

# Atoms and Stars IST 2420 and IST 1990

Fall 2005

Sections 001, 005, 010 and 981

Instructor: David Bowen

Class #2

[www.is.wayne.edu/drbowen/aasf05](http://www.is.wayne.edu/drbowen/aasf05)

# Tonight

- Handouts
  - Class 2 Notes
  - Moodle handout for interested face-to-face students
- Initial the sign-in sheet
- Review of names
- Pictures for Moodle?

# Changes

- I may not be able to make office hours the next few weeks – cell phone
- Lamphere: chairs up on desks
- Campus: confusion about face-to-face Vs POL
- Duane Cooper now registered at Lamphere
- Deborah Cuthbertson registered on campus
- Anyone want to switch (see me):
  - Between campus and Lamphere
  - Between face-to-face and partially online

# Changes to Syllabus

- IST 1990 and IST 2420 Partially Online
  - o Posts when you are scheduled to be in class do not count
  - o Plagiarism is applied to Moodle work
  - o Self-plagiarism is included here as copying from a previous post, perhaps with only minor changes, without quotation marks.
  - o 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)

- 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 First Class

- Lamphere: covered notes through slide 18 plus slide 28
- Campus: covered notes through slide 15
- Both: covered notes for IST 2420 partially online and IST1990

# The First Class

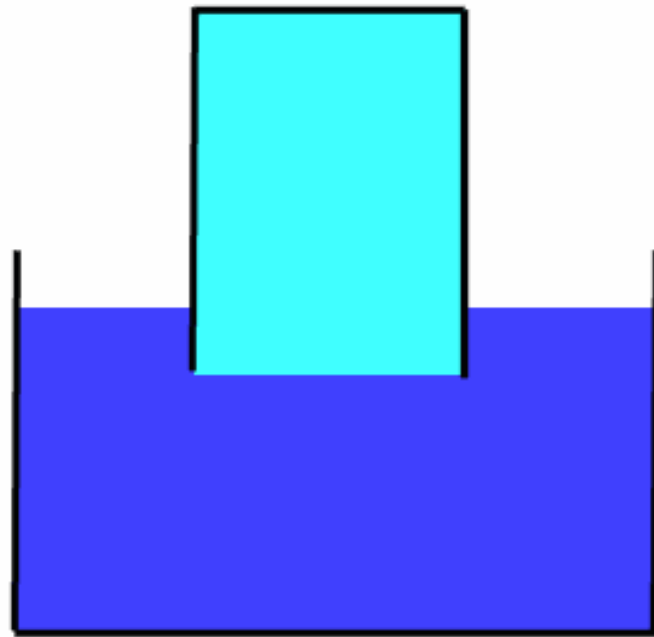
- Lab 1 at Lamphere – I made mistakes
  - o Put pop can directly on hot-plate coils
  - o Submerge can in ice-water *completely*
    - Need deeper container - bucket
    - Need two gloves
  - o Not enough ice
  - o This will be a demonstration for the second class

# Some Greek Science (#28)

- Aristotle:
  - o Universe is full, no room left
  - o If something moves in air, air must move out of way, then move in behind
  - o Cannot be a vacuum – “Nature abhors a vacuum”
    - “abhors” – hates, but here “will not allow”

# Lab 1

- Observations



**CupInBowl.GIF**

# Lab 1

- Aristotle:
  - o World is full, if water would fall out of cup when you lifted it up out of water, there would have to be room made for it, air would have to enter.
  - o Leads to “nature abhors a vacuum” – one would never exist
  - o Has to be a second hole to let air in

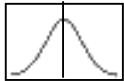
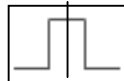
# Labs

- You should not expect to be able to finish the whole lab, including all of the questions, during the lab period.
- Should be able to finish the things you actually do, perhaps discuss some of the other questions, but mostly these will be homework.

# From the Lab Manual

- Keep hypotheses separate from observations
  - (Setting, procedure and observation or measurement) separate from (hypotheses, calculations and explanations)
  - Which is which? “Because the water in the bucket was cold, when we boiled water in the can and then submerged it upside-down, the can turned red.”

# From the Lab Manual

- Measurements have errors
  - Errors may make similar things appear different
  - May make different things appear similar
  - Should always analyze the effects of errors
  - Errors are a complex topic 
    - A degree of compatibility
  - Here, use a simple model 
    - Compatible or not, yes or no
  - Here, find errors by repeating measurements
    - Error = difference between highest and lowest

# From the Lab Manual

- The Null Hypothesis
  - If two measurements agree within their errors of measurement:
    - No basis for claiming that they are different
    - Therefore, justified in assuming they are equal
  - A challenge to improve the technique and reduce the error of measurement

# Review of Essay Assignment

- Due February 9
- Topic: We have studied the process by which Aristotle's view that nature abhors a vacuum was replaced by the sea of air hypothesis. Following Copi's seven step account of the scientific method, explain how this transition took place. Draw on material from the reading, class discussion, and the laboratory experiments. Also write about what this tells us about the scientific method.

# Essay Assignment (cont'd)

- 3 to 4 pages, 12-point Times Roman, double-spaced, 1" margins top and bottom, 1½" left and right.
- Content: 40%. Reading and understanding course materials, applying them to topic, consistent point of view

# Essay Assignment (cont'd)

- Form: 40%. Title page, Introduction (roadmap), Body (organized, transitions between topics, detail to support general points), Conclusion (review content, draws to an end)
- Mechanics: 20%. Spelling, grammar, punctuation. Use spell-check and grammar-check (note on passive) or dictionary.

# Common Writing Problems

- Functional grammar
  - Rules of grammar have a purpose – to transmit meaning
  - Rules of grammar are always changing
  - Different grammars for different groups
  - Get too far from the group's grammar and you are not understood (must change with changes)
  - The further you get from the group's grammar, the harder it is to understand you
  - Being able to use good standard grammar is like dressing well for a job interview

# #1 Reason for Writing

- To organize your own thinking

# #1 Way to Good Writing

- Have something you want to say

# More Examples and Details

- [www.is.wayne.edu/olgt](http://www.is.wayne.edu/olgt) then link to Writing Guide, or [The Everyday Writer](#)
- Writing Center in 2310 UGL / 313-577-2544

# Organization

- Many possibilities for organization
  - Historical
  - Logical
  - Specific to general, or general to specific
  - Combination
- Signal transitions from one topic to another
  - Paragraphs help here

# Quick-and-Easy Organization

- Write body first
- Once you have figured out what you are going to say (the Body), write the Introduction and Conclusion afterwards
- Body should have general statements and specific examples and quotes

# Sentences

- A sentence:
  - Verb (action)
  - Subject (did the action)
  - Complete thought
  - (starts with capital, period at end)
- (Y/N) Because he hit the ball.
- (Y/N) John hit the ball.

# Sentences

- Is it a sentence? Consider it all by itself.
- Common sentence problem #1:
  - Sentence fragment – something that starts with a capital and ends with a period but is not a sentence
    - Because he hit the ball. John ran to first base.
    - Fix by joining to main thought with a comma (,)
      - Because he hit the ball, John ran to first base.

# Sentences

- Is it a sentence? Consider it all by itself.
- Common sentence problem #2:
  - Run-on sentence – two or more sentences written as one
    - John hit the ball he ran to first base.
    - Fix by breaking into two sentences
      - John hit the ball. He ran to first base.
    - Or by joining with semicolon (;) to show causality
      - John hit the ball; he ran to first base

# Number (singular/plural)

- Both subject and verb have number
  - If these are not the same, signals conflict
    - Members join the club
    - A member joins the club
    - “One s”
- Without a reason, do not change number from sentence to sentence
  - (Bad) People should take care of their health.  
You should take your vitamins.

# Tense (past, present, future)

- Without a reason, do not change tense from sentence to sentence

# Citations

- “Scientific investigation is not, as many people seem to suppose, some kind of modern black art.” (Huxley, 1)
- Cite the source even if you are paraphrasing

# Punctuation

- Apostrophe (‘)
  - Contraction
  - Possession (‘s or s’)
    - Some words inherently possessive, no ‘ (e.g. theirs)
  - Never for pluralization
- Lists
  - Separate list items with commas (last one is optional)
  - If any list has a comma inside, separate items with semicolon

# Wrong Word

- Some words are commonly confused – memorize or use list or dictionary
  - o its Vs it's
  - o whose Vs who's
  - o their Vs there
  - o too Vs to
  - o accept Vs except
  - o Many, many more
- End of writing section, on to something else

# 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:
  - o data / observations / experiments
  - o hypotheses / laws / theories

# Overview (#16)

- Data / observations / experiments
  - Direct, not secondhand
  - Must be repeatable by anyone who cares to try
    - Often suggested by a hypotheses / law / theory, but must be repeatable even if you disagree
    - Anything important is repeated
    - Some things (speed of light) repeated for 100+ years
      - Improved technique triggers another round of measurements

# Overview (#17)

## Components of science

- #1: Data / observations / experiments
  - If data from different scientists disagree, discrepancy must be checked and resolved
  - Results cannot depend on beliefs or preferences – such effects must be checked and resolved
  - Often data suggested by a theory, but data stand even if theory fails

# Overview (#18)

- Data or observations.
  - o Must be recorded, not restricted or secret, with procedure (what you did, including preparation) and results (what you saw / measured)
    - So that others can repeat and verify your results
  - o Discrepancies must be resolved before others take it seriously
  - o Raw notes kept, will be reviewed if questions arise

# 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)

- o 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
- o Simpler theory preferred to complicated
- o 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.

# What's out there? (#27)

- Universe – everything (15 billion years old)
- Galaxy – large group of stars
  - Ours - “The Galaxy”
- Solar system – sun, planets, moons etc. (5 billion years old)
  - Greeks knew what they could see with the naked eye – some stars, Sun, Earth, our Moon, five other planets - Mercury, Venus, Mars, Jupiter, Saturn

# Readings

- Huxley, “We Are All Scientists”
  - Induction. Apples, Math compared to Red Shift
  - Must put a supposed theory or hypothesis to every test
    - Popper: science must be “falsifiable” – single failure can be doom to a theory
  - Hypothesis is normal
- DB: science prefers:
  - simple law before complicated one
  - universal law before specific

# Readings (cont'd)

- Copi, “Science and Hypothesis”
  - Recent, long after the birth of modern science
  - Often uses Sherlock Holmes to illustrate
  - Seven steps
  - Science has
    - Practical benefit
    - Value in itself as knowledge
  - Scientists focus on a problem
    - Hypothesis to focus on pertinent facts
    - Used to gather more facts
    - “Aha” – serious hypothesis - creative

# Readings (cont'd)

- Copi, “Science and Hypothesis”
  - Finding consequences of hypothesis
    - DB: If none, “not science”
  - Consequences must be tested
  - Application to problems
    - DB: Today, can lead to technology. Transistor, microchip, programmable computer, laser

# Readings (cont'd)

- Copi, “Science and Hypothesis”
  - Example of caloric theory of heat to kinetic
  - Caloric – a substance, add it to matter, temperature goes up
  - Count Rumford – worked on cannons
    - Boring generated very large amount of heat, could not believe you could mix in that much caloric
    - What could you add a lot of? Motion, led to...

# Readings (cont'd)

- Copi, “Science and Hypothesis”
  - Kinetic theory of heat
  - Sir Humphrey Davy compared theories, devised test
    - Two pieces of ice, keep them frozen, rub together. Caloric could not get in
    - Did this, they melted, demonstrating kinetic theory
  - Later, Joule more tests, also measurements

# Readings (cont'd)

## 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 Alexandria: light travels from eye, when we open eyes we see stars instantly, so speed is infinite

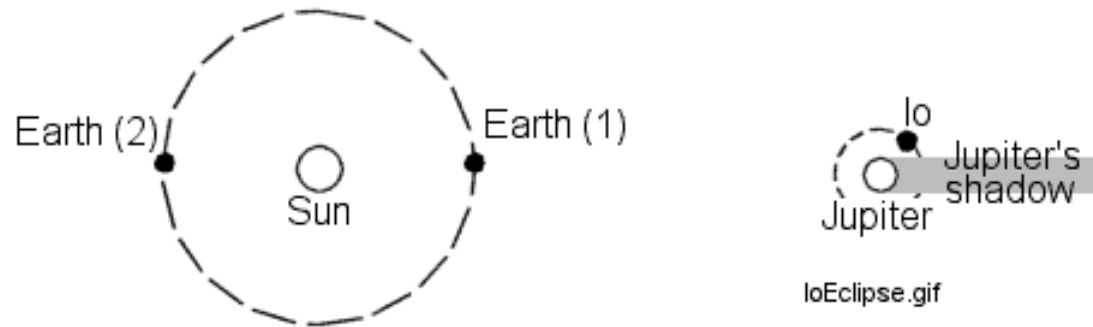
# Readings (Speed of Light cont'd)

- Arabs Avicenna and Alhazen 11<sup>th</sup> 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.
- 1665 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)



- 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 (1905), speed of light is maximum velocity for any object
- Also =  $c$  in  $E = mc^2$

# Background: History of Science



# History of Science (cont'd)

- Greeks (Aristotle, Plato and others)
  - General theories preferred
- 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
- Northern Europe
- US
  - Science generates of technology

# Assignments

- For next week:
  - Reader: “Greeks Bearing Gifts”
    - Problem with page numbers. Duplicate page numbers for pages 103 through 112. This article starts on the *first* Page 110.
- In two weeks:
  - Be ready for Experiments 2, 3 and 8
  - POL folks are back with us that night

# IST 1990

- Handout: Essay topics for all three essays
  - o Also on the course web site, of course