Activity 2.5 - Physics 30 – Mr. Immel
Electrostatics and Coulomb's Law
Pre-Test Assignment - Due Date: ________________

Read all the parts of your assignment carefully and record your answers in the appropriate place.

1. Name and briefly describe three methods that could be used to electrostatically charge an object.

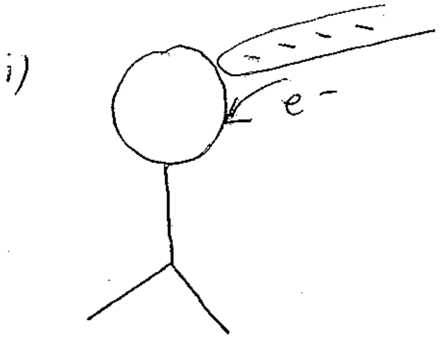
1) friction - involves rubbing 2 dissimilar insulators together
eg) rubber + fur.

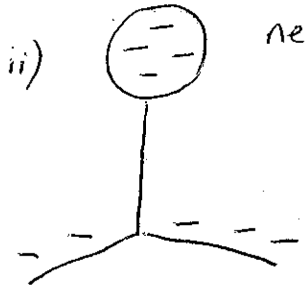
2) induction - involves polarizing (seperating charges) on a substance by placing a charged object near it.

3) conduction - involves touching a charged object to another charged object or to another uncharged object.

2. A negatively charged rubber rod is momentarily touched to the knob of a neutral electroscope and then removed. DRAW DIAGRAMS TO AID YOUR ANSWER.

a. What is the charge on the knob?





negative

b. What is the charge on the leaves?

negative

c. What is this method of charging called?

charging by conduction (contact)

d. What happens to the leaves? the leaves diverge (repel) because of similar "–" charges.

e. How could you prove that the electroscope has a negative charge?

Bring another "–" rod close. If the leaves spread apart more, they were negatively charged.

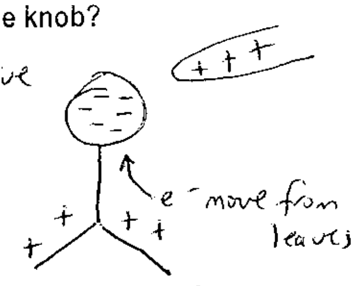
leaves diverge more.

3. A positively charged glass rod is held near the knob of a neutral electroscope. DRAW DIAGRAMS TO AID YOUR ANSWER.

note: only e⁻ move
∴ polarization has occured but the electroscope is still neutral.

a. What is the charge on the knob?

negative



b. What is the charge on the leaves?

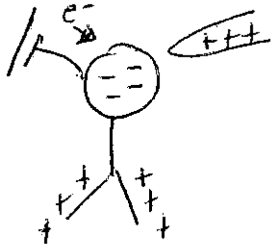
positive

c. What is this method of charging called?

charging by induction.

d. Explain what happens to the leaves. the leaves diverge because they are positively charged because the e^- have been attracted to the knob.

e. Explain what happens if the knob is now grounded.

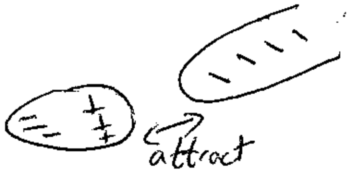


The ground allow e^- to enter the electroscope to neutralize the + leaves.

f. Explain what happens to the electroscope if the ground is removed and then the glass rod is removed.

Free e^- redistribute and the electroscope has a net negative charge. The leaves diverge because of repulsion of excess negative charges.

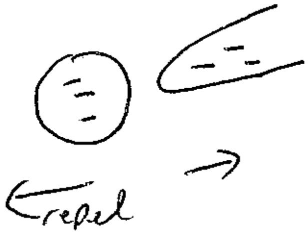
4. a. It is observed that a charged rubber rod will attract a small piece of neutral paper. Explain how this occurs.



The e^- on the paper polarize (separate) so that one side is negative and the other is positive. The paper is charged by induction.

b. Eventually the rubber rod will "spit" the piece of paper away and will not attract it anymore. Explain why this occurs.

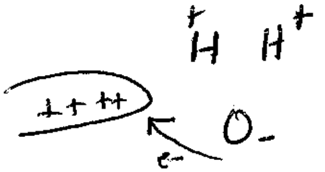
Once the rod and the paper touch (conduction), the e^- move from more (rod) to less (paper). until they are balanced. Since both the rod and paper are negative, they will repel.



5. Why is it possible for a charged rubber rod to hold its charge better on a dry day than on a humid day?

On a humid day "polar" water molecules will absorb charges (e⁻) away from the charged rubber rod.

"charge theft"



7. Imagine that you have an object with an unknown electrostatic charge. If you are also given a rubber rod, fur, and a neutral electroscope, describe how you could find the type of charge on the object.

① rub the rubber with fur - the rubber will gain a negative charge by friction.

② touch the unknown charge to the electroscope ... the leaves will diverge. (note: the electroscope and unknown charge will be the same by conduction)

③ bring the rubber rod ~~near~~ the electroscope; if the leaves diverge, the object has a negative charge, if the leaves come together, the object is positive

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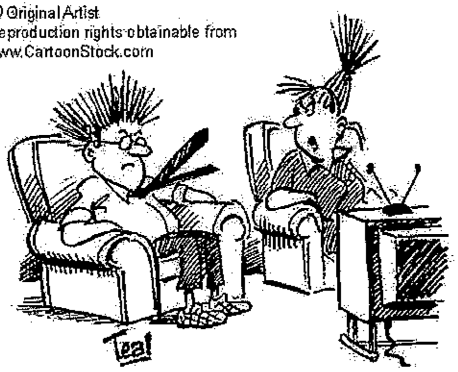
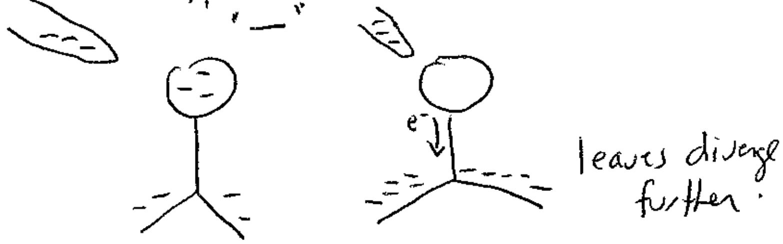


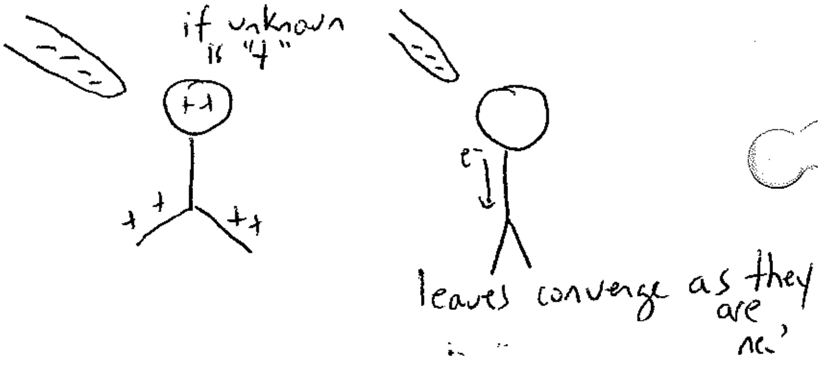
"I told you nylon carpets were a mistake."

diagrams

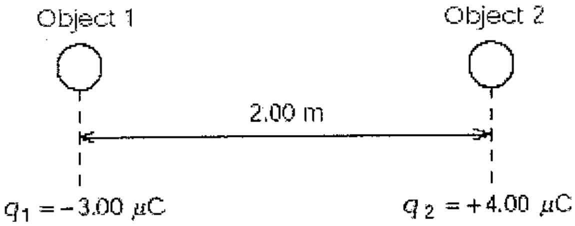
if unknown is "—"



if unknown is "+"



8. The following diagram shows two identical metal objects separated by a distance of 2.00 m.

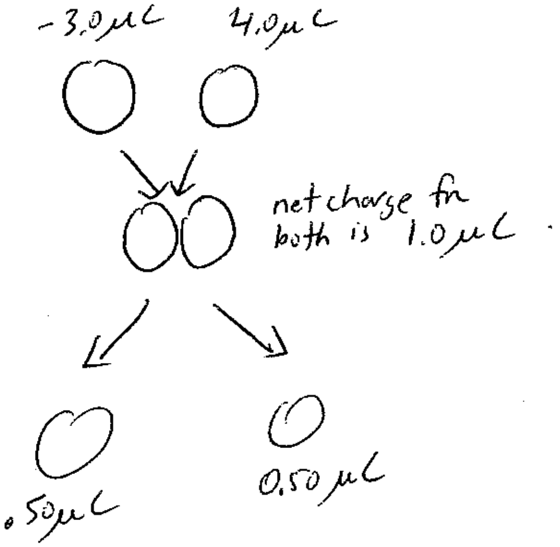


a. Calculate the magnitude of the electrostatic force between the two charges. Coulombs Law

$$F_{el} = k\frac{q_1 q_2}{R^2} = \frac{8.99\times10^9 \cdot (3\times10^{-6})(4\times10^{-6})}{(2.00)^2}$$

$$= 2.70\times10^{-2} N$$

b. Imagine that the two identical objects are brought to the middle, touched to each other, and then returned to their original positions. Determine the new charge on each object. Concisely explain your answer. Use your answer to calculate the new electrostatic force between the objects. Hint: Draw a diagram!

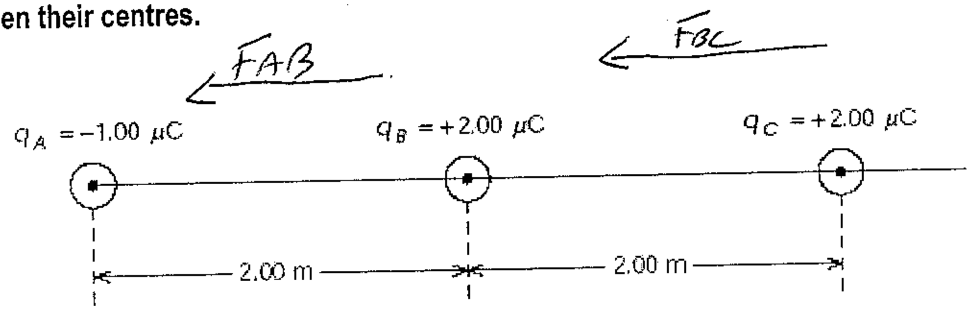


$$F_{el} = k\frac{q_1 q_2}{R^2}$$

$$F_{el} = \frac{8.99\times10^9 (.5\times10^{-6})^2}{(2.00_m)^2}$$

$$= 5.6\times10^{-4} N$$

9. **The following diagram shows three charged objects, A, B, and C, and the distances between their centres.**



Calculate the magnitude and direction of the net electrostatic force acting on object B.

$F_{AB} = \frac{kq_1q_2}{r^2}$

$F_{AB} = \frac{(8.99\times10^9)(1\times10^{-6})(2\times10^{-6})}{2^2}$

$F_{AB} = 4.495\times10^{-3} N$

$F_{BC} = \frac{kq_1q_2}{r^2}$

$= \frac{(8.99\times10^9)(2\times10^{-6})^2}{2^2}$

$F_{BC} = 8.99\times10^{-3} N$

$F_{net} = BC + AB$

$= 1.35\times10^{-3} N$ [W]

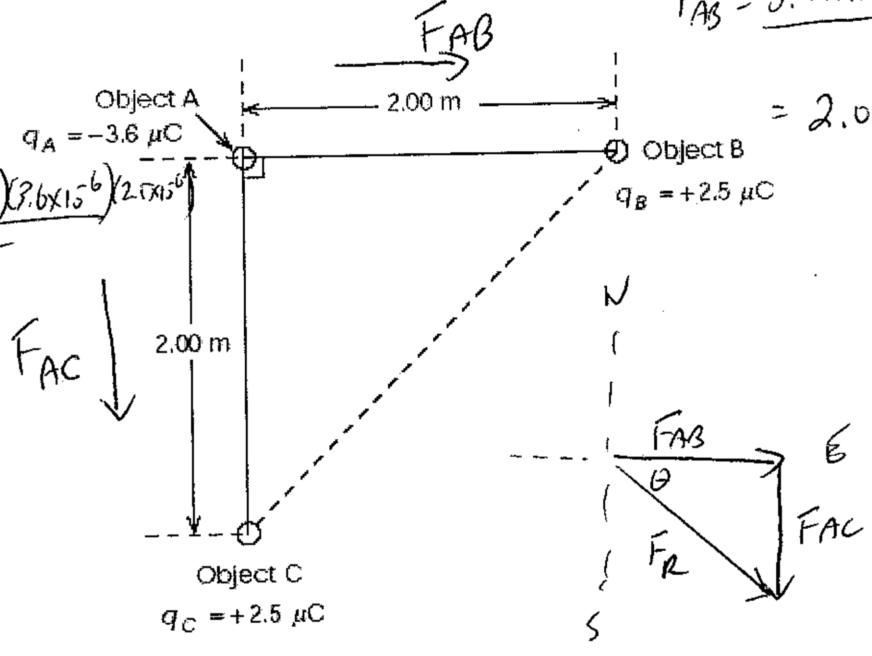
10. **The following diagram shows three charged objects, A, B, and C, arranged at the corners of a right angle triangle.**

$F_{AB} = \frac{8.99\times10^9(3.6\times10^{-6})(2.5\times10^{-6})}{(2.00)^2}$

$= 2.0..\times10^{-2} N$

$F_{AC} = \frac{(8.99\times10^9)(3.6\times10^{-6})(2.5\times10^{-6})}{2^2}$

$= 2.0\times10^{-2} N$



$\tan\theta = \frac{2.0\times10^{-2}}{2.0\times10^{-2}}$

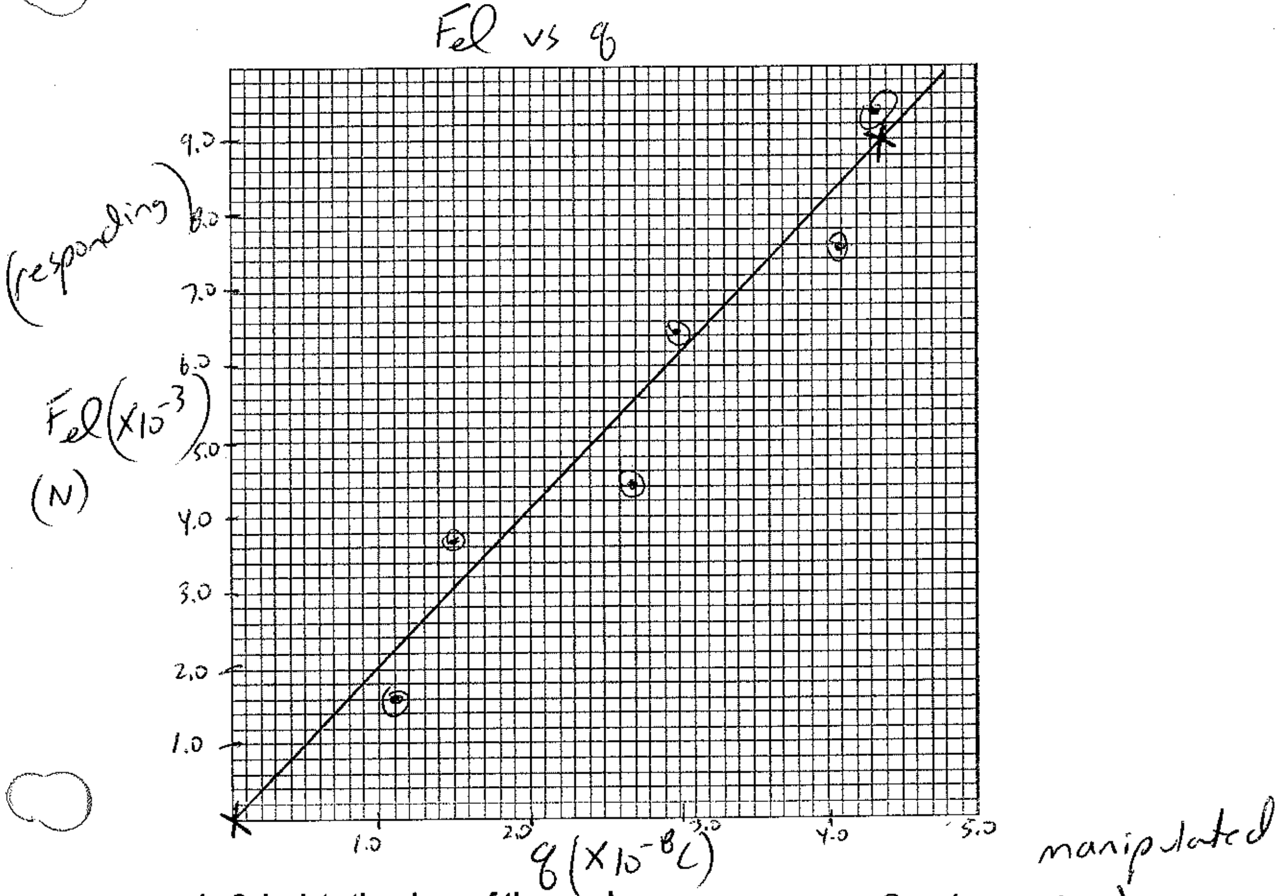
[45° SE]

Calculate the magnitude and direction of the resultant electrostatic force acting on object A.

$F_R = \sqrt{(2.0\times10^{-2})^2 + (2.0\times10^{-2})^2}$

$F_R = 2.9\times10^{-2} N$

a. Produce a graph of the data and draw the best-fit straight line.



b. Calculate the slope of the graph

note points must be on line of best fit (marked x)

$$slope = \frac{rise}{run} = \frac{(9.0\times10^{-3}-0)N}{(4.4\times10^{-8}-0)C} = 2.0\ldots\times10^{5}\,\frac{N}{C}\ \left(\frac{F_{el}}{q}\right)$$

c. Use the value for slope and the information provided on the diagram to calculate the magnitude of the charge on the source.

$$F_{el} = k\frac{q_1 q_2}{R^2}$$

$$\frac{F_{el}}{q_1} = \frac{kq_2}{R^2}$$

$$slope = \frac{8.99\times10^{9}\,q_2}{(.45)^2}$$

$$2.0..\times10^{5} = \frac{8.99\times10^{9}\,q_2}{.2025}$$

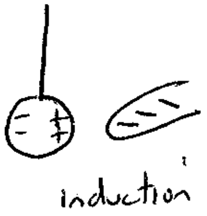
$$4.6\times10^{-6}\,C = q_2$$

Name: ______________________ Class: _________________ Date: _________ ID: A

Electrostatics - Coulomb's Law MC Practice

Multiple Choice
Identify the choice that best completes the statement or answers the question.

<table>
<tr><th colspan="4">An experiment is performed involving a negatively charged rod and a conducting sphere, which is suspended from a support by an insulated thread. Listed below are procedures demonstrating the methods of charging of objects and possible observations.</th></tr>
<tr><th colspan="2">Procedure</th><th colspan="2">Observation</th></tr>
<tr><td>I.</td><td>the negatively charged rod is brought near the conducting sphere</td><td>i.</td><td>the conducting sphere is first attracted to the negatively charged rod</td></tr>
<tr><td>II.</td><td>the conducting sphere is touched by the negatively charged rod</td><td>ii.</td><td>the conducting sphere is then repelled by the negatively charged rod</td></tr>
</table>

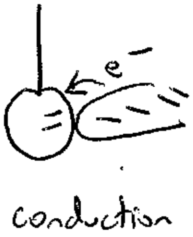


C 1. Refer to the above experiment. As the negatively charged rod is brought near the conducting sphere, the observation that the conducting sphere is first attracted to the charged rod is because the side of the sphere, closest to the rod, has become charged:

a. positively by conduction
[✓ c.] positively by induction
b. negatively by conduction
d. negatively by induction

B 2. Refer to the above electrostatic experiment. As the conducting sphere is touched by the negatively charged rod, the observation that the conducting sphere is then repelled by the charged rod is because the side of the sphere, closest to the rod, has become charged:

a. positively by conduction
c. positively by induction
[✓ b.] negatively by conduction
d. negatively by induction



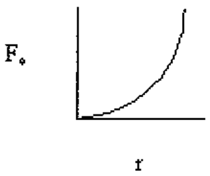
Electrostatic Experiment

In a Coulomb-type experiment, students investigated the relationship between the force of electrostatic repulsion, $|\vec{F}_e|$, acting on two similarly charged spheres, Q_1 and Q_2, and their separation distance, *r*, as described by the equation $|\vec{F}_e| = k\frac{Q_1Q_2}{r^2}$. The following are the results of their experiment:

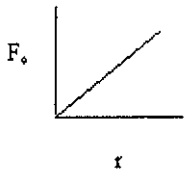
Separation Distance, "r", (x10^{-2} m)	**Magnitude of the Force of Repulsion "$\vert\vec{F}_e\vert$", (N)**
1.00	89.90
2.00	22.50
3.00	9.99
4.00	5.62
5.00	3.60

D 3. Based on the above results from the electrostatic experiment, the shape of the graph that **correctly** displays the relationship between the electrostatic force of repulsion and the separation distance between the two charges is:

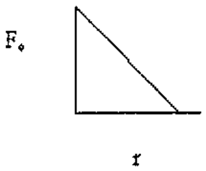
a.



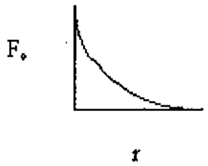
c.



b.



[✓ d.]



Coulomb's law

$F_{el} = \frac{kq_1 \cdot q_2}{R^2}$

$F_{el} \propto \frac{1}{R^2}$

* as distance increases between electric charges, the Fel decreases.

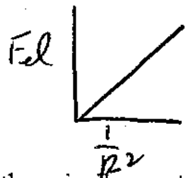
D 4. Refer to the above results from the electrostatic experiment. To obtain a straight-line graph, students should manipulate the data table to plot a graph with electrostatic force, $|\vec{F}_e|$, as a function of:

a. r

b. r^2

c. $\frac{1}{r}$

[✓ d.] $\frac{1}{r^2}$



Fel	R	$\frac{1}{R^2}$
1	1	1
.25	2	.25
.11	3	.11

____ 5. A metal sphere, X, with a charge of +6 Q is touched to another similar metal sphere, Y, with a charge of –2 Q. When they are separated, the resulting charges on spheres X and Y, respectively, will be:

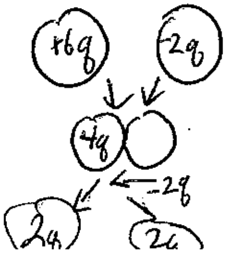
a. +4 Q, neutral

b. +3 Q, –1 Q

[✓ c.] +2 Q, +2 Q

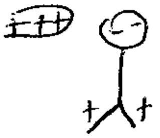
d. +4 Q, –2 Q

Conduction



C 6. A positively charged rod is held near the knob of an uncharged electroscope. The charges on the knob and the leaves of the electroscope, respectively, will be:

a. negative and negative
b. positive and negative
[✓ c.] negative and positive
d. positive and positive



D 7.

Electrostatics and Gravitation
1. Can exhibit repulsive forces.
2. Cannot exhibit repulsive forces. ✓
3. Can induce objects to become polar.
4. Cannot induce objects to become polar. ✓
5. Can exert forces over very great distances.
6. Cannot exert forces over very great distances. ✓

The statements that distinguish the effects of gravitation from those of electrostatics and apply only to gravitation are:

✓ only apply to gravity forces.

a. 1, 4, and 5
b. 2, 3, and 5
c. 1, 3, and 6
[✓ d.] 2, 4, and 5

Determining the Charge on a Sphere	
Given an ebonite rod, fur, and an electroscope, steps in an experimental procedure to determine the unknown charge on a sphere, are stated below:	
1.	Bring the electroscope close to the sphere with an unknown charge.
2.	Touch the ebonite rod to the electroscope.
3.	Rub the ebonite rod with the fur.
4.	Observe the leaves on the electroscope.

C 8. Refer to the above information. The **correct** sequence of steps to conclusively determine the unknown charge on the sphere are:

a. 1, 2, 3, and 4
b. 2, 3, 4, and 1
[✓ c.] 3, 2, 1, and 4
d. 4, 1, 3, and 2

C 9. Refer to the above information. The methods of charging objects in steps 1, 2, and 3, respectively, are:

a. friction, conduction, and induction
b. conduction, friction, and induction
[✓ c.] induction, conduction, and friction
d. conduction, induction, and friction

C 10. The first experimental apparatus used to accurately measure the magnitude of the electrostatic force between two charged objects was the:

a. Van de Graaff generator
b. mass spectrometer
[✓ c.] torsion balance
d. current balance

$F_{el} = \frac{k q_1 q_2}{R^2}$ $F_{el} \propto \frac{1}{R^2} \propto \frac{1}{(2)^2} \propto \frac{1}{4} F_{el}$

B 11. An electron and a proton, separated by a distance "r", experience an electrostatic force, "F_e". If the distance between the electron and the proton were doubled, then the electrostatic force would be:

a. $\frac{1}{2}$ F_e c. 2 F_e

[✓ b. $\frac{1}{4}$ F_e] d. 4 F_e

A 12. A small sphere with a charge of "-Q", a distance "r" from another small sphere with a charge of "+Q", experiences an electrostatic force, "F_e". If the charge on one sphere is doubled and the charge on the other sphere is halved, the electrostatic force between the two charges would be:

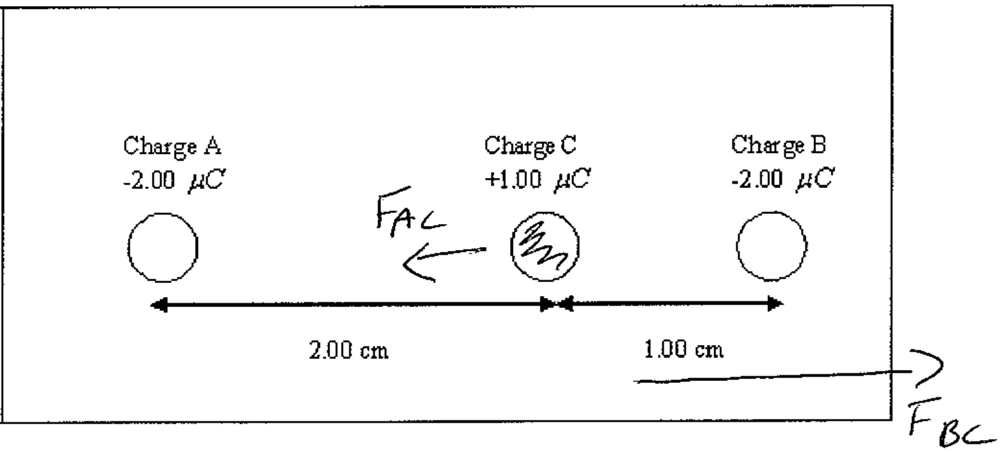
[✓ a. the same] c. $\frac{1}{2}$ F_e

b. 2 F_e d. 4 F_e

$$F_{el} = \frac{k q_1 q_2}{R^2} = \frac{(1)(2)(.5)}{(1)^2} = 1 F_{el}$$

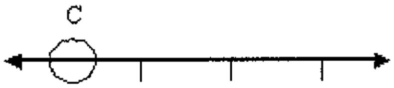
quatities that remain unchanged are set to "1"

Three charges are situated as shown in the diagram:



A 13. Based on the above diagram, the **correct** free-body diagram showing the forces acting on charge C is:

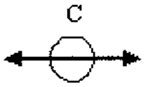
[✓ a.]



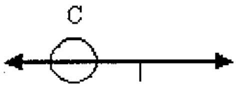
since A is twice as far away from C it exerts only $\frac{1}{4}$ the F_{el}.

$\left(F_{el} \propto \frac{1}{2^2}\right)$

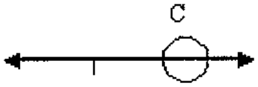
b.



c.

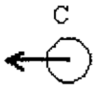


d.

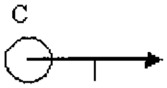


D 14. Based on the above diagram, the **correct** free-body diagram showing the net force on charge C is:

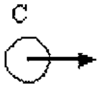
a.



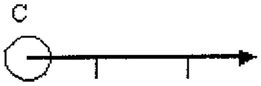
b.



c.



[✓ d.]



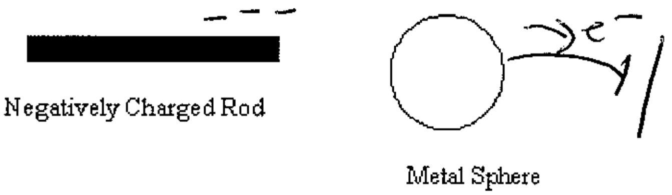
$F_{net} = -1 + 4 = +3$

Numeric Response

15.

Charging Objects

A negatively charged rod is held near a metal sphere. The sphere is then touched with a grounding wire.
The grounding wire is removed before the rod is removed.



Listed below are some statements that refer to the procedure described above.

1.	Protons are attracted and migrate to the left side of the sphere.
2.	The grounding wire conducts excess electrons from the sphere to Earth.
3.	The sphere is left with a final positive charge.
4.	The grounding wire conducts excess protons from Earth to the sphere.
5.	The sphere is left with a final negative charge.
6.	Electrons are repelled and migrate to the right side of the sphere.

The **correct** statements, in order, are ______, ______, and ______. (Record all **three digits** of your answer on the answer sheet.)

6 2 3