Light

9/30/2009
Opening Discussion

- http://www.youtube.com/watch?v=hdvGSgpTQ6U
- Do you have any questions about the quiz?
- Have you seen anything interesting in the news?
- What did we talk about last class?
Minute Essays

- Theories about before the big bang?
- Projectile motion?
- Differences between types of potential energy.
- Tides
  - Tidal locking of other moons.
  - Tidal bulges, tidal friction, and angular momentum transfer.
  - Breaking SL9.
- Ocean waves, more than tides.
- Did early humans see a bigger Moon?
More Minute Essays

- Math examples in class.
- How significant is the stuff we just covered in this class?
- Is gravity a theory?
- Why we are crashing something into the Moon? No significant damage to the Moon.
- What is my favorite genre of music?
- DPS conference: English? Topics? My presentation?
- LCROSS observing?
More Minute Essays

- Using Newtonian forms of equations for gravity.
- Is it possible there is no gravity and it is all electric or magnetic forces?
- Could there have been two moons related to ocean basins and one fell and took out the dinosaurs?
- What is the gravitational constant and how do we know it?
Centrifugal Force and Circular Orbit Velocity

- Objects want to move in a straight line. When a force causes an object to move on a curved path, we often describe its tendency to want to go straight as a pseudo-force called centrifugal force.

\[ F_c = \frac{mv^2}{r} \]

- Setting centrifugal force equal to gravitational force gives the circular orbit velocity.

\[ v_{circular} = \sqrt{\frac{GM_1}{d}} \]
Energy and Power

- We have talked about energy, its forms, and the fact that light carries radiant energy.
- Many times we don't care so much about total energy as how fast energy is delivered. This is called power.
- The mks unit of power is a Watt. $1 \text{ W} = 1 \text{ J/s}$
- You are all familiar with this unit as it is how we grade lightbulbs.
- An average human burns energy roughly at 100 W.
Interaction of Matter and Light

- There are four ways light interacts with matter:
  - Emission – matter can give off its own light.
  - Absorption – matter can absorb light that strikes it.
  - Transmission – matter can transmit light and let it pass through.
  - Reflection/scattering – matter can reflect light back or scatter it in some other direction.

- When you look around, what you are really seeing is light that has reflected off the surfaces. Color comes from some of the light being absorbed.
What is Light?

- This question troubled science for many years.
- Newton though light was made of particles. He was the first to show that the colors of the rainbow were a property of the light, not the material splitting it.
- Later experiments showed that light behaves as a wave.
- Einstein's Nobel prize is for experiments showing light has particle characteristics.
- Turns out it is both! Quantum Mechanics!
Wavelength and Frequency

- We often care about the wave nature of light.
- Waves are characterized by wavelength, \( \lambda \), frequency, \( f \), and amplitude. We don't generally need amplitude.
- The speed of a wave is given by the product of the wavelength and the frequency.
  \[ \text{speed} = \text{wavelength} \times \text{frequency} = \lambda f \]
- For light the speed is always the same, \( c \).
  \[ \lambda f = c \]
Waves in What?

- Waves in a pond move energy, but not material. Locally the water just goes up and down as the wave propagates outward.
- Waves generally require a medium to propagate through, like the water or air.
- People proposed a “luminiferous ether” as a medium for light. Experiments showed there was no medium for light.
- Light is a self-propagating perpendicular electromagnetic wave. It requires no medium.
The Electromagnetic Spectrum

- **Penetrates Earth Atmosphere?**
- **Wavelength (meters):**
  - Radio: $10^3$
  - Microwave: $10^{-2}$
  - Infrared: $10^{-5}$
  - Visible: $.5 \times 10^{-6}$
  - Ultraviolet: $10^{-8}$
  - X-ray: $10^{-10}$
  - Gamma Ray: $10^{-12}$

- **About the size of...**
  - Buildings
  - Humans
  - Honey Bee
  - Pinpoint
  - Protozoans
  - Molecules
  - Atoms
  - Atomic Nuclei

- **Frequency (Hz):**
  - $10^4$
  - $10^8$
  - $10^{12}$
  - $10^{15}$
  - $10^{16}$
  - $10^{18}$
  - $10^{20}$

- **Temperature of bodies emitting the wavelength (K):**
  - 1 K
  - 100 K
  - 10,000 K
  - 10 Million K
Energy of Light

• Light also behaves like a collection of particles we call photons. Each photon carries a certain amount of energy depending on its wavelength/frequency.

\[ E = hf = h \times \frac{c}{\lambda} \]

• The constant \( h \) is Plank's constant and it is equal to \( 6.626 \times 10^{-34} \) [J*s]. Note that this is a REALLY small number. Single photons don't carry much energy.
Minute Essay

- Did you realize that radio waves, microwaves, and X-rays were all really just light? Are you surprised by how little of the electromagnetic spectrum you can see with your eyes?

- Note that assignment #2 has been moved so you will have next week to work on it.