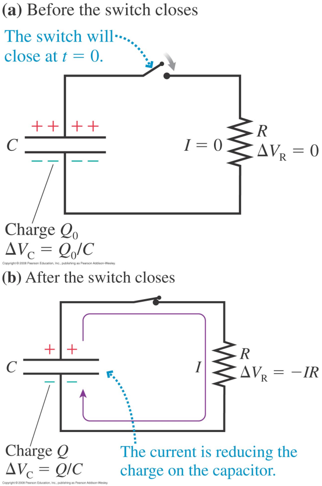


- We have only been discussing DC circuits so far. However, using a capacitor we can create an RC circuit.
- In this example, a capacitor is charged but the switch is open, meaning no current flows.
- The switch closes and current flows through the resistor, discharging the capacitor. The current stops once the capacitor is discharged.
- The voltage around the loop is

$$\Delta V_C + \Delta V_R = \frac{Q}{C} - IR = 0$$

RC Circuits

- The rate of charge leaving the capacitor is equal to the rate of charge passing through the circuit (the current)

$$I = -\frac{dQ}{dt}$$

- The loop then becomes (dividing by R and rearranging)

$$\begin{aligned}
\frac{Q}{C} - IR &= 0 \\
\frac{Q}{C} + \frac{dQ}{dt}R &= 0 \\
\frac{Q}{RC} + \frac{dQ}{dt} &= 0 \\
\frac{dQ}{Q} &= -\frac{1}{RC}dt
\end{aligned}$$

- We can solve this by integrating it.

RC Circuits

- The integral is

$$\int_{Q_0}^{Q} \frac{dQ}{Q} = -\frac{1}{RC} \int_0^t dt$$

- We can do that integral

$$\ln Q|_{Q_0}^{Q} = \ln Q - \ln Q_0 = \ln\left(\frac{Q}{Q_0}\right) = -\frac{t}{RC}$$

- Solving for Q gives

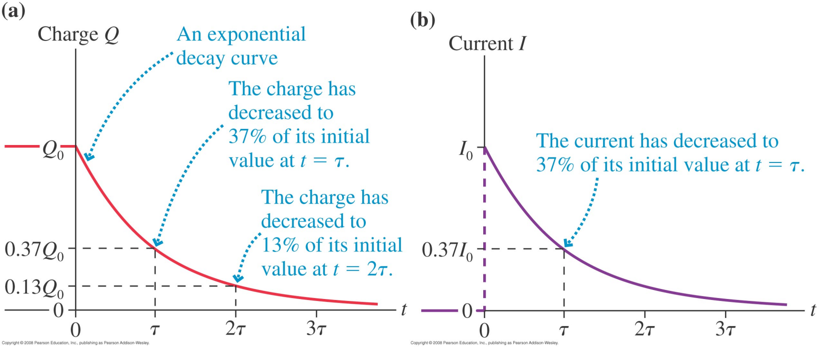
$$Q = Q_0 e^{-t/RC} = Q_0 e^{-t/\tau}$$

  where $\tau = RC$ is the time constant of the circuit.

- The resistor current is then

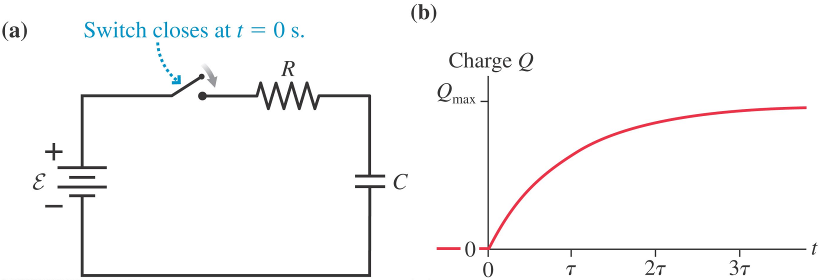
$$I = -\frac{dQ}{dt} = \frac{Q_0}{\tau} e^{-t/\tau} = \frac{Q_0}{RC} e^{-t/\tau} = \frac{\Delta V_C}{R} e^{-t/\tau} = I_0 e^{-t/\tau}$$

RC Circuits



(a)
Charge Q
An exponential decay curve
The charge has decreased to 37% of its initial value at $t = \tau$.
The charge has decreased to 13% of its initial value at $t = 2\tau$.
Q_0
$0.37Q_0$
$0.13Q_0$
0
0
τ
2τ
3τ
t
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.
(b)
Current I
The current has decreased to 37% of its initial value at $t = \tau$.
I_0
$0.37I_0$
0
0
τ
2τ
3τ
t
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.

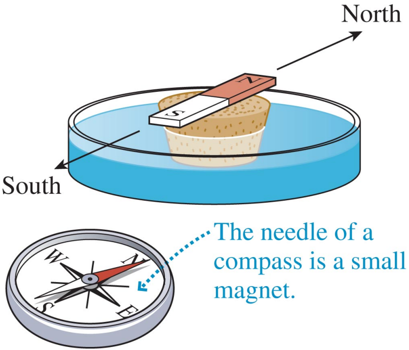
Charging a Capacitor

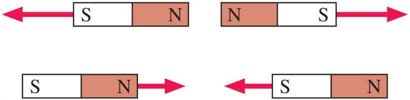


The Magnetic Field (Chapter 33)

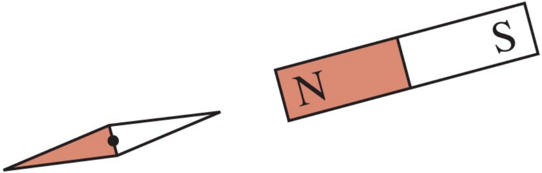
- Now, it is time for magnetism! Another major topic change.
- You all know about magnets already, since you use them to post your artwork on your fridge.
- You also carry around, listen to or somehow use objects build with magnets in your everyday life.
- You can tell that electrcity and magnetism are related by how often we say EM. However, historically they are completely distinct phenomena.
- Magnetism was also understood in a macroscopic sense before the microscopic basis was known.
- We will try to get a feeling for both the macroscopic and microscopic pictures of magnetism and for the relationship between electricity and magnetism.

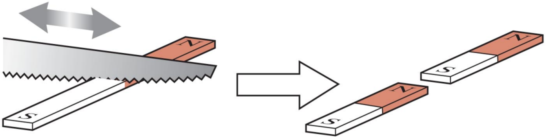
Things You Already Know About Magnetism (33.1)



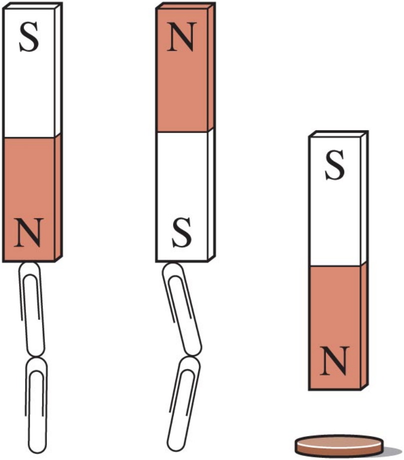


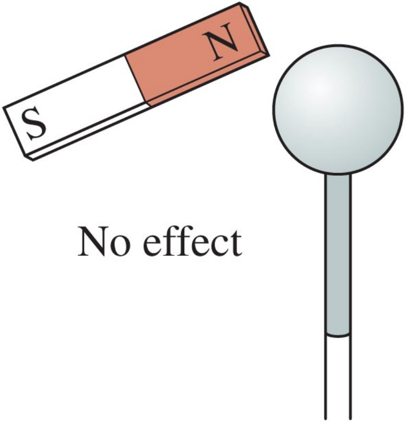
Things You Already Know About Magnetism





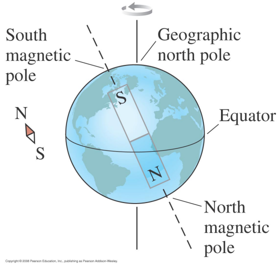
Things You Already Know About Magnetism





Monopoles, Dipoles and Geomagnetism

- Every magnet which has ever been observed has had both a north and south pole...even if you cut 'em up!
- Experiment seems to tell us that all magnets are dipoles.
- People are actively searching for magnetic monopoles, since there is no reason for them not to exist....but no luck yet...



- The "north" end of a magnet is "north seeking" on the earth.
- This must mean that the geographic north pole of the earth is actually near a magnetic south pole! The north-seeking side of a compass needle would be repelled by a magnetic north pole...

The Discovery of the Magnetic Field (33.2)

- The connection between electricity and magnetism was discovered in 1816 by Oersted during a classroom lecture demonstration!
- He happened to leave a compass nearby while doing an electricity demo and saw the needle move.
- It turns out that a charge distribution (ie. an electric field) has no effect on a compass needle. However, a moving charge distribution (ie. a current) produces a force which moves the needle.
- Current generates a magnetic field!