Name:______________________________

Electrostatics Test Review

7

Understanding the Electrostatic Equations

The electrostatic equation chart is capable of solving almost every electrostatic problem, if you understand it well.

q_1 causes E at a point a distance r from q_1. q_2 is a 2nd charge at point P.

	Potential		Potential Energy
SCALARS →	$V = k_c \frac{q_1}{r}$ $\Delta V = -E\Delta d$ *(gh [J/kg])*	V (J/C) | J (Nm)	$PE = k_c \frac{q_1 q_2}{r}$ $\Delta PE = -qE\Delta d$ *(mgh [J])*
VECTORS →	*(g [N/kg])* $E = k_c \frac{\lvert q_1 \rvert}{r^2}$ $= \frac{V}{\Delta d}$ *Field*	N/C (V/m) | N	*(mg [N])* $F_e = k_c \frac{\lvert q_1 q_2 \rvert}{r^2}$ $= qE$ *Force*

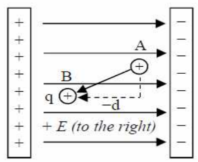
× r (× d) ↕ ÷ r (÷ d)

For multiple charges E is different for each charge, so you must x or ÷ by r for each individual charge (ie: $PE_{total} \neq F_{net}r$).

÷ q_2 ⟷ × q_2

q_2 is independent of the charges which cause E. So, for multiple charges you can x or ÷ F_{net} by q_2.

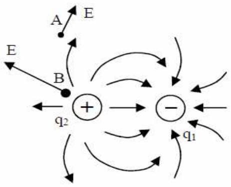
Non-k_c Equations



A parallel plate capacitor with two oppositely charged plates is an excellent example of a uniform electric field. E is constant in strength and direction everywhere between the plates and away from the edges. So the non-k_C equations should be used.

Notes: Since E is uniform, q will have the same F everywhere between the plates. d is negative since it is moved to the left. Q gains PE because a +q has moved closer to the + plate. When calculating $\Delta PE_{A \text{ to } B}$, d is the component parallel to E.

k_c Equations



Around point charges there is a non-uniform electric field. Notice that E has different strength and direction at points A and B. Therefore, you will have to use the k_C equations.

Calculating V at point A is simple, since V is a scalar:

$$V = k_c \frac{q_1}{r_1} + k_c \frac{q_2}{r_2}$$ where r_1 is the distance to q_1, etc.

Calculating F or PE would only be possible, of course, if there was a third charge at point A. Then:

$$F_{1on3} = k_c \frac{q_1 q_3}{r_1^2} \quad F_{2on3} = k_c \frac{q_2 q_3}{r_2^2}$$ and vector addition would be necessary to find F_{net}.

Fill in the following blanks with the words **electrons** or **protons**.

__________________ are negatively charged and __________________ are positively charged. The __________________ reside in the nucleus of atoms and are tightly bound; they will never leave an atom as a result of electrostatic procedures. On the other hand, __________________ are located outside the nucleus and are easily removed from or added to atoms. As an object begins to gain or lose __________________ from its atoms, it becomes positively or negatively charged. A negatively charged object has more __________________ than __________________. A positively charged object has more __________________ than __________________.

Use the triboelectric series to answer the following questions:

When you pull a **cotton** sweater off your **skin**, electrons are transferred from the ________________ (cotton, skin) to the ________________ (cotton, skin). As a result, your body acquires a __________ (+ , -) charge and the cotton sweater acquires a __________ (+ , -) charge.

When you rub a **glass** rod with a **silk** cloth, electrons are transferred from the ________________ (glass, silk)to the ________________ (glass, silk). As a result, the glass rod acquires a __________ (+ , -) charge and the silk cloth acquires a __________ (+ , -) charge.

Suppose you rub a rubber rod with a silk cloth and a second rubber rod with a wool sweater. The silk cloth will acquire a _________ (+ , -) charge; the wool sweater will acquire a _________ (+ , -) charge. The sweater and the cloth will then be observed to ____________________ (attract, repel, not interact with) each other.

Suppose you rub a glass rod with a silk cloth and a second glass rod with rabbit fur. The silk cloth will acquire a _________ (+ , -) charge; the rabbit fur will acquire a _________ (+ , -) charge. The rabbit fur and the silk cloth will then be observed to ____________________ (attract, repel, not interact with) each other.

A Gravity Analogy

Gravity is the most commonly know field force and provides the easiest way to understand the electrostatic quantities. The equations are then easy to remember: g = E; m = q; h = d.

E is like g

The acceleration due to gravity, "g", is also known as the gravitational field. g is caused by mass (the earth). E is caused by charges, q.

Near the earth g is constant: ~9.8 m/s², like E is constant between a parallel plate capacitor.

Far from the earth, g is not constant, like a point charge.

F_e is like mg

F_W = mg, which is the weight due to a mass put inside a constant g. Likewise, q_2 feels a force from the E created by q_1 (or the capacitor), so F_e = -qE.

Both m's have the same force of weight when g is constant. F_e is position independent, too, if E is constant (lines are ||).

PE is like mgh

PE = mgh = -qEΔd. Remember that PE equals the work to move the object to that place and PE equals the amount of kinetic energy the object will have if released.

At B, F_e= E = 0, but PE ≠ 0 because it would take W to get it there. C doubles the PE given by A, since if released B feels 2 + q's pushing it away.

V (-Ed) is like gh

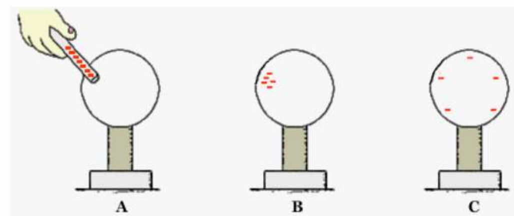
Think of gh as the gravitational potential for energy at a point (in J/kg). The gravitational potential for energy could be increased by increasing h or g (on Jupiter, for instance).

The 4 kg has more PE than the 2 kg, but they have the same potential (gh). The 2 kg has more potential than the 5 kg.

		Constant Field— (Field lines are parallel, like near the earth or near a charged flat plate)		Point Sources (2 particles) Field lines radiate outward	
		Gravitational (caused by mass)	Electric (caused by charge)	Gravitational (caused by mass)	Electric (caused by charge)
Vectors	Force (F)	$= mg$ (in N)	$= qE$ (in N)	$F_g = G\frac{m_1 m_2}{r^2}$ (in N)	$F_e = k_c \frac{q_1 q_2}{r^2}$ (in N)
Vectors	Field (potential for a force)	$= g$ (in N/kg)	$= E = \frac{V}{\Delta d}$ (in N/C)	$= G\frac{q_1}{r^2}$ (in N/kg)	$E = k_c \frac{q_1}{r^2}$ (in N/C)
Scalars	Potential Energy (PE or U)	$= mg\Delta h$ (in J) h=0 on ground	$\Delta PE = -qE\Delta d$ (in J)	$PE = G\frac{m_1 m_2}{r}$ (in J)	$PE = k_c \frac{q_1 q_2}{r}$ (in J)
Scalars	Potential (for energy) or Voltage	$= g\Delta h$ (in J/kg)	$\Delta V = -E\Delta d$ (in J/C)	$= G\frac{m_1}{r}$ (in J/kg)	$V = k_c \frac{q_1}{r}$ (in J/C)

Triboelectric Series
Celluloid
Sulfur
Rubber
Copper, Brass
Amber
Wood
Cotton
Human Skin
Silk
Cat Fur
Wool
Glass
Rabbit Fur

Consider the conduction charging process described below:



A: A teacher holds a negatively charged metal bar by its insulating handle and touches it to a metal sphere (attached to an insulating stand).
B: The teacher pulls the metal bar away and the metal sphere acquires a charge.
C: The excess negative charge spreads uniformly about the surface of the metal sphere.

3. Diagram A is the charging step. How does the sphere become charged?
 a. Electrons move from the insulating stand into the sphere.
 b. Electrons move from the charged metal bar into the sphere.
 c. Protons move from the sphere into the negatively charged bar.

4. When the metal bar is pulled away in Diagram B, the metal bar is _____.
 a. positively charged b. electrically neutral
 c. still negatively charged, but has fewer excess electrons than it previously did.

5. Diagram C shows the excess negative charge distributed differently than it is in Diagram B. Explain why the excess negative charge would distribute itself as it does in Diagram C.

Alteration in both the Quantity of Charge and the Distance

_________ Two charged objects have a repulsive force of .080 N. If the charge of one of the objects is doubled, and the distance separating the objects is doubled, then what is the new force?

_________ Two charged objects have a repulsive force of .080 N. If the charge of both of the objects is doubled and the distance separating the objects is doubled, then what is the new force?

_________ Two charged objects have an attractive force of .080 N. If the charge of one of the objects is increased by a factor of four, and the distance separating the objects is doubled, then what is the new force?

_________ Two charged objects have an attractive force of .080 N. If the charge of one of the objects is tripled and the distance separating the objects is tripled, then what is the new force?

A balloon with a charge of 4.0×10^{-5} C is held a distance of 0.10 m from a second balloon having the same charge. Calculate the magnitude of the repulsive force. **PSYW**

Calculate the electrical force (in Newtons) exerted between a 22-gram balloon with a charge of -2.6 μC and a wool sweater with a charge of +3.8 μC; the separation distance is 0.75 m. (NOTE: a μC or microCoulomb is a unit of charge; $10^6\ \mu C = 1$ C) **PSYW**

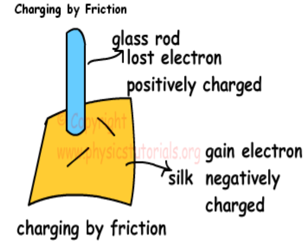
Use your understanding of electric force and electric field to fill in the following table.

	Charge creating the E field (C)	Charge used to test the E field (C)	Force experienced by test charge (N)	Electric Field Intensity (N/C)	Distance (fictional units)
a.	4.0×10^{-4} C	1.0×10^{-6} C	0.20 N		**d**
b.	4.0×10^{-4} C	2.0×10^{-6} C		2.0×10^{5} N/C	**d**
c.	8.0×10^{-4} C	1.0×10^{-6} C	0.40 N		**d**
d.	8.0×10^{-4} C	2.0×10^{-6} C		4.0×10^{5} N/C	**d**
e.	8.0×10^{-4} C		0.60 N		**d**
f.	8.0×10^{-4} C	1.0×10^{-6} C		1.0×10^{5} N/C	**2d**
g.	8.0×10^{-4} C	2.0×10^{-6} C			**2d**
h.	8.0×10^{-4} C		0.10 N		**2d**
i.	4.0×10^{-4} C			8.0×10^{5} N/C	**0.5 d**
j.	4.0×10^{-4} C				**0.5 d**

Types of Charging

Charging means gaining or losing electron. Matters can be charged with three ways, charging by friction, charging by contact and charging by induction.

Charging by Friction



When you rub one material to another, they are charged by friction. Material losing electron is positively charged and material gaining electron is negatively charged. Amount of gained and lost electron is equal to each other.

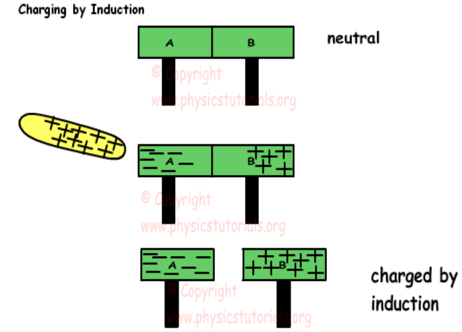
Charging by Contact

There are equal numbers of electrons and protons in a neutral matter. If something changes this balance we can say it is charged.

1. When charged object touches to a neutral object, they both have same charge.

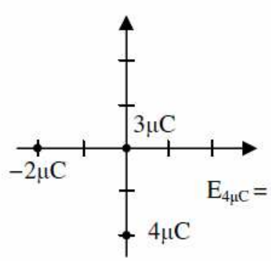
2. When two charged matter touch each other, total charge of the system is conserved and they share the total charge according to their capacities. If they have same amount of different charges, when we touch one another they become neutral. If the amount of charges is different then, after flow of charge they are both negatively or positively charged. Having opposite charges after contact is impossible.

Charging by Induction



A and B conductors are neutral at the beginning. When we put a positively charged plate near them, it attracts the electrons in the conductors. Electrons move to the left part and protons stays. Thus, when we separate plates A and B they are charged by induction, A is negatively charged and B is negatively charged. Be careful, there is no contact; they are charged only by induction.

Two fixed charges are placed on the x-y axis, as shown on the diagram. A third charge of 3μC is moved from infinity to the origin. Each line is 1 cm.



$E_{-2\mu C} =$

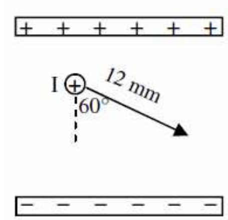
$E_{4\mu C} =$

A. Calculate the electric field due to each charge at the origin.

B. Calculate the net electric field at the origin, both magnitude and direction.

C. Calculate the net force on the 3μC charge.

5. A +3C charge is moved in a uniform electric field that has a field strength of 500 N/C.



A. Calculate the distance it moves parallel to the field.

B. Which direction does the electric field point?

C. Calculate the ΔPE of the charge.

D. Since electric field is also in V/m and the plates are separated by 18mm, calculate the voltage of the plates.

E. If this is a 6μF capacitor, how much charge is held on it?