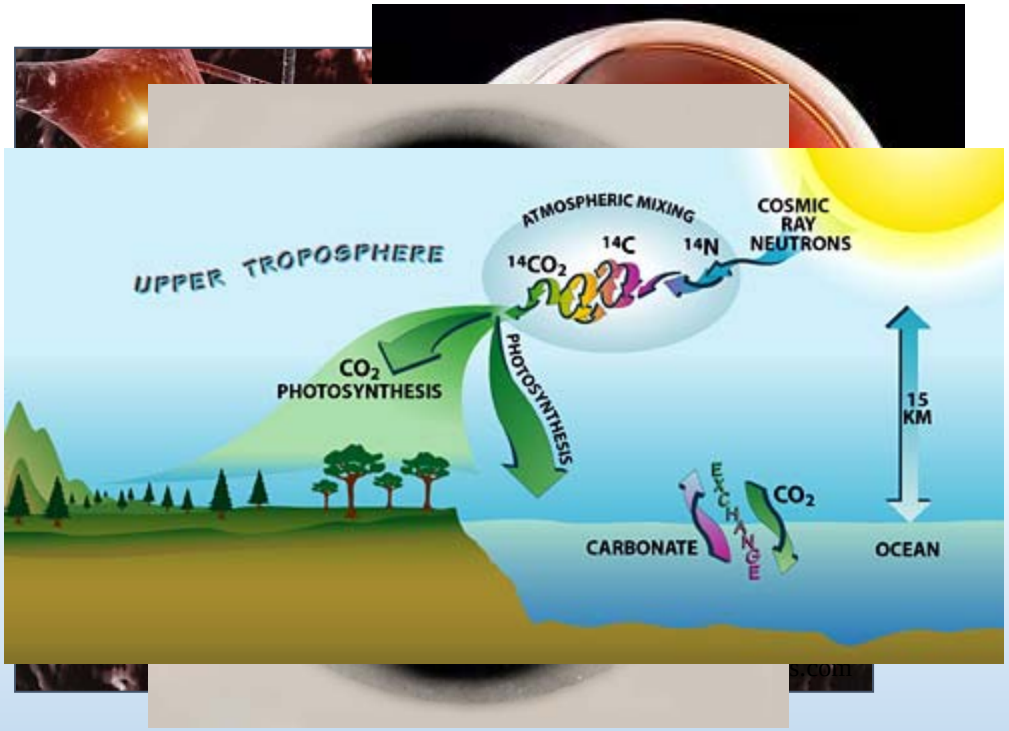
Welcome to Physics 102!

- 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 2-3pm, 161 Loomis

- Discussion coordinator: Elaine Schulte
- Lab & exam coordinator: Bryce Gadway

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 this semester

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

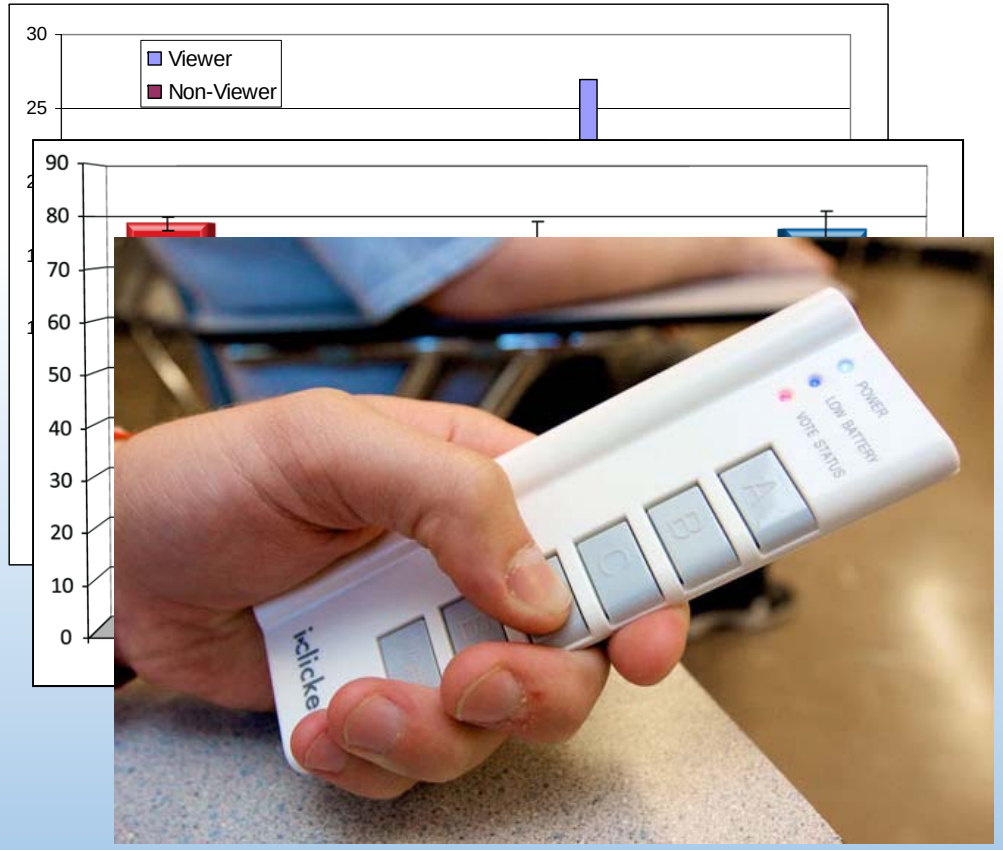
- 2 points/Pre-lecture x 25 lectures = 50 points
- 2 points/Checkpoint & Lecture x 25 lectures = 50 points
- Note that there are 28 lectures, so you have some free ones

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.

- 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/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

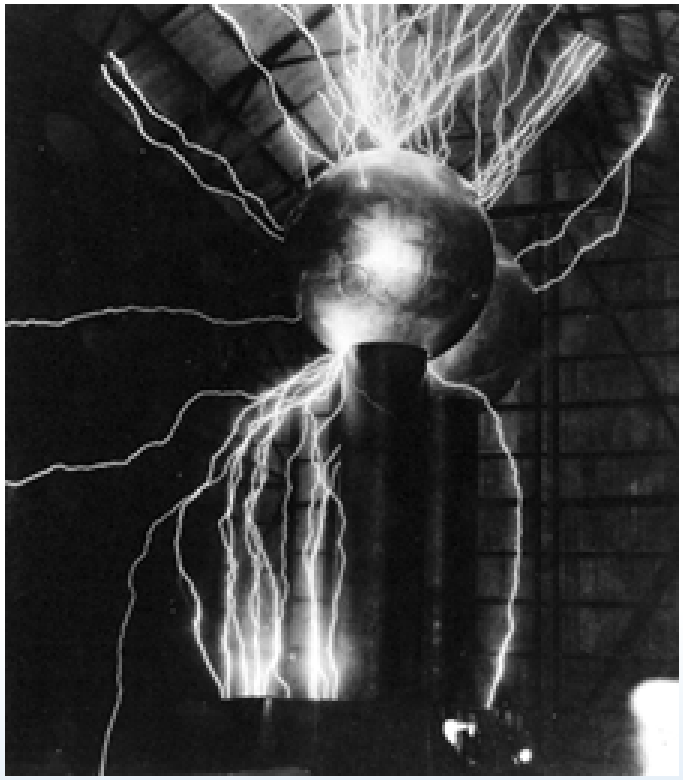
Macroscopic

- 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

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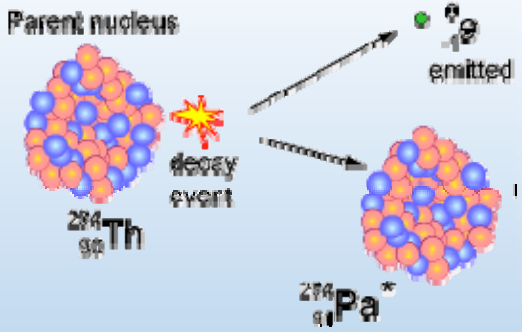

Weak

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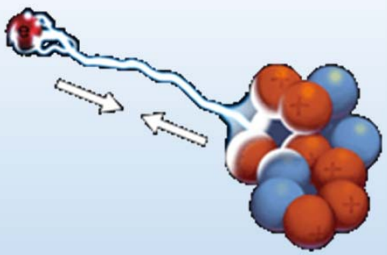

Electromagnetic

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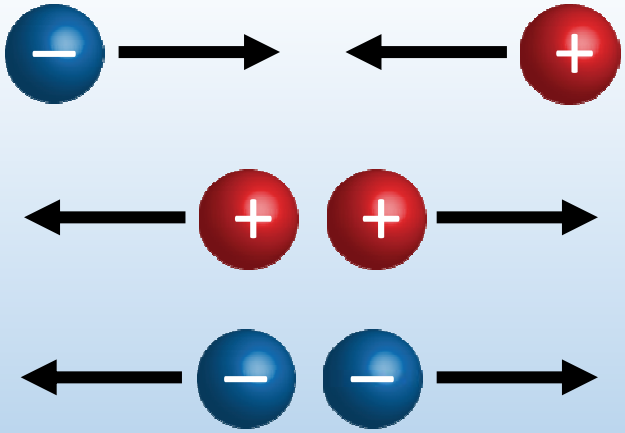
Strong

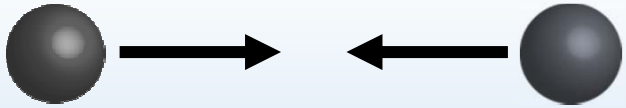
weakest — strongest

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





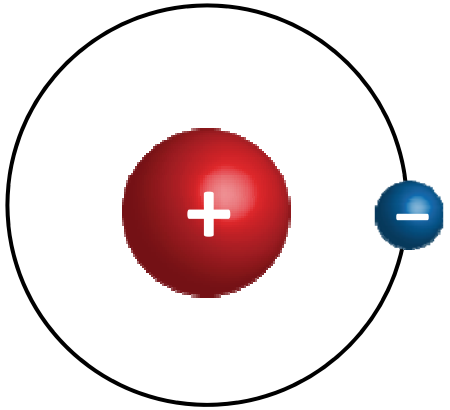
DEMO

Units of electric charge

- Symbol: *q* or *Q*
- Unit: [Coulomb] = [C]

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

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



- How much charge is 1 C?

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

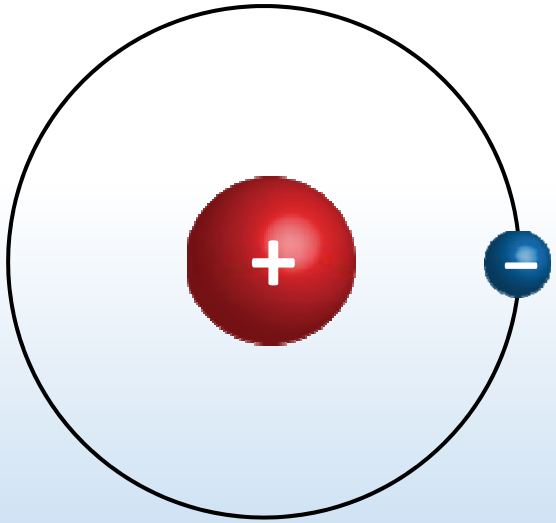
You would need ...ol ...t...ol ...d OH^-

25 gallon jugs of water!

Conservation of charge

Charges are physical entities (ex: electrons, protons)

Cannot be created or destroyed



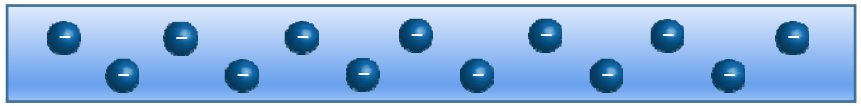
The net charge in a closed system is conserved

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

Conductors & insulators

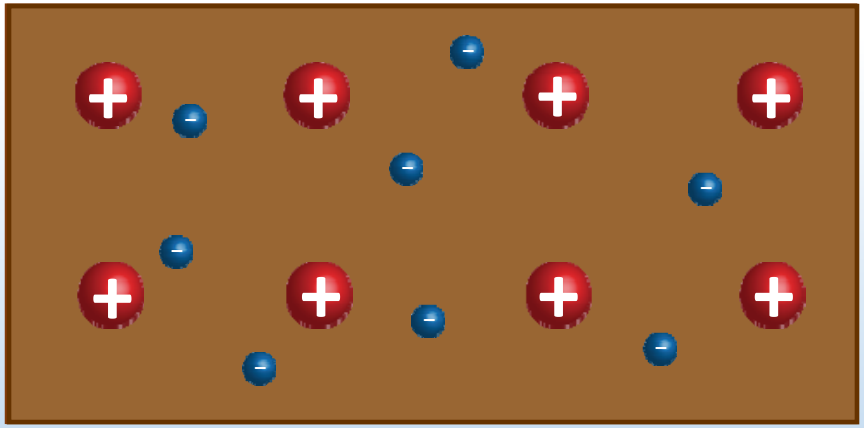
Q: How do electrons behave in a perfect conductor?

charges move freely



Q: How do electrons behave in a perfect insulator?

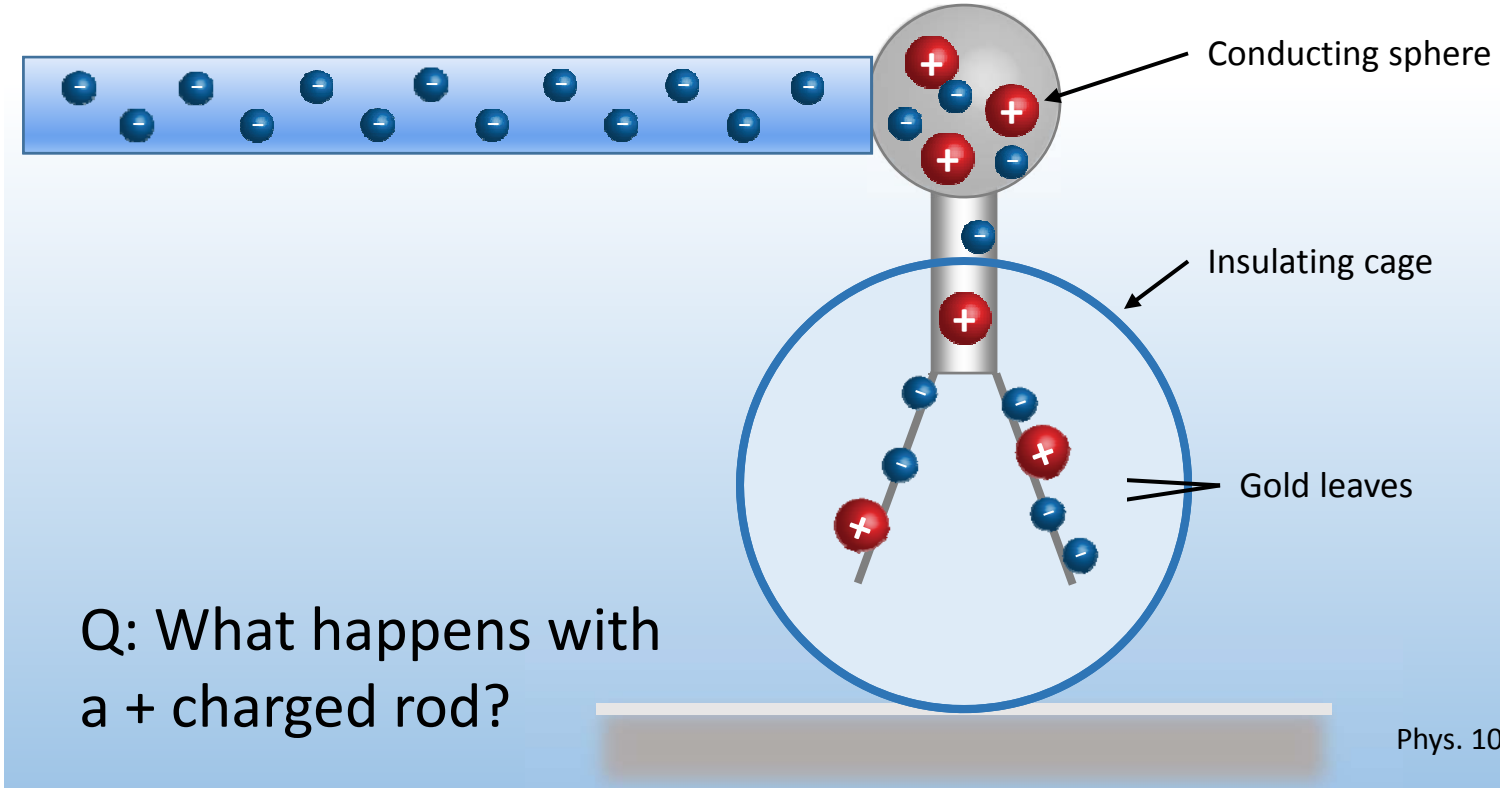
charges don't move



Most things are in between perfect conductor / insulator

Demo: electroscope

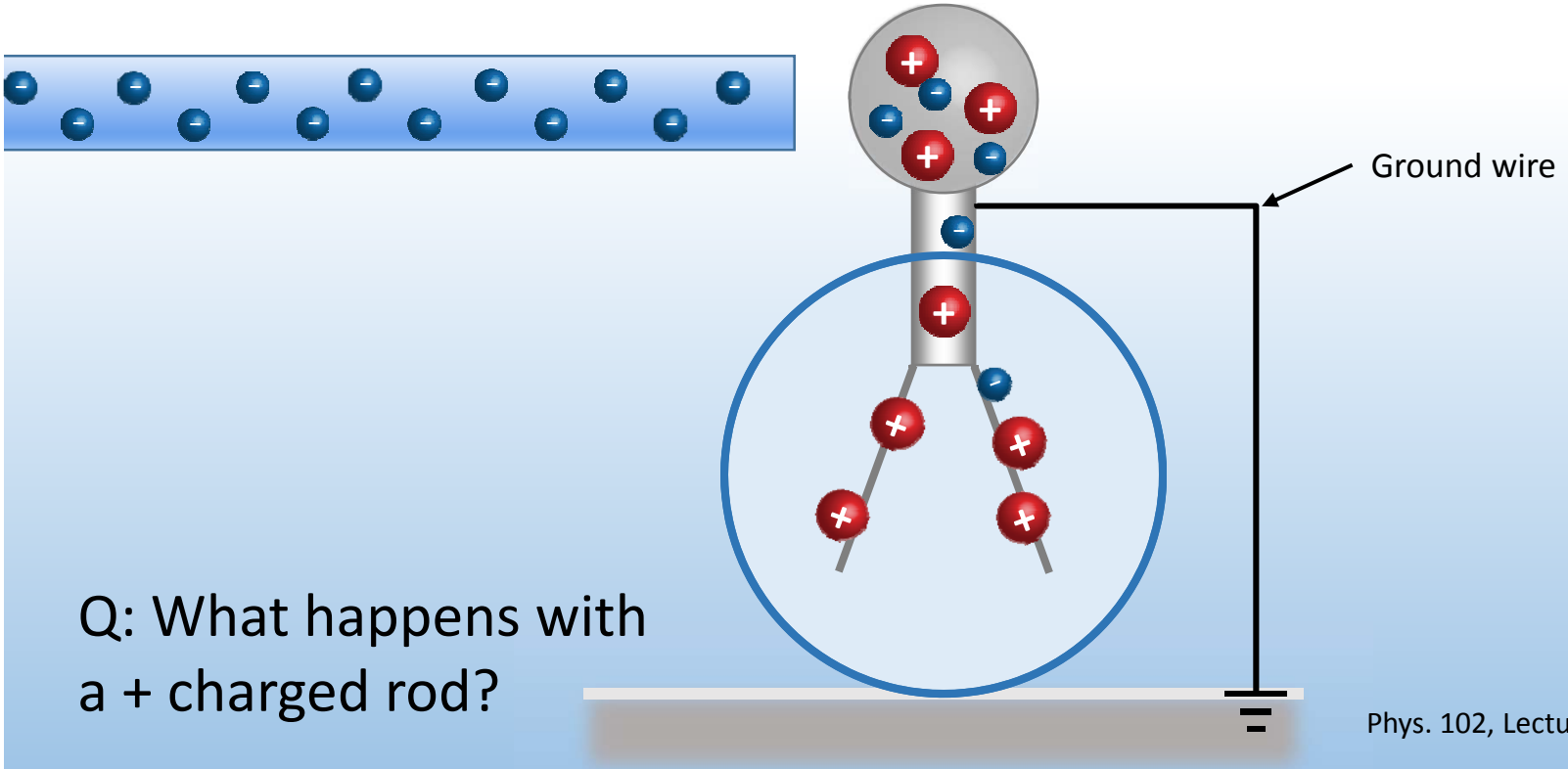
- Charging by *conduction*
  - Charged rod is brought near scope
  - Charged rod touches scope transferring some charge
  - Scope is left with same charge as rod



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



Q: What happens with a + charged 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

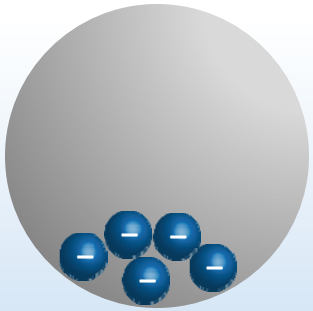
If the conducting electroscope were replaced by an *insulating* ball and then charged by induction as above, what would be the net charge on the ball?

A. positive B. zero C. negative

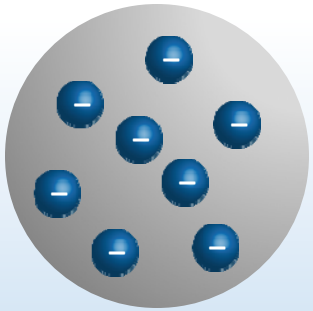
ACT: Conductors

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

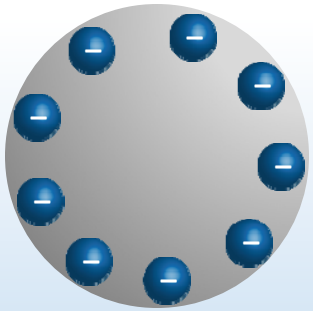
A. At the bottom



B. Spread uniformly



C. On the surface



Fundamental concepts:

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

DEMO

Coulomb's Law

(1785)

Force between charges q_1 and q_2 separated a distance r:

Magnitude

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

"Coulomb constant"

$$k = 9\times10^9\ N\cdot m^2/C^2$$

Or: $$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$$

"Permittivity of free space"

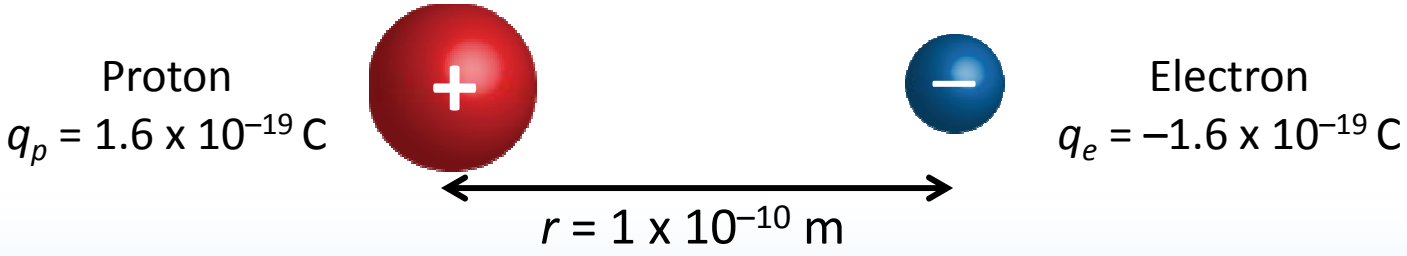
$$\varepsilon_0 = 8.85\times10^{-12}\ C^2/N\cdot m^2$$

Direction

Opposite charges attract, like charges repel

Calculation: Coulomb's Law

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



$$F = \frac{k|q_p||q_e|}{r^2} = \frac{9\times10^9\, N\cdot m^2/C^2\,|1.6\times10^{-19}\,C||-1.6\times10^{-19}\,C|}{(10^{-10}\,m)^2} = 2.3\times10^{-8}\,N$$

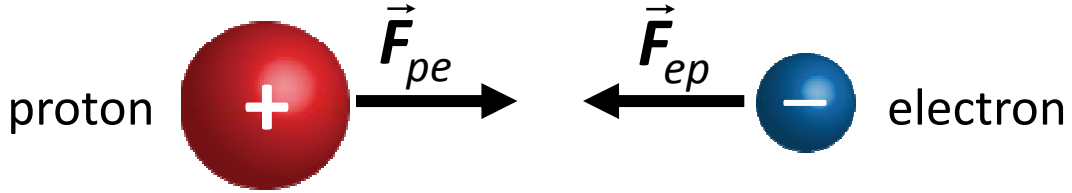
Compare to gravitational force between them (Phys. 101)

$$F_G = \frac{Gm_pm_e}{r^2} = \frac{6.7\times10^{-11}\,N\cdot m^2/kg^2(1.7\times10^{-27}\,kg)(9\times10^{-31}\,kg)}{(10^{-10}\,m)^2} = 1.0\times10^{-47}\,N$$

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

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

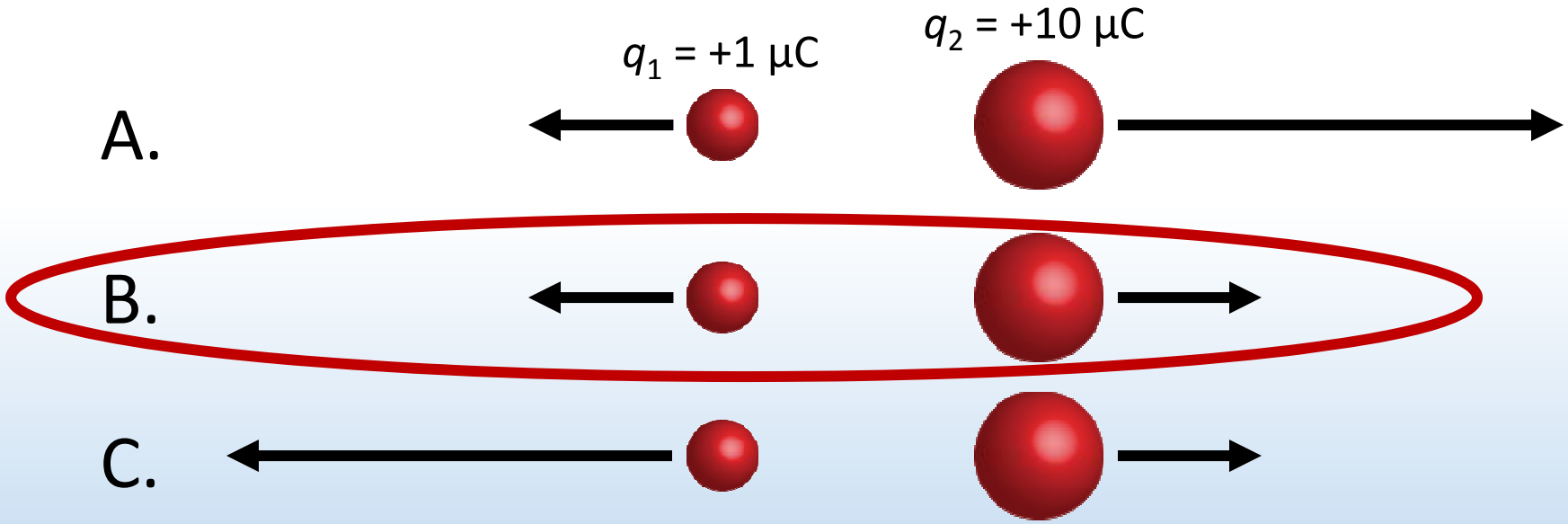
What is the direction of the force on the *electron due to the proton*?

F_{pe} = force on proton due to electron

F_{ep} = force on electron due to proton

ACT: Coulomb's Law

Two charges q_1 = +1 μC and q_2 = +10 μC are placed near each other. Which of the following diagrams correctly depicts the forces acting on the charges?



The two charges exert forces equal in magnitude and opposite in direction (Newton's Third Law! – Phys. 101).

$$F_{12} = F_{21} = \frac{k|q_1||q_2|}{r^2} \qquad \vec{F}_{12} = -\vec{F}_{21}$$

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

Prior to next lecture….

- Complete Pre-lecture & Checkpoint before 8:00 AM on the day of lecture!