Atoms and Stars
IST 2420
and IST 1990

Fall 2005

Sections 001, 005, 010 and 981

Instructor: David Bowen

Class #3: September 21 and 26

www.is.wayne.edu/drbowen/aasf05

Tonight

- Handouts
  - Class 3 Notes
- Initial the sign-in sheet
- Review of names
- Pictures for Moodle?
  - Only IST 1990 and Partially Online IST 2420 need these

Changes

- Anyone want to switch?
  - Between campus and Lamphere
  - Between face-to-face and partially online
  - See me for either switch
- I may not be able to make office hours the next few weeks – cell phone
- Changes from previous classes (see separate file)

Changes to Syllabus (Repeat)

- IST 1990 and IST 2420 Partially Online
  - Posts when you are scheduled to be in class do not count
  - Plagiarism is applied to Moodle work
  - Self-plagiarism is included here as copying from a previous post, perhaps with only minor changes, without quotation marks.
  - Posts will be graded within Moodle
    - Postings grade will be sum of individual posting grades divided by number of posts required

Changes to Lab (POL only, repeat)

- Partially Online – FAX Data Sheet, turn rest in as file (i.e. follow Syllabus)
  - o OK for Lab 1 if you have already FAXed everything
  - o Otherwise I cannot make comments on your work to explain the grade.

The Second Class

- Lamphere: covered 2nd Notes except Slides 48 through 55
- Campus: covered 2nd Notes 33 through 41 and 48 through 55
- Both: reviewed readings: “We Are All Scientists,” “Science and Hypothesis” & “The Development of the Concept of Atmospheric Pressure” (separate handout)

Web Sites

- "The Course Web Site" www.is.wayne.edu/drbowen/aasf05
  - All handouts
  - Links to Moodle
  - Plus…
- Moodle
  - General: techtools.culma.wayne.edu/moodle
  - Straight: techtools.culma.wayne.edu/moodle/course/view.php?id=14

Errors: Summary

- Here, simplified treatment of measurement errors
- Make multiple measurements
- Best guess at real value = average
- Error = highest value minus lowest
- If two sets of measurements agree within (or close to) error, cannot reject Null Hypothesis

Errors: Summary

- Null Hypothesis
  - If two sets of measurements agree within (or close to) errors, cannot claim from measurements that they are different
  - Justified in saying they are the same and that errors are random
- Systematic errors – difference greater than error: something is different (e.g. technique, thing being measured)

Overview (#15)

- 3 areas to course - some will want more religion and culture, some more science content, but science process a core here
- Two pillars of science:
  - data / observations / experiments
  - hypotheses / laws / theories

Overview (#19)

- #2. Hypotheses / laws / theories
  - Hypothesis: first step - a guess, explain the data
  - Law is older term, theory is newer term (less assured)
  - Accepted theory must:
    - Be capable of being disproven (falsifiability)
    - Explain all (vast majority) data – time lag OK
    - Discrepancies must be addressed and eventually resolved

Overview (#20)

- Accepted theory must (continued):
  - Have direct evidence - not accepted just because rival theory fails
    - If two theories agree with data, must look for and do critical experiments that decide between them
  - Be productive - predict new, unsuspected measurements, new phenomena, new results, which must be tested and which must agree
- Simpler theory preferred to complicated
- Lack of consistency must be fixed

Overview (#21)

- Typical sequence of advance: measurement, description, understanding, (recently - app 50 years, after WW II), control (technology)
  - Understanding is often first association (statistical) then causal
- Science is progressive
  - Start in small area, expand

Overview (#22)

- Science is progressive
  - Later theory / experiment can change earlier theory
    - Example: Einstein's 1915 General Theory of Relativity changed ideas about his 1905 Theory of Special Relativity
    - However, old results still correct but range extended
  - Scientific knowledge provisional – subject to change

Overview (#23)

- Science is progressive
  - Scientific knowledge can change rapidly at the frontier
    - Later experiments can show errors in the first ones
    - Extending theory beyond data can introduce errors
    - See next slide
- Science is not:
  - Fair – theories do not have a right to be considered – someone must want to do this

Why do scientists change their minds?

- While focus is being studied, new facts arise, hypotheses must be changed
- At some point, tests are made, focus moves on
  - No change in Kinetic Theory of Heat for about 200 years

Overview (#24)

- Science is not:
  - Democratic – no votes, nor formal consensus, theories can come "back to life" (string theory)
  - Not based on authority – Newton and Einstein can be (were) wrong
- Individual scientists often do not follow these rules
  - Science works socially – check each other

Overview (#25)

- Individual scientists often do not follow these rules (continued)
  - Scientific arguments can be fierce
    - Issue about women and aggressive argument
    - Our heroes – the people who overthrew the established order
    - Instant success: prove someone else wrong
  - Scientists often become advocates of a theory
    - Social interaction corrects this

Overview (#26)

- Scientists are skeptical about truth claims
  - Many strongly-held beliefs have been shown to be wrong, e.g. common ideas about space
  - Many purely rational arguments have been shown to be wrong – e.g. Aristotle
- Developing a hypothesis / theory / law is highly creative.
  - Experiments do not tell you how to explain them.

Readings

"Greeks Bearing Gifts," Chapter 4 in Section 1 ("From Ape to Alexander") in Science and Technology in World History: An Introduction, by James E. McClellan and Harold Dorn

- Hellenic Period 600 – 300 BC (BCE)
  - "natural philosophy" – scientific theory without regard to practical applications, for its own sake
  - Freestanding, independent "schools"

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Built on Egyptian and Mesopotamian cultures but Greece decentralized, dependant on trade, loved arguing about politics
  - Actually originated on western shore of Turkey (see next slide)
  - pre-Socratic

Readings (cont'd)

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - o Thales (~625 - ~545 BC) was pivotal
    - Theories became identified with a person, previously scientists were anonymous
    - Natural explanations, not attributed to Gods
    - Not, however, atheistic
    - Water as fundamental element, first instance of theory about what things are made of
  - o Other Greeks had other theories

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Empedocles (~545 BC): earth, air, fire, water
    - Also two forces, Love and Strife
  - Pythagoreans followed Pythagoras (~525 BC)
    - Introduced math, focus on number (hidden reality)
    - Pythagoras – right triangle $a^2 + b^2 = c^2$
    - Implied irrational numbers, didn't like this
    - Plane geometry (Elements), mathematical proofs

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Atomists (Leucippus and Democritus) ~420 BC
    - Atoms - indivisible, elementary
    - Not much influence at the time
  - "Philosophers of Change"
    - Heraclitus ~500 BC, change is constantly happening
    - Parmenides ~480 BC, change is an illusion
    - Reliability of senses, possibility of knowledge

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - o Unlike other fields, medicine held to usefulness
    - Hippocrates ~425 BC – observation
    - Four humors, health is a balance between them
  - o No unity, common method, or sustained research
  - o Changed with unifications of Plato and Aristotle, after Socrates
  - o Socrates 470? – 399 B.C. (put to death)
    - Nothing certain about natural world, turned to human nature, the good life

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Plato 428 – 347 BC
    - Student of Socrates
    - Plato's Academy at Athens – survived 800 years
    - Geometry important – four elements + aether, corresponded to five regular solids
    - Astronomy, based on first principles (ideal form): earth central, mechanically linked to spheres that carry heavenly bodies. Heavens alive, divine, perfect, in uniform motion ("save the phenomena")

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Plato
    - Others inserted additional spheres to account for retrograde motion and other effects, simplicity lost
      - Spheres intersection
      - Scientific community, shared model
  - Aristotle 384 – 322 BC
    - Studied under Plato
    - 343 Phillip II of Macedon made him tutor to Alexander (Alexander the Great)

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Aristotle
    - First technology supplied needs, then we can study philosophy, motivated by curiosity
    - Sensation & observation the only road to knowledge
      - Against transcendentalism of Plato
    - Four elements composed of primal matter with qualities hot-cold, wet-dry superimposed
      - A rational basis for alchemy
    - Earth at center of universe due to gravity

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - Aristotle
    - Spherical earth – based on shadow on moon
    - Motionless – object thrown straight up returns
    - Everything up to the moon is natural, heavens are aether (incorruptible, unlike elements)
    - Natural motion in straight lines on earth, circles in heavens, all else requires outside impetus
      - Problems with arrow
    - Heavier objects have greater force, fall faster

Readings (cont'd)

- Hellenic Period 600 – 300 BC
  - 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)
  - o Empire split into three parts
  - o 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)
  - Eratosthenes, head of Library at Alexandria
    - Famous calculation of circumference of earth
    - Also geography and cartography
  - 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

Readings (cont'd)

- Hellenistic Period (after 323 BC)
  - Ptolemy (2nd cent AD) used new tools to simplify geocentric model of heavens
    - Epicycle (small circle rotated on sphere, plant on larger circle)
    - 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)
  - Alchemy – transmutation of base elements into gold after Platonic forms
    - Often mystical and secret
  - Archimedes
    - Simple machines – level, wedge, screw, pulley, windlass
    - Balance led to theory of weight
  - Many small incremental practical improvements

Readings (cont'd)

- Hellenistic Period (after 323 BC)
  - Roman engineering important but little Roman science, little translation of Greeks into Latin
  - Roman navy, roads, aqueducts basis of empire
  - Invention of cement
  - 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)
  - o Decline and fall of Roman Empire – causes much debated
  - o 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)
  - Eastern part lasted longer but conquered by Islam in 7th cent
  - Last Western Roman noble, Boethius, executed by Ostrogoth king Theodoric in 524
  - Literacy declined, knowledge of Greek disappeared

Background: History of Science

History of Science (cont'd)

- Greeks (Aristotle, Plato and others)
  - General, "ultimate" theories preferred, reasoning was supreme, exceptions to theories tolerated, science not practical
- Romans
  - Christians came to dominate
  - Concerned with God's will, perfection of God
- India?
- Arabs / Muslims

History of Science (cont'd)

- Southern Europe
  - Specialization, systematic interplay of theory and experiment, limited goals for theories, focus on exceptions, concern with practical
- Northern Europe
- US
  - Science generates technology

Assignments

- Next week – primarily labs:
  - Lab Manual: read Experiments 2, 3 and 8
  - POL folks are back with us that night
- Two weeks:
  - Reader: An Inventory of the Universe, A Case History in Astronomy and Physics: The Speed of Light, Euclid
  - Report on Experiment 2
  - Essay 1 (face-to-face: on diskette)

IST 1990 (Repeat)

- Handout: Essay topics for all three essays
  - Also on the course web site, of course
- Don’t forget “Notes on IST 1990 books” on course web site