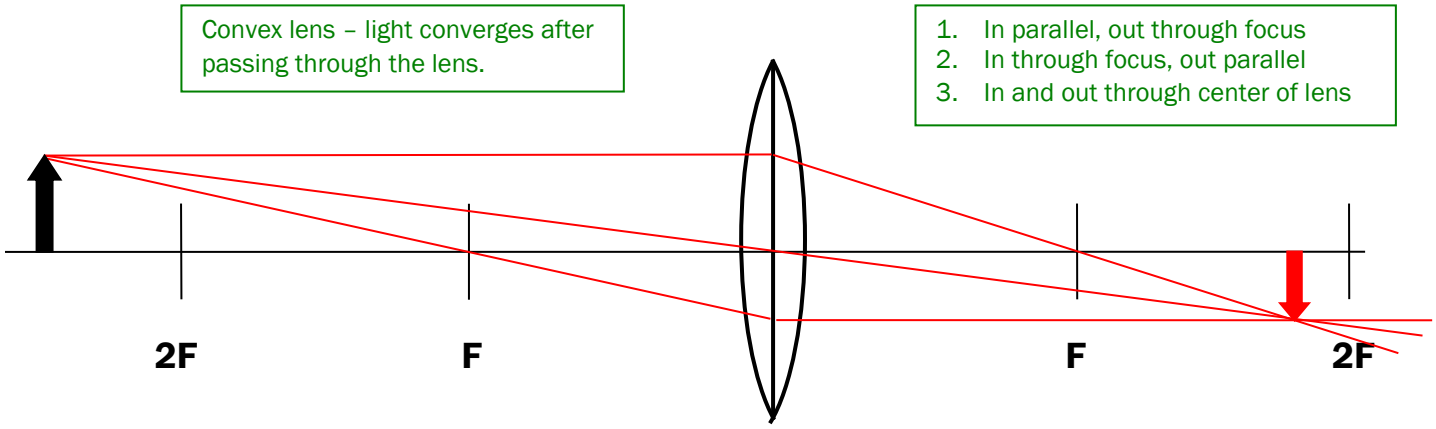
Name: _____Answer Key_____ Date: _____

Honors Physics Test #13 Review

Reflection and Refraction

1. Read Chapters 14, 15, & 16.
2. Terms to know: electromagnetic spectrum, diffuse reflection, regular reflection, refraction, index of refraction, Snell's Law, total internal reflection, critical angle, dispersion, monochromatic, interference, diffraction, diffraction grating, focal length, ray diagrams, concave, convex.
3. Which color of light has the highest frequency? Highest wavelength? Highest speed?
   Violet = high frequency Red = high wavelength All have same speed
4. Which type of electromagnetic radiation has the highest frequency? Highest wavelength? Highest speed?
   Gamma = high frequency Radio = high wavelength All have same speed
5. How do fiber optic cables work?
   Plastic or glass that uses total internal reflection to contain the information within the cable as it moves
6. What is dispersion? What causes it? Give an example.
   Dispersion is when white light is separated into different colors after traveling through a substance with an index of refraction higher than air. The different colors travel at different speeds and are separated.
7. Which color of light slows down the most when white light shines through a glass prism? Which color bends the most from its straight-line path?
   Violet slows the down the most, causing the it to bend the most
8. When a ray of light passes from a high index to a low index substance, which way will the ray bend? From a low index to a high index?
   High to low = slow to fast = bend away Low to high = fast to slow = bend toward
9. Why do light rays bend when they enter a substance? Under what two conditions will a light ray **not** bend?
   The light waves are slowed down by the different medium's index of refraction.
   They will not bend if they enter at 90^0 or if the medium has the same index of refraction as the one the light just left
10. What is the Law of Reflection? Snell's Law?
    Reflection = Incident angle = reflected angle Snell = $n_1 \sin\theta_1 = n_2 \sin\theta_2$
11. What is total internal reflection? When will it occur? Can it occur if the ray is traveling from a low index to a high index substance? From a high index to a low index substance?
    TIR = no refracted ray, it is completely reflected – it occurs when going from a higher to a lower
12. What is the critical angle? What is the angle of refraction when the angle of incidence is the critical angle?
    The refracted ray lies along the boundary of the two mediums. It has an angle of 90
13. What are some applications of refraction?
    Telescopes, archer fish, projectors, cameras,
14. Be able to calculate the angle of reflection, angle of refraction, critical angle, index of refraction, speed of light in a substance, and draw all these angles.
15. As a light ray travels from a low index to a high index substance, what happens to its wavelength, speed, frequency, and period?
    Frequency and period stays SAME, speed decreases, wavelength decreases
16. What are some examples of the diffraction and interference of light?
    Mirages, rainbows
17. Be able to use the mirror and lens equations for both mirrors and lenses. Know the differences between concave and convex mirrors and lenses.
18. Be able to draw ray diagrams for both mirrors and lenses.

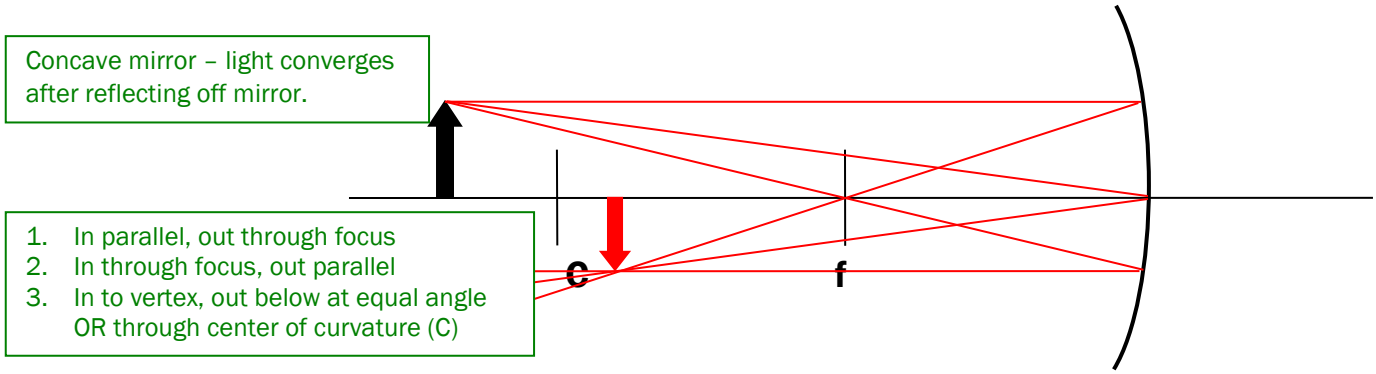
19. An arrow is placed in front of the lens as shown below. Locate the image of the arrow by means of a well-drawn ray diagram. Use a straightedge for all rays and clearly indicate the image.



20. What would happen to the image if the lens above were replaced by one with a lower index of refraction?

Since the light rays are going from Fast to Slow, they bend Toward the normal. In a lower index of refraction, they would not bend as much, this would place the image closer to C than it currently is. The image would also be taller than it currently is.

21. An arrow is placed in front of the concave mirror as shown below. Locate the image of the arrow by means of a well- drawn ray diagram. Use a straight edge for all rays and clearly indicate the image.



22. A pencil is placed 5.0 cm in front of the mirror from the previous question, whose focal length is 8.0 cm. Calculate where the image will be located and the magnification of the pencil.

Don't forget to take the reciprocal after subtracting the fractions

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \rightarrow \frac{1}{d_i} = \frac{1}{8.0cm} - \frac{1}{5.0cm}$$

Honors Equations!

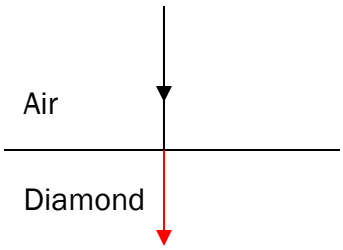
$$d_i = -13cm$$

The negative means virtual image

$$m = -\frac{d_i}{d_o} = -\frac{-13cm}{5.0cm} = 2.6 \text{ times bigger}$$

The positive means upright image

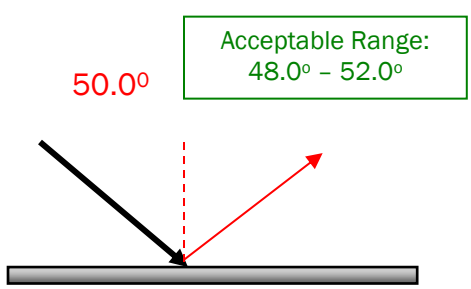
23. A ray of light traveling in air is incident on an air-diamond boundary as shown in the diagram. Draw the path of the light ray in the diamond.



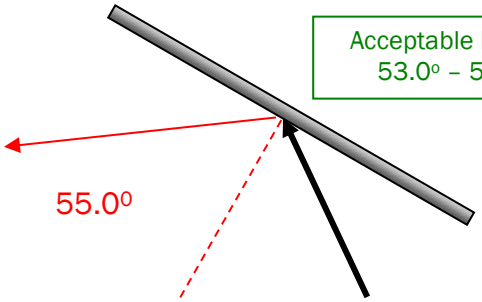
(An incident angle of 0^0 will pass straight through)

All parts of the wave cross at the same time, so there is no bending!

24. Using a protractor, draw and label the normal line and the reflected ray for each diagram below. Measure and label the angle of incidence and the angle of reflection.



Acceptable Range: 48.0º – 52.0º



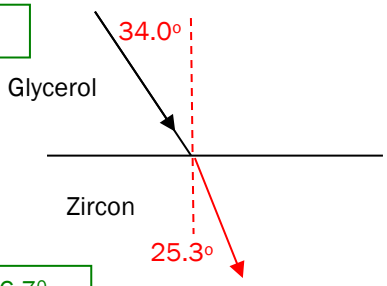
Acceptable Range: 53.0º – 57.0º

25. The diagram below represents an interface between glycerol and zircon. A ray of light is shone through the glycerol, which strikes the zircon and then passes through zircon. It strikes the surface at the angle shown.

a. Measure and record the angle of incidence

Angle of incidence = 34.0º

Acceptable Range: 32.0º – 36.0º



b. Calculate the angle of refraction as the light enters the zircon.

$$\theta_2 = \sin^{-1}\left(\frac{n_1 \sin\theta_1}{n_2}\right) = \sin^{-1}\left(\frac{1.47 \sin 34.0°}{1.92}\right) = 25.3°$$

Acceptable Range: 23.9⁰ – 26.7⁰

c. Draw the path of the light ray into the zircon, using a protractor.

d. Compare the speed of light in glycerol to the speed of light in zircon.

The speed of light is slower in zircon than in glycerol because it has a higher index of refraction, so it slows light down more.

e. If the wavelength of the light ray in the glycerol is 5.95 x 10^{-7} m, what is the wavelength of the light in the zircon?

$$\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2} \rightarrow \lambda_2 = \frac{n_1 \lambda_1}{n_2}$$

$$\lambda_2 = \frac{(1.47)(5.95 \times 10^{-7} m)}{1.92}$$

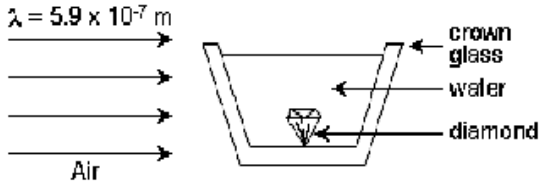
$$\lambda_2 = 4.56 \times 10^{-7} m$$

26. A beam of light crosses between two different media. Refraction can occur if

(A) all of the light is reflected
(B) the media have different indices of refraction
(C) the angle of incidence is 0^0
(D) there is no change in the speed of the wave

Refraction is the bending of wave when it enters a new material. This happens because the wave changes speed.

27. In the diagram below, monochromatic light ($\lambda = 5.9 \times 10^{-7}$ m) in air is about to travel through crown glass, water and diamond.



It travels the slowest with the highest index of refraction.

In which substance does light travel the slowest?

(A) water (B) diamond (C) air (D) crown glass

n = 1.33 | n = 2.42 | n = 1.00 | n = 1.52

28. As a teacher showed slides by projecting them on a fixed screen, a student complained that the image was too small. The teacher enlarged the image by moving the projector away from the screen, but the image blurred. The image should then have been brought in focus by

(A) moving the lens closer to the slide
(B) increasing the power of the projector lamp
(C) decreasing the amount of light in the room
(D) moving the lens away from the slide

Projectors use convex lenses – image distance and object distance have an inverse relationship. When image distance is increase (screen and lens further apart) need to decrease object distance (slide and lens closer together)

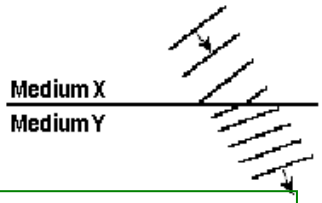
29. The speed of light in glycerol is approximately

(A) 3.0×10^8 m/s (B) 2.0×10^8 m/s (C) 1.0×10^7 m/s (D) 4.4×10^8 m/s

$$v = \frac{c}{n} = \frac{3.00 \times 10^8 \frac{m}{s}}{1.47}$$

30. The diagram below represents wave fronts traveling from medium X into medium Y.

It CANNOT be:
A – because one line (wavefront) is in two medium
B – because the wave bends meaning it changed speed
D – superimposed means two waves on top of each other, there's only one wave



All points on any one wave front shown must be

(A) traveling in the same medium
(B) traveling with the same speed
(C) in phase
(D) superimposed

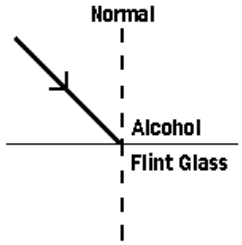
In phase means "on the same part of the wave" – the wave fronts represent the crests or troughs, but each line is all the same thing

31. The convex spherical mirror found on the passenger side of many cars contains the warning: "Objects are closer than they appear." Which phrase best describes the image of an object viewed in this mirror?

(A) virtual and larger than the object
(B) real and larger than the object
(C) virtual and smaller than the object
(D) real and smaller than the object

Convex mirrors diverge light – always make smaller virtual images

32. The diagram below shows a ray of monochromatic light incident on an alcohol-flint glass interface.

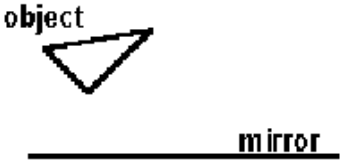


Flight glass has a higher index of refractions so the speed is lower and when entering a slower material light bends toward the normal

What occurs as the light travels from alcohol into flint glass?

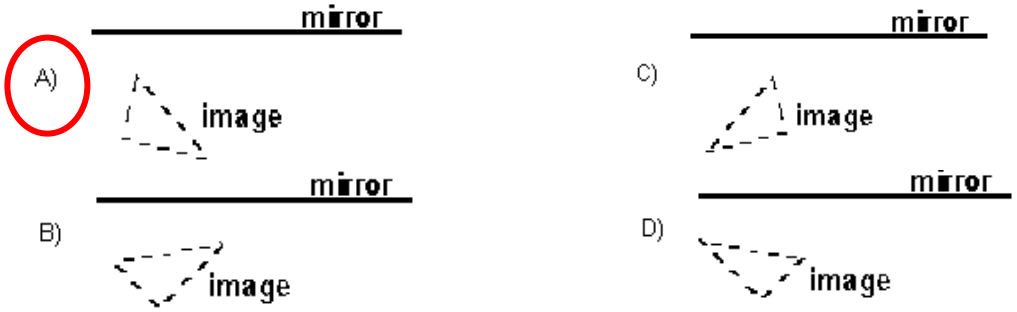
(A) The speed of the light decreases and the ray bends away from the normal.
(B) The speed of the light increases and the ray bends towards the normal.
(C) The speed of the light increases and the ray bends away from the normal.
(D) The speed of the light decreases and the ray bends towards the normal.

33. An object is placed in front of a plane mirror as shown in the diagram below.



It is a reflection over the axis. The right vertex is furthest away, so in the image it needs to be furthest away.

Which diagram below best represents the image that is formed?

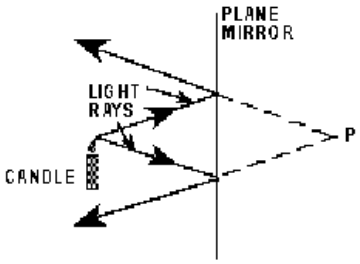


34. A monochromatic ray of light (f = 5.09 x 10^{14} Hz) traveling in air is incident upon medium A at an angle of 45^0. If the angle of refraction is 29^0, medium A could be

(A) fused quartz (B) Lucite (C) flint glass (D) water

$$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = \frac{1.00\sin(45°)}{\sin(29°)} = 1.46$$

35. The diagram below represents two light rays emerging from a candle flame and being reflected from a plane mirror.



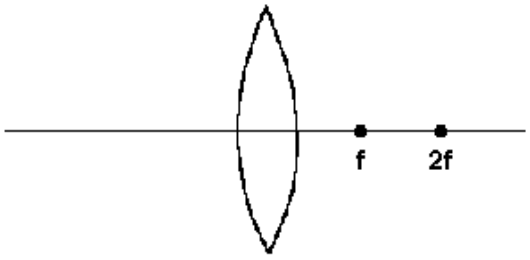
Plane mirrors always produce virtual images.

P is the point behind the mirror where the light appears to come from.

What does point P represent?

(A) the focal point of the mirror
(B) the center of curvature of the mirror
(C) the virtual image point of the candle flame
(D) the real image point of the candle flame

36. The diagram below shows a convex (converging) lens with focal length f.



When object distance is less than the focal length, it acts as a magnifying glass – produces a larger virtual image

Where should an object be placed to produce a virtual image?

(A) between f and the lens
(B) between f and 2f
(C) at 2f
(D) at f

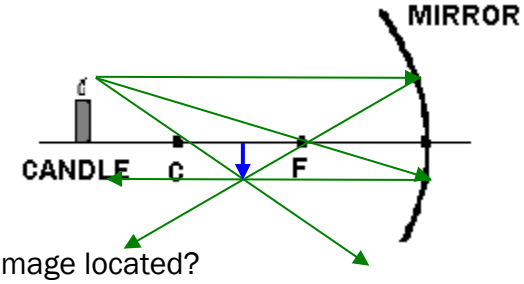
37. The radius of curvature of a spherical mirror is R. The focal length of this mirror is equal to

(A) $\frac{R}{2}$ (B) $\frac{R}{4}$ (C) $4R$ (D) $2R$

Focal length is half the radius of curvature

38. A candle is located beyond the center of curvature, C, of a concave spherical mirror having principal focus F, as shown in the diagram below.

Sketch a quick ray diagram



1. In parallel, out through focus
2. In through focus, out parallel
3. In and out through center of lens

Where is the candle's image located?

(A) behind the mirror
(B) beyond C
(C) between F and the mirror
(D) between C and F

39. In a vacuum, a monochromatic beam of light has a frequency of 6.3×10^{14} hertz. What color is the light?

(A) green (B) red (C) yellow (D) blue

On the reference tables use the Electromagnetic Spectrum to look the color up by frequency

40. A student placed an object at various distances (d_o) from a converging lens. The corresponding image distance (d_i) was measured and recorded in the data table below.

d_o	0.15 m	0.20 m	0.30 m
d_i	0.30 m	0.20 m	0.15 m

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{0.15m} + \frac{1}{0.30m}$$

What is the focal length of the lens?

(A) 0.20 m (B) 0.15 m (C) 0.30 m (D) 0.10 m

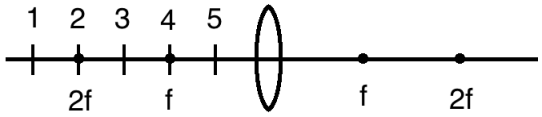
41. The image formed by a plane mirror alone is always

(A) real (B) virtual (C) larger (D) smaller (E) inverted

42. A converging lens has a focal length of 20 cm. A candle is placed at 30 cm from the lens, and an image is formed 60 cm from the lens. The magnification is

(A) 0.5 (B) 0.67 (C) 1.5 (D) 2.0 (E) 3.0

Questions 43 through 45 relate to the converging lens and principal axis shown and the choices that follow. The focal length f and twice the focal length 2f are marked on either side of the lens.



43. At which position could a candle be placed so that a virtual image could be formed?

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

44. At which position could a candle be placed so that an image smaller than the candle would be formed?

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

45. At which position could a candle be placed so that neither a real nor virtual image could be formed?

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

46. Which of the following causes a wave to change its speed and wavelength?

(A) reflection (B) refraction (C) interference (D) polarization (E) dispersion

47. Which of the following creates two angles that are equal to each other?

(A) reflection (B) refraction (C) interference (D) polarization (E) dispersion

48. Which of the following causes white light to separate into distinctive frequencies?

(A) reflection (B) refraction (C) interference (D) polarization (E) dispersion

49. A candle may be placed on the principal axis at the following distances from the center of a convex lens

I. at the focal length
II. at 3/2 the focal length
III. less than the focal length
IV. greater than double the focal length

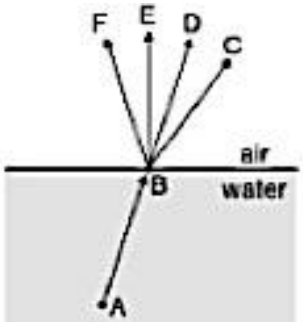
Which of the above will produce an image that is larger than the actual candle?

(A) I only (B) I, II, and III (C) II and III (D) II, III, and IV (E) I, II, III, and IV

50. Total internal reflection occurs when

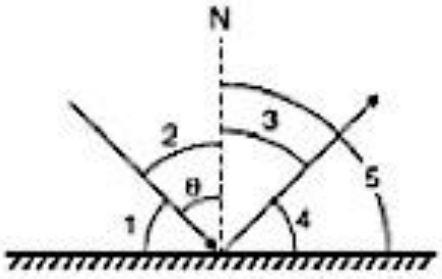
(A) light passes from air into water
(B) light refracts as it exits glass into air
(C) light reflects off of a mirror
(D) light passing through glass is reflected inside the glass
(E) the angle of incidence is less than the critical angle

51. A ray of light is shined from beneath the water to air above as shown above. Which of the following rays is the refracted ray



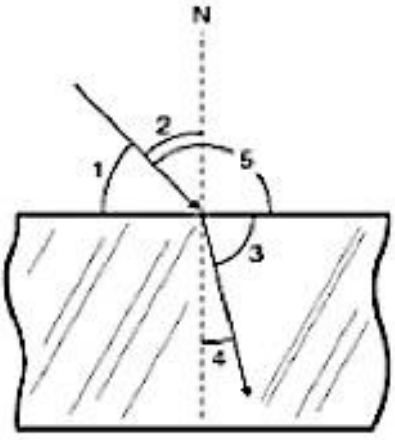
(A) AB (B) BC (C) BD (D) BE (E) BF

52. In the figure shown, the angle of incidence is θ. Which angle is the angle of reflection?



(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

53. A beam of light passes from the air through a thick piece of glass as shown. Which of the following angles is the angle of refraction?

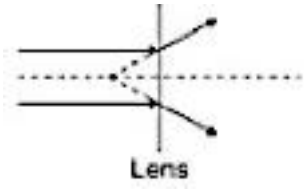


(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

54. A beam of light passes from air into glass. Which of the following statements is true?

(A) The angle of incidence is greater than the angle of refraction in the glass
(B) The angle of incidence is less than the angle of refraction in the glass
(C) The angle of incidence is equal to the angle of refraction in the glass
(D) The frequency of the light decreases
(E) The frequency of the light increases

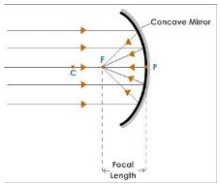
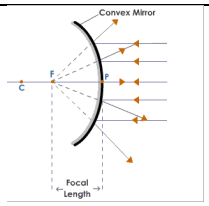
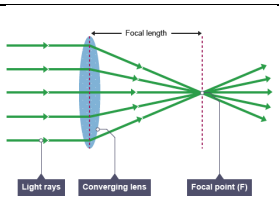
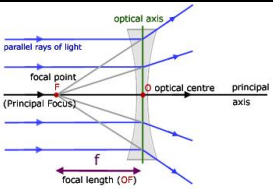
55. A light ray pass through a thin lens having a focal point f as shown above. Which of the following best describes the lens? [Hint: More than one correct answer]



(A) The lens is a converging lens
(B) The lens is thicker in the center than on the edges
(C) The lens is thinner in the center than on the edges
(D) The lens will always produce real images
(E) The lens will always produce virtual images

Answers:
22. d_i = -- 13 cm
m = 2.6x bigger
23. see sheet in classroom
24. 50.0°, 55.0°
25. a. 34.0°
b. 25.3°
e. 4.56 x 10^{-7} m

26. B
27. B
28. A
29. B
30. C
31. C
32. D
33. A
34. A
35. C
36. A
37. A
38. D
39. D
40. D
41. B
42. D
43. E
44. A
45. D
46. B
47. A
48. E
49. C
50. D
51. B
52. C
53. D
54. A
55. C, E

	Converging	Diverging
Mirror	 Concave	 Convex
Lens	 Convex	 Concave
Properties	Beyond F – real, inverted, various size On F – DNE Inside F – virtual, upright, larger	ALWAYS – virtual, upright, smaller, closer