EXPERIMENTS IN MODERN AND APPLIED PHYSICS

387/388/506

- Web page: http://www.physics.rutgers.edu/ugrad/389/
  - Instructor :

    Prof. Eva Y. Andrei
    - eandrei@physics.rutgers.edu
  - TA :

    Phil Rechani
    - phillipmyinbox@gmail.com

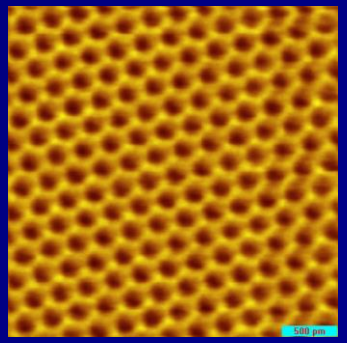
Pre-requisite –326/27or or equivalent course

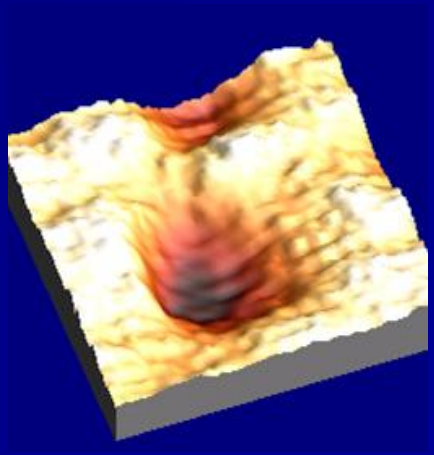
My Research

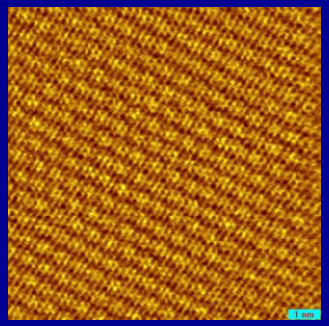
- Experimental research in condensed matter physics
  - Graphene

➢ One-atom thick Carbon crystal: in which electrons behave like ultra-relativistic massless particles

http://www.physics.rutgers.edu/~eandrei/







Your TA: Phil Rechani

- **Recent Graduate** of Physics

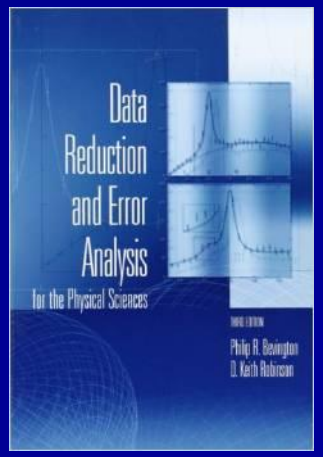
  Honors Thesis Consisted of Wrestling Equations to understand gold particles probed by relativistic electrons. Understands boats better.

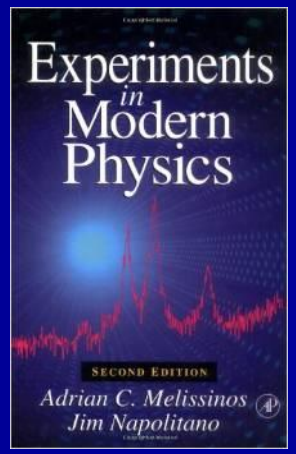
Interests in Academia:

- Simplifying physics in my mind, and hopefully in others
- Understanding many aspects of mathematics and how it relates to physics
- Understanding weird concepts like intrinsic variables in quantum theory, the validity of point particles, and annihilation
- AVOIDING IMPENETRABLE SOLUTIONS

Course Materials

- **Textbook**: *Experiments in Modern Physics,* by A.C. Melissinos and J. Napolitano, 2'nd edition
- Taylor, “Introduction to Error Analysis”
- Bevington "Data reduction and error analysis for physical sciences"
- Web, textbooks, journals





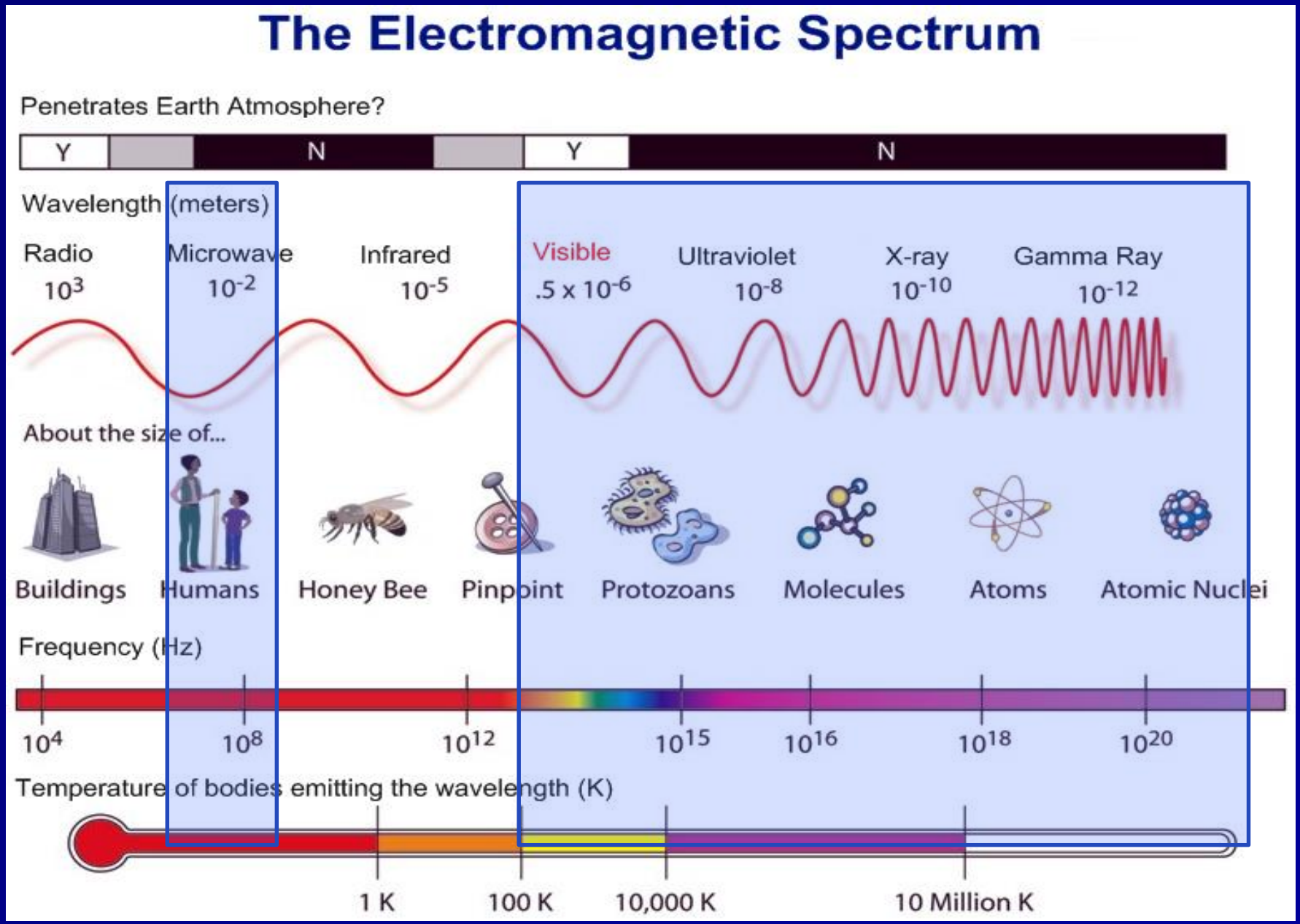
Outline

- Objectives
- Course structure
- Student responsibilities
- Course policies and grading
- Getting started

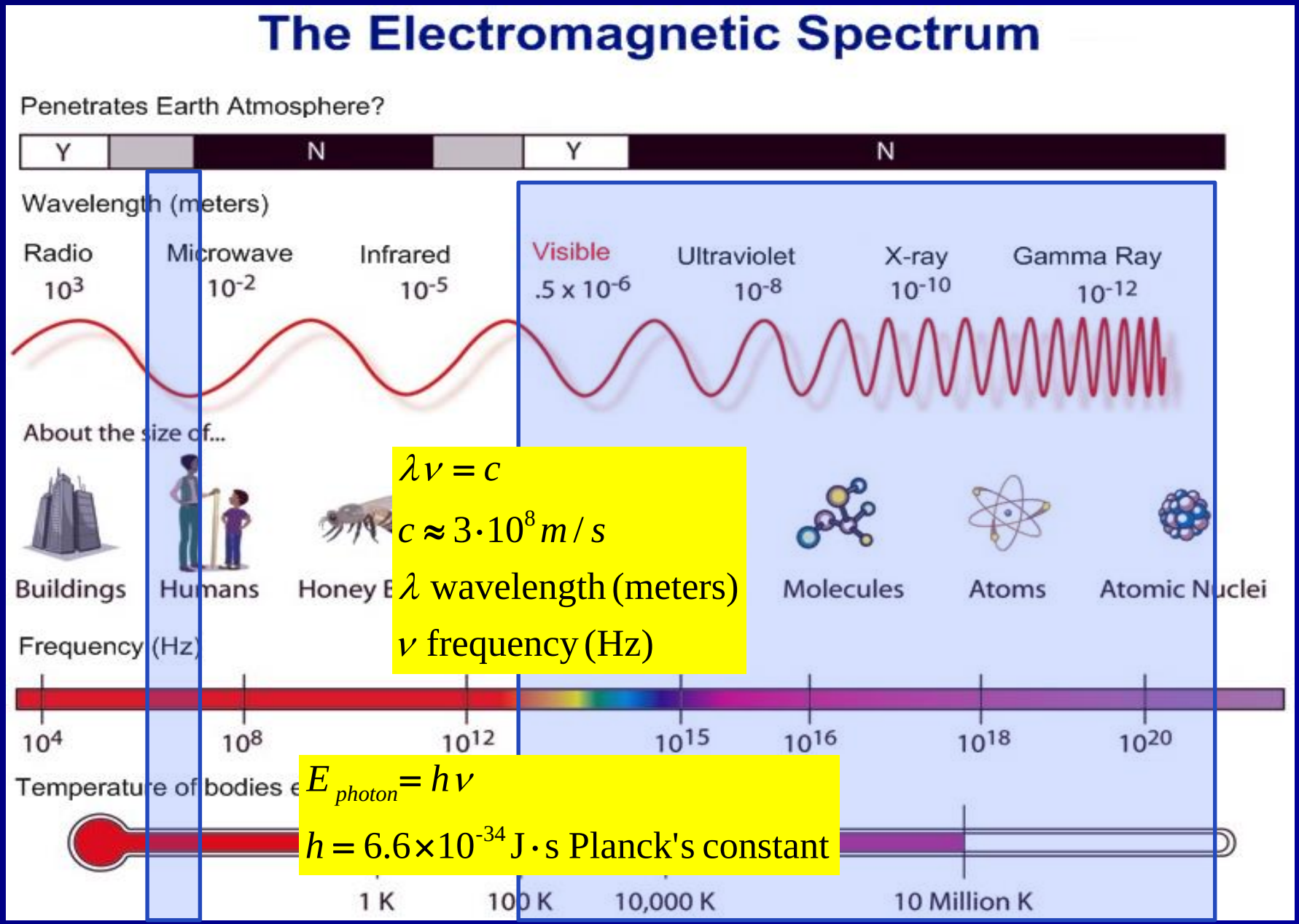
Objectives

- Reproduce experiments that led to major advances in science – a journey of discovery
- Refine your scientific skills
  1. Theoretical background
  2. **Collect data**
  3. **Document work**
  4. Analyze Data Estimate errors
  5. Report
  6. Presentation
- As close to real life as possible

EM Spectrum Covered by our Experiements



The Experiments



The Experiments

Experiments	EM spectrum	Wave (classical) or particle (quantum)?	You will learn / measure
Speed of Light	Visible	Measure speed of EM wave	• Manipulate, chop, split, polarize and detect light
Electromagnetic Boundary conditions	Visible	• Interaction of light with mater • wave nature of light	• Maxwell Equations • Fresnel' equations • Snell's law • Total internal reflection • Brewster angle
Interferometry	Visible	• Wave nature of light	• Michelson interferometer
Photoelectric effect	Visible	• Interaction of light with mater • Quantum	• Planck constant • Work function of metal
Franck Hertz	Visible	• Interaction of electrons with mater • Quantum nature	• Quantization of atomic levels
Zeeman Effect	Visible	• Interaction of electrons with mater • Quantum	• Electron spin • Splitting of atomic levels in magnetic field
Muon decay	Visible	• Interaction of electrons with mater • Quantum	• Cosmic radiation • Lifetime of muons
NMR	Microwave	• nuclear moment with radiation • Quantum	
X-rays	X-ray	• Interaction of EM radiation with mater • wave nature	• Periodic structure of crystals • Identify materials by crystal structure
Gamma Decay	Gamma ray	• Interaction of EM radiation with mater • Quantum	• Photoelectric effect • Compton effect • Pair creation

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Structure

1)	homework assignment	5%
2)	4 Preparatory question sets	15%
3)	4 experiments (group)	15%
4)	Maintain lab book	10%
5)	4 lab reports (group)	30%
6)	1 Oral presentation	25%

Structure

➢ Prior to Starting a New Experiment

- ➢ Theoretical background
  - Lab writeup
  - Supplementary material

Understand
physics, equipment, procedure

- ➢ Preparatory questions
  - Work out in notebook before each experiment.
  - Hand in to TA before touching equipment

- ➢ Permission to start new experiment.
  - Request permission from TA

Structure

➢ Prior to Starting a New Experiment

- ➢ Lab book entry: objectives and procedures

  ⇨ State the physics idea to be tested.

  ⇨ List experimental procedures and their relation to the physical principle to be tested.

  ⇨ To-do list: calibrations; data collection plan

  ⇨ Assign tasks, plan lab time with your partners

Structure

➢ Running the experiment

- ➢ Understand and set-up equipment
  - ⇨ Read manuals
  - ⇨ Supplementary material
  - ⇨ Figure out how equipment works

Lab computers:
Username: student
Passwd: modernphysicslab

- ➢ Troubleshooting, equipment problems .
  1. Stay calm!
  2. Check: power, cable connections, batteries, switches..
  3. Read and follow directions in manual and lab writeup
  4. Consult with a group who ran experiment before
  5. If all else fails ask TA

Structure

➢ Running the experiment

Taking data and keeping records.

⇨ Keep detailed and dated records in your notebook

- Record procedures, equipment and software settings
- Paste pictures of the equipment, scope displays, etc in

⇨ Keep data organized and accessible to the team

⇨ Preliminary data analysis in class is KEY to catching mistakes, fill in missing points etc

Structure

➢ Writing the Report

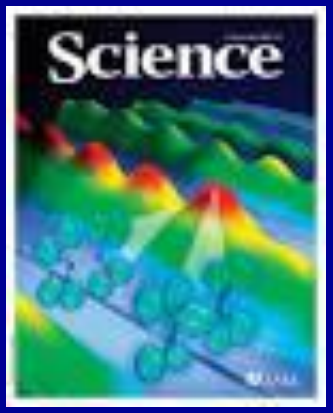
Format

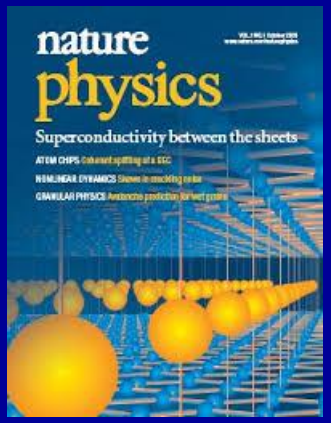
• Length ~ 3200 words Phy. Rev. Lett. format.

• Author order should reflect the group effort. If equal contributions list names in alphabetic order.

Sections.

1. Abstract (~200 words)
2. Introduction (purpose, theory, approach)
3. Apparatus
4. Data presentation
5. Analysis and Results (graphs, calculations, answers)
6. Discussion (measurement uncertainties)
7. Conclusions
8. Bibliography
9. Appendix





Structure

➢ Final Presentation

Conference Format

- ⇨ Orals are designed as a mini conference
- ⇨ One team of presenters per oral session
- ⇨ Present findings and answer audience questions
  - Topic: 4'th experiment of the semester
  - Each partner presents (Theory, apparatus and data, analysis)
  - Length: 12-15 minutes with an additional 10 minutes for Q&A.
  - Format: Power point
- ⇨ Each group will attend all classes during orals
  - When not presenting groups will participate as Questioners.

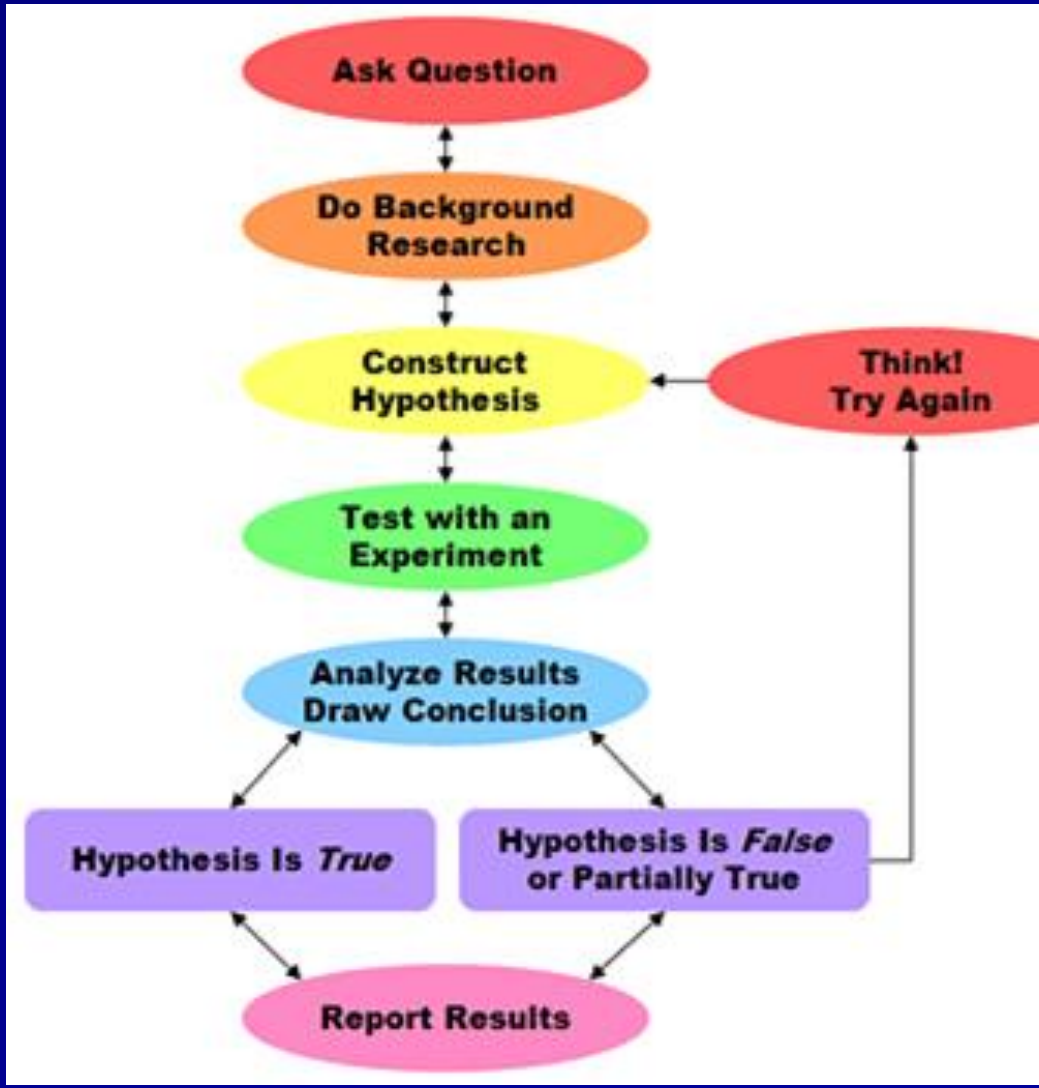
Logistics

- ⇨ Last 4 classes of the semester
- ⇨ 2 parallel sessions in rooms 112W and 401W
- ⇨ Each group will be assigned time/place slots
  - for their presentation.
  - for attending other presentations.
- ⇨ Schedule posted on the course website

Due date

- ⇨ Email presentation file to the instructor
- ⇨ 24 hours (at the latest) prior to the scheduled talk

The Scientific Method



The Scientific Method

anticipation

- Preparatory questions,
- Writeup, journals, library, internet
- List your own questions - guess answers

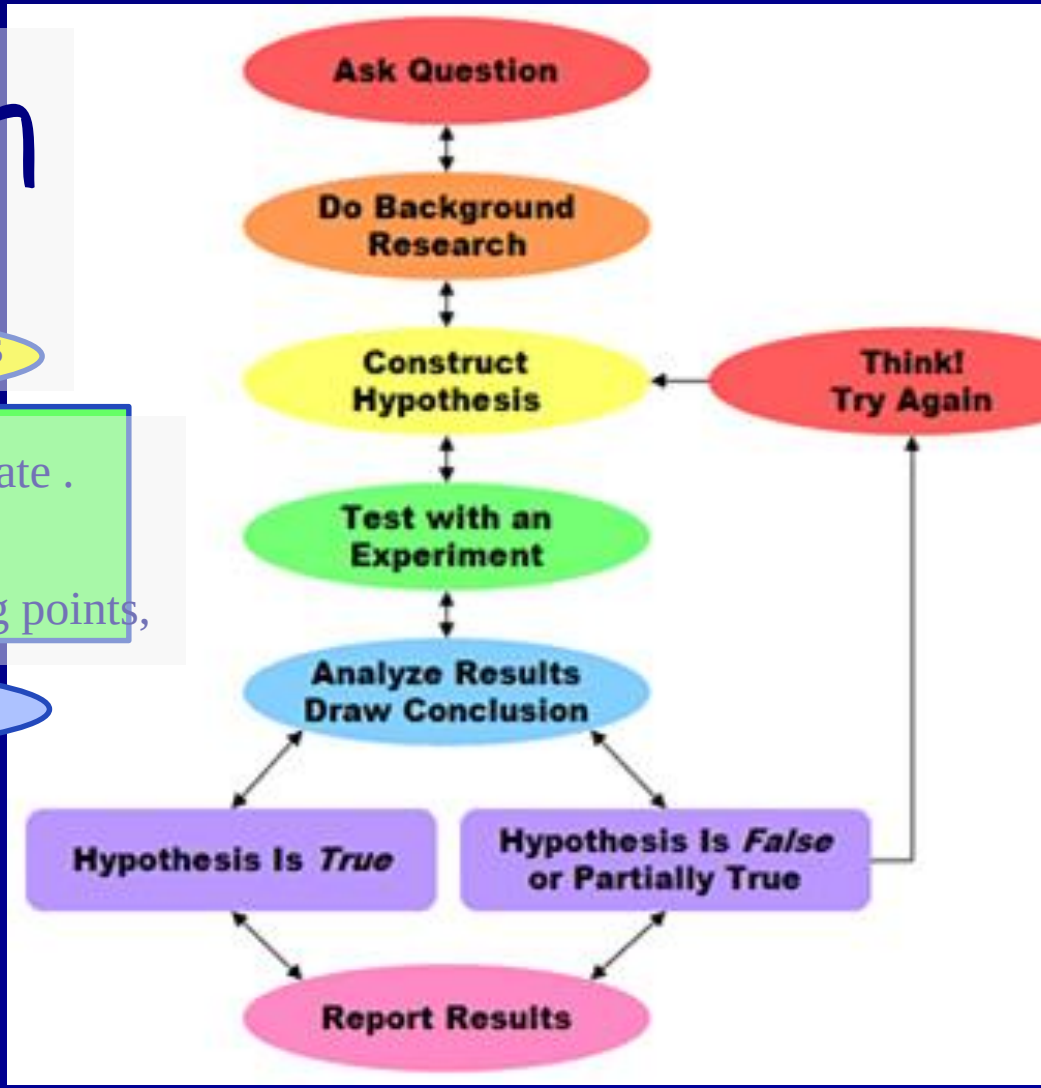
frustration

- Plan experiments, make timeline, collaborate .
- Understand the equipment
- Take data, check consistency, fill in missing points,

Experiment successful: analyze, conclusions

elation

- Communicate results :
- write report
- oral presentation



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Student responsibilities

- Team Work :

- Each member must share responsibility and contribute to the team effort:

1. Collect data
2. Notebook
3. Data Analysis
4. Report
5. Final presentation

- Keep work area clean and tidy !
- No Food
- No Drink
- No Newspapers
- Return reference material and tools at the end of each lab.

Student responsibilities

➢ Plan your time

- ⇨ The equipment is reserved for your group during the allotted time slot. You may use it any time during this period but not beyond.
- ⇨ Start writing report early– theory, apparatus, procedure, data analysis during class.
- ⇨ If you need to work after hours contact Stefanie Miller to program your card: Serin W221, 848-445-9034, smiller@physics.rutgers.edu

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Policies

➢ Ethics in Science

- ➢ Do not Plagiarize
  - Use of web and other resources is encouraged as long as it is properly cited.
  - You may receive outside help as long as their contribution is acknowledged

- ➢ Do not Fabricate or Falsify
  - document everything as you go (Notebook) including mistakes
  - Comparison to known values is ok, but not substitution or modification of the data

- ➢ DATA FABRICATION = F
- Rutgers policy on academic integrity
  http://academicintegrity.rutgers.edu/integrity.shtm

Policies

Grading

- Attendance is mandatory.
  - Unexcused absence = -10%
- Grades:
  - Class work 15%
  - Preparatory questions and homework 20%
  - Notebook 10%
  - Lab reports 30% (late report deduction 4pt/day)
  - Oral presentation 25%

Policies

- How to Succeed in this course

- Attend all classes
- Be punctual, plan your time, start writing report early
- Do your own work
- No Food, no Drink, no Newspapers in the lab
- Leave your work area CLEANER than you found it
- Have FUN!

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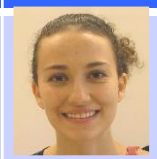
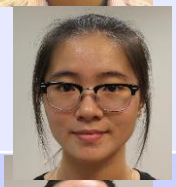
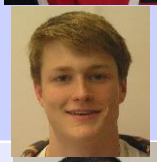
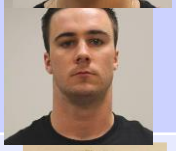
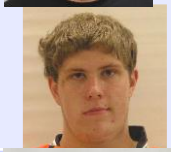
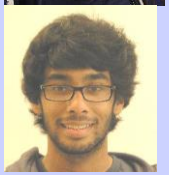
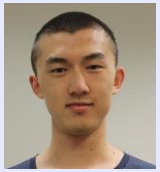
Getting started

- Preliminary work Jan 17 – 22
  - Meet your lab partners
- Homework
  - Go over reading assignment and do homework
- Prepare for first experiment
    - Read course information on the course webpage
    - Study lab writeup and reading
    - Answer preparatory questions
    - Obtain Lab book
- First lab meeting: January 23

Tour of course webpage

http://www.physics.rutgers.edu/ugrad/389/

group	partners	What they look like
1	COULTER JENNIFER B HENDRIK BOSTELMANN-ARP HOANG KINH	  
2	PATEL DHRUVIT P ASLAM FAZAL R WU PEIJIN	  
3	TERRIS SYDNEY MIRKOVIC VLADIMIR KWIETNIAK MARC	  
4	RITCHIE GRAHAM N LAU CHUN K DUDEK DAVID R	  
5	ELLSWORTH BRIAN CHATTERJEE SIDHARTH PATEL ROCKIE	  
7	HOWARD JOEL PARETS PERIS LAIA ZHOU BOJUN	  
8	CLAVIJO ALEXIS RAMDIN DARAM FRANK MAXIMILIAN