Atoms and Stars
IST 2420
and IST 1990

Class 12
Winter 2006
Instructor: David Bowen

Course web site: www.is.wayne.edu/drbowen/aasw06
IST 1990 Moodle: techtools.culma.wayne.edu/moodle

Agenda

- Assignments, passbacks, initial signin sheet
- Pick up:
  - Notes for Class 12
  - Specific Gravity table for Experiment 7
- Experiment 9
- Upcoming assignments
  - Experiment 4
- Try Brownian motion computer demo again
- Essay 2
- Reading: Chemistry
- Waves and the Uncertainty Principle
- Lab 7: Specific Gravity

Experiment 9

- Method: measuring circumference using pins and string
- Circle: Method agrees with $C = \pi d$
- Ellipse: Method does not agree with $C = \frac{3}{7}\pi(a+b)$
- Can method work for circle but not ellipse?
- In science, which is more trustworthy? Theory or experiment?
- Power of authority

Changes in Lab Schedule

- Changes to Syllabus lab schedule:
  - Lab 7 tonight
  - Lab 11 on April 12
  - We will not do Lab 4 (we will go over the content)

Upcoming …

- Next week (April 12):
  - Reader: New York Times on Kansas & Big Bang (emails), Black Holes, Global Warming, Icecaps and Hurricanes: the Proof of Climate Change
  - Manual: Lab 11
  - Due: Report for Lab 7
  - SET
- April 19 (last regular class)
  - Essay 2 due
  - Review for Final Exam
- April 26: nothing that night but the Final Exam

Semester is Ending!

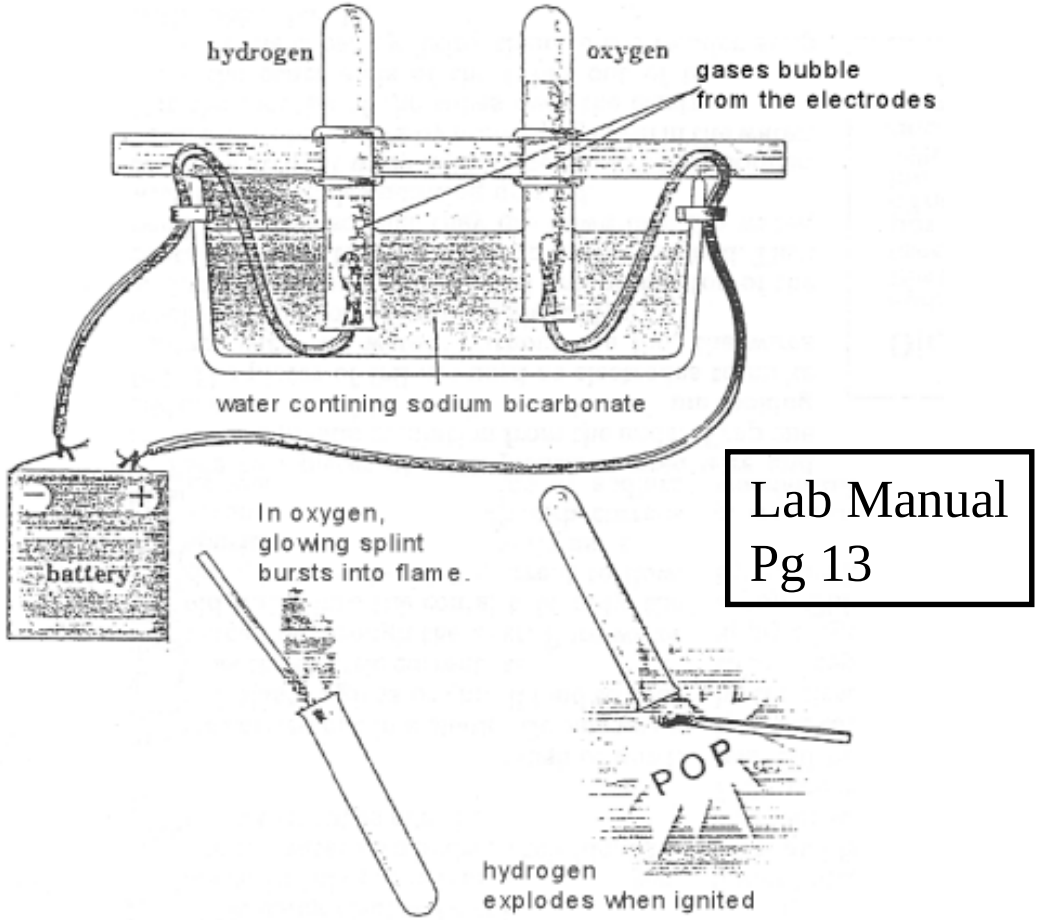
- If you have been relying on being able to turn work in late, *it is time to get going*
  - Alternatives: D, E, I, X, drop – see counselor!
- Getting ready for Final:
  - Read Information Sheet carefully – a lot of information there
  - Look at Final Topics carefully
  - Use Review Session!
    - Final Where-Is probably April 12

16^{ths} on the Final

- Last week there were some comments that you wanted to do the full math (division) on the Final, for converting from 16^{ths} to decimal.
  - Options:
    - Do not do the division
    - Table of 16^{ths}, with “ringers”
    - You do the division
  - Choice?

Experiment IV (not done) (Q11)

- Chemical composition of water
- Electrical current decomposes water: H_2O ➔ 2H + O



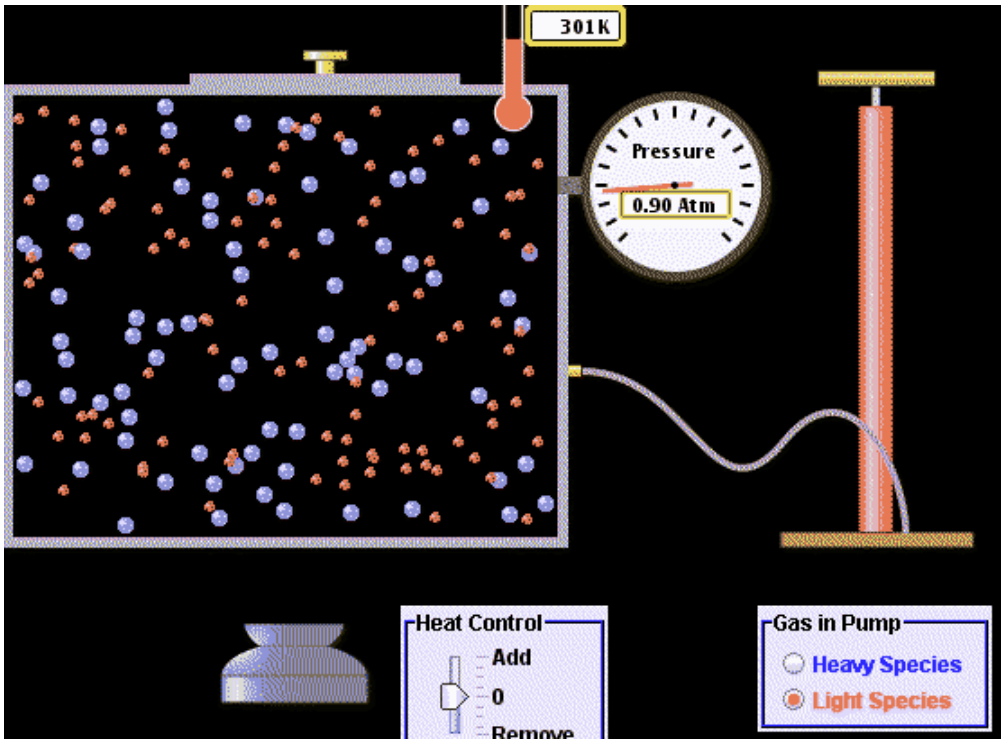
Lab Manual Pg 13

Atomic Nature of Matter (Repeat)

- First direct evidence 1827 Robert Brown (10c#2)
  - Noticed spores jiggling under microscope
  - "Brownian motion" – bombarded by molecules
  - See next slide, or

    http://www.colorado.edu/physics/phet/web-pages/simulations-base.html
  - Now we have more direct evidence
- Atoms bond into molecules – many types (10c#1)
  - Molecules - compounds
  - Molecules have separate properties from atoms
  - Burning is combination with O
    - New - modern automobiles very little CO

Brownian Motion



Imagine the red molecules were so small that we couldn't see them – blue ones would "jostle" for no apparent reason.

Essay 2

TOPIC: What has this course been about? You should answer this question with a core concept or idea, perhaps with dependent parts, and illustrated ~~with~~ by referring to course experiences, such as labs and discussions, and materials, such as readings, notes, lab materials, and so on. Start with the "Course Description" section in the Syllabus. You can agree with, make changes to, or disagree with this description, but if you disagree, include an equivalent description – that is, one that covers the course as a whole.

Essay 2 (cont'd)

SYLLABUS: "This course is … about the transition from Greek philosophy to modern science. The period of Greek philosophy is roughly 600 BC to 400 AD, and modern science developed first in certain of the physical sciences (physics and chemistry) in Europe roughly during the period 1400 to 1800 AD. …"

Essay 2 (cont'd)

SYLLABUS (cont'd): "The main topics covered in this core of the course will be:

- The reliability and value of science
- The basic history of the rise of science
- The content of the various theories and experiments"

So…

Essay 2 (cont'd)

- Does this course "hang together," or are the various parts disconnected?
- Is there a "core" Is the core what I said?
- If yes, how do the parts of the course support the core?
- If no, is there another core, or is there no core?
  - Illustrate with examples either way

Essay 2 (cont'd)

Requirements:

- 3 – 4 pp, double-spaced, 12-point Times Roman font or equivalent, margins 1" top and bottom, 1½" on sides
- Grading:
  - 40% Form: four parts, organization
  - 40% Content: use materials, apply them
  - 20% Mechanics: grammar, spelling

Readings – Chemistry (Q10c#2)

- Chemistry developed after Newton (physics)
  - Alchemy – transmutation of elements
  - Medicine
  - Industry – much demand for chemicals 1700s
  - Mechanical approach from Descartes & Newton
- 1700 still the four Aristotelian elements
  - Earth – fixed volume & shape
  - Water – fixed volume only

Chemistry

- 1700 still Aristotelian elements
  - Air – volume & shape expanded to container
  - Fire passed through container walls
- 1727 – Stephen Hale: released “fixed” air (put out flames) from solids, much interest
- 1749 Jean-Jacques DeMairan evaporated liquids (e.g. ether) in a vacuum, froze water
  - But liquids supposed to evaporate into air
  - Fire combined with liquid = air? Many types?
    - Water could be solid, liquid, vapor –differ by fire?

Chemistry

- How could “big four” be elements?
- 1750s Joseph Black experiments with “magnesia alba,” gave off “fixed air” that extinguished flame (CO_2), denser than “common air,” turned limewater cloudy
  - Use limewater test to show fixed air came from fermentation & charcoal combustion, would not support life
    - “Fixed air” became specific name for this gas (CO_2)

Chemistry

- 1766 Henry Cavendish: “inflammable air” H
- 1772 Joseph Priestley obtained “fixed air” in other ways, demonstrated solubility in water (& taste – birth of carbonated beverage industry)
  - Many other types of air – “dephlogisticated air” O
    - Phlogiston theory of combustion – burning releases phlogiston – from Germany, industrially useful
    - When air is saturated with phlogiston, combustion and life cease

Chemistry

- Antoine Lavoisier (1743 – 1794)
  - Graduated in law but continued science studies
  - Accurate weighing, also many practical results
  - (Calcination – turn a metal to powder (“calx”) by heating in air below melting point – phlogiston theory explained this as driving off phlogiston)
  - But Lavoisier’s weighing showed that weight of calx increased, for all metals – a problem for phlogiston theory of combustion

Chemistry

- Calx of mercury (oxide of mercury) when heated gave off air (gas) that supported combustion and life
  - Priestley found this air better (5×) for combustion and life than “common air” (air) – “eminently respirable air”
    - Lavoisier had assumed it was common air
  - Lavoiser confirmed this, but common air was then a mixture

Chemistry

- 1778 Lavoisier showed this air also formed acids, named it oxygen (“acid former”) (but we now know that hydrogen makes acid)
- 1783 Cavendish’s assistant told Lavoisier about Cavendish’s experiment of applying spark to inflammable air (H), finding dew which was identified as water
  - Lavoisier – water was not an element, combination with oxygen for all combustion

Chemistry

- Lavoisier named flammable air “hydrogen” for “water former”
- Lavoisier and others formed new chemical terminology – speaking well was like reasoning well
  - Oxide – combination with oxygen
  - Names indicated amount of oxygen (ous > ic)
    - Sulfurous acid H_2SO_3
    - Sulfuric acid H_2SO_4

Chemistry

- Lavoisier terminology
  - Gas – any vapor
  - Air – the atmosphere, a mixture (80% N, 20% O)
  - Fire was *caloric* (no correct theory until 19th century – started by Count Rumford)
- John Dalton (1766 – 1844), meteorologist
  - Converted to chemistry when he understood air was a mixture – why didn't different gases separate by gravity?

Chemistry

- John Dalton (1766 – 1844), meteorologist
  - Also gases dissolved in water proportional to pressure – why?
  - Hypothesized gases composed of atoms, each gas interacted with itself (see later slide)
  - "Law of definite proportions" – chemicals combined by weight in simple ratios
  - Dalton proposed formulae based on these – *chemical atomism*

Chemistry

- John Dalton (1766 – 1844), meteorologist
  - Dalton proposed formulae based on these
  - Many of his formulae were wrong
    - Example: he said water is HO
    - More were right, enough to straighten out the errors over time
  - (DB) Physicists did not accept chemical atomism until they accepted Maxwell and Boltzmann at the end of 19th century
  - (DB) Direct observations of atoms in 20th century

Chemistry (DB)

- John Dalton (1766 – 1844), meteorologist
  - What led Dalton to hypothesize atoms?
    - Characteristics of matter
      - Solids cannot occupy the same space
      - Some liquids can
      - All gases can
    - Why didn't lighter gas rise, heavier sink
      - Composition of atmosphere the same to 15,000'
      - Fog
    - Gases could interpenetrate if it was atoms with lots of empty space in between
    - Water could be gas, liquid, solid, these must have atoms
    - Extended to all liquids and solids

Two different types of things

- Particle (“thing,” “object”)
  - Examples: baseball, soup can, projectile, star
  - One location (or center)
  - Newton’s three laws govern motion
- Wave
  - Examples: waves in water, sound waves, radio waves
  - Spread out, exists in many places
  - “Wave Equations” governed motion (not Newton)

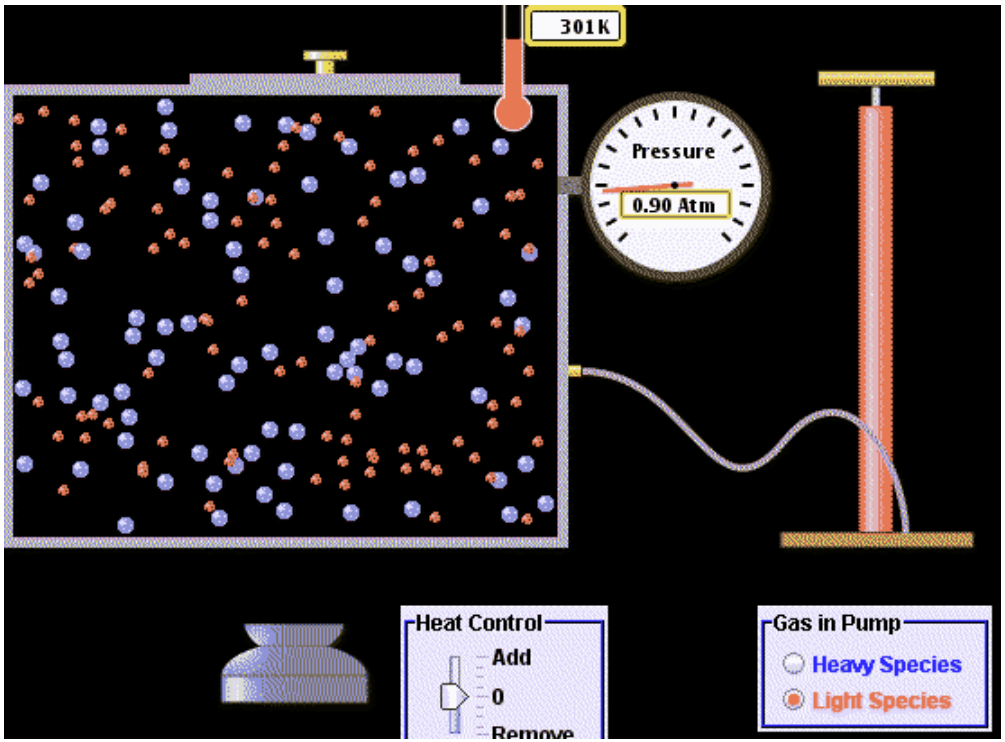
Two different types of things

	Particle	Wave
Position:	Definite – one position (center)	Spread out, no one place
Try to catch it – result is:	Get all or none	Only get part, if that
Collision with another:	Ricochet, bounce, shatter	Pass through each other
Existence:	All by itself	In something – the "medium" (before Maxwell)

Demonstrations

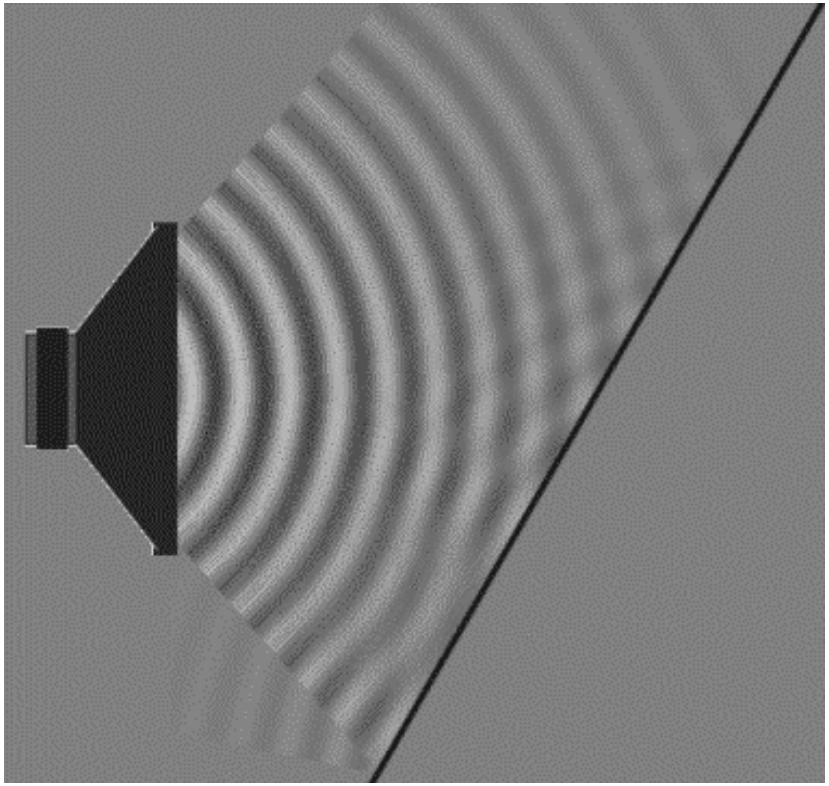
- PhET (Physics Education Technology)
  http://www.colorado.edu/physics/phet/web-pages/simulations-base.html
  - Particles: Gas Properties – they bounce
  - Waves: Sound >> Interference by Reflection
- Interference: light ➔ peak, dark ➔ trough
  - http://www.colorado.edu/physics/2000/schroedinger/big_interference.html – some areas gray (unlit)
- Light: early 1800s, Thomas Young proved light is a wave – "double slit experiment"
  - http://www.colorado.edu/physics/2000/schroedinger/two-slit2.html
  - **Confine a wave – it spreads out**

Particles collide…



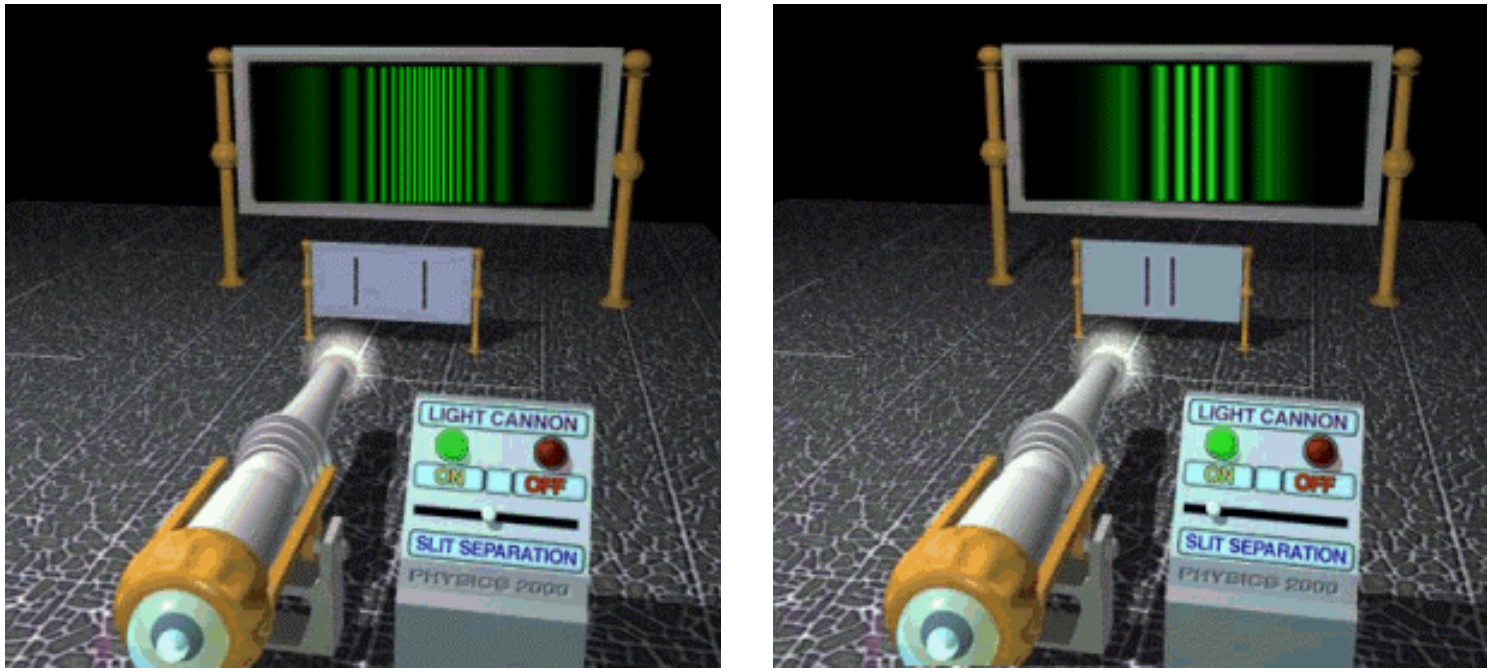
Particles of gas mix together, collide

but waves pass through each other



Sound wave and its reflection
(type – sound - is unimportant here)

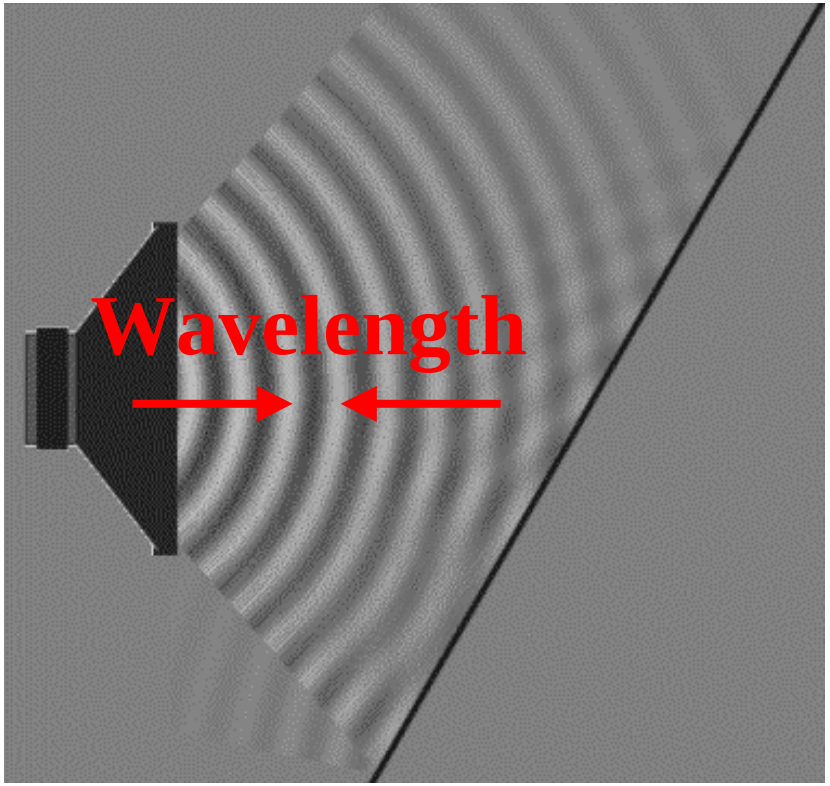
Waves “interfering”



Confine a wave and it spreads out

Waves

- Wavelength – distance between peaks (or troughs)
- Fixed speed
- Until 20th century, Wave / Particle – we thought everything was one or the other

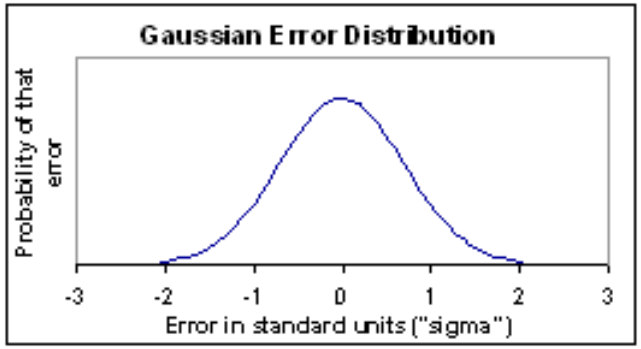


Wave-Particle Duality

- In 20th century, with rise of Quantum Mechanics, we understood that everything was both.
  - For a wave, x (position) and v (velocity) connected
    - Momentum p = m × v (m = mass, amount of matter)
  - Led to “Uncertainty Principle”
    - Irreducible uncertainty in our knowledge

Uncertainty Principle

- 1795 Carl Friedrich Gauss (college student)



- Also Uncertainty Principal 1927 Werner Heisenberg – cannot locate particle exactly

Uncertainty Principle

$$\sigma(x) \times \sigma(v) = \frac{\text{a very small number}}{\text{mass}}$$

- No practical effect at macroscopic level
  - o A philosophical problem with The Mechanical Universe and with “The God’s eye view” or The Clockwork Universe over age of universe
- Important at atomic and molecular level
  - o Uncertainties are large on atomic scale
  - o What underlies our reality is strange

Experiment 7

- Specific Gravity – property of material:
  SG: (object weight)/(displaced water weight)
- S.G. is a help in identifying the material
- Displaced water – immerse object in water, water level rises, this is displaced water
- Weighing objects (wood block, dumbbell, displaced water):
  - Weight in pounds and ounces using fish scale
  - Use string slings for block and dumbbell

Experiment 7

- Converting pounds and ounces to decimal pounds:
  1. Divide # ounces by 16 (result between 0 and 1), call this “X” (round to nearest tenth)
  2. Check: multiply X by 16, should get about the original # ounces – SHOW THIS CHECK ON DATA SHEET !!!
  3. Add X to # pounds to get decimal pounds

Experiment 7 (cont'd)

- For #7, you will probably have to use different amounts of water in the tub for each object.
  - Hold object down if necessary (i.e. wood), cover with water, remove object, then start that part of the lab

Experiment 7 (cont'd)

- Converting inches and sixteenths to decimal inches:
  - Same as for pounds and ounces to decimal ounces, INCLUDING CHECK !!! (Slide 10)
- For step # 5, ignore rounded edges and grooves in block: $V = L \times W \times H$
- Same for #6, volume of water
  - H = change in height with/without block