

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*

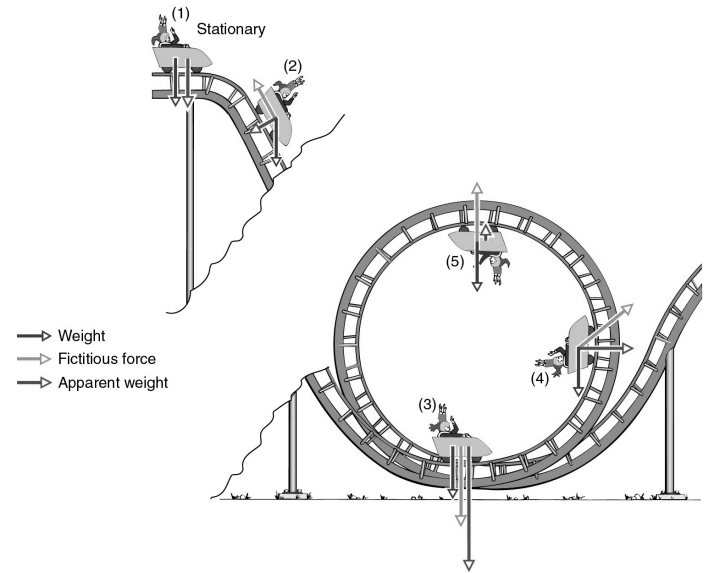
- Design and start-up (1991-1992)
 - Custom fit the course to non-scientists
 - Focus on concepts, not formulas
 - Build course around everyday objects
 - Goals: students should
 - learn physics concepts well
 - learn to see physics in their world
 - encounter physics in context
 - begin to feel that 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

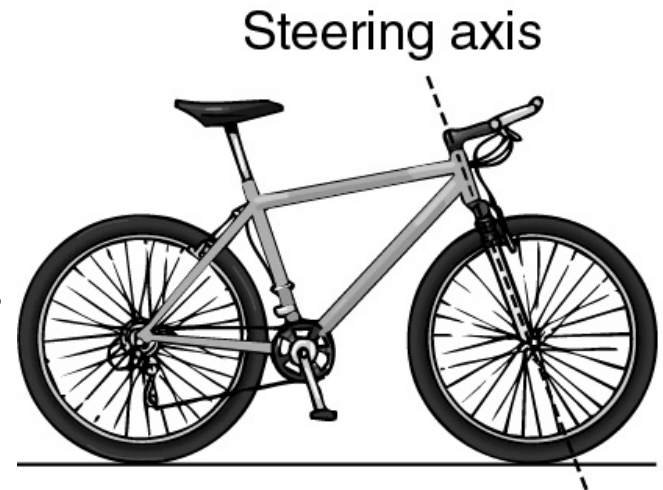
Roller Coasters

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



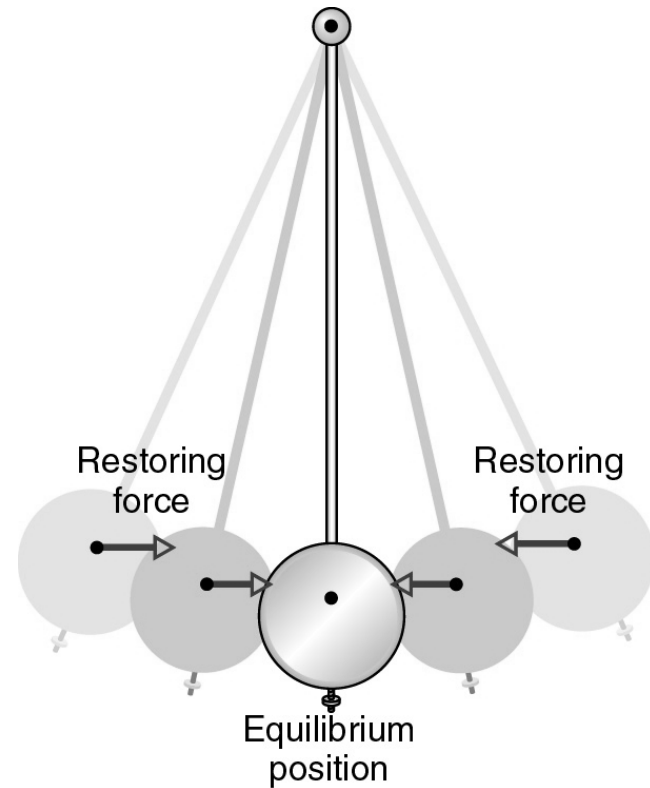
Bicycles

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



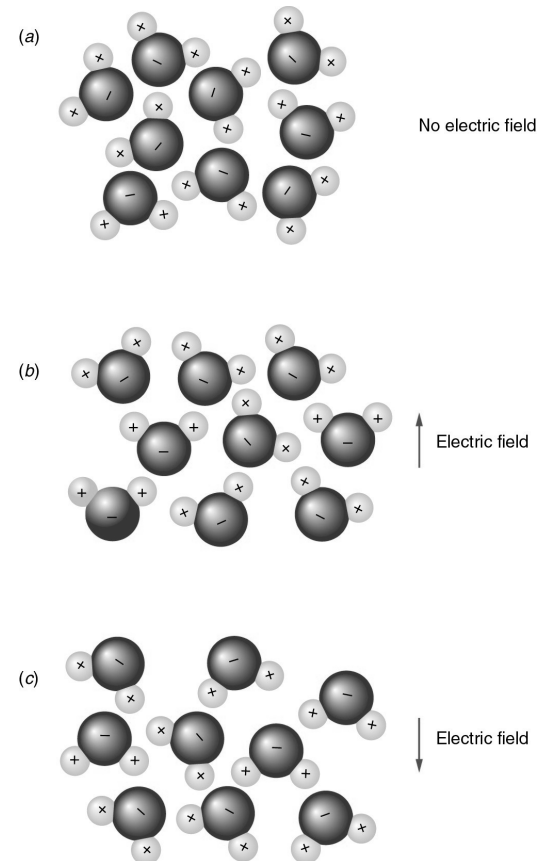
Clocks

- 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