1. Fiber optics makes use of the phenomenon of
   1) diffraction
   2) interference
   3) polarization
   4) total internal reflection
   5) Doppler shift

2. At the interface between a liquid with an index of refraction of \( \sqrt{3} \) and a transparent solid with an index of refraction of 2, an incident ray of light undergoes total internal reflection. Which of the following is necessarily true?
   1) The beam originated in the solid and was incident at an angle greater than 30°.
   2) The beam originated in the solid and was incident at an angle greater than 60°.
   3) The beam originated in the liquid and was incident at an angle greater than 30°.
   4) The beam originated in the liquid and was incident at an angle greater than 60°.
   5) None of these are necessarily true.

3. Light with a speed \( v_1 \) is incident upon a medium in which its speed is \( v_2 \). If the light is totally internally reflected in the first medium, which of the following is true concerning \( v_1, v_2 \), and the angle of incidence to the normal \( \theta \)?
   1) \( v_1 < v_2, \ \theta < \sin^{-1}(v_1/v_2) \)
   2) \( v_1 < v_2, \ \theta > \sin^{-1}(v_1/v_2) \)
   3) \( v_1 > v_2, \ \theta < \sin^{-1}(v_1/v_2) \)
   4) \( v_1 > v_2, \ \theta > \sin^{-1}(v_1/v_2) \)
   5) \( v_1 = v_2, \ \theta > \sin^{-1}(v_1/v_2) \)

4. The diagram below shows two light rays originating from source \( S \) in medium \( y \). The dashed line represents a normal to each surface.

![Diagram of light rays](image)

Light originating from source \( S \) could produce total internal reflection at
   1) surface \( yz \), only
   2) surface \( xy \), only
   3) neither surface \( xy \) nor \( yz \)
   4) both surface \( xy \) and \( yz \)
   5) It is impossible to determine without knowing the indices of refraction of the media.

5. Total internal reflection occurs at what angle in a material with an index of refraction of 1.4, if it is placed in air?
   1) 25°
   2) 37°
   3) 46°
   4) 60°
   5) 80°
6. An object is placed at point X near two plane mirrors held at right angles to each other as shown above. How many images of the object would an observer at point Y see?

1) 1  4) 4
2) 2  5) 5
3) 3

7. A student walks directly towards a plane mirror with a speed of 1.0 m/s. Relative to the student, how fast is the image moving?

1) 0.25 m/s  4) 2.0 m/s
2) 0.50 m/s  5) 4.0 m/s
3) 1.0 m/s

8. An object is placed 50 cm from a plane mirror. Which of the following describes the image?

1) 50 cm from the object and upright
2) 50 cm from the object and inverted
3) 100 cm from the object and upright
4) 100 cm from the object and inverted
5) 150 cm from the object and upright

9. In the diagram below, a light ray leaves a light source and reflects from a plane mirror.

At which point does the image of the source appear to be located?

1) A  4) D
2) B  5) Source
3) C

10. All of the following about planar mirrors are true EXCEPT

1) they produce real images
2) they produce upright images
3) the object and image distances are equal
4) the object and image sizes are equal
5) they reflect light at its angle of incidence

11. Which of the following statements about a convex mirror is true?

1) It can form a real image.
2) The image is always inverted.
3) Its focal length is positive.
4) The image is closer to the mirror than the object.
5) The image is larger than the object.
12. Which of the following cannot produce a real image?

   I. A concave lens
   II. A convex mirror
   III. A concave mirror

1) I, only        4) I and III, only
2) III, only      5) I, II, and III
3) I and II, only

13. An object is placed a distance 25 cm away from a convex spherical mirror. The mirror forms an image a distance 20 cm away from the mirror. If the object is then placed a distance 60 cm away, how far from the mirror will the image appear?

1) 37.5 cm        4) 60 cm
2) 48 cm          5) 75 cm
3) 55 cm

14. Which of the following is true about convex mirrors?

<table>
<thead>
<tr>
<th>Nature of image</th>
<th>Focal Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Always virtual</td>
<td>Positive</td>
</tr>
<tr>
<td>(B) Always virtual</td>
<td>Negative</td>
</tr>
<tr>
<td>(C) Always real</td>
<td>Positive</td>
</tr>
<tr>
<td>(D) Always real</td>
<td>Negative</td>
</tr>
<tr>
<td>(E) Real or virtual</td>
<td>Negative</td>
</tr>
</tbody>
</table>

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

15. A person is standing in front of a diverging (convex) mirror. What type of image does the mirror form of the person?

1) erect, virtual, and smaller than the person
2) erect, virtual, and the same size as the person
3) erect, real, and smaller than the person
4) inverted, real, and the same size as the person
5) inverted, virtual, and the same size as the person

16. At what distance away from the focus $F$ must an object be to create a real image in a convex mirror?

1) $F$
2) $2F$
3) $F^2$
4) $\frac{1}{2}F$
5) Convex mirrors never make real images.

17. Which one of the following statements concerning the image formed by a concave mirror is true?

1) It produces a virtual image for an object distance less than the focal length.
2) It produces a virtual image for an object distance greater than the focal length.
3) When an object is placed at its center of curvature, the reflected rays are parallel.
4) It produces an upright image for an object distance greater than the focal length.
5) It produces an inverted image for an object distance less than the focal length.

18. An object is placed 1.4 m in front of a concave spherical mirror whose focal length is 70 cm. The image is

1) real, located 35 cm from the mirror
2) real, located 70 cm from the mirror
3) real, located 140 cm from the mirror
4) virtual, located 70 cm from the mirror
5) virtual, located 140 cm from the mirror

19. A dog stands a distance of 40 cm from a spherical concave mirror with a radius of curvature of 1.2 m. How far away will the dog's image seem to be from it?

1) 24 cm        4) 120 cm
2) 64 cm        5) 160 cm
3) 100 cm
20. In the diagram below, how far from the mirror is the light bulb (object) most likely located?

21. A spherical concave mirror is used in the back of a car headlight. Where must the bulb of the headlight be located to produce a parallel beam of reflected light?
   1) between the principal focus and the mirror
   2) at the principal focus of the mirror
   3) between the focus and the center of curvature of the mirror
   4) at the center of curvature of the mirror
   5) beyond the center of curvature of the mirror

22. Which phenomenon may cause a concave mirror to form fuzzy, out-of-focus images?
   1) spherical aberration
   2) chromatic aberration
   3) dispersion
   4) refraction
   5) polarization

23. An object 0.15 meter tall placed 0.25 meter in front of a concave mirror produces an image 0.20 meter tall. The image distance is approximately
   1) 0.12 m
   2) 0.19 m
   3) 0.30 m
   4) 0.33 m
   5) 0.45 m
24. An object arrow is placed in front of a concave mirror having center of curvature \( C \) and principal focus \( F \).

Which diagram best shows the location of point \( I \), the image of the tip of the object arrow?

1)  

![Diagram 1](image1.png)

2)  

![Diagram 2](image2.png)

3)  

![Diagram 3](image3.png)

4)  

![Diagram 4](image4.png)

5) none of the above

25. An object is outside of the focal length of a concave mirror. The image is

1) upright and real  
2) upright and virtual  
3) inverted and real

26. An image of an object produced by a mirror is enlarged, virtual and erect. The object was

1) outside of the focal length of a concave mirror  
2) outside of the focal length of a convex mirror  
3) inside the focal length of a convex mirror  
4) inside the focal length of a concave mirror  
5) at the focal length of a convex mirror

27. 

![Diagram of lens system](image5.png)

An object is placed as shown in the figure above. The lens in the diagram has a focal length \( f \). As compared to the object, the image formed by the lens is

1) upright and larger.  
2) upright and the smaller.  
3) inverted and larger.  
4) inverted and the same size.  
5) inverted and smaller.
28. The set of lenses shown below.

Which of the lenses, when placed in air, will cause parallel rays of light to converge?
1) I and III only       4) I, II, and V only
2) I, II and III only  5) I and V only
3) III and IV only

29. An object is placed 2.0 centimeters from a thin converging lens with a focal length of 6.0 centimeters. The image is
1) virtual and 3.0 cm from the lens.
2) virtual and 6.0 cm from the lens.
3) real and 1.5 cm from the lens.
4) real and 3.0 cm from the lens.
5) real and 6.0 cm from the lens.

30. An object is placed near a converging lens that has a focal length of f. At what distance should the object be placed so that the image is the same height as the object?
1) \( \frac{1}{2}f \)       4) \( 4f \)
2) \( f \)             5) infinity
3) \( 2f \)

31. Which of the following sorts of images cannot be made by a single converging lens?
   I. virtual and inverted
   II. real and upright
   III. real and inverted
1) I only       4) I and III only
2) II only      5) I, II, and III
3) I and II only

32. A converging lens with a focal length of 60 cm projects an image on a screen. If the ratio of the size of the image to the size of the original object is 1:4, what is the distance from the image to the lens?
1) 15 cm       4) 60 cm
2) 30 cm       5) 75 cm
3) 45 cm

33. An object is placed 15 centimeters to the right of a converging lens of focal length 30 centimeters. Where is the image located?
1) 30 cm to the right of the lens
2) 10 cm to the right of the lens
3) 10 cm to the left of the lens
4) 15 cm to the left of the lens
5) 30 cm to the left of the lens

34. As an object is moved toward the optical center of a bi-concave lens
1) the image of the object moves away from the lens and gets shorter
2) the image of the object moves away from the lens and gets taller
3) the image of the object moves toward the lens and gets shorter
4) the image of the object moves toward the lens and gets taller
5) None of the above

35. Which of the following cannot create an image larger than the object?
1) converging lens       4) biconvex lens
2) diverging lens        5) none of the above
3) converging mirror
36. What causes chromatic aberration in a lens?
   1) Each wavelength of light reflects from the surface of the lens.
   2) Each wavelength of light is refracted a different amount by the lens.
   3) White light waves interfere inside the lens.
   4) White light waves diffract around the edge of the lens.
   5) The surfaces of the lens are not smooth.

37. An object is placed at a distance of 2f from a diverging lens of focal length f. Which of the following is true concerning the image formed?
   1) It is larger and virtual.
   2) It is the same size and virtual.
   3) It is smaller and virtual.
   4) It is larger and real.
   5) It is smaller and real.

38. An object is placed a distance of two focal lengths from a diverging lens. As the object is brought from 2F to 0.5F
   1) the image will be begin virtual and inverted, disappear at F, and then return to being virtual and inverted
   2) the image will remain virtual and upright
   3) the image will begin virtual and inverted, then become real and upright at distance F
   4) the image will be being real and inverted, disappear at F, then return to being real and inverted
   5) the image will remain real and inverted

39. Parallel light rays are incident on a concave lens. Which of the following is true?
   1) The light waves converge on the side of the lens on which they were incident.
   2) The light waves diverge on the side of the lens on which they were incident.
   3) The light waves converge on the other side of the lens.
   4) The light waves diverge on the other side of the lens.
   5) The light waves continue parallel on the other side of the lens producing a virtual image.

40. A biconvex lens has a focal length of magnitude 40 cm. An image is formed of an object of height 2 cm placed 60 cm from the lens. The distance from the object to the image is
   1) 12 cm
   2) 24 cm
   3) 36 cm
   4) 72 cm
   5) 120 cm

41. A thin diverging lens has a focal length f of −10 cm in air. An object is placed a distance of 30 cm (−3f) from this lens.
   (a) State whether the image is real or virtual.
   (b) Determine the distance from the lens to the image.
   (c) Determine the ratio of the height of the image to the height of the object.
   (d) The object, initially at a distance of 30 cm from the lens, is moved toward the lens. Sketch a graph of the image distance versus the object distance as the object distance varies from 30 cm to zero.
   (e) State whether the focal length of the lens would increase, decrease, or remain the same if the lens were used in water instead of air.
42. Light of frequency $5.0 \times 10^{14}$ Hz strikes a glass/water boundary at an angle of incidence $\theta_1 = 25^\circ$. The ray is partially reflected and partially refracted at the boundary, as shown below. For light of this frequency, glass has an index of refraction of 1.50 and water has an index of refraction of 1.33.

(a) Determine the value of $\theta_2$.
(b) Determine the value of $\theta_3$.
(c) Determine the speed of the light in the water.
(d) Determine the wavelength of the light in the glass.
(e) What is the largest value of $\theta_1$ that would result in a refracted ray?

43. An object of height 3 cm is placed 10 cm from a thin converging lens of focal length 15 cm.

(a) Draw a ray diagram showing the position and size of the image formed.
(b) State whether the object is real or virtual, explain your reasoning.
(c) Determine the distance from the image to the center of the lens.
(d) Is the image erect or inverted? What is the size of the image?
(e) The object is now moved to a distance of 30 cm from the lens. Determine the image position, size, and orientation.
Review - Geometric Optics
Answer Key
[New Exam]

1. 4
2. 2
3. 2
4. 2
5. 3
6. 3
7. 4
8. 3
9. 2
10. 1
11. 4
12. 3
13. 1
14. 2
15. 1
16. 5
17. 1
18. 3
19. 5
20. 4
21. 2
22. 1
23. 4
24. 3
25. 3
26. 4
27. 3
28. 3
29. 1
30. 3
31. 3
32. 5
33. 5
34. 4
35. 2
36. 2
37. 3
38. 2
39. 4
40. 5
41. (a) virtual
   (b) 7.5 cm
   (c) 0.25
   (e) decrease
42. (a) 25°
   (b) 28.5°
   (c) 2.26 \times 10^8 \text{ m/s}
   (d) 400 \text{ nm}
   (e) 62.5°
43. (b) the image is virtual since the rays of light do not converge.
(c) 30 cm.
(d) erect, 9cm.
(e) The image is real and inverted, 3cm tall and 30 cm from the lens.