

# PHYS 2140

Physics for Students of Science and  
Engineering  
**PART II: ELECTRONS AND PHOTONS**  
Fall Semester 2006  
Victor Karpov

**Please Pick Up  
Your Syllabus**

## Syllabus

- Check out the syllabus carefully: the schedule of lectures, quizzes and exams, the grading system, and the homework.
- *The bookstore information.*
- *This is all also on the Physics 2140 web site.*
- Also be sure you know the time and place of your *lab section* and Tuesday *discussion section*.

## Web site



Find our *homepage*:

Go to [www.physics.utoledo.edu](http://www.physics.utoledo.edu)

Click on "Course Links" and find  
PHYS2140, V. G. Karpov

Or go directly to

[<http://astro1.panet.utoledo.edu/~vkarpov/physics-2140.html>](http://astro1.panet.utoledo.edu/~vkarpov/physics-2140.html)

## The Daily Quizzes

- Same system as used in 2130.
- Turning Technology RF communication.
- Buy transmitter in book store.
- Unique ID number is built in.
- Encourage attendance, interaction, feedback.
- Research shows these things are good!

**Bring RF unit to all lectures**

## Homework

- **For tomorrow:**
  - Ch. 21 Questions 1,2; Problems 2,7,13,65
- **Thursday: no Quiz, no class**
  - Take care of your clickers!

## What is physics?

- **The structure of the physical world.**
  - What basic units are things made of?
  - The fundamental particles
    - Quarks, leptons, gluons, photons, gravitons
- **The laws of nature.**
  - How do these basic units behave?
  - The fundamental interactions
    - Gravitational, Electromagnetic, Nuclear

## This Semester: 4-week segments

1. **Electric Charges and Fields**  
Chs. 21-25
2. **Electrodynamics**  
Chs 26-32
3. **Optics and Relativity**  
Chs 33-37
4. **Quantum Physics**  
Chs 38-44

## A World of Electric Charge

- The world is made of charged particles
- The common ones are
  - **The proton:** Charge  $Q_p = +e$
  - **The electron:** Charge  $Q_e = -e$
  - **The neutron:** Charge  $Q_n = 0$
- There is also **the photon:**
  - Photons have zero charge, but they interact with the charges of the others.

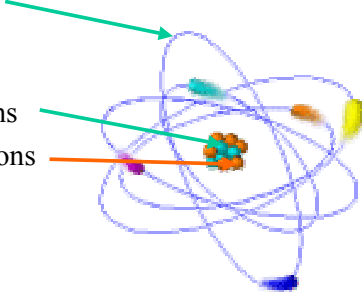
## Atoms

### Electrons

### Nucleus

Protons

Neutrons



## Atomic number and mass number

- $Z = \text{atomic number} = \text{no. of } e\text{'s} = \text{no. of } p\text{'s}$   
(so  $Q=0$  for a neutral atom)
- $A = \text{mass number}$   
= no. of protons + no. of neutrons  
( $m_p = m_n \gg m_e$ )
- $N_A = \text{Avagadro's number} = 6 \times 10^{23}$   
(number of atoms in one *mole* )

$N_A$  is defined so that the mass of  $N_A$  atoms is A grams

**Example** Two isotopes of uranium:

$U_{235}$  ( $^{235}U_{92}$ ) has  $Z=92$ ,  $A=235$   
(92p's, 92e's, 143n's)

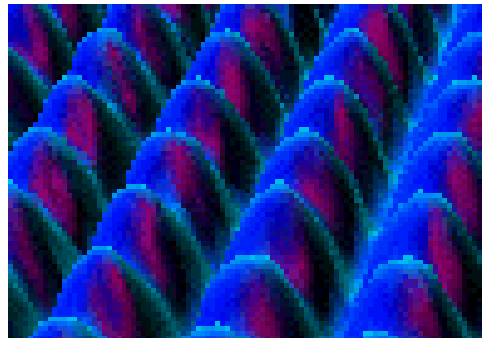
$U_{238}$  ( $^{238}U_{92}$ ) has  $Z=92$ ,  $A=238$   
(92p's, 92e's, 146n's)

Question: How many atoms in 1 kg of  $U_{235}$ ?

Answer: One mole is 235 grams, so 1 kg is  $1000/235 = 4.26$  moles. The number of atoms in a mole is  $N_A = 6 \times 10^{23}$  so the answer is

$$4.26 \times 6 \times 10^{23} = 2.6 \times 10^{24} \text{ atoms}$$

## Surface of a pure metal showing individual atoms.



## Chapter 21

- Electric Charge
- Coulomb's Law
- Review
  - Powers of Ten
  - Vector Calculations
  - Atoms and Electrons

## I. Electric Charge

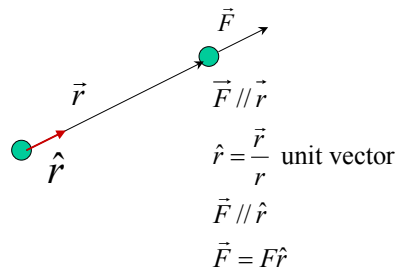
- Two kinds: positive and negative
- Matter is made of charged particles: protons, electrons, atoms, molecules
- Charge is *conserved* and *quantized*
- The elementary charge:  $e = 1.6 \times 10^{-19} \text{ C}$ .
- Electric current -- the rate of flow of charge
- Conducting and insulating materials

## II. Coulomb's Law

$$F = k \frac{Q_1 Q_2}{r^2}$$

- Inverse square law, attraction and repulsion
- SI units: Coulomb and Ampere
- The Coulomb constant:  $k = 9 \times 10^9 \text{ SI units}$ .

## III. Vector notation



## III. Vector Notation

$$\vec{F} = k \frac{Q_1 Q_2 \vec{r}}{r^3} = k \frac{Q_1 Q_2 \hat{r}}{r^2}$$

If two forces act on a body, then the net force is the **vector sum**:

$$\vec{F} = \vec{F}_1 + \vec{F}_2$$

**BUT** remember that the **magnitudes** may **NOT** add:

$$\vec{A} = \vec{B} + \vec{C} \text{ does not mean that } A = B + C$$

## Chapter 21 Homework

- Read Chapter 21
  - Note Checkpoints 3,4
  - Do Questions 1,2 – not graded
  - Do Problems 2, 7, 13, 65 graded in Wiley Plus
  - Test bank Questions 1,2 graded in Wiley Plus
- Log onto Wiley Plus system
- Do tonight, ask questions tomorrow!
- Bring PRS units Wednesday
- **No weekly Test this Thursday.**

## Syllabus

- Does everyone have a syllabus?
- Do you know the time and place of your *lab section* and Tuesday *discussion section*?
- Do you know how to find the web site?  
[www.physics.utoledo.edu](http://www.physics.utoledo.edu)
- Any questions about the course?

## Notes about quizzes and exams

- Do the powers of 10 in your head.
- Use only one or two significant figures – that's enough to show you have the basic principles right.

For example  $k \approx 9 \times 10^9 \approx 10^{10}$  SI units

## Example Problem

Two charges are separated by 3 meters. If each charge is 2 microcoulombs, what is the force by one charge on the other?

### Solution

$$Q = 2 \mu C = 2 \times 10^{-6} C$$

$$F = k \frac{Q^2}{r^2} = \frac{9 \times 10^9 \times (2 \times 10^{-6})^2}{3^2}$$

$$F = \frac{9 \times 4 \times 10^{-3}}{9} = \underline{4 \times 10^{-3} N}$$