School_____

Team Number_____

Optics

Proceed to the laser shoot (40%) when your team number is called.

Physical Optics (30%)

1. What are the four colors used in the CMYK color model? (2 points)

2. *Muscae Volitantes* are microscopic particles of cellular debris freely floating in what part of the eye? (1 point)

3. Suppose that the electric field of an electromagnetic wave decreases in magnitude. Does the magnetic field increase, decrease, or remain the same? (1 point)

4. Two galaxies have their Doppler shifts measured from earth. Galaxy A has its spectral lines red-shifted by 200 nm, and Galaxy B has its spectral lines blue-shifted by 300 nm. (2 points)
   a. Which galaxy is moving faster?

   b. Which galaxy is moving away from us?

5. In a dark room, magenta light is shined on a green T-shirt. What color does the T-shirt appear to be? (1 point)

6. What is an emission (bright line) spectrum? (2 point)

7. In meters per second, what is the speed of light in a vacuum? (1 point. ½ point if rounded to 3)

8. Light is most refracted when it enters what part of the eye? (1 point)

9. Explain why a lump of sugar appears white even though each individual grain is transparent. (2 points)

10. A spaceship is moving away from an asteroid at a relative velocity of 2.8481×10^8 m/s. The spaceship sends a signal with a frequency of 5×10^6 Hz to a base located on the asteroid. What is the frequency of the signal measured by the base? (2 points)

11. What is the slowest recorded speed of light? (1 point)

12. Surgically removing what part of the eye greatly improves UV sensitivity? (1 point)

13. A beam of yellow light and a beam of magenta light are both shined on a white wall. What color does the wall appear to be? (1 point)

14. What type of cell is responsible for color vision? (1 point)

15. When light with a wavelength of 350 nm is shined on a sample of highlighter fluid, the fluid emits a bright yellowish green grow.
    a. What is the frequency of the original light? On what portion of the electromagnetic spectrum is this light?(2 point)

    b. What is the name for the glowing of the highlighter fluid? (1 point)

16. Would an object moving left to right with respect to you have a Doppler shift? Why or why not? (2 points)

17. What primary color is the human eye most sensitive to? (1 point)

18. Arrange the seven main types of electromagnetic radiation form lowest to highest frequency (4 points; .5 point for each given, 1 point for correct order, .5 point for lowest to highest)

19. What type of spectrum is produced by electrons dropping from an excited state to a lower energy state? (1 point)

20. What part of the eye has a structure similar to an onion, made up of about 22,000 very fine layers? (1 points)

21. What color is a perfect mirror? (1 point)

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Snow reflects almost all of the light incident upon it. However, a single beam of light is not reflected in the form of parallel rays. This is an example of ____ reflection off of a ____ surface.
a. regular; rough
b. regular; specular
c. diffuse; specular
d. diffuse; rough

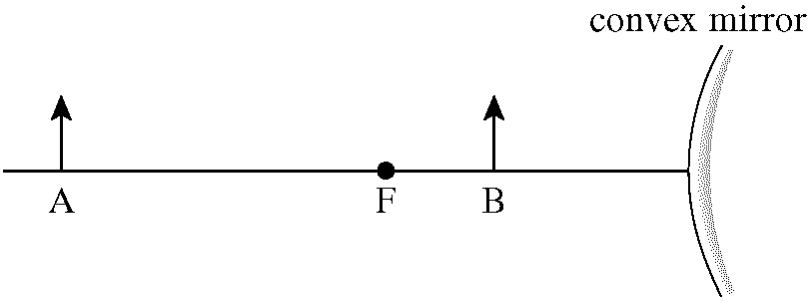
____ 2. When incoming rays of light strike a flat mirror at an angle close to the surface of the mirror, the reflected rays are
a. inclined high above the mirror's surface.
b. parallel to the mirror's surface.
c. perpendicular to the mirror's surface.
d. close to the mirror's surface.

____ 3. When a straight line is drawn perpendicular to a flat mirror at the point where an incoming ray strikes the mirror's surface, the angles of incidence and reflection are measured from the normal and
a. the angles of incidence and reflection are equal.
b. the angle of incidence is greater than the angle of reflection.
c. the angle of incidence is less than the angle of reflection.
d. the angle of incidence can be greater than or less than the angle of reflection.

____ 4. If a light ray strikes a flat mirror at an angle of 14° from the normal, the reflected ray will be
a. 13° from the mirror's surface.
b. 27° from the normal.
c. 90° from the mirror's surface.
d. 14° from the normal.

____ 5. If you stand 3.0 m in front of a flat mirror, how far away from you would your image be in the mirror?
a. 1.5 m
b. 3.0 m
c. 6.0 m
d. 12.0 m

____ 6. Which of the following best describes the image produced by a flat mirror?
a. virtual, inverted, and magnification greater than one
b. real, inverted, and magnification less than one
c. virtual, upright, and magnification equal to one
d. real, upright, and magnification equal to one



____ 7. In the diagram above, the image of object *B* would be
a. real, reduced, and upright.
b. virtual, enlarged, and upright.
c. virtual, reduced, and inverted.
d. virtual, reduced, and upright.

____ 8. Which best describes the image of a concave mirror when the object is located somewhere between the focal point and twice the focal-point distance from the mirror?
a. virtual, upright, and magnification greater than one
b. real, inverted, and magnification less than one
c. virtual, upright, and magnification less than one

d. real, inverted, and magnification greater than one

____ 9. A parabolic mirror, instead of a spherical mirror, can be used to reduce the occurrence of which effect?
a. spherical aberration
b. mirages
c. chromatic aberration
d. light scattering

____ 10. Refraction is the term for the bending of a wave disturbance as it passes at an angle from one ____ into another.
a. glass
b. medium
c. area
d. boundary

____ 11. Which is an example of refraction?
a. A parabolic mirror in a headlight focuses light into a beam.
b. A fish appears closer to the surface of the water than it really is when observed from a riverbank.
c. In a mirror, when you lift your right arm, the left arm of your image is raised.
d. Light is bent slightly around corners.

____ 12. The ____ of light can change when light is refracted because the wavelength changes.
a. frequency
b. media
c. color
d. transparency

____ 13. Light is NOT refracted when it is
a. traveling from air into a glass of water at an angle of 35° to the normal.
b. traveling from water into air at an angle of 35° to the normal.
c. striking a wood surface.
d. traveling from air into a diamond at an angle of 45°.

____ 14. When light passes at an angle to the normal from one material into another material in which its speed is higher,
a. it is bent toward the normal to the surface.
b. it always lies along the normal to the surface.
c. it is unaffected.
d. it is bent away from the normal to the surface.

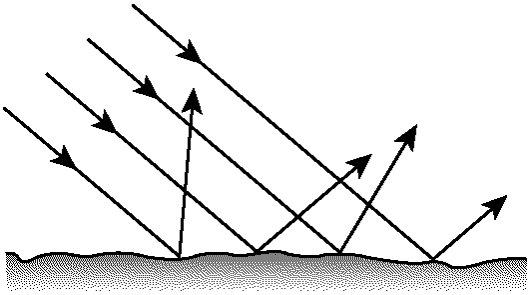
____ 15. When a light ray moves from air into glass at an angle of 45°, its path is
a. bent toward the normal.
b. bent away from the normal.
c. parallel to the normal.
d. not bent.

____ 16. Which of the following describes what will happen to a light ray incident on a glass-to-air boundary at greater than the critical angle?
a. total reflection
b. total transmission
c. partial reflection, partial transmission
d. partial reflection, total transmission

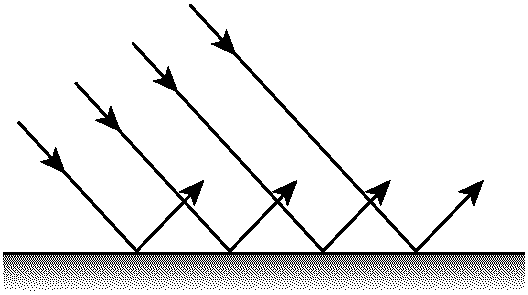
____ 17. Atmospheric refraction of light rays is responsible for which effect?
a. spherical aberration
b. mirages
c. chromatic aberration
d. total internal reflection in a gemstone

____ 18. If atmospheric refraction did not occur, how would the apparent time of sunrise and sunset be changed?
a. Both would be later.
b. Both would be earlier.
c. Sunrise would be later, and sunset would be earlier.
d. Sunrise would be earlier, and sunset would be later.

Short Answer



19. What type of reflection is illustrated in the figure above?



20. What type of reflection is illustrated in the figure above?

21. When rays of light are incident upon a spherical mirror far from the principal axis, fuzzy images form. What is this characteristic of spherical mirrors?

22. Spherical aberration may be avoided by employing a _____ mirror or by making sure that the diameter of a spherical mirror is sufficiently _____.

23. The focal point and center of curvature of a spherical mirror all lie along the _____.

24. When does refraction occur?

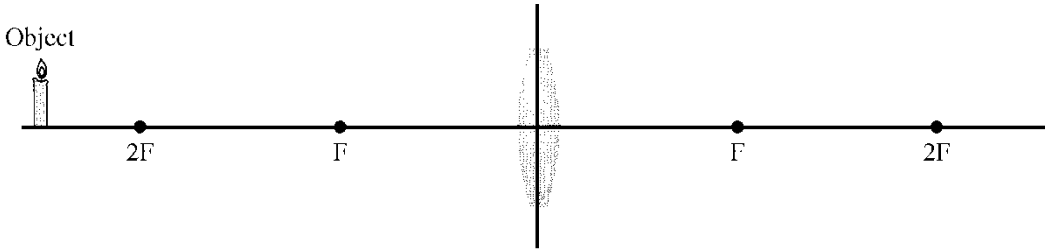
25. Why is it impossible to see an atom with a compound microscope?

26. In a refracting telescope, is the image upright or inverted? Explain.

27. The critical angle for internal reflection inside a certain transparent material is found to be 48°. If entering light has an angle of incidence of 52°, predict whether the light will be refracted or whether it will undergo total internal reflection.

28. Why do motorists sometimes see what appear to be wet spots on the road on a dry summer day?

29. What is dispersion?



30. What is the position and kind of image produced by the lens above? Draw a ray diagram to support your answer.

Problem

31. Where would the image of a 4.0 cm tall object that is 12 cm in front of a flat mirror be located?

32. A convex mirror has a focal length of –17 cm. What is the radius of curvature?

33. A ray of light passes from air into fluorite (n = 1.434) at an angle of 19° to the normal. What is the refracted angle?

34. An object is placed along the principal axis of a thin converging lens that has a focal length of 22 cm. If the distance from the object to the lens is 36 cm, what is the distance from the image to the lens?

35. A ray of light travels across a liquid-to-glass interface. The index of refraction for the liquid is 1.75 and 1.52 for the glass. If the light meets the interface at an angle of 59°, predict whether the light will be refracted or whether it will undergo total internal reflection.