**Challenging Optics Review** - ANSWERS5/6/15 **Name ANSWERS**

***Definitions:*** Light, normal, law of reflection, law of refraction, refraction, total internal reflection, critical angle, focal point, magnification

***Problems:* Know how to solve questions similar to the following:**

1. A laser beam is shot at a comet in outer space and the beam is reflected off its shiny surface and returns to Earth. The entire process takes 22.4 seconds. How far away is the comet from Earth?

Total distance (there and back) equals 2d = (c)(t)

d= 3.36 x 109 m = 3.36 million km

1. A ray of light is shone from water into diamond with an angle of incidence in water of 43°. Calculate the angle of refraction in diamond.(ndiamond = 2.42)

1.33sin(43°)=2.42sin(θr)

θr = 22°

1. A scuba diver shines a light from underwater at an angle of 33° to the vertical. What angle will it emerge from the water into the air above? (nwater = 1.33 ; nair = 1.0003 )

1.33sin(33°)=1.00sin(θr)

θr = 46°

1. A certain convex lens forms an image which is 86.0 cm from the lens, when a candle is placed 6.50 cm from the lens. What is the focal length of the lens, and what will be the magnification of the image?

a) f = 6.04 cm

b) mag = -13.2

1. A converging mirror of focal length 5.5 cm has an 11 cm tall candle placed 16 cm in front of it. By calculations only, locate and describe the image.

di = 8.4 cm

mag = -0.52

image size = 5.8 cm

Real, Inverted, Reduced image, located between F and 2F

1. What is the critical angle for a laser beam which is in a glass fiber (n = 1.52) that is surrounded by water (n=1.33)?

Critical angle is angle of incidence which leads to refraction angle of 90°. 1.52sin(θc)=1.33sin(90°)

θc = 61°

1. Locate and describe the images created by the following mirrors:

C

F

Real, magnified, inverted

F

C

Virtual, magnified, upright

C

F

Virtual, reduced (smaller), upright

1. Locate and describe the images created by the following lenses:

F

F’

Rays exit parallel – no image

Image distance = undefined

F

F’

Real, reduced, inverted

F’

Virtual, reduced, upright

F’

F

Virtual, magnified, upright

**Use the diagrams in your textbook to help you with the following two problems.**

1. Using a concave mirror, where can you place an object (relative to the center and focal point) so that the image is:
   1. Real, and larger than the object? Between F (focal point) and 2F (the center)
   2. Real, and the same size as the object? At 2F (the center)
   3. Real, and smaller than the object? Farther than 2F from mirror (outside center)
   4. Non-existent? At Focal Point (Rays come out in parallel beam)
   5. Virtual, and larger than the object? Inside F (Closer to mirror)
2. Using a convex lens, where can you place an object (relative to the focal point) so that the image is:
   1. Real, and larger than the object? Between F (focal point) and 2F
   2. Real, and the same size as the object? At 2F
   3. Real, and smaller than the object? Farther than 2F from lens
   4. Non-existent? At focal point of lens
   5. Virtual, and larger than the object? Inside focal length of lens (do<f)

**Short Answer Questions: Answer on separate page in complete sentences, so a reader can tell, from your answer, what was asked.**

1. Explain how the human eyeball uses a lens to form images. What type of lens is it? Knowing what you know about object placement versus focal length, is there anywhere you can place an object in front of your eye and not be able tosee an image?

Light rays are focused by the convex cornea and convex (adjustable) lens to converge light rays so they form a real image on the retina. Cells in the retina absorb light and create electrical signals which are sent through the optic nerve to the brain, which interprets the electrical impulses and creates the images we perceive.

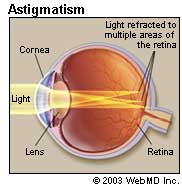
1. What causes dispersion from a prism or a raindrop?

The index of refraction controls how much a light ray is bent. The index of refraction is different for different frequencies (colors) of light, so each color is bent a different amount, causing the colors to diverge at slightly different angles. Violet light is bent slightly more than red light.

1. Side-view mirrors on a car are convex. What type of image will these types of mirrors produce?

Convex mirrors only produce virtual, upright, reduced images. The small images make drivers perceive that objects are far away, which is why the mirrors have the warning, “objects in mirror are closer than they appear”.

1. Many vision problems occur when the eye’s cornea and lens don’t focus light onto the retina. Laser eye surgery reshapes the cornea of the eye. Using your knowledge of refraction terminology (ie., focal length, object distance, image distance, etc.) choose one vision problem, and describe how reshaping the cornea fixes a particular vision problem.

If the person is nearsighted (myopic), the rays focus before the retina. Making the cornea flatter will make the rays not converge as quickly, which will improve the vision. If the person is farsighted (has hyperopia) the cornea is made more convex, which converges the rays more quickly to focus properly on the retina.

Astigmatism is a condition in which the cornea (or lens) is not properly round, and does not focus light rays at one distance or one location on the retina. It may be more curved along one axis than along the other. A computer is used to calculate how to reshape the cornea using laser surgery.

1. Fiber optic cables allow for the transportation of information at the speed of light. Explain how fiber optic cables work, and how they can are able to bend light around objects in the ground.

Fiber optic cables are made of thin fibers of glass with a high index of refraction, surrounded by other materials (plastic) with a lower index of refraction. Light which is at a high angle from the normal, greater than the critical angle, can’t refract out of the glass because the calculated angle of refraction would be greater than 90°, which means it would still be inside the glass. This means the beam undergoes total internal reflection, and can travel a long distance without the signal getting weak. Light pulses are sent down the cables, carrying the information that allows us to download our files and movies.

1. As a gifted spear fisherperson, you have the ability to stand on the river bank and see fish under water. In order to aim your spear correctly you need to know a little bit about refraction. Explain why you can’t aim directly at the fish.

The light coming from the fish and exiting the water bends, or refracts, away from the normal as it exits. This makes the fish appear higher than it actually is. Aim below the fish. 