IB Physics SL Y2 - Fall 2014 Final Exam Review (Day 1)

Electric Force and Field

6.2.1 State that there are two types of electric charge.
6.2.2 State and apply the law of conservation of charge.
6.2.3 Describe and explain the difference in the electrical properties of conductors and insulators.
6.2.4 State Coulomb's law.
6.2.5 Define electric field strength.
6.2.6 Determine the electric field strength due to one or more point charges.
6.2.7 Draw the electric field patterns for different charge configurations.
6.2.8 Solve problems involving electric charges, forces and fields.

6.2.1 State that there are two types of electric charge.

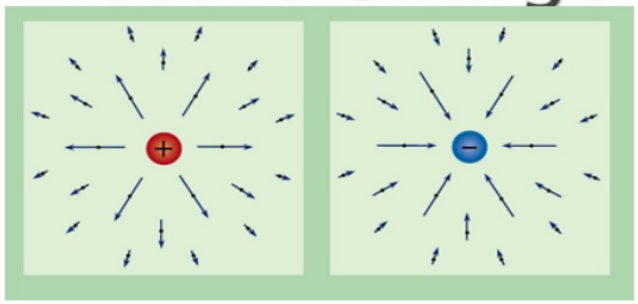
Electric Charge

"Charge" is a property of subatomic particles.

Facts about charge:

- There are 2 types basically, positive (protons) and negative (electrons)
- LIKE charges REPEL and OPPOSITE charges ATTRACT
- Charges are symbolic of fluids in that they can be in 2 states, STATIC or DYNAMIC.

Electric Charge – The specifics

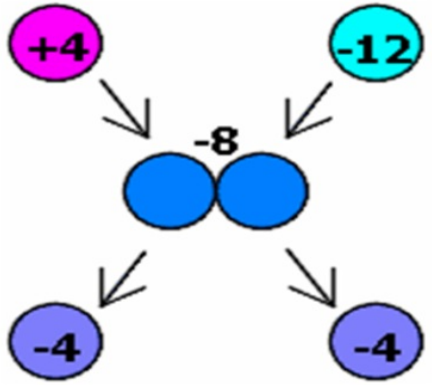


- The symbol for CHARGE is "q"
- The unit is the COULOMB(C), named after Charles Coulomb
- If we are talking about a SINGLE charged particle such as 1 electron or 1 proton we are referring to an ELEMENTARY charge and often use, ***e*** , to symbolize this.

Particle	Charge	Mass
Proton	1.6×10^{-19} C	1.67×10^{-27} kg
Electron	1.6×10^{-19} C	9.11×10^{-31} kg
Neutron	0	1.67×10^{-27} kg

6.2.2 State and apply the law of conservation of charge.

Charge is "CONSERVED"



Charge cannot be created or destroyed only transferred from one object to another. Even though these 2 charges attract initially, they repel after touching. Notice the NET charge stays the same.

6.2.3 Describe and explain the difference in the electrical properties of conductors and insulators.

Conductors and Insulators

The movement of charge is limited by the substance the charge is trying to pass through. There are generally 2 types of substances.

Conductors:
Allow charge to move readily though it.

Insulators:
Restrict the movement of the charge

Conductor = Copper Wire
Insulator = Plastic sheath

6.2.4 State Coulomb's law.

Electric Force

The electric force between 2 objects is symbolic of the gravitational force between 2 objects. RECALL:

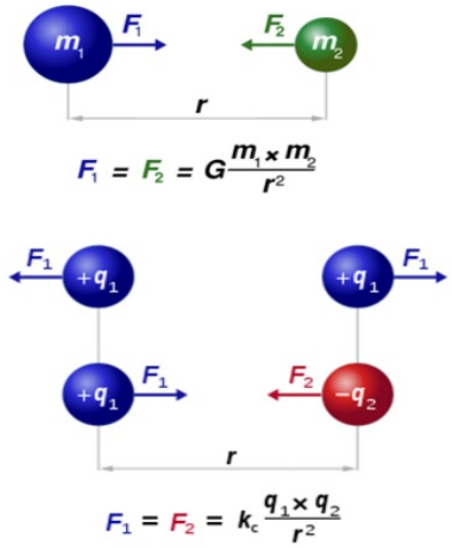
$$F_g \alpha Mm \quad F_g \alpha \frac{1}{r^2}$$

$$F_E \alpha q_1 q_2 \quad F_E \alpha \frac{1}{r^2} \quad F_E \alpha \frac{q_1 q_2}{r^2}$$

k = constant of proportionality

k = Coulomb constant $= 8.99x10^9 \frac{Nm^2}{C^2}$

$$F_E = k\left|\frac{q_1 q_2}{r^2}\right| \rightarrow Coulomb's\ Law$$



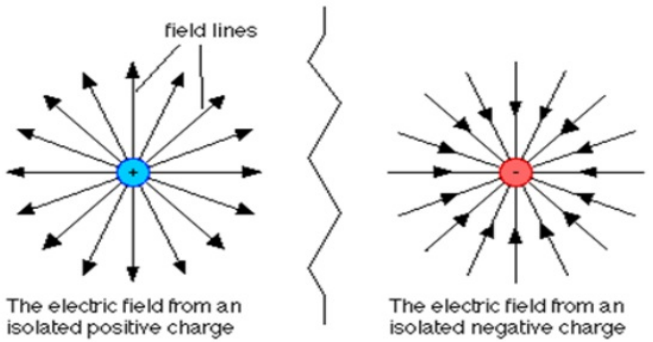
6.2.5 Define electric field strength.

Electric Fields

By definition, the are "LINES OF FORCE"

Some important facts:

- An electric field is a vector
- Always is in the direction that a POSITIVE "test" charge would move
- The amount of force PER "test" charge



The electric field from an isolated positive charge

The electric field from an isolated negative charge

If you placed a 2nd positive charge (test charge), near the positive charge shown above, it would move AWAY.

If you placed that same charge near the negative charge shown above it would move TOWARDS.

Electric Fields and Newton's Laws

$$F_g = G\frac{mM}{r^2}, \quad F_e = k\frac{qQ}{r^2}$$

$$\frac{F_g}{m} = g, \qquad \frac{F_e}{q} = E$$

Once again, the equation for ELECTRIC FIELD is symbolic of the equation for WEIGHT just like coulomb's law is symbolic of Newton's Law of Gravitation.

The symbol for Electric Field is, "E". And since it is defined as a force per unit charge he unit is Newtons per Coulomb, N/C.

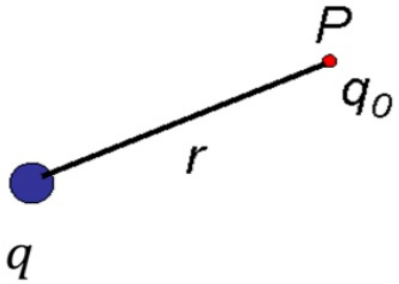
NOTE: the equations above will ONLY help you determine the MAGNITUDE of the field or force. Conceptual understanding will help you determine the direction.

The "q" in the equation is that of a "test charge".

6.2.6 Determine the electric field strength due to one or more point charges.

An Electric Point Charge

As we have discussed, all charges exert forces on other charges due to a field around them. Suppose we want to know how strong the field is at a specific point in space near this charge the calculate the effects this charge will have on other charges should they be placed at that point.



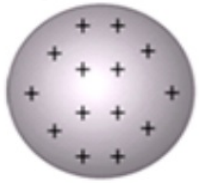
$$F_E = k\frac{qq_0}{r^2} \qquad E = \frac{F_E}{q_0} \rightarrow F_E = Eq_0$$

$$Eq_0 = k\frac{qq_0}{r^2}$$

$$E_{\text{point charge}} = \frac{kq}{r^2}$$

6.2.7 Draw the electric field patterns for different charge configurations.

1. Positively charged sphere



2. Positive point charge

3. Negative point charge

5. Two positive charges

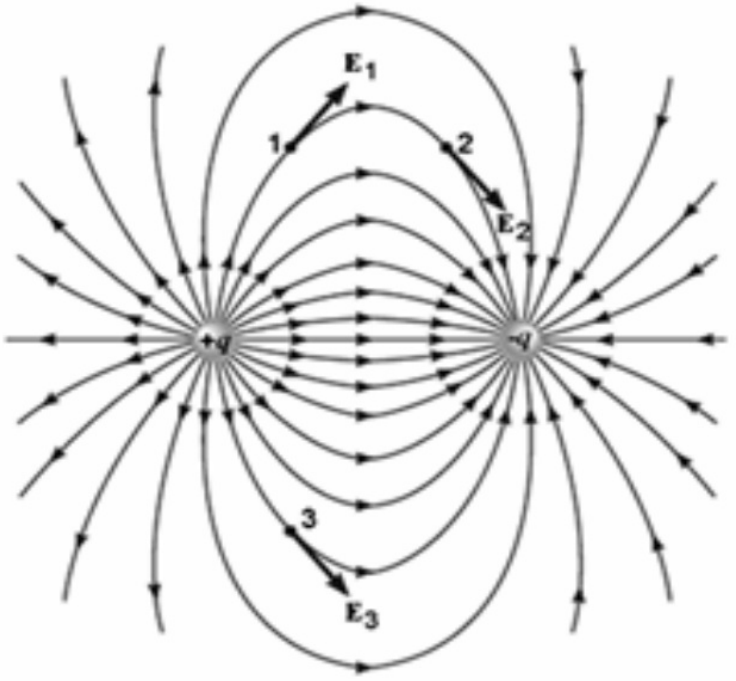
6. Two negative charges

7. Two unlike charges

8. Oppositely charged parallel plates

Properties of Electric Field Lines

1. Never cross
2. Show the direction of force on a small positive test charge
3. Out of positive, into negative
4. Direction of electric field is tangent to the field lines
5. Density of field lines is proportional to field strength (density = intensity)
6. Perpendicular to surface
7. Most intense near sharp points



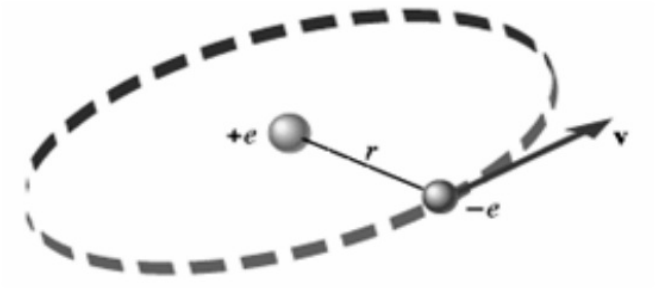
4

6.2.8 Solve problems involving electric charges, forces and fields.

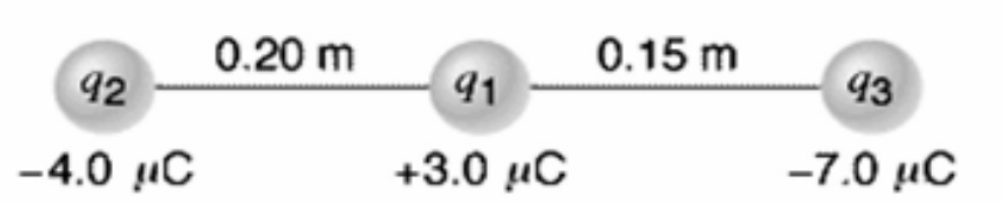
P1. A balloon has gained 2500 electrons after being rubbed with wool. What is the charge on the balloon? What is the charge on the wool?

P2. A rubber rod acquires a charge of -4.5 μC. How many excess electrons does this represent?

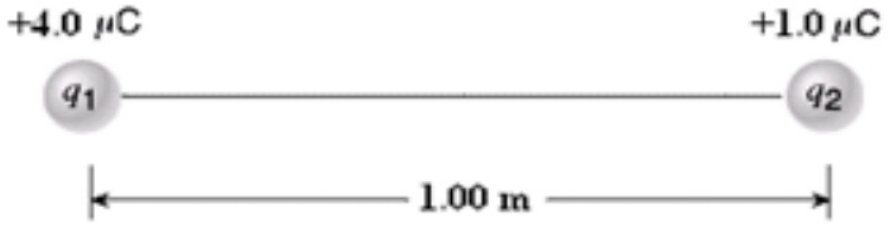
P3. Use the Coulomb force to estimate the speed of the electron in a hydrogen atom. ($r = 5.29 \times 10^{-11}$ m)



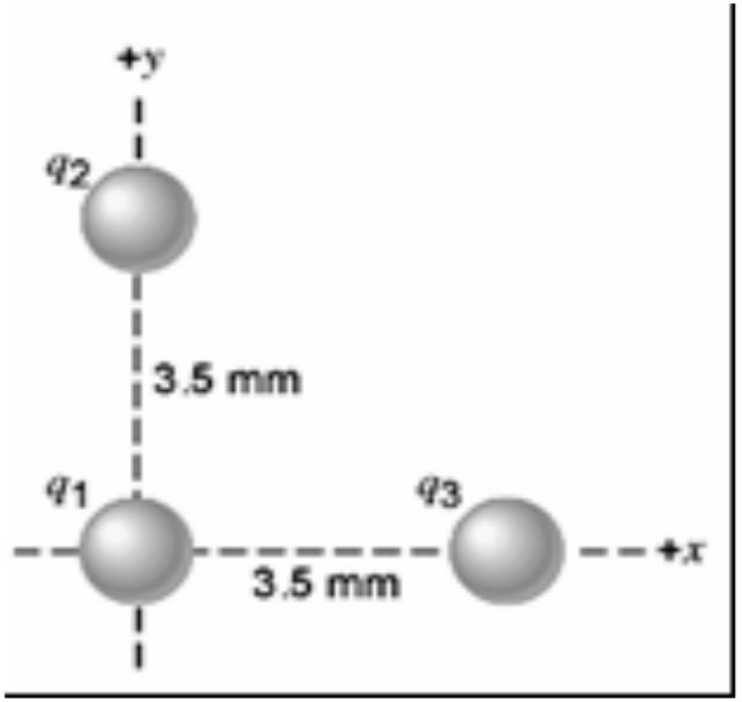
P4. Determine the net electrostatic force on charge q_1, as shown below.



P5. Where can a third charge of +1.0 μC be placed so that the net force acting on it is zero?



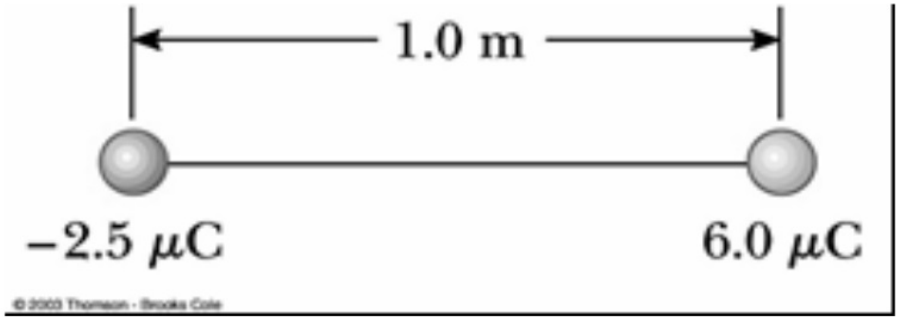
P6. Three point charges of -2.0 μC are arranged as shown.
Determine the magnitude and direction of the net force on charge q_1.



P7. (a) Find the magnitude and direction of the electric field at a spot 0.028 m away from a sphere whose charge is +3.54 μC and whose radius is 0.60 cm.

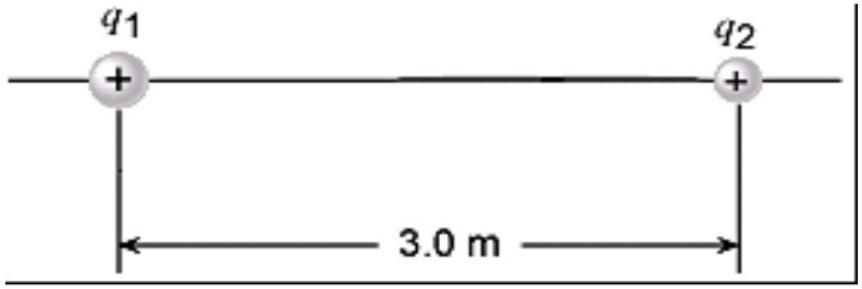
P7. (b) Find the magnitude and direction of the electric force acting on a -7.02 nC charge placed at this spot.

P8. (a) Find the magnitude and direction of the net electric field halfway between the two charges shown below.



P8. (b) Determine the electric force on a proton placed at this spot.

P9. Two positive point charges, q_1 = +16 μC and q_2 = +4.0 μC, are separated in a vacuum by a distance of 3.0 m. Find the spot on the line between the charges where the net electric field is zero.



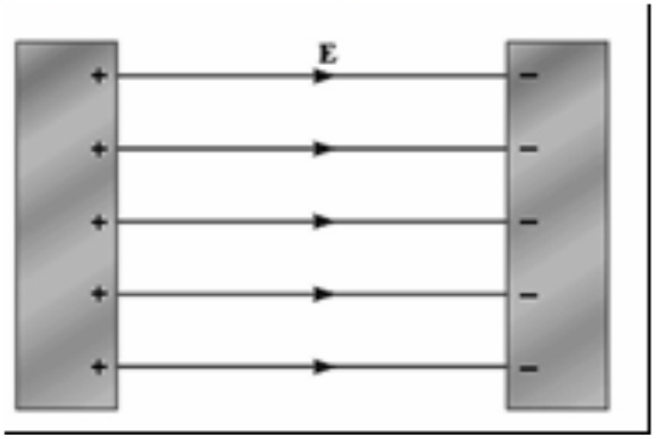
P10. A proton is released from rest near the positive plate. The distance between the plates is 3.0 mm and the strength of the electric field is 4.0×10^3 N/C.

(a) Describe the motion of the proton.

(b) Write an expression for the acceleration of the proton.

(c) Find the time it takes the proton to reach the negative plate.

(d) Find the speed of the proton when it reaches the negative plate.



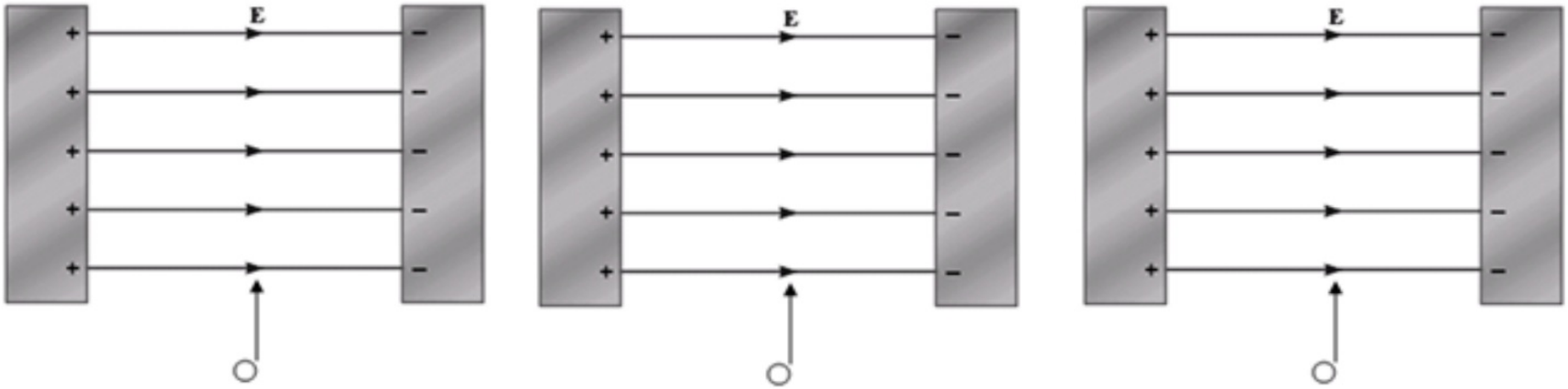
P11. A particle is shot with an initial speed through the two parallel plates as shown.

(a) Sketch and describe the path it will take if it is a proton, an electron, or a neutron.

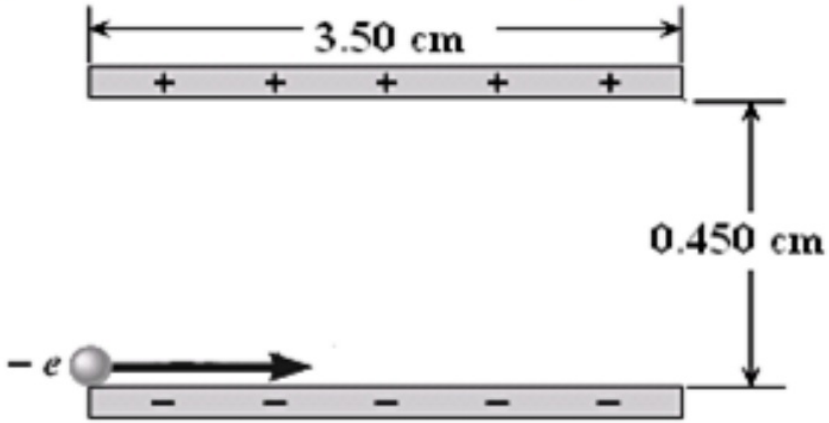
(b) Which particle will experience a greater force?

(c) Which particle will experience a greater acceleration?

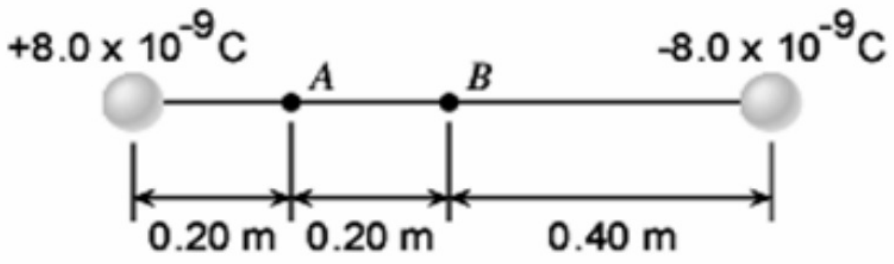
(d) Which particle will experience a greater displacement?



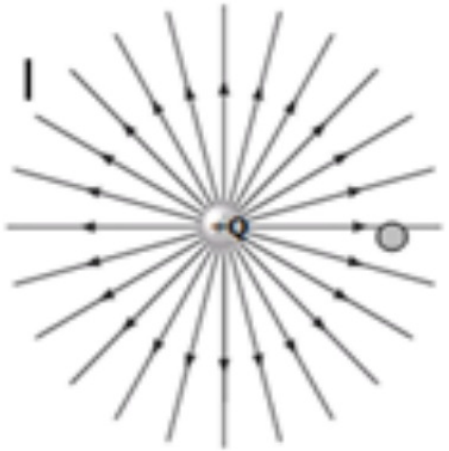
P12. In the figure, an electron enters the lower left side of a parallel plate capacitor and exits at the upper right side. The initial speed of the electron is 5.50×10^{6} m/s. The plates are 3.50 cm long and are separated by 0.450 cm. Assume that the electric field between the plates is uniform everywhere and find its magnitude.



P13. (a) Calculate the net electric field at each spot (A and B).



P13. (b) Calculate the net electric force on a proton placed at each spot.



Electric Force	Electric Field
Two objects needed – interaction between the two	One object needed – property of that one object
Magnitude: $F = Eq$ $F = kQq/r^2$	Magnitude: $E = F/q$ $E = kQ/r^2$
Units: N	Units: N/C
Type: vector	Type: vector
Direction: likes repel, unlikes attract	Direction: away from positive, towards negative
Sign: don't use when calculating – check frame of reference	Sign: don't use when calculating – check frame of reference