Chapter 21 Electric Current and Circuits



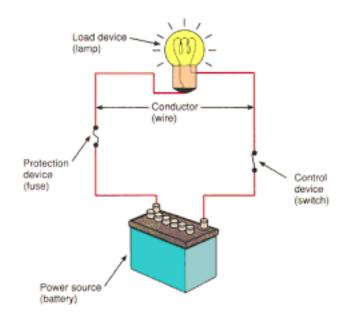
(a)

Revised 7.23.2020 Some diagrams from Pearson Physics by Walker. Used with permission

As an introduction to this chapter you should view the following movie.

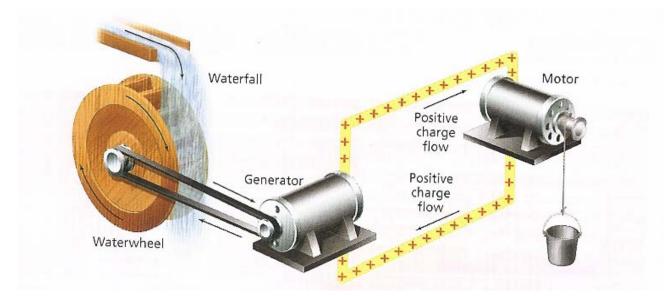
If you cannot click on the link, then copy it and paste it into your see web browser.

http://www.ionaphysics.org/movies/VIR.mp4

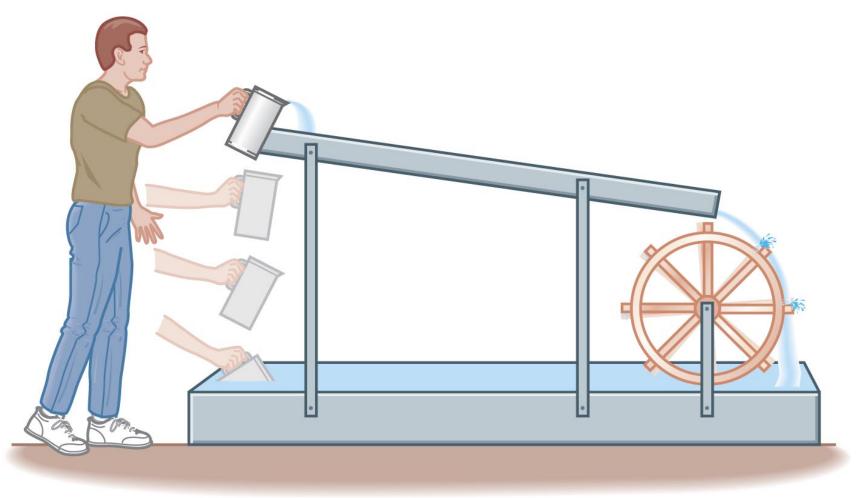


Electric circuits always have a source of energy, a load (which uses energy) and a complete closed circuit.

A battery or a generator is the energy source.



You may speak of positive or negative charge flowing. In solids it is electrons which move. In a fluid you may have +ions moving one way and – ions moving the other way.



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The man does work lifting up the water and then the water does work turning the wheel.

In the electrical circuit the battery or generator does work moving the charge to a higher potential and then the charge does work turning the motor, or lighting the bulb, etc.

Electric Current - when charge flows from one place to another.

Current is measured in Amperes (or Amps)

I = q/t Therefore an Amp = Coulomb/sec



Andre Marie Ampere

Current =charge/time

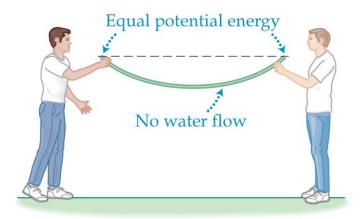
I = q/t

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1 amp = 1 coulomb/second (C/s)
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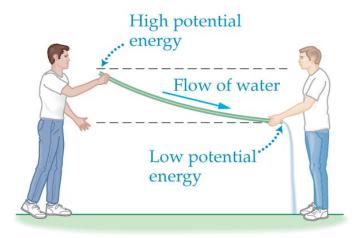
Example:

A normal household circuit can carry a maximum of 15 amps. How many coulombs pass through the circuit each minute?

Current will flow from higher potential to lower [SEP] potential.



(a) Equal potential energy \rightarrow no flow © 2014 Pearson Education, Inc.



(b) Water flows from high potential energy to low.

Potential Difference is measured in Volts

V = w/q Therefore a Volt = Joule/Coulomb

1. How much work will it take to move 1 electron through a potential difference of 10 volts?

=









	V	Capacity	Diameter	Length
	Volts	Amp hr	mm	mm
AAA	1.2	0.35	10.5	44.5
AA	1.2	0.7	14.2	50
Α	1.2	2.2	17	50
В				
B C	1.2	2.5	26	46
D	1.2	8	33	58

2. How much charge can be moved through a potential difference of 9.0 volts by 30 Joules of work.

3. It takes 20 Joules of work to move 1.3 coulombs from point A to point B. What is the potential difference between the points?

Current = charge/time Amp = coul/s

4. How many coulombs go through a circuit in 2.0 minutes if there is a current of 15 Amperes in the circuit?

5. If a current of 20 mA flows through a 5.0 volt circuit for 10 seconds, what is the total

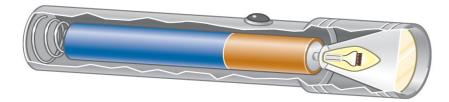
amount of charge which has moved through the circuit?

A Schematic Diagram is an electrical "blueprint". It uses standard symbols and is always drawn very neatly.

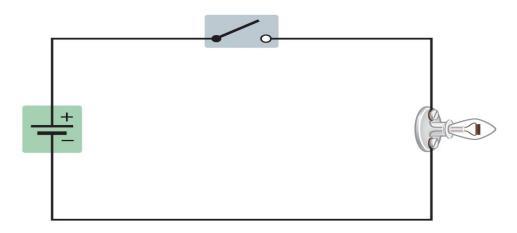
http://www.kpsec.freeuk.com/symbol.htm

Table 21.1 Elements of Electric Circuits				
Circuit Element	Symbol	Physical Characteristics		
Resistor		Resists the flow of electric current. Converts electric energy into thermal energy.		
Ideal wire		An ideal wire has zero resistance. It is used to connect various elements in a circuit.		
Battery	╧┨┠═	A device that produces a constant difference in electrical potential between its two terminals.		
Switches (open and closed)	✓₀ ⊷	Devices used to control whether electric current is allowed to flow through a circuit or a portion of a circuit.		
Diode	-▶+	A device that allows electric current to flow in one direction only.		
Incandescent lightbulb		A device containing a resistor that gets hot enough to give off visible light.		

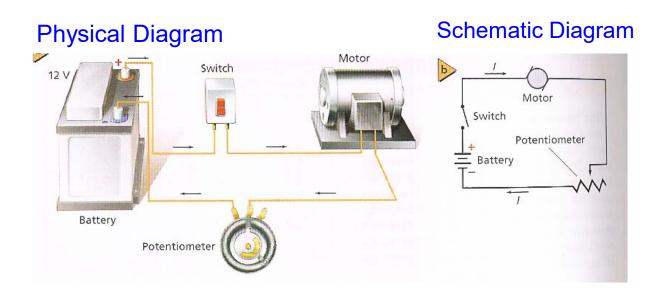
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(a) A simple flashlight

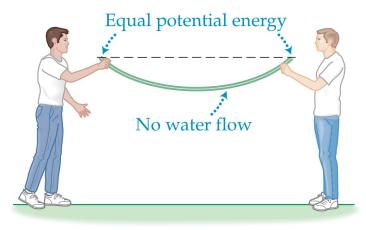


(b) Circuit diagram for flashlight

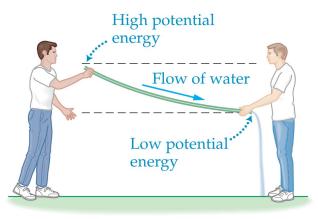


Batteries produce Direct Current DC DC always flows in the same direction. Household outlets supply Alternating Current AC AC reverses direction (in the US the frequency is 60 Hz)

Difference in potential (Voltage) causes current to flow.



(a) Equal potential energy \rightarrow no flow



(b) Water flows from high potential energy to low.

Resistance: Opposition to current flow measured in Ohms Ω

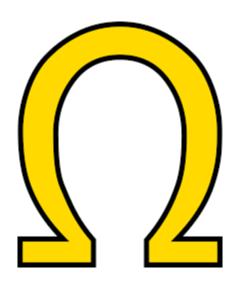
Higher Voltage = more current Higher Resistance = less current

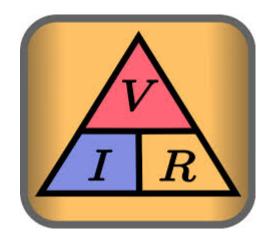
V = I R V = Voltage - in volts I = Current - in Amps R = Resistance - in Ohms



Georg Ohm

Problem: A potential difference of 24V is applied to a 150 Ohm resistor. How much current will flow?

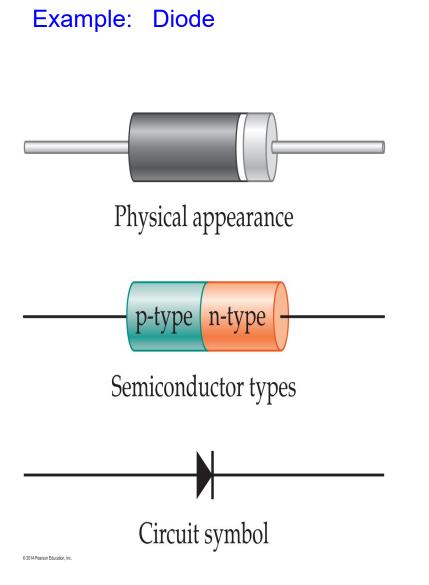


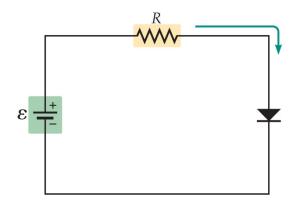


Problem:

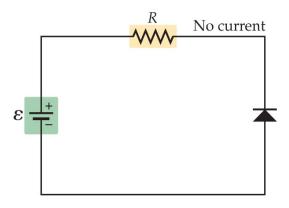
You have an air conditioner which operates at 120 V and draws 7.5 A. Find the equivalent resistance.

Conductors: - permit current flow (low resistance) Insulators: - prevent current flow (high resistance) Semi-conductors: may act as conductors or as insulators, independing upon the circumstances.



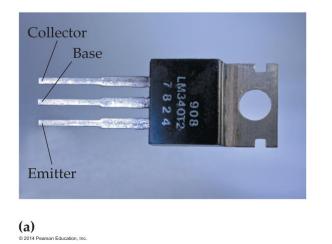


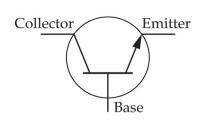
(a) Forward-biased diode



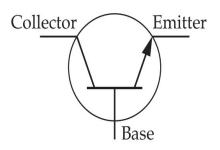


Semiconductor example 2: Transistor

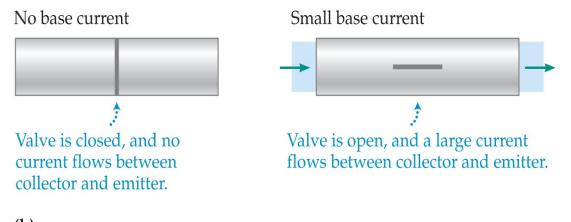






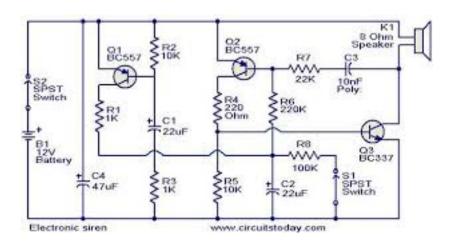




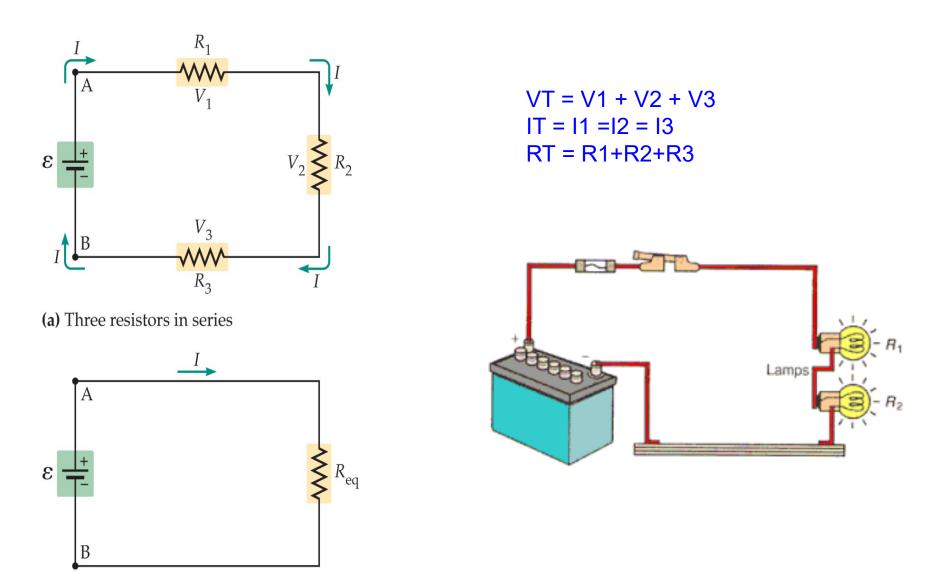


(b) © 2014 Pearson Education, Inc. There are two kinds of circuits, series and parallel. Watch this movie for a good introduction.

http://www.ionaphysics.org/movies/SeriesParallel.mp4



Electric Circuits: Series Circuit: Only one path for current



⁽b) Equivalent resistance has the same current. © 2014 Pearson Education, Inc.

Electric Circuits: Series Circuit: Only one path for current VT = V1 + V2 + V3 IT = I1 =I2 = I3 RT = R1+R2+R3

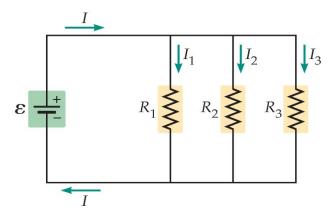
You have 2 resistors in series. One is 100 ohms and the other is 300 ohms. Find the total resistance of the circuit.

Electric Circuits: Series Circuit: Only one path for current VT = V1 + V2 + V3 IT = I1 =I2 = I3 RT = R1+R2+R3

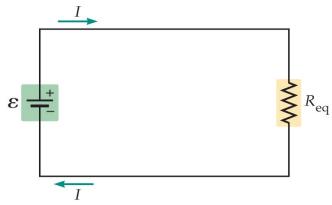
You have 2 resistors in series. One is 100 ohms and the other is 300 ohms. Find the total resistance of the circuit. If 8 V is supplied by the battery, what is the current in the circuit? Electric Circuits: Series Circuit: Only one path for current VT = V1 + V2 + V3 IT = I1 =I2 = I3 RT = R1+R2+R3

You have 2 resistors in series. One is 100 ohms and the other is 300 ohms. Find the total resistance of the circuit. If 8 V is supplied by the battery, what is the current in the circuit? How many volts are across the 100 ohm resistor?

Parallel Circuit: More than one path for current

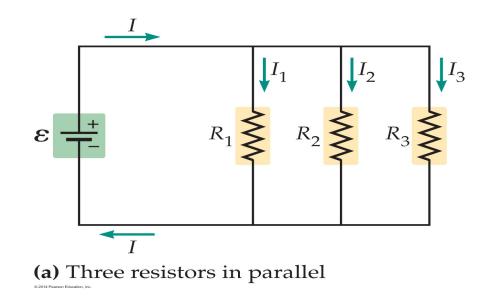


(a) Three resistors in parallel



(**b**) Equivalent resistance has the same current.

VT = V1 = V2 = V3 IT = I1+I2+I3 1/RT = 1/R1 + 1/R2 + 1/R3



You have three resistors, R1 = 200 Ohms, R2 = 200 Ohms, $\frac{1}{100}$ Separation R3 = 100 Ohms. They are wired in parallel and connected $\frac{1}{100}$ to a 10 Volt battery. Calculate I1, I2, I3, I, and Rt

Power = Voltage*Current P=V*I

A 100 watt light bulb operates at 120 volts. How much current flows through the bulb? How much electrical energy is consumed each hour the bulb is left operating?



James Watt

Alessandro Volta

Andre Ampere

Power = work (or energy)/Time Therefore Energy = power * time

P=VI W = VIt Work or energy is usually measured in Joules. However, that is a small *sepunit*. Electrical energy rates are usually stated as so many cents per *sep*kilowatt hour.



(a)

Problem: You go on vacation and leave a 100 Watt bulb burning for 14 days. How many kWhr does the bulb use?

Electric rates in the continental US vary a lot. See this chart:

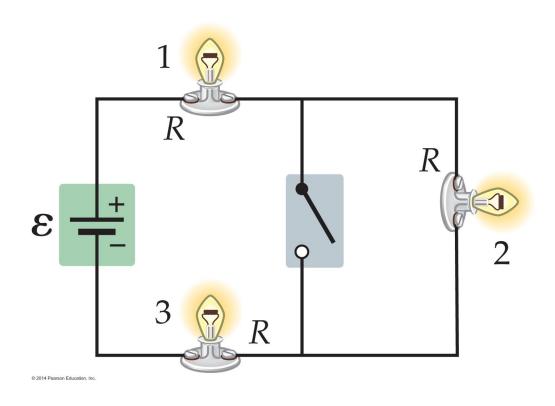
http://www.npr.org/blogs/money/2011/10/27/141766341/the-price-of-electricity-in-your-state

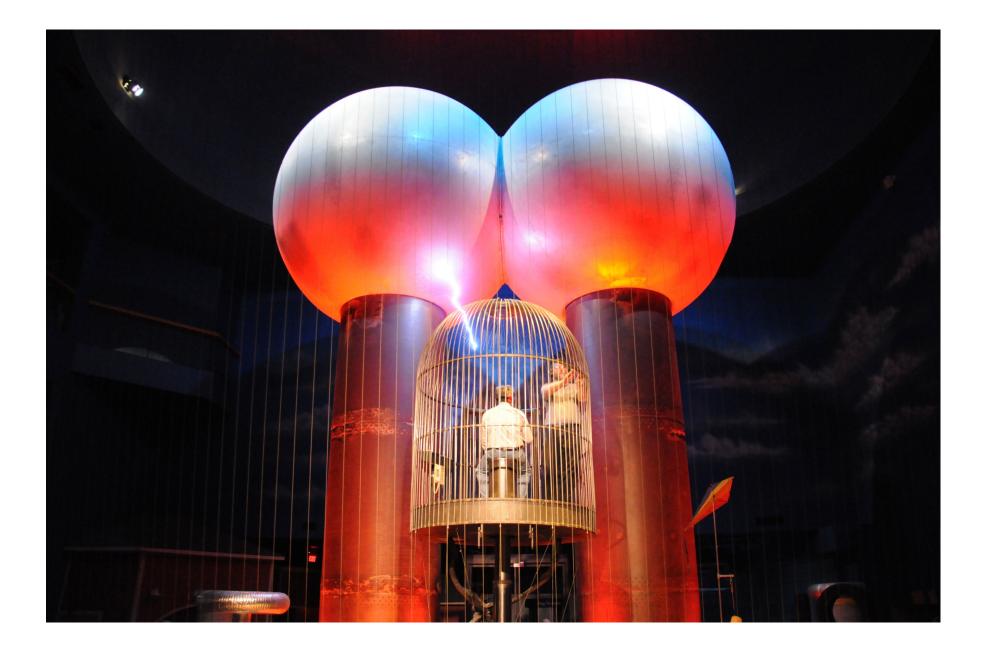
Calculate the cost of running the bulb for the 14 days you were EPaway.

Here is a challenge:

Three light bulbs are wired $\begin{bmatrix} I \\ SEP \end{bmatrix}$ according to the diagram.

Assuming current will tend to [sep] flow along the path of least [sep] resistance, state what will happen [sep] when the switch (currently shown [sep] in the open position) is closed.





This gigantic Van de Graaff generator is located in the Museum of Science in Boston.