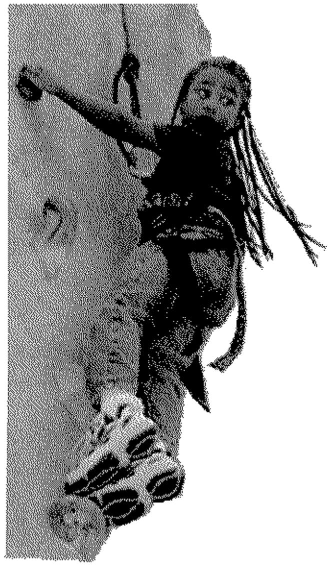
Lecture
2/15/05

A Puzzle

- Suppose we have created a number of charged objects (types A and B or + and -).
- Opposite types attract, like types repel.
- Both kinds attract non-electrified matter.
- What’s going on?

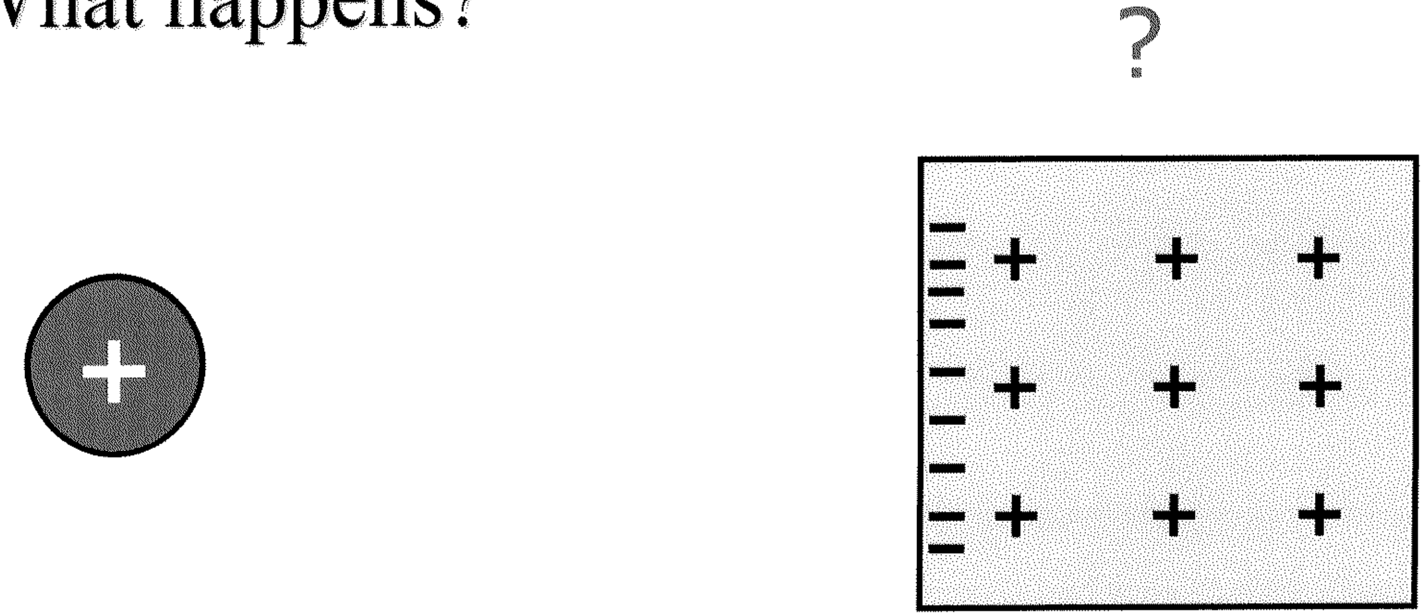
Model:
Charge – A hidden property of matter

- Matter is made up of two kinds of electrical matter (positive and negative) that cancel when they are together and hid matter's electrical nature.
- Matter with an equal balance is called <u>neutral</u>.
- Like charges repel, unlike charges attract.



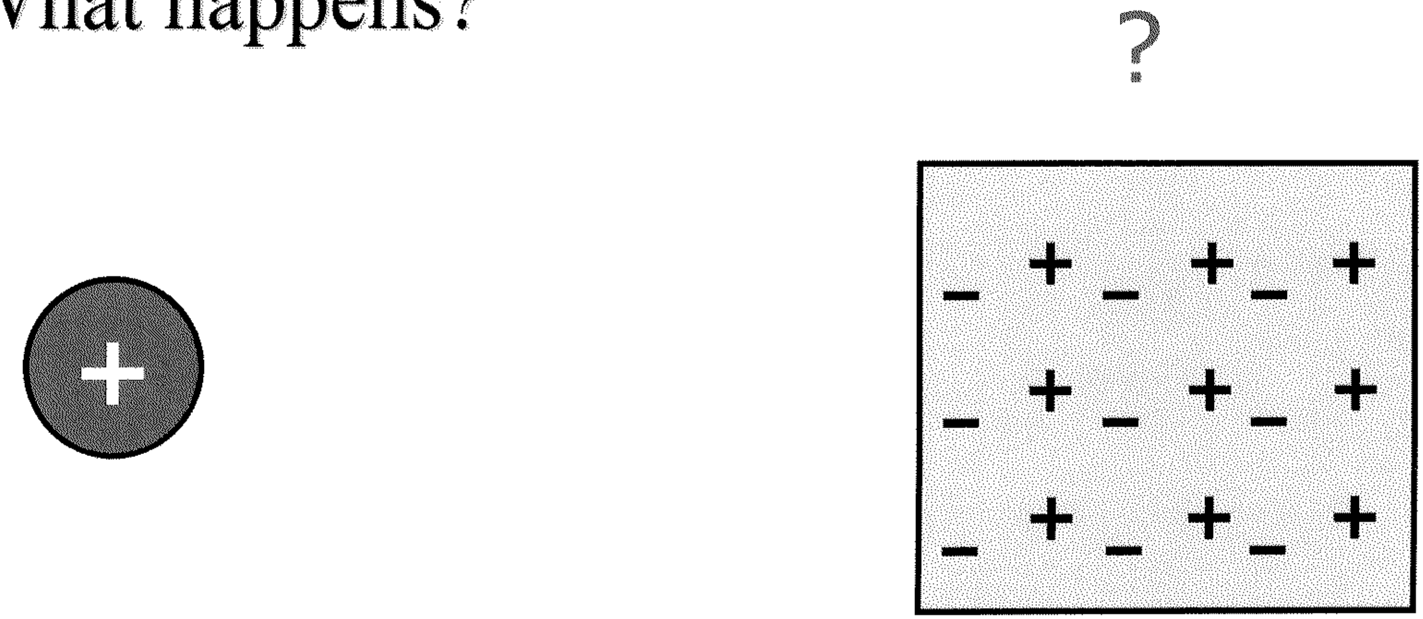
Polarization

- Consider a + charge object brought up near an uncharged (neutral) conductor.
  What happens?



Polarization

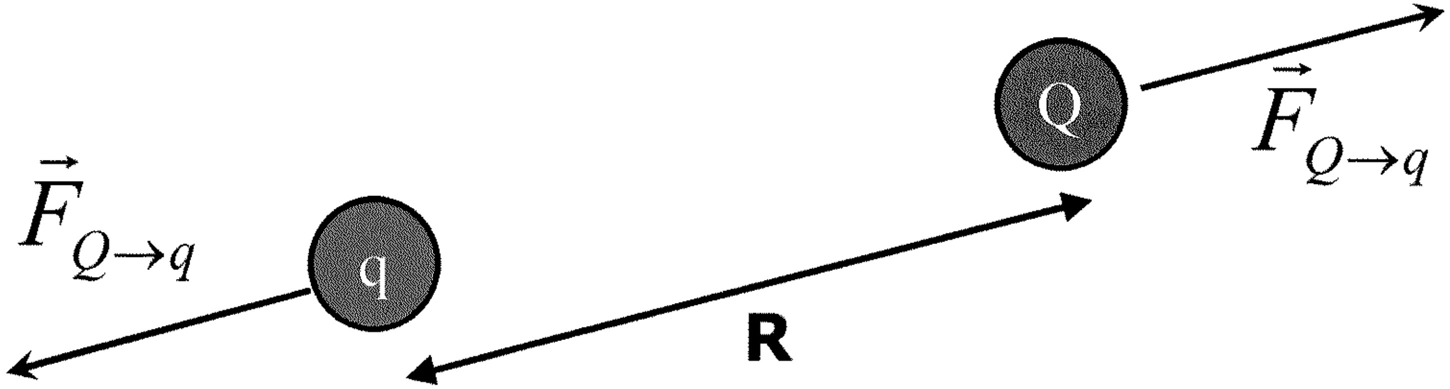
- Consider a + charge object brought up near an uncharged (neutral) insulator.
  What happens?



Conductors and Insulators

- Insulators
  - In some matter, the charges they contain are bound and cannot move around freely.
  - Excess charge put onto this kind of matter tends to just sit there.
- Conductors
  - In some matter, charges in it can move around throughout the object.
  - Excess charge put onto this kind of matter redistributes itself or flows off
    (if there is a conducting path to ground).

Coulomb's Law



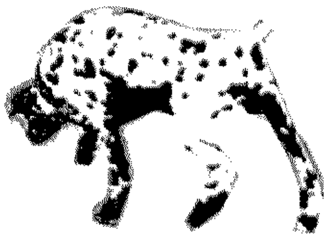
$$F_{Q\to q} = F_{q\to Q} = \frac{k_C q Q}{R^2}$$

Quantifying Charge

- Need an operational definition.
- Charge is a new kind of quantity (to M, L, T, add Q).
- Choose our scale:
  A small object has a charge of 1 C (= 1 Coulomb) if two identical such charges held at a distance of 1 m exert forces of 8.99×10^9 N on each other.
- This corresponds to choosing the constant

$$k_C = 8.99 \times 10^9 \text{ N-m}^2/\text{C}^2.$$

Making Sense of Coulomb's Law



- Changing the test charge
- Changing the source charge
- Changing the distance
- Interpret the sign

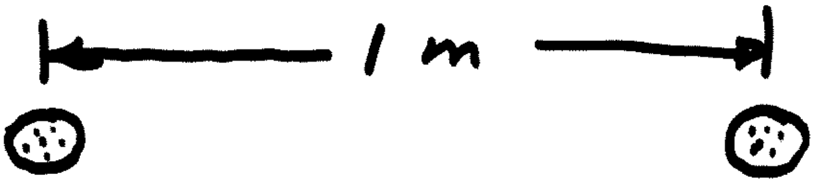
$$F_{Q\to q} = F_{q\to Q} = \frac{k_C qQ}{R^2}$$

$$F = \frac{k_c q Q}{R^2}$$

$$k_c = 9 \times 10^9 \frac{Nm^2}{Q^2}$$

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

Suppose one could remove one electron from each molecule of each of two golf balls spaced one meter apart.



The charge on each ball would be roughly

$$q = Q = +1.6 \times 10^{-19} \underset{\substack{\uparrow \\ \text{Avogadro's Number}}}{\left[6 \times 10^{23}\right]}$$

$$\cong 10^5 C$$

$$F = \frac{10^{10}\ 10^{5}\ 10^{5}}{1^{2}}$$

$$\cong 10^{20}\ N\ !!!$$

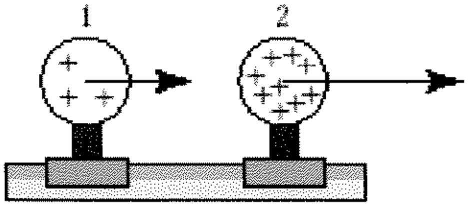
NORMAL MATTER HAS HIDDEN IN IT <u>ENORMOUS</u> ELECTRICAL FORCES.

WHY DON'T WE OBSERVE SUCH FORCES ??

HOW MANY ELECTRONS WOULD WE HAVE TO RUB OFF TO GET FORCES LIKE THOSE WE'VE SEEN HERE?

Two uniformly charged spheres are firmly fastened to and electrically insulated from frictionless pucks on an air table. The charge on sphere 2 is three times the charge on sphere 1. Which force diagram correctly shows the magnitude and direction of the electrostatic forces?

1.



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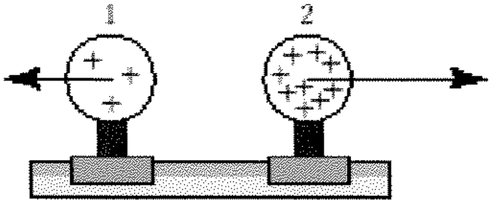

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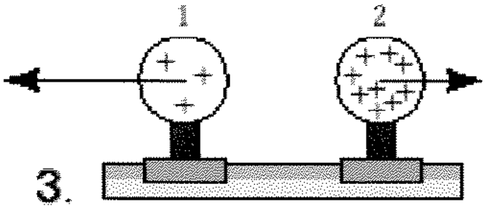

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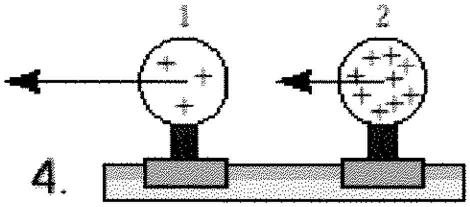

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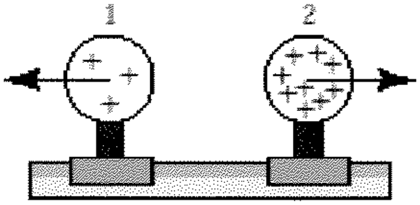

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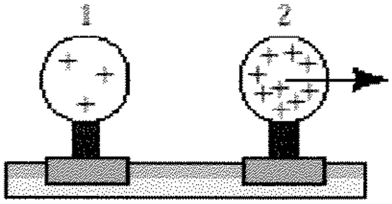


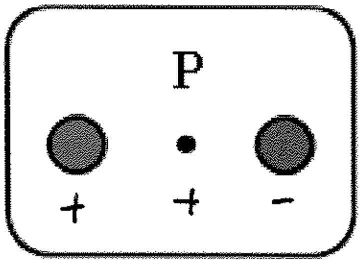
7. None of the above

Below are shown 4 sets of charges.
Red charges are "+" and blue are "-".

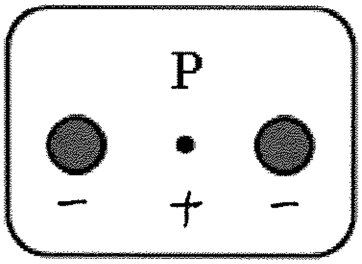
They have the same magnitude (20 μC) but are of opposite sign.

A charge of +5 μC is placed at point P.

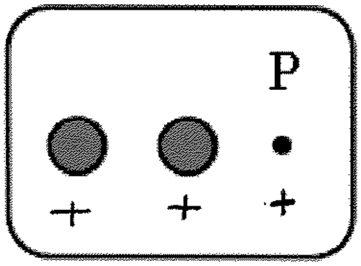
Rank the diagrams according to the magnitude of the net force on P from largest to smallest.



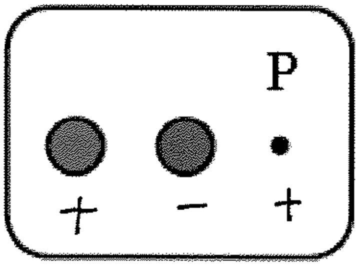
A



B



C



D

Multiple Charges: Superposition

- One charge is too simple. Most of the time there are lots of charges.
- What do we do if we have more than one source charge creating forces on our test charge?

Superposition: We calculate the force each charge produces and add them like vectors – just like we would any forces.

Example