

Atoms and Stars

IST 2420

Class 4, February 5
Winter 2007

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Course web site: www.is.wayne.edu/drbowen/aasw07

Handouts & Announcements

- Class 4 Notes
- Graph paper for Lab 3 Part 2
- Initial the sign in sheet

Essay 1 due next week

- On a 3½” diskette
- Do readings as assigned in Syllabus

Due tonight

- Report for Lab 3.
 - Do not copy the Data Sheet over, or retype it
 - Procedure & Observation a MUST for each part
 - Analysis has ONLY items NOT on Data Sheet

Lab 3 Part 1 Calculations

Calculations on the times to roll down the track
(from the Lab Manual):

1. First, average the times and find the error for *each distance by itself* (e.g. the four times for A0 – B1 by itself) in Part E
 - o Do not find the average and error for things you do not think are equal (e.g. we do not expect A0 – B1 and A0 – C4 to be equal – the second distance is longer)
2. After #1, then divide the *averaged* times according to part F in the lab manual
 - o Do not divide the errors

Lab 3 Pt 1 Calculations (cont'd)

Calculations on the times to roll down the track:

3. Then (the core): are the divided times equal, within the errors? (also from Part F)
 - A. Find the highest and lowest divided averages from #2 and subtract them (= DIFF)
 - B. Find the two highest averages from 1 and add them (= ERROR)
 - C. Are the divided times equal, within the errors?
 - i. If $\text{ERROR} > \text{DIFF}$ then results are compatible and your results support $s = \frac{1}{2}at^2$ with constant acceleration a
 - ii. If $\text{DIFF} > 3 \text{ ERROR}$, not compatible, do not support ...
 - iii. In between? “Gray area”

Online Grade Reports (repeat)

- See your line in my grade book
- Disabled by default – turn in form if you want this (you should want this)
 - Check to enable and write a password
- Demo
- Later
 - Will have averages, projected grade
 - How to make up each assignment
- www.is.wayne.edu/drbowen/aasw06

Early Academic Assessments

- Early Academic Assessments (EAA) on the basis of work through tonight
- Your EAA will be on Online Grade Reports
- If you are off to a slow start, you will get a warning letter or email from the University
 - Does not go in record, does not affect grades
 - Recommendation to see a counselor
- If Online Grade Report says “OK”, no letter, no email

EAA Grades:

- -H: deficient in homework
- -L: deficient in lab work
- -E: deficient in exams and/or quizzes
- -T: deficient in attendance
- Can be doubled up, e.g. -LT
- ---: three or more problems
- These are the online grades, but they get spelled out in letter (email?)

Lab Reports – Listen Up!

- Label with your name and Lab # at top
- Full names of lab partners, in your handwriting (learn their names!)
- Data Sheet has (a) Procedure and (b) Observation / measurement.
 - Hypothesis, if present, CLEARLY SEPARATED.
 - Suggestion: Procedure, Observation, Hypothesis labels for those sections, underlined

Lab 2

- Since we did not observe vacuum, did not here disprove that “nature abhors (will not allow) a vacuum”
 - “Nature abhors” – one side of container only
 - “Sea of Air” – pressure difference between sides
- Many people had NO procedures
- ALWAYS say what the Procedure was
- CLEARLY separate hypotheses (reasons)
- Max height suction = 34 feet of water

Science and Religion getting along:

The New American Bible (Catholic), 1991, Pg 27,
#15. HOW DO YOU KNOW? (what the Bible says):

“... Sometimes, it is secular science which gives Christians the lead to reconsider their Bible understanding. The discoveries of Copernicus and Galileo made Christians aware that Genesis 1 is not a sacred lesson in science but a poem on creation. Most scientists hold that the human species has developed somehow from lower forms of life. This knowledge helped Christians to understand that Genesis 2 and 3 is not a lesson in Anthropology, but an allegory, teaching us the lesson that sin is the root of all evil.”

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 15 BYA
 - Local clumps → galaxies, stars, planets
- Hierarchy
 - These orbit around stars (sun): planets, asteroids, meteoroids
 - 9 planets (DB: now 8) and the sun are our solar system
 - 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
 - $H \rightarrow He$. 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 (DB: now 8) planets
 - Inner four planets solid (earth), outer gaseous
 - Planets shine with steady light (stars twinkle because of small size), wander, near plane of sun
 - Planets shine with reflected light from 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

- o Meteoroides 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):
 - o 5+ billion years sun → *red giant*, enlarges to engulf Venus, earth oceans and atmosphere gone, this lasts several hundred million years
 - o 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 relative to light
- 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

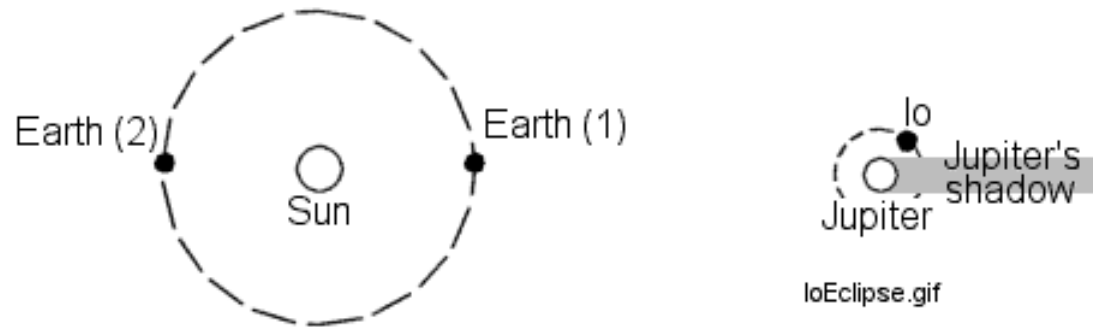
Readings (Speed of Light cont'd)

- Arabs Avicenna 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 Q14

Readings (Speed of Light cont'd)

- Galileo experiment: time round trip on hilltops at different distances. Done by others, no difference seen. Q14
- 1665 Robert Hooke said light might just be “exceeding quick” Q14
- 1676 Danish astronomer Ole Roemer used eclipses of Io, moon of Jupiter, to measure speed of light Q14 & ff

Readings (Speed of Light cont'd)



- 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
 - 2 A.U., ~1,000 sec, then A.U. estimate = 70 million miles
- With modern A.U. value, get 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
 - Light year – *distance* light travels in a year
 - Light from distant star started out earlier – looking at distant stars is looking back in time.
 - Example: Light reaching us now from a star 6 light years away started 6 years ago
- Also speed of light = 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

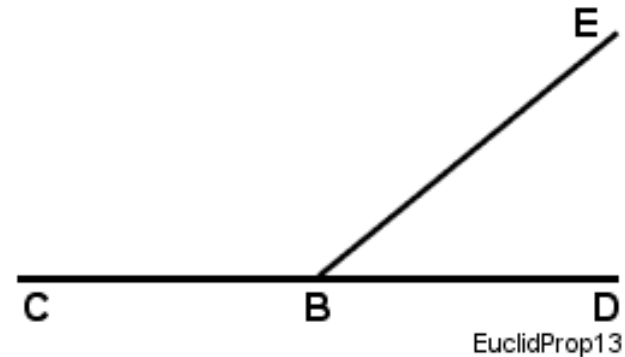
Euclid (Pp 74 – 79), book Elements Q10

Proof in mathematics and geometry

- Postulate #4: all right angles (90°) 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 $a - c = b - c$.

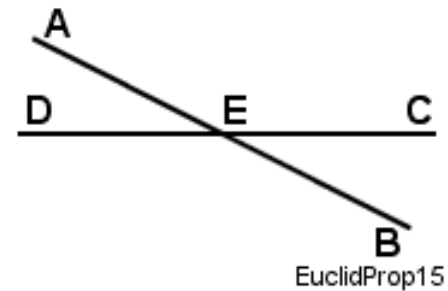
Reading (Euclid's Elements)

- Propositions: proven
- Proposition 13:
A straight line
consists of two
right angles
(180°): $\angle CBE + \angle EBD = 180^\circ$
- Next, Proposition 15.



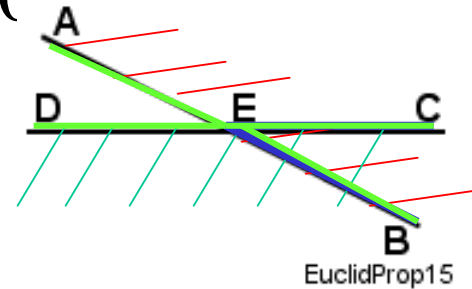
Reading (Euclid's Elements)

- 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.



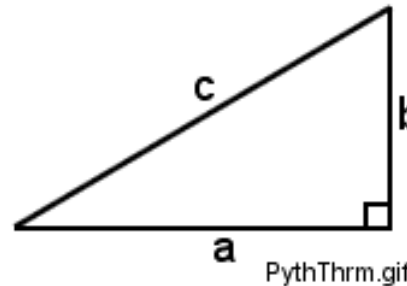
Reading (Euclid's Elements)

- $\angle AEC + \angle CEB = 180^\circ$ Q10
(AEB is a straight line)
- $\angle DEB + \angle CEB = 180^\circ$
(DEC is a straight line)
- $\angle AEC + \angle CEB = \angle DEB + \angle CEB$
(Things equal to the same thing are equal)
- $\angle AEC = \angle DEB$ (subtract $\angle CEB$ from each,
equals subtracted from equals are equal)



Reading (Euclid's Elements)

- Proposition 47:
Pythagorean
Theorem



- For a right triangle (has one right angle),
 $a^2 + b^2 = c^2$
 - o 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
 - o start with assumptions
 - o draw unarguable conclusions from assumptions
 - o assumptions can be wrong – spherical geometry
 - on a sphere, angles of a triangle add up to less than 360°
- Physical science can be put on this basis (axiomatic)
 - o Assumptions and results can be overturned with new experiments

Readings (cont'd)

- Hellenic Period 600 – 300 BC
 - o Aristotle
 - Motion must occur in a material medium, not a vacuum (would have infinite speed, logically impossible)
 - Atomism implies vacuum between atoms, impossible, rejected
 - Also close biological observer, hierarchical taxonomy
 - Basis for higher learning in other cultures, religions

Readings (cont'd)

- Hellenistic Period after Alexander (323 BC)
 - Empire split into three parts
 - Social support for research
 - Museum and Library at Alexandria 280 BC
 - 500,000 scrolls, 100+ scientists and scholars
 - Abstract, formal mathematics
 - Other libraries also – Pergamum, Plato's Academy
 - Had legal status
 - Useful results emphasized but fame of sponsor also

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - o Eratosthenes, head of Library at Alexandria
 - Famous calculation of circumference of earth
 - Also geography and cartography
 - o Aristarchus
 - Heliocentric, earth turns on axis, rotates sun
 - Held implausible because things would fall off
 - No parallax of stars observed (accuracy too poor)
unless universe much larger than thought

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - Ptolemy (2nd cent AD) used new tools to simplify geocentric model of heavens
 - Epicycle (small sphere moved on larger sphere, planet on small sphere)
 - Eccentrics (circle displaced from earth)
 - Equant – point from which planet appeared to move at constant speed
 - Almagest – manual of Astronomy

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - o Alchemy – transmutation of base elements into gold after Platonic forms
 - Often mystical and secret
 - o Archimedes between 290 & 280 BC, to 212 or 211 BC
 - Simple machines – level, wedge, screw, pulley, windlass
 - Balance led to theory of weight
 - o Many small incremental practical improvements

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - o Roman engineering important but little Roman science, little translation of Greeks into Latin
 - o Roman navy, roads, aqueducts basis of empire
 - o Invention of cement
 - o Greek physician Galen (130 – 200 AD) became known in Empire
 - Some advances, but thought veins and arteries separate, so blood not able to circulate

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - Decline and fall of Roman Empire – causes much debated – argued today: is our society declining?
 - Decline in science also
 - No desire even to preserve existing knowledge
 - Skepticism about possibility of secure knowledge
 - Several theories
 - No clear social role or support
 - Availability of slaves meant little incentive for improvement
 - Other-worldly orientation of new religions, especially Christianity

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - o Tolerance of Christianity 313 AD, became state religion of Roman Empire in 391 AD
 - Hostility towards earlier civilizations included science
 - o Alexandria damaged when retaken 270-275 after Syrian and Arab invasion
 - Christian fanatics murdered Hypatia, first female mathematician, last scholar at Library in 415
 - o Empire split, Western attacked by barbarians

Readings (cont'd)

- Hellenistic Period (after 323 BC)
 - o Eastern part lasted longer but conquered by Islam in 7th cent
 - o Last Western Roman noble, Boethius, executed by Ostrogoth king Theodoric in 524
 - o Literacy declined, knowledge of Greek disappeared

Some Greek Science

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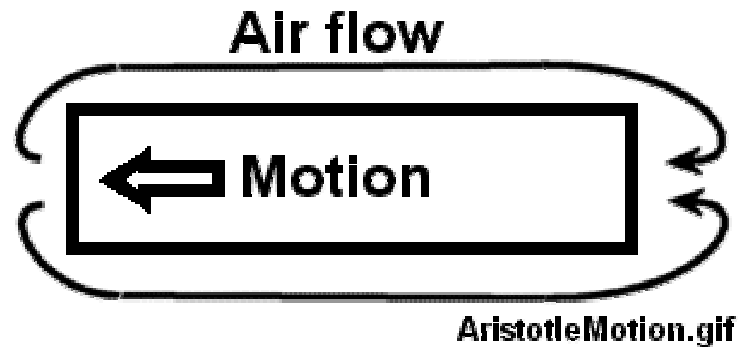
- Aristotle:
 - A philosopher, not a scientist in modern sense
 - Theories (explanations) only, not experiment
 - Used common knowledge and reason (logic)
 - No experiments to decide between theories as with Davy and caloric Vs kinetic theories of heat & 34'
 - Ideas were dominant for about 2,000 years
 - Became an authority – if your theory agreed with Aristotle, that was enough then (not now)
 - “Natural states” – needed no other explanation

Some Greek Science

- Aristotle:
 - o Universe is full, no room left
 - o Cannot be a vacuum (vacuum: nothing)
 - “Nature abhors a vacuum”
 - “abhors” – hates, but here “will not allow”
 - o Terrestrial physics: force necessary for motion
 - When force stops, motion stops immediately
 - Natural state of an object is rest (stopped)

Some Greek Science

- Aristotle:
 - Terrestrial physics: force necessary for motion
 - If something coasts, air must move out of way, then move in behind to push



- Plausible, but later disproven

Some Greek Science (cont'd)

- Aristotle (cont'd):
 - o Celestial physics: heavens are perfect
 - Smooth, spherical, flawless
 - Natural state: moving in a circle with constant speed
 - Earth at center (geocentric)
 - o Elements – not made up of other matter
 - Earth, water, air, fire – from center of earth out
 - Natural state of terrestrial matter
 - “Element”: these are not made up of anything else, everything else is made up of these
- Science changed these ideas!

Aristotle cf. Torricelli & Newton

(cf. = “compared to”)

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

Aristotle: Atmospheric Pressure

- Observation: wine does not run out of a barrel unless there is a hole in the top
- Aristotelian explanation: If wine did run out, air would have to enter barrel to make room.
 - Therefore, “nature abhors a vacuum”
 - No limit to the height of the liquid column
- But we do see a vacuum if column is high enough
 - Therefore, “nature abhors a vacuum” is wrong
 - In science, “nature is the final arbiter”

...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)
 - No force pushing down on the top of the liquid
- Pressure *difference* bottom-to-top pushes water up – key to Torricellian explanations

Temperamental Can

- Steam in can, bottle condenses in cold water
 - Steam condenses to water, *much* less volume (1,000:1)
- 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

Temperamental Can & Newton

- $F = ma$ (Newton, 1687)
 - Force = mass \times acceleration
 - 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
 - Sudden pressure difference (outside to inside) crushes can

Science and Industry

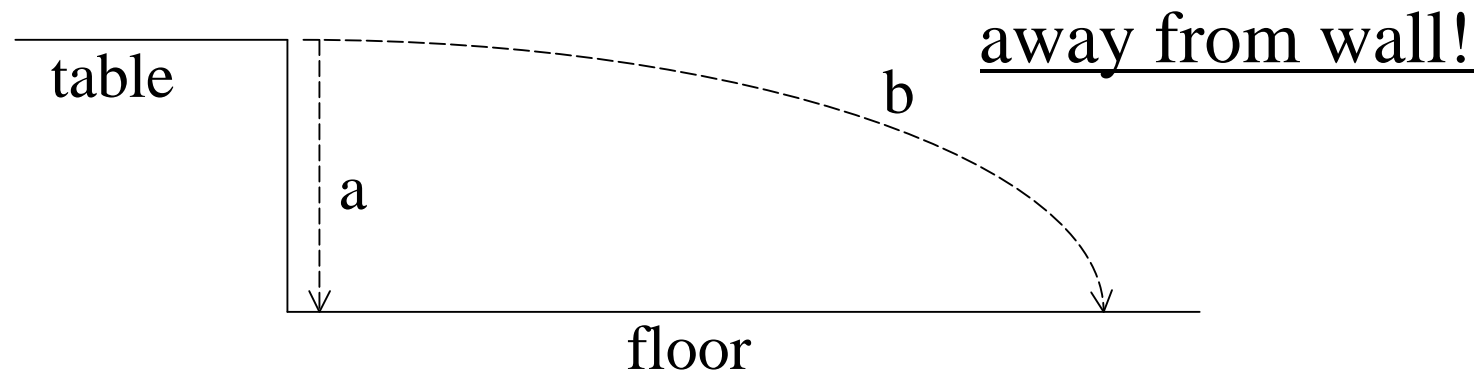
- Scientific method not followed in recent drug-company controversies (e.g. Vioxx)
- Conditions in industry are indeed different
 - Data and internal theories are proprietary (trade secrets)
 - Executives have authority
 - Decisions are made, and are to be followed
 - Executives often do not get bad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

Aristotle & Archimedes Q11

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)

Lab 3 Part 2

- Is there a relationship between the time for an object to fall and its horizontal motion?
- Compare (a) pure vertical fall to (b) starting horizontally and falling
 - Hit a wall? That is a do-over! \therefore point apparatus



Lab 3 Part 2 (cont'd)

- Shooting blocks off of table
 - One should drop pretty much straight to the floor
 - Other should go a considerable distance horizontally before hitting the floor

