PROPERTIES OF LIGHT

CHAPTER 26

ELECTROMAGNETIC WAVES

- Light is an oscillation of electric and magnetic fields.
- If you wave an electrically charged rod in empty space, you produce vibrating electric and magnetic fields.
- These fields make up electromagnetic waves.

ELECTROMAGNETIC WAVES

- There is only one speed for electromagnetic waves in any medium.
- The electromagnetic radiation of any frequency is the same as the speed of light.
- This speed is 300,000 km/second. (in free space)

THE ELECTROMAGNETIC SPECTRUM

- All electromagnetic waves travel at the same speed and differ from one another in frequency.
- EM waves are classified according to frequency
- The classifications overlap (for example, microwaves and infrared waves share some of their frequencies…

THE ELECTROMAGNETIC SPECTRUM

- The same concepts that we talked about when we studied other waves still apply.
- The frequency of the wave is the frequency of the vibrating source.
- Different frequencies correspond to different wavelengths.
- THE HIGHER THE FREQUENCY, THE SHORTER THE WAVELENGTH.

THE ELECTROMAGNETIC SPECTRUM

- Light is only a small part of the EM spectrum.
- A radio or television receiver is simply a device that sorts and amplifies the currents of electrons dancing to the rhythms of EM waves.
- The universe is “a dense sea of radiation occupied only occasionally by specks of matter.”

TRANSPARENT MATERIALS

- When light is transmitted through matter, some of the electrons in the matter are forced into vibration.
- Vibrations in the emitter are transmitted to vibrations of the receiver.
- The way a receiving material responds when light hits it depends on the frequency of the light and the natural frequency of the electrons in the material.

TRANSPARENT MATERIALS

- Materials such as glass and water allow light to pass through in straight lines.
- We say they are transparent to light.
- When a light wave hits the electrons in these materials, the electrons begin vibrating.

TRANSPARENT MATERIALS

- Materials respond more to vibrations at one frequency than at another (just like with sound).
- Different atoms and molecules have different natural vibration frequencies.
- These frequencies depend on how strongly it is attached to its atom or molecule.

TRANSPARENT MATERIALS

- Electrons in glass have a resonance frequency in the ultraviolet range.
- When ultraviolet light hits the glass, resonance occurs, and the vibration of electrons builds up to large amplitudes.
- During this time, the atom collides with neighboring atoms and gives up this energy as heat.
- Glass is NOT transparent to ultraviolet light.

TRANSPARENT MATERIALS

- At lower wave frequencies, electrons n the glass are forced into vibration, but at lower amplitudes than when they are resonating.
- The atoms hold the energy for a shorter time, and are able to reemit it as light.

TRANSPARENT MATERIALS

- Glass is transparent to all the frequencies of visible light.
- The frequency of remitted light that is passed from atom to atom is identical to the frequency of the light tht produced the vibration in the first place.

TRANSPARENT MATERIALS

- There is a slight time delay between absorption and reemission.
- This results in a lower average speed of light through a transparent material.
- Light travels at different average speeds through different materials.

TRANSPARENT MATERIALS

Material	Speed of light (%c)
Vacuum	300,000km/s 100%
Water	75%
Glass	67%
Diamond	41%

TRANSPARENT MATERIALS

- When light emerges from these materials, it travels at its original speed.

TRANSPARENT MATERIALS

- In class, infrared waves, cause not only the electrons but entire atoms and molecules to vibrate.
- This increases the internal energy of the structure.
- This is why infrared waves are often called heat waves.
- This is also why glass is not transparent to infrared light.

OPAQUE MATERIALS

- Most things around us are opaque
- They absorb light without reemitting it.
- Vibrations given by light to their atoms and molecules are turned into random kinetic energy.

OPAQUE MATERIALS

- Metals are shiny because when light shines on their free electrons, their energy does not transfer from atom to atom, but is reflected instead.
- Earth's atmosphere is transparent to most light, but not to high-energy ultraviolet light (though some gets through).

SHADOWS

- When we stand in sunlight, some of the light is stopped while other rays continue in a straight-line path.
- The region where light rays do not reach is called a shadow.

SHADOWS

- Total shadow is called an umbra.
- A partial shadow is called a penumbra.
- A penumbra forms when light from a broad source is only partially blocked.
- It also forms when some of the light is blocked but where other light fills in the edges of the shadow.

SHADOWS

- Objects close to their shadow cast a sharp shadow.
- Light coming from slightly different directions does not spread much behind the object.
- The farther they are from the shadow, the “fuzzier” it becomes.
- Penumbras are formed, and the umbra becomes smaller.

SHADOWS

- A lunar eclipse occurs when Earth casts a shadow on the moon.
- A solar eclipse occurs when the moon casts a shadow on the Earth.
- Solar eclipses have a well-defined umbra and penumbra.

SHADOWS

- If you stand in the umbra part of the shadow, you experience darkness during the day…a total eclipse.
- If you stand in the penumbra part of the shadow, you see a crescent of the sun.

THE EYE

- As light enters the eye, it moves through the transparent cover called the cornea.
- The cornea does about 70% of the bending of the light needed to focus the image.
- The light then passes through the pupil, behind which is the lens.

THE EYE

- The lens finishes focusing the light that then passes through the vitreous humor (a jello-like fluid).
- Finally, the light hits the retina.
- The retina covers about 2/3 of the back of the eye.
- For clear vision, light must focus directly on the retina.
- If the focal point of the light is before or after the retina, the vision will be blurry.

THE EYE

- The retina is composed of tiny antennae that resonate to the incoming light.
- These are called rods and cones.
- Rods are most prevalent near the edges of the retina, cones most dominant in the middle.
- Rods are responsible for vision in low light.
- Cones are responsible for color vision.

THE EYE

- Primates and a species of ground squirrel are the only mammals that have three different types of cones and experience full color vision.
- Other mammals have mostly rods, which only register lightness or darkness.
- In essence, most mammals see in grayscale.