Name:_____ Date:_____ Hour:_____

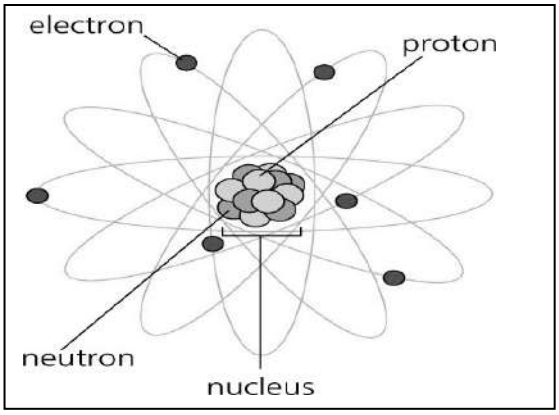
Physics Notes: Chapter 16 ELECTRIC CHARGE AND STATIC ELECTRICITY 2/24/15

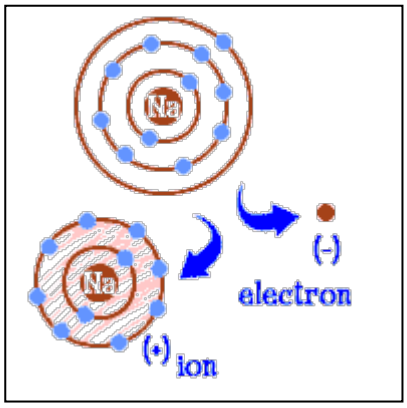
16.1 Electric Charge

Electrical energy is associated with electric charges. An electric charge is a property that causes subatomic particles such as _____ and _____ to attract or repel each other. Two types of electric charges called positive and negative. Protons have a _____ charge and _____ have a negative charge.

In an _____, the positively charged _____ is surrounded by a cloud of negatively charged _____. The number of _____ equals the number of electrons which results in a _____ atom.

If an atom has unequal numbers of protons and electrons, it will have a net _____. Since protons are trapped in the nucleus and do not move, an atom must _____ or _____ electrons in order to become charged. If it gains electrons, it becomes _____ charged. If an atom loses electrons, it becomes _____ charged.





Measurement of Charge

In 1909, Robert Millikan did an experiment in which he carefully measured tiny charges on oil droplets suspended in midair. He discovered that there was a minimum charge, or a *fundamental charge*, and that the charges on the droplets were all multiples of this minimum charge. This charge is called "e" and is the amount of charge of an electron or a proton.

The SI unit of electric charge is the _____ (C),. An electron or proton carries a very small charge, 1.602×10^{-19} C. It would take _____ electrons or protons to add up to a single Coulomb of charge.

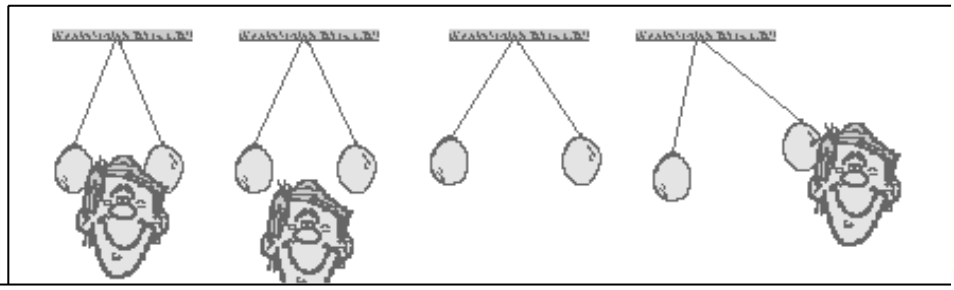
Static Electricity and Charging

Static electricity is the study of the distribution of electric charges, including how charge is _____ between objects. Static means "not moving"; electric charge moving through wires is called "current electricity". Net charges can be built up by friction, by _____, and by induction. Even though there is a charge transfer, the _____ charge is the _____ before and after the transfer. This is known as the _____ _____ _____.

Charging by Friction

An example of charging by friction would be rubbing a balloon on your head. How is a net charge produced? The latex balloon _____ electrons _____ than your hair does, so the balloon picks up electrons and becomes _____charged. Because your hair _____ electrons, it becomes _____ charged. Opposite charges _____ , so your hair and the balloon are attracted to each other.

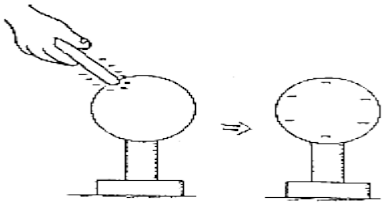
Tend to lose electrons	(+)
	human hands (dry)
	glass
	human hair
	nylon
	cat fur
	silk
	cotton
	steel
	wood
	amber
	ebonite
	plastic wrap
Tend to gain electrons	Teflon®
	(–)



Two balloons rubbed on hair will become negatively charged and will be attracted to the hair, which is positive. If the balloons are hung next to each other, they repel because they both have a negative charge.

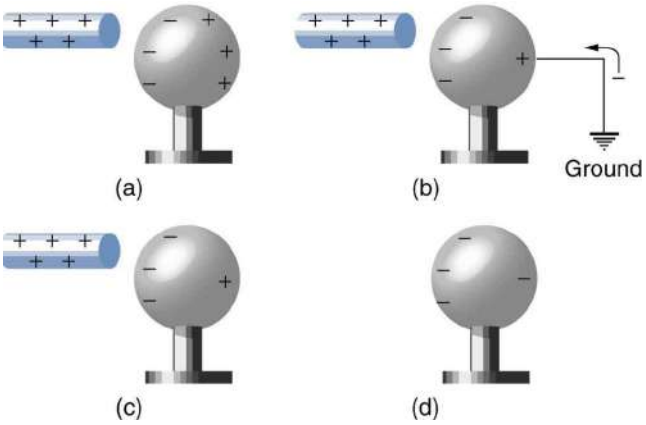
Charging by Contact

_____ something that has a charge can transfer the charge to you or from you to it. For example, if you touch a negatively charged rod to a metal ball, then then charge will distribute so the ball receives some of the negative charge (extra electrons). The rod will still be negative, but less so.



Charging by Induction

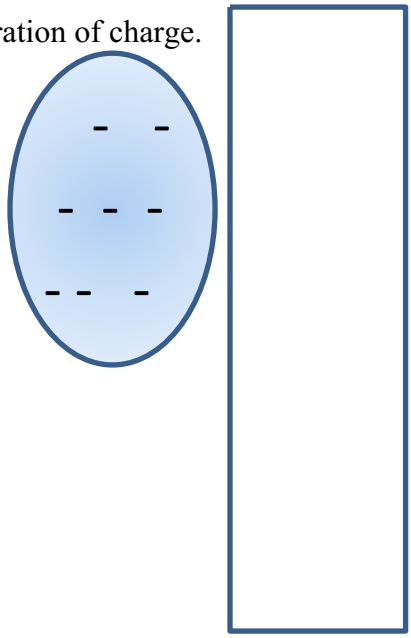
As you walk across a carpet, you pick up extra _____, and have a negative charge. If you were to reach for a metal doorknob, electrons from your hand would repel electrons in the doorknob, leaving a _____ charge on the part of the doorknob closest to your hand touched it. This transfer of charge without contact between materials is called _____.



In the diagram (a) to the right, the positively charged rod induces a separation of charge, by pulling _____ to the near side. In (b), connecting the sphere to the ground allows electrons to come up to balance the positive charge on the right. The electrons are then trapped when the sphere is disconnected from ground. Notice that through induction, the *positive* rod is able to give the sphere a *negative* charge, without ever touching the sphere!

Polarization through induction.

When a charged object is brought near a neutral object, it can induce a separation of charge. The balloon in the diagram is negatively charged, and will cause _____ in the wall to slightly to the _____.

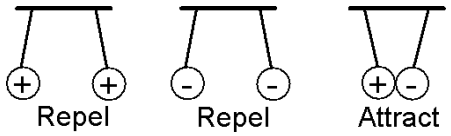


The protons will stay put because they are _____ in the _____. This results in the wall being slightly polarized, which means one side is more positive and one side is more negative.

DRAW THE CHARGES IN THE WALL.

16.2 Electric Forces

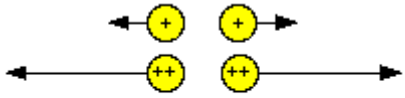
Opposite charges _____ each other. Like charges repel each other. Neutral charges are not attracted or repelled to either type of charge.



Neutral objects, though, can be polarized, with more negative charge on one side, and positive on another, so they can still be attracted to charged objects.

Electric forces can attract or repel. The electric force between two objects depends on the amount of electric _____, as well as the _____between objects. As the objects get further from each other, the force decreases. If you double the distance, the force decreases to one fourth of what it was. If you triple the distance, the force decreases to one ninth of what it was. ($2^2 = 4$, and $3^2=9$) This is similar to the gravitational force between objects. For example, a space shuttle is _____ affected by the Earth's gravitational pull in outer space compared to the surface.

Double the distance, force drops to 25%



Double each charge, force gets 4 times as strong

Gravitational forces seem strong, but electric forces inside an atom are much stronger. If you charge a couple of pennies with a thousandth of a Coulomb, and put one 1 meter above the other, the electrical force between them would be hundreds of times greater than the weight of the pennies, and would shoot the top penny up into the air.

Coulomb's Law

The force between two charges depends on the strength of the charges and r, the distance between their centers.

$$F = k\frac{q_1 q_2}{r^2} \qquad k = 8.99 \times 10^9\ N\cdot m^2/C^2$$

The force is attractive if the sign is negative (opposite charges) and repulsive if the sign is positive (like charges).

1) Calculate the electrical force between two objects which are 2.94m apart, and have charges of $+1.40 \times 10^{-4}$C, and $+3.50 \times 10^{-4}$ Coulombs. Is the force attractive or repulsive?

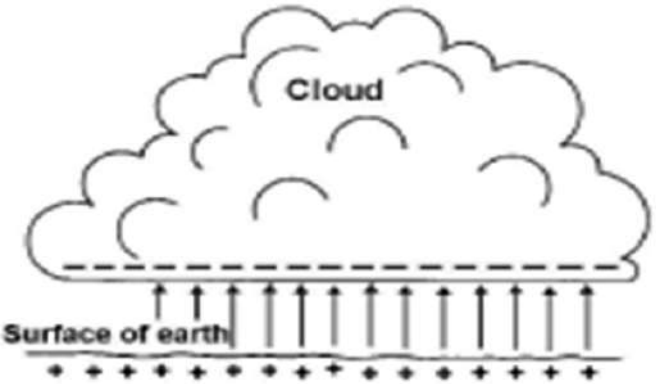
2a) Calculate the force between two objects which are 36.2 cm apart, and have charges of $+1.40 \times 10^{-3}$C, and -2.50×10^{-2} Coulombs. (Pay attention to the units!)

b) If 1N equals 0.225 pounds, how many pounds of force would be pulling these objects together?

Static Discharge

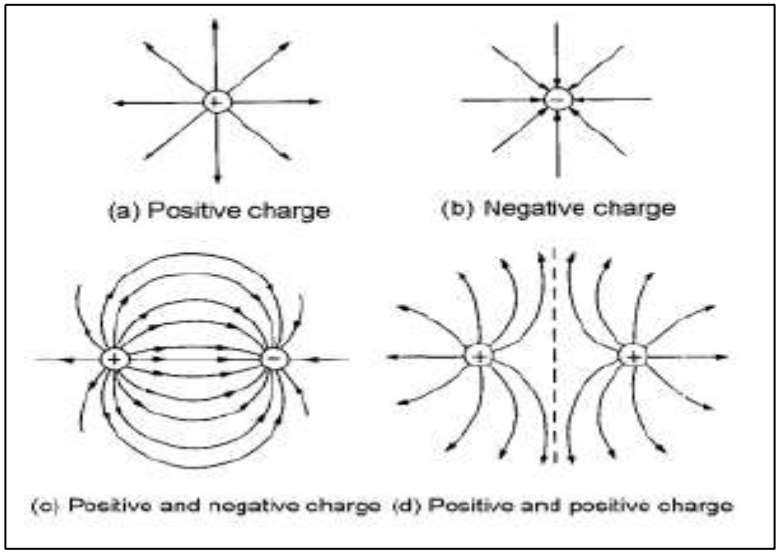
Have you ever gotten a _____ from a doorknob or other object? That spark that you feel is a static discharge. Static discharge occurs when a _____ for charges to travel suddenly forms. The _____ between you and the doorknob is the pathway. This shock can happen when you are _____ to another object and occurs less from farther away.

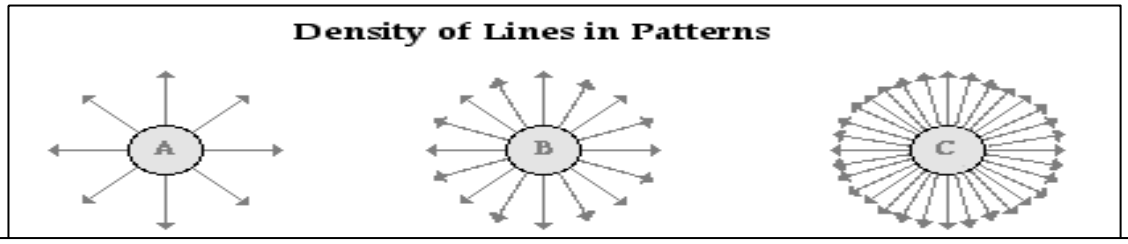
_____ is a more dramatic form of static discharge. How does this occur? Charge can build up in a storm cloud from _____ between moving air masses. _____ charge in the _____ part of the cloud induces a _____ charge in the _____ below the cloud. As the amount of charge in the cloud _____, the force of attraction between charges in the cloud and charges in the ground _____. (Remember, stronger electric forces increase attraction or repulsion between charges.) Eventually the _____becomes charged, forming a _____ for electrons to travel from the cloud to the ground.



16.3 Electric Fields

The _____ that an electric charge has on other charges in the _____ around it is the charge's _____. The _____ of an electric field depends on the _____ of charge that produces the field and the _____ from the charge. In other words, small charge produces a _____ electric field. Electric fields can be represented with lines as shown below. Notice that the electric field of a positive charge points _____ and the electric field of a negative charge points _____.





The density of electric field lines around these three objects reveals that the quantity of charge on C is greater than that on B which is greater than that on A. Also, as distance from the charge increases, the density of the lines decreases, representing a weaker field. The electric field is *inversely proportional to the square of the distance.*

The strength of a gravitational field indicates how much a certain mass will weigh. Earth's gravitational field is 9.81 Newtons per kilogram at the surface, and gets weaker as you get farther from the earth's center.

Electric fields are measured in Newtons per Coulomb, and give the force on each unit charge.

$$E = k\frac{q}{r^2} \qquad F=qE$$

1. Calculate the electric field at a distance of 1.34 m from a point charge of +1.87 mC

2. What would be the size and direction of the force on a test charge of 7.81 nC at that point?

Questions

1. When does an object have a net charge?_____
_____.

2. If an atom gains 2 electrons, what is its net charge?_____ If an atom loses 3 electrons, what is its net charge?_____

3. What is an electric field?_____
_____
_____

4. What two factors can affect the strength of an electric field?
   a)

   b)

5. In what three ways can charge be transferred?
   a)

   b)

   c)

6. Is it likely that static discharge would occur if you were 10 feet from a doorknob?_____
What must be formed in order for static discharge to occur?_____

7. What is the relationship between the strength of electric force and the amount of charge?

What is the relationship between electric force and the distance between charges?

8. When a balloon is rubbed on dry hair, what net charge does it gain?_____ What net charge does the dry hair gain?_____

Name:___KEY_____ Date:_____ Hour:_____

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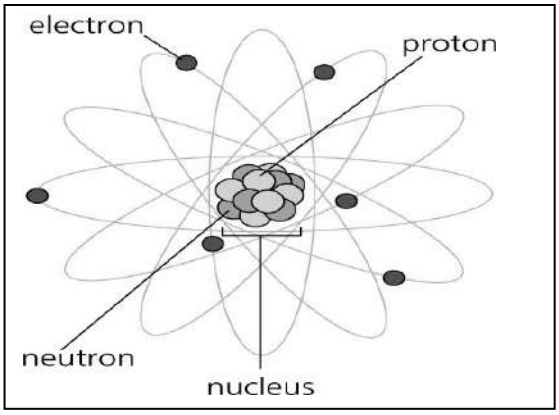
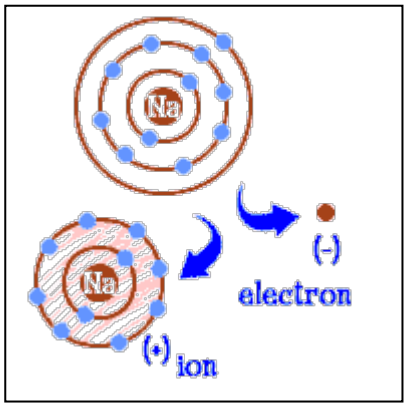
In an __atom____, the positively charged __nucleus_____ is surrounded by a cloud of negatively charged _____electrons_____. The number of _____protons__ equals the number of electrons which results in a ___neutral__ atom.

If an atom has unequal numbers of protons and electrons, it will have a net __charge___. Since protons are trapped in the nucleus and do not move, an atom must _gain___ or _lose__ electrons in order to become charged. If it gains electrons, it becomes _____negatively_____ charged. If an atom loses electrons, it becomes _____positively_____ charged.





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The SI unit of electric charge is the __Coulomb____ (C). An electron or proton carries a very small charge, 1.602 x 10^{-19} C. It would take ____6.24 x 10^{18}_____ electrons or protons to add up to a single Coulomb of charge. $\frac{1C}{1.602\ x\ 10^{-19}\frac{C}{e}} = 6.24\ x\ 10^{18}e$

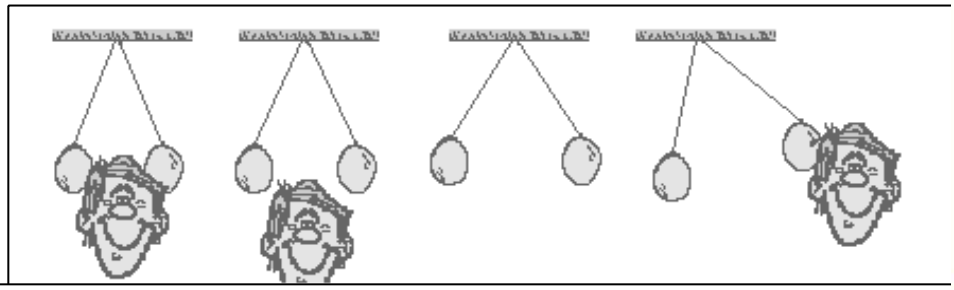
Static Electricity and Charging

Static electricity is the study of the distribution of electric charges, including how charge is _____transferred_____ between objects. Static means "not moving"; electric charge moving through wires is called "current electricity". Net charges can be built up by friction, by __contact_____, and by induction. Even though there is a charge transfer, the _____total_____ charge is the ____same___ before and after the transfer. This is known as the __conservation of charge_____ _____.

Charging by Friction

An example of charging by friction would be rubbing a balloon on your head. How is a net charge produced? The latex balloon __attracts___ electrons __more___ than your hair does, so the balloon picks up electrons and becomes _____negatively____charged. Because your hair __loses___ electrons, it becomes ___positively___ charged. Opposite charges __attract_____ , so your hair and the balloon are attracted to each other.

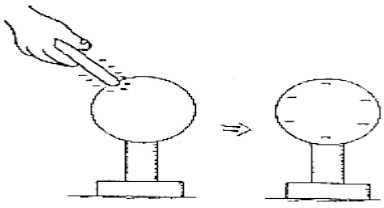
Tend to lose electrons	(+)
	human hands (dry)
	glass
	human hair
	nylon
	cat fur
	silk
	cotton
	steel
	wood
	amber
	ebonite
	plastic wrap
Tend to gain electrons	Teflon®
	(–)



Two balloons rubbed on hair will become negatively charged and will be attracted to the hair, which is positive. If the balloons are hung next to each other, they repel because they both have a negative charge.

Charging by Contact

___Touching_____ something that has a charge can transfer the charge to you or from you to it. For example, if you touch a negatively charged rod to a metal ball, then then charge will distribute so the ball receives some of the negative charge (extra electrons). The rod will still be negative, but less so.



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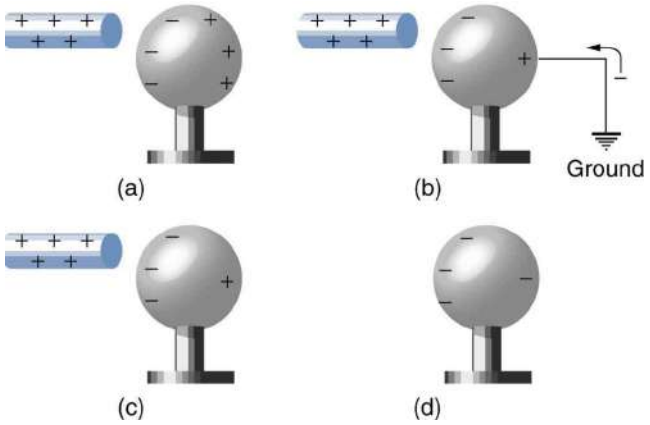
As you walk across a carpet, you pick up extra ____electrons_____, and have a negative charge. If you were to reach for a metal doorknob, electrons from your hand would repel electrons in the doorknob, leaving a _____positive____ charge on the part of the doorknob closest to your hand touched it. This transfer of charge without contact between materials is called ___charging by induction_____. In the diagram (a) to the right, the positively charged rod induces a separation of charge, by pulling _electrons____ to the near side. In (b), connecting the sphere to the ground allows electrons to come up to balance the positive charge on the right. The electrons are then trapped when the sphere is disconnected from ground. Notice that through induction, the *positive* rod is able to give the sphere a *negative* charge, without ever touching the sphere!



Polarization through induction.

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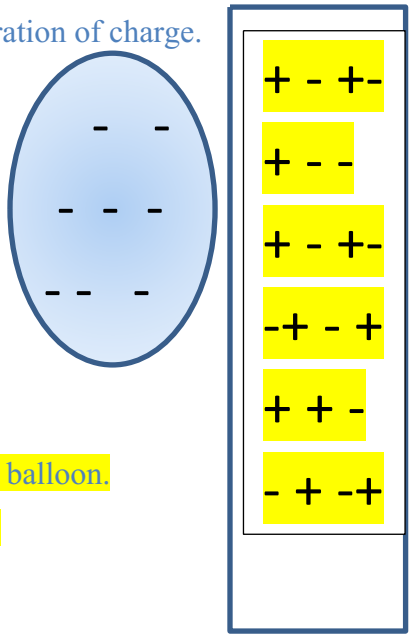


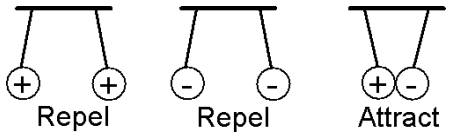
DRAW THE CHARGES IN THE WALL.

More positive close to the balloon, more negative away from balloon.

Total number of positives and negatives are EQUAL!

16.2 Electric Forces

Opposite charges __attract__ each other. Like charges repel each other. Neutral charges are not attracted or repelled to either type of charge.



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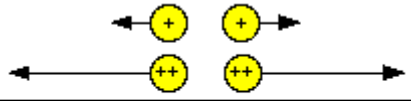
Double the distance, force drops to 25%



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$$F = k\frac{q_1 q_2}{r^2} \qquad k = 8.99 \times 10^9\ N\cdot m^2/C^2$$

The force is attractive if the sign of the force is negative (opposite charges) and repulsive if the sign is positive (like charges).

1) Calculate the electrical force between two objects which are 2.94m apart, and have charges of $+1.40 \times 10^{-4}$C, and $+3.50 \times 10^{-4}$ Coulombs. Is the force attractive or repulsive?

Force = 51.0 Newtons, repulsive (like charges)

2a) Calculate the force between two objects which are 36.2 cm apart, and have charges of $+1.40 \times 10^{-3}$C, and -2.50×10^{-2} Coulombs. (Pay attention to the units!)

$F = -2.40 \times 10^6$ N (attractive)

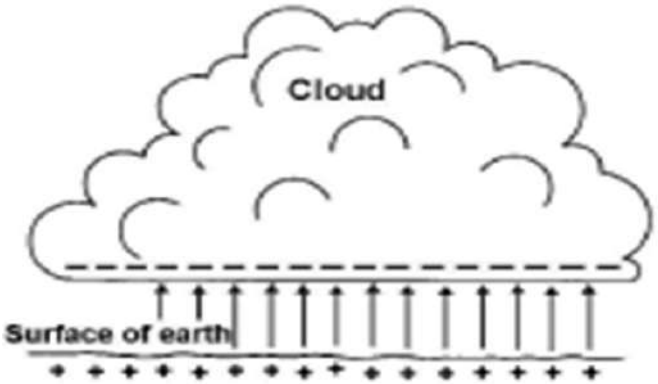
b) If 1N equals 0.225 pounds, how many pounds of force would be pulling these objects together?

F = 540,000 pounds!

Static Discharge

Have you ever gotten a __shock_____ from a doorknob or other object? That spark that you feel is a static discharge. Static discharge occurs when a __pathway_____ for charges to travel suddenly forms. The _spark_ between you and the doorknob is the pathway. This spark can happen when you are ___close____ to another object and but is less likely when you are farther away.

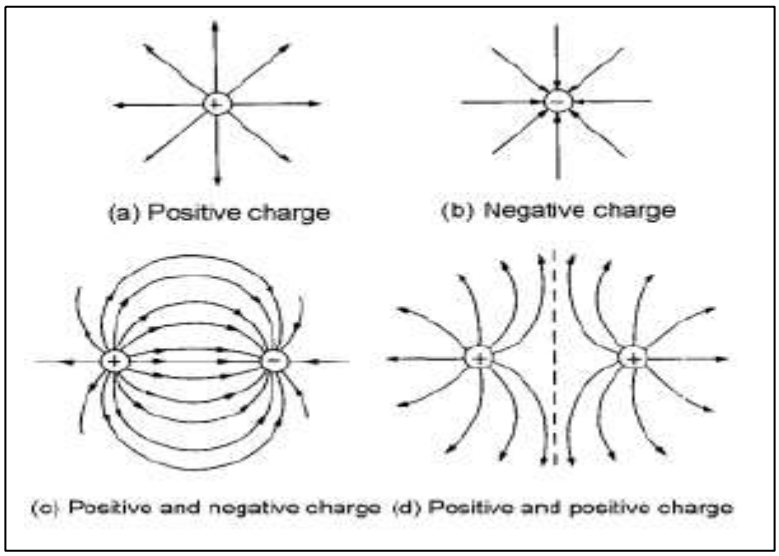
___Lightning_____ is a more dramatic form of static discharge. How does this occur? Charge can build up in a storm cloud from ___friction___ between moving air masses. _____Negative___ charge in the ____lower___ part of the cloud induces a ___positive_____ charge in the __ground_____ below the cloud. As the amount of charge in the cloud ___increase__, the force of attraction between charges in the cloud and charges in the ground ___increase_____. (Remember, stronger electric forces increase attraction or repulsion between charges.) Eventually the __air___ becomes ionized, forming a ____pathway___ for electrons to travel from the cloud to the ground.

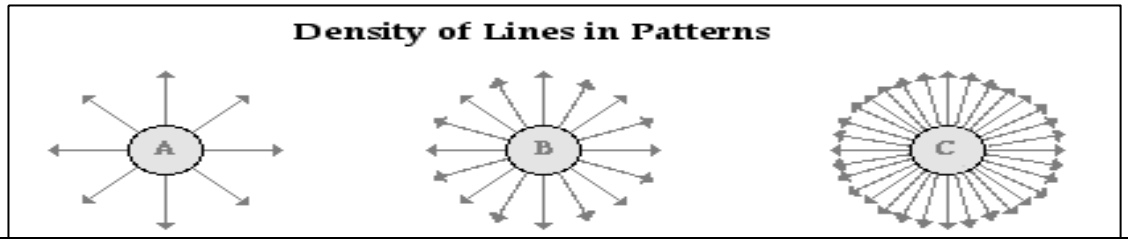


16.3 Electric Fields

The strength of a gravitational field indicates how much a certain mass will weigh. Earth's gravitational field is 9.81 Newtons per kilogram at the surface, and gets weaker as you get farther from the earth's center. A bigger mass is affected more by the gravitational field, and has a bigger force (weight).

The __effect__ that an electric charge has on other charges in the __space_____ around it is the charge's __electric field_____. The _____strength____ of an electric field depends on the ____amount____ of charge that produces the field and the ____distance_____ from the charge. In other words, small charge produces a __small_____ electric field. Electric fields can be represented with lines as shown below. Notice that the electric field of a positive charge points ____outward_____ and the electric field of a negative charge points ____inward_____. The lines show the force on a proton!





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1. Calculate the electric field at a distance of 1.34 m from a point charge of +1.87 mC

2. What would be the size and direction of the force on a test charge of 7.81 nC at that point?

Questions

1. When does an object have a net charge?_____
_____.

2. If an atom gains 2 electrons, what is its net charge?_____ If an atom loses 3 electrons, what is its net charge?_____

3. What is an electric field?_____
_____
_____

4. What two factors can affect the strength of an electric field?
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   b)

5. In what three ways can charge be transferred?
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6. Is it likely that static discharge would occur if you were 10 feet from a doorknob?_____
What must be formed in order for static discharge to occur?_____

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What is the relationship between electric force and the distance between charges?

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