Atoms and Stars
IST 2420
and IST 1990

Class 9
Winter 2006
Instructor: David Bowen

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

Agenda

- Assignments and passbacks
- Midterm results
- Essay 2
- “Expanding circles” – a model of scientific progress
- Physical Science and natural disasters
- Upcoming assignments
- Lab 13: Parallax

Tonight

- Handouts:
  - Notes for Class 9
  - Questions for Final Exam
- Due:
  - Report for Lab 13
- Coming up: “pi day,” “π day” 3-14, also Einstein’s birthday

Next Class

- No class on Wednesday March 15 – Spring Break
- Due Wednesday March 22: Report for Lab 10
- Pick up in March 22 class: Information Sheet for Final Exam

Midterm Makeup

- I have had only one request for a makeup, with no schedule, so I pick
- Midterm Makeup is Wednesday March 22, 5 – 6 PM, in 309 Shapero Hall
- Must arrive before 5:10 to take makeup
- Will be a new exam from the 29 questions, and may include repeats

Midterm Results

- Circled grade is curved, the one that counts
- Other grade is raw score. To check this:
  - Grade for each question is average of grades for each part
  - Raw score is average of question grades
- Curving: grade = raw × 0.5357 + 42.4286, rounded
  - 100 curves to 100
  - 66.4 (average) curves to 82
  - Comments (review, not again)

Midterm Results (cont'd)

- Best grades on Q1 (Part B: 95%)
  - You should push me to put more math on exams
- Worst part Q3 Part C (characteristics of "pillars") – 33%
- Worst question Q4 – roles of each culture

Midterm Results (cont'd)

- Q2 – Aristotle & Archimedes
  - See notes for Class 4, slide 53
- Q3 – the two "pillars"
  - A & B: experiment makes science reliable, theory makes it valuable (see Implication 2 for "Expanding Circles" tonight)
  - C: experiments are validated, repeatable, public, theories are productive, unifying, consistent with all (most) experiments

Midterm Results (cont'd)

- Q4 – roles of the primary cultures
  - Prehistoric: tracked phases of moon
  - Early urban: "recipe" science (not explanatory)
    - Agriculture, astronomy, math & geometry, medicine
  - Greeks: theory (explanatory) but no experiment (so not modern science) except for Archimedes
  - Islamic: advances in agriculture, astronomy, math & geometry, medicine, transmitted Greek writings
  - Renaissance: united theory and experiment – rise of science

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 by referring to course experiences, such as labs and discussions, and materials, such as readings, notes, lab materials, and so on. A starting point is 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)

- This topic does NOT ask for a simple listing of all of the topics and activities ("laundry list"), and does not ask for an evaluation of me or the course (that's for SET).
- The topic asks for "a" core concept and suggests a starting point for your analysis
- Due 4/19. Note that we have not covered all of the core topics yet.
- Review Syllabus for other requirements
  - All quotes must have references

Expanding Circles

What Happens When Science Progresses

- Science always has a boundary, expands it
- What happens when:
  - … two circles meet?
    - Three examples: Newton uniting celestial and terrestrial motions, Maxwell uniting Electricity and Magnetism, Boltzmann uniting atomic theory and Newtonian mechanics
    - DB: both areas are improved, plus a bonus
  - … our knowledge becomes complete over part of the surface? (tonight)
- But first …

Expanding Circles

- Second Law of Thermodynamics
  - If a hot object and a cold one are in contact, energy always goes from hot to cold (cold object warms up, hot object cools down, temperature in both becomes the same), never the reverse (hot object gets hotter, cold one, colder)
    - Atoms in hot object more energetic (Rumford), travel more
    - Slowed down by collisions with slower atoms from cold object, but these are sped up
    - Statistical Mechanics explains why this happens
    - Demonstration – diffusion – atoms of dye

Expanding Circles

- Expanding Circles – three examples
  - When two domains meet, become fused into one with a bonus
  - Not a compromise – both areas transformed
- Implications:
  - This is additional evidence for science
    - If theories were imaginary, different imaginations would rule
  - Hard to attack just one area of science, since they are becoming more tightly tied together
    - Creationists and Intelligent Design advocates finding they have to attack 4.5 billion year age of earth, Big Bang, etc. (readings)

Expanding Circles

- Implication #2:
  - Joined circles expand to fill plane of knowledge
    - In earlier times, science and technology developed independently
      - When there were interactions, technology drove science
    - In 19th century, influence became mutual
      - Contribution of Thermodynamics to steam engine efficiency

Expanding Circles

- Implication #2:
  - In 20^{th} century, science began to drive technology. These 20^{th}-century technologies were predicted by science well ahead of time:
    - Atomic / nuclear energy (didn't understand until later that $E = mc^2$ made this prediction)
    - Laser
    - Computer, transistor, microchip, Internet
    - Radio, TV
    - Jet and rocket engines

Expanding Circles

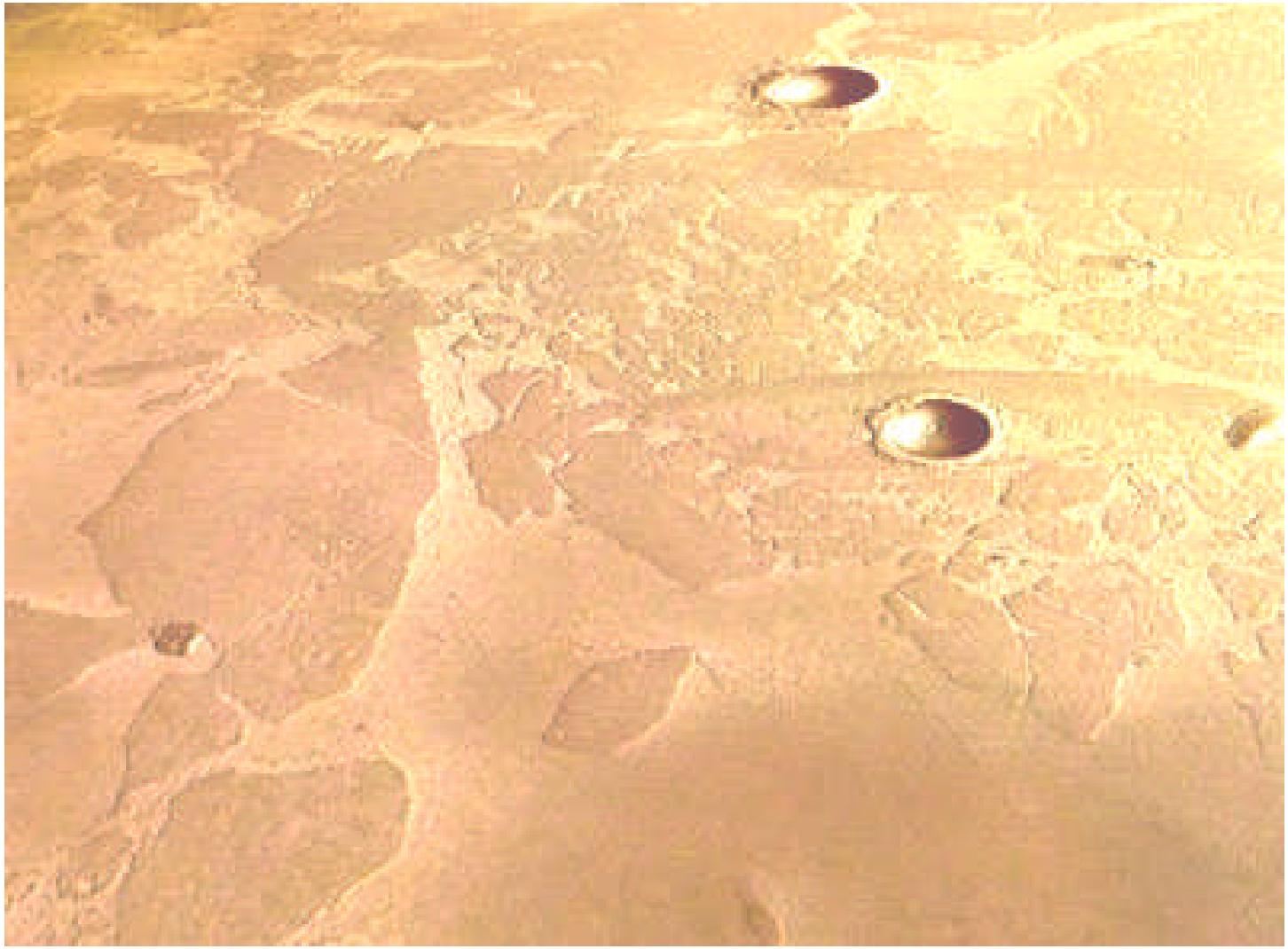
- Implication #2:
  - Science driving technology (cont'd):
    - Industry uses science to develop products better-faster-cheaper
    - Designs are science-based, often simulated on computers before prototyping
    - Theory – what makes science valuable, not only for scientists, but for society
    - WMU study: Michigan has to do better at this to be competitive
      - Manufacturing
      - Life sciences

Expanding Circles

- Implication #2:
  - Science driving technology (cont'd):
    - Many scientists believe that US lead in science and technology is disappearing
      - Degrees granted
      - Science prizes e.g. Nobel
      - Scientific articles published
      - Patents granted, etc.
    - … and that this threatens our technology and economy
    - Probably need at least a core of people who understand "big picture" for innovation

Reading: "The Planet Mars and Kepler's Three Laws of Planetary Motion"

- "My Very Excellent Mother Just Sent Us Nine Pizzas" – planets and their order out from the sun
- Mars a special case for Kepler, for mankind too – life on Mars?
- Illusory "canals" on Mars, "War of the Worlds"
- Recent indications of water, "Mars Express" (next slide). Life there?



A dust-covered frozen sea?

"The Planet Mars and Kepler's Three Laws of Planetary Motion"

- Mars (and other planets) get brighter and dimmer
  - In geocentric theory, hard to explain this
  - Heliocentric: natural – closer to & further from us
    - Retrograde Motion demo
- Kepler's three laws:
  1. Planetary orbits are ellipses, sun at one focus
  2. Planet sweeps out equal areas in equal times
  3. $T^2 \propto R^3$ ($\propto$ means "is proportional to") – 3/8/1618
     - Period T (length of year), mean radius R

A Common Sequence

- Brahe → Kepler → Newton
- Accurate measurements → "empirical" theory (little explanatory power, descriptive only) → explanatory theory

A Common Sequence

- Reader says Physics has no explanation for gravity
  - Modern Physics does have explanations

Reading: The Crime and Punishment of Galileo Galilei

- Galileo Galilei 1564 – 1642
- Started life as a rather ordinary mathematician
- 1608 Hans Lipperhey invented telescope in Holland
- Galileo got hold of one, improved it, looked at the heavens systematically

Galileo

- Moon had mountains and valleys
  - Not perfect(ly smooth)
  - Had to study shadows over weeks
- Four moons of Jupiter
  - Earth not unique in this way
  - Had to study motions over time
- 1610 *Siderius nuncias* (Starry messenger)
  - Sensational

Galileo

- Left university at Padua for court appointment to Medici in Florence
- Reputation among people and nobles
- Joined private organizations – Academia dei Lincei (Academy of the Lynx-eyed)
- Controversies about telescope
- Supported Copernican astronomy publicly

Galileo

- 1616 Church declared Copernicus to be heretical, Galileo had to promise not to "hold or defend" it (but teach?)
- 1623 Galileo's friend Maffeo Barberini became Pope Urban VIII
- Approved Galileo's book project (*Assayer*) but said it had to present Ptolemy and Copernicus as equal alternatives

Galileo

- Pope also changed title to *Dialogue on the Two Chief World Systems*
- 1632 (Galileo 68) book published, formally neutral but really Copernican
  - Advocate for Ptolemey was called Simplicio
  - Simplicio characterized as a high official
  - Phases of Venus (like moon's but require a telescope) incompatible with geocentrism

Galileo

- Phases of Venus (“horned Venus”):
  - Lit by sun, we see it from different angles
- Worse: book in popular language (Italian) and popular
- Also dealt with other difficulties of spinning earth, mainly by saying everything moves along with the earth
- His argument in book that tides show earth’s motion is false

Galileo

- 1632 (same year as publication), Pope ordered sales stopped, copies retrieved, all materials taken from printer, special committee which handed matter over to Inquisition
- Galileo called to Rome, legalistic defense
- Compromise but Pope insisted on heresy charges (punished by burning at stake)

Galileo

- 1633 convicted on lesser charge, forced to denounce Copernicus and supporters, house arrest
- Started a new career.
- 1638 Discourses on Two New Sciences returned to earlier work
  - Strength of beams (advance)
  - Balls rolling down tracks

Galileo

- Used experiments to confirm hypotheses
  $s \propto t^2$
  - Does not show data, discuss errors
- Then projectile motion
  - Horizontal (circular) and vertical motions independent
  - Inertia
  - Gunnery tables from theory, but not needed

Post-Galileo

- Theories did not take hold in Italy
  - Inquisition
  - Galileo's manner, e.g. controversy, did not train students
- Scientific revolution moved north and east to France, Holland, England

Post-Galileo

- 1596 – 1650 René Descartes
  - o “Cartesian” coordinates – x, y, z (3D)
  - o Mechanical universe 1644 Principles of Philosophy (vague, not modern)
- Others in Holland: Huygens, van Leeuwenhoek (microscope, “animalcules”)
  - o Englishman Robert Hooke 1635 – 1703
  - o Slow acceptance of miniature world

Post-Galileo

- Isaac Newton 1642 – 1727
- Science is active, promotes human welfare, contrasts with passive Greek concept
  - Archimedes an exception among Greeks
- 1561 – 1626 Francis Bacon – philosopher of science (what is the logic behind science?)
  - Scientific method
  - Skepticism
  - Importance of experiment

Natural Disasters #1

- Hurricanes, tornadoes, earthquakes, tsunamis, mudslides
- Hurricanes best understood
  - Rising air over warm ocean – spirals counterclockwise as seen from above in Northern Hemisphere due to earth's rotation
  - Picks up water vapor, condenses out higher up

Natural Disasters #2

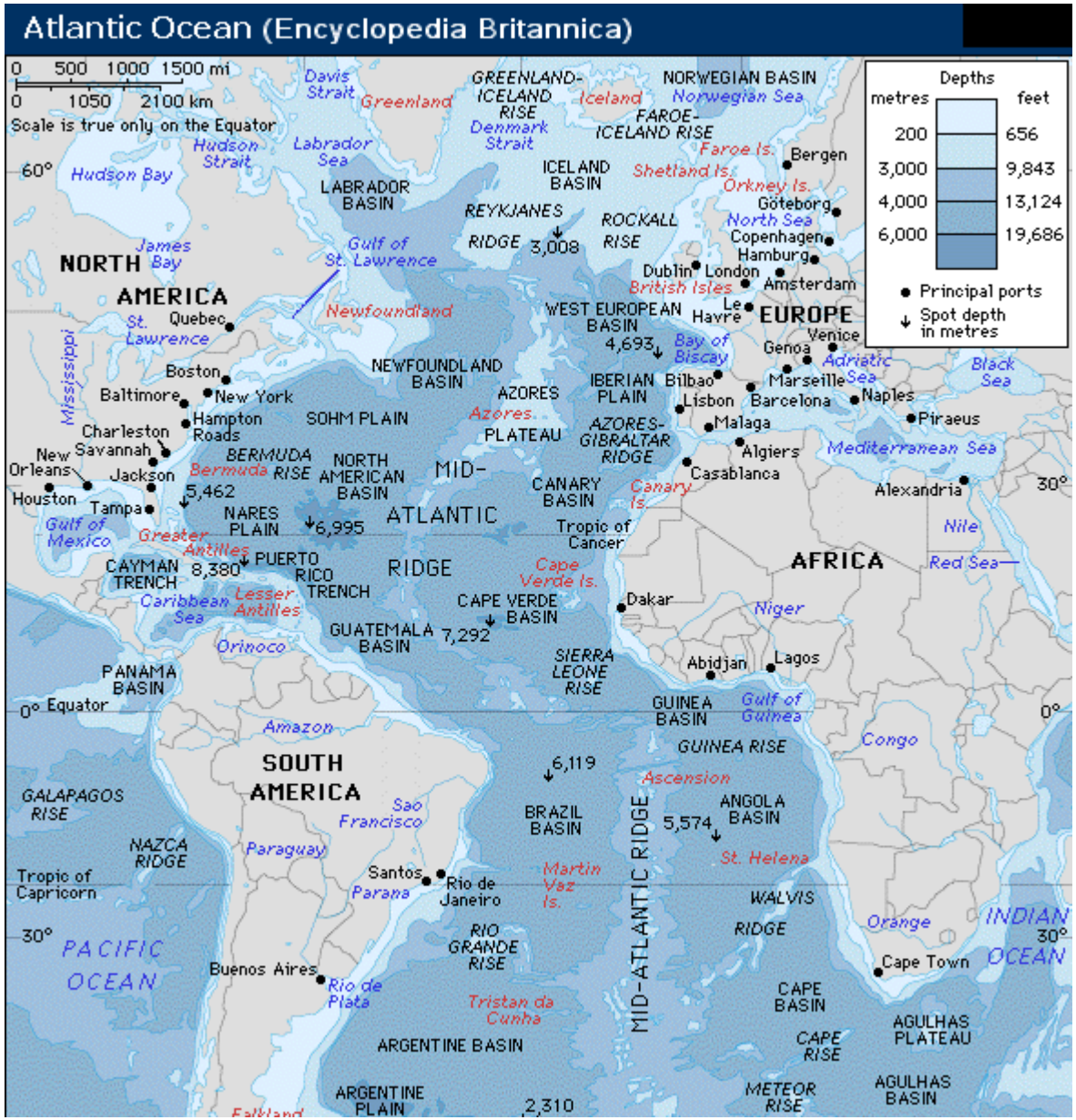
- Hurricanes best understood
  - When water condenses, air heats again – “fuel”
  - Strength: indicated by low pressure in the eye
    - No storm, 30” Mercury – if eye gets to 27”, get out of there! (Katrina)
  - Very large size, winds to about 200 mph
  - Called typhoons in Asia
- Tornadoes also circular, form over land, smaller but higher winds (about 300 mph)
  - Less well understood than hurricanes (“supercell”)

Natural Disasters #3

- Earthquakes
  - o “Plate Tectonics gives general explanation
  - o Earth molten when formed ~ 4.5 BYA
  - o Cooled, surface condensed into continents (thin “plates”) floating on molten core (“magma”)
  - o Currents in core, like currents in boiling water, carry plates, like the skin on cooking pudding
  - o Plates crash into each other ➔ earthquakes

Example: North & South America were joined to Europe and Africa, magma is boiling up at Mid-Atlantic Ridge, pushing them apart.

Geography and species from before split match across Atlantic ocean



Natural Disasters #5

- Earthquakes
  - As plates crash, tension in “crust” builds up
  - Longer time between quakes ➔ larger quake
  - Cannot presently tell when quake will happen
- Tsunami – wave formed from underwater earthquake
  - Sensors, warning system, disaster network can move population out – Hawaii and Alaska monitoring centers
  - No such system in Asian 2004 tsunami, being built now

Natural Disasters #6

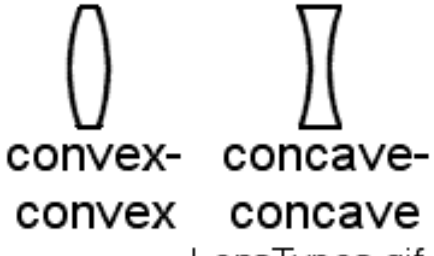
- Mudslides
  - o Deforestation and development mean vegetation on hillsides being cut back
  - o People living in these areas due to growth in population
  - o Heavy rains weaken hillside
  - o Depth of slide can be hundreds of feet or more
  - o Can be foreseen, but weak societies cannot act

Natural Disasters #7

- Natural Disasters
  - At present, we cannot predict or control these
  - We are learning a lot about them
    - Earthquake and hurricane construction codes
    - Modern buildings in California much better against quakes, in Florida against hurricanes
  - Prediction will come first, control is a maybe

Lab 10: Lenses

- General – light is easier to see than bunny
- Lenses are in tissue paper inside envelopes
- Labels on envelopes do not mean anything
- Each envelope has five lenses – keep track by type – write a description of each lens
  - Three convex with increasing thickness
  - One concave
  - Other types: plane, plano-convex, plano-concave
  - Need to match measurements with lens later



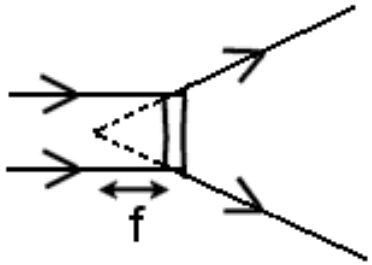
LensTypes.gif

Lab 10 (cont'd)

- Exercise I.
  - For this part, start with the lens touching the paper. As you move the lens towards you, if you see a dramatic change in the image, keep the lens closer to the paper.
    - Afterwards – what happens as you move lens past the point of dramatic change?
  - What type of lens is magnifying? Reducing?
  - For magnifying lens, how does focal length vary with curvature?

Lab 10 (cont'd)

- Exercise II: image properties
  - Real (can be projected on a screen) Vs Virtual (behind lens, can be seen but not projected)
  - Inverted (upside down) Vs Non-Inverted
  - Magnified (larger than object) Vs Reduced
- Measure focal length in mm
  - Measuring focal length for reducing lens
    - Skip this



DivergeFocus.gif

Lab 10 (cont'd)

- Exercise III (telescope):
  - o Two lenses are objective (closer to object) and eyepiece (closer to your eye)
  - o Good telescope – focal length for objective is longer than for eyepiece – *choose lenses*

$$M = \frac{f_{obj}}{f_{eye}}$$

  - o Good idea to make screen for objective: cut hole in card, slightly smaller than lens, tape lens to card, bend card to stand lens up
- Do not do the <u>WRITING ASSIGNMENT</u>