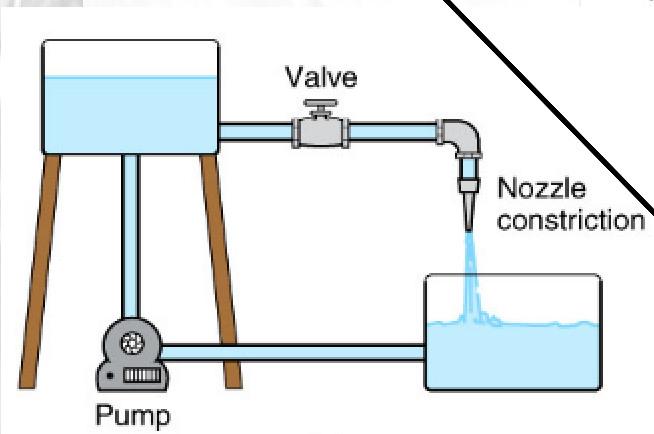
For loads with a resistance R.
The current through the load is I

The power consumed by the load is P
V is the voltage drop here.

resistor (R)

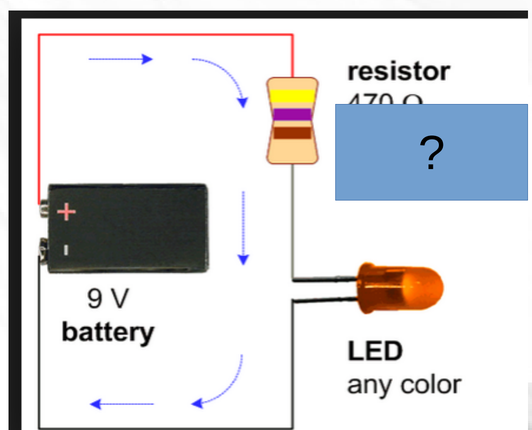
Imagine the electric circuit as
A hydraulic system.

Adding more loads = making the pipe
more narrow = less current can flow



A resistor is a special kind
of conductor/load . We can pick its resistance R.
They are used to decrease the amount of current in a circuit
To control the current. .

A resistor is used, for example,
to decrease the current
in a circuit with a LED.
The LED is killed if the
current is larger than 20mA
The voltage drops across the
LED is 1.7V (does not go by Ohms' law)
Find the minimum value of R to protect
The LED

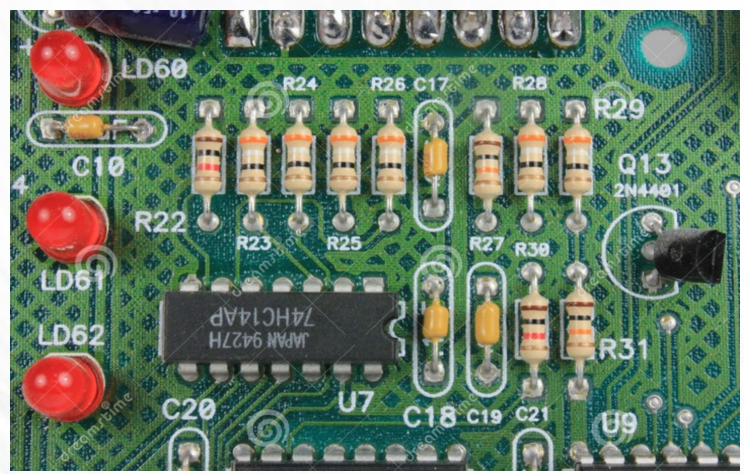


Increase R =
Decrease I

A resistor is a special Load. It turns electric energy Into heat.

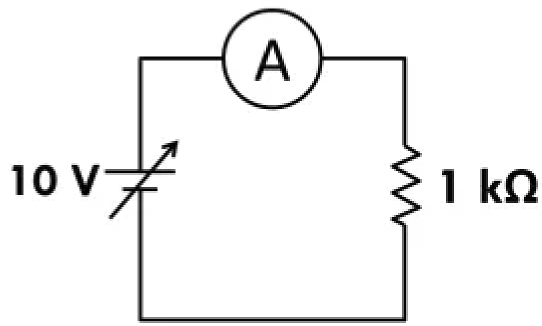
The resistor is also used to Limit the amount of current.

A potentiometer or pot is A variable resistor.



Circuit Diagram

Setup the circuit diagram as shown below:



During a lab a student connect a power supply
To a load (resistor) that has a resistance
R = 1Kohms = 1,000 ohms.

The voltage of the power supply can be changed
From 0V to 10V. The voltage across
The resistor is the same.
(schematic)

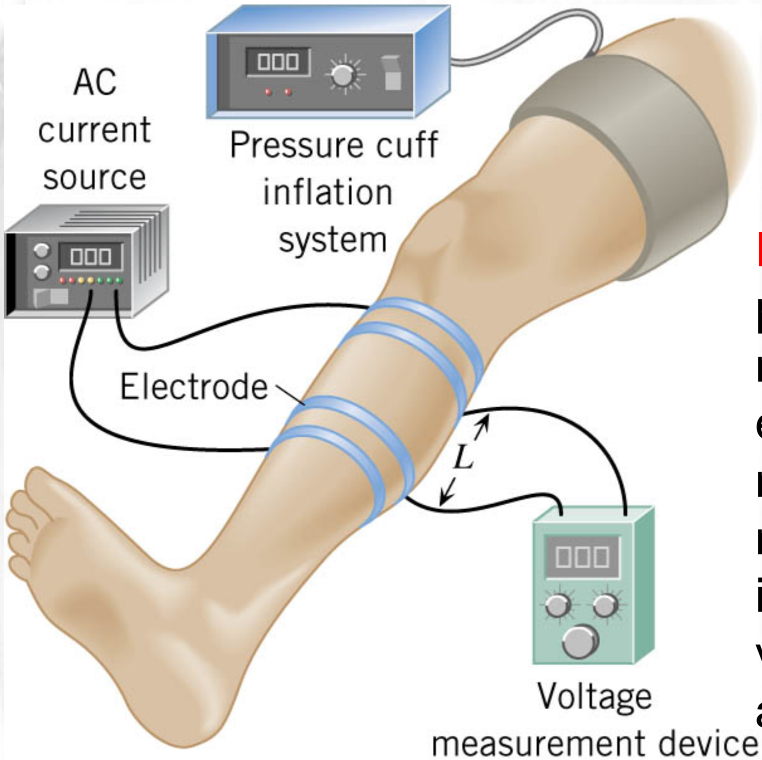
The student measures the current flowing in
The circuit as a function of voltage and
Report his data in the table below.

Voltage (V)	Current (mA)
0 V	0 V
1 V	1 mA
2 V	2 mA
3 V	2.99 mA
4 V	4 mA
5 V	5 mA
6 V	6 mA
7 V	6.99 mA
8 V	8 mA
9 V	9 mA
10 V	10 mA

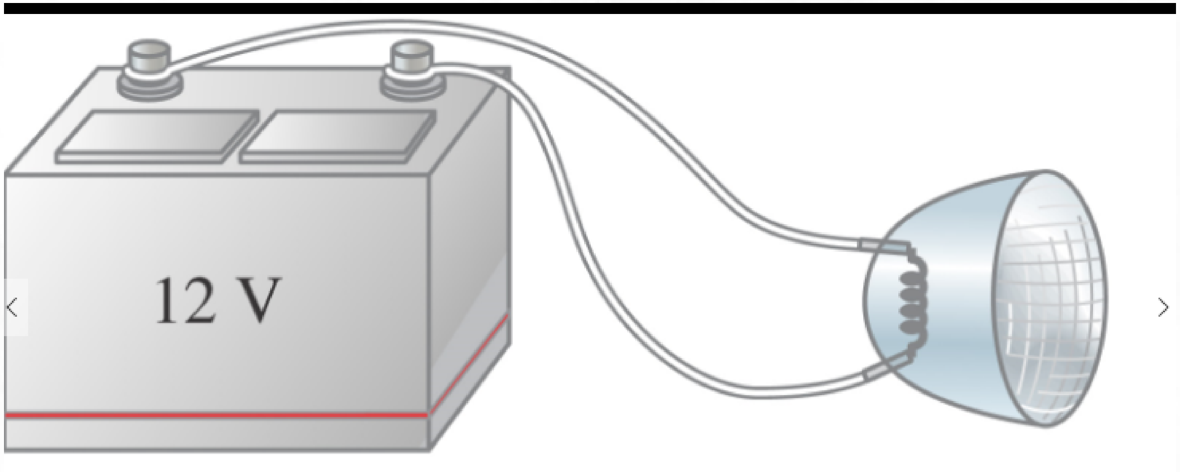
The current is in mA. Add a third column to convert toA.

What is the resistance of the resistor ?
What is the relationship between voltage and current ?

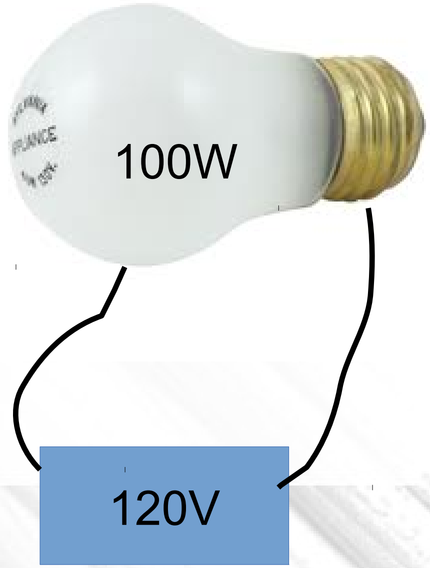
Use a spreadsheet to show that you get a line
And find the equation of the line.



Impedance phlebography, or impedance plethysmography (IPG), is a non-invasive medical test that measures small changes in electrical resistance of the chest, calf or other regions of the body. These measurements reflect blood volume changes, and can indirectly indicate the presence or absence of venous thrombosis. This procedure provides an alternative to venography, which is invasive and requires a great deal of skill to execute adequately and interpret accurately.



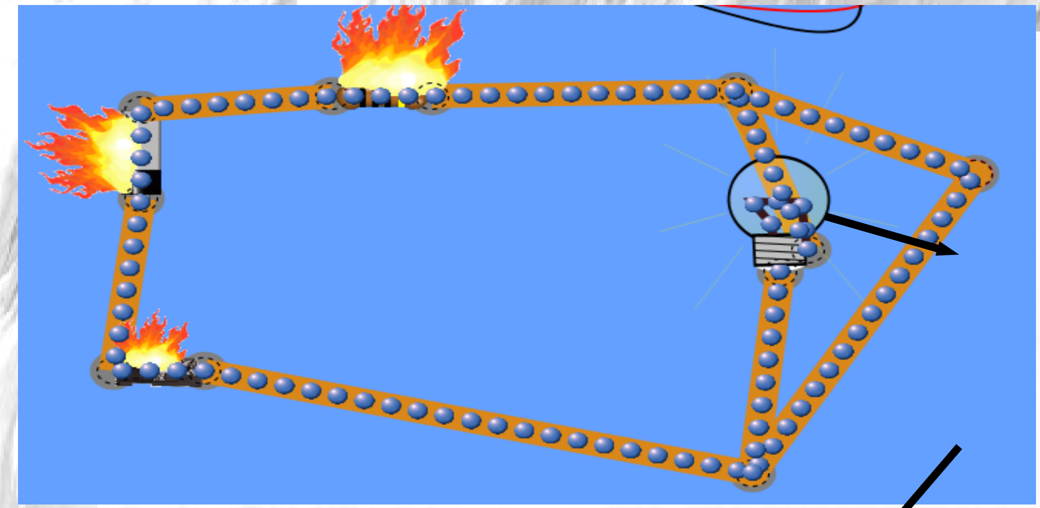
Find the resistance of the headlight.
And light bulb

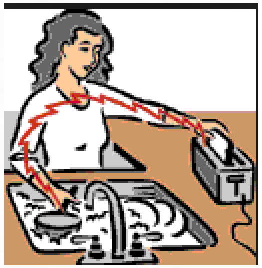


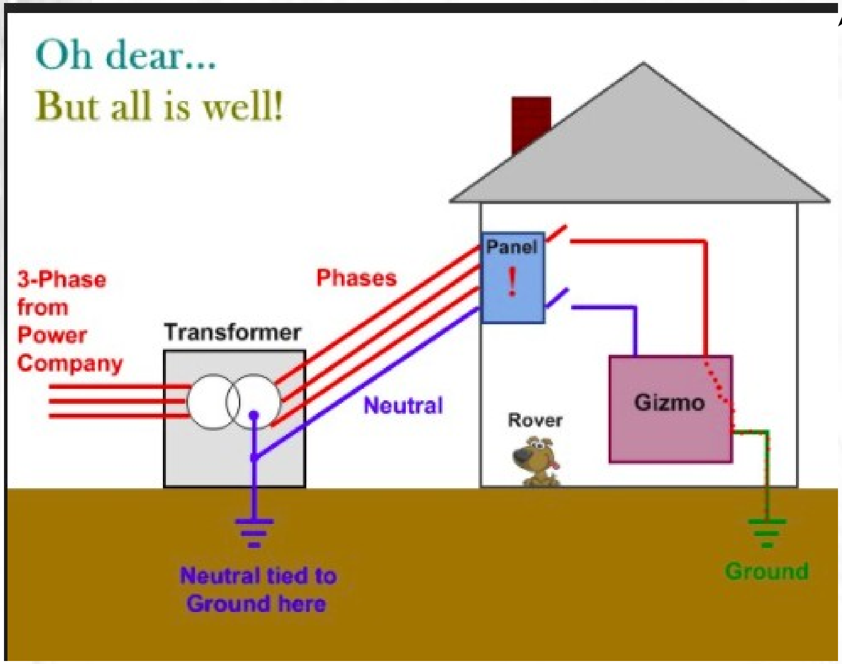
So new equations:

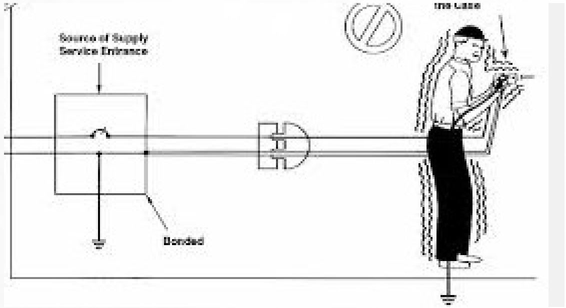
Power = $VI = RI^2 = V^2/R$

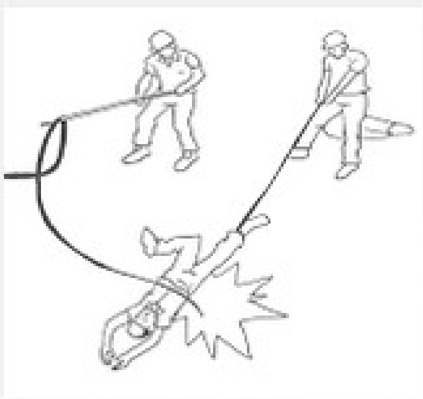
Shorts. Charges always choose the path of least resistance.











https://www.howequipmentworks.com/electrical_safety/

Electric power ($P=V\,I$ and $E=P\,t$)

Problems

1) A 6V battery delivers 0.5A of current to an electric motor connected across its terminal.
A) What is the power rating of the motor?
B) How much energy does the motor use is 5.0 min?

2) The current through a light bulb across the terminals of a 120V outlet is 0.5A. At what rate does the bulb use The electric energy?

3) The current through a toaster connected to a 120V source is 10A. What is the power rating of the toaster?

4) A light bulb uses 1.2A when connected across a 120V source. What is the wattage of the bulb?

5) What current flow through a 75W light bulb connected to a 120V outlet ?

6) The current through the starter motor of a car connected to a 12V battery is 210A. What electric energy is Delivered in 10s ?

7) A flashlight bulb is connected across a 3V difference in potential. The current is 1.5A.
A) What is the power rating of the lamp?
B) How much electric energy does the lamp convert in 10s.

8) A lamp draws 0.5A from a 120V generator.
A) how much energy does the generator deliver ?
B) How much energy does the lamp convert in 5 minutes ?

Ohm's law (V = RI)

Every conductor offers resistance to an electric current. This resistance causes a potential difference to exist between the ends of a conductor when Current passes through. To control the flow of current, resistors are used. They have given resistances.

1) An automobile headlights with a resistance of 30ohms is placed across a 12V battery. What is the Current through the circuit.

2) A voltage of 75V is places across a 15 ohms resistor. What is the current through the resistor ?

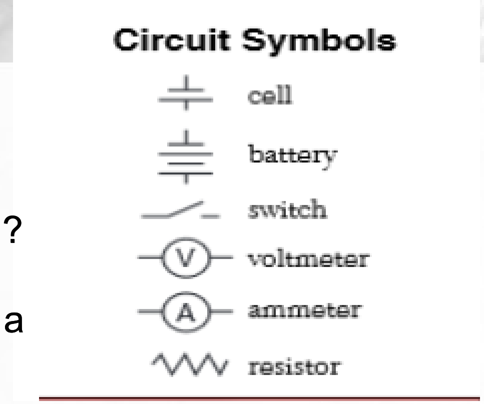
3) A lamp draws a current of 0.5A when it is connected to a 120V source.
A) What is the resistance of the lamp?
B) What is the power rating of the lamp ?

4) A motor with an operating resistance of 32ohms is connected to a voltage source. The current in the circuit is 4A. What is the voltage of the source?

5) A transistor radio uses $2\ 10^{-4}$ A of current when it is operated by a 3V battery. What is the resistance Of the radio circuit ?

6) A resistance of 60 ohms has a current of 0.4A throughout it when it is connected to the terminal of a Battery, What is the voltage of the battery?

Diagramming Electric circuits



1) Draw a schematic to show a circuit that includes a 90V Battery, and a resistance of 45 ohms. What is the ammeter reading ?

2) Draw a circuit diagram to include a 60V battery, an ammeter and a Resistance of 12 ohms. Indicate the ammeter reading.
Draw a voltmeter across the resistance. What is the reading.

3) Draw a circuit diagram to include a 16 ohms resistor, a battery, and an ammeter that reads 2A. Draw the voltmeter across the battery. Indicate the voltage of the battery

Heating effect of electric currents.

The power consumed by a resistor = V I = R I^2 = V^2/R. The resistor turns the Electric energy into heat. Thermal energy = power x time= R I^2 x time

1) A 15 ohms electric heater operates on a 120V outlet.
A) What is the current through the heater?
B) How much energy is used by the heater in 30 seconds

2) a 30 resistor is connected to a 60V.
A) What is the current in the circuit?
B) How much energy is used by the resistor in 5 minutes.

3) A 100.0W light bulb is 20% efficient . That means 20% of the electric energy is converted to light energy.
A) How many joules does the light bulb converts to light each minute of its operation.
B) how many joules of heat does the light bulb produce each minute ?

4) The resistance of an electric stove element at operating temperature is 11 ohms
A) 220V are applied across it, What is the current through the element?
B) How much energy does the element use in 30s ?
C) The element is being used to heat a kettle containing 1.20kg of water. Assume 70% of the heat Is absorbed by the water. What is the increase of temperature during the 30s ?
With (energy consumed by water) = (mass of water) x 4186 x (change in temperature)
(so if you provide 4186 joules then 1 kg mass of water has 1 degree increase of temperature)

5) An electric heater is rated 500W.
A) How much energy is delivered in half an hour
B) The heater is being used to heat a room containing 50kg of air.
With (energy consumed by air) = 1000 x (mass air) x (change in temperature)
and 50% of the thermal energy heats the air of the room, what is the change in Air temperature ?

6) How much energy does a 60W light bulb use in half an hour ? If the light bulb is 12% efficient, how Much heat does it generate during the half hour ?

The kilowatt hour It is a unit of energy. 1 kWh is the energy represented by 1000 watts Delivered continuously for 3600s. See next page to see how to find energy in kWh and to find the Money to pay the utility company.

1) A TV set draws 2A when operated on 120V.
A) How much power does the set use?
B) if the set is operated for an average of 5 hours per day, what kWh does it consume per month (30days) ?
C) at $0.80 per kWh, what is the cost of operating the set per month ?

2) A clock has a resistance f 12,000 ohms and is plugged into a 115V outlet.
A) How much current does it draw ? B) How much power does it use ? C) At a rate of $0.09 per kWh What does it cost to operate the clock for 30 days?

How to find energy in Kwh and the amount of money to pay the utility company

1) The power is in watts (W). divide by 1000 to get the power in KW
For example 50,000 W is 50KW

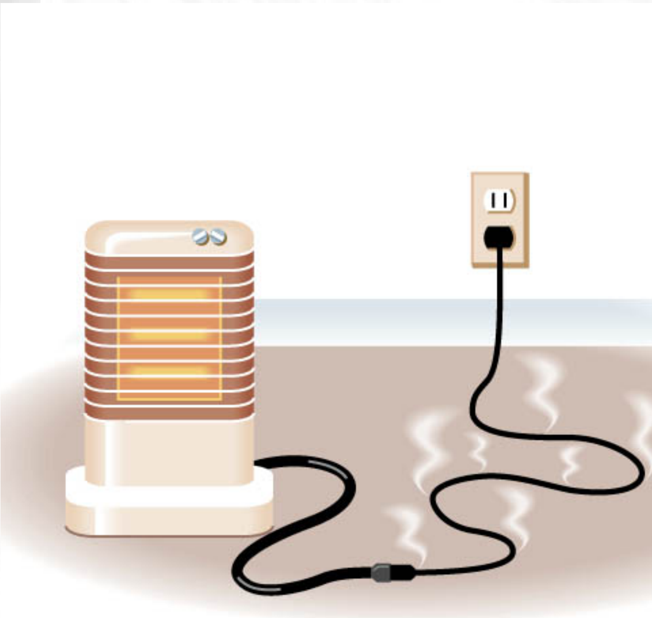
2) Find the time during which the loads functions in hours (not in seconds As it is done usually).
For example: 30 minutes = 0.5 hours

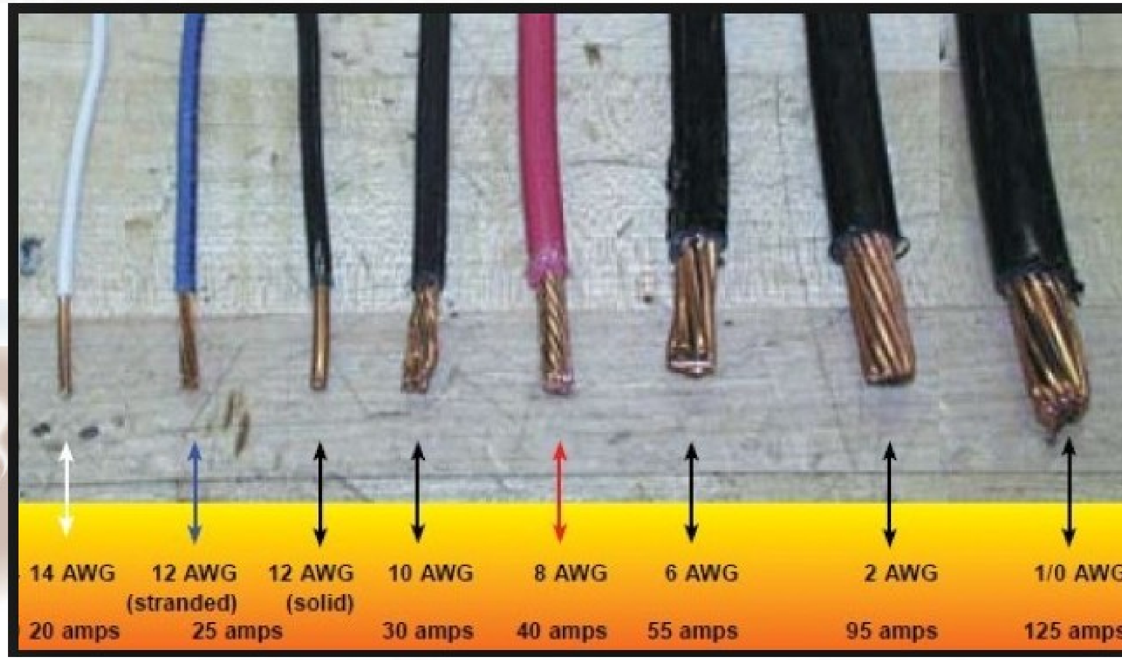
3) multiply powers (kW) by time(hours) to get energy in Kwh
Example: 50KW x 0.5 hours = 25KWh

4) multiply by the rate. If they charge you $0.10/KWh
Then you pay 25KWh x $0.1/Kwh = $2.50

Conceptual Example 7 Extension Cords and a Potential Fire Hazard

During the winter, many people use portable electric space heaters to keep warm. Sometimes, however, the heater must be located far from a 120-V wall receptacle, so an extension cord must be used. However, manufacturers often warn against using an extension cord. If one must be used, they recommend a certain wire gauge, or smaller. Why the warning, and why are smaller-gauge wires better then larger-gauge wires?

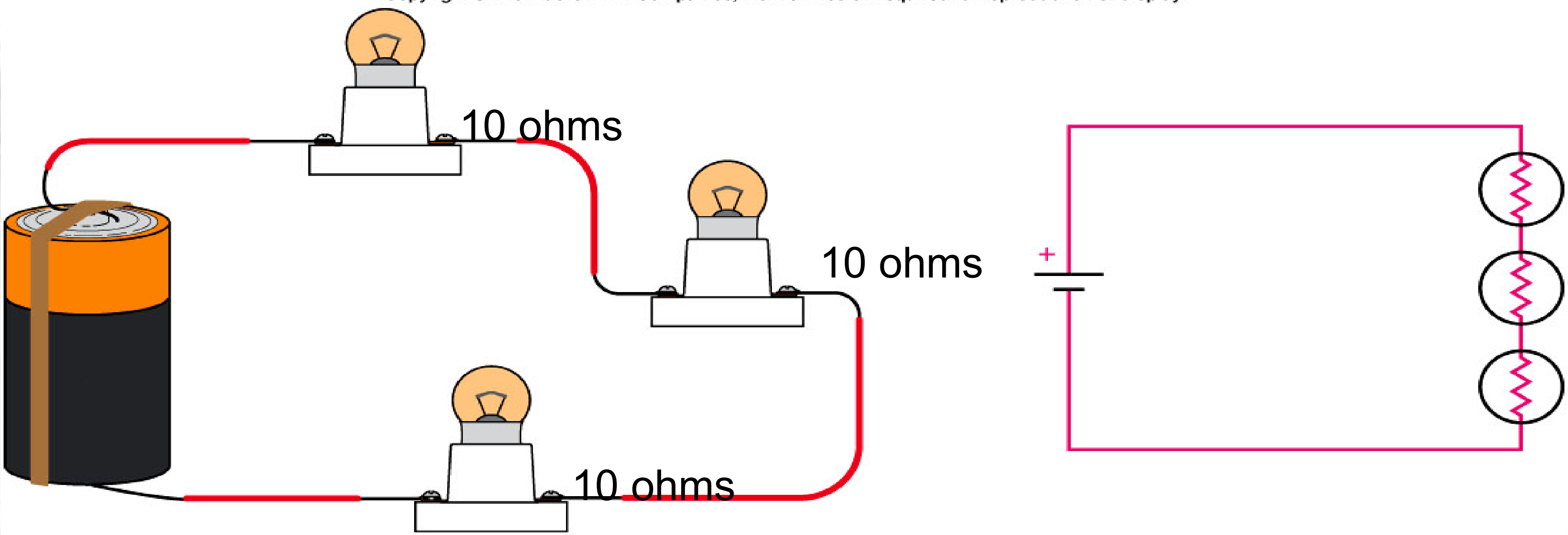




http://knowledge.sonicelectronix.com/car-audio-and-video/accessories-and-installation/wire-gauge-size/

https://www.tenaquip.com/shop/resources/electrical/extension-cords.jsp?lang=en_US

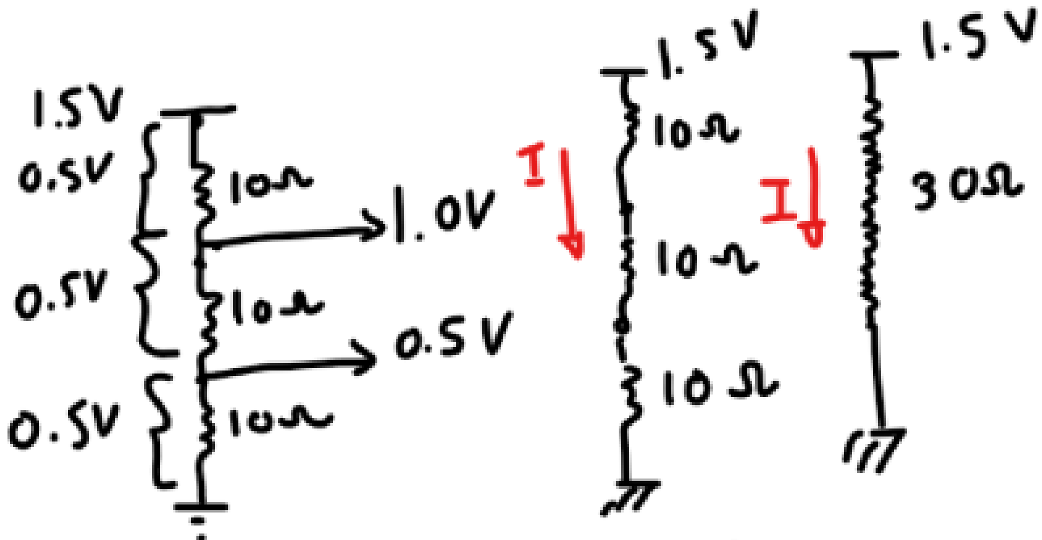
Circuit in series



If the battery is 1.5V and if the loads are the same (same resistance)
Then the voltage drop across each is only 0.5V (they share equally).

The resistance is three times the resistance with 1 light bulb.

So power for each load is divided by 9 (compared to only 1 light bulb)
Find the current

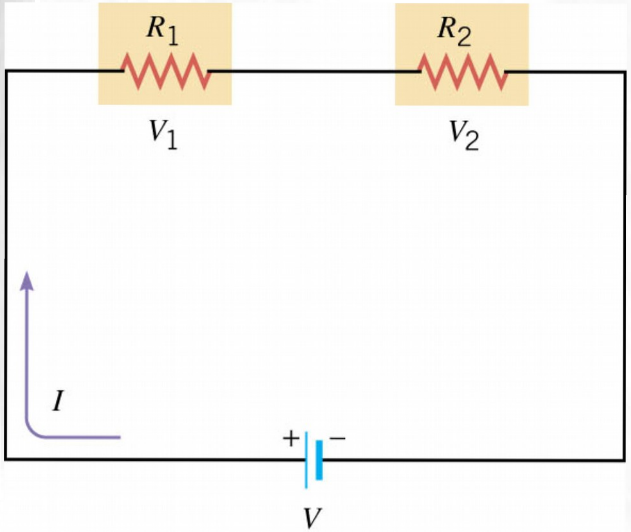


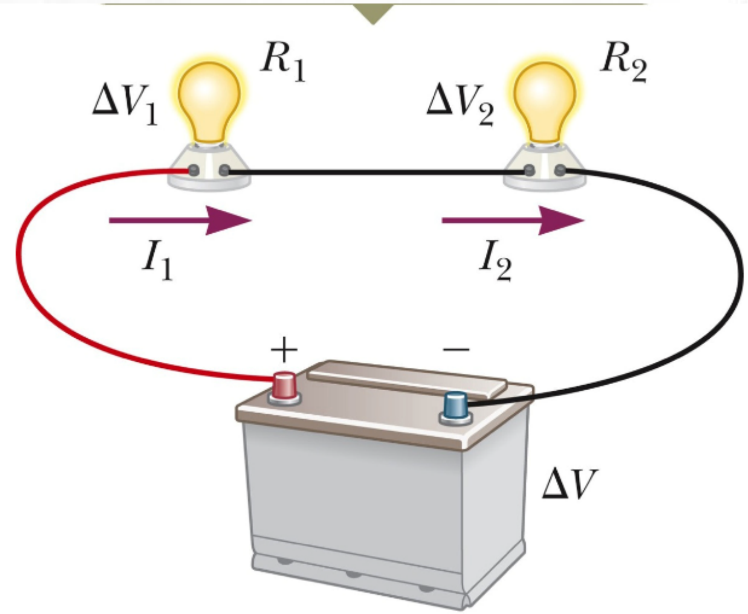
$I = \frac{1.5}{30} = 0.05A = 50mA$

Series Wiring

There are many circuits in which more than one device is connected to a voltage source.

Series wiring means that the devices are connected in such a way that there is the same electric current through each device.

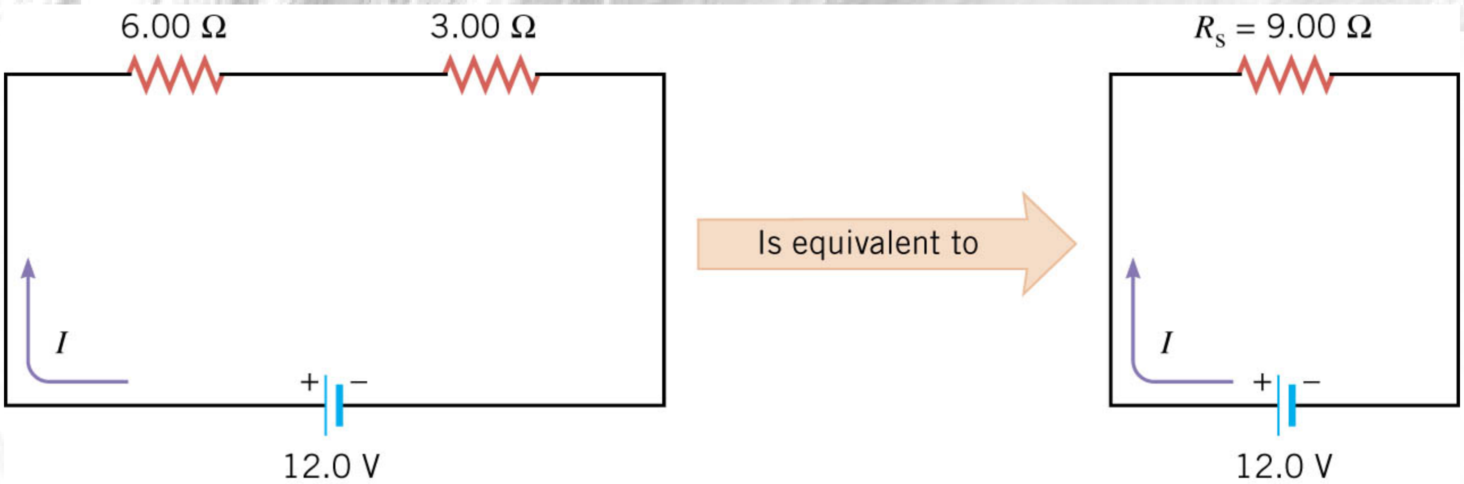




I1=I2=I

Examples: R1=10 ohms and R2 = 40 ohms I=2 A
Battery is V=100V

Find the voltage drop across each load V1 and V2.
Compute V1 + V2. Compare to V.
Let's say you a load of 50ohms with the 100V battery.
Compute I. Conclusion ?



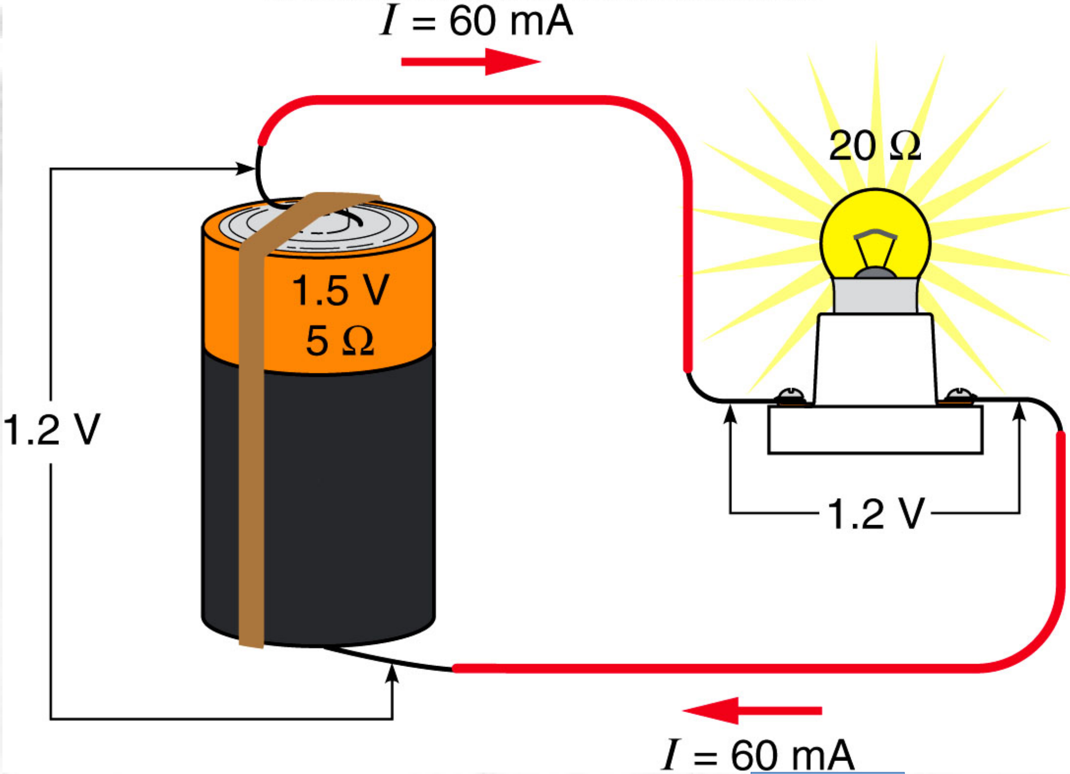
Example 8 **Resistors in a Series Circuit**

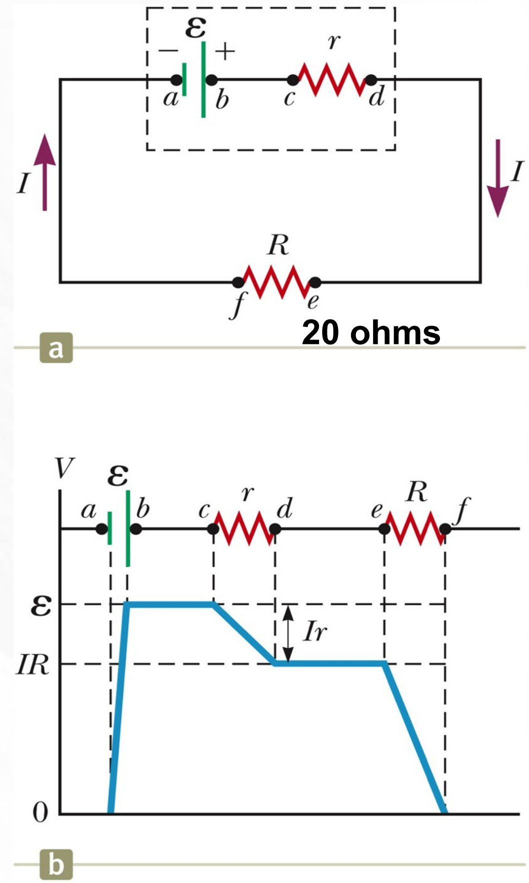
A 6.00 Ω resistor and a 3.00 Ω resistor are connected in series with a 12.0 V battery. Assuming the battery contributes no resistance to the circuit, find (a) the current, (b) the power dissipated in each resistor, and (c) the total power delivered to the resistors by the battery.

Batteries have internal resistor. That's why they get hot.

1.5V

5 ohms





60mA

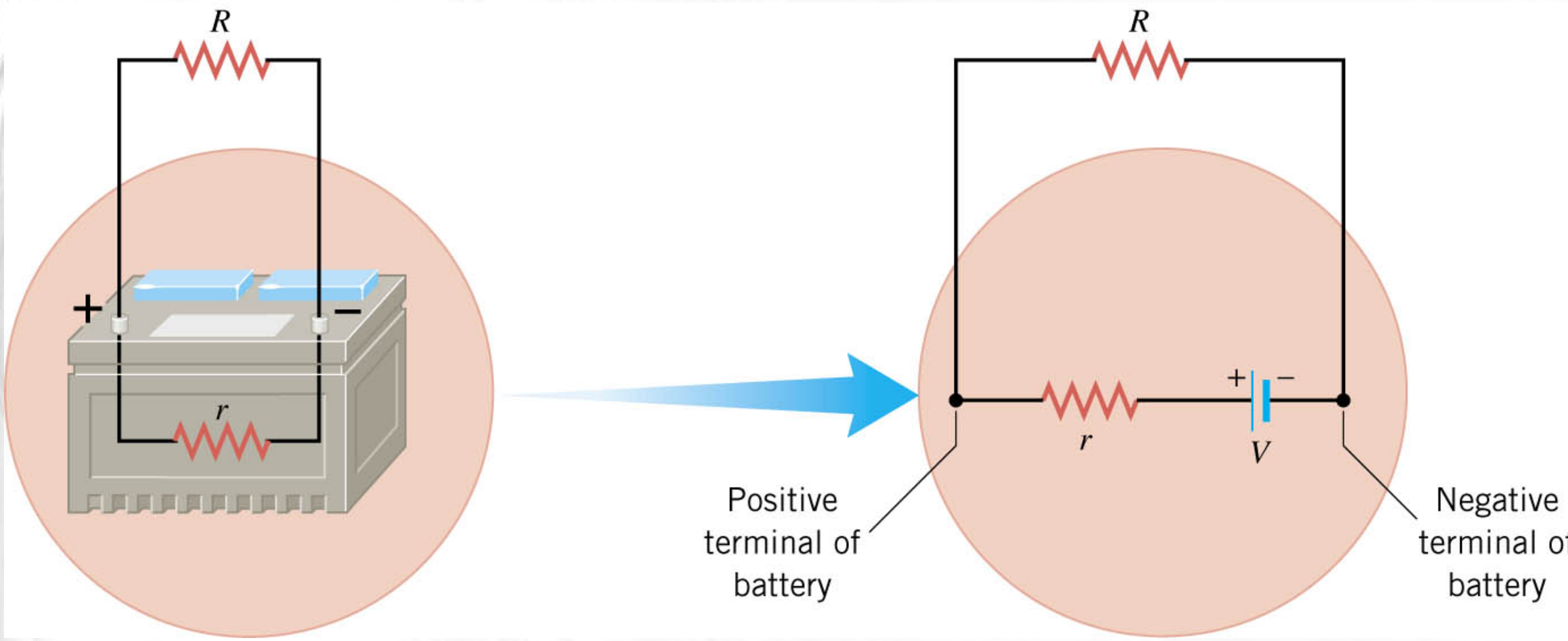
20 ohms

1.5V is the emf

Find the current

Batteries and generators add some resistance to a circuit. This resistance is called ***internal resistance.***

The actual voltage between the terminals of a batter is known as the ***terminal voltage.***



the resistance of the load is 500 ohms and the internal resistance of the battery is 10ohms. emf is 12 V

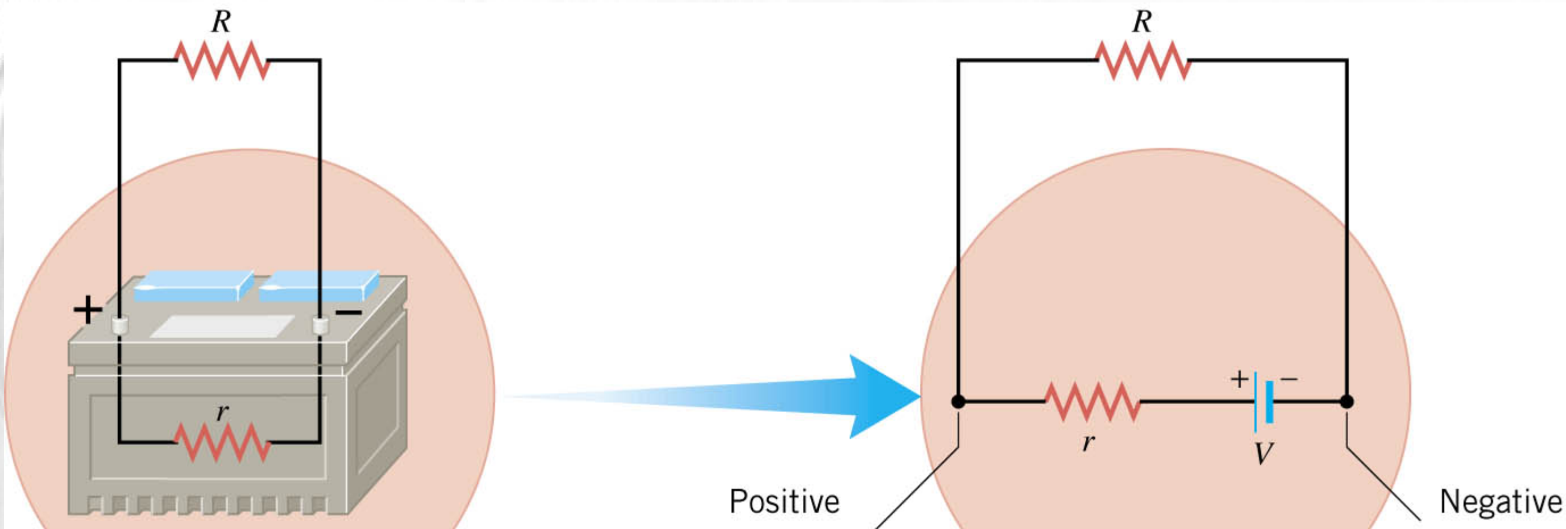
A) Find I

B) Find the voltage delivered by the battery to the load

C) energy consumed by the load in 3 hours

Batteries and generators add some resistance to a circuit. This resistance is called ***internal resistance.***

The actual voltage between the terminals of a batter is known as the ***terminal voltage.***



Example: $r = 10\,\Omega$ $R = 500\,\Omega$ $V = 12\,V$

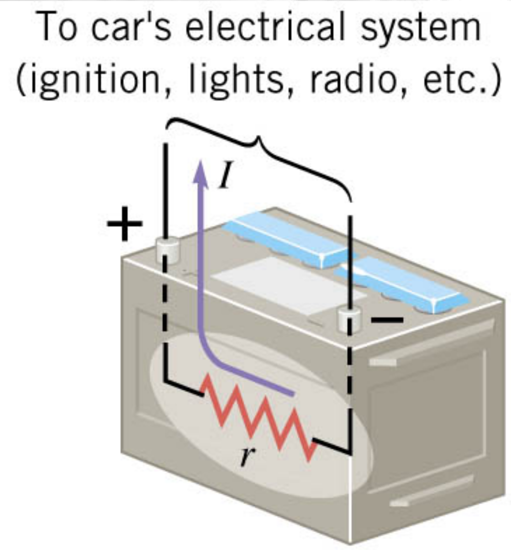
① $R_{combined} = 510\,\Omega$ so $I = \frac{12}{510} = 23.5\,mA$

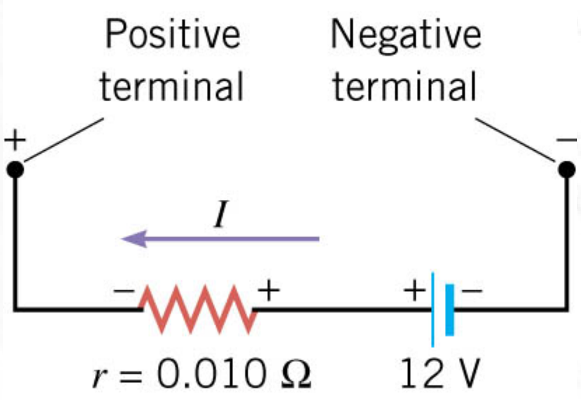
② voltage drop across internal resistance } $0.0235 \times 10 = 0.235\,V$

③ So battery $= 12 - 0.235 = 11.75\,V$ instead of 12V

***Example 12* The Terminal Voltage of a Battery**

The car battery has an emf of 12.0 V and an internal resistance of 0.0100 Ω. What is the terminal voltage when the current drawn from the battery is (a) 10.0 A and (b) 100.0 A?





(a)

(b)

1) 15 resistors of 10 ohms are connected in series to a 30V battery. What is the current in the circuit?

2) Three 20 ohms resistors are connected in series across a 120V generator.
A) What is the effective resistance of the circuit ?
B) What is the current in the circuit?

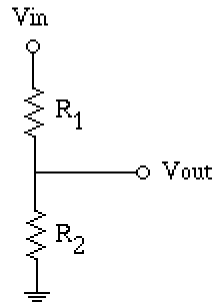
3)*A 10 ohms, a 15 ohms, and a 5 ohms are in connected a 90V battery
A) What is the effective resistance of the circuit ?
B) What is the current in the circuit ?

4)* Ten Christmas tree bulbs connected in series have equal resistances.
When connected to a 120V outlet, the current through the bulbs is 0.5A
A) What is the effective resistance of the circuit ?
B) What is the resistance of each bulb.

5)* A lamp having a resistance of 10 ohms is connected across a 15V battery.
A) What is the current across the lamp?
B) what resistance must be connected in series with the lamp to reduce the current to 0.5A

6) *A R1=5 ohms and a R2=10ohms resistor are connected in series and placed across a 45V potential diffe
A) What is the effective resistance of the circuit?
B) What is the current trough the current ?
C) What is the voltage drop across each resistor ?
D) Compute (R1(R1+R2)) x 45V. Compare to voltage across 10ohms.
This is called a voltage divider. See next page.

Voltage Divider



$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

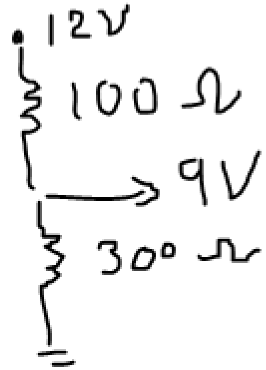
Example: $V_{in} = 12V$

$R_1 = 100\Omega$

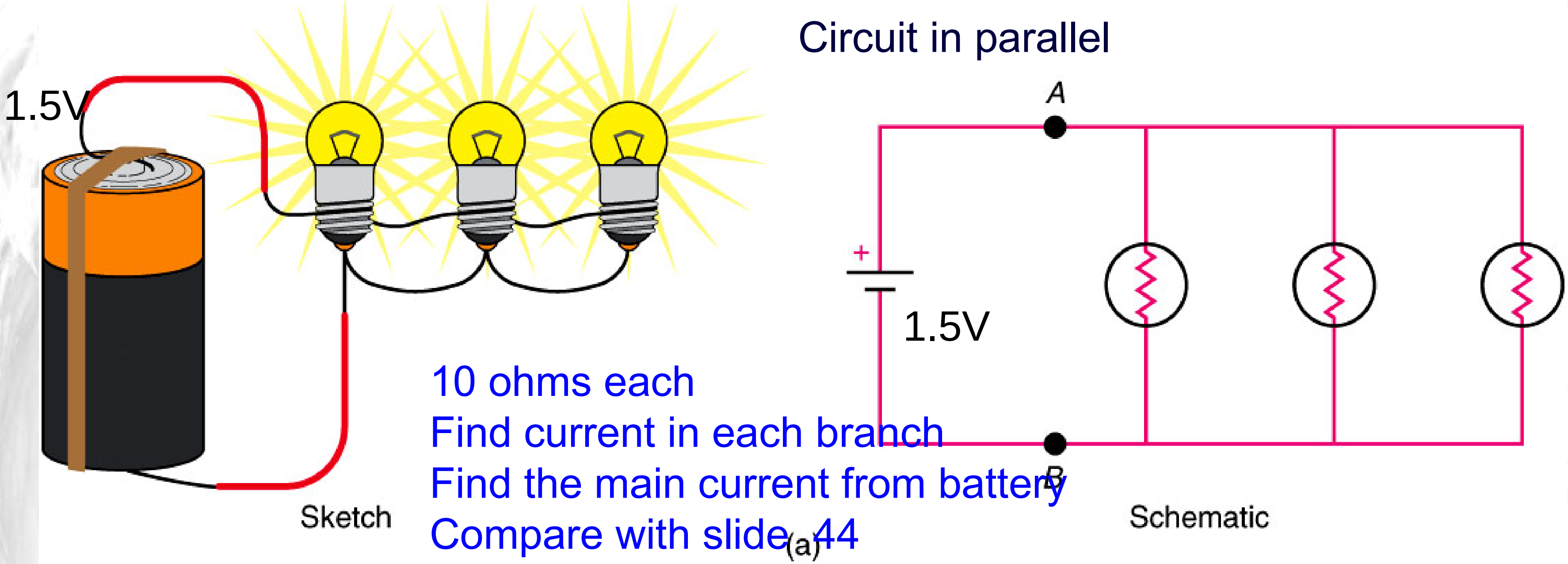
$R_2 = 300\Omega$

$$V_{out} = 12 \times \left(\frac{300}{100+300} \right) = 12 \times \frac{3}{4}$$

$$V_{out} = 9V$$

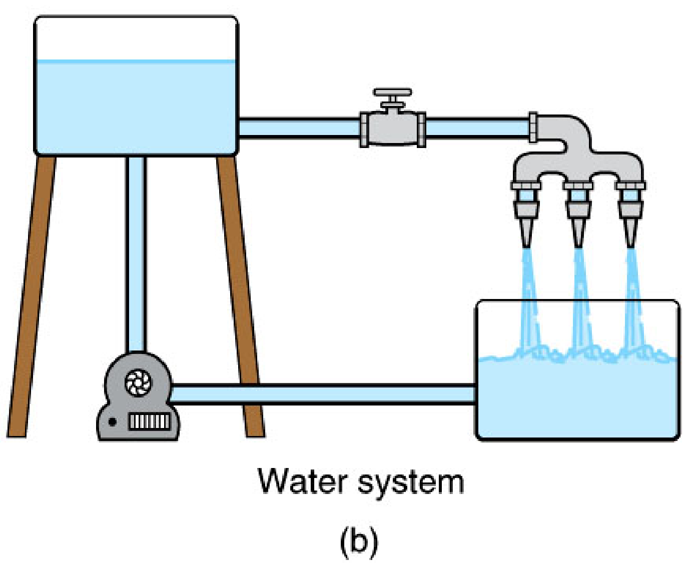


Circuit in parallel



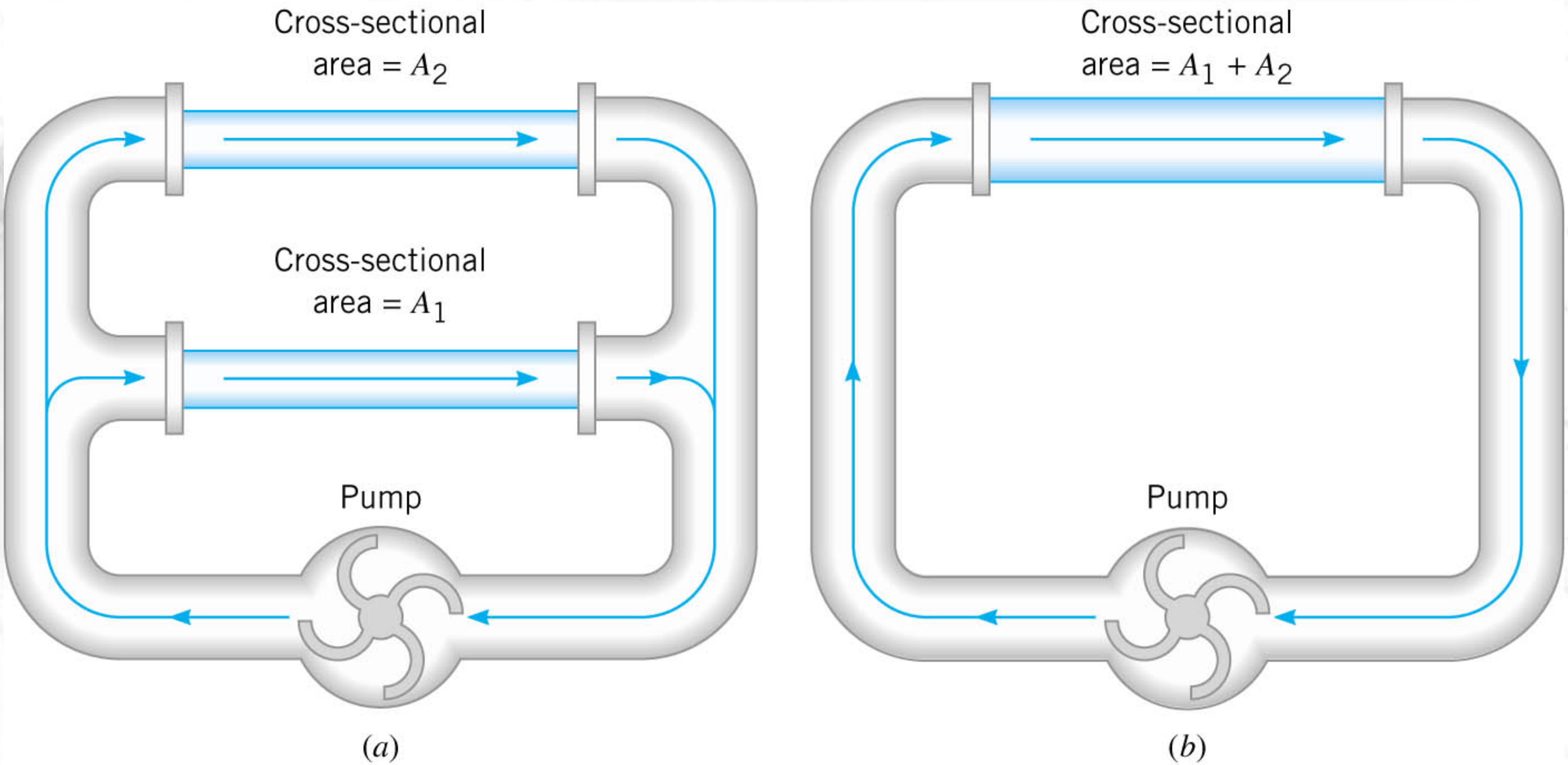
10 ohms each
Find current in each branch
Find the main current from battery
Compare with slide 44

Parallel wiring means that the devices are connected in such a way that the same voltage is applied across each device.



More water with 3 pipes than with 1
=
Less resistance in The circuit

Parallel Wiring



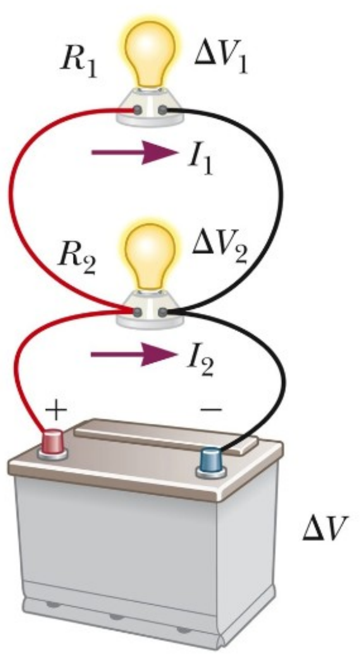
The two parallel pipe sections are equivalent to a single pipe of the same length and same total cross sectional area.

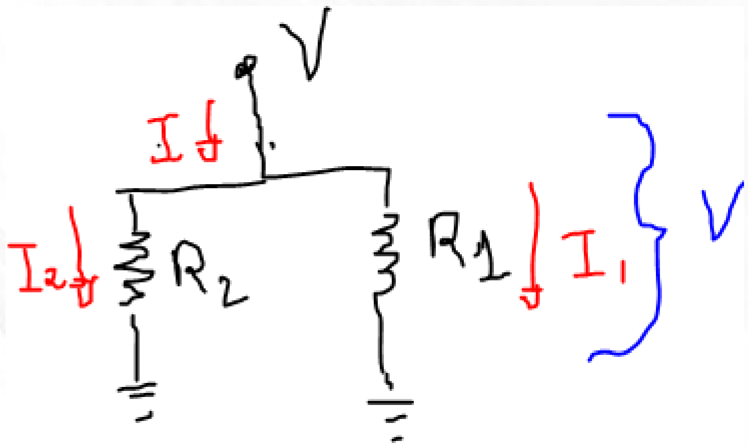
SO Isource = I1 + I2

Parallel Wiring: Kirchhoff law for current

When two resistors are connected in parallel, each receives current from the battery as if the other was not present.

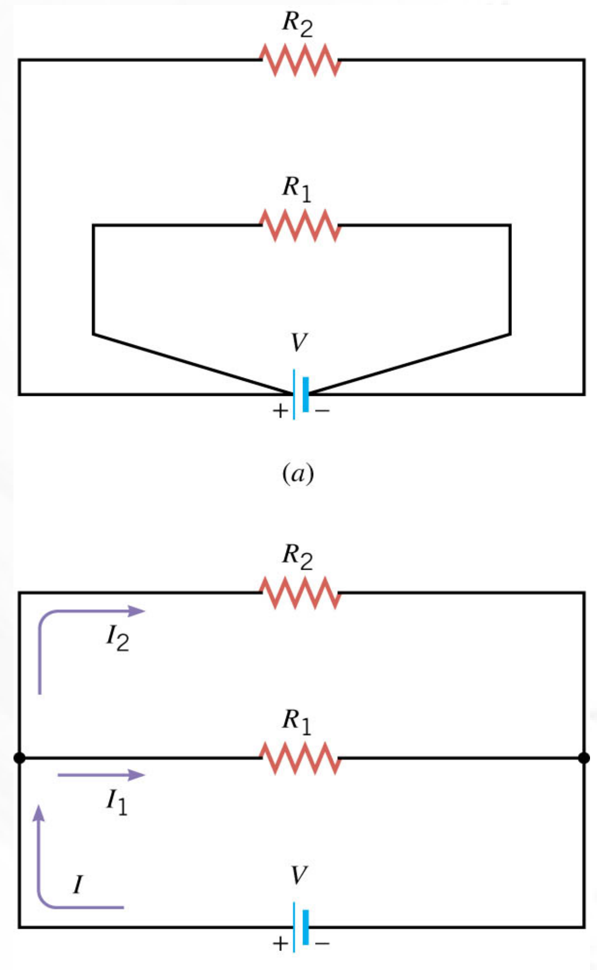
Therefore the two resistors connected in parallel draw more current than does either resistor alone.





$$I = I_1 + I_2$$

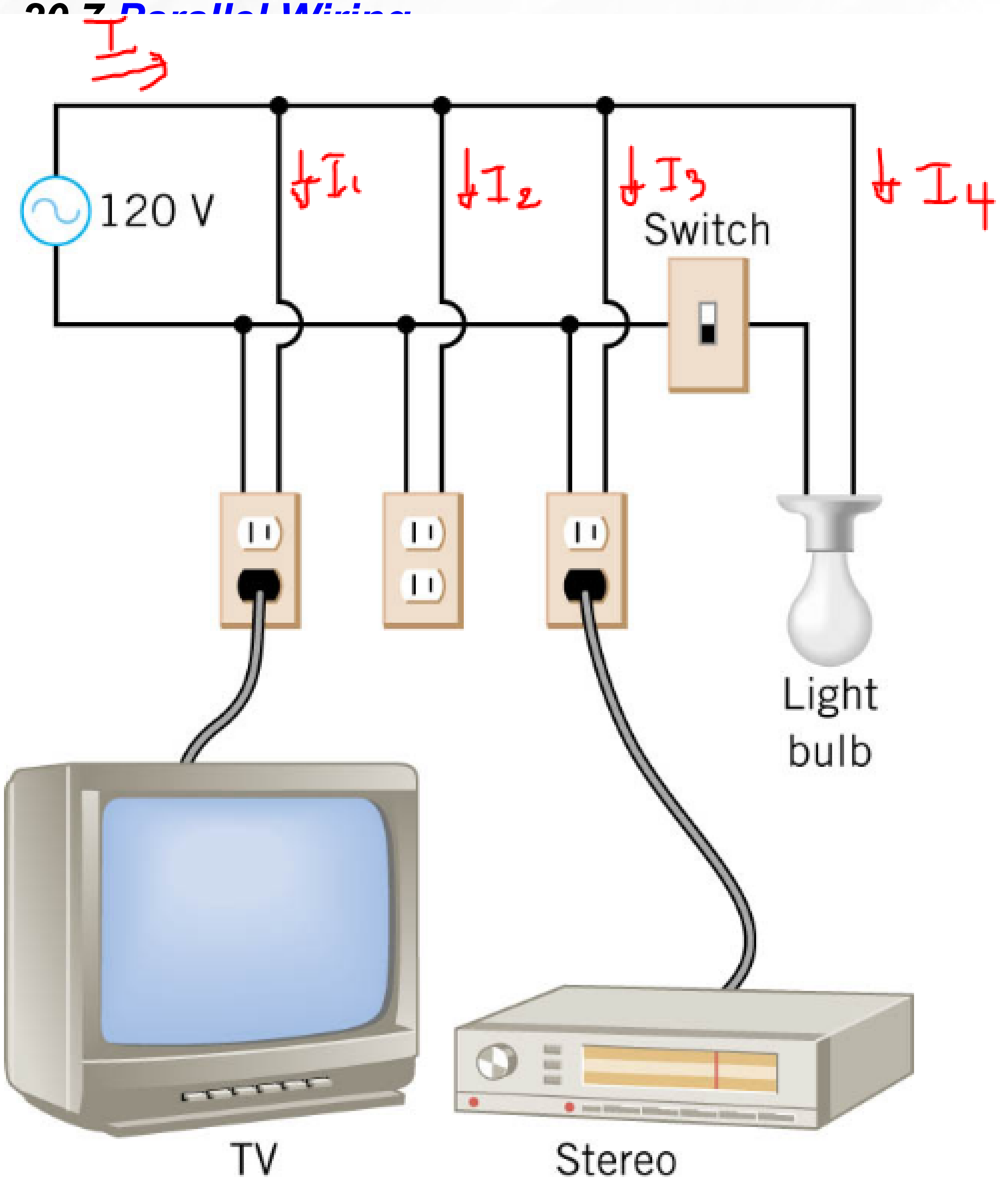
$$V = V_1 = V_2$$



(a)

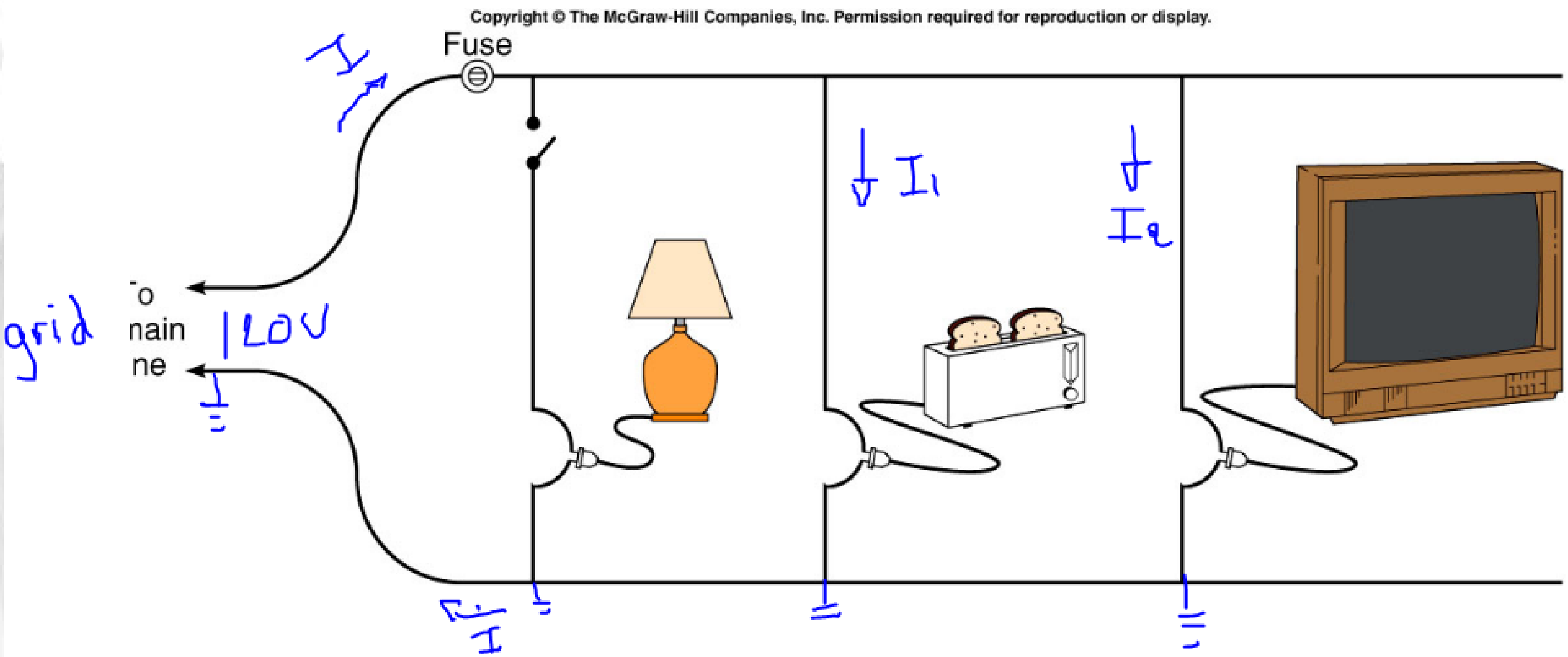
(b)

20.7 Parallel Wiring



$$\underbrace{V}_{120\,V} = V_1 = V_2 = V_3 = V_4$$

$$I = I_1 + I_2 + I_3 + I_4$$



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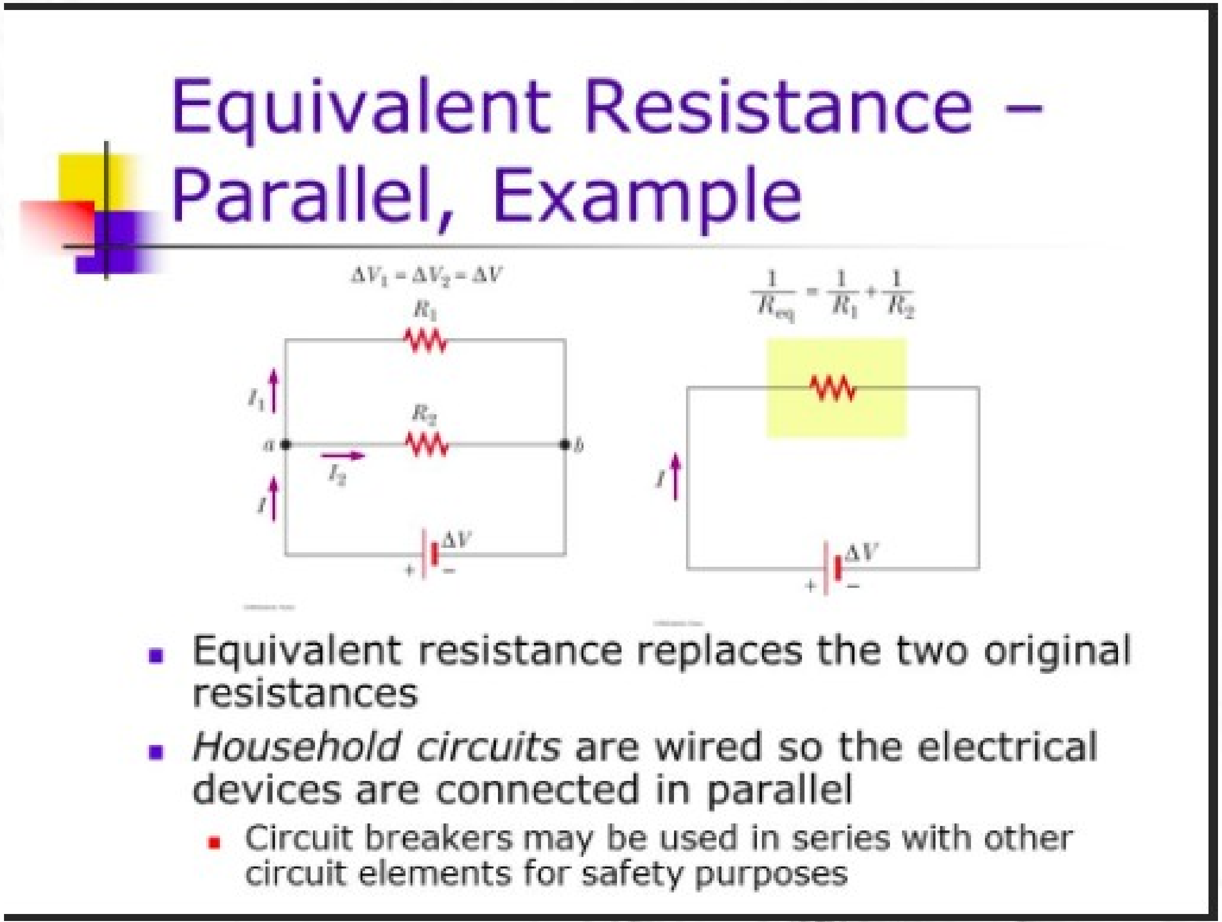
Fuse
To
main
line
I
I
I_1
I_2
grid
120V

Parallel Wiring

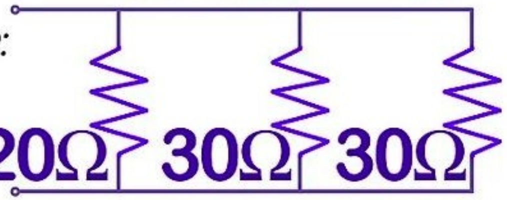
parallel resistors R1, R2, R3 + ….

The equivalent is :
$(1/R1 + 1/R2 + 1/R3 + \dots)^{-1}$

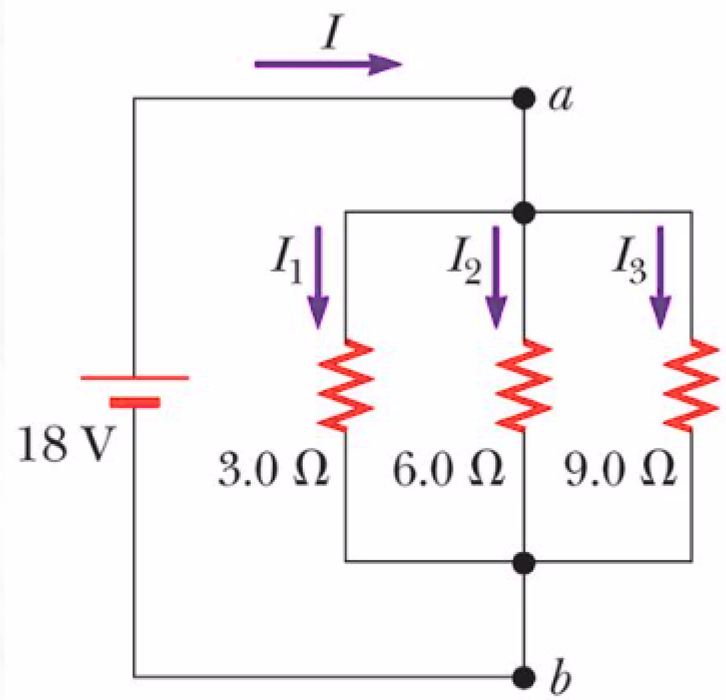


$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \dots \frac{1}{R_n}}$$

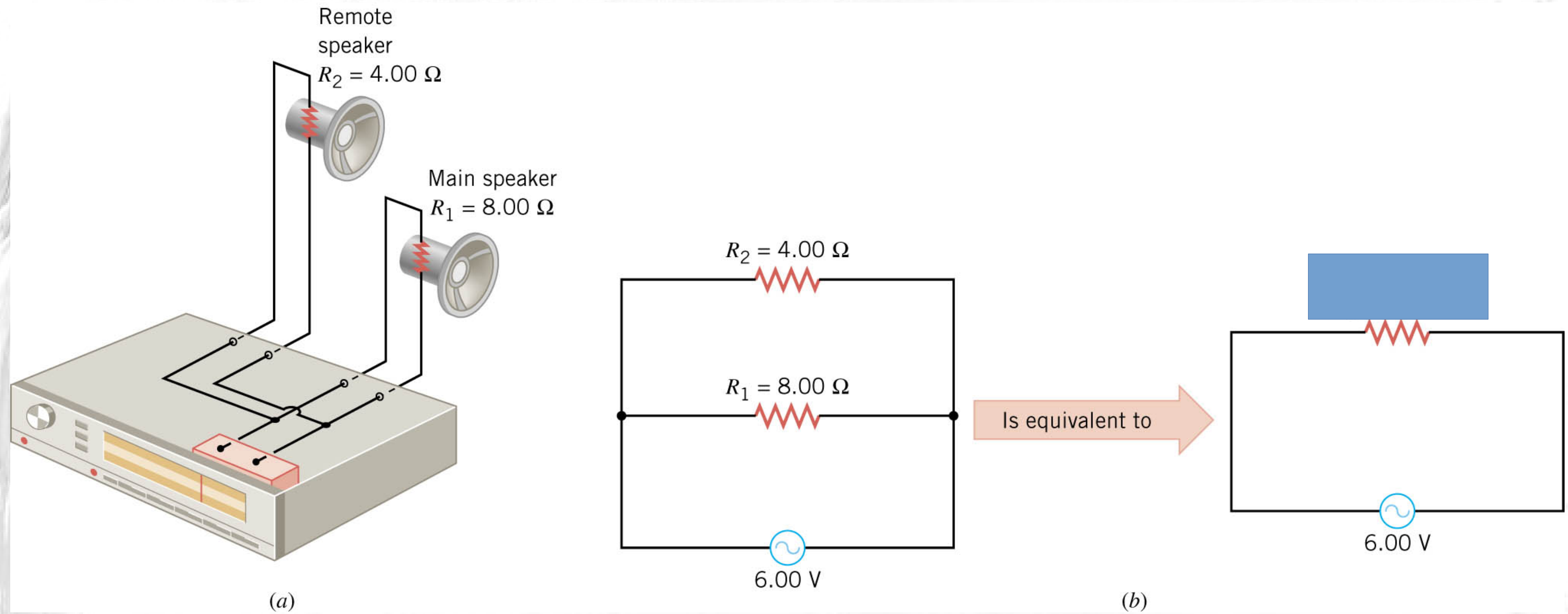
Example:



$$\frac{1}{\frac{1}{20\Omega} + \frac{1}{30\Omega} + \frac{1}{30\Omega}} = \boxed{8.57\Omega}$$



A) find the equivalent resistance
B) find I the main current
C) find I1, I2, I3



Example 10 Main and Remote Stereo Speakers

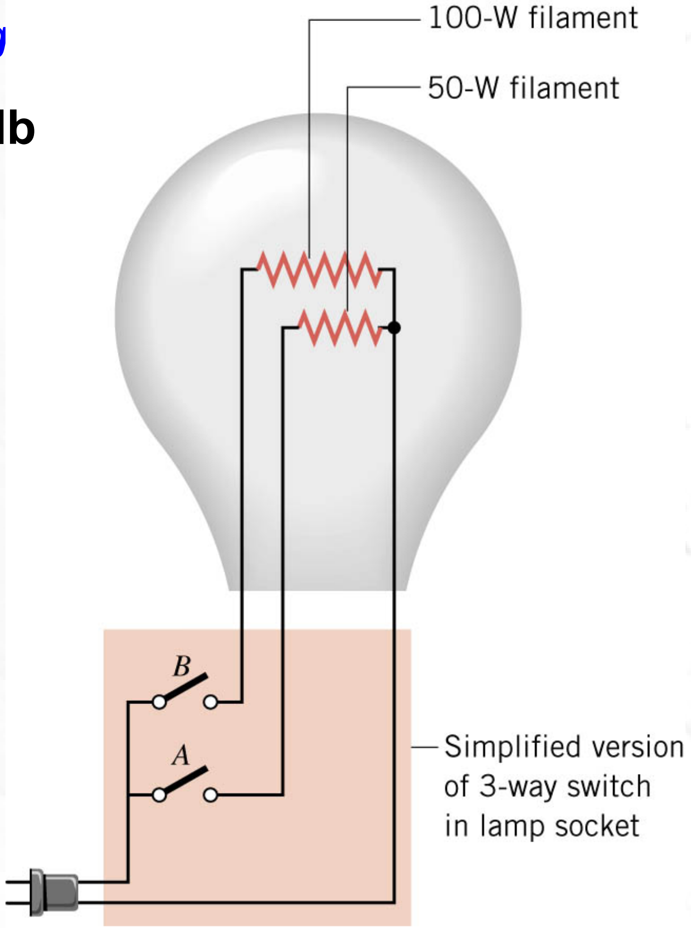
Most receivers allow the user to connect to “remote” speakers in addition to the main speakers. At the instant represented in the picture, the voltage across the speakers is 6.00 V. Determine (a) the equivalent resistance of the two speakers, (b) the total current supplied by the receiver, (c) the current in each speaker, and (d) the power dissipated in each speaker.

Conceptual Example 11 A Three-Way Light Bulb and Parallel Wiring

Within the bulb there are two separate filaments. When one burns out, the bulb can produce only one level of illumination, but not the highest.

Are the filaments connected in series or parallel?

How can two filaments be used to produce three different illumination levels?



1) Three resistors of 60 ohms, 30 ohms and 20 ohms are connected in parallel across a 90V difference In potential.

A) Find the effective resistance of the circuit

B) Find the current in the entire circuit I

C) Find the current through each branch of the circuit I1, I2, I3

D) Compare I to I1+I2+I3

2) three 15 ohms resistors are connected in parallel and placed across a difference in potential of 30V.

A) What is the effective resistance of the parallel circuit ?

B) What is the current through the entire circuit ?

C) What is the current though each branch?

3) Two 10 ohms are connected in parallel and placed across the terminals of a 15V battery.

A) What is the effective resistance of the parallel circuit ?

B) What is the total current in the circuit ?

C) What is the current though each branch ?

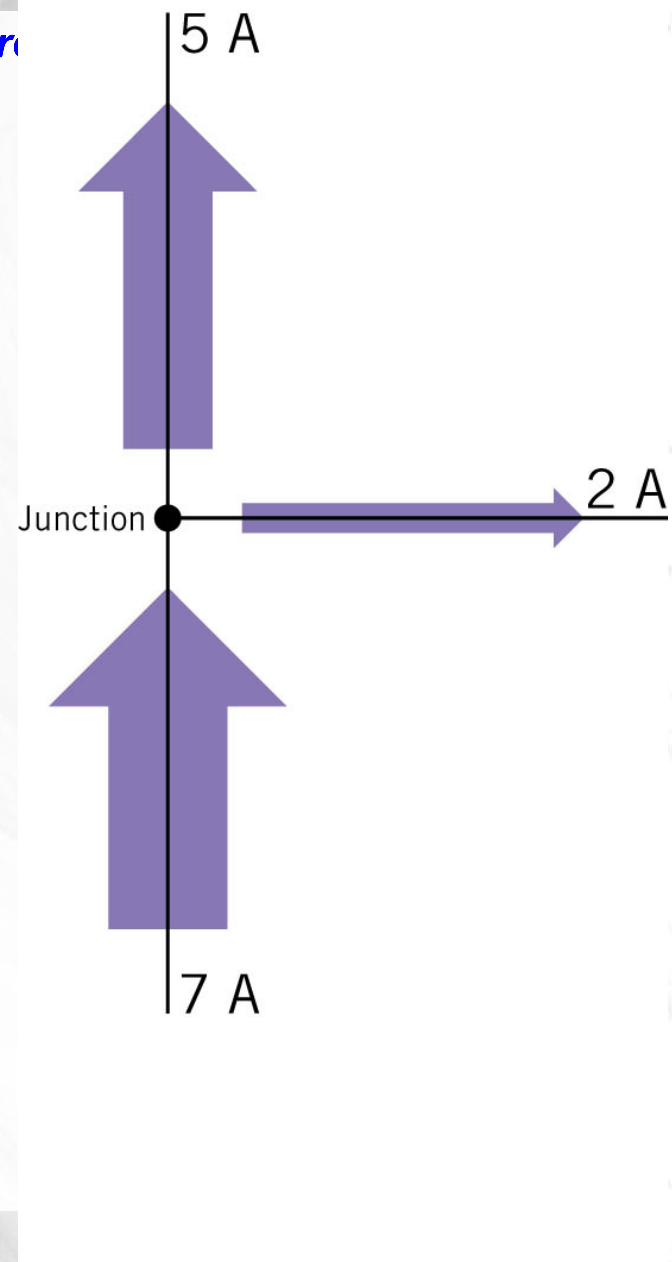
4) A 120 ohms and a 60 ohms and a 40 ohms resistor are connected in parallel and placed across a difference of potential of120V.

A) What is the effective resistance of the parallel circuit

B) What is the current in the entire circuit

C) What is the current through each branch of the circuit?

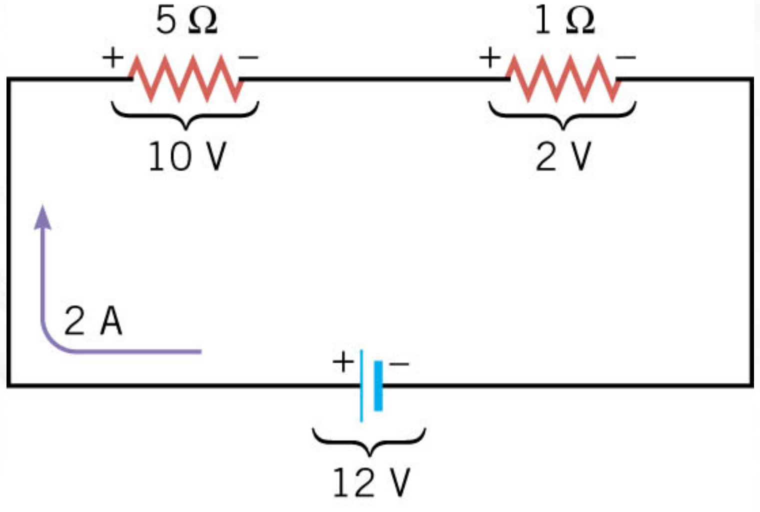
Kirchhoff's law for curr
or junction rule



The junction rule states that the total current directed into a junction must equal the total current directed out of the junction.

Kirchhoff’s law for voltage or loop rule

The loop rule expresses conservation of energy in terms of the electric potential and states that for a closed circuit loop, the total of all potential rises is the same as the total of all potential drops.



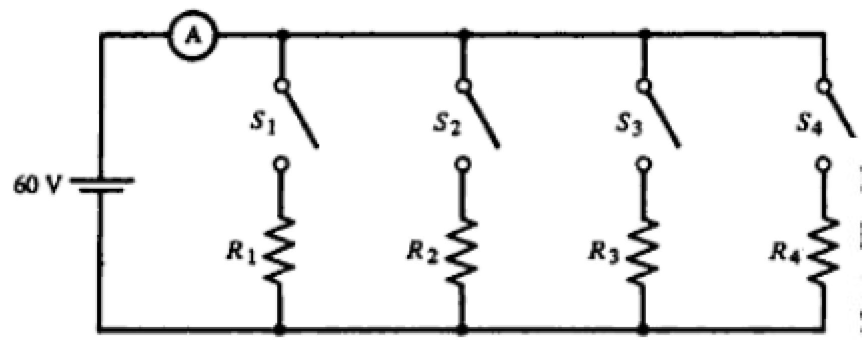
KIRCHHOFF'S RULES

Junction rule or Kirchhoff 's current law

The sum of the magnitudes of the currents directed into a junction equals the sum of the magnitudes of the currents directed out of a junction.

Loop rule or Kirchhoff 's voltage law

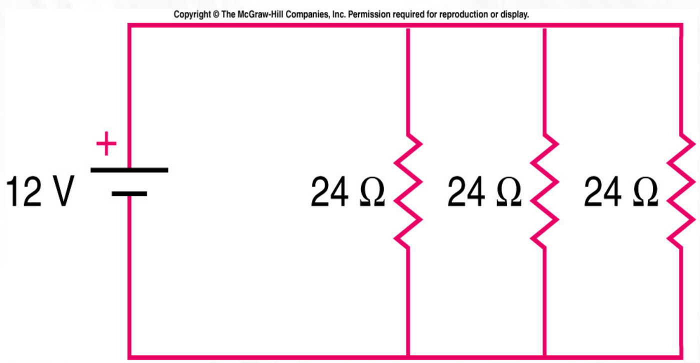
Around any closed circuit loop, the sum of the potential drops equals the sum of the potential rises.



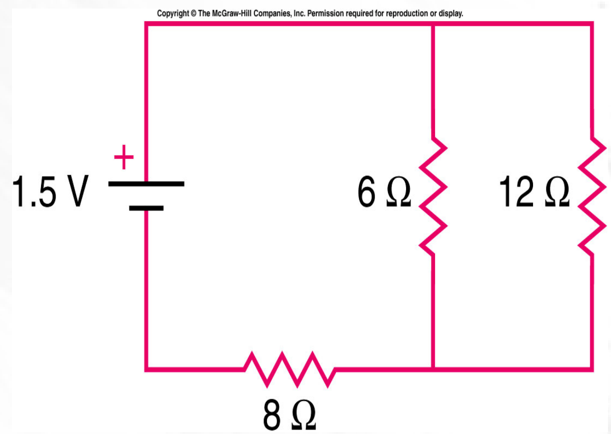
1) resistors are 8, 24, 30. 20 ohms.

In Figure 10-11, the same four resistors as in Figure 10-10 are connected in parallel. Find (a) the combined resistance; (b) the current in the battery; (c) the current in the 8-ohm resistor; and (d) the power dissipated in the 24-ohm resistor.

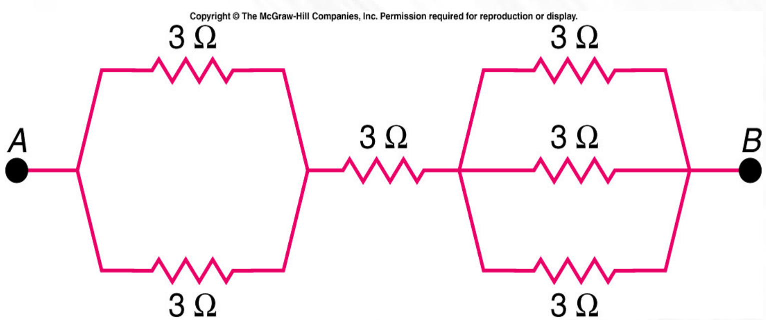
2) find the main current. And current in each branch.,



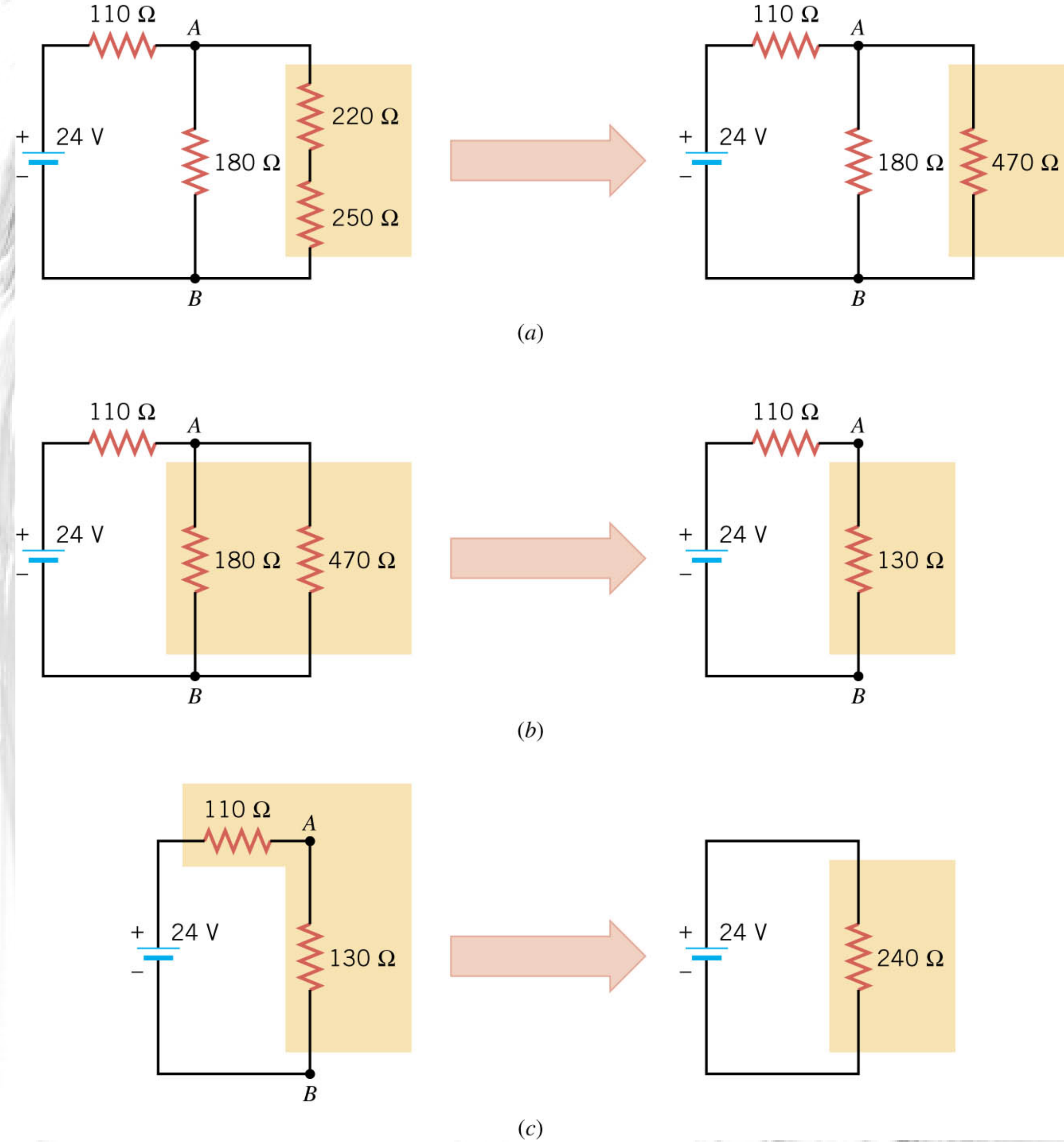
3) find the main current. And current in each branch,

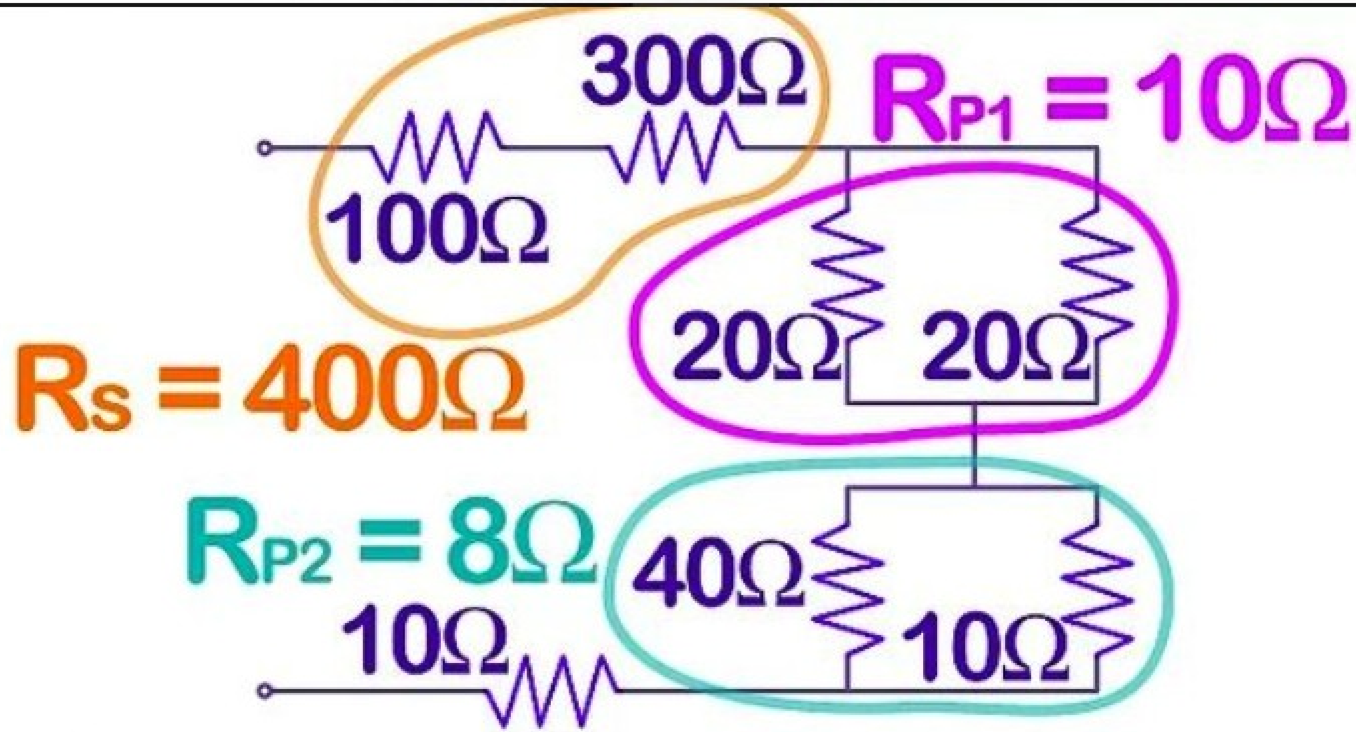


4)



Find the combined resistance

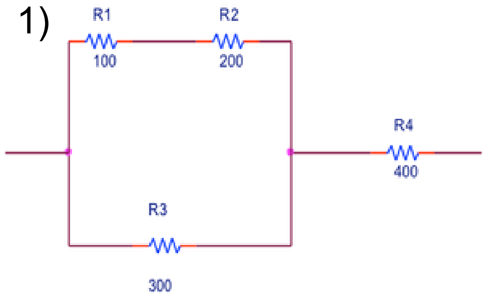

110 Ω
A
24 V
180 Ω
220 Ω
250 Ω
B
470 Ω
(a)
130 Ω
(b)
240 Ω
(c)



$$= 400\Omega + 10\Omega + 8\Omega + 10\Omega$$

$$= \boxed{428\Omega}$$

1)



What is the equivalent resistance of the resistors above?

- 1000 Ω
- 700 Ω
- 550 Ω
- 191 Ω

2) Suppose a 60W light bulb is being powered by 85V. What is the resistance of the bulb ?

3) Two 60ohms resistors are connected in parallel . This parallel arrangement is connected in series with a 30 ohms resistor. The entire circuit is then placed across a 120V potential difference

A) Draw a diagram of the circuit.

B) What is the effective resistance of the parallel portion of the circuit?

C) What is the effective resistance of the entire circuit ?
and the current in the circuit ?

D) What is the the voltage across the 30 ohms resistor ?

E) What is the voltage across the parallel portion of the circuit ?

F) What is the current in each branch of the parallel portion of the circuit ?

4) Three 15 ohms resistors are connected in parallel. This arrangement is connected in series with a 10 ohms resistor. The entire circuit is then placed across a 45V difference in potential.

A) Draw the diagram of the circuit

B) What is the effective resistance of the parallel portion of the circuit ?

C) What is the effective resistance of the entire circuit ?

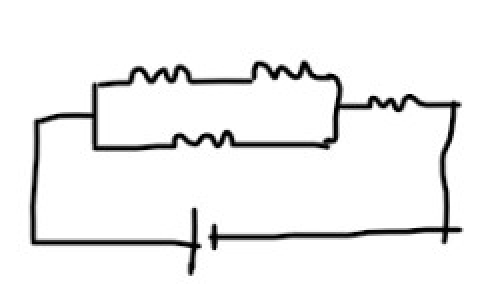
D) What is the current in the entire circuit?

E) What is the voltage drop across the 10 ohms resistor ?

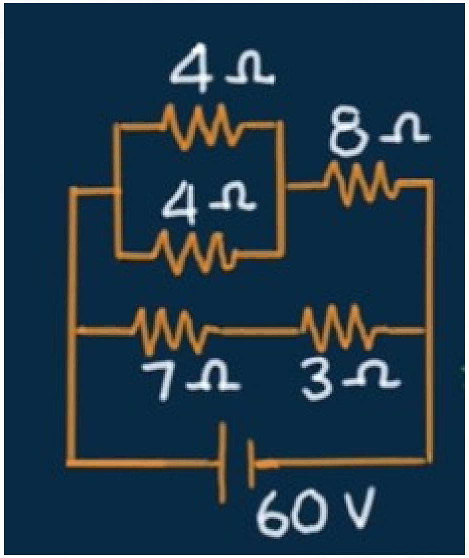
F) What is the voltage drop across the parallel portion of the circuit ?

G) What is the current in each branch of the parallel portion of the circuit?

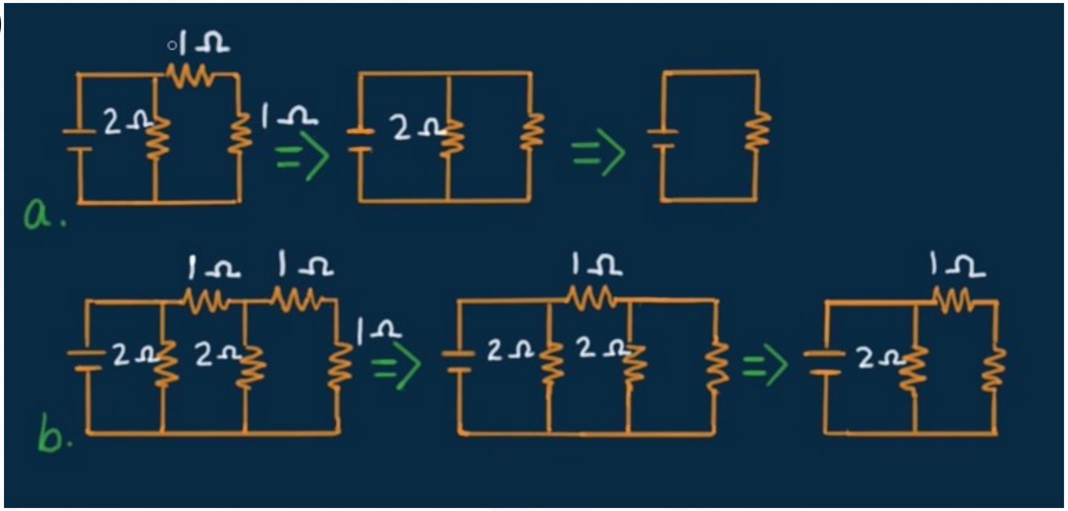
1)The circuit is a 200ohms+300 ohms in parallel with a 100 ohm followed by a 400ohms
The power supply us 12V
1) find the effective resistance of the circuit and I
2) find the voltage drop across the 400 ohm resistance
3) find the voltage drop across the parallel component
(2 branches)
4) find I1, I2
5) find the voltage drop across the 200 ohms
6) the voltage drops across the 300 ohms.

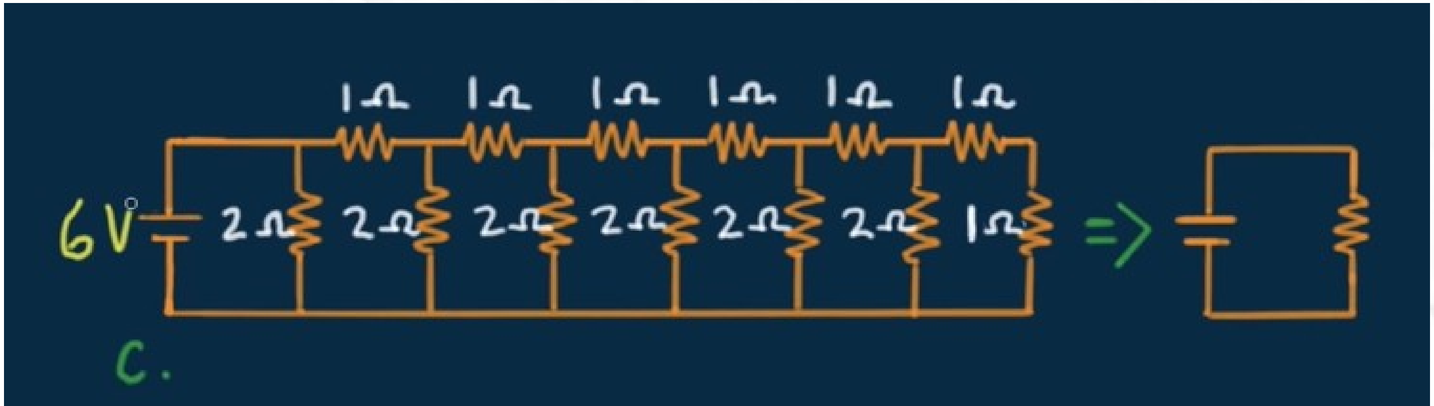


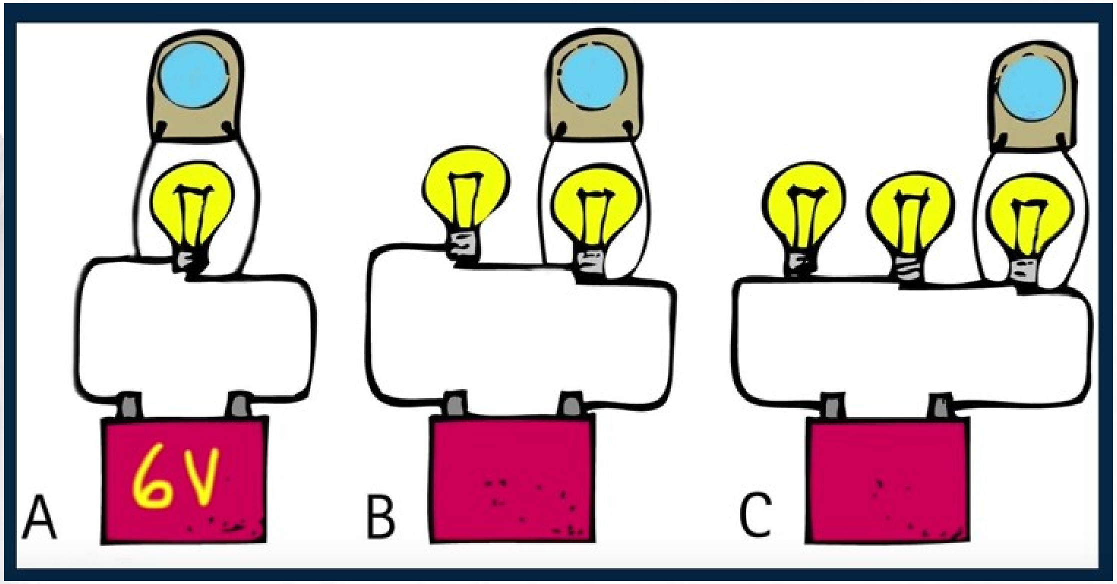
2)

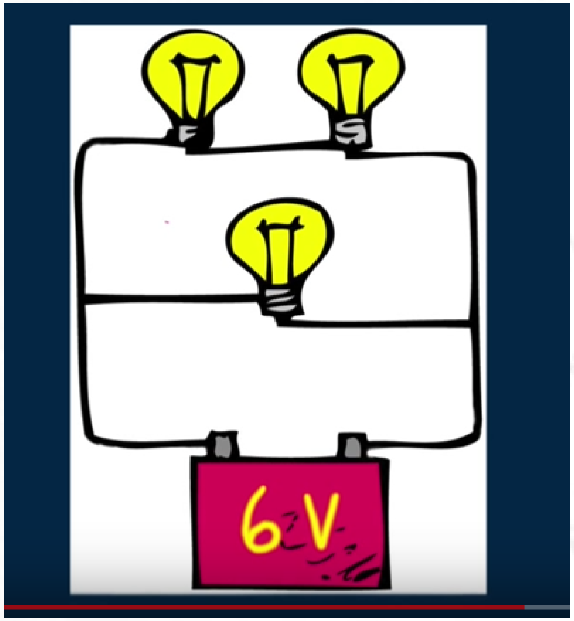


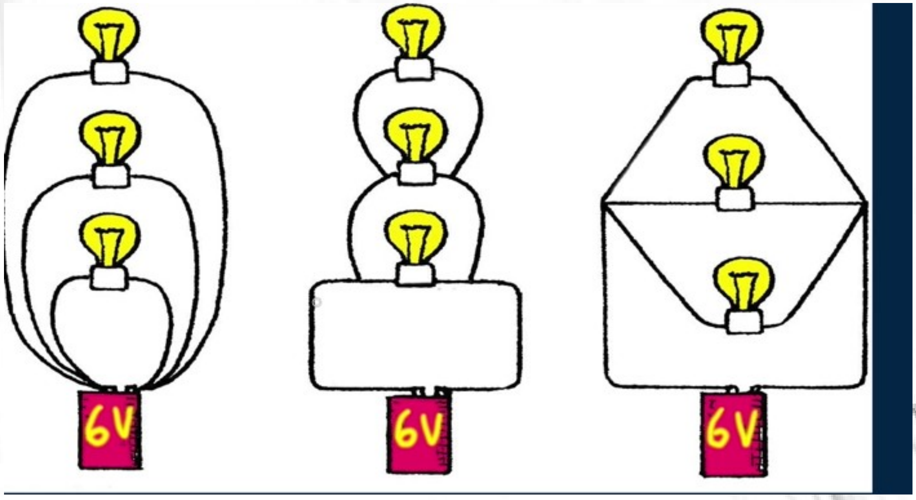
3)





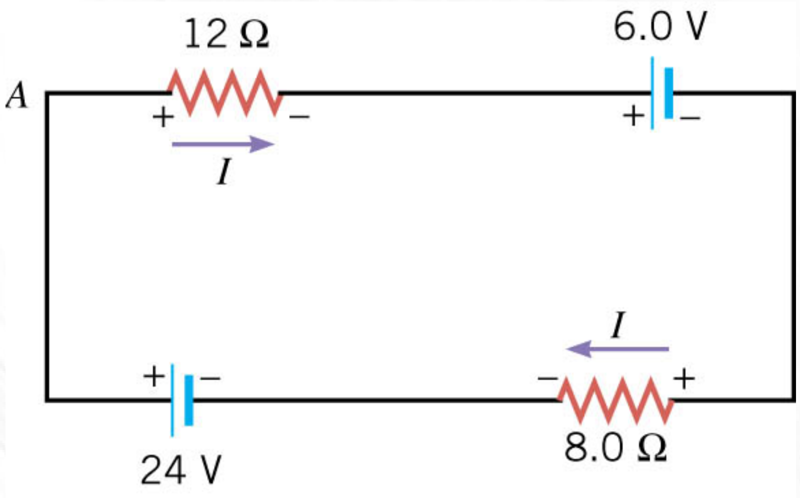

6V
A
B
C

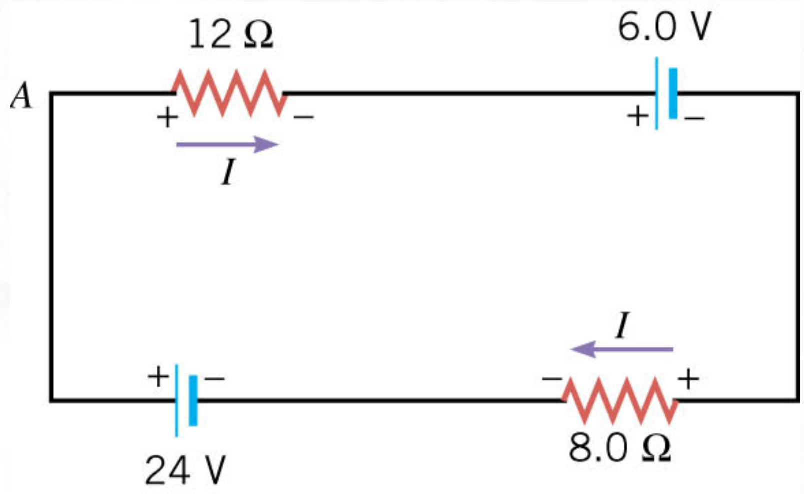

6V


6V
6V
6V

Find the current I

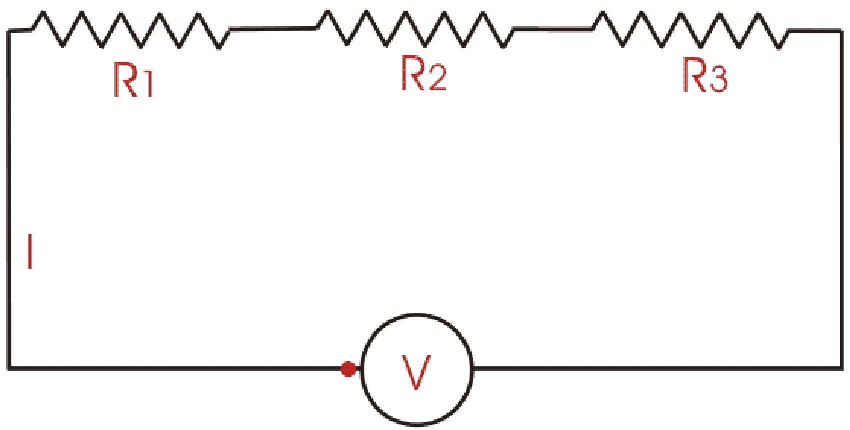
Hint: Remember how batteries are set in series to add voltages.

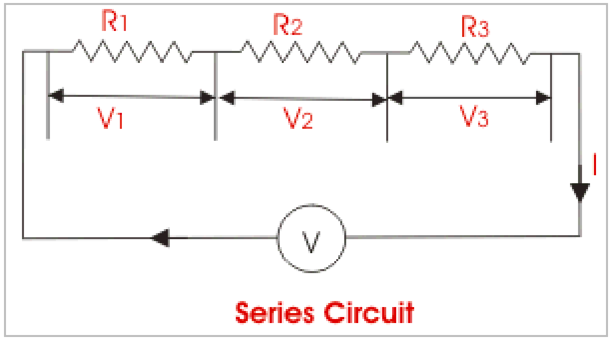




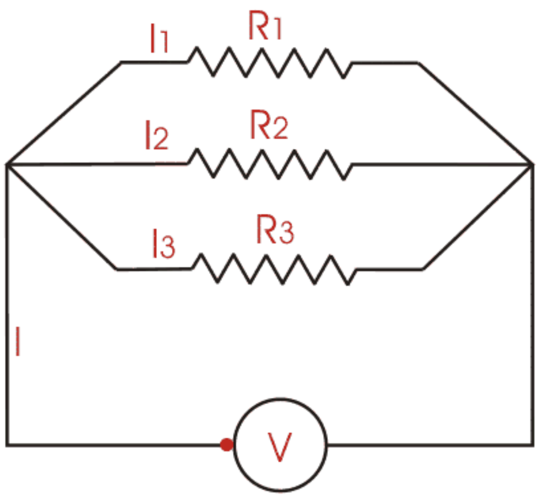
$24 - 12I - 6 - 8I = 0 \qquad I = 0.90\ A$

24 is potential rise. 12I 8I and 6 are potential drops





$R_{equivalent}$ = R1+R2+R3   V1+V2+V3=V I1=I2=I3=I I_{power_supply} = V / $R_{equivalent}$



Parallel circuit

$R_{equivalent}$ = $(1/R1+1/R2+1/R3)^{-1}$

I1+I2+I3=I_{power_supply}

V1=V2=V3=V

http://www.electrical4u.com/electrical-dc-series-and-parallel-circuit/

Equations so far/units

t is the time elapsed Units = seconds (s)

E = total energy consumed/produced. Units = joules(J)

Q = amount of charge . Units = coulombs (C)

I = current or amount of charge per unit second =number of charge/ time = **Q/ t**
Units: Amps(A) or equivalent to coulombs/second (C/s)

V or ΔV = difference of potential or voltage or tension
= Energy per unit charge = **E/Q**
Units = volts (V) equivalent to joules/coulomb (J/C)

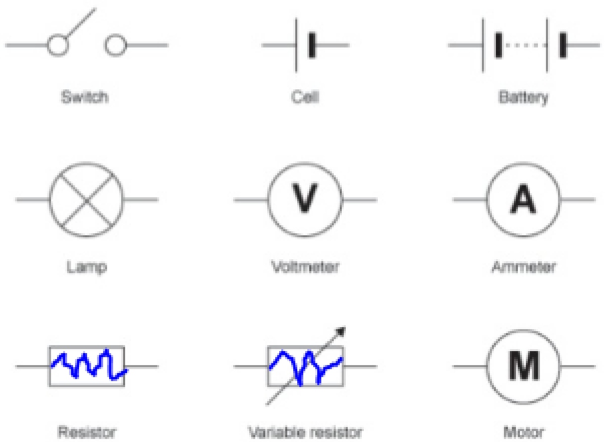
P = power = energy consumed/produced per unit second = **E / t = V I**
Units = watts(W) or joules/second(J/s)

R = resistance units= ohms (Ω)

P= V I E = P t or P=E/t V = E / Q I = Q/t

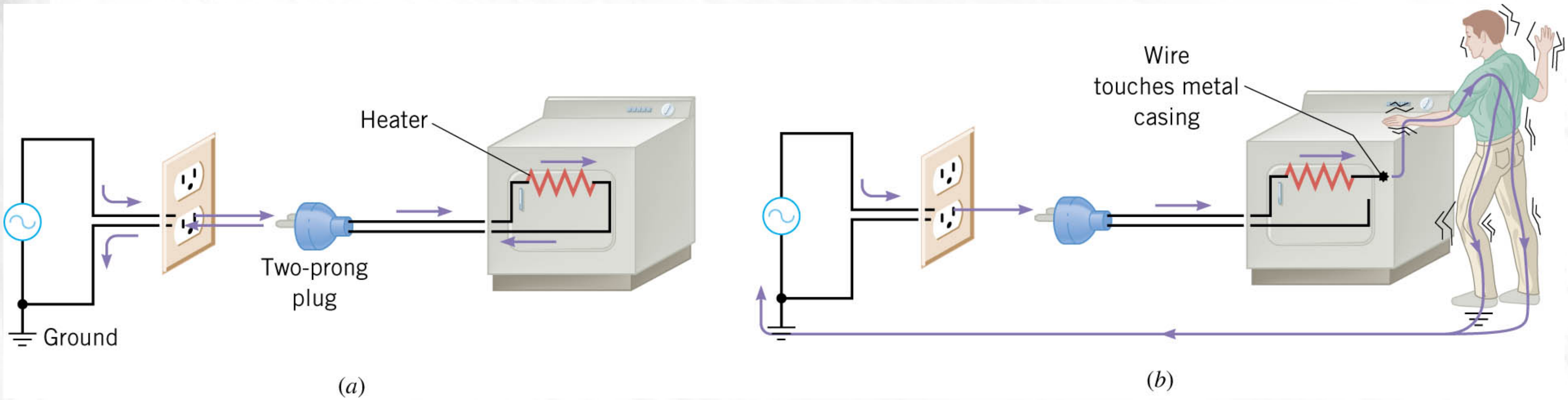
Voltage drop across resistance R with a current I through it : **V = RI** (ohms law)

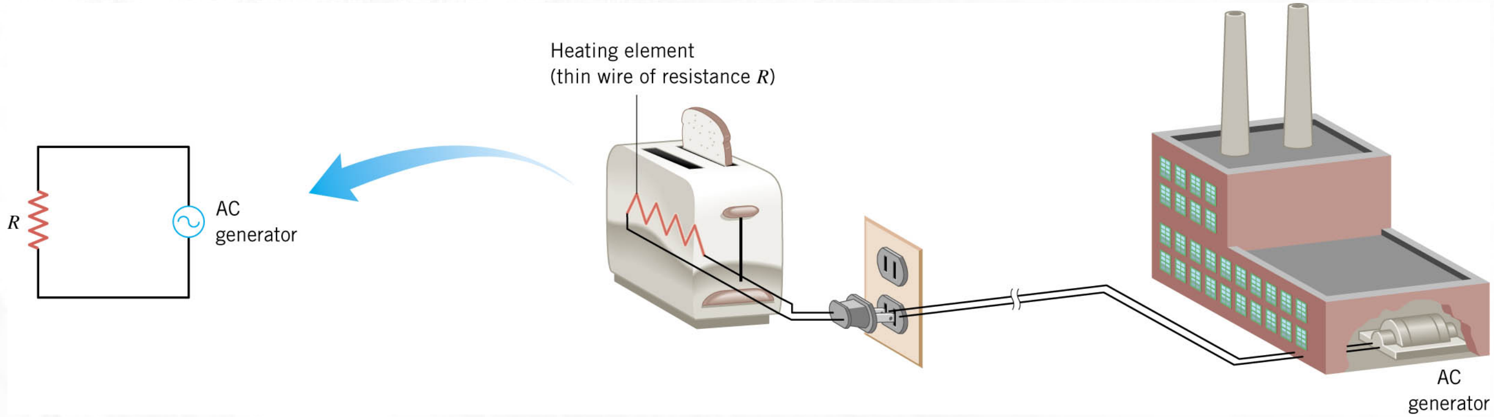
Basic Circuit Symbols



You should familiarize yourself with these symbols

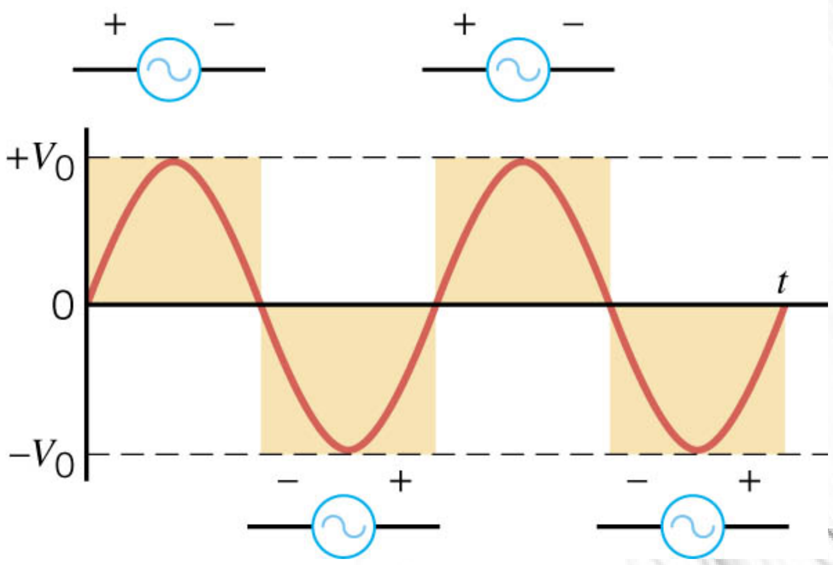
To reduce the danger inherent in using circuits, proper ***electrical grounding*** is necessary.

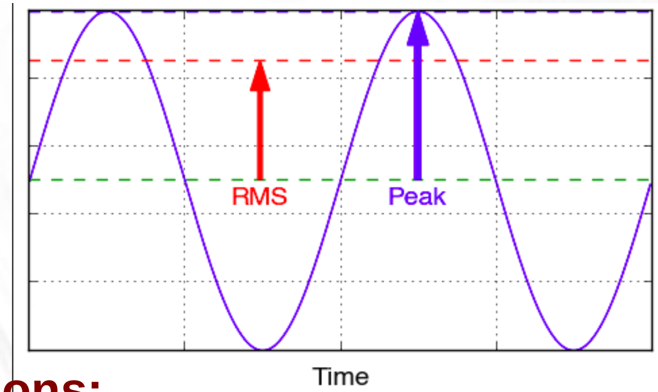


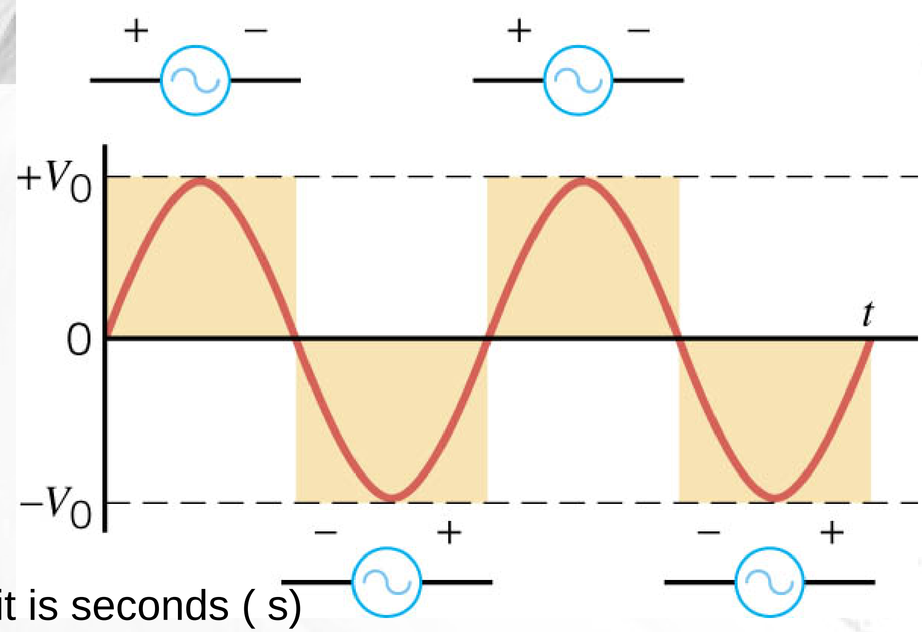


In an AC circuit, the charge flow reverses direction periodically.

https://www.youtube.com/watch?v=P-Umre5Np_0







Definitions:

- The time for 1 cycle is the period (T). The unit is seconds (s)
- The number of cycles per second is the frequency (f) . Unit is Hertz (Hz)
- We have f = 1/T
- Vo (or Io) is the peak value of the sine wave or amplitude.
  Peak value can be visualized with an oscilloscope
- Voltmeter does not read the peak value but the rms value (root mean square)

Vrms= Vo/1.41. Or Vrms = 0.71 Vo (71% of Vo). Vo=1.41 Vrms

- the average power is Vrms x Irms

For example if f=60Hz what is the period ? What about f=50Hz
If the period is 0.5s what is the frequency ?

-Alternating voltage (or current) in the US has a frequency of 60Hz .
The peak voltage is about 170V. What is the rms value recorded by a voltmeter?
In Europe the frequency is 50Hz. The rms value is 220V. What is the peak value

Go on wolfram alpha and type :plot 180*sin(2pi x / 60) for x between 0 and 180

Example 6 Electrical Power Sent to a Loudspeaker

A stereo receiver applies a peak voltage of 34 V to a speaker. The speaker behaves approximately as if it had a resistance of 8.0 Ω. Determine (a) the rms voltage, (b) the rms current, and (c) the average power for this circuit.