Old Dead Guys Part II

Intro Light
Quotes & Cartoon of the Day

"If we can make them small enough, we can wear them on our wrists."

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Astronomy 1 - Elementary Astronomy
LA Mission College
Levine F2015
Announcements

- First HW not graded, but key posted
- First midterm Thursday
  - Rest of schedule still needs tweaking
- Did you see the lunar eclipse?
- In the News: Water on Mars!
WATER ON MARS UPDATE
Water on Mars 9/28/15

- Full press conference here:
Recurring Slope Lineae (RSL) are dark streaks that appear and disappear seasonally.

- discovered 2010 in MRO images (Mars Reconaissance Orbiter)
  - by an undergrad! Now a grad student at GA Tech & lead author of paper
- running water (icemelt?) had been hypothesized
Current result uses spectra from MRO to ID minerals:

- detects hydrated salts in streaks from orbit
- interpreted as residue from salty water which flows at -10°F when streaks lengthen
- “likely a shallow subsurface flow, with enough water wicking to the surface to explain the darkening”
Last Class

- Eclipses (if not done Monday)
- History Ancients-Galileo
This Class

- About the Midterm
- History review Kepler, Galileo, Newton
- Gravity & Tides
- Intro to light (time permitting)
Lunar Eclipse Replay & Kepler Preview
About the Midterm
About the Midterm

- Through Lunar Phases/Eclipses
- Material covered in class and on homework should be a good guide to what’s on the exam
- You may bring an index-card-sized handwritten note card
- Bring a Scantron and a #2 pencil
- About 20-25 MC and comparable points in short answer/matching/ranking/etc.
Overview of Topics for Midterm

- **Science**
  - Scientific Method
    - what are the key components
  - Theory, Hypothesis, Role of data
    - what makes a usable scientific hypothesis
  - Be able to distinguish science from not-science
Overview of Topics for Midterm

- The Night Sky
  - Coordinate Systems -- the Celestial sphere
    - Zenith/Horizon
    - Celestial Pole and Equator (Right Ascension and Declination)
    - Relationship of these as a function of observer’s latitude
    - Read a map in RA and Dec
  - What’s a Constellation?
  - Describing brightness — Magnitude Scale
    - compare brightnesses given magnitude numbers
Overview of Topics for Midterm

- **The Night Sky**
- **Diurnal Motion**
  - daily patterns due to Earth’s rotation
  - everything rises E and sets W
  - Be able to interpret diagrams such as those in “Position” LT
  - How do up time and transit location depend on rise/set location?
  - What is a circumpolar star.
  - changes with latitude
Overview of Topics for Midterm

- The Night Sky

- Annual Patterns
  - Apparent motion of Sun due to Earth’s orbit
  - Apparent motion of zodiacal constellations due to Earth’s orbit
  - Know stars rise earlier on subsequent nights
  - Definition of the Zodiac
  - Interpret diagrams like those in “Seasonal Stars” LT
Overview of Topics for Midterm

• The Night Sky

• Lunar Phases and Eclipses
  • Understand and describe cause of phases
  • Recognize/match position of Moon relative to Earth and Sun associated with each phase
  • Distinguish waxing and waning given orbital direction
  • Determine rise, set and transit times for a given phase
  • Understand which phases are associated with eclipses
  • Understand and describe why eclipses are not seen every month.
Overview of Topics for Midterm

- The Night Sky
- Planetary motion
  - know typical motion is west-to-east (rising later each day)
  - know definition of apparent retrograde motion
  - be able to recognize apparent retrograde motion on diagrams
  - be able to describe cause of apparent retrograde motion/make a sketch
Overview of Topics for Midterm

- **Energy and Seasons**
  - What is energy
  - know Earth has an axial tilt and what this means
  - recognize geometry associated with various seasons
    - e.g. on a diagram
  - recognize/describe the consequences of tilt toward or away from the sun
    - day length, directness of illumination, location of sunrise/set
  - know term equinox and solstice
  - describe/recognize what causes summer to be warm, winter cold and spring/fall in between.
Old Dead Guys

Greece to Kepler in 10 minutes
Kepler’s Laws

explaining retrograde motion
The 3 Laws Summarized

• First Law: **Planetary orbits are ellipses** with the Sun at one focus

• Second Law: **Planets are traveling fastest along their orbit** when closest to the Sun

• Third Law: **Planets farther from the Sun** take longer to complete an orbit.
Kepler’s Laws Can Be Generalized

- Kepler’s laws work for Earth satellites
- Work any time a relatively small (low mass) object orbits a relatively large (high mass) object
Let's Practice
Kepler’s second law says “a line joining a planet and the Sun sweeps out equal areas in equal amounts of time.” Which of the following statements means nearly the same thing?

A. Planets move the same speed at all points during their orbit of the Sun.

B. Planets move fastest when they are moving toward the Sun.

C. Planets move faster the closer they are to the Sun.
During how many of the portions of the planet’s orbit (A, B, C, or D) would the planet experience an increase in speed for at least a moment?

A. Only during one of the portions shown.
B. During two of the portions shown.
C. During three of the portions shown.
D. During four of the portions shown.
E. None of the above.
Jupiter takes longer to orbit the Sun than the Earth does. Which of Kepler’s 3 laws describes this?

A. Kepler’s first law (shapes)
B. Kepler’s second law (equal areas in equal times)
C. Kepler’s third law (period/distance relationship)
If the Earth were moved to twice its current distance from the Sun, how would the length of a year be affected?

A. It would be half as long
B. It would be the same
C. It would be more than twice as long
Which of the following best describes what would happen if Mercury and Jupiter were to switch places in their orbits about the Sun?

A. Jupiter, the larger planet, would have a shorter orbital period than before.

B. Mercury, the smaller planet, would have a shorter orbital period than before.

C. Neither of the two planets would have any change in their orbital periods.
GALILEO GALILEI: FALLING ROCKS, OBSERVATIONS, THE Telescope AND THE Inquisition
Galileo Galilei

- 1564-1642
  - Tycho 1546-1601
  - Kepler 1571-1630
- Greatly improved the newly telescope, (did NOT invent the telescope!)
- First to report telescope observations of the sky
- support the Copernican Model of the Universe
Biographical Notes

- Born in Pisa, son of a musician
- Roman Catholic, considered the priesthood
- Had 2 daughters and a son (out of wedlock)
  - “Galileo’s Daughter” by Dava Sobel
- Studied Medicine at Pisa but wound up a Mathematician
- Contemporary of Kepler, but dismissed his ideas about tides and elliptical orbits
- Got in trouble with the Inquisition over Heliocentrism
  - “It is surely harmful to souls to make it a heresy to believe what is proved.” (Galileo Galilei via Brainyquote.com)
  - Herin hangs a fascinating tale, for which we don’t have time...
  - Ultimately recanted and spent the last 10 years of his life under house arrest
Galileo

- Galileo is also credited with
  - Playing a major role in making science science rather than philosophy (aka the Scientific Revolution)
  - "Philosophy is written in this grand book, the universe ... It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures;...." Galileo Galilei in The Assayer
  - Demonstrating that two objects fall at the same rate regardless of their mass (if you can neglect air resistance)
    - Actual experiment probably apocryphal
    - But illustrative of his approach
Galileo

- [http://www.biography.com/people/galileo-9305220](http://www.biography.com/people/galileo-9305220)
- [http://www.history.com/topics/galileo-galilei](http://www.history.com/topics/galileo-galilei)
Galileo’s Observations

- Built telescope in 1609
- Published Sidereus Nuncius (Sidereal Messenger) in 1610
- Moon has mountains & valleys.
  - Heavens are not perfect
- Milky way is made up of individual stars.
  - Stars must be far away...and not on a fixed sphere
- Four “planets” orbiting Jupiter.
  - The Earth is not the only “center of revolution”
- Subsequent important observations
  - The sun had spots.
  - Heavens are not perfect
  - Venus had phases.
  - Venus MUST orbit the Sun
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NEWTON’S LAW OF UNIVERSAL GRAVITY
Newton on History Channel

Newton’s Law of Universal Gravity

• Maybe it was an apple, maybe it was Kepler

• But Newton realized something causes all objects to be attracted to one another
  • The Moon to the Earth
  • The Earth to the Sun
  • The Apple to the Earth

• this force increases with the masses of the objects and decreases with their distance from one another.

• He also realized that it depended very strongly on distance
Newton’s Law of Universal Gravity

\[ F_g = \frac{GMm}{r^2} \]

- The gravitational force between two bodies is proportional to their masses and inversely proportional to the square of the distance between them.

- \( G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \)
Newton’s Law of Universal Gravity

\[ F_g = \frac{GMm}{r^2} \]

- M and m are the masses of the two bodies
- r is the distance between them
- \( F_g \) is the Gravitational force
- \( F_g \) is in N when the masses are in kg and the distance in meters
TED-ED Gravity

Let’s Practice
If the mass of Mars’ moon Deimos tripled, the gravitational exerted by Deimos on Mars would____.

A. increase to 3x what it was
B. increase to 9x what it was
C. decrease to 1/3 what it was
D. decrease to 1/9 what it was
If the distance between Deimos and Mars became three times what it is currently, the gravitational force exerted by Mars on Deimos would ____.

A. increase to 3x what it was
B. increase to 9x what it was
C. decrease to 1/3 what it was
D. decrease to 1/9 what it was
If an asteroid knocked the Moon so that it’s orbit was twice the distance from the Earth that it is now, the gravitational force of the Earth on the Moon would become _____.

A. 1/4 as large  
B. 1/2 as large  
C. the same  
D. 2x as large  
E. 4x times as large
Tides
Gravity & Tides

- Gravity strongest on nearest stuff, weakest on farthest.
- Water distorts — bulge.
- Both Sun and Moon do this.
- Which is stronger?
Tides

Spring Tide

- Gravitational pull of Moon & Sun creates a bulge of water
- Earth rotates through the bulge

Neap Tide
What IS Physics? ..... er, Light?
In astronomy, we usually cannot perform experiments with our objects of study.

We observe them = we collect & analyze light.

White light is made up of all the visible colors of light.

wavelength determines color
What is light?

- Electromagnetic radiation
- Coordinated variation of electric & magnetic fields
- sometimes also behaves like a stream of particles
Light: Information from Space

- Visible light is only a small fraction of all electromagnetic radiation
  - visible light, infrared light, UV light, radio, microwave, Xray, Gamma ray...
  - When astronomers refer to “light” they often mean all of the above, not just visible light
  - The color, intensity, timing, etc. all provide information about the object observed
The Speed of Light

• Electromagnetic radiation is the fastest thing known to exist

• It moves at the “speed of light” in a vacuum (i.e. in space) regardless of source or wavelength
  • more slowly in a medium such as air, water or glass
  • behavior in a medium may depend on its wavelength

• The speed of light is a fundamental property of the universe

• speed of light = \( c = 3 \times 10^8 \text{ m/s} = 300,000 \text{ km/s} \)
TED-Ed Light Visible & Invisible
The Electromagnetic Spectrum

- All these are the same thing as visible light.
- Gamma rays -- highest frequency, shortest wavelength, greatest energy per photon.
- Radio waves -- lowest frequency, longest wavelength, least energy per photon.
Wave-particle duality
Light behaves like both wave and particle

- **A wave is disturbance or oscillation** (of a physical quantity), that travels through matter or space, accompanied by a transfer of energy
  - example: water waves, sound waves
  - characterized by wavelength, frequency, speed
  - key property is **interference**

- **A particle** in the physical sciences is a **small localized object** to which can be ascribed physical properties.
  - example: bullets, pebbles, sand grains, electrons, protons
  - characterized by size, shape, speed, specific amount of energy, mass, etc.
  - particles do not display interference
Particles Waving
The Original Double-slit Experiment
Light behaves like both wave and particle

- Light displays interference
  - Double-slit experiment
  - Wave behavior

- Light deposits energy in discrete (quantized) amounts
  - depending only on wavelength
  - photoelectric effect

- The “particle of light” or “quantum of light” is called a photon
  - Particle behavior
WRAP-UP
Topic for Next Class

- Midterm
Reading Assignment

• Ch 3&4 in Astro
• Ch 3,4&10 in the Astropedia
Homework

- No new HW yet. Study