Atoms and Stars
IST 2420
and IST 1990

Fall 2005

Sections 001, 005, 010 and 981

Instructor: David Bowen

Class #5: October 5 and 10

www.is.wayne.edu/drbowen/aasf05

Tonight

- Handouts
  - Class 5 Notes
- Initial the sign-in sheet
- Review of names
- Due:
  - Essay 1 (diskette)
  - Lab 2 Report

Lab 8

- Very few groups completed all labs last time
- Most got through “the cart” – Lab 8 Part I
- I will not count Lab 8 Part II as part of this lab session – Part II report not due, only Part I
- We will do Part II as part of the next lab session – watch for changes in the lab assignment

New Error Example

- We are treating errors by looking at the spread in individual measurements. The exact theory of errors also does this, although our formulae here are simplified
- John makes four measurements of the classroom clock: 10.42, 9.85, 10.12 and 9.68 sec.
- Best guess (also in exact theory) = average
- Error (simplified) = (highest – lowest) / 2

New Error Example (cont'd)

- John's average = (10.42 + 9.85 + 10.12 + 9.68) / 4 = 40.07 / 4 = 10.02
- John's error (simplified) = (10.42 – 9.68) / 2 = 0.74 / 2 = 0.37
- John's result = average ± error = 10.02 ± 0.37
  - "±" is read "plus or minus"
- Suppose Helen's result is 9.93 ± 0.45
- Are John's and Helen's results the same, or different?

New Error Example (cont'd)

- In the theory of errors, this is the same as the question of whether or not the errors, plotted from their respective averages, overlap
  - See graph on Slide 9 for Class 4 notes
- Mathematically, is the sum of their errors greater than the difference between their averages? If so, their measurements are compatible and the Null Hypothesis applies

New Error Example (cont'd)

- Sum of errors: 0.37 + 0.45 = 0.82
- Difference of averages: 10.02 – 9.93 = 0.09
- Since 0.82 is greater than 0.09, their measurements are compatible. Even though their results are not the same number, they are compatible, taking the errors into account.
- If the difference is, say, three times the sum, then the results are incompatible (gray area)

Makeup Labs

- A large number of people, particularly in the Partially Online sections, have missed lab sessions.
- I am willing to schedule a makeup session, for people who will actually come to the session.
- I have emailed those affected; respond to my emails, if you want to make up labs.

Science and Industry

- Priscilla Phifer (campus) noted that scientific method was not followed in recent drug-company controversies (e.g. Vioxx)
- Conditions in industry are indeed different
  - Data and internal theories are proprietary (trade secrets)
  - Executives have authority
  - Decisions are made, and are to be followed
  - Executives often do not get bad news
- So yes, scientific method often not strictly followed in business and industry

Review: Aristotle & Archimedes

Aristotle	Archimedes
Abstract interest	Practical
Covered all topics	Specialized
Descriptive	Quantitative
We have moved past his Physical Science (geocentric, motion stops without force, etc.)	Physical Science still current (displaced water, simple machines)

Aristotle cf. Torricelli & Newton

(cf. = “compared to”)

- Primarily for labs, at this time
- Atmospheric Pressure
- Terrestrial (i.e. earth-bound) Motion

Aristotle: Atmospheric Pressure

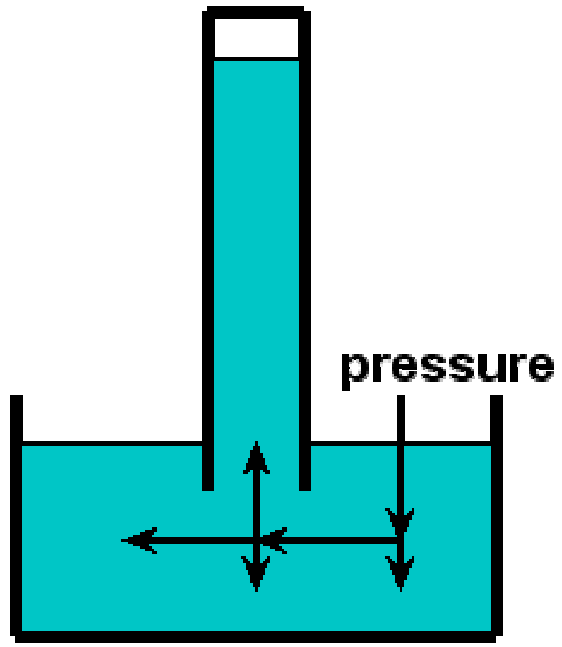
- “Nature abhors a vacuum”
- Observation: wine does not run out of a barrel unless there is a hole in the top
  - Slide 1 in “Notes on Atmospheric Pressure reading”
- Aristotelian explanation: If wine did run out, without air entering, there would be a vacuum, which is impossible
  - No limit to the height of the liquid column

…and Torricelli (1644 A.D.)

- Atmospheric pressure = the weight of a column of air from ground to top of atmosphere
  - This is limited (pressure of 34’ water, 30” mercury)
    - (This limitation is NOT due to a limitation of Torricelli’s or our technology – it is a limit on all suction pumps)
  - Within liquid, pressure transmitted in all directions
    - See next slide
  - A column up-ended in a liquid has atmospheric pressure pushing up on the the bottom of the liquid
  - If that column of liquid is closed at top, there is no force pushing down on the top of the liquid
- Pressure difference bottom-to-top pushes water up

Torricelli (again)

- Pressure transmitted from atmosphere pushing down to water pushing up on bottom of column
- Pressure equivalent to 34’ water = 30” Mercury
- That is maximum height that can be supported



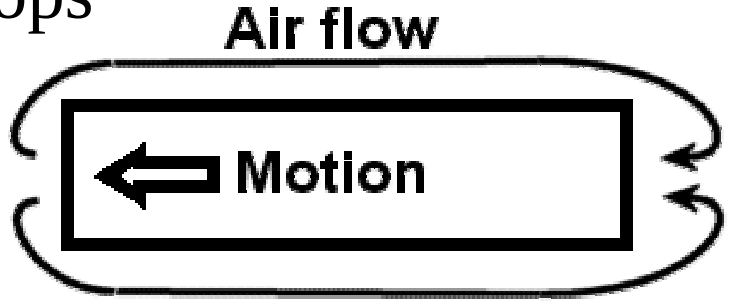
WaterColumn.gif

Temperamental Can

- Steam in can, bottle condenses in cold water
  - Steam condenses to water, *much* less volume (1000:1)
- Pressure difference (outside to inside) crushes can, bottle
- For right-side up pop can, atmospheric pressure equalizes through hole in top
- For upside-down can, to equalize pressure, why doesn't water just get sucked up?
  - With vacuum pump, straw, and cup, no collapse
    - Instead, water is sucked up – why not with can?
  - Answer: *speed* of condensation – see Newton, later

Terrestrial Motion: Aristotle

- Object only moves if force applied
  - Object stops if force stops
- Universe is full
  - Air moves out at front, comes in at back



AristotleMotion.gif

  - Explanation for coasting: air coming in from back pushes object to keep it moving
  - (Today: air actually streams *away*, vacuum in back, creates drag)

…and Newton (1687 A.D.)

- Newton's Second Law: F = ma
  - o force = mass × acceleration
  - o Acceleration = change in velocity (speed and/or direction)
  - o Constant speed in a straight line: no acceleration, no force
  - o Inverse also true: no force means no acceleration, result is no change in velocity: no change in speed and no change in direction
    - "An object in motion tends to stay in motion. An object at rest tends to stay at rest."

Temperamental Can & Newton

- F = ma
  - Steam inside can must condense very quickly to make Temperamental Can work – slow condensation would just suck water up like straw
  - Large acceleration means large force inward
  - Outside force does not increase, so inward inside force must drop quickly to draw water up
  - Decreases pressure inside can
  - Pressure difference (outside to inside) crushes can

This Course: The Big Picture

- We are following the development of modern astronomy (“Stars”)
- One side trip for what earlier people knew
- Another for the speed of light
- Then Copernicus, Brahe, Kepler, Galileo, Newton
- Then Atoms: rise of modern Chemistry

Readings #1

An Inventory of the Universe

- Big Bang, created space, extremely hot
- Expanded, cooled, condensed
  - Local clumps ➔ galaxies, stars, planets
- Hierarchy
  - Orbit around stars (sun): planets, asteroids, meteoroids
  - Stars in galaxies
  - Distances according to this also
  - Solar system all in approximately same plane
  - AU = Astronomical Unit = earth-sun distance

An Inventory of the Universe

- AU: 93 million miles – earth-sun distance
- Light Year – distance light travels one year approximately 6 trillion miles
- With unaided eye: sun, moon, five planets, a few thousand stars, three other galaxies, some comets
- Dark matter – unlit, may be bulk of matter

An Inventory of the Universe

- Galaxies: spiral (us), elliptical, irregular
  - Stars, dust, gas, mostly empty space
  - Groups of galaxies: clusters (us: Local Group)
- Stars: shine, power from nuclear fusion
  - H → He. Surface thousands of degrees, interiors up to millions of degrees. Gas only.
- Nebulae: dust, gas clouds mainly where stars are formed
  - reflection, emission, dark (may be backlit)

An Inventory of the Universe

- Solar system: sun, nine planets
  - Inner four planets solid (earth), outer gaseous
    - Planets shine with steady light (stars twinkle because of small size), wander, near plane of sun
  - Asteroids (planetoids), diameters from two miles or less, up to 500 mi
  - Moons (sixty total in solar system)
  - Comet – visible only on approach to sun (tail points away from sun). Comets discovered constantly but most invisible.

An Inventory of the Universe

- Meterorides burn up in earth's atmosphere, visible then (meteors)
  - Hundreds of tons of meteor debris fall to earth each year

- Sun's future (how other stars behave):
  - 5+ billion years sun ➔ *red giant*, enlarges to engulf Venus, earth oceans and atmosphere gone, this lasts several hundred million years
  - Then white dwarf, shrinks, cools, earth dark, cools perhaps close to absolute zero, life in solar system ends

Readings #2

Speed of Light

- Sound slow enough that we can hear lag
- Light is faster, we cannot ordinarily see lag
- Most Greeks believed light has infinite speed
  - Hero of Alexandra: light travels from eye, when we open eyes we see stars instantly, so speed is infinite

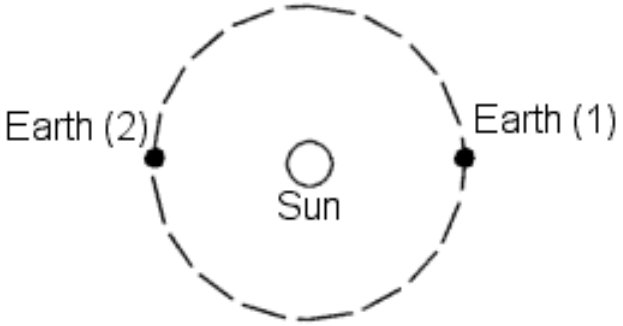
Readings (Speed of Light cont'd)

- Arabs Avicena and Alhazen 11th cent: light is something, cannot be in two places at once
- Roger Bacon ~1250 and Francis Bacon ~1600 believed light has finite speed
- Johannes Kepler ~1600 light has infinite speed
- Rene Descarte ~1625 said if light speed infinite, lunar eclipse position would lag, not observed, so must be infinite

Readings (Speed of Light cont'd)

- Galileo experiment: time round trip on hilltops at different distances. Done by others, no difference seen.
- 1165 Robert Hooke said light might just be "exceeding quick"
- 1676 Danish astronomer Ole Roemer used eclipses of Io, moon of Jupiter, to measure speed of light

Readings (Speed of Light cont'd)



IoEclipse.gif

- Motion in orbit regular, like a clock (here, Io)
- "Late" eclipse in Earth position 2 due to light traveling across diameter of earth's orbit
- Estimated speed at 140,000 mi/sec
- Modern value 186,000 mi/sec

Readings (Speed of Light cont'd)

- After Einstein's theory of Special Relativity (1905), speed of light is maximum velocity for any object
- Also = c in $E = mc^2$
- Einstein's 1915 General Theory of Relativity said c can be exceeded in an expanding Universe, so some stars from Big Bang are far enough away that their light cannot get back to us
  - We will never see them (beyond our "event horizon")

Reading #3

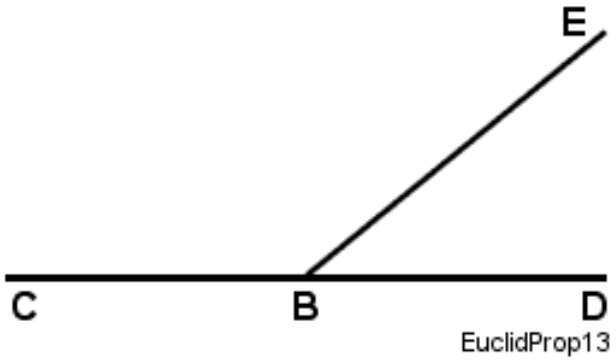
Euclid (Pp 74 – 79), book Elements

Proof in mathematics and geometry

- Postulate #4: all right angles (90º) are equal
- Common notion #1: things equal to the same thing are equal. If a = c and b = c then a = b
- Common notion #3: if equals are subtracted from equals then the remainders are equal. If a = b then a – c = b – c.

Reading (Euclid's Elements)

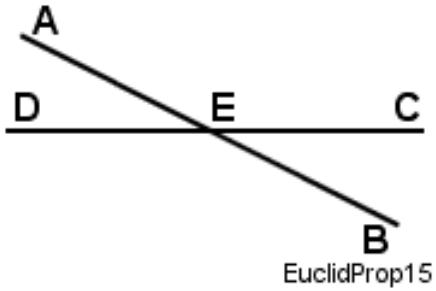
- Propositions: proven
- Proposition 13:
  A straight line
  consists of two
  right angles
  (180º): ∠CBE + ∠EBD = 180º



- Next, Proposition 15.

Reading (Euclid's Elements)

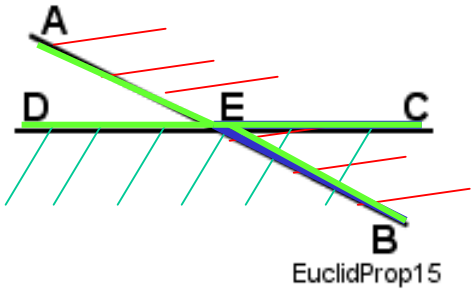
- Proposition 15: If two straight lines cut each other, the vertical angles are equal (i.e. $\angle AEC = \angle DEB$)



- Proof on next slide, relies upon earlier Postulate #4, Common Notions #1 & #3, and Proposition #13.

Reading (Euclid's Elements)

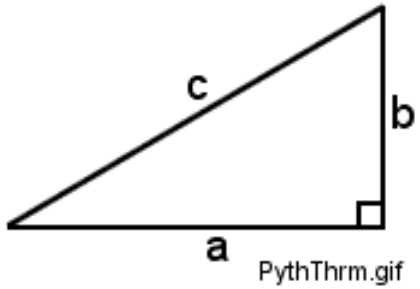
- ∠AEC + ∠CEB = 180º
  (AEB is a straight line)
- ∠DEB + ∠CEB = 180º
  (DEC is a straight line)



- ∠AEC + ∠CEB = ∠DEB + ∠CEB
  (Things equal to the same thing are equal)
- ∠AEC = ∠DEB (subtract ∠CEB from each, equals subtracted from equals are equal)

Reading (Euclid's Elements)

- Proposition 47: Pythagorean Theorem



PythThrm.gif

- For a right triangle (has one right angle), $a^2 + b^2 = c^2$
  - Example: 3, 4, 5 triangle, $3^2 + 4^2 = 9 + 16 = 25$
    $5^2 = 25$, so $3^2 + 4^2 = 5^2$
- Formula known to Egyptians, maybe earlier, but proven by Pythagoras

Reading (Euclid's Elements)

- Mathematics
  - start with assumptions
  - draw unarguable conclusions from assumptions
  - assumptions can be wrong – spherical geometry
    - on a sphere, angles of a triangle add up to less than 360º
- Physical science can be put on this basis (axiomatic)
  - Assumptions and results can be overturned with new experiments

Assignments 2420

- Next week:
  - Reader: Motions in the solar system
  - Report on Experiment 3
- Two weeks:
  - Report on Experiment 8
  - Reader:
    - Copernicus Incites a Revolution
    - The Planet Mars and Kepler's Three Laws of Planetary Motion

Assignments 2420 (cont'd)

- Two weeks (cont'd):
  - Reader (cont'd):
    - Copernicus Incites a Revolution
    - The Planet Mars and Kepler's Three Laws of Planetary Motion
    - What is Gravity?
    - Case History in Astronomy: Johannes Kepler
    - The Watershed to the start of Chapter 6 ("The Giving of the Laws" on Pg 189)
      - What is Creativity really like?

Assignments 2420 (cont'd)

- Two weeks (cont'd):
  - Be ready for Q & A Review for Midterm
- Three weeks – POL will join us again
  - Midterm (one hour) plus labs afterwards

Moodlers (POL & 1990)

- See “SUCCESS” on course web site

2420 POL

- Summaries
- Average two postings per week
  - Try answering the Exam questions!!!
    - Get me on record in writing
    - Rehearsal – the best way to study

IST 1990

- Reading – see Syllabus
- On the course web site:
  - Essay topics for all three essays
  - Notes on IST 1990 books
- Postings every week
  - Two credits: average one per week
  - Four credits: average two per week
- Essay 1 due in two weeks
- Four credit: extra readings online: PW = “apple”