

Atoms and Stars

IST 2420

Class 11, April 2
Winter 2007

Instructor: David Bowen

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

Agenda

- Assignments and passbacks
- Pick up these Notes for Class 11
- Upcoming assignments
- Miscellaneous
- Readings: Atomic Nature of Matter
- Life Science: “Bird Flu” – current science
- Lab 9: Archimedes’ Exploits (cont’d)

Upcoming ...

- Next week:
 - Reader: Chemistry
 - Manual: Lab 7 – Specific Gravity
 - Turn in Lab 9 as a whole
- April 16: SET
- April 23 (last regular class)
 - Essay 2 due
 - Review for Final Exam
 - Due: all work to count in regular grade
- April 30: nothing that night but the Final Exam

Stuff

- Remember to initial the sign-in sheet
- In your lab report, don't write that you followed the procedure in the lab manual, if there is no lab procedure for that part (for example, if that part is only a calculation).
- Don't put off Essay 1!!! See me instead.

Changes in Lab Schedule

- Last week, I extended Lab 9 over two weeks
- No lab report due this week; turn in a single report for both weeks on April 9
- See remarks on first part of Lab 9 later tonight
- Changes to Syllabus lab schedule:
 - Lab 7 on April 9
 - Lab 11 on April 16
 - We will not do Lab 4 (we will go over the content)

Grade What-If

- Grade What-If (on course web site – see first slide for this URL)
 - o Reminder: to get current course average, do NOT put anything in for assignments you haven't been graded for yet
 - If you put anything in, remove it using “delete” key
 - o To see what happens if you miss assignments, put in zeroes for those (this is what I will do)

Writing

- “lens” not “lense”
 - Plural is “lenses”
- For cart in case where wheels not covered with tape, this is “untaped” rather than “untapped.”
- For help on writing:
 - www.is.wayne.edu/olgt
 - Writing Center 2310 UGL 313-577-2544
 - Have something you want to say, then organize

Semester is Ending!

- If you have been relying on being able to turn work in late, *it is time to get going*
 - Alternatives: D, E, I, X, drop – see counselor!
- Getting ready for Final:
 - Read Information Sheet carefully – a lot of information there
 - Look at Final Topics carefully
 - Use Review Session!
 - Final Where-Is probably April 16

Limits on Space Travel

- The idea of space travel has always been attractive.
- Einstein's Special Theory of Relativity (1905) set limitations on space travel.
 - Maximum possible speed is speed of light – one year to travel one light year (but today we cannot reach even a small fraction of this)
 - Nearest star is 4 light years away
 - Galaxy ~100,000 light years across

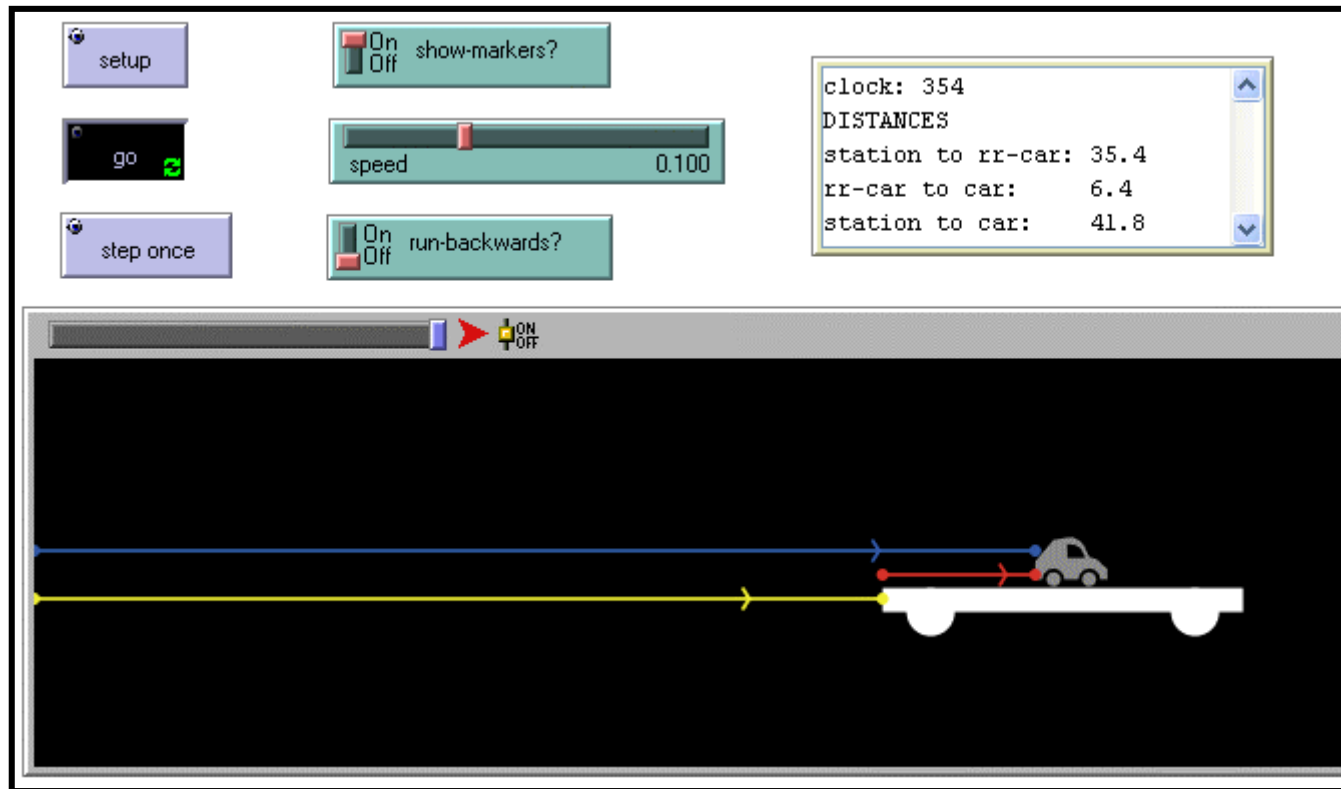
Background

- Before 1905, we could not see expected changes in the speed of light when the direction of the earth changed as it orbited the sun.
- Tried to explain this by saying that distance-measuring devices got shorter in direction of motion.
- Didn't work.

Relative Motion

- Newton said that speeds in the same direction should add, nothing special about light.
- Simulation – car traveling on top of a railroad car:
http://www.is.wayne.edu/drbowen/Class-Room_Models/Welcome.htm
- Speed of car with respect to station = speed of railroad car + speed of car on railroad car
- Speed of light could be exceeded – no issue for Newtonian view

Relative Motion



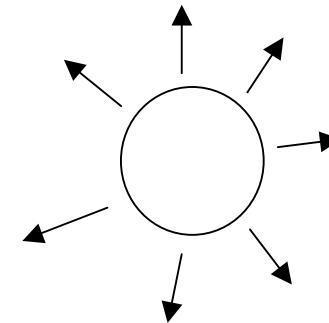
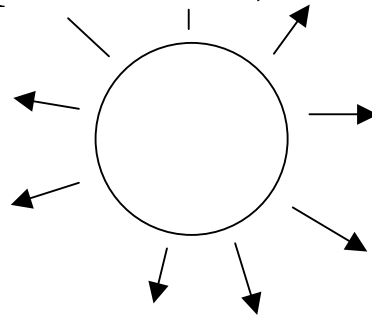
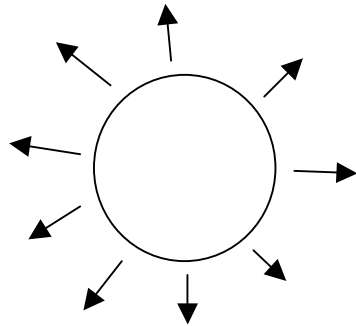
Relative motion of rr-car and car on top. car speed wrt station = rr-car speed + car speed on top of rr-car

Special Relativity

- Newtonian Relativity simple, correct at low speeds, but wrong for very high speeds (light).
- Einstein's Theory of Special Relativity (1905) said constant measured speed of light is a property of space and time themselves. No explanation – that's the way things are, a fundamental condition.
- Space and time went from the passive stage for the universe to active players in the drama.
- Revolutionary, but it works.

Expanding Circles (Review)

- Implication #1: eventually, expanding circles must meet and overlap
 - Different approaches, different theories – will not agree



Expanding Circles (Review)

- Implication #2: circles could meet and fill the space
 - o What happens then?
 - o DB: what happens is what makes science valuable

Expanding Circles

- Implication #2:
 - Joined circles expand to fill plane of knowledge (Q17)
 - In earlier times, science and technology developed independently
 - When there were interactions, technology drove science
 - Some improvement of scientific instruments resulting from theory in Newton's time (1687 *Principia*, 1704 *Opticks*)
 - In 19th century, influence became mutual
 - Example: contribution of Thermodynamics (movement of heat) to steam engine efficiency

Expanding Circles

- Implication #2: (Q16, Q17)
 - o In 20th century, science began to drive technology. These 20th-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, telephone, cell phone
 - Jet and rocket engines

Expanding Circles

- Implication #2: (Q16, Q17)
 - o 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:
 - o 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

Three waves of science?

1. Physical science – the subject of this course –
mature, quantitative (95%)
 - Very controversial when it was new
 - 1400 – 1800 AD, although very long roots & still developing
 - Now pretty much settled for everyday objects
2. Biological or life science – qualitative (30%?)
 - Much newer, evolution is the basis, still controversial publicly, but for scientists it is settled
 - 1800 – 1935 AD
 - Coming into general use in society & economy
 - Will qualitative change to quantitative?

Three waves of science?

3. Cognitive science – how emotions and the mind work – just starting (5%)
 - o Will be as controversial, if not more
 - o Potential for controversy: Science of Desire : The Gay Gene and the Biology of Behavior & The God Gene (spirituality) / Dean Hamer
 - Spirituality predestined for some, denied to others?
 - A single gene is unlikely to be the sole cause
 - o Will call into question how we view ourselves

Summary, Once More...

- Strong dose of the value of science here
- One more time, about science:
 - Two pillars – repeatable experiment (what makes it reliable) and explanatory theory (what makes it valuable)
 - Developed 1600 – 1800 AD: Copernicus to Dalton
 - Developing hypotheses and theories is creative
 - Has a boundary but expands aggressively
 - ∴ not a complete basis for living
 - Now drives technology
 - We all use it
 - Conflicts with some, but not all, religious beliefs
 - People of all ethnicities have been able to contribute

Two parts

- Newton ended the “Stars” part of this course
- This week start the “Atoms” part
- “Element” – Greeks understood this to be something fundamental, without parts, not made from other things, could not be broken down
 - Aristotle: air, earth, fire & water are elements
 - First discoverers of atoms disproved Aristotle, thought atoms were the Greek elements
 - Today we still call atoms “elements,” but not in the same sense – they are made of other things
 - Still have question of what (if anything) is elemental

And now...

- “Atoms”
- Before Einstein & $E = mc^2$, matter and energy separate
- Atomic Theory – all matter is made up of atoms
- Start by looking at our knowledge of atoms
- Then, how did this knowledge come about?

Readings

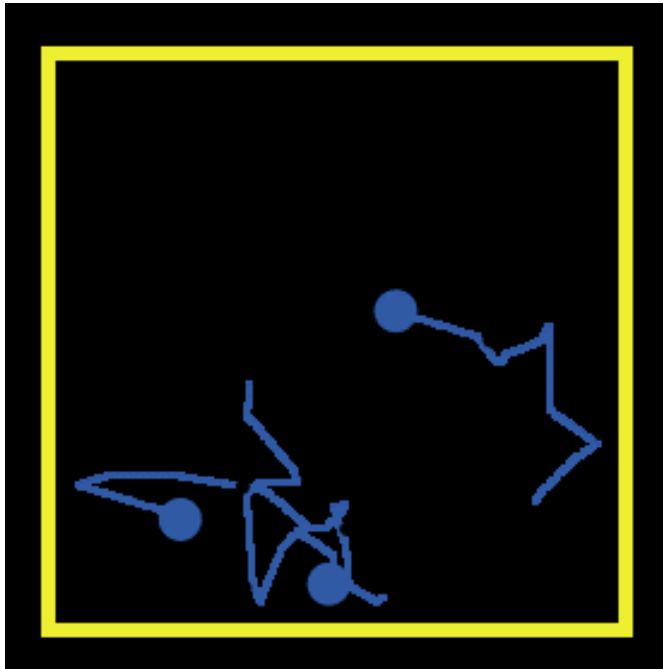
“Atomic Nature of Matter”, Hewitt

- All matter is atoms (“Atomic Theory”)
 - Atoms are elements – “indivisible” – mostly empty (10c#1)
 - 109 types total, 90 are natural, rest radioactive
 - Each type has its own properties, e.g. weight, reactions
 - Hydrogen most common atom in universe
 - Rare by itself on earth
 - Life primarily C, H, O, N
- Atoms small enough to be invisible - waves

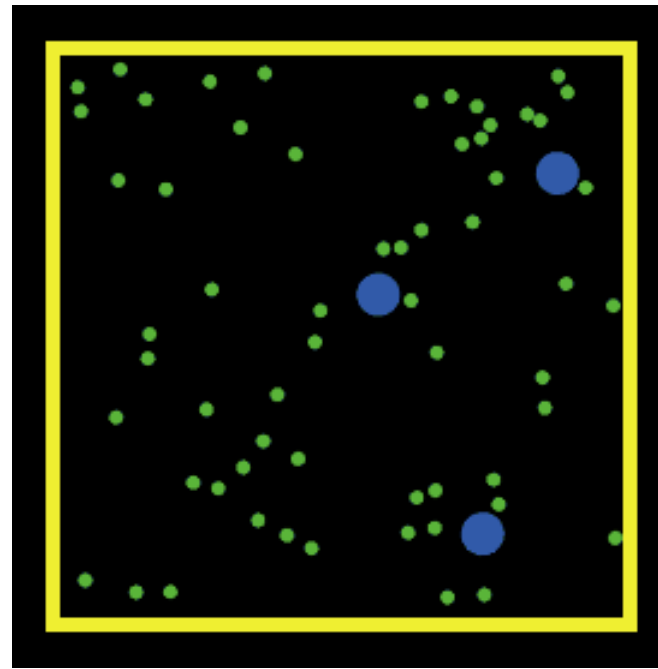
Atomic Nature of Matter

- First direct evidence 1827 Robert Brown (10c#2)
 - o Noticed spores jiggling under microscope
 - o “Brownian motion” – bombarded by molecules
 - Robert Brown, 1827
 - o See next slides, or
 - http://www.is.wayne.edu/drbowen/Class-Room_Models/Welcome.htm
 - <http://www.colorado.edu/physics/phet/web-pages/simulations-base.html>
 - o Now we have more direct evidence
- Atoms bond into molecules – many types (10c#1)
 - o Molecules - compounds
 - o Molecules have separate properties from atoms
 - o Burning is combination with O
 - New - modern automobiles very little CO

Brownian Motion

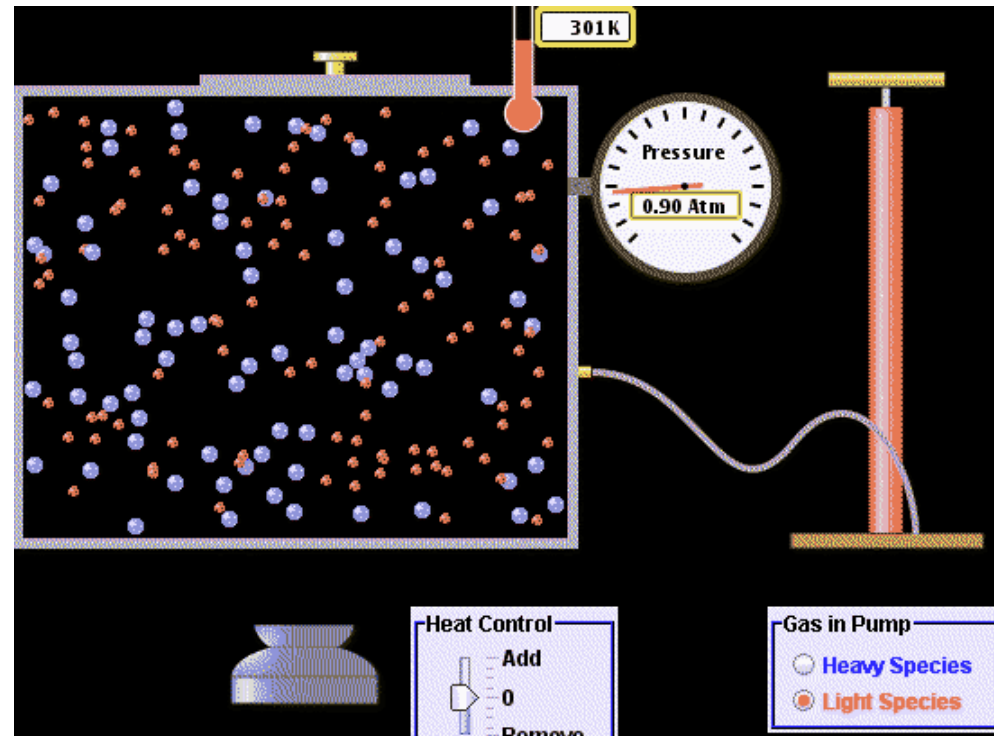


Jagged tracks of pollen particles.



Gas molecules made visible. Jagged tracks explained as due to collisions with gas molecules.

Brownian Motion



Imagine the red molecules were so small that we couldn't see them – blue ones would “jostle” for no apparent reason.

Atomic Nature of Matter

- 1811 (Amedeo) Avogadro's hypothesis (now Law)
 - At same T & P, equal Vs of gas have equal #s
 - Each atom, molecule heavier → gas heavier
 - Amu = atomic mass unit
 - C ≡ 12 amu, H ≈ 1 amu, O ≈ 16 amu, U ≈ 238 amu, H₂O ≈ 18 amu – also combine in gm, lb etc.
- Atom has electrons orbiting nucleus
 - Electrons – volume but very little mass
 - Nucleus – mass but very little volume

Atomic Nature of Matter

- Electron, e – negative charge, flow of electrons is electrical current
- Nucleus has neutrons, n (no charge) and protons, p (positive charge)
 - Cube 3/8” would weigh 133,000,000 tons
- Like charges repel, unlike charges attract
 - Nucleii positive, repel each other
 - Atoms neutral; number of e = number of p
 - (not = under special circumstances)

Atomic Nature of Matter (end)

- Electrons in shells (2, 8, 18, ...)
 - If shells filled, element is inert
 - Unfilled shells determine activity
 - #p = atomic number, chemical characteristics
 - Same element even if atom loses or gains electrons
- Antimatter – anti-electron (1932), anti-neutron, anti-proton
 - Annihilate → 100% energy (light)
 - Nuclear reactions normally 1%
- End of article...

Element, Compound, Mixture

(Q10 a-b)

- Element: matter with all atoms the same
 - Examples: C, S, H, O
- Compound: made up of the same molecules
 - Examples: H₂O, CO₂
 - Matter with all molecules the same
 - Atoms bond together into chemical combination
 - Always the same composition

Element, Compound, Mixture (end)

- Mixture (Q10a-b)
 - o Atoms and molecules not close enough to bond
 - o Composition varies
 - o Examples:
 - Air (mostly N and O) but variable
 - Amount of greenhouse gases an issue – CO₂
 - Earth – composition extremely variable
 - Add various fertilizers
 - Dough – vary composition for different breads
 - Cinnamon and sugar
 - o Constituents could in principle be separated

Epistemology

- Several times you have asked me “Is this absolutely true?” I tend to hesitate with questions like this – here is why.
- Epistemology – the study of knowledge – why do we accept things as true?
- Two properties we would like for truth:
 - Eternal – unchanging
 - Universal – the same everywhere

Epistemology (end)

- Science doesn't do “eternal”
 - Scientific truth is provisional – subject to change
 - We keep learning new things and improving theories
- Religions have problems with “universal”
 - Each religion claims universality but how can different religions differ, if there is one truth?
 - For science and religion, Galileo agreed with modern Catholic doctrine – there is one truth
 - Reinterpret Bible if it disagrees with accepted science

Current Issue: Bird Flu

- Spread of Avian Flu strain H5N1(A)
 - Many infectious diseases cross from animals to humans in poor regions where animals and humans live together
 - Biggest problem would be evolution or mutation from (animal-infects-human) strain to (human-infects-human) – this is what scares the experts
 - New virus, no immunity , serious, spreads quickly
 - H5N1(A) from Asia, still (bird-infects-human)
 - If more humans exposed, more chance to evolve

Bird Flu (cont'd)

- (Bird-to-human) path is slow, not the big concern
- H5N1(A) spreading faster among birds than anticipated
 - Asian commerce not understood
 - Governments slow to prevent, react
 - Now being spread by wild bird migrations
 - Spread to domestic flocks via falling fecal matter
 - Perhaps in US by August
 - Infected poultry that is well cooked is safe to eat
 - Not generally known, devastates local poultry industries (France)
 - Now infecting other animal species
 - More possible paths to human-to-human infection

Bird Flu (cont'd)

- Two possible paths to cross from animal-to-human to human-to-human
 1. Direct
 - Historically most devastating – 1918 flu epidemic
 2. Combination with human virus
 - We have some exposure and immunity, has been milder
- Two approaches to protection:
 1. Slow the spread of infected birds – not working as well as hoped – see above
 2. Prepare for treatment of humans

Bird Flu (cont'd)

- Treating humans
 - o No specific vaccine yet
 - Tamiflu is generic
 - Vaccines currently slow to produce, so stockpile them
 - Hoarding?
 - Virus will further evolve (mutate) so vaccines become less effective over time, stockpiling may not work well
 - o Stockpiling ventilators – expensive, lagging
 - o Training first responders and medical personnel (public?)
 - Collect and track spread
 - o Quarantine laws, regulations and practices
 - Happening in US and Western countries

Bird Flu (cont'd)

- May take a long time to evolve into human-to-human
 - Just last week: strikes deep in human lungs, evolution path is longer than previously thought, chance smaller
 - May not be a virulent strain when it happens
 - Hard to maintain vigilance and effort
 - May never evolve into human-to-human
- If (when?) becomes human-to-human, with global culture, can travel very fast
 - Are people infectious without yet having symptoms?
This would be much worse
 - AIDS can be spread before symptoms appear
 - Not known yet for this

Bird Flu (cont'd)

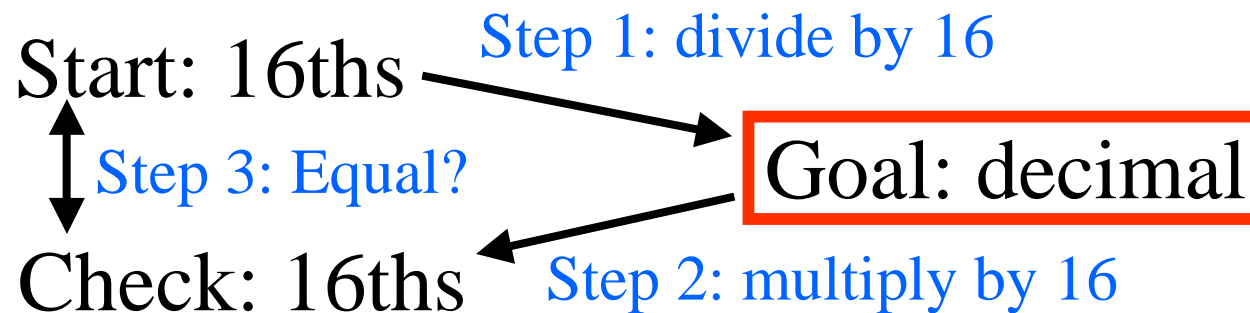
- UN genetic database for H5N1(A)
 - Currently limited-access so investigators can still publish papers while putting in latest info
 - One Italian woman scientist says it should all be public, putting her results on the web
 - Issue of scientific communication
- What is the final story for Avian Flu? We don't know.

Bird Flu (end)

- A small chance of a large disaster
 - Humans have not dealt well with this type of situation
- Science is far from complete
 - Major parts unknown
 - Chance of evolution to (human-to-human)
 - Seriousness if this happens – spread, lethality
 - Ability to develop and manufacture vaccines
 - The boundary of scientific knowledge very clear – experts disagree on seriousness
 - Some say very serious crisis, others say a minor concern

Experiment 9: last week

- Measure curved shapes by winding string around shape, measuring string
- Converting 16ths to decimal & the check:



- The Goal is the tenths!!!

Experiment 9: last week

- $C = \pi d$ and value of π can be proven in Plane Geometry (Euclid)
- Lab 9: measuring C and d to check formula and value of π
 - Archimedes did something similar with volumes of geometric shapes (cone, pyramid, cube) – measure instead of formula
- All groups found agreement between formula and measurement within .1” or .2”

Experiment 9: overall

- Important conclusions from last week:
 - The formula is almost certainly correct
 - Value of π almost certainly correct
 - The method for measuring C is valid within .1” or .2”
 - Method: putting pins along path, looping string along pins, removing string and measuring its length
- Circle part and ellipse part are connected. DO NOT treat them as separate.
- Should measurement errors be the same, or different?
- If they are different, how can this happen?