Energy Conservation

Spring 2013

Lecture 5

UCSD

Physics 12

Conservation and Exchange of Energy

Nothing Comes for Free

Energy is Conserved

• Conservation of Energy is different from Energy Conservation, the latter being about using energy wisely
• Conservation of Energy means energy is neither created nor destroyed. The amount of energy in the Universe is constant!!
• Don’t we create energy at a power plant?
  – Oh that this were true—no, we simply transform energy at our power plants
• Doesn’t the sun create energy?
  – Nope—it exchanges mass for energy

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Energy Exchange

• Though the total energy of a system is constant, the form of the energy can change
• A simple example is that of a simple pendulum, in which a continual exchange goes on between kinetic and potential energy

Perpetual Motion

• Why won’t the pendulum swing forever?
• It’s hard to design a system free of energy paths
• The pendulum slows down by several mechanisms
  – Friction at the contact point: requires force to oppose; force acts through distance → work is done
  – Air resistance: must push through air with a force (through a distance) → work is done
  – Gets some air swirling: puts kinetic energy into air (not really fair to separate these last two)
• Perpetual motion means no loss of energy
  – solar system orbits come very close
Some Energy Chains:

- A coffee mug with some gravitational potential energy is dropped
- Potential energy turns into kinetic energy
- Kinetic energy of the mug goes into:
  - Ripping the mug apart (chemical: breaking bonds)
  - Sending the pieces flying (kinetic)
  - Into sound
  - Into heating the floor and pieces through friction as the pieces slide to a stop
- In the end, the room is slightly warmer

Gasoline Example

- Put gas in your car, containing 9 Cal/g
- Combust gas, turning 9 Cal/g into kinetic energy of explosion
- Transfer kinetic energy of gas to piston to crankshaft to drive shaft to wheel to car as a whole
- That which doesn’t go into kinetic energy of the car goes into heating the engine block (and radiator water and surrounding air), and friction of transmission system (heat)
- Much of energy goes into stirring the air (ends up as heat)
- Apply the brakes and convert kinetic energy into heat
- It all ends up as waste heat, ultimately

Bouncing Ball

- Superball has gravitational potential energy
- Drop the ball and this becomes kinetic energy
- Ball hits ground and compresses (force times distance), storing energy in the spring
- Ball releases this mechanically stored energy and it goes back into kinetic form (bounces up)
- Inefficiencies in “spring” end up heating the ball and the floor, and stirring the air a bit
- In the end, all is heat

Why don’t we get hotter and hotter

- If all these processes end up as heat, why aren’t we continually getting hotter?
- If earth retained all its heat, we would get hotter
- All of earth’s heat is radiated away
  \[ F = \alpha T^4 \]
- If we dump more power, the temperature goes up, the radiated power increases dramatically
  - Comes to equilibrium: power dumped = power radiated
  - Stable against perturbation: \( T \) tracks power budget
Rough numbers

- How much power does the earth radiate?
- \[ F = \sigma T^4 \text{ for } T = 288^\circ\text{K} = 15^\circ\text{C} \text{ is } 390 \text{ W/m}^2 \]
- Summed over entire surface area (4\(\pi\)R\(^2\), where R = 6,378,000 meters) is \(2.0 \times 10^{17}\) W
  - for comparison, U.S. production is \(3 \times 10^{12}\) W
- Solar radiation incident on earth is \(1.8 \times 10^{17}\) W
  - just solar luminosity of \(3.9 \times 10^{26}\) W divided by geometrical fraction that points at earth
- Amazing coincidence of numbers! (or is it…)

No Energy for Free

- No matter what, you can’t create energy out of nothing: it has to come from somewhere
- We can transform energy from one form to another; we can store energy, we can utilize energy being conveyed from natural sources
- The net energy of the entire Universe is constant
- The best we can do is scrape up some useful crumbs

References & Assignments

- Assignments
  - Read Chapter 2
  - Homework #1 due Friday, April 12
  - Homework #2 is now available:
    - go to Assignments page for link; I created all problems: none from book
    - start early on this one (toughest of quarter?)
- Quiz
  - nominally, deadline is Friday by midnight…
  - …but still need to get TED revved up
  - monitor e-mail for announcement of availability
  - may extend deadline if delayed