Physics: Electrostatic Force part 1

14 Electrostatic Force

ENGAGE: Zap!

Ever got out of a car, gone to close the door and received an electric shock? What about taking off a polar fleece sweater or jacket? Try it in a darkened room and you will see sparks flash as the jersey rubs against the material of your shirt. What about lightning? What causes that? Study the photo of the little girl’s hair (right) What’s causing that to happen?

1. What do you think is causing these phenomena? Where does the electricity come from? Discuss your ideas with others in your class and write down a summary of these ideas:

________________________________________________________________________
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ANS:
EXPLORE: Balloon electrostatics

Balloons are well known for producing some interesting electrostatic effects:

INVESTIGATION 2.5: Balloon electrostatics See appendix for equipment list.

1. In a still, warm room, fully inflate a balloon and hang it from the ceiling or an insulated support with nylon thread or fishing line.

2. Rub the balloon with a piece of wool/synthetic material or a sweater so that it becomes charged.

3. Predict what will happen if you bring the material or sweater used to rub the balloon near the balloon.

4. Carry out step 3 and record your observations:

5. Fully inflate a second balloon and hang it from the ceiling with more nylon fishing line near the first balloon.

6. Rub both balloons with the same material (wool/synthetic fabric or a sweater). This should give the balloons a charge of the same sign and a similar amount.

7. Predict what will happen to these similarly charged balloons as they hang near each other.

8. Carry out step 7 and record your observations:

9. Leave the balloons hanging near each other for a few minutes. Record any changes that take place:

INVESTIGATION 2.6: Threading the needle See appendix for equipment list.

1. Try threading a standard sewing needle with thin plastic thread (such as from a thread of plastic string). Keep trying!

2. Now thread the needle with normal cotton thread of the same thickness. Was it easier?

ANS:
2. (a) What happened when you tried to thread the needle with plastic thread?

(b) What happened when you tried to thread the needle with cotton thread?

(c) Suggest why there was a difference in how the threads behaved while being threaded:

ANS:

Electrostatics are part of a wider group of non-contact forces called electromagnetism. They push or pull on objects without touching them. Electrostatic forces occur when charged objects interact with objects around them.

Charge exists as two kinds (positive and negative) and is the basic ingredient of all electricity. Electricity divides into two general areas: (i) static electricity (or electrostatics) is about stationary accumulations of charge (ii) current electricity, which involves a continuing flow of charged particles (usually negative electrons).

Charge is present in all the materials around us, but we are usually unaware of it because most of the positive and negative charge is balanced and evenly spread. The balance can be “disturbed”, e.g. by rubbing materials together. This usually results in electrons being transferred from one material to another. The material gaining the electrons is then said to be negatively charged while the material losing the electrons is said to be positively charged.

Objects with like charges repel each other while objects with opposite charges attract each other.

3. For each situation below, state whether the balloons will repel or attract each other:

(a) 

(b) 

ANS:

4. A student rubs a balloon with silk to create a charge on the balloon’s surface, then brings the balloon near some small pieces of tissue paper. Predict what will happen to the tissue paper and explain your prediction. Try it and find out:

ANS:
Coulomb’s force and inverse square law

**EXPLORE: Coulomb’s force and the inverse square law**

- In 1785, French physicist Charles-Augustin de Coulomb published an equation to explain the force between electric charges (known as Coulomb’s law). It stated that the magnitude of the electrostatic force between two charges is proportional to the product of the charge magnitudes (their size) and inversely proportional to the square of the distance between them.

\[
F = \frac{k q_1 q_2}{r^2}
\]

- Coulomb’s constant: \(8.99 \times 10^9 \text{ Nm}^2/\text{C}^2\)

- Unlike gravity, which is always attractive, electrostatic force forces are either attractive (if the charges are opposite) or repulsive (if the charges are the same).

- Note the similarity between the Coulomb’s law and Newton’s law of gravitation:

\[
F = \frac{G M_1 M_2}{r^2}
\]

- Recall that the effects of gravity decrease over distance, where the strength of gravity is inversely proportional to the square of the distance between the objects. We can now see that same relationship for electromagnetic forces in Coulomb’s equation.

**INVESTIGATION 2.7: Observing the inverse square law** See appendix for equipment list.

1. With a black marker pen, make a dot about 2 cm in diameter on a deflated balloon. Make the dot as round and as uniform as possible.

2. Measure the diameter of dot and calculate its area. Use the formula for the area of a circle: \(A = \pi r^2\) (remember to divide the measured diameter by 2 to get the radius before you make your calculations).

3. Record the area of the dot in the table below. Record the intensity of the dot’s color using a scale 0–10 (0 being transparent and 10 being the original opacity of the dot).

4. Partially inflate the balloon, measure the dot again, and calculate its area. Record its intensity (0–10).

5. Continue inflating the balloon one or two breaths at a time, measuring the dot and calculating its area each time. Record the intensity of the black of the dot each time using your 0–10 scale.

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<tr>
<th>Dot radius (mm)</th>
<th>Dot area (mm²)</th>
<th>Color intensity</th>
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