

University Physics 2 (Calculus Based)

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Please pick up syllabus.



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Today

- Course Overview
 - Syllabus
 - Blackboard
 - course web site
 - see course home page: madisoncollegephysics.net/phys2spr25
 - Homework 1
- Clickers
- Chapter 5: Electric Charges and Fields

Clickers

- pick up a clicker (numbers on next page)
 - write down its number
- power on
 - replace (3) batteries if needed
- click in
 - make sure you get a green light

Clickers

name	clicker
Akere	19
Baker	27
Bayer	34
Benavides	39
Bhandare	41
Claas	43
Deteyawa	7
Drozd	6
Flesch	2
Garcia	21

name	clicker
Gartner	30
Giefer	31
Heller	37
Hudson	45
Inan	48
Jallow	11
Jenkins	12
Jerome	17
Kotte	3
McCarty	32

name	clicker
Mileham	10
Nowak	18
Peterson	28
Pulvermacher	33
Reyes	4
Richards	50
Salman	15
Shebani	20
Temple	16
Vargas	26
Zuehlke	42

Electricity and Magnetism

$$F = G \frac{m_1 m_2}{r^2}$$

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



Electricity and Magnetism

Chapter 5: Electric Charges and Fields

5.1 Electric Charge

5.2 Conductors, Insulators, and Charging by Induction

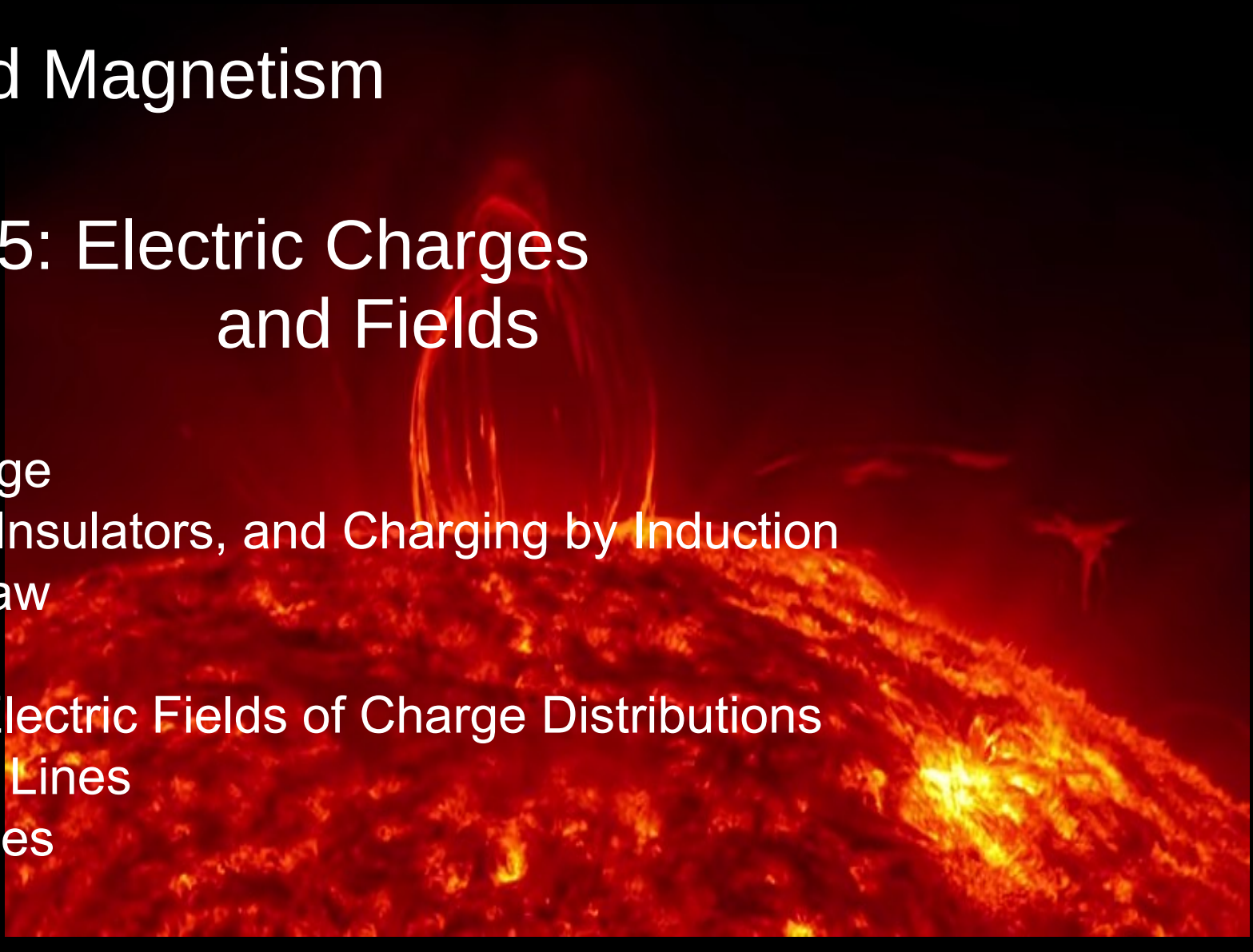
5.3 Coulomb's Law

5.4 Electric Field

5.5 Calculating Electric Fields of Charge Distributions

5.6 Electric Field Lines

5.7 Electric Dipoles



Electric Charge

- positive and negative, carried (ordinarily) by the proton and electron
- Symbol q (or Q); units Coulombs (C)
- charge is quantized, appearing in multiples of
$$e = 1.602 \times 10^{-19} \text{ C}$$
- electrons can easily move around to charge objects
 - protons are not mobile

Materials: Conductors & Insulators

- charges (electrons) move easily through a **conductor**
 - charges in a conductor are like small balls in a jar that repel each other
- charges cannot move through an **insulator**
 - however an insulator can become electrically charged

Other materials:

semiconductors: electrical conductivity can be controlled

superconductors: zero resistance to electron flow

Electric Charge

Which has the most negative net charge?

Proton



(a)

Electron



(b)

17 protons
19 electrons

(c)

1,000,000 protons
1,000,000 electrons

(d)

Glass ball missing
3 electrons

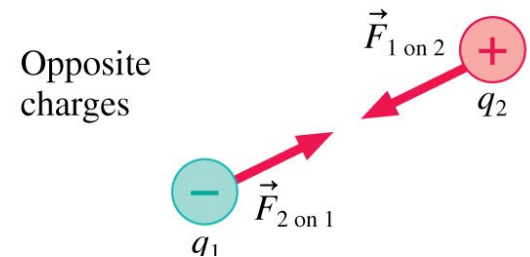
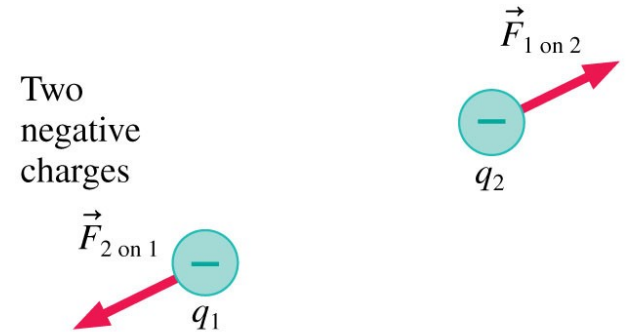
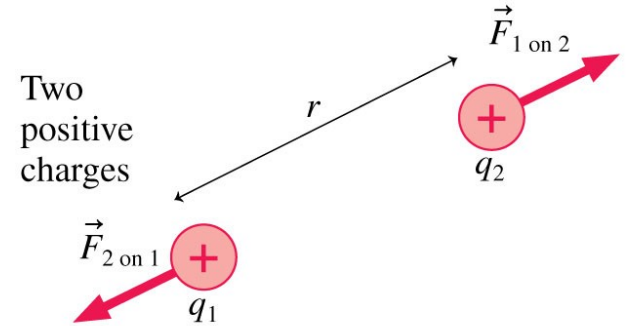


(e)

Coulomb's Law

The force exerted by charge 1 on charge 2 is

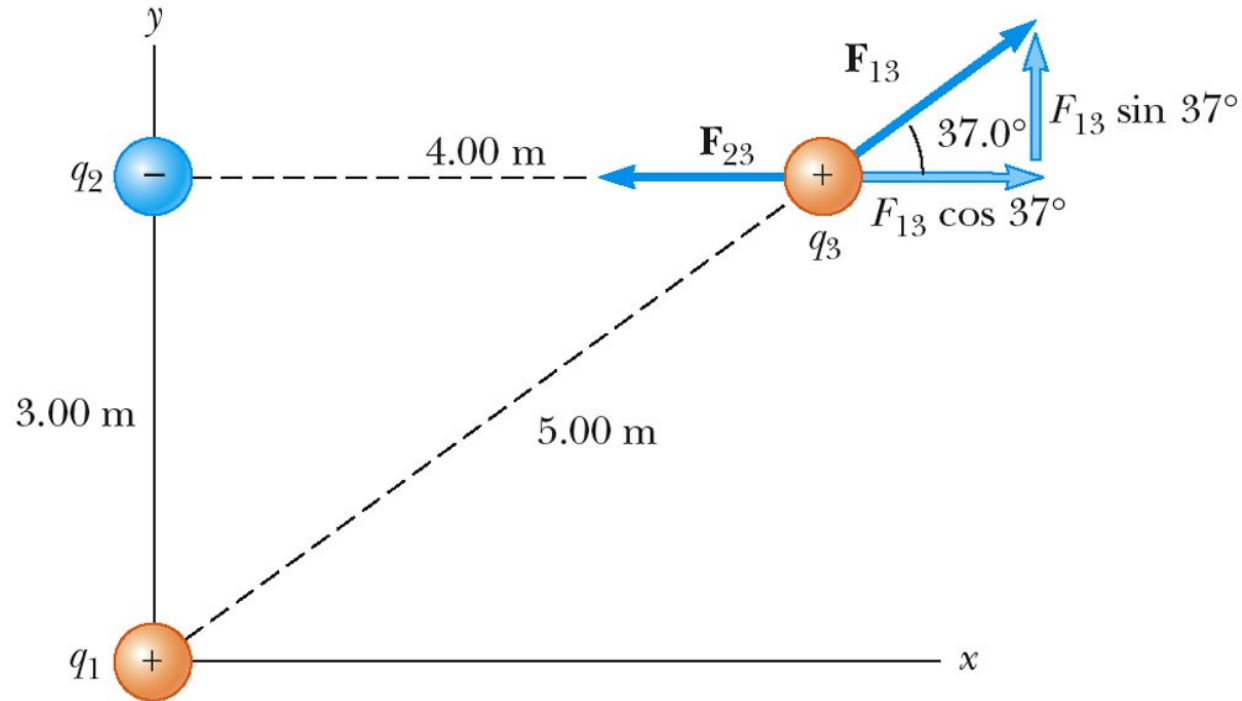
$$\vec{F}_{1 \rightarrow 2} = k \frac{q_1 q_2}{r^2} \hat{r}_{1 \rightarrow 2}$$



Coulomb's Law

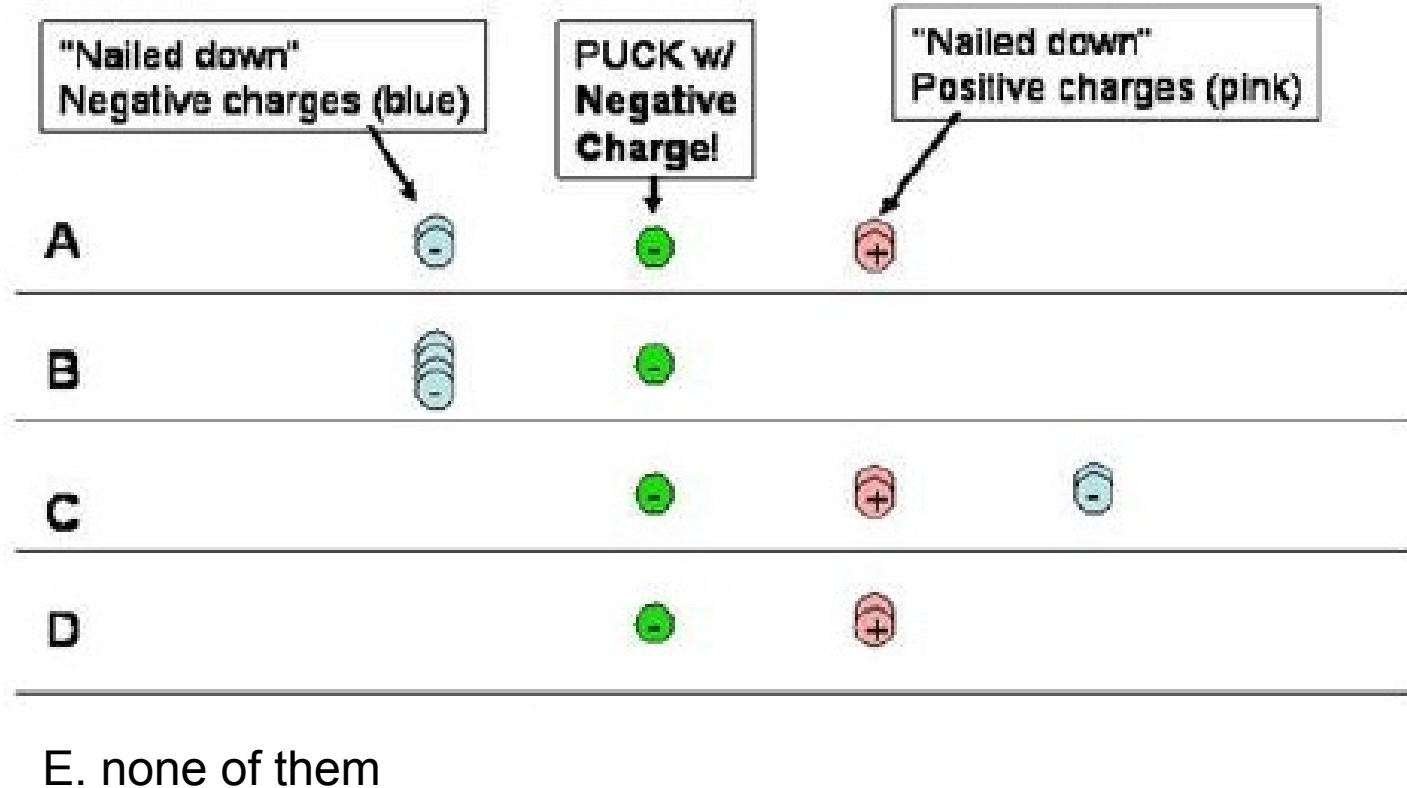
The net force on charge 3 is a vector sum.

$$\vec{F} = \vec{F}_{13} + \vec{F}_{23}$$



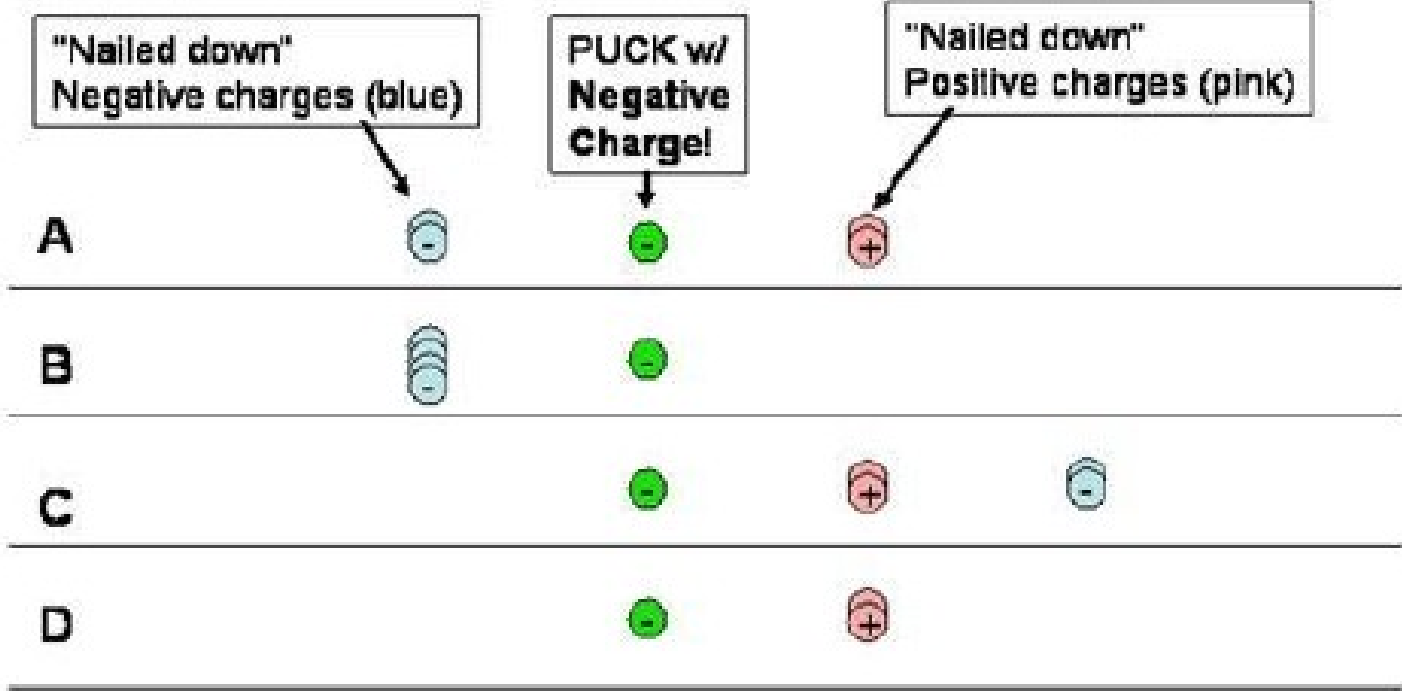
Coulomb's Law

Which of the green "pucks" feels a net force to the left?



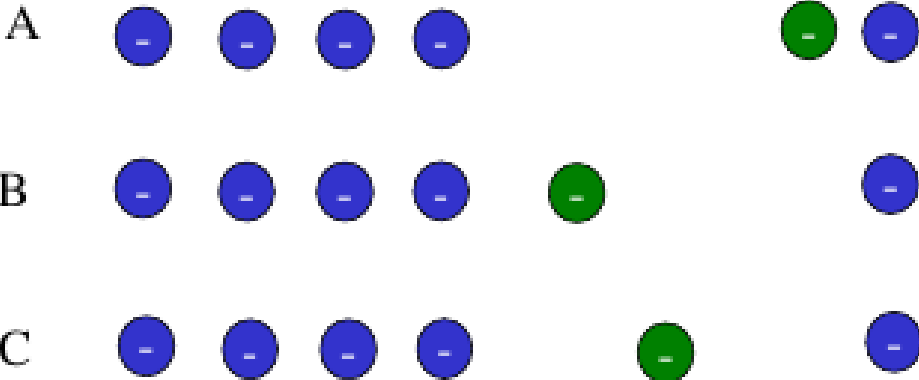
Coulomb's Law

Which puck feels the greatest force?



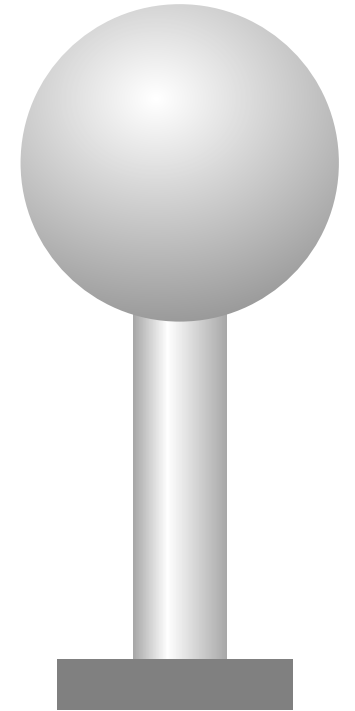
Coulomb's Law

Which puck is most likely to not move?



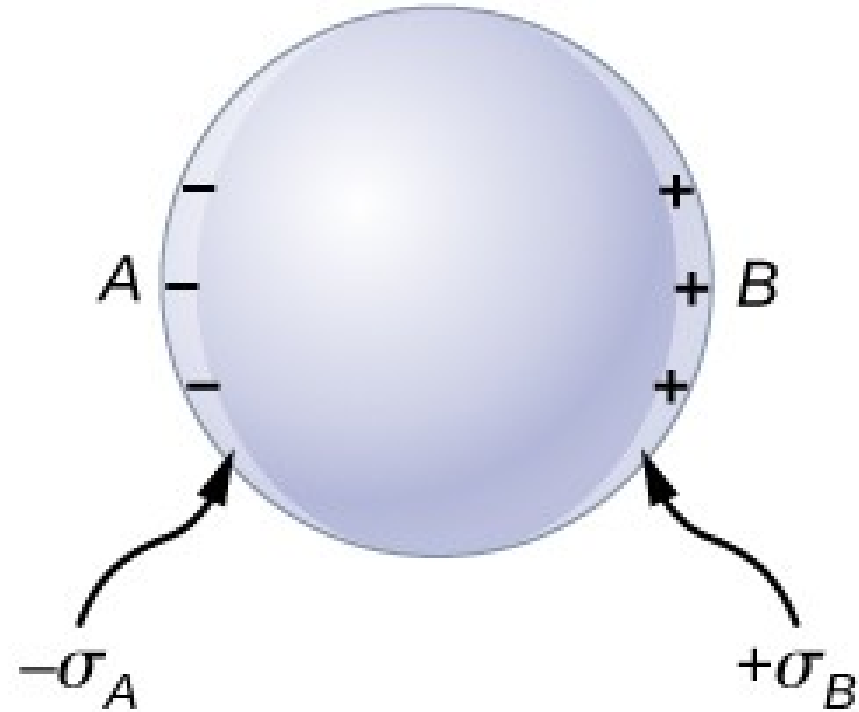
Conductors

A neutral conductor is full of positive and negative charges, free to move.



Conductors

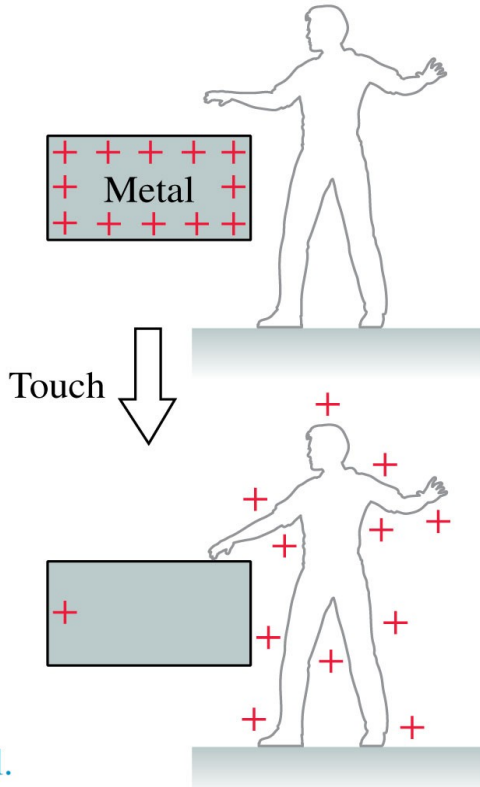
What happens when you bring an external charge near a conductor?



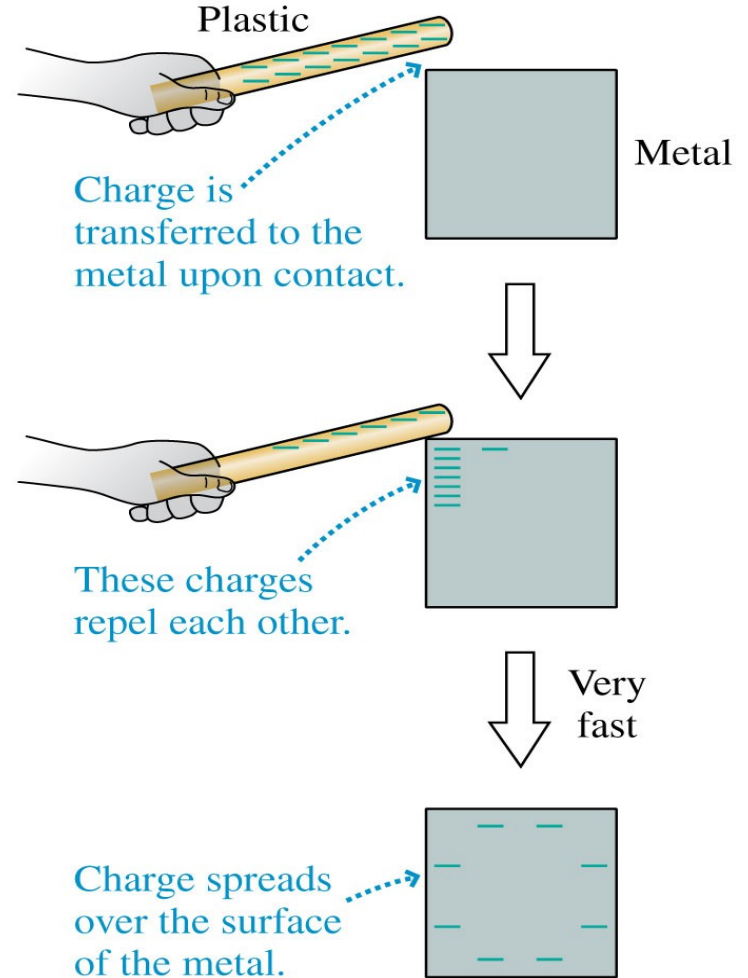
Charging a Conductor

charging by conduction:

The metal is positively charged

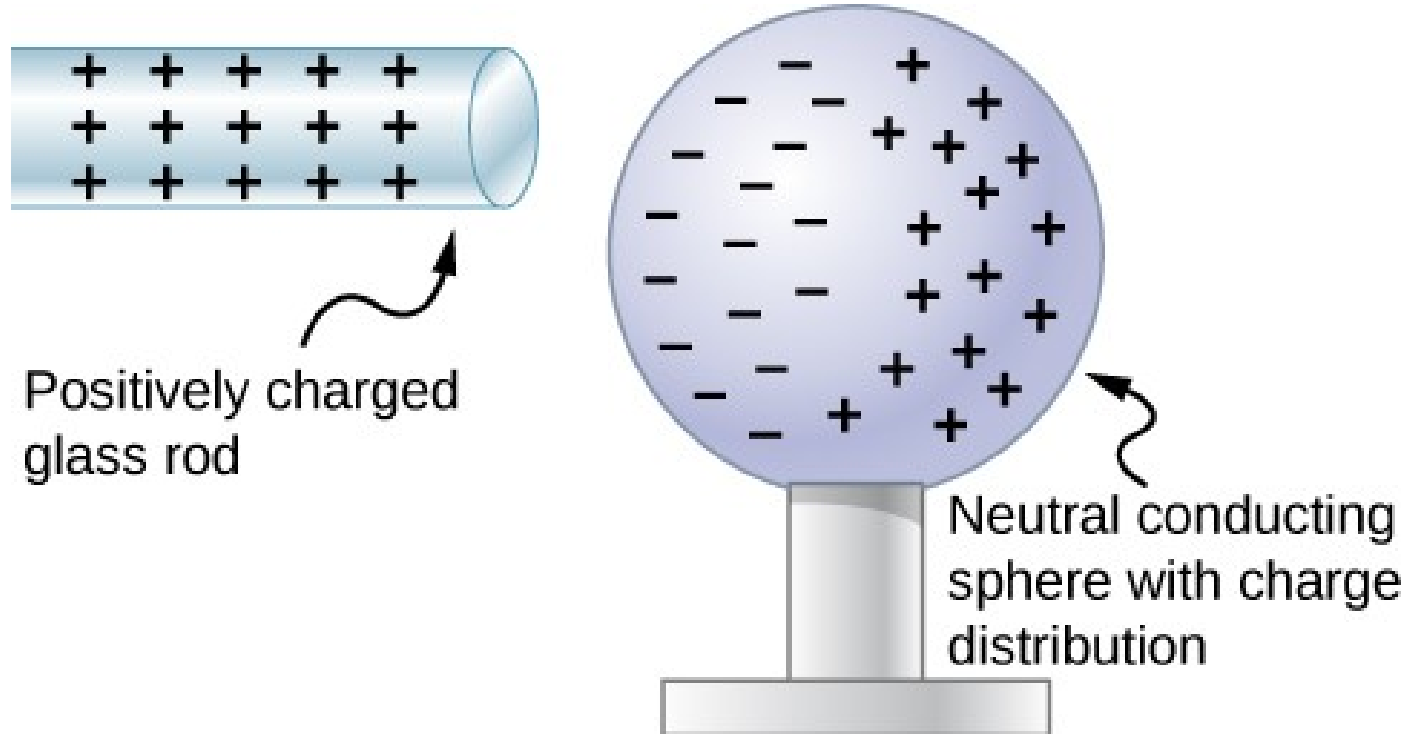


Charges spread through the metal + human system. Very little charge is left on the metal.



Charging a Conductor

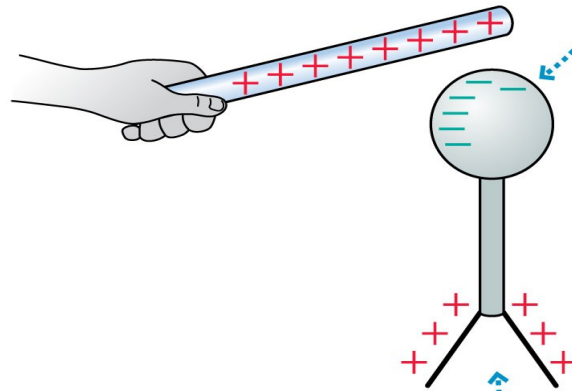
charging by induction:



Charging a Conductor

charging an electroscope by induction:

The electroscope is polarized by the charged rod. The sea of electrons shifts toward the positive rod.

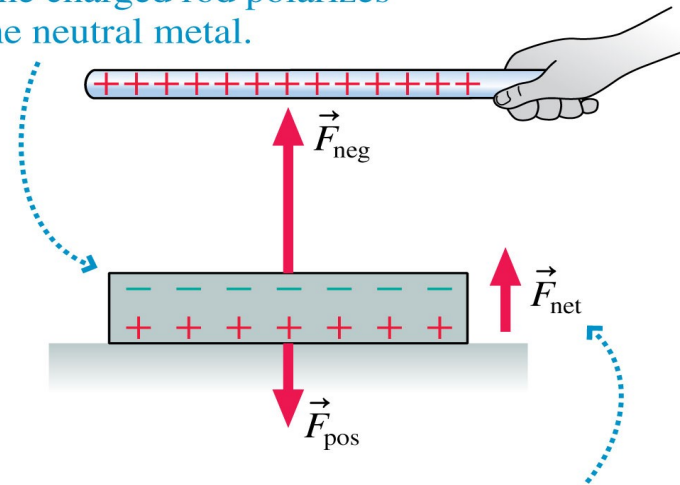


Although the net charge on the electroscope is still zero, the leaves have excess positive charge and repel each other.

Charging a Conductor

charging by induction:

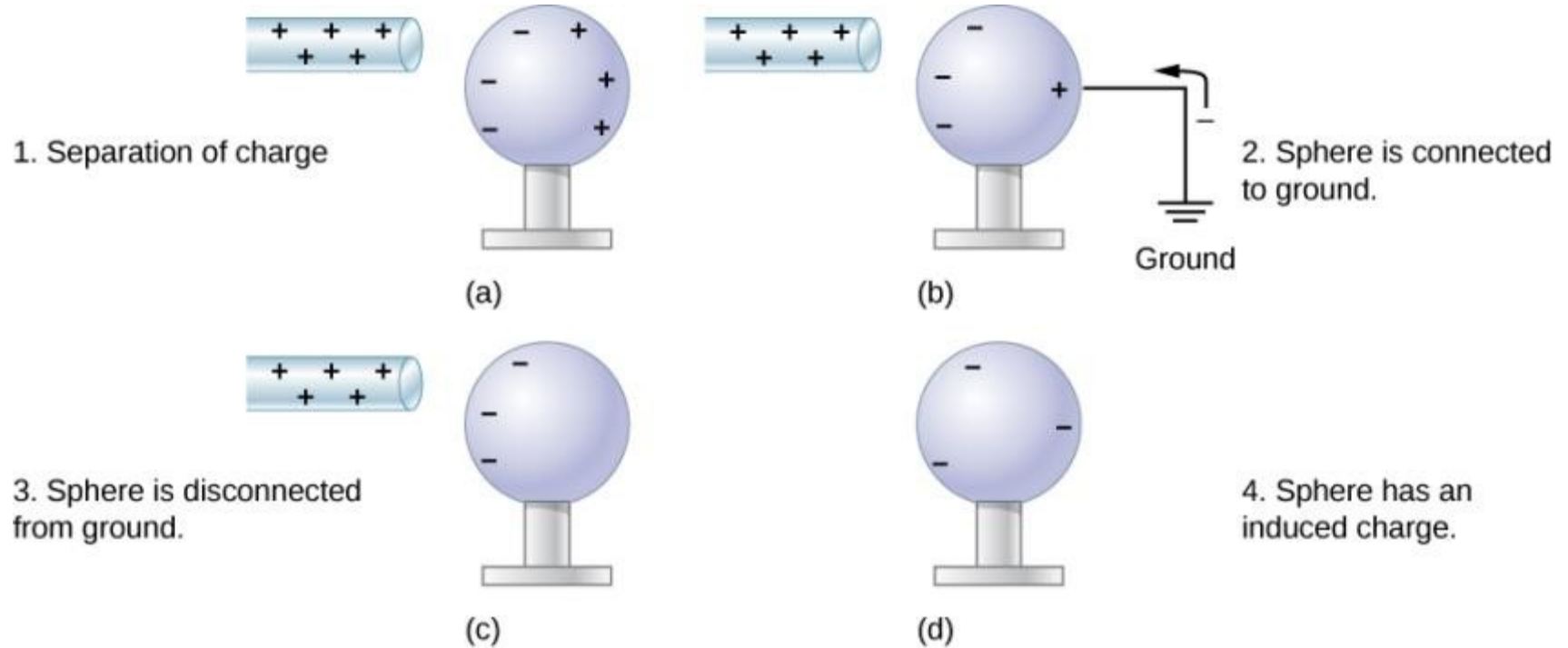
1. The charged rod polarizes the neutral metal.



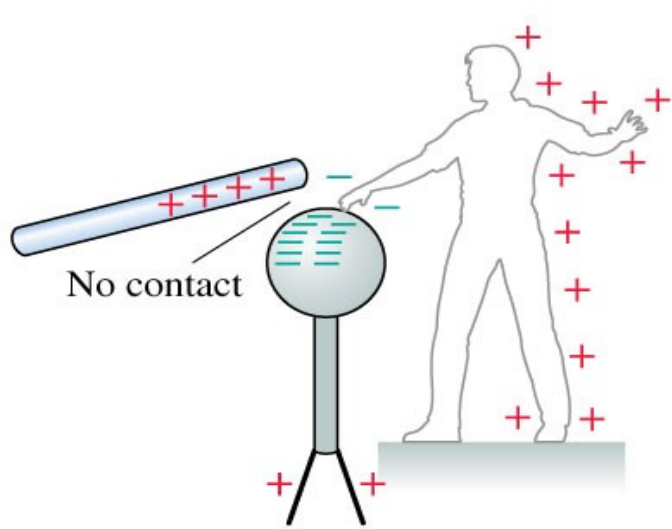
2. The nearby negative charge is attracted to the rod more strongly than the distant positive charge is repelled, resulting in a net upward force.

Charging a Conductor

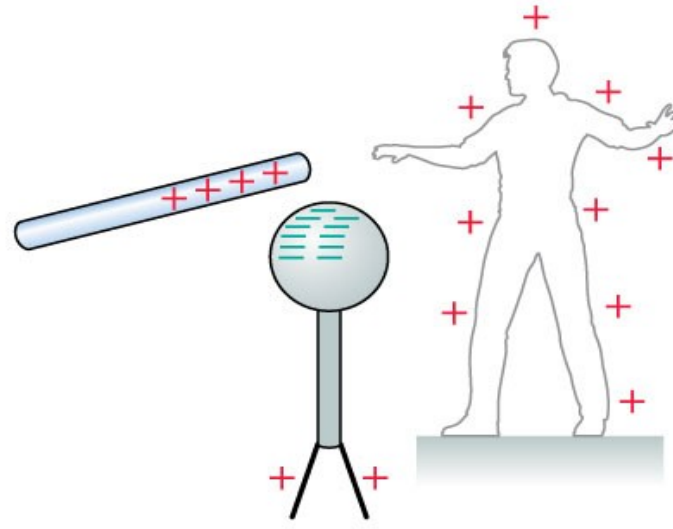
charging by induction:



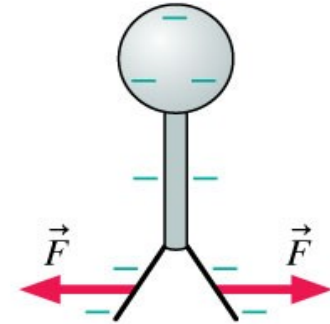
Charging a Conductor



1. The charged rod polarizes the electroscope + person conductor. The leaves repel slightly due to polarization.



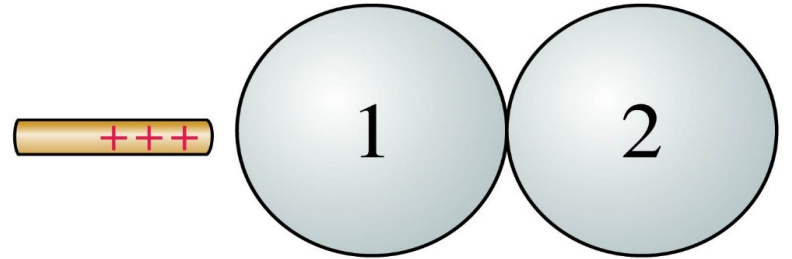
2. The negative charge on the electroscope is isolated when contact is broken.



Charging a Conductor

Metal spheres 1 and 2 are touching. Both are initially neutral.

- The charged rod is brought near.
- The spheres are separated.
- The charged rod is then removed.



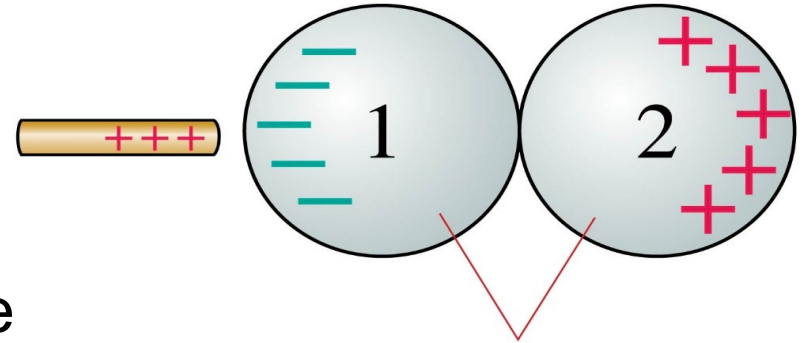
Afterward, the charges on the sphere are

- Q_1 is + and Q_2 is +
- Q_1 is + and Q_2 is -
- Q_1 is - and Q_2 is +
- Q_1 is - and Q_2 is -
- Q_1 is 0 and Q_2 is 0

Charging a Conductor

Metal spheres 1 and 2 are touching. Both are initially neutral.

- The charged rod is brought near.
- The spheres are separated.
- The charged rod is then removed.



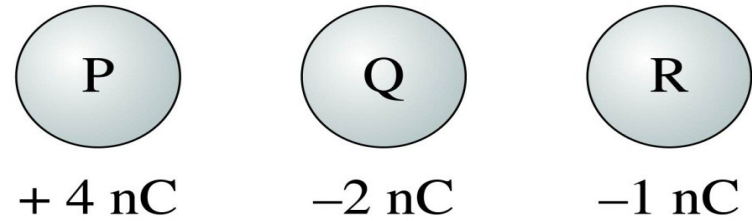
Charge polarization

Afterward, the charges on the sphere are

- Q_1 is + and Q_2 is +
- Q_1 is + and Q_2 is -
- Q_1 is - and Q_2 is + ✓
- Q_1 is - and Q_2 is -
- Q_1 is 0 and Q_2 is 0

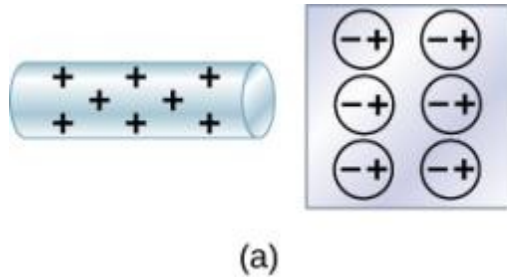
Charging a Conductor

Identical metal spheres are initially charged as shown. Spheres P and Q are touched together and then separated. Then spheres Q and R are touched together and separated. Afterward the charge on sphere R is

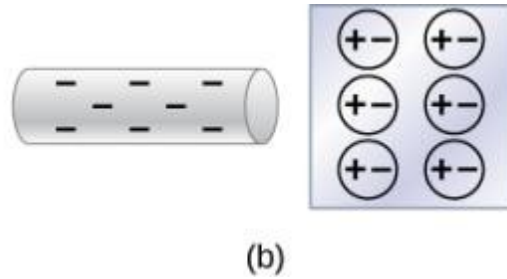


- A. -1 nC or less
- B. -0.5 nC
- C. 0 nC. ✓
- D. +0.5 nC
- E. +1.0 nC or more

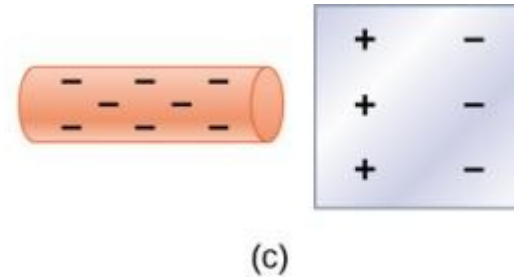
Charge Induction



insulator



insulator



conductor

(see balloon sim)

Charge Induction

A rod attracts a positively charged hanging ball.
The rod is

- A. Positive.
- B. Negative.
- C. Neutral.
- D. Either A or C.
- ✓ E. Either B or C.

