Physics 12: Energy and the Environment

A Physics Perspective on our Society's Needs

Tom Murphy

Course Objectives

1. Become well informed on the topic of energy and its use in our society, so that you may participate in the national debate and make smart decisions
2. Understand the physical concept of energy and learn to identify it in the world around us
   - kinetic energy (energy of motion)
   - gravitational energy
   - chemical energy
   - thermal energy (a form of kinetic energy)
   - light (radiative) energy
   - nuclear energy

Course Objectives, continued

3. Comprehend Energy Conservation
   - loss-less exchange of energy between forms
   - never created or destroyed—just converted/exchanged
4. Learn to calculate energy content/conversion
   - most quantitative part of course
   - forms foundation for all that follows
   - applications to familiar everyday systems
   - math isn't hard, but units can be a pain

Course Objectives, continued

5. Learn about the energy usage in our lives
   - where we get it, where/how we use it, how we distribute it
   - some discussion of *why* we need so much energy
6. Discuss the future of energy production
   - fossil fuels can't last forever (or even very long)
   - alternative production of energy
7. Discuss the side-effects of energy production
   - environmental issues
   - sociological issues

Course Strukture

- Homework 3 times per week (due every lekture)
- 2 quizzes per week
- 5 midterms
- 2 final exams
- oh—and a 20 minute presentation
- highest grade is B-
- In kase you hadn't guessed… April Fools!

Course Structure

- Class meeting times:
  - Lectures in York 2622 MWF 3:00–3:50
    - PowerPoint presentations
      - Lecture materials will be made available on the web
    - Interactive Transmitter to promote discussion/learning
    - Demonstrations
    - Exams: Midterm Mon. May 6; Final Wed. June 12
  - Discussion section meets in CSB 005, Wed 4:00–4:50 PM
    - Opportunity for discussions on course material, exam prep, etc.
    - Math background and exercises
    - Work out example problems and questions

Resources

- Your Fellow Students!
  - Encouraged to work together in class and on homework (but not on quizzes or exams!). BUT COPYING PROHIBITED: use own words
- 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: Matthew Hasling
  Office hours: Thursday, 2:30–3:50, SERF 434
  E-mail: *mhasling@physics.ucsd.edu*
- Web: physics.ucsd.edu/~tmurphy/phys12/
- TED site (quizzes, discussion board, etc.)
- Physics Tutor Center: M–Th 3–8 PM, 2nd floor Mayer Hall
- Text:
  - *Energy and the Environment*, 2nd edition Ristinen and Kraushaar

Grading

Weight	Format	Due	Comments
20%	Homework (drop 1)	Fri, in class	no late HW work together, but NO COPYING
15%	Quizzes (drop 1)	Friday, by midnight	via WebCT
up to 15%	Class Particip.	every lecture	via transmitter system
<30%*	Midterm*	May 6 (Mon)	3:00 PM, in class
<35%*	Final*	June 12 (Wed)	3:00 PM

* Midterm and Final may count for as little as 15% or 20%, respectively, given extent of classroom participation and worst exam performance. Example: if you have 60% of the participation credit and bomb the final, the midterm still counts 30%, but the final will counts 9% less, or 26% instead of 35%–the other 9% filled in by participation credit.

What's with this transmitter business?

- A part of your grade (up to 15% participation) comes from the interactive transmitter
  - using iClicker
- Promotes:
  - interaction, attention, investment in class/answer
  - feedback for both student and professor
  - *thinking* → *learning*
- Timeline:
  - Start using today
  - Credit starts Friday

How Much Math!?

- The first part of the course is the most quantitative, but the math itself is straightforward
  - just +, −, ×, ÷, and a bit of x^y
- Don't let it psych you out when you see it…
- I'd like you to develop a healthier relationship with quantitative analysis
  - numbers can be less rigid than you think
  - cut loose, and allow $\pi = 10/3 = \sqrt{10} = 3$
  - estimates don't have to be exact to be **useful**

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 easy
- Explore, think, ask, speculate, admire, enjoy!
  - Bring interesting topical ideas (recent news) to class

Any Questions on Course Structure?

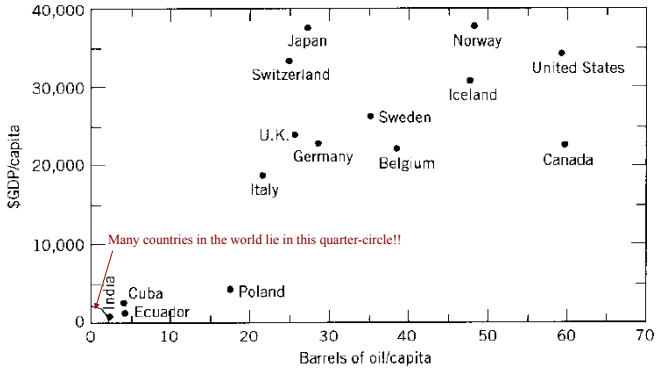
Course Preview: the Big Picture

- We use *a heck of a lot* of energy
  - primitive society uses < 100 W of power per person
  - our modern society burns 10,000 W per person
  - surely not in our homes! Where is this going on?
- Energy availability has enabled us to focus on higher-level issues as a society
  - art
  - science
  - home shopping network

Once upon a time…

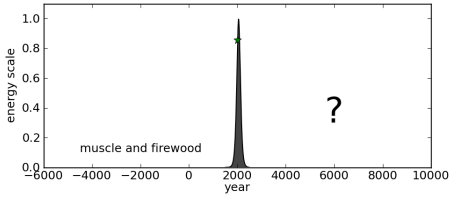
- Long ago, almost all of our energy came from food (delivering muscle power), and almost all our energy went into securing food for ourselves
- Enter the work animal, supplementing our muscle power and enabling larger-scale agriculture
- Next burn wood to run boilers, trains
- 150 years ago, muscular effort and firewood provided *most* of our energy—and today this is less than 1% of the story
- Today, more energy *goes into* growing/harvesting food than *comes out of* food!

The Great Energy Disparity



We live in a special time and place…

- We use almost 100 times the amount used by the poorest inhabitants of the world
- This phase has only lasted for the last century or so
- Most of our resources come from fossil fuels presently, and this has a short, finite lifetime



Global Energy: Where Does it Come From?

Source	10^{18} Joules/yr	Percent of Total
Petroleum*	158	40.0
Coal*	92	23.2
Natural Gas*	89	22.5
Hydroelectric*	28.7	7.2
Nuclear Energy	26	6.6
Biomass (burning)*	1.6	0.4
Geothermal	0.5	0.13
Wind*	0.13	0.03
Solar Direct*	0.03	0.008
Sun Abs. by Earth*	2,000,000	then radiated away

* Ultimately derived from our sun

Courtesy David Bodansky (UW)

Energy is cheap! So what's the problem?

- We spend about $9/day, or $3,200/yr per person on energy in the U.S.
  - about 16% of GDP
  - saves us much more than 16% of our time (labor-saving devices, transportation, etc.)
- But we're running through our resources at a phenomenal rate
  - let's see if this lasts even another hundred years!
- Our world will see a profound change in the next century as we adjust to a world without gasoline

Still fuzzy on the concept of energy?

- Don't worry—we'll cover that in great detail in the coming weeks
- Energy is defined as the *capacity to do work*
- But what is *work*?
  - we'll get to this in the next lecture
- At some level, *I* don't know what energy is: why there is such a thing, why it's conserved, where it all came from, etc.
  - these are deep and interesting questions that some physicists try to understand

Why am I worried?

- I am spooked by my recent "predictions" that have come true
  - thought housing would go down 50% (and sold early 2006!)
  - claimed in summer 2008 that I wouldn't be surprised if the stock market lost half its "value"
- Now I can't shake my concerns over our energy dependence and where declining resources will take us
  - and I blame it on physics 12!
- Otherwise normally optimist, problem solver
- The good news: we *can* physically get through this
- The bad news: the good news is only possible if people are *educated* and seek *long-term* over short-term gains
  - part of why Physics 12 may be the most important thing I do

My Personal Trajectory

- Ever since teaching Physics 12 in 2004, I have:
  - devoted a great deal of time into understanding the challenges that face us
  - built my own solar photovoltaic off-grid system
  - measured everything energy-related in my house
  - started gardening, replaced grass with CA natives
    - also rainwater catchment for watering garden
    - chickens soon!
  - reduced energy profile dramatically, so now < $1/5^{th}$ the energy footprint of typical San Diegans
  - started a blog, *Do the Math*, with > 2.5 million hits

Assignments

- Check out the course web page:
  - physics.ucsd.edu/~tmurphy/phys12/
- Reading:
  - Chapter 1 of Ristinen and Kraushaar
  - also read the Appendix
  - optional: read Galactic Scale Energy post on Do the Math (DtM)
- First homework will be due Friday, April 12
  - see main course website for assignment
- First quiz by Friday (midnight), April 12
- Transmitter use (iClicker) starting Friday, April 5
- Get established on TED
  - see course website for tips on getting connected