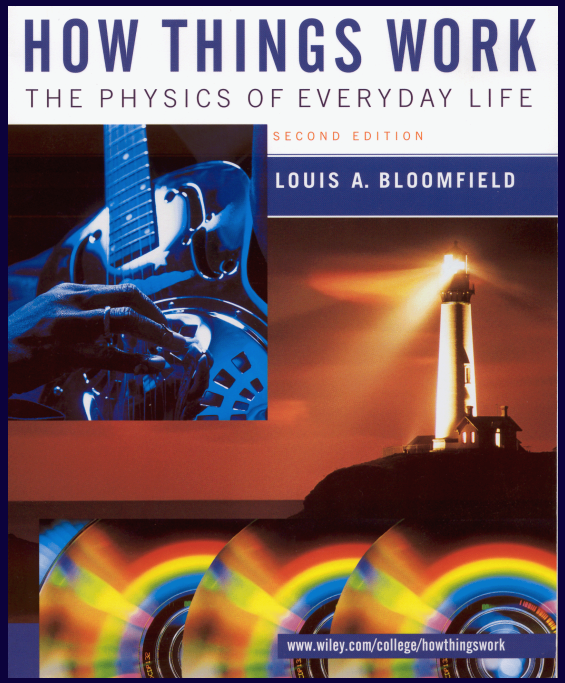

How Things Work

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What is *How Things Work*?

- Teaching physics in the context of objects
  - Objects ahead of physics concepts
  - Physics concepts ahead of formulas and calculations
- A backward course in physics

Relationship to Core Knowledge

- Physics knowledge lies in the concepts
  - Words, formulas, calculations are secondary
  - Physics lives in the how and why
  - Physics does not live in the what, who, where, when
  - There is no physics in:
    - stringing together buzzwords or memorizing facts
    - the formal "scientific method"
    - following formulaic recipes or mindless "potted" experiments
  - Physics is in observing, thinking, understanding

Overview

- Motivation for *How Things Work* (*HTW*)
- Structure of *HTW*
- History of *HTW*
- Examples of objects
  - Roller Coasters
  - Bicycles
  - Microwave Ovens
- Observations about *HTW*

Motivation for HTW

- Difficulties with teaching physics
  - Only one intro course: *Physics-for-Physicists (PfP)*
  - To non-scientists, *PfP* is
    - Academic
    - Unfamiliar
    - Irrelevant
    - Boring
    - Frightening
  - Neglects how science developed – in context of objects
  - Active learning, hands-on work, enthusiasm can't fix

Motivation (con't)

- Difficulties facing UVa Physics Dept in 1991
  - Too few students
  - No growth in major, graduate, or service courses
  - Limited appeal for the one non-scientist course (*PfP*!)
  - Non-scientists feared physics
- Personal motivations
  - To teach students with broader interests
  - To return to what attracted me to physics

Structure of *HTW*

- 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

Chapter 7. Resonance and Mechanical Waves

7.1 Clocks
(time and space, natural resonance, harmonic oscillators, simple harmonic motion, frequency)

7.2 Violins and Pipe Organs
(sound, music, vibrations of a string and column of air, higher-order modes, harmonics, sympathetic vibration)

7.3 The Sea and Surfing
(tidal forces, tidal resonances, standing waves, traveling waves, wavelength, wave velocity)

History of *HTW*

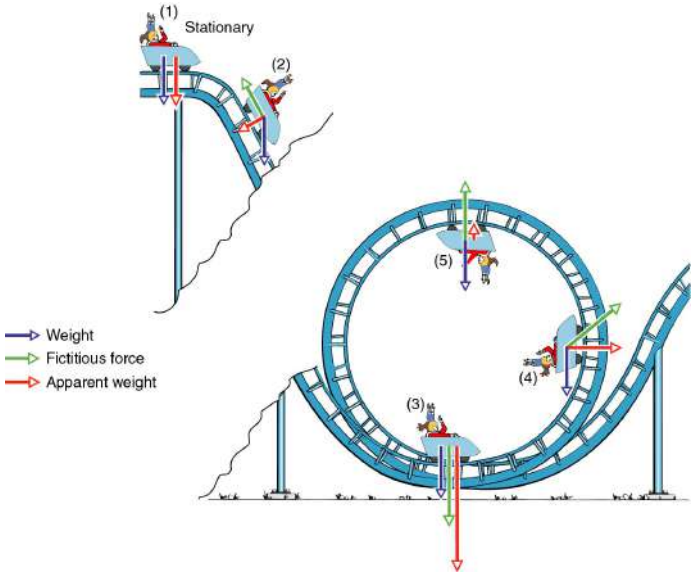
- Design and start-up (1991-1992)
  - Custom fit the course to non-scientists
  - Focus on concepts, not formulas
  - Build course around everyday objects
  - Goals: students should
    - learn physics concepts well
    - learn to see physics in their world
    - encounter physics in context
    - begin to feel that physics is important
    - learn how things around them work
  - Expected fall enrollment 20-25, actual enrollment: 92

History (con't)

- Growth and development (1992-1996)
  - Rearrangement and reduction of material
  - Enrollment grew to between 350 and 500 per semester
  - Lecture notes evolved into a book
- Further development (1996-present)
  - Further reduction of material to avoid a frantic pace
  - Working to stay "on message"
  - Getting students involved

Roller Coasters

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

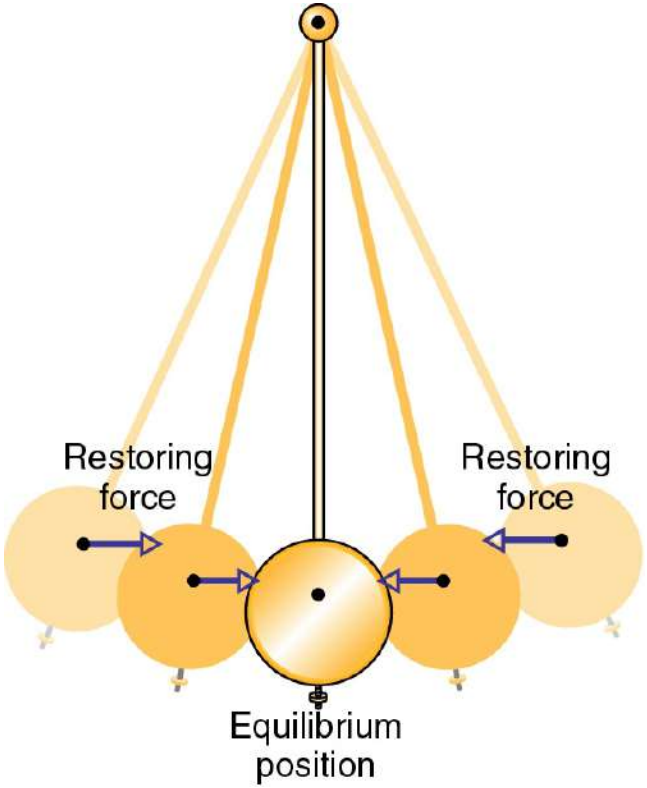


Bicycles

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

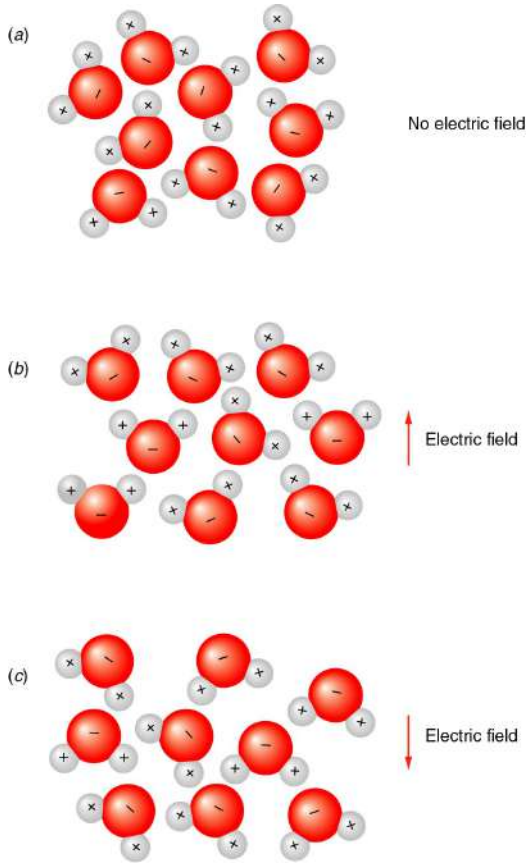
Clocks

- 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



Observations about *HTW*

- Impact of *How Things Work* at UVa
  - Many non-scientists now learn physics
  - These students find physics useful
  - Much less fear of physics – a cultural change
  - Physics is now a valued part of the University
  - Other physics courses are flourishing

Observations (con't)

- My experiences
  - I'm enjoying teaching more than ever
  - I feel as though I make a difference
  - I'm visible to the students and the University
  - I often explain of physics to individuals and the media
  - I've learned a great deal of basic physics