Unit 2 - Optics

Key Words - *See textbook glossary, textbook chapters and notes*

wave	electromagnetic radiation	spectrum
reflection	refraction	transparent
transluscent	opaque	iris
lens	pupil	sclera
cornea	retina	optic nerve
blindspot	rod cells	cone cells
near-sighted	far-sighted	astigmatism
blindness	snow blindness	colour blindness

Questions:

1. Compare the speed of light with the speed of sound.

   Speed of light (approx 1 billion km/h) is MUCH faster than the speed of sound (approx 1200 km/h). This accounts for why we ***see*** *events (e.g. lightning) before we* ***hear*** *them (e.g. thunder)*

2. Describe three technologies that utilize light

Using mirrors and lenses we are able to manipulate light to do many things; be able to descirbe ***ANY 3*** *of the following:*

- *Microscope – magnify small organisms*
- *Telescope – magnify space objects*
- *Periscope – uses mirrors to allow a submariner to see above the ocean surface*

- *Binoculars – magnifies a faraway object*
- *Fibre optics – allows data to travel as light through wire*
- *Camera – allows an image to be captured in a single picture*
- *Prescription contact lenses – changes where an image is focused in the eye so it's clear*
- *Lasers – a device that generates an intense beam of one colour of light*
- *Movie projectors – projects frames from a moving reel of film to create moving pictures*
- *Overhead projectors – a device that enlarges a transparency image onto a wall using a mirror*

3. Describe the following properties of light:

- *Rectilinear propagation – light travels in a straight line (creating shadows if it is blocked by an object)*

- *Light reflects (from a mirror creating a reflection, and from all other objects too causing us to see them as a particular colour)*

- *Light refracts or bends when it travels from one material to another because it changes speed slightly (making objects appear bent too)*

- *Light disperses into all the colours that make up WHITE light (red, orange, yellow, green, blue, indigo and violet) when it passes through a prism because each colour is a different wavelength and is bent a different amount*

- *Light travels through a vacuum (that is, light does NOT require particles of matter to travel) which is why we see light from faraway stars even through empty space*

4. Describe the various types of electromagnetic radiation (know where they fall on the electrogmagnetic spectrum, how are they dangerous, how do we use them or encounter them in everyday life):

Type of Electromagnetic Radiation	*Facts and Examples*
1. Radio Waves	• *The longest wavelength and lowest energy and frequency* • *Can be used to help us see the inside of our bodies and diagnose illness and injury (e.g. MRI)* • *We are not yet certain about the effect of long-term exposure to radio waves*
2. Microwaves	• *Have the shortest frequency and highest energy of all RADIO waves* • *Food cooks in a microwave because microwaves cause water molecules in the food to vibrate, gain energy and heat up* • *Also used in radio telescopes, telecommunications and radar*
3. Infrared	• *Longer wavelength and lower energy and frequency than visible light (infrared means below red)* • *Used in remote controls, heat lamps, motion sensors, thermal imaging*
4. Visible Light	• *Can be continually detected by our eyes* • *The complete spectrum of visible light can be seen due to dispersion through a prism.* • *The constituent colours of white light are red, orange yellow, green, blue, indigo, violet*

Type of Electromagnetic Radiation	*Facts and Examples*
5. *Ultraviolet*	• *Very energetic – shorter wavelength and higher energy and frequency than visible light* • *Have the ability to kill bacteria in food, water and medical supplies* • *Produced by the sun* • *Necessary for our health and is used as therapy for jaundice in newborns, BUT too much exposure can cause skin cancer* • *Also used to detect fingerprints by CSI*
6. *X-Rays*	• *Even shorter wavelength and higher frequency than UV* • *Used to photograph teeth and bones and complete security screening of luggage at airports* • *Over exposure can lead to cancer (protection by lead aprons)*
7. *Gamma rays*	• *Highest energy and frequency and the shortest wavelength* • *Produced by the hottest regions of the universe and by nuclear reactions* • *Focused bursts of gamma radiation are used to kill cancer cells*

5. What is the difference between specular and diffuse reflection?

See pg 176-177.

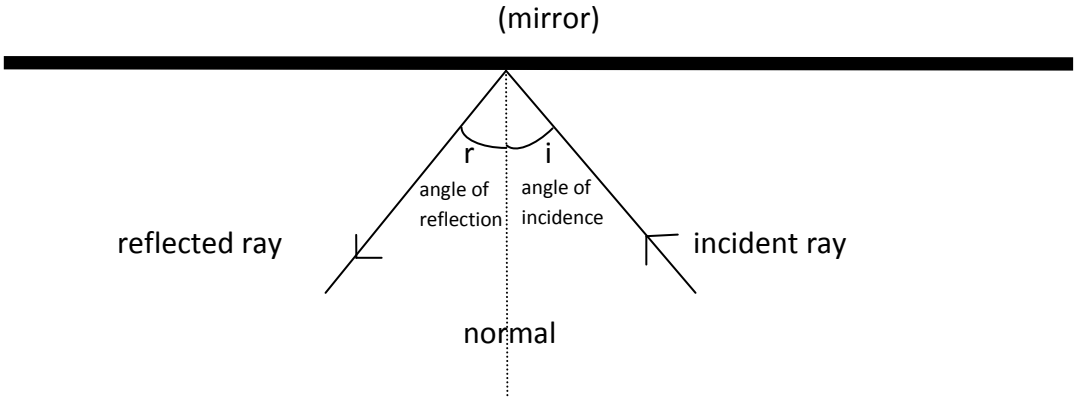
Reflection from a mirror or mirror-like surface which produces an image of the surroundings is called specular reflection (for example when you see yourself

in the mirror). This occurs because the material is VERY smooth and all light is reflected uniformly which produces a clear image.

Reflection from a rough surface does not produce a clear image because light rays reflect off the surface randomly at all angles . As a result the object has the appearance of being translucent and we see what is on the surface (for example, ink print on the page of a book, shirt material, etc.)

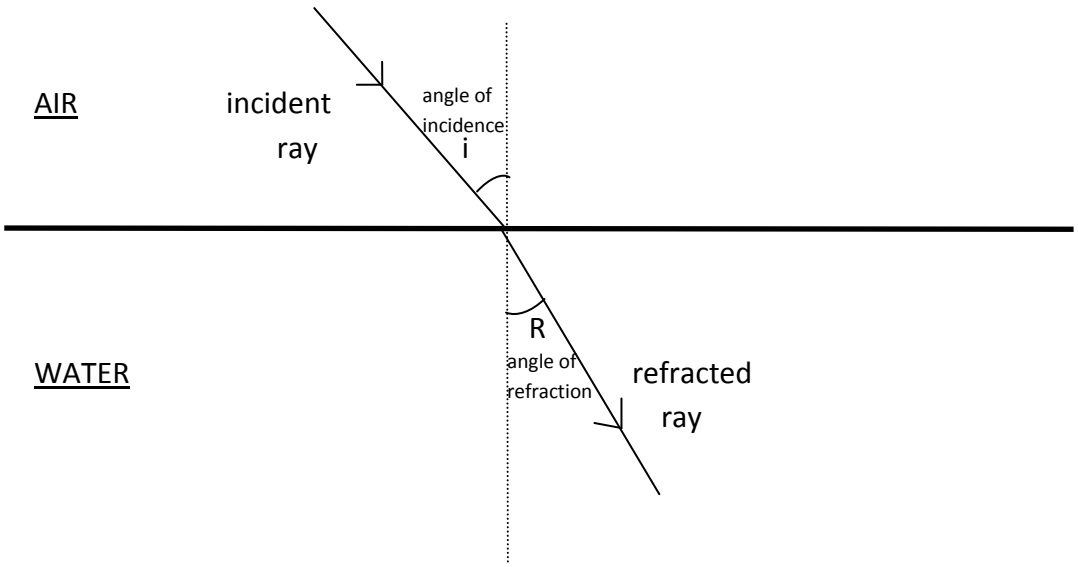
6. Draw a ray diagram for a reflection. Include:
    a. Incident ray
    b. Reflected ray
    c. Normal
    d. Angle of incidence (i)
    e. Angle of reflection (r)

Ray Diagram for a reFLECtion:



7. Draw a ray diagram for a refraction. Include :
    a. Incident ray
    b. Refracted ray
    c. Normal
    d. Angle of incidence (i)
    e. Angle of refraction (R)

Ray Diagram for reFRACtion



8. What is the relationship between the angle of incidence and the angle of reflection?

The Law of reflection states that the angle of reflection is equal to the angle of incidence. This means that whatever angle the incoming light ray hits the mirror surface is the same angle that the reflected ray will make when it bounces off (for example if it hits the mirror at 32 degrees to the normal it will reflect back at 32 degrees to the normal. See pg 178

9. How is an image made by a plane mirror different than the object that's creating it? How is it the same?

*The image created by a plane mirror is **reversed** (right to left and left to right) compared to the object being reflected. The image and object are **the same size, the same distance away from the mirror, and both are upright**.*

10. What happens when light travels from one medium into another medium with a higher density?

*When light travels from one medium to another medium with a higher density (for example from air into water or oil) on an angle, the light ray slow down and are therefore **refracted towards the normal**. See pg 179.*

11. Label the basic parts of an eye (pupil, iris, sclera, cornea, lens, retina, muscles, optic nerve)

See page 229 and 230.

12. Describe how the eye focuses light to form an image

Light rays pass through a focussing sysem involving the cornea, lens and spaces in the eye filled with a watery fluid in order to form an image on the retina at the back of the eye. Light rays begin to be focussed as they pass through the cornea. The cornea provides most of the focussing by refracting incoming light rays so that they converge (come together) toward the retina. The lens does

the remaining focussing by changing its shape. Muscles in the eye contract to cause the lens to become thicker which allows us to focus on near objects. When these muscles relax, the lens becomes thinner which allows us to see distant objects. These actions fine-tune our focus so that a clear image is projected onto the retina, which can then be sent to the brain through the optic nerve.

13. For each vision problem, provide a definition, what causes it, and how it is corrected:

    See pg 234

    a. Myopia (near-sighted)

    Near-sighted vision occurs when people can see nearby objects clearly but cannot bring distant objects into focus. It is caused by an eye that is longer than normal which results in the lens converging light rays to form an image in front of the retina. By the time the light rays strike the retina they are spreading out again which causes a fuzzy image. A lens is used to diverge the light rays slightly so the image forms farther back, ON the retina.

    b. Hyperopia (far-sighted)

    Far-sighted vision occurs when people can see distant objects clearly but cannot bring nearby objects into focus. It is caused by an eye that is shorter than normal which results in the lens not converging light rays in time to form an image ON the retina (the image falls behind it and is therefore fuzzy). A lens is used to converge the light rays more quickly so they will come into focus exactly ON the retina.

c. Astigmatism

This is a condition caused be a distorted shape of the cornea which causes an image to be focussed on more than one point of the retina, resulting in blurred vision. Eyeglasses or contact lenses can correct this or laser surgery can be used to reshape the cornea.

14. Describe the different types of blindness we discussed (legally blind, snowblind, colour blind)

A person who is legally blind has a vision impairment that keeps them from doing important life activities. A legally blind person most likely can perceive some light or have limited vision. For example, they may see a small part of the middle of a whole scene, they may see only the edges of normal vision, they may be able to only detect light and darknes, or they may in fact not be able to detect any light at all.

Snowblindness is a temporary but very painful condition of temporary or complete blindness caused by overexposure to the glare of sunlight such as what you would experience out on fields of snow.

Colour blindness is rare and is the ability to see only in shades of grey (the cone cells in a colour blind person are deficient). Other colour vision deficiencies are more common and may involve only one or two kinds of cone cells. For example, a person who is "Red-green colour blind" cannot tell red and green apart because those cone cells are affected.

15.Describe two uses for fibre optics.

See the STSE article for several examples. Fibre optic scopes (fibre optic cable with a light/camera at the end) are used by Doctors to examine a person's lungs and throat for tumours or to take tissue samples, they can be inserted into a person's body through a small cut in a relatively painless procedure to examine body organs, or can be used to perform less risky, faster and less painful surgeries which cause less scarring. Fibre optics can also be used as part of imaging systems that involve cameras/lighting on long flexible fibre optic cables that can be inserted into and inspect the inside of engines and plumbing (without taking everything apart).