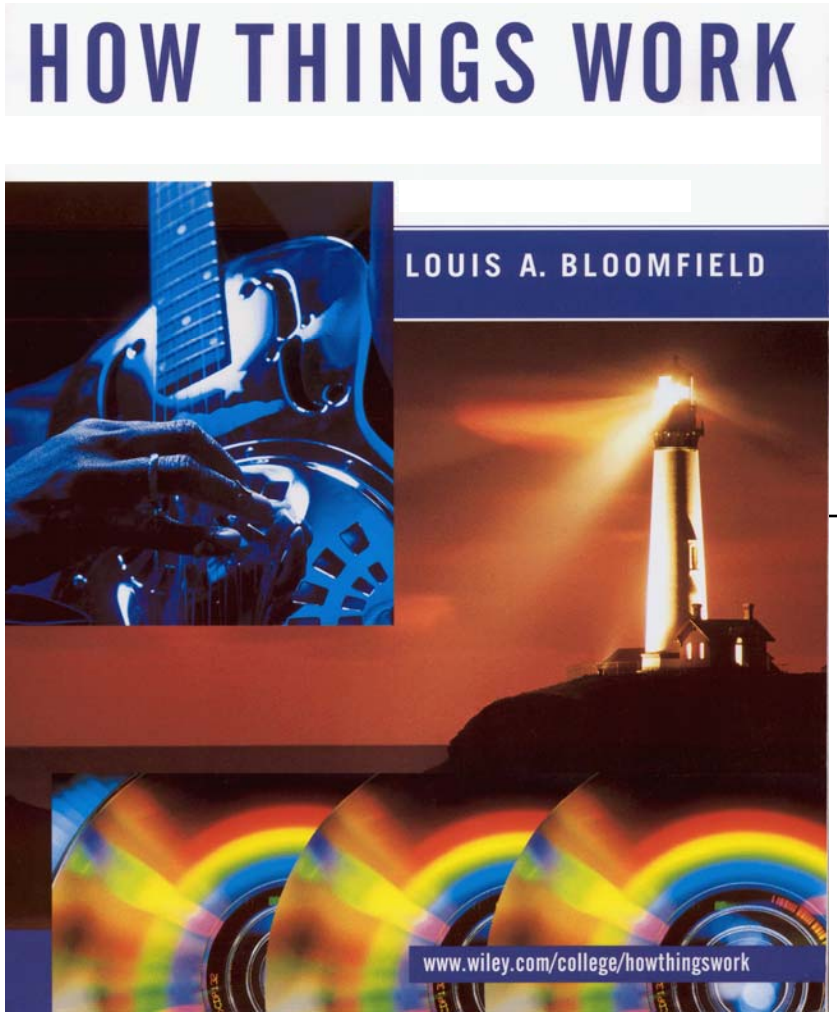

Teaching Physics in the Context of Everyday Objects

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What is *How Things Work*?

- It's Physics in the Context of Objects
  - It puts objects before physics concepts
  - It puts physics concepts before formulas
  - It's "backwards"
- It's the "Case Study" Method
- It's how Scientists actually Discover Science
- It's what Makes Science Fun

Overview of this Presentation

- Motivation for *How Things Work*
- Structure of *How Things Work*
  - For Example: Music Boxes
- Possible Objects for a *How Things Work* Course
- Some Illustrations:
  - Roller Coasters
  - Bicycles
  - Clocks
  - Microwave Ovens
- Observations about *How Things Work*

Why *How Things Work*?

- "Oh, I'm a physicist" … *(end of conversation)*
- Conventional physics outreach is often:
  - magic & mysteries *(no explanation).*
  - factoids *(what, where, when, but never why or how).*
  - names *(memorization of random information).*
  - recipes *(mindless plugging and chugging).*
  - formalized "scientific method" *(repeating canned experiments).*

Why *How Things Work*? (con't)

- In contrast, *How Things Work*
  - grows naturally from the ordinary, everyday world.
  - explains rather than obscures.
  - emphasizes thought and understanding.
  - builds confidence appropriately rather than destroying it.
  - is useful in everyday life.
- The audience for *How Things Work* is
  - anyone who is curious about the world around them.
  - absolutely enormous and largely untapped.

Structure of *How Things Work*

- A hierarchy with three levels
  - Level 1: Areas of Physics – for the instructor
  - Level 2: Objects of Everyday Life – for the students
  - Level 3: Concepts of Physics – for both

7. Heat and Phase Transitions

7.1 Woodstoves

(thermal energy, heat, temperature, chemical bonds and reactions, conduction, thermal conductivity, convection, radiation, heat capacity)

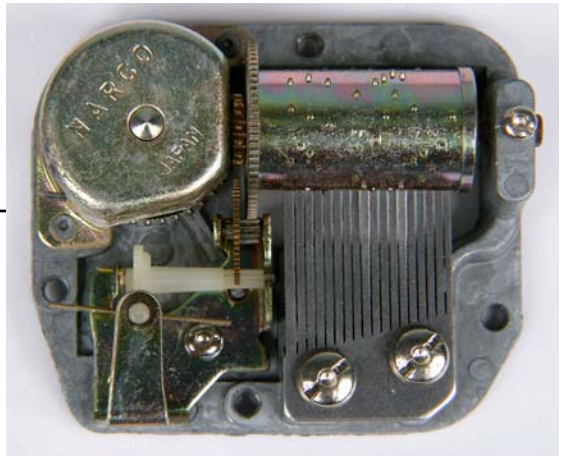
7.2 Water, Steam, and Ice

(phases of matter, phase transitions, melting, freezing, condensation, evaporation, boiling, relative humidity, latent heats of melting and vaporization)

7.3 Incandescent Lightbulbs

(electromagnetic spectrum, light, black body spectrum, emissivity, Stefan-Boltzmann law, thermal expansion)

For Example: Music Boxes



- They Introduce New Concepts:

  9. Resonance and Mechanical Waves

  9.1 Music Boxes

  (natural resonance, harmonic oscillators, simple harmonic motion, frequency, pitch, sound, music, harmonic and non-harmonic overtones, sympathetic vibration, standing and traveling waves, transverse and longitudinal waves, velocity, frequency, and wavelength in mechanical waves, superposition)

- They Reinforce Old Concepts:
  - Energy and Work (Chapter 1)
  - Springs and Stable Equilibria (Chapter 3)
  - Aerodynamics (Chapter 6)

Music Boxes: Questions to Address

- *What* are vibration, pitch, sound, and music?
- *Why* does a tine vibrate?
- *Why* do different tines have different pitches?
- *Why* is a tine's pitch independent of its volume?
- *How* does sound from the music box reach us?
- *How* does the music box produce sound?
- *Why* does a music box sound like a music box?

There is a great deal of physics here in these *why* and *how* questions!

Choosing Objects for a *How Things Work* Course

- Set your physics agenda first, then choose objects
- A typical object has one central physics issue
- Play up that central issue whenever possible
- Caveats *(learned from painful experience)*
  - Some objects present physics concepts better than others
  - Some objects aren't of general interest
  - Less is more; you can't do everything
- *HTW*'s Table of Contents follows this approach

How Things Work Table of Contents

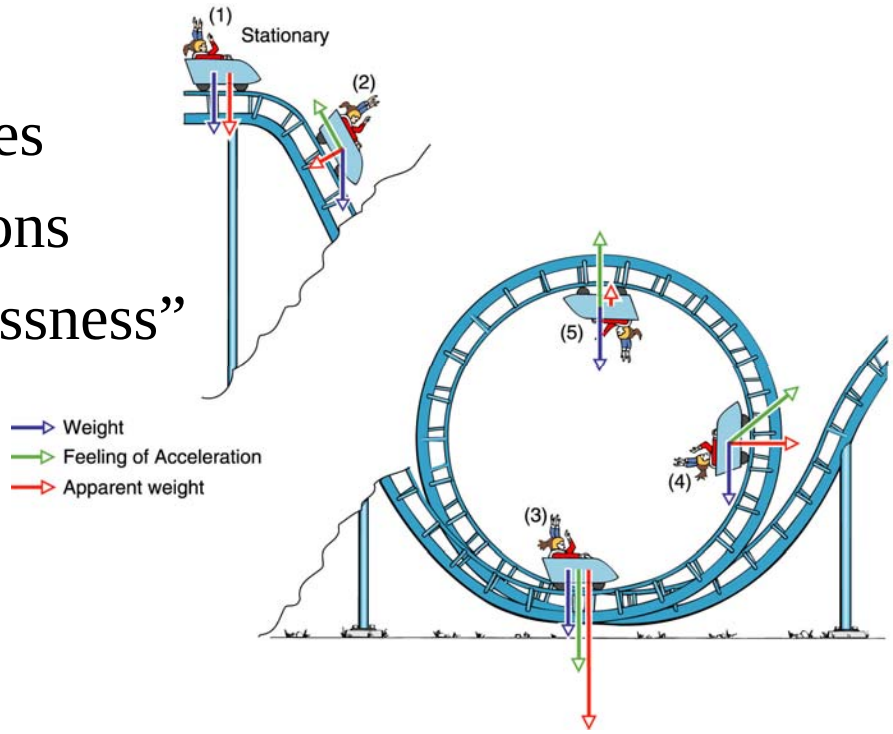
How Things Work Table of Contents (con't)

HTW is an Educational Framework

- My goals for *HTW* are to help students
  - begin to see science in everyday life
  - learn that science isn't frightening
  - learn to think logically in order to solve problems
  - develop and expand their physical intuition
  - learn how things work
  - see that the universe is predictable rather than magical
  - see the history of science and technology
- Employ any of the best classroom techniques
- HTW sets the stage for exceptional productivity

Roller Coasters

- How do loop-the-loops work?
- Physics concepts involved:
  - Inertia
  - Acceleration and forces
  - Centripetal accelerations
  - Weight and “weightlessness”

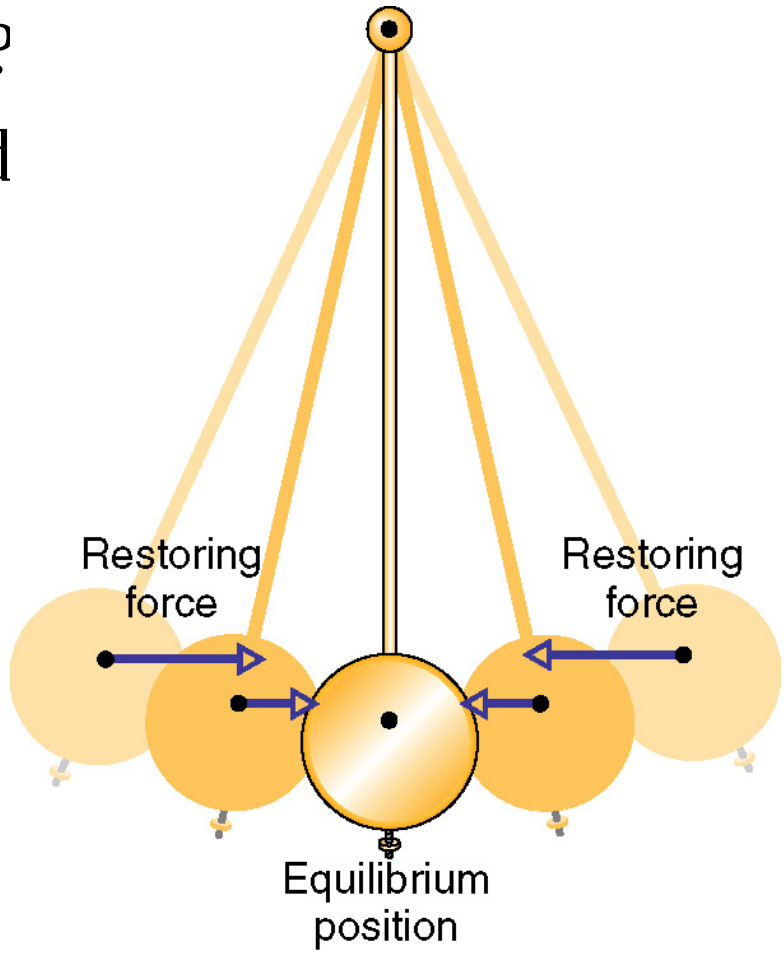


Bicycles

- Why are bicycles so stable?
- Physics concepts involved:
  - Equilibrium
  - Energy and acceleration
  - Stable and unstable equilibriums
  - Static stability
  - Gyroscopic precession
  - Dynamic stability

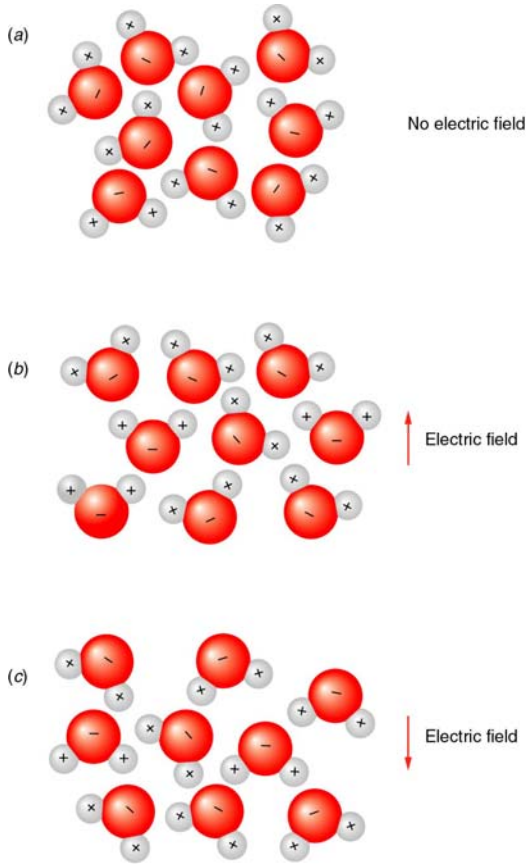
Clocks

- How do clocks keep time?
- Physics concepts involved
  - Time and Space
  - Forces and Acceleration
  - Harmonic Oscillators



Microwave Ovens

- How do microwave ovens cook?
- Physics concepts involved:
  - Electric fields
  - Polar molecules and free charges
  - Electrostatic forces and torques
  - Electromagnetic waves
  - Wavelength and frequency



Philosophy of *How Things Work*

- It's a true outreach course, not a recruiting course
- Its purpose is to inform bright, eager non-scientists
  - They don't know what physics is
  - They don't know why physics matters
  - They respond to relevance, value, and respect
  - *HTW* is about *them*, not about *us*
- If you build it, they will come

Observations about *How Things Work*

- The impact of *How Things Work*
  - Many non-science students are now learning physics
  - These students find physics useful
  - There is less fear of physics – a cultural change
  - Physics has become a valued part of the curriculum
  - Other physics courses are flourishing

Observations about *How Things Work* (con't)

- My own experiences
  - I'm enjoying teaching more than ever
  - I feel as though I make a difference
  - I get to explain physics widely
  - I've learned a great deal of science