Physics 052

L8

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Ch 16 & 19: Electricity and Magnetism

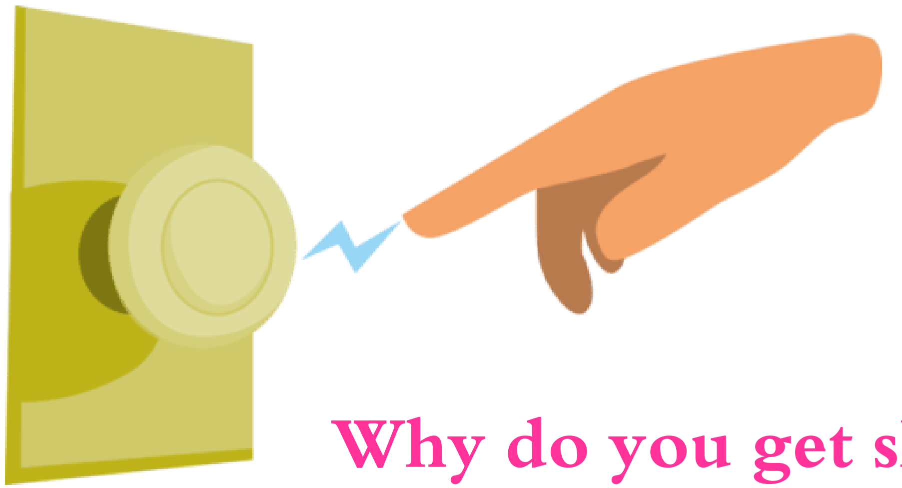
A cardiac catheterization laboratory stands ready to receive a patient suffering from atrial fibrillation. The large white objects on either side of the operating table are strong magnets that place the patient in a magnetic field. The electrophysiologist performing a catheter ablation procedure sits at a computer in the room to the left. With guidance from the magnetic field, he or she uses a joystick and other controls to thread the magnetically sensitive tip of a cardiac catheter through blood vessels and into the chambers of the heart.

What are we going to talk about today?

Ch 16 & 19: Electricity and Magnetism

- 16.1 Electric Forces.
- 16.2 The Electric field.
- 19.1 Magnetic field

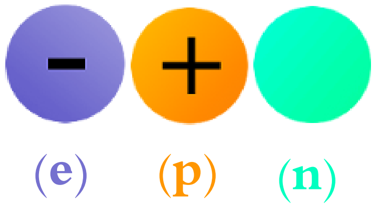
Charles Coulomb
French physicist
(1736–1806)



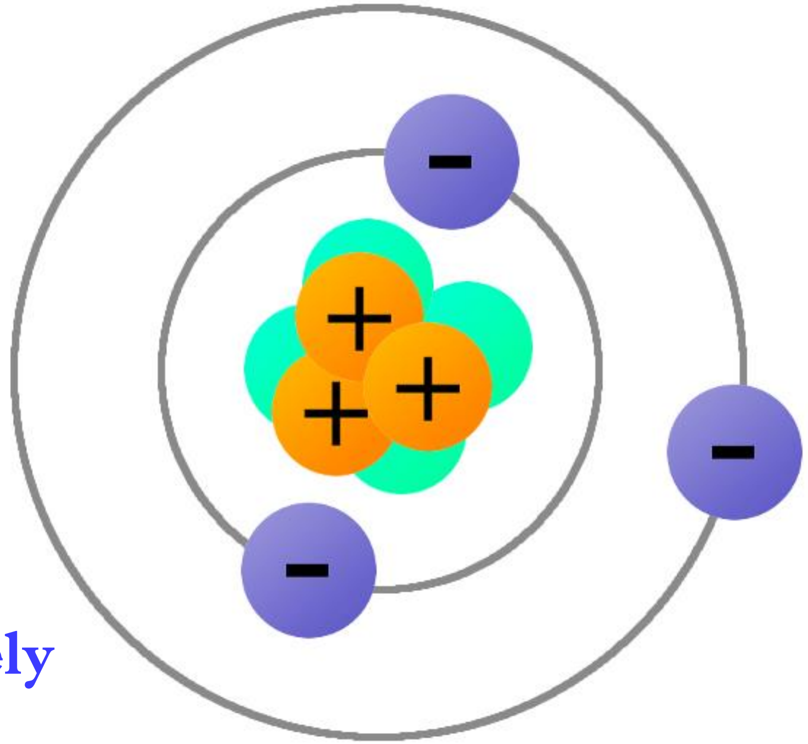
Why do you get shocks when you touch the doorknob ? (Click Here)

Electric Charge

Everything in the world is made up of atoms. Each atom has smaller parts in it, electrons protons and neutrons.



Atomic Particle	Charge	Mass
Electron (e)	-1.6×10^{-19} C	9.11×10^{-31} Kg
Proton (p)	$+1.6 \times 10^{-19}$ C	1.673×10^{-27} Kg
Neutron (n)	0	1.675×10^{-27} Kg

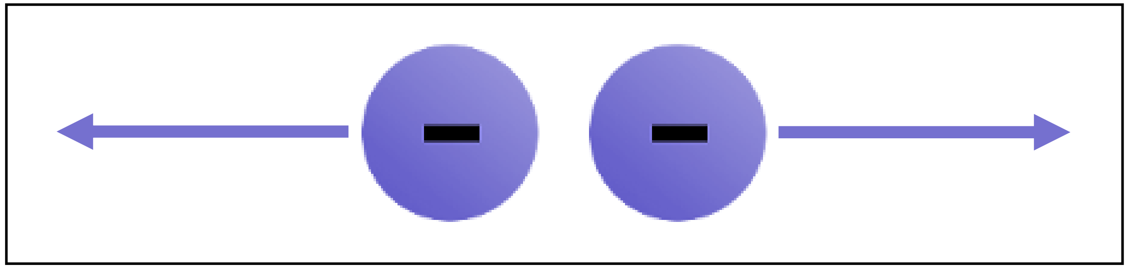


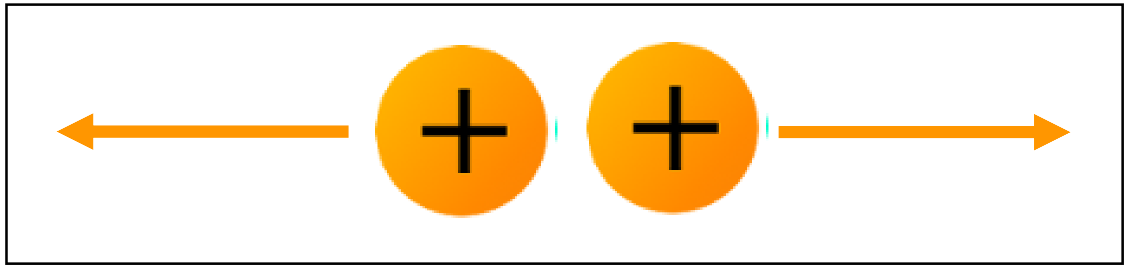
- The coulomb (Unit: C) is (SI) unit of electric charge
- The coulomb is equivalent to the charge of approximately 6.242×10^{18} proton.

Rules of Electric Charges

- Charge cannot be created or destroyed (Conserved) but it can be moved around.
- The law of electric charges states that:

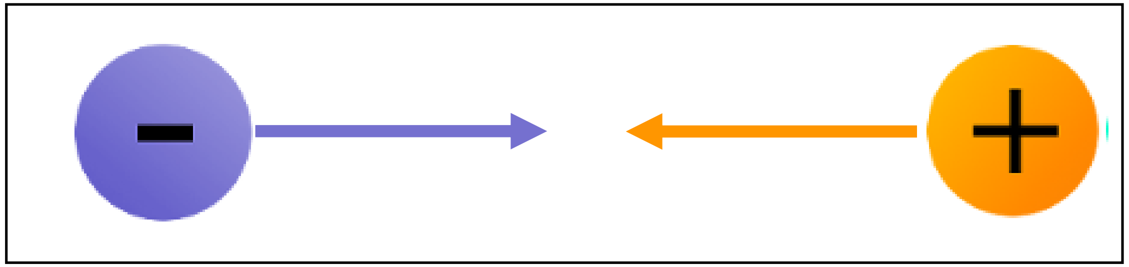
1– like charges repel





2– opposite charges attract.

Protons are positively charged and electrons are negatively charged, so they are attracted to each other.



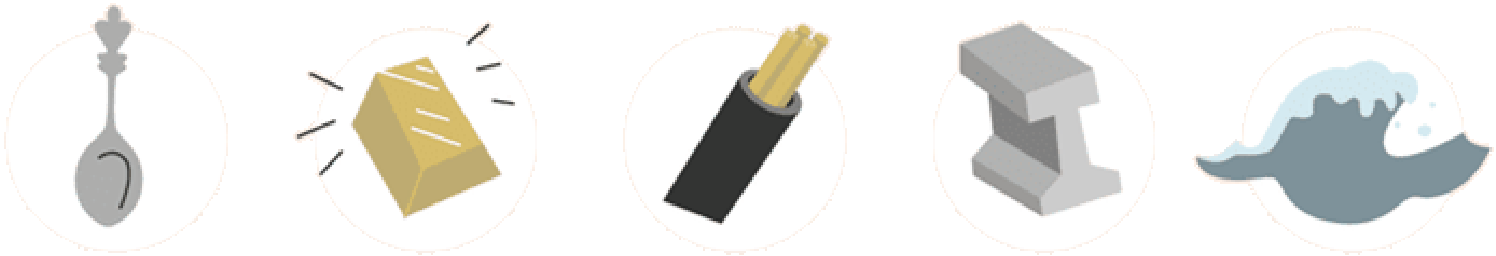
16.1 Electric Forces

16.1 Electric Forces

Two basics type of materials

1– Conductors:

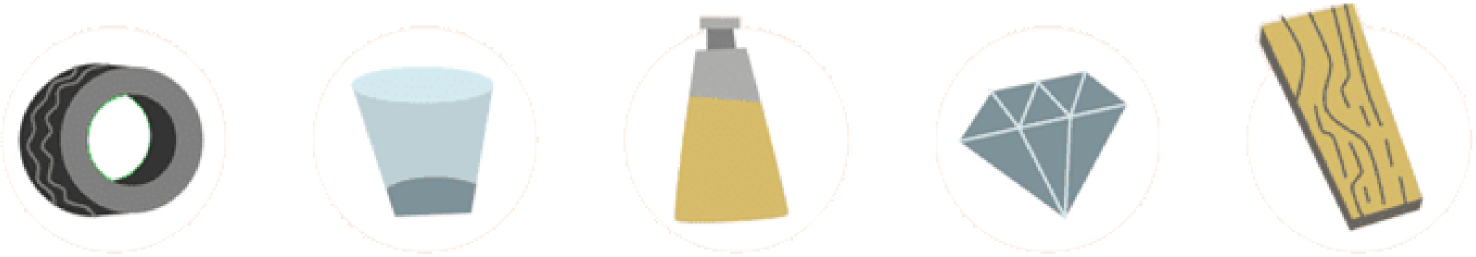
Materials, that allow the free movement of charges, such as :



Silver Gold Copper Steel Sea water

2– Insulators:

Materials, that don't allow the free movement of charges, such as:



Rubber Glass Oil Diamond Dry wood

Coulomb's Law

Coulomb found that the electric force between two charged objects is:

1– Proportional to the product of the charges on the objects

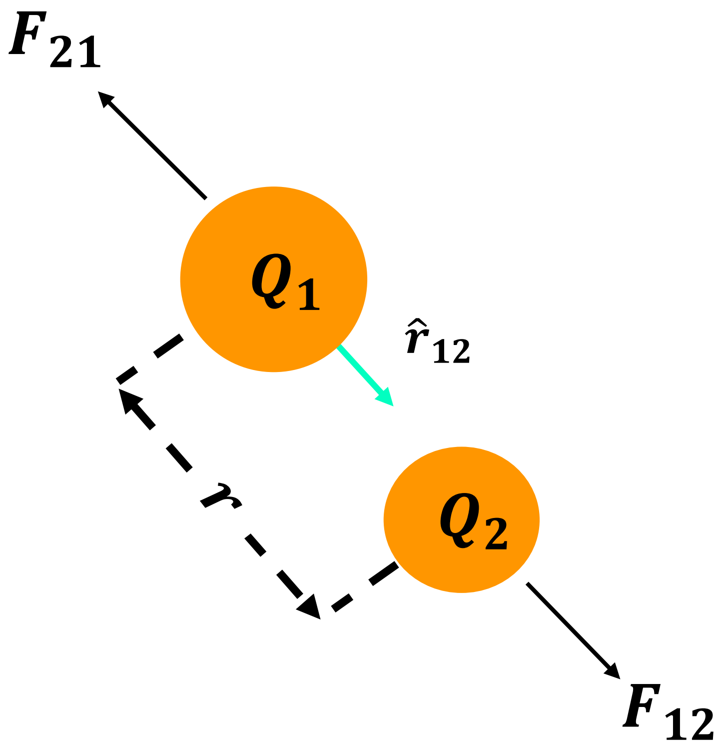
$$F_{12} \propto Q_1 Q_2 .$$

2–Inversely proportional to the separation of the objects squared

$$F_{12} \propto \frac{1}{r^2} .$$

Therefore the equation giving the force for charged particles which called Coulomb's can be written as:

$$\vec{F}_{12} = k\frac{|Q_1||Q_2|}{r^2}\hat{r}_{12}$$

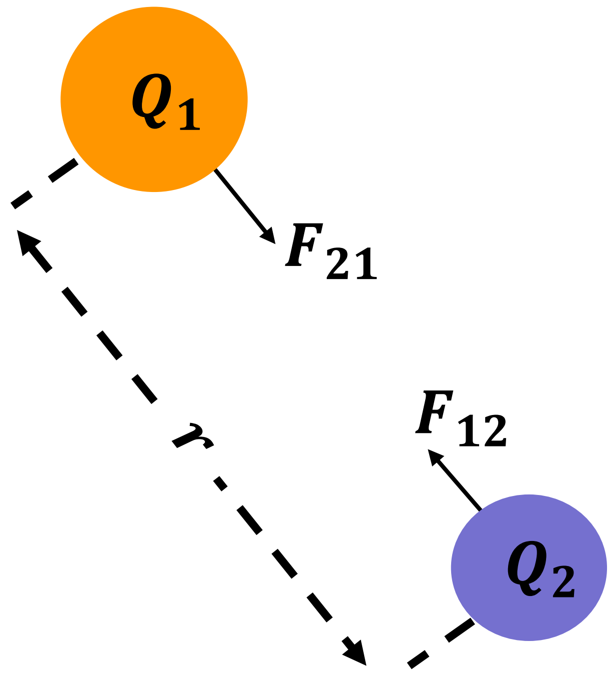


When the charges are of the same sign the force is repulsive. The force F_{21} exerted by Q_2 on Q_1 is equal in magnitude and opposite in direction to the force F_{12} exerted by Q_1 on Q_2.

Coulomb's Law

$$\vec{F}_{12} = k\frac{|Q_1||Q_2|}{r^2}\hat{r}_{12}$$

k being a proportionality constant, having a value of $8.988\ x\ 10^9\ Nm^2/C^2$



$\hat{r}_{12}$ is a unit vector pointing from object 1 to object 2

The direction of the force is either parallel or antiparallel to this unit vector depending upon the relative signs of the charges

When the charges are of opposite signs, the force is attractive.

The force F_{21} exerted by Q_2 on Q_1 is equal in magnitude and opposite in direction to the force F_{12} exerted by Q_1 on Q_2.

As with all forces, the electric force is a vector quantity, with a unit N

Checkpoint 1:

Object A has a charge of $+2\,\mu C$, and object B has a charge of $+6\,\mu C$. Which statement is true about the electric forces on the objects?

A. $\vec{F}_{AB} = -3\vec{F}_{BA}$

B. $\vec{F}_{AB} = -\vec{F}_{BA}$

C. $3\vec{F}_{AB} = -\vec{F}_{BA}$

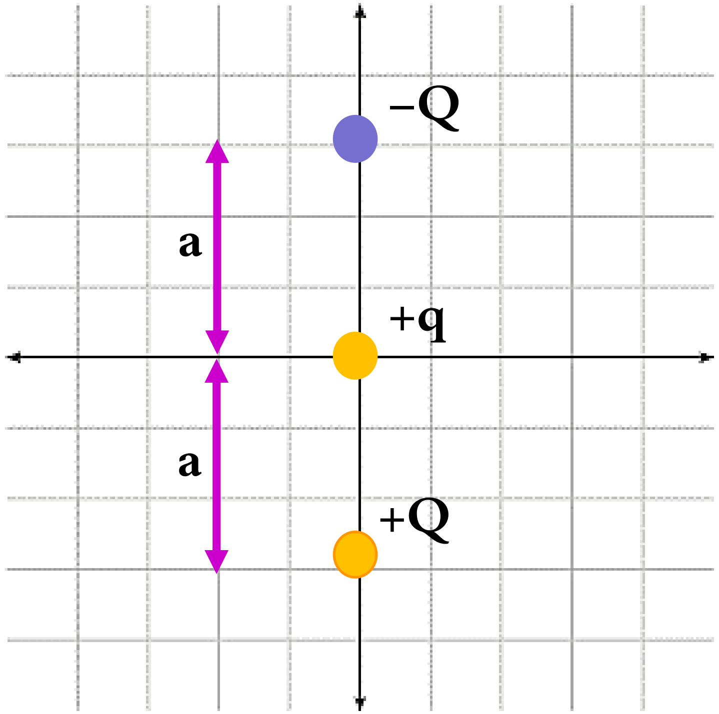
D. $\vec{F}_{AB} = \vec{F}_{BA}$

16.1 Electric Forces

Example 16.1, P 375:

A positive charge q is near a positive charge Q and a negative charge – Q

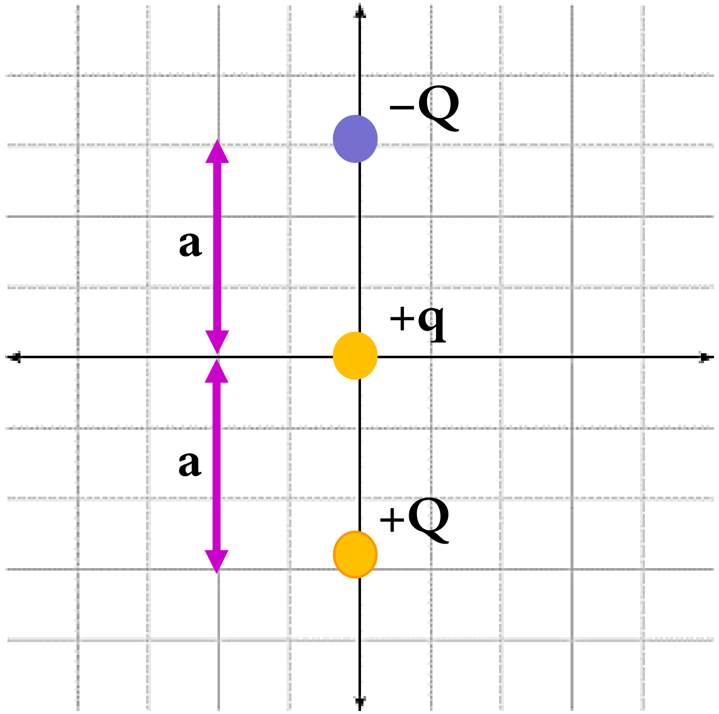
(a) Find the magnitude and direction of the force on q. (**Ans:** $\vec{F} = 2k\frac{qQ}{r^2}\hat{y}$)



Example 16.1, P 375:

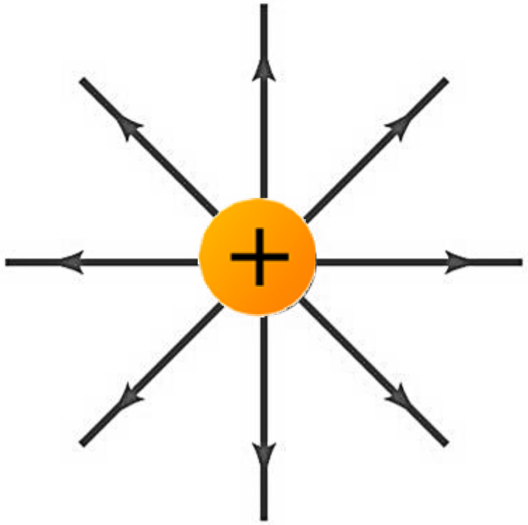
A positive charge q is near a positive charge Q and a negative charge – Q

(b) If q=10^{-6}C, Q=2×10^{-6}C, and a= 1m, find the force on q.(Ans: $\vec{F} = 3.6 \times 10^{-2} \hat{y}$)

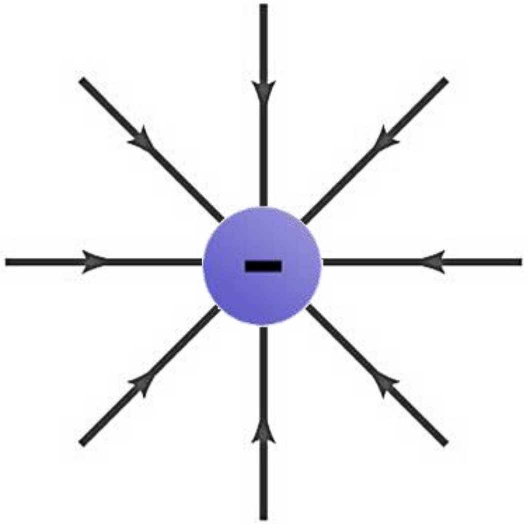


Electric Field Lines

The electric field can be represented by field lines. These lines start on a positive charge and end on a negative charge.



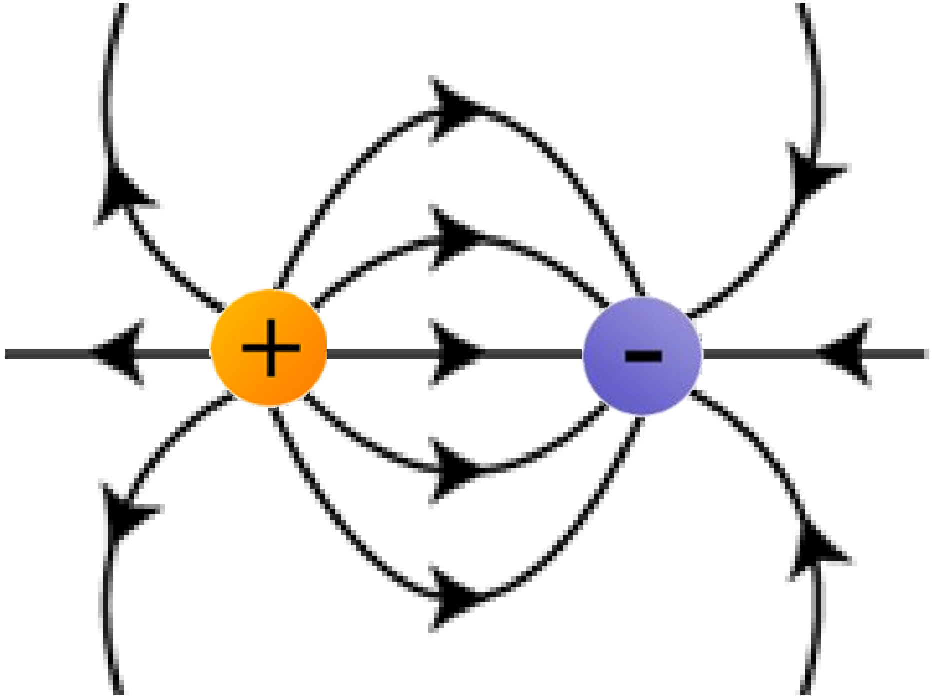
A positive charge sets up an electric field pointing away from the charge



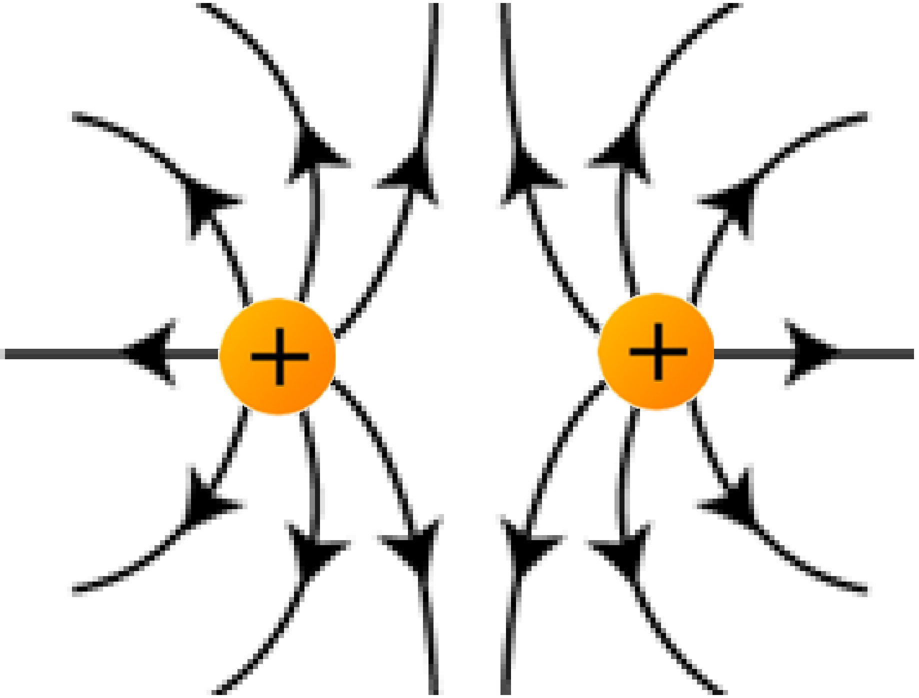
A negative charge sets up an electric field pointing towards the charge

Electric Field Lines

Electric field lines between two charges



Opposite charges

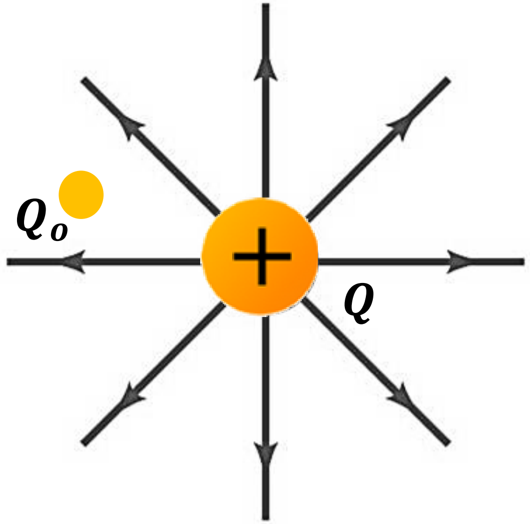


Like charges

Electric Field Lines

We define the electric field due to the source charge at the location of the test charge Q_o to be the electric force on the test charge per unit charge.

$$\vec{E} = \frac{\vec{F}}{Q_o}$$



Then the electric field of a point charge given by

$$\vec{E} = k\frac{Q}{r^2}\hat{r}$$

- Electric field is a vector quantity.
- The S.I unit of electric field is the N/C

Checkpoint 2:

A test charge of $+3\ \mu C$ is at a point P where an external electric field is directed to the right and has a magnitude of $4 \times 10^6\ N/C$. If the test charge is replaced with another test charge of $-3\ \mu C$, what happens to the external electric field at P ?

A. It is unaffected.

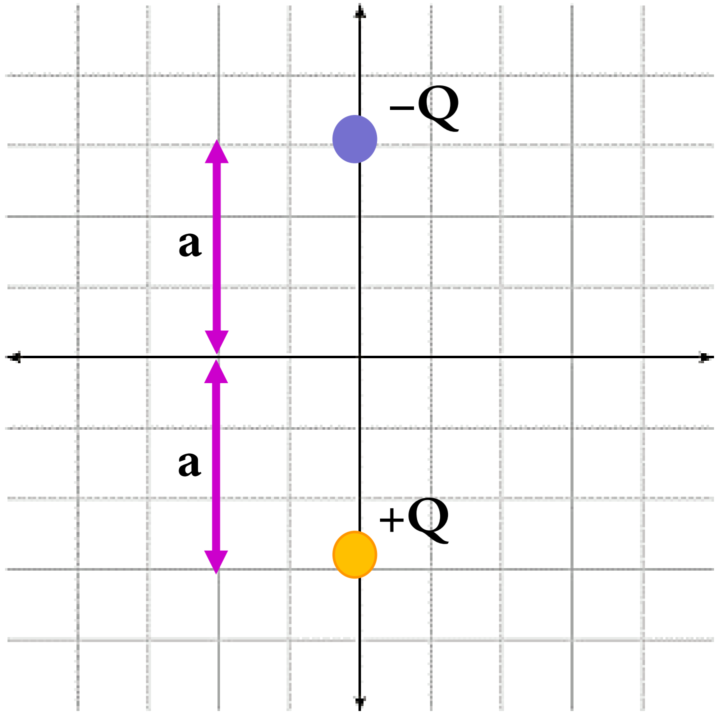
B. It reverses direction.

C. It changes in a way that cannot be determined.

Example 16.2, P 377:

The charges Q and –Q of the preceding example are shown again in Fig.

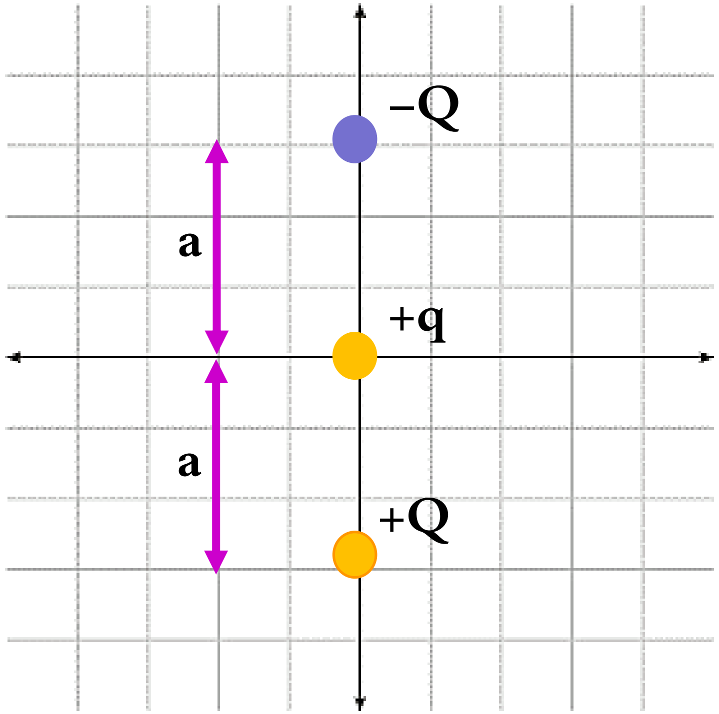
(a) Q=2 $\times 10^{-6}$C, and a= 1m, find the electric field at the origin. (Ans: $\vec{E} = 2k\frac{Q}{r^2}\hat{y}$)



Example 16.2, P 377:

The charges Q and –Q of the preceding example are shown again in Fig.

(b) Find the force on the charge q=10^{-6}C. Placed at the origin. (Ans: $\vec{F} = 3.6 \times 10^{-2}\hat{y}$)

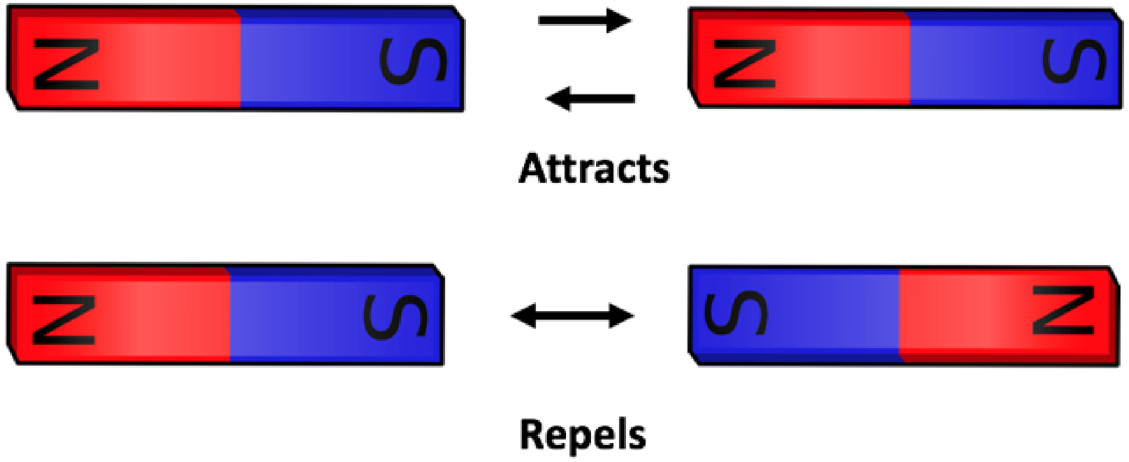


19.1 Magnetic field

The first known magnets were naturally occurring lodestones, a type of iron ore called magnetite (Fe_3O_4). People of ancient Greece and China discovered that a lodestone would always align itself in a longitudinal direction if it was allowed to rotate freely. This property of lodestones allowed for the creation of compasses two thousand years ago, which was the first known use of the magnet.

Properties of Magnets :

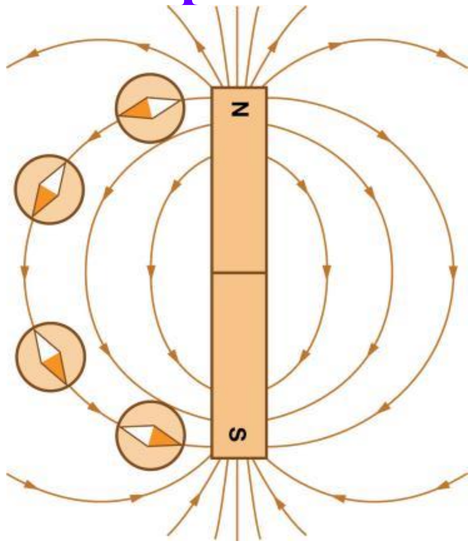
- Magnets have two ends called poles, north and south poles
- There are no single poles.
- Like poles repel, Opposite poles attract
- Magnetic poles can never be isolated
- If you break a magnet, each piece will have a north and a south pole.



19.1 Magnetic field

Magnetic fields : A region in which a magnetic force can be detected.

- Direction of a magnetic field is the direction in which the north pole of a compass needle points at that location .
- Start at N pole and end at S pole
- Magnitude of the field is higher closer to the pole
- The more lines in one area means stronger field
- At every point in space there is a magnetic force



- Magnetic Field is a vector quantity written as $\vec{B}$.
- The S.I unit of Magnetic fields is Tesla (T).