

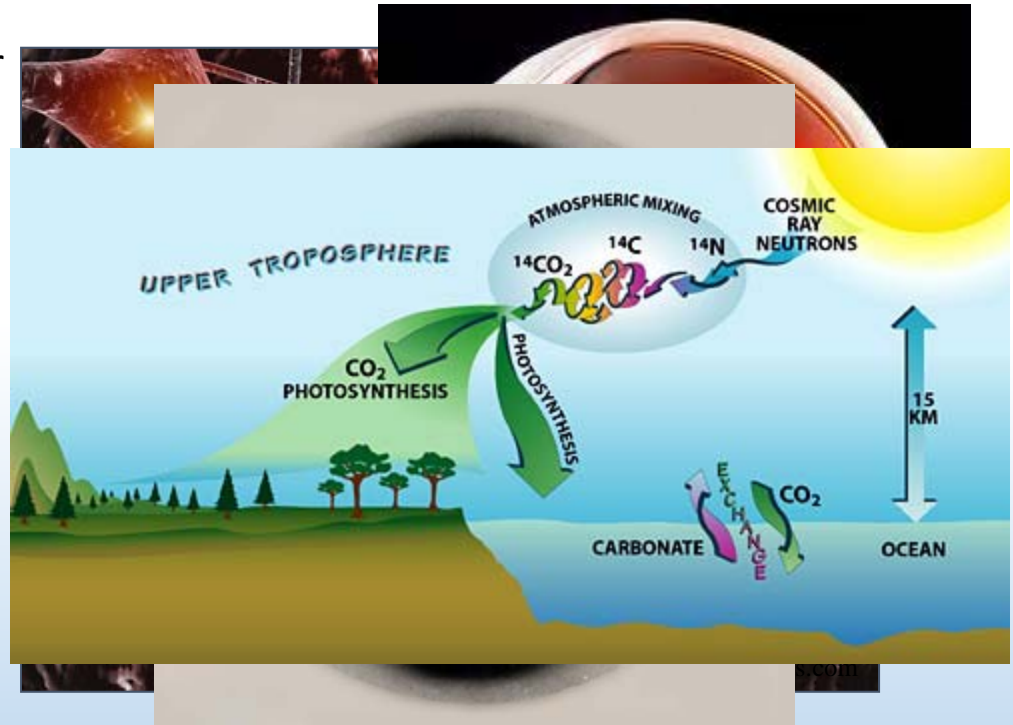
Welcome to Physics 102!

- Electricity & Magnetism

(forces that hold atoms & molecules together
living cells)

- Optics

- Atomic & Nuclear Physics



Please turn cell phones off

Meet the course directors

- Lecturer: Yann Chemla
ychemla@illinois.edu
Biophysics (<http://www.illinois.edu/~ychemla>)
Office Hours: Monday 3-4pm, 161 Loomis



- Discussion coordinator: Yoshi Oono
- Lab & exam coordinator: Karin Dahmen



When emailing me:

- Email must be sent from @illinois.edu
- Subject line should begin with “PHYS102 question:”
- Message should contain:
your full name, NetID, discussion section, TA name
- Questions about physics:
Do not use email, use office hours (see course website)
- Before emailing:
Verify information is not already on the course website
The course directors reserve the right to penalize your HW score if you ask questions via email that are answered on the website

Course Website

- <http://courses.physics.illinois.edu/phys102/>

- First Discussion: Syllabus

What you should be doing and when you should be doing it

Lectures posted after they are given

- First Lab:
- Exam dates:
- Course Description / Excused Absences
- Required Materials

Be sure to register your i-Clicker prior to lecture

Course Philosophy

- Think about it (pre-lecture & checkpoint)
- Untangle it (lectures)
- Play with it (labs)
- Challenge yourself (homework)
- Close the loop (discussion/quiz)

New features
FA14-SP15

The order is important!

Pre-lectures & CheckPoints & ACTS

View Pre-lecture

2 points for completing Pre-lecture



Answer CheckPoints

1 point for attempt at CheckPoint

ACTS: use iClicker in class

1 point for answering the questions

Bonus points for correct answers



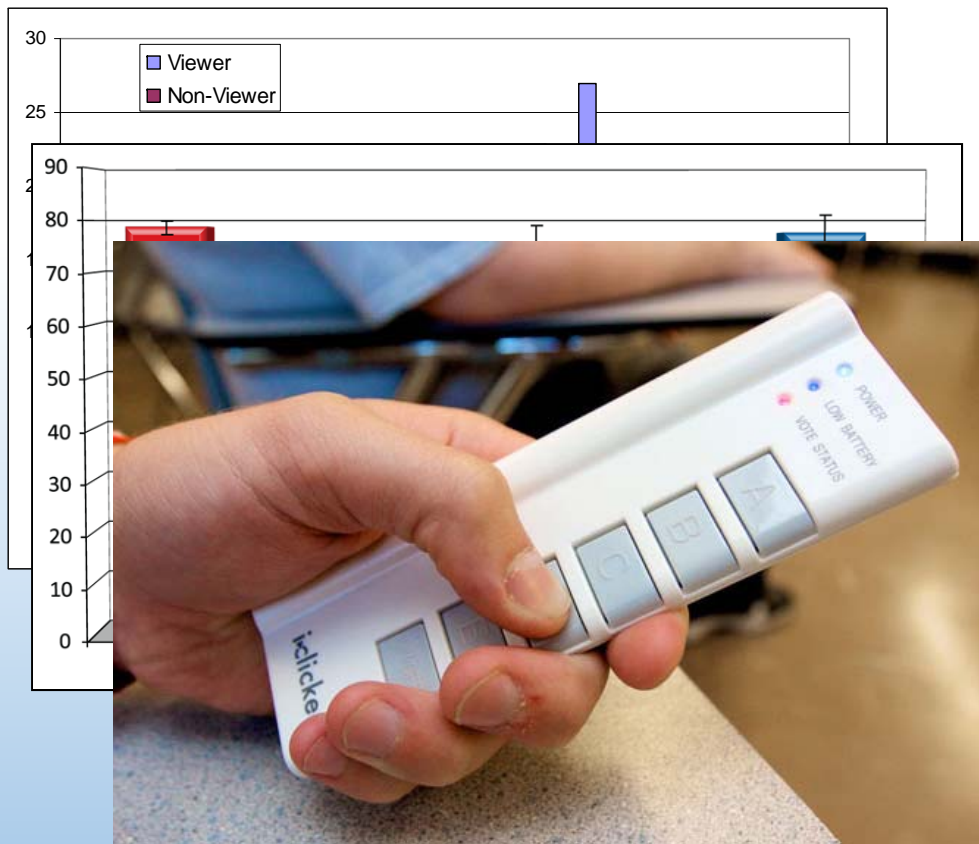
- 2 points/Pre-lecture x 25 lectures = 50 points
- 2 points/Checkpoint & Lecture x 25 lectures = 50 points
- Note that there are 28 lectures, so you have some free ones

Register i-Clicker before lecture: **gradebook**

Lecture preparation & participation

Pre-lecture is an online, animated textbook

Students do better when they come prepared & participate!





ACT: iClicker test

- Let's take a poll. What is your major?
 - A. pre-med
 - B. biology (MCB or IB), non pre-med
 - C. other
 - D. undecided
- iClicker registration problems? Check registration in the Gradebook first.

Course grading

Pre-lectures	50
Checkpoints & Lectures	50
Homework	150
In-class discussion quizzes	100
Labs (+ pre-lab)	150
Hour exams (3 x 100 each)	300
Final Exam	200
Total	1000

} We drop 3 lowest scores

} We drop the lowest score
HW: 80% credit up to 1 week late

- **Bonus Points:** You can earn up to 1 extra bonus point in every lecture (for a maximum of 25 bonus points for the semester) by getting the right answers to all of the iclicker questions. They are added to non-exam scores at the end of semester
- **Excused absences:** We DO NOT excuse missed Pre-lectures, Checkpoints, or Homework.

Physics Dept. Letter Grades

We do not use traditional 90, 80, 70, etc. letter grade cutoffs

- **This is a challenging course!**
- Usually, mean & median = B–
20% of students get C or lower

- Keys to doing well:

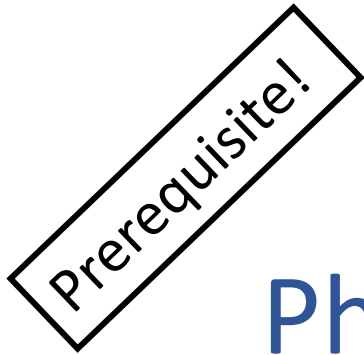
Prepare for lectures (Pre-lectures, reading)

Don't miss out on “easy” points (Pre-lectures, Checkpoints, HW)

Keep up with the material

<https://courses.physics.illinois.edu/phys102/course-grading.asp>

A+	1000-950
A	950-920
A-	920-900
B+	900-880
B	880-860
B-	860-835
C+	835-810
C	810-780
C-	780-750
D+	750-720
D	720-690
D-	690-610
F	0-610



Course content

Physics 101

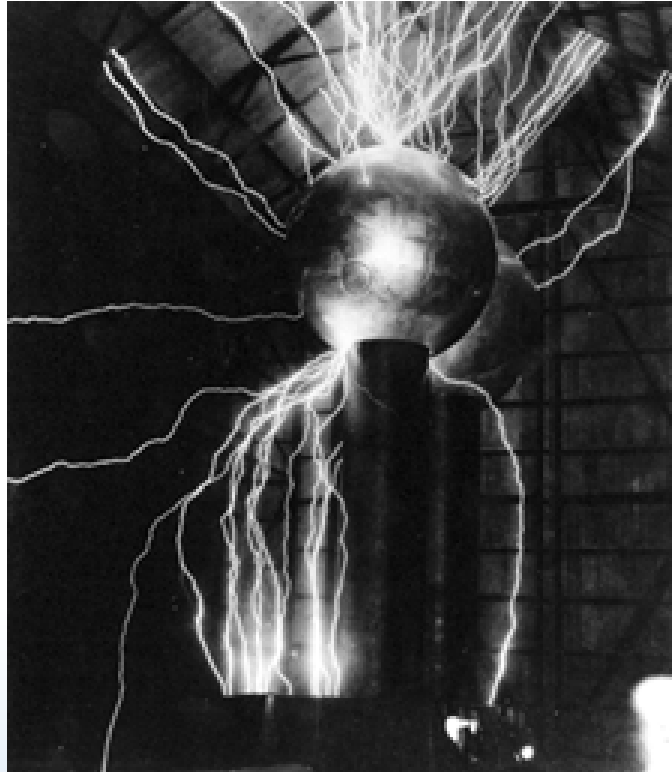
Macroscopic

- Kinematics
- Forces
- Energy
- Fluids
- Waves (Sound)

Physics 102

Microscopic

- Electricity & circuits
- Magnetism & induction
- Optics
- Atomic & nuclear physics



Phys 102 – Lecture 1

Electric charge & Coulomb's law

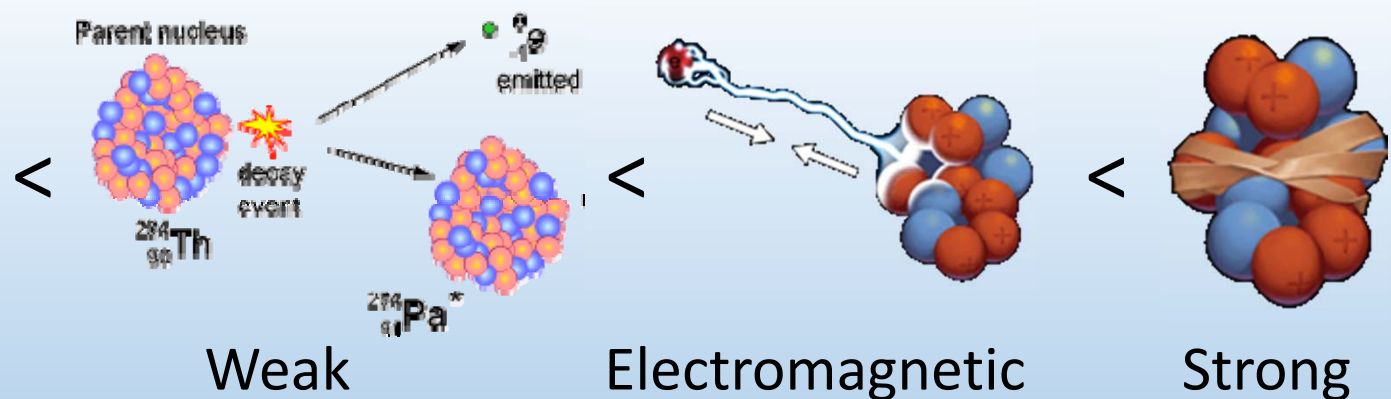
4 Fundamental forces of Nature

Phys. 101 Gravitational force (solar system, galaxies)

Phys. 102 { Electromagnetic force (atoms, molecules)
 { Strong force (atomic nuclei)
 { Weak force (radioactive decay)



Gravitational



weakest

strongest

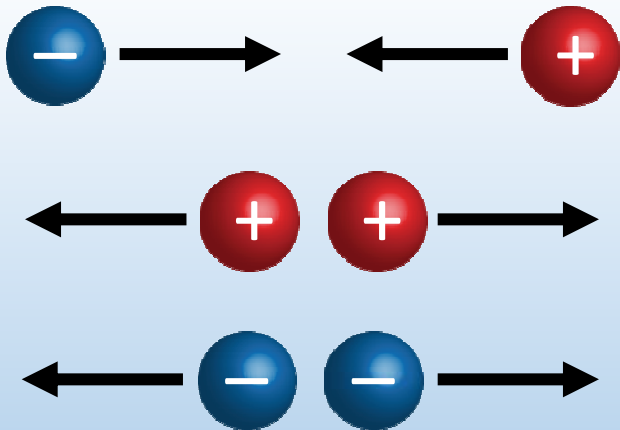
Electric charge

Charge is an intrinsic property of matter, like mass

- EM force -> electric charge

Positive & negative charge

Opposite charges attract, like charges repel



- Gravity -> mass

Mass always positive

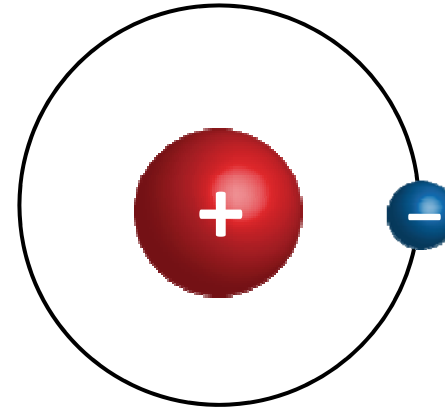
Gravity always attractive



DEMO

Units of electric charge

- Symbol: q or Q
- Unit: [Coulomb] = [C]
Electron: $-e = -1.6 \times 10^{-19} \text{ C}$
Proton: $+e = +1.6 \times 10^{-19} \text{ C}$



- How much charge is 1 C?

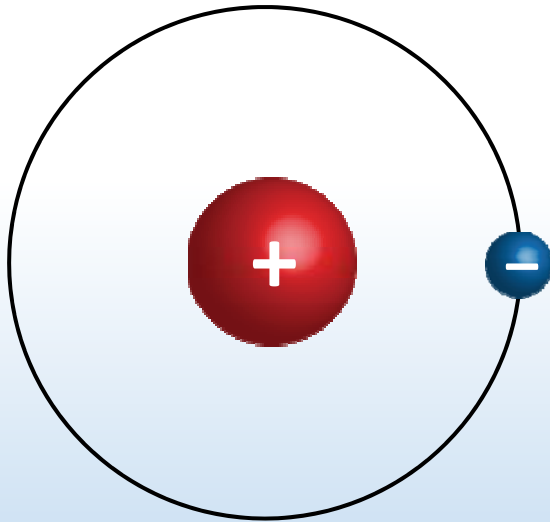
Imagine you could separate H^+ and OH^- ions in pure water (pH 7.0)



You would need
25 gallon jugs of water!

Conservation of charge

Charges are physical entities (ex: electrons, protons) & cannot be created or destroyed



The net charge in a closed system is conserved

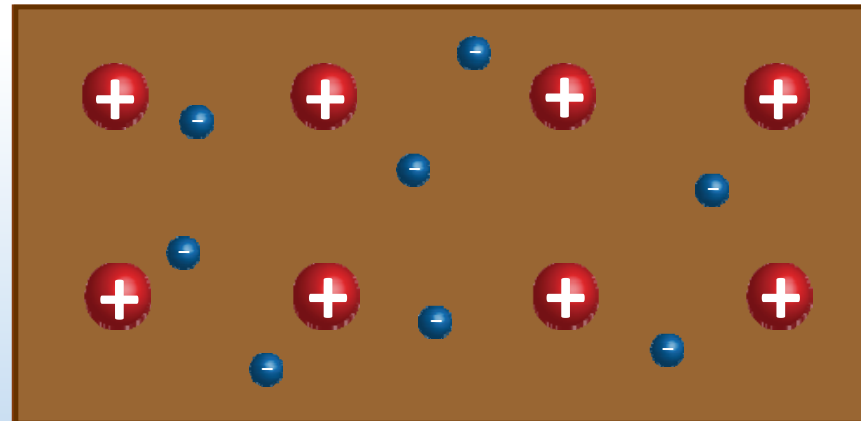
However, charges (often electrons) can be transferred from one object to another

Conductors & insulators

Q: How do electrons behave
in a perfect conductor?



Q: How do electrons behave
in a perfect insulator?



Most things are in between
perfect conductor / insulator

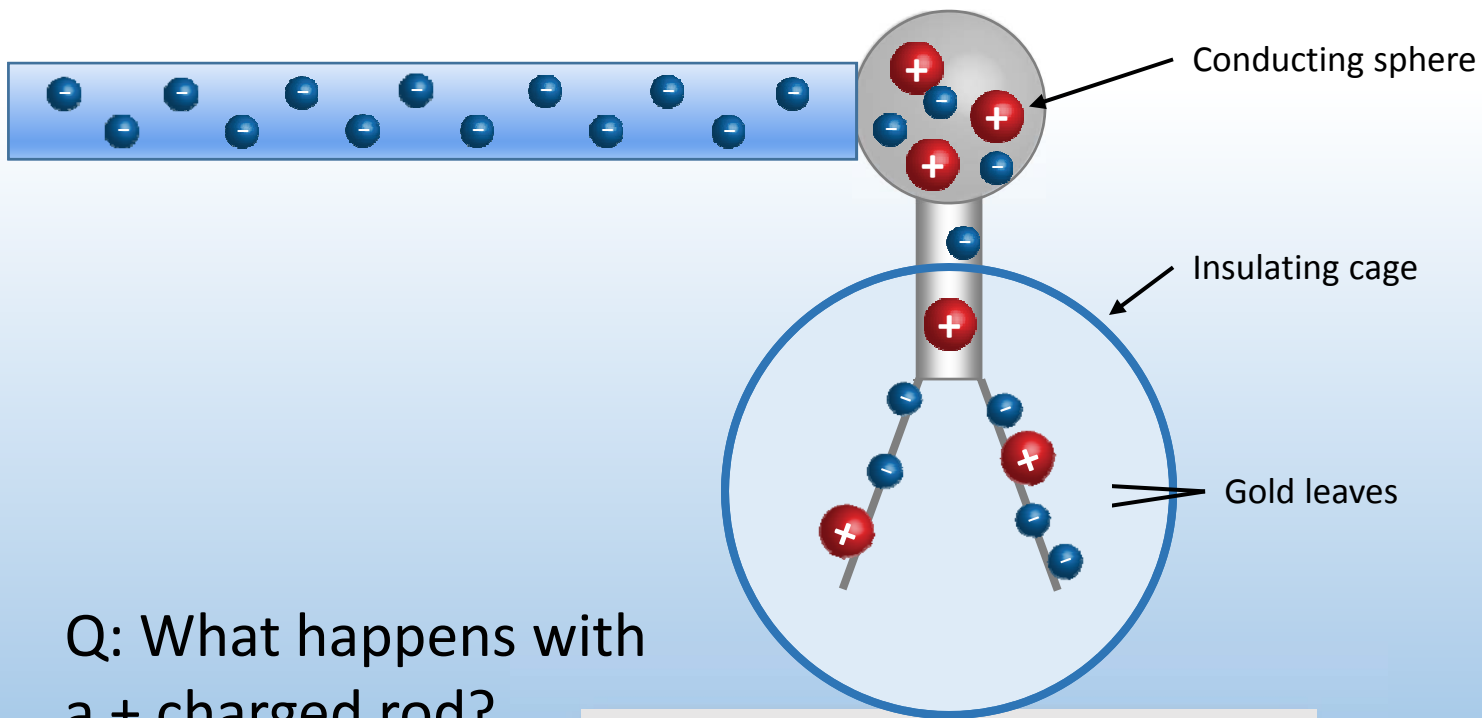
Demo: electroscope

- Charging by conduction

Charged rod is brought near scope

Charged rod touches scope transferring some charge

Scope is left with same charge as rod



Q: What happens with
a + charged rod?

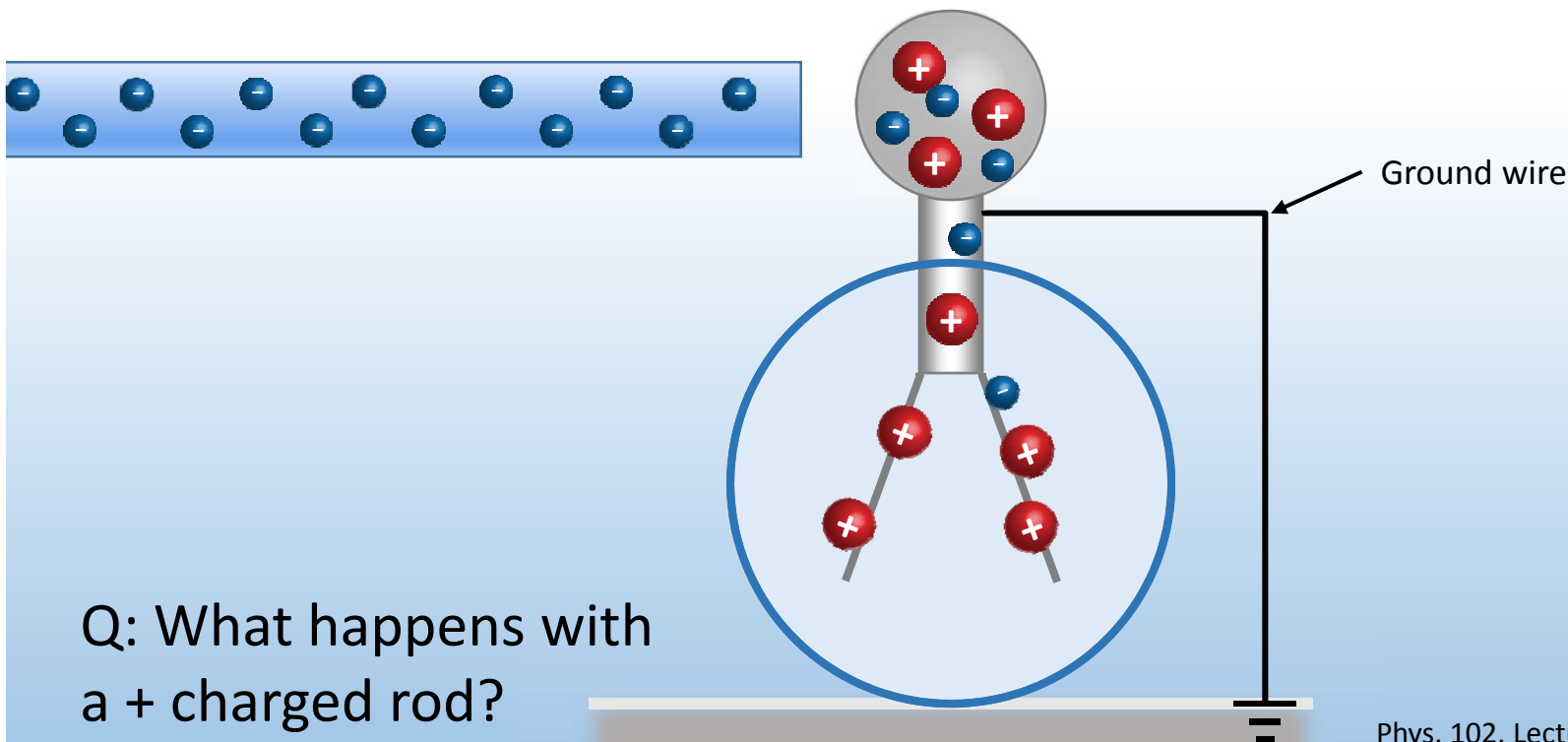
Demo: electroscope

- Charging by *induction*

Charged rod is brought near scope (but does NOT touch)

Scope is briefly grounded allowing charge to flow on (or off)

Scope is left with opposite charge as rod





ACTs: Electroscope

A *positively* charged rod is used to charge an electroscope by *induction*. What is the resulting net charge on the electroscope?

A. positive

B. zero

C. negative

If the conducting electroscope were replaced by an *insulating* ball and then charged by induction as above, what would be the net charge on the ball?

A. positive

B. zero

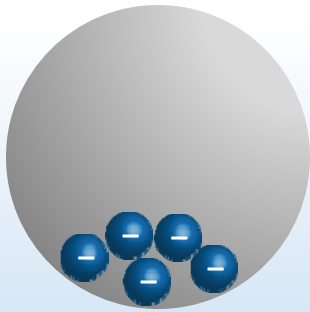
C. negative



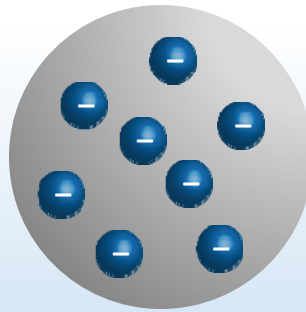
ACT: Conductors

Electrons are placed on a neutral conducting sphere. Which of the following diagrams correctly depicts how the charges are distributed?

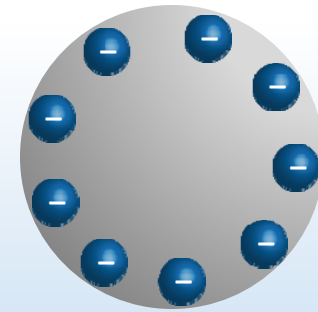
A. At the bottom



B. Spread uniformly



C. On the surface



Fundamental concepts:

- 1) Charges move freely in conductor
- 2) Like charges repel

DEMO

Coulomb's Law

(1785)

Vector

Force between charges q_1 and q_2 separated a distance r :

Magnitude

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

$[N]$ $[C]$ $[m]$

“Coulomb constant”

$$k = 9 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$$

$$\text{Or: } F = \frac{1}{4\pi\epsilon_0} \frac{|q_1| |q_2|}{r^2}$$

“Permittivity of free space”

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / \text{N} \cdot \text{m}^2$$

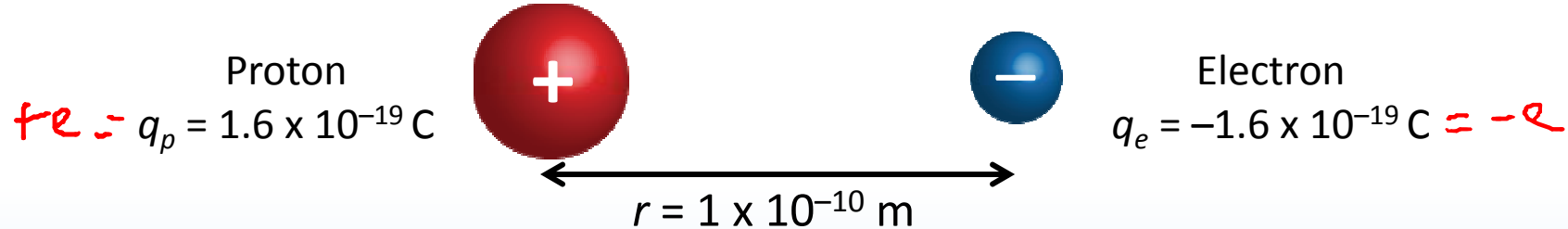
Direction

Opposite charges attract, like charges repel

Sign of charges matters here ↑

Calculation: Coulomb's Law

What is the magnitude of the force on the proton due to the electron in hydrogen?



$$F = \frac{k|q_p||q_e|}{r^2} = \frac{9 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2 |1.6 \times 10^{-19} \text{ C}| |-1.6 \times 10^{-19} \text{ C}|}{(10^{-10} \text{ m})^2} = 2.3 \times 10^{-8} \text{ N}$$

Compare to gravitational force between them (Phys. 101)

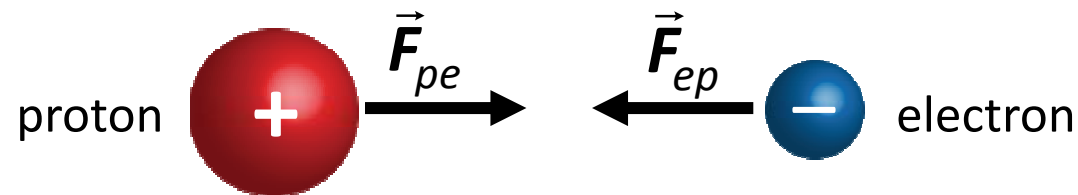
$$F_G = \frac{Gm_p m_e}{r^2} = \frac{6.7 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2 (1.7 \times 10^{-27} \text{ kg})(9 \times 10^{-31} \text{ kg})}{(10^{-10} \text{ m})^2} = 1.0 \times 10^{-47} \text{ N}$$

1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000 !



ACT: Coulomb's Law

What is the direction of the force on the proton due to the electron in the hydrogen atom?



A. Left

B. Right

C. Zero

What is the direction of the force on the *electron due to the proton*?

F_{pe} = force on **proton** due to **electron**

F_{ep} = force on **electron** due to **proton**

Summary of Today's Lecture

- Electric charge
- Conservation of charge
- Conductors and insulators
- Coulomb's Law for the force between charges

$$F = \frac{kq_1q_2}{r^2}$$

Much more on Coulomb's Law in next lecture