Static Electricity

Introductory Question

- A woman rubs her feet on the carpet and gives a shock to her identical twin. If the twin also rubs her feet on the carpet before being touched, the shock will be

A. larger
B. smaller
C. the same size

Observations about Static Electricity

- Static electricity builds up on some objects
- Clothes in the dryer often develop static charge
- Objects with static charge may cling or repel
- Static electricity can cause shocks
- Static electricity can make your hair stand up

6 Questions about Static Electricity

- Why do some clothes cling while others repel?
- Why do clothes normally neither cling nor repel?
- Why does distance reduce static effects?
- Why do clingy clothes stick to uncharged walls?
- Why do clingy clothes crackle as they separate?
- Why do some things lose their charge quickly?

Question 1

- Why do some clothes cling while others repel?

Electric Charge (Part 1)

- Clothes that cling or repel carry a physical quantity called electric charge or simply "charge"
- Charge comes in two types:
  - Charges of the same type repel
  - Charges of different types attract
  - Franklin named the types "positive" and "negative"
- Clothes acquire static charges while in the dryer
  - Clothes that cling evidently carry opposite charges
  - Clothes that repel evidently carry like charges

Question 2

- Why do clothes normally neither cling nor repel?
  - What happens in the dryer to cause static effects?

Electric Charge (Part 2)

- Electric charge
  - is a conserved quantity
  - is quantized in multiples of the fundamental charge
- Electric charge is measured in coulombs
- One fundamental charge is 1.6×10^{-19} coulombs
- Charge is intrinsic to some subatomic particles
  - Each proton has +1 fundamental charge
  - Each electron has –1 fundamental charge

Net Charge

- An object's net charge
  - is the sum of all its individual charges
  - tends to be zero or nearly zero
- An electrically neutral object
  - contains as many + charges as – charges
  - has zero net charge
- Clothes tend to be neutral
- Neutral clothes neither cling nor repel

Charge Transfers

- Contact can transfer electrons between objects
  - The object with the stronger affinity for electrons gains electrons and becomes negatively charged
  - The other object loses electrons and becomes positively charged
- Rubbing objects together ensures
  - excellent contact between their surfaces
  - significant charge transfer from one to the other.
- A dryer charges clothes via these effects

Introductory Question (revisited)

- A woman rubs her feet on the carpet and gives a shock to her identical twin. If the twin also rubs her feet on the carpet before being touched, the shock will be

A. larger
B. smaller
C. the same size

Question 3

- Why does distance reduce static effects?

Electric Charge (Part 3)

- Two charges push or pull on one another
  - with forces that are equal in magnitude
  - but opposite in direction.
- These electrostatic forces are
  - proportional to the amount of each charge
  - inversely proportional to (distance between charges)^2
- Electrostatic forces obey Coulomb's law:

$$\text{force} = \frac{\text{Coulomb constant} \cdot \text{charge}_1 \cdot \text{charge}_2}{(\text{distance between charges})^2}$$

Question 4

- Why do clingy clothes stick to uncharged walls?

Electric Polarization

- A neutral wall contains countless charges
- When a negatively charged sock nears the wall,
  - the wall's positive charges shift toward the sock,
  - the wall's negative charges shift away from it,
  - and the wall becomes electrically polarized.
- Opposite charges are nearer and attract strongly
- Like charges are farther and repel less strongly
- The charged sock clings to the polarized wall

Question 5

- Why do clingy clothes crackle as they separate?

Voltage

- Charge has electrostatic potential energy (EPE)
- Voltage measures the EPE per unit of charge
  - Raising the voltage of positive charge takes work
  - Lowering the voltage of negative charge takes work
- Voltage is measured in volts (joules/coulomb)

Separating Opposite Charges

- Separating opposite charges takes work,
  - so the positive charges undergo a rise in voltage
  - and the negative charges undergo a drop in voltage.
- Positive charge at high voltage
  - can release EPE by moving to lower voltage
  - may move by way of a discharge or spark!
- Negative charge at low voltage,
  - can release EPE by moving to higher voltage

Question 6

- Why do some things lose their charge quickly?

Conductors and Insulators

- Insulators have no mobile electric charges
- Conductors have some mobile electric charges,
  - usually electrons (e.g., metals)
  - but occasionally ions (e.g., salt water)
- In a conductor, the mobility of charge permits
  - like charges to disperse or escape
  - opposite charges to aggregate and cancel
- Conductors can lose their charges quickly

Summary about Static Electricity

- Even neutral objects contain countless charges
- Objects can transfer charge during contact
- Clothes often develop net charges during drying
- Oppositely charged clothes cling to one another
- and spark as separation raises their voltages.
- Conductivity tends to let objects neutralize.