Everyday Energy

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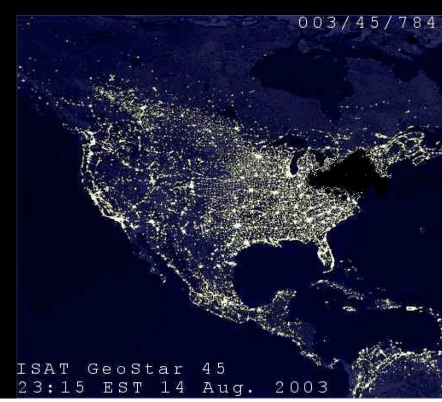
Feb. 25, 2005



Objectives

- Illustrate that you're already very familiar with the concept behind energy, even if you don't think you know any physics

- Understand energy as a deep organizing and unifying principle for making sense out of the world, and connecting to the wonder behind everything

Common Experiences

- You get tired climbing a long flight of stairs.

- You get hungry if you exercise and don't eat.

- A lamp won’t emit light if it isn’t plugged in.

- Your car stops moving if it runs out of gas.

- Sand warms up when the Sun shines on it.

- You speed up as you coast downhill on a bicycle, and slow down as you coast back up the next hill.

Common Theme

(various ways to state it)

- Change to one part of the world is accompanied by a corresponding change to another part of the world
- There is some sort of “capacity” to make things happen, & this *capacity must be taken away from something else* and given to the part of the world you want to change
- No free lunch – You can’t get something for nothing

More insight on constraints…

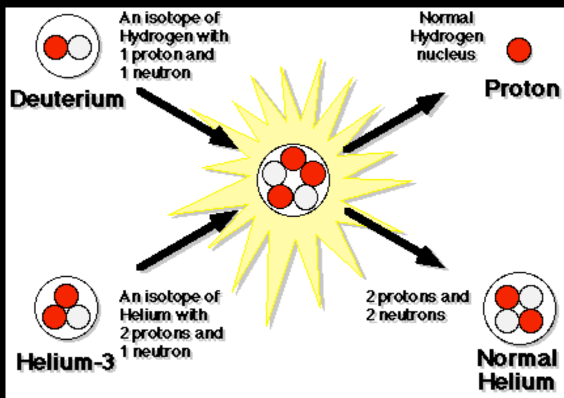
- If I tell you I could power the city of Portland for a year with no source of this power, you’d think I was crazy, and you’d be right!

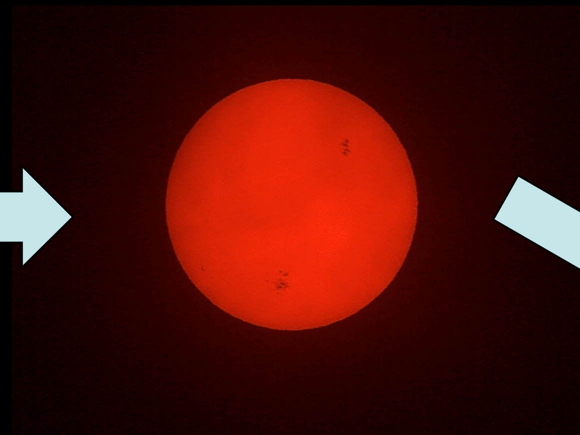
- But if I said I could power the city on the capacity stored in a single brick, you might also think I was crazy…but you’d be wrong!

Most things are possible, but nature dictates specific pathways we must follow to make them happen

Tracing the flow of “energy”

mass





sunlight

plants

food

activity

More Precisely: Defining **Energy**

Specific numbers we can assign to the "capacity" that gets passed along from one part of the world to another.

Nature has very definite rules for calculating how much energy each system has:

- "The ability to do work"

  Energy = Work = Force x Distance

- Kinetic

  Energy = (1/2) x (mass) x $(\text{speed})^2$

- Gravitational Potential

  Energy = (mass) x (height) x “g” [$g=9.8\ m/s^2$]

- Thermal

  Energy = (Heat Capacity) x (Temperature)

- Mass

  Energy = (mass) x (speed of light)^2

  [$E=mc^2$]

Law of Conservation of Energy

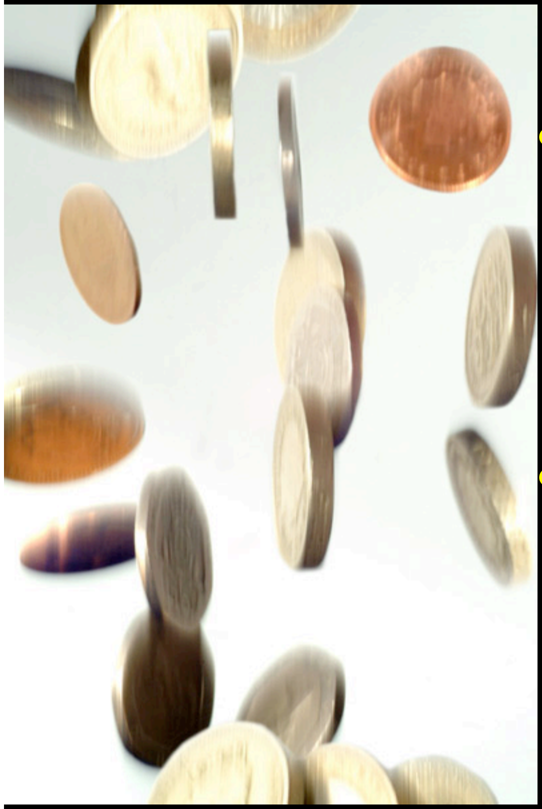
More precise version of our earlier statement: The amount of “something” (energy) you must give up from one system, to get a particular thing to happen to another system, is always the same.

Energy lost in one place = Energy gained somewhere else

Another way of saying it:

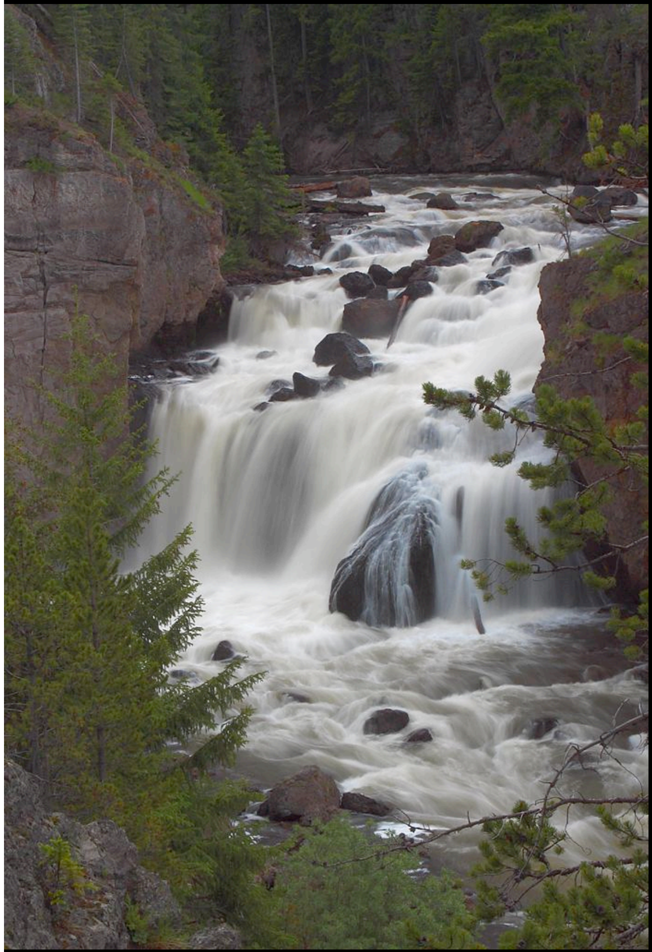
Energy cannot be created or destroyed. It can be transformed into different forms and moved from one part of the world to another. But if you add up all the different forms (making sure you haven't missed anything), the total amount of energy never changes.

Financial Accounting Analogy



- Corporation may have many different bank accounts
- Money goes in and out of accounts, for many different purposes: payment for supplies, purchases by customers, salaries paid, etc.
- No matter how many transfers occur, someone always has the money – in one of the accounts, or in their pocket. If it appears to have been lost, there's just an account (or pocket!) we don't know about.

Amazing Power of this Law…



Once you know the energy, you can forget about the details of the system: You tell me what you want to do, and how much energy you have, and I'll tell you if it's possible

Portland General Electric

Units of Energy

- Thanks to energy conservation, we can really pick anything we want to use as the standard of reference - e.g. the amount of energy to heat a cup of water by 10 ºC

- To express any amount of energy in terms of our basic unit, all we have to do is convert the energy into our reference form, and see how much it is.

Common Units

- Calorie (food, capital C) – Energy to raise 1 kg of water by 1 ºC

- Joule – Energy of work done by force of 1 Newton through a distance of 1 meter (4,200 Joules in 1 Calorie)

- Watt – 1 Joule/second. (A unit of power - the rate of energy transfer from one form to another.)

- Kilowatt Hour (kWhr) – Energy transferred if you let a power of 1000 Watts run for 1 hour. (1 kWhr = 3.6 million Joules)

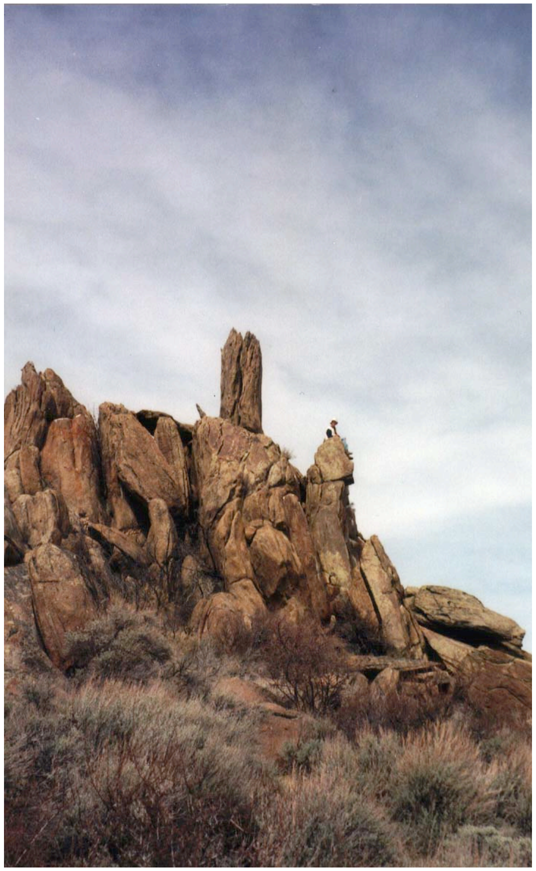
Example: Food into Height

$$E = m \times g \times h$$

$$\approx 50 \text{ kg} \times 10 \frac{m}{s^2} \times 1000 \text{ m}$$

$$= 500{,}000 \text{ Joules} \times \frac{1 \text{ Calorie}}{4{,}200 \text{ Joules}}$$

$$\approx 120 \text{ Calories}$$



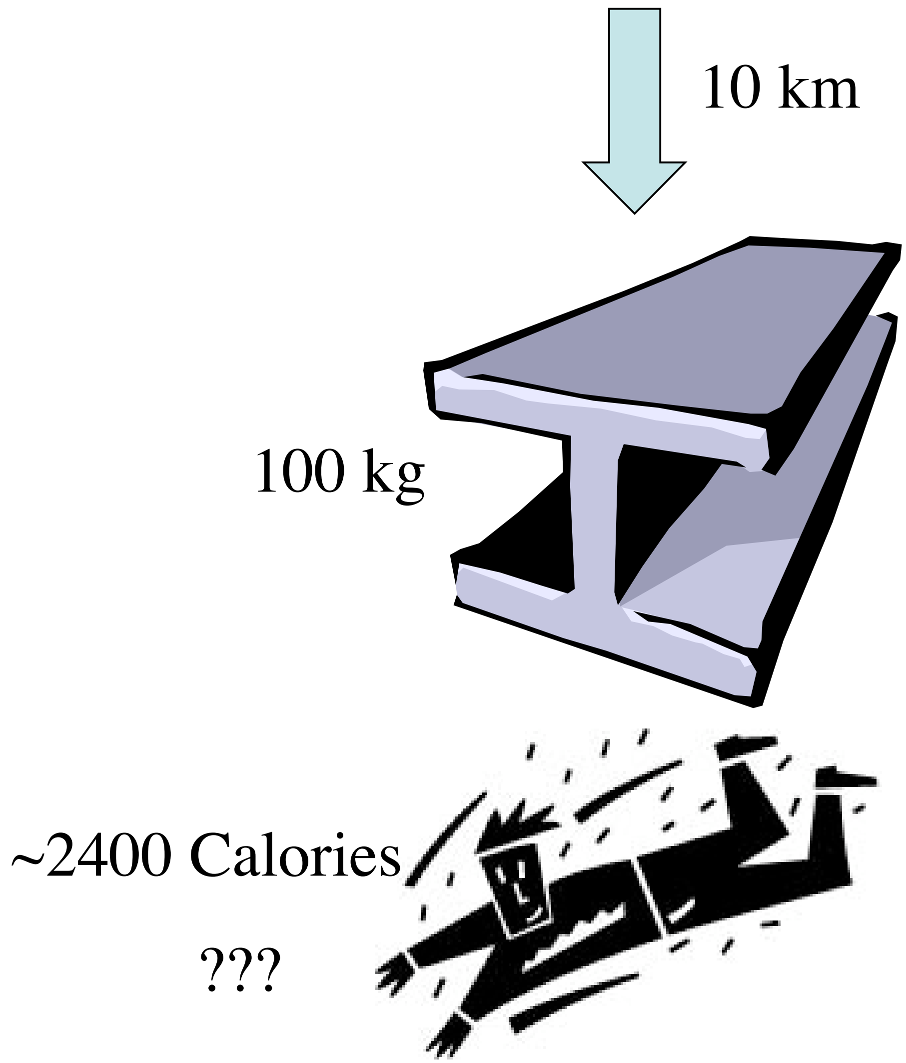
Handy Numbers

- Average solar energy available at Earth's surface: about 300 Watts/m^2
- Total annual human energy use: about 4×10^{20} Joules or about 10^{14} kWhr
- Typical power requirements: auto at 50 miles/hr = 70 kiloWatts (gallon of gas has about 130 million Joules); cooking range = 12 kiloWatts; microwave = 1.4 kiloWatts; color TV = 350 Watts

Why Do We Worry About "Conserving Energy?"

- It's not just a question of whether the energy is available at all
- It also matters whether it's in a form we can convert to achieve the task at hand…

The form of energy matters!!



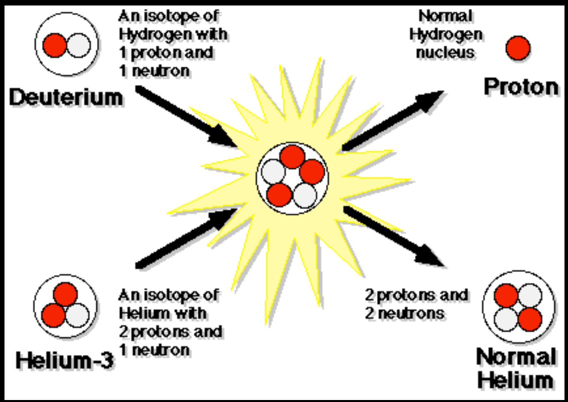
What *Is* Energy?

"It is important to realize that in physics today, we have no knowledge of what energy *is*.…There are formulas for calculating some numerical quantity, and when we add it all together it gives…always the same number. It is an abstract thing in that it does not tell us the mechanism or the reasons for the various formulas."

— Richard Feynman

Tracing the flow of energy

mass



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