
Newton


Einstein

Physics 10: Concepts in Physics

The Rules of the Universe

Tom Murphy

Course Objectives

1. Explore the approach that physics brings to bear on the world around us
   - Reductionism
   - Scientific Method
     - Gravitation and General Relativity as a case study
   - Empiricism & Skepticism
   - Quantitative Models

Course Objectives, continued

2. Appreciate the influence physics has on us all
   - Begin to see physics in the world around you
   - Develop your natural intuition, stimulate curiosity
   - Think into the unknown (ooh that's scary!)
3. Understand basic laws of physics
   - Newton's laws of motion, gravitation (even relativity)
   - Concepts of mass, force, acceleration, energy, momentum, power, etc.
   - Electromagnetism
   - Quantum Mechanics
   - Light and optics

Course Objectives, continued

4. Map out the hierarchy of the Universe
   - The cosmos
     - Earth, Moon, Sun, Solar system
     - Stars, our Galaxy, other galaxies
     - Cosmological scales: clustering, *accelerating* Universe
   - The microcosmos
     - Molecules, compounds, atoms
     - Subatomic particles, fundamental forces
5. Exposing the limits of our understanding
   - Complexity: chaos, biological systems, economics
   - Unification schemes: string theory, supersymmetry
6. Enhance your scientific literacy
   - know the difference between science and the supernatural
   - feel encouraged to read popular science articles/books

Course Structure

- Full class meets 3 times per week in WLH 2005
  - MWF 2:00–2:50 PM
    - Lectures
      - PowerPoint presentations
      - Lecture materials will be made available on the web
    - Demonstrations (lots of these!)
    - Exams: Midterm May. 2; Final Friday, June 13, 3PM
- Discussion section meets once per week
  - W 4:00–4:50 PM: Warren Lecture Hall 2111; Jim Wilson
    - Opportunity for discussions on course material, exam prep, etc.
    - Work out example problems and questions
    - Mock Quizzes
- Problem sessions once per week
  - Th 8:00–9:50 PM, Center Hall 212; Jim Wilson
    - Primary focus on homework, some exam prep/review

Resources

- Your Fellow Students!
  - Encouraged to work together on homework, exercises (but not on exams!)
- Professor : Tom Murphy

  Office in SERF building, Room 336, office hours Th 1:30–2:30 PM, or by appointment, 858.534.1844, *tmurphy@physics.ucsd.edu*
- Teaching Assistant: Jim Wilson

  Office in SERF 434, office hours Th 2:30 PM – 4:00 PM

  jawilson@physics.ucsd.edu
- Web: physics.ucsd.edu/~tmurphy/phys10/
  - Also WebCT for assignments, transmitter registration, etc.
- Text
  - *Conceptual Physics*, Ninth Edition, Paul G. Hewitt
  - used text to save you guys $$

Grading

Weight	Format	Due	Comments
25%	Homework	Friday in class	No late submissions
10%	Question/Obs.	by F, WebCT	Boolean (P/F)
up to 15%	Class Particip.	every lecture	via transmitter system
<30%*	Midterm*	May 2 (Fri)	2:00 PM, in class
<35%*	Final*	Jun. 13 (Fri)	3:00 PM

* Midterm and Final may count for as little as 15% or 20%, respectively, given extent of classroom participation. Example: if you have 6/10 points for classroom participation, you can deduct 9% from **either** the midterm **or** the final weight (whichever grade is worse).

What's with these questions/observations?

- Science is as much about *questions* as *answers*.
  - **Every other week**, you'll submit a question or observation about the physical world around you.
    - Something you've always wondered about
    - Something you recently noticed
    - Something that class prompted you to think about
  - Will post some from each submission on website
    - with answers (when possible) or discussion
  - Goal is to increase your awareness, observational skills
    - We're immersed in physics: easy to ignore, but also easy to see!
    - You'll begin to think more deeply before shoving problem aside
    - Allow your natural curiosity to come alive

Questions/Observations, continued

- Examples:
  - Questions
    - What makes velcro stick?
    - Why do my cheerios attract each other into little flotillas?
    - Where do trees get their mass? Out of dirt? Why aren't there holes in the ground around trees if this is the case?
    - Why is the sky blue? Why not purple?
  - Observations
    - I've noticed small rainbow patches in the sky way off to the sides of the sun on hazy winter days. What are those?
    - I've heard that toilets flush the other way around in the southern hemisphere, but on my trip to New Zealand, they flushed the same way as they do here! What's up with that?!

Topics to be Covered

- What constitutes physics
- The BIG picture: macro- and micro-cosmos
- Newton's laws of motion, energy, momentum, etc.
- Gravity and Relativity: from Newton to Einstein
- Electromagnetism and Light
- Quantum Mechanics and associated weirdness
- The frontiers of physics
- The role of physics in our society

Transmitter Logistics

- We will use infrared transmitters in *every* lecture
  - As a check on understanding
  - To give practice on quiz-like questions
  - Instant feedback (for me and for you)
  - Surveys/opinion gathering
  - Class Participation!!!
- Available at Bookstore
  - new 13-button ones for $34 (may buy back at end)
    - $26 used; also seek out friends who might have one
  - older 6-button units will NOT work!
- You'll register your transmitter through WebCT site
  - instructions are posted on the class website

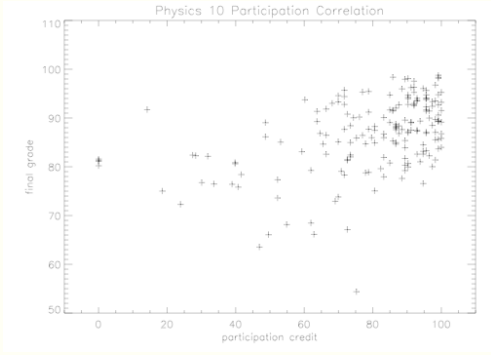
How Much Math!?

- This course will largely focus on qualitative, conceptual content
- That does not mean the ideas are trivial!
- We will be using
  - Simple graphs
  - Occasional basic algebra
  - Averages
- Don't let it psych you out when you see it…

Expectations

- Attend lectures and discussion section
- Participate!
  - If it doesn't make sense, **ask**! Everyone learns that way.
  - Don't be bashful about answering questions posed.
  - In-class voting system should make this fun
- Do the work:
  - It's the only way this stuff will really sink in
  - exams become easier
- Explore, think, ask, speculate, admire, enjoy!
  - Physics can be fun, enriching, beautiful

Does it Pay to Come to Lecture?



- No one who came more than 80% of time did very poorly
- Few who came infrequently got more than a low B

Any Questions on Course Structure?

Digression: Why are you here?!

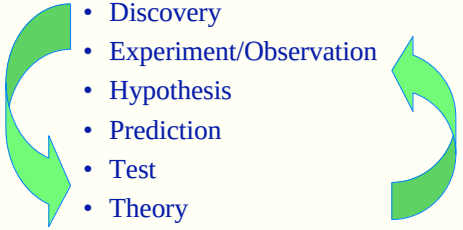
- "Because I was born."
- "My parents made me come."
- "It's just what you do after high school…"
- "I want to get a job, man"
- "I'm here to learn—to think—to build my brain."

- College is an opportunity: do your best to seize it!
- What I wish for each of you to come out with:
  - Ability to think critically (not afraid to think indep.)
  - Skepticism about information given to you (agenda?)
  - Willingness to see complexity/multiple sides of issue

What Is Science?

- Which of the following best describes "science"?
  - A compendium of answers
  - A set of rules about the natural world
  - A methodology
  - Exploration, curiosity; a compendium of questions
  - Observation, experimentation
  - Boring guys in white coats with nerdy senses of humor
- Science has bits of all these (esp. middle four)

Science = A Process for Change!



- Discovery
- Experiment/Observation
- Hypothesis
- Prediction
- Test
- Theory

An ongoing cycle – the "scientific method"

Scientific Method: The dynamic interplay between theory and experiment

Science also brings an Attitude

Scientists must accept their experimental findings even when they *would like* them to be different. They must *strive* to distinguish between what they see and what they *wish* to see, for scientists, like most people, have a vast capacity for fooling themselves.

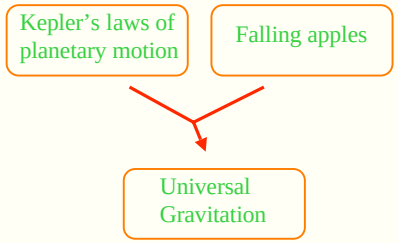
People have always tended to adopt general rules, beliefs, creeds, ideas, and hypotheses without thoroughly questioning their validity and to retain them long after they have been shown to be meaningless, false, or at least questionable. The most widespread assumptions are often the least questioned. Most often, when an idea is adopted, particular attention is given to cases that seem to support it, while cases that seem to refute it are distorted, belittled, or ignored.

What is "Physics"

- An attempt to rationalize the observed Universe in terms of *irreducible* basic constituents, interacting via basic forces.
  - Reductionism!
- An evolving set of (sometimes contradictory!) organizing principles, theories, that are subjected to experimental tests.
- This has been going on for a long time.... with considerable success

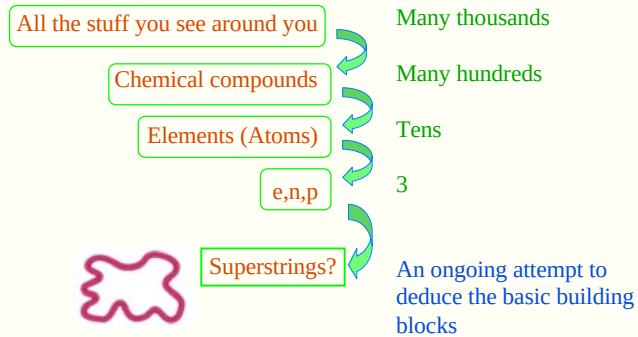
Reductionism

- Attempt to find unifying principles and properties *e.g.*, gravitation:



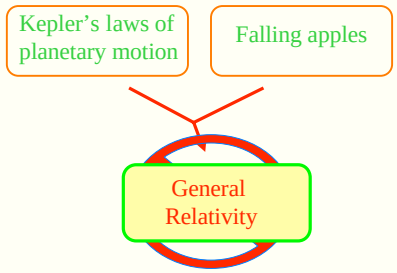
"Unification" of forces

Reductionism, continued



An Evolving World View

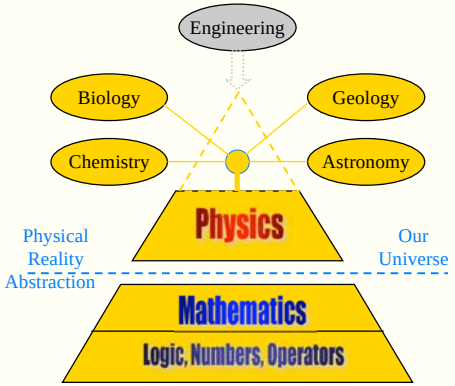
- As our understanding grows, theories are supplanted (or subsumed)



Should we even pay attention, then?

- Science is always on the move
  - theories that long stood up to experiment are shot down
- But usually old theory is good enough to describe all experiments predating the new trouble-making experiment
  - otherwise it would never have been adopted as a theory
- Ever higher precision pushes incomplete theories to their breaking points
- Result is enhanced understanding
  - deeper appreciation/insight

Mathematics: the natural language of Physics



Subdisciplines of Physics

- Astrophysics
- Condensed matter physics
- Atomic/Optical Physics
- Nuclear Physics
- Particle Physics
- Plasma Physics
- Biophysics
- ....

Experimental vs. Theoretical

Mapping the Intellectual Frontier

- One (but by no means the only) way to organize our ignorance is in terms of length scales
- Our intuition and everyday experience spans only a very small range of this scale

Really small "ordinary" Really big

Subatomic Particles you Observable Universe

To Start: An Intellectual Roadmap

- First Up – Solar System to the Universe
- Next Week – Atoms and subatomic particles
- Assignments:
  - Check out course web page:
    - physics.ucsd.edu/~tmurphy/phys10/
  - also, make sure you have access to WebCT page
  - Reading:
    - Hewitt, pp. 2–3, pp. 9–17 (boxes optional)
    - Supplement on the Universe (posted on website)