**Pa Multi-Region STEM Physics Review (Year 2)**

**April, 2015**

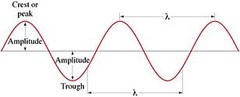
**Optics**

*Mathematical relationships among frequency, wavelength, and speed*

Wavelength () : the distance between consecutive peaks or troughs of a wave

Frequency (*f* or ): number of cycles per second

Speed (v or c): rate of motion of wave, c = 300,000,000 m/s in free space



** = c/*f***

**Example:** M cones in the human retina respond best to light of frequency

*f* = 5.55 × 1014 Hz. What is the wavelength of the light?

Distance versus time: **d = vt** or **d = (vtecho)/2**

**Example:** A bat emits a sound wave with a speed of 320 m/s and receives an echo from a nearby cave wall 0.08 s later. How far is the wall?

*Speed, frequency, and wavelength of light in various materials*

When light enters a material: speed = slower, **vmatter = c/n**

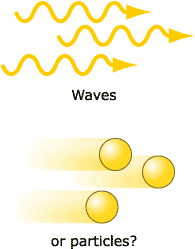
wavelength = shorter, **matter = /n**

frequency = same

Speed is slowed by a factor called the *index of refraction*: n ≥ 1

nair = 1, nwater = 1.33, nglass = 1.5, ndiamond = 2.42

**Example:** Red light from a He-Ne laser with wavelength 632 nm enters into shines into a swimming pool full of water. What is the wavelength in water?



*Evidence for light as a wave or a particle*

Wave: nonlocalized vibration

Particle: localized matter or energy

Waves Both Particles

interference reflection photoelectric effect

diffraction refraction Compton scattering

polarization dispersion

**Example:** Explain what interference is and how it shows the wave nature of light.

*Effect of different frequencies (or photon energies) on matter and living tissue*

Higher frequencies of light (higher energy per photon) are more likely to cause damage to tissue by ionization.

**Example:** After applying sunscreen at the beach, the bather’s skin can be seen where the sunscreen was applied. Is the sunscreen ineffective when used like this? Why or why not?

**Action at a Distance—Newton’s Law of Gravitation and Coulomb’s Law**

*Calculate forces between two masses or two charges*

Gravity between two objects depends **only** on

1. masses of both objects (m1, m2)
2. center-to-center distance (r)

Gravity does **not** depend on size of objects, atmosphere, density, etc.

**F = (G m1 m2 )/r2**

**Example 1:** If the sun were suddenly to shrink to the size of a black hole (6 km across) without exploding, how would Earth’s orbit change?

**Example 2:** If a 1 kg mass located 6,370 km from the center of Earth is pulled downward with a force if 9.81 N, what is the mass of Earth? (Note: G = 6.67 × 10-11 Nm2/kg2)

**Example 3:** If the 1-kg mass is moved to twice that distance from Earth, how does the force on it change?

Force between two electrically charged objects depends **only** on

1. charges of both objects (Q1, Q2)
2. center-to-center distance (r)

**F = (k Q1 Q2 )/r2**

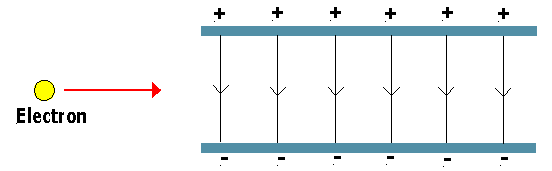
**Example:** Two metal balls, each with a charge of 3 nC, are separated by 0.5-m center-to-center distance. What is the direction and magnitude of the force between them? (Note: k = 9.0 × 109 Nm2/C2)

*Forces of electric and magnetic fields on charges*

An electric field shows the direction of the force on a **positive** charge.

The force on a negative charge (e.g., electron) is in the opposite direction.

**Example 1:** Why do electric field lines go from positive to negative surfaces (as shown below)?



**Example 2:** What direction is the force on the electron in the diagram shown above?

A magnetic field (from N to S poles) causes a charged particle to make a circular path around it.

**For a negatively charged particle** (e.g., an electron), the motion is given by the right-hand rule #3

1. point thumb along magnetic field
2. electron moves in direction of fingers of right hand

**Example:** If the diagram above shows a **magnetic** field, what direction is the force on the electron?