Name: McDevitt

$$\vec{F} = \frac{k q_1 q_2}{r^2} \quad \text{Coulomb's Law}$$

$$k = 9 \times 10^9 \frac{Nm^2}{C^2}$$

AP Physics: Electrostatics and Coulomb's Law… so far!

1. Two charges are separated by some distance and exert a force on each other. What new force will exist if the distance is doubled? Halved? (Be sure to distinguish which answer is which.)

   r is Halved: $\vec{F} = \frac{k q_1 q_2}{(\frac{1}{2}r)^2} = \frac{k q_1 q_2}{\frac{1}{4}r^2} \Rightarrow 4 \cdot \frac{k q_1 q_2}{r^2} = 4\vec{F}$ // r is doubled: $\vec{F} = \frac{k q_1 q_2}{(2r)^2} = \frac{1}{4}\frac{k q_1 q_2}{r^2} = \frac{1}{4}\vec{F}$

2. Two charges are separated by some distance and exert a force on each other. What new force will exist if both charges are doubled?

   $$F = \frac{k(2q_1)(2q_2)}{r^2} = 4\frac{k q_1 q_2}{r^2} = 4\vec{F}$$

3. Two identical point charges are separated by a distance of 3.0 cm (remember, 100cm=1m) and they repel each other with a force of 0.000040 N. What is the amount of each charge?

   $\vec{F} = 0.00004 N$

   $r = 3cm = 0.03m$

   $q_1 = q_2 = q = ?$

   $$0.00004 N = \frac{\left(9 \times 10^9 \frac{Nm^2}{C^2}\right) q^2}{(0.03m)^2} \Rightarrow q = \sqrt{\frac{(0.00004N)(0.03m)^2}{\left(9\times10^9\frac{Nm^2}{C^2}\right)}}$$

   $$q = q_1 = q_2 = 2 \times 10^{-9} C$$

4. Referring to the above question, what will the new force be if the distance between the point charges is doubled?

   r is doubled: $F_{new} = \frac{k q_1 q_2}{(2r)^2} = \frac{1}{4}\frac{k q_1 q_2}{r^2} = \frac{1}{4}F_{original} \Rightarrow \frac{1}{4}(0.00004N) = 1 \times 10^{-5} N = F_{new}$

5. How many electrons would be required to have a total charge of -1.00 Coulombs on a pith ball?

   $1e^- = -1.6 \times 10^{-19} C$

   $$-1C \left| \frac{1 e^-}{-1.6 \times 10^{-19} C} \right| = 6.24 \times 10^{18} e's$$

6. If two identical charges, 1.000 C each, are separated by a distance of 1.00 km, what is the force between them? (1000m = 1km)

   $q_1 = q_2 = 1C$

   $r = 1km = 1000m$

   $\vec{F} = ?$

   $$\vec{F} = \frac{\left(9 \times 10^9 \frac{Nm^2}{C^2}\right)(1C)(1C)}{(1000m)^2}$$

   $\vec{F} = 9000N \approx 8990N$ ← if use $k = 8.99 \times 10^9 \frac{Nm^2}{C^2}$

7. Two point charges are separated by a distance 10.0 cm. If one charge is $+2.00 \times 10^{-5}$ C and the other is -6.00×10^{-6} C, what is the force between them?

   $r = 10cm = 0.1m$

   $q_1 = 2 \times 10^{-5} C$

   $q_2 = -6 \times 10^{-6} C$

   $$\vec{F} = \frac{\left(9 \times 10^9 \frac{Nm^2}{C^2}\right)(2 \times 10^{-5} C)(-6 \times 10^{-6} C)}{(0.1m)^2}$$

   $\vec{F} = -108N \Rightarrow$ attractive force b/c charges are opposite

8. Determine the electrostatic force between a proton and an electron that are separated by 5.00×10^{-7} m. Is this an attractive force or repulsive force? Why?

   $r = 5 \times 10^{-7} m$

   $q_1 = 1.6 \times 10^{-19} C$

   $q_2 = -1.6 \times 10^{-19} C$

   $$\vec{F} = \frac{\left(9 \times 10^9 \frac{Nm^2}{C^2}\right)(1.6 \times 10^{-19} C)(-1.6 \times 10^{-19} C)}{(5 \times 10^{-7} m)^2}$$

   $\vec{F} = 9.24 \times 10^{-16} N \Rightarrow$ attractive force

9. How many electrons are on each object if two identical negative objects experience a repulsive force of 2.30 x 10-9 N when separated by a distance of 1.00 mm? (1000 mm = 1m)

$q_1 = q_2 =$ Negative = ?

$\# e^- = ?$

$\vec{F} = 2.3 \times 10^{-9}\,N$

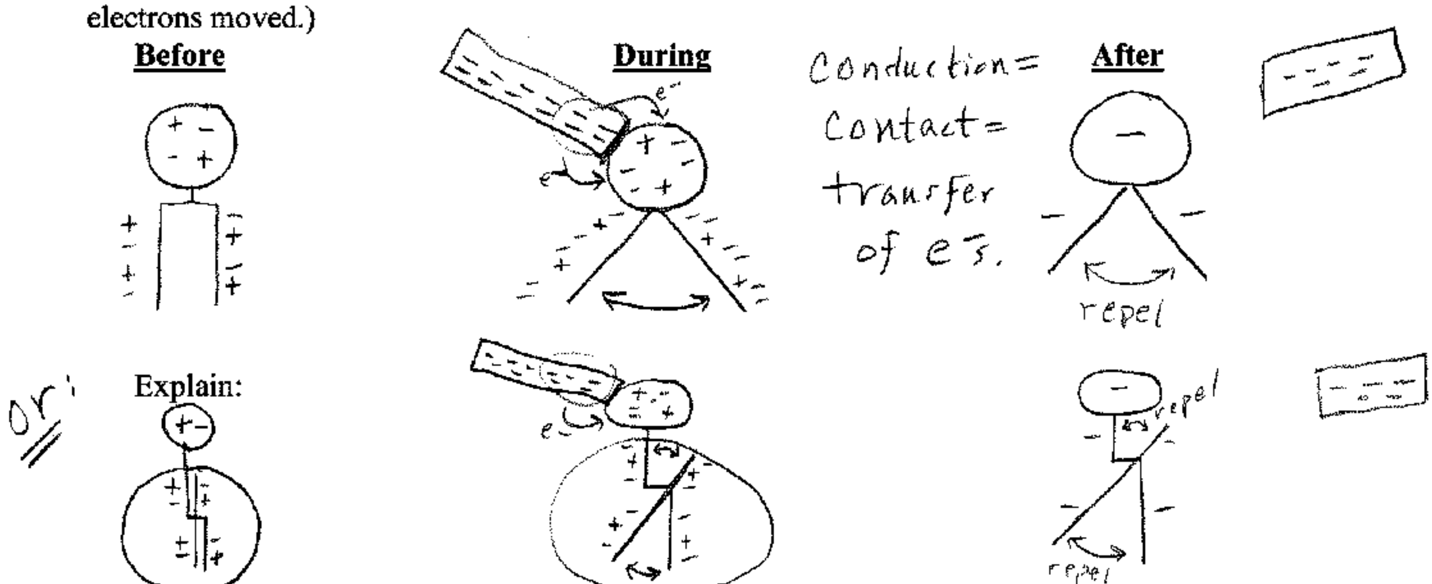
$r = 1\,mm = 0.001\,m$

$$2.3 \times 10^{-9}\,N = \frac{\left(9 \times 10^{9}\,\frac{Nm^2}{C^2}\right) q^2}{(0.001\,m)^2}$$

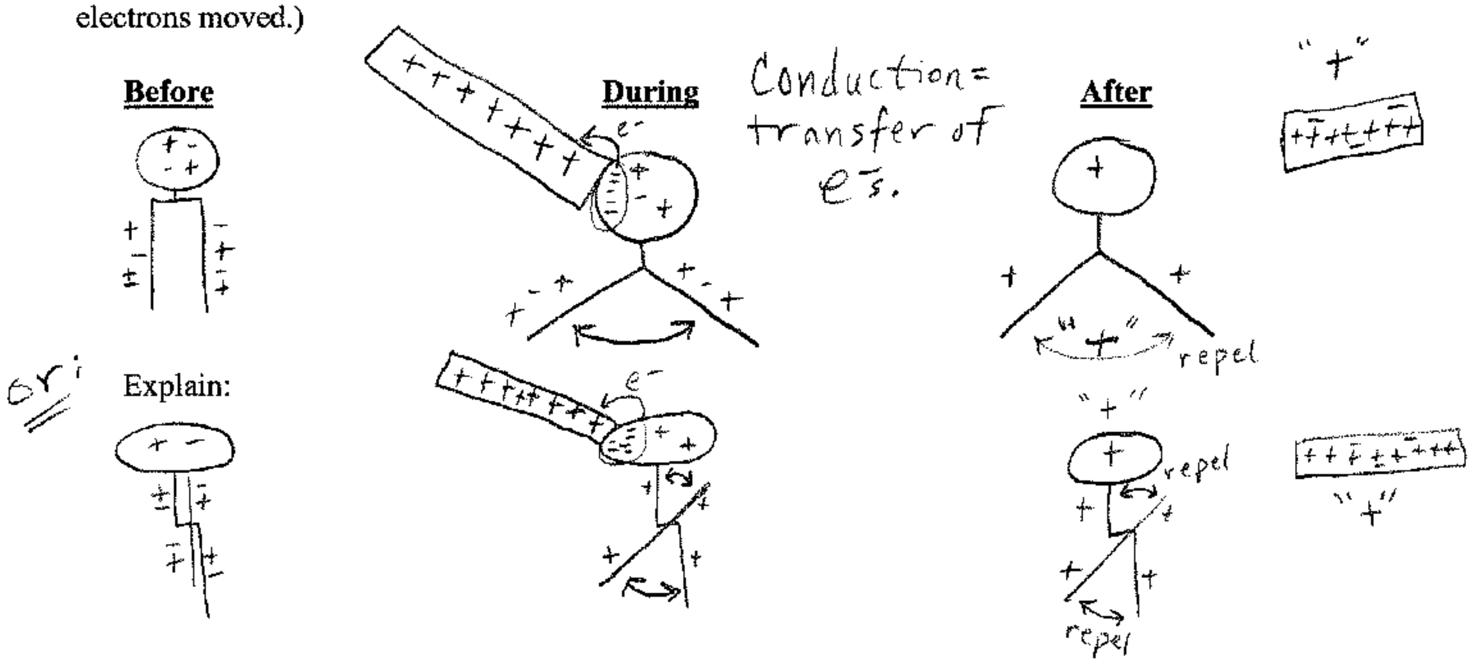
$$q = \sqrt{\frac{(2.3 \times 10^{-9}\,N)(0.001\,m)^2}{\left(9 \times 10^{9}\,\frac{Nm^2}{C^2}\right)}}$$

$$q = -5 \times 10^{-13}\,C \left| \frac{1\,e^-}{-1.6 \times 10^{-19}\,C} \right| \cong \boxed{3.16 \times 10^{6}\,e^-s}$$

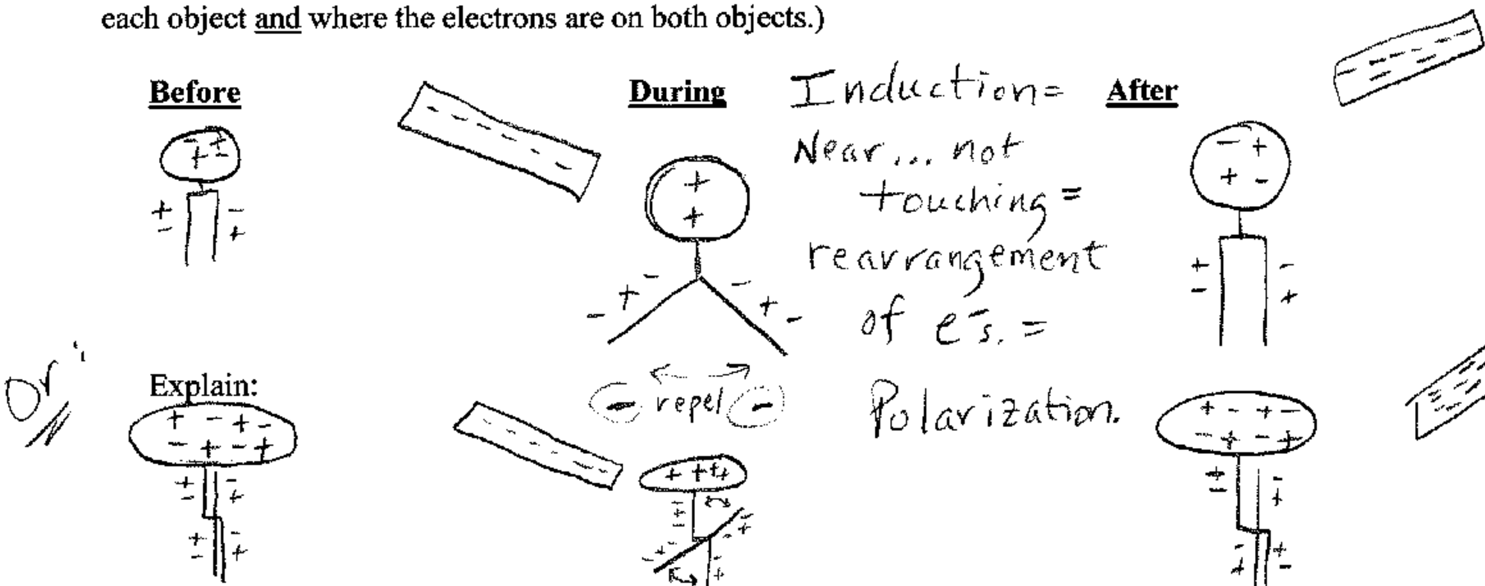
10. Draw "before, during and after" diagrams of a neutral electroscope being charged by conduction with a negative object. Include in your diagram the exact number of excess electrons you start with on the charged object and end with. (Clearly show where electrons moved from/to and how many electrons moved.)



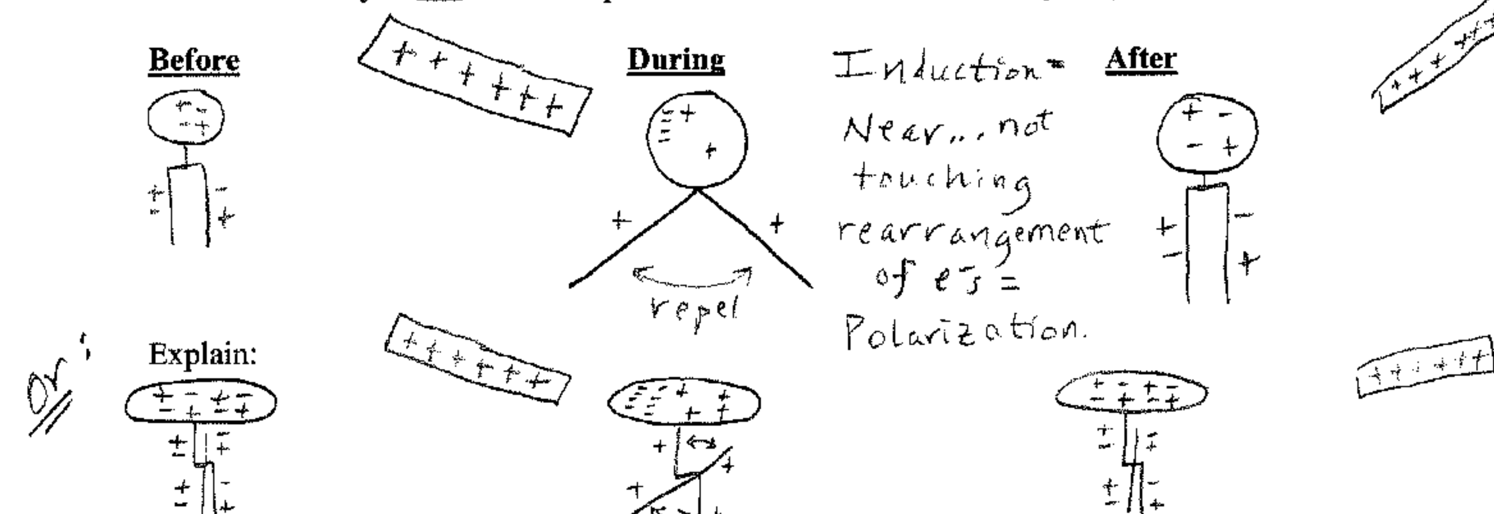
11. Draw "before, during and after" diagrams of a neutral electroscope being charged by conduction with a positive object. Include in your diagram the exact number of excess protons you start with on the charged object and end with. (Clearly show where electrons moved from/to and how many electrons moved.)



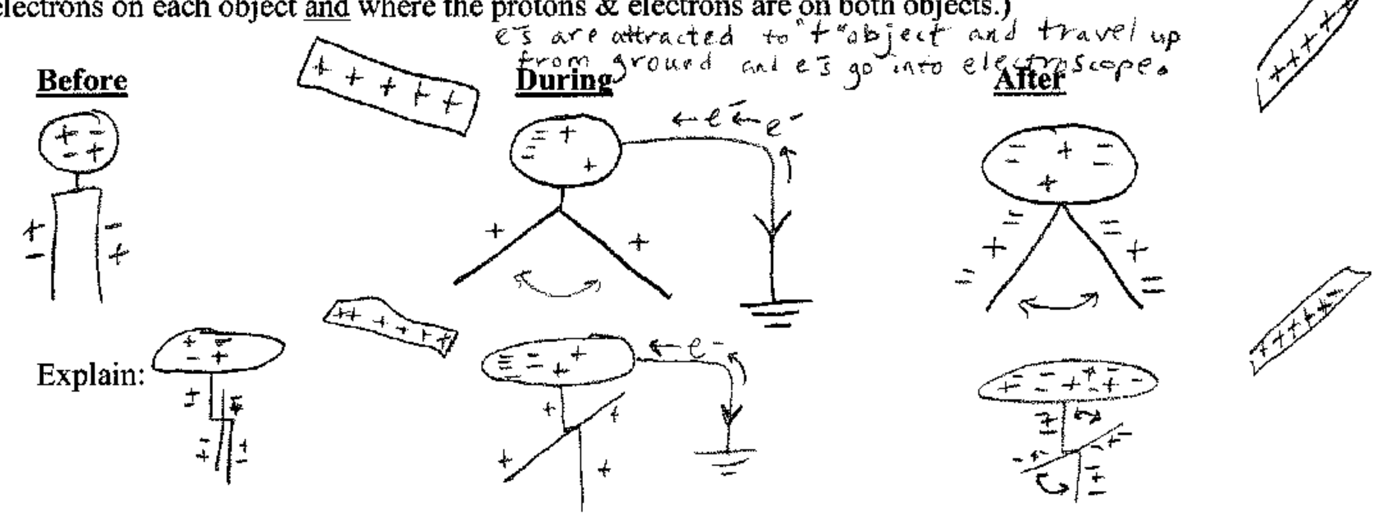
12. Draw "before, during and after" diagrams of a neutral electroscope being temporarily charged by induction with a negative object. Include in your diagram the exact number of excess electrons you start with on the charged object and end with. (Clearly distinguish the amount of electrons on each object and where the electrons are on both objects.)



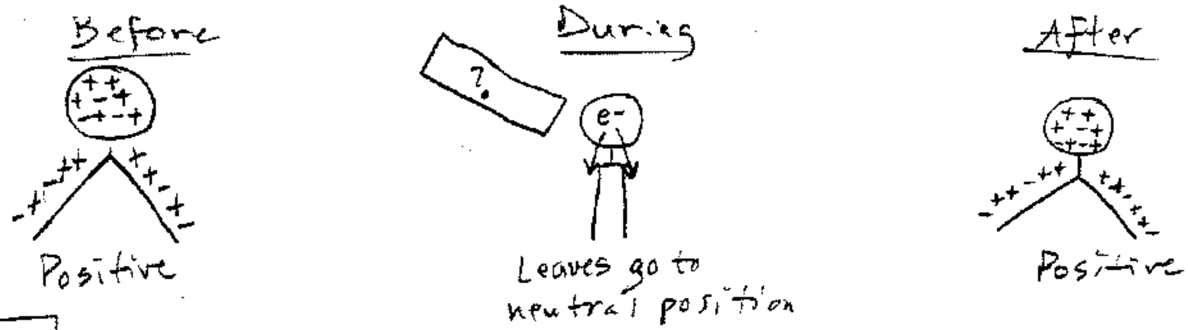
13. Draw "before, during and after" diagrams of a neutral electroscope being temporarily charged by induction with a positive object. Include in your diagram the exact number of excess protons you start with on the charged object and end with. (Clearly distinguish the amount of protons & electrons on each object and where the protons & electrons are on both objects.)



14. Draw "before, during and after" diagrams of a neutral electroscope being permanently charged by induction with a positive object. Include in your diagram the exact number of excess protons you start with on the charged object and end with. (Clearly distinguish the amount of protons & electrons on each object and where the protons & electrons are on both objects.)



15. You bring a rod of unknown charge up close to a positively charged electroscope and the leaves move to the neutral position. When you remove the rod the leaves go back to their original charged position. What is the charge on the rod AND explain why the leaves moved to the neutral position when the rod was brought close to the electroscope.



Answer → During: The leaves going to a more neutral position is caused by some e^-s moving from the top (ball) of electroscope down to leaves making the leaves have an even number of "+" and "−" charge. Rod must be Negative!

16. You bring a rod of unknown charge up close to a negatively charged electroscope and the leaves moves away even more. When you remove the rod the leaves go back to its original charged position. What is the charge on the rod AND explain why the leaves move away even more when the rod was brought close to the electroscope.

uring: The rod must be negatively charged to repel even more e^-s in the ball (top of electroscope) to the leaves which become more negative.

17. Clothes immediately removed from the dryer sometimes have static cling… Why?
(cling → stick)

Through friction, e^-s are transferred from one type of clothing to another. Result = 2 objects oppositely charged.