1. The diagram below shows light rays in air about to strike a glass window.

When the rays reach the boundary between the air and the glass, the light is
A) partially reflected and partially refracted
B) totally refracted
C) totally reflected
D) partially reflected and partially diffracted

2. Which diagram best represents the path taken by a ray of monochromatic light as it passes from air through the materials shown?

A) ![Diagram A]
B) ![Diagram B]
C) ![Diagram C]
D) ![Diagram D]
3. A ray of light \( f = 5.09 \times 10^{14} \text{ Hz} \) traveling in air is incident at an angle of \( 40^\circ \) on an air-crown glass interface as shown below.

What is the angle of refraction for this light ray?
A) 78°  B) 40°  C) 25°  D) 37°

4. The diagram below represents a ray of monochromatic light \( f = 5.09 \times 10^{14} \text{ Hz} \) passing from medium \( X \) \( (n = 1.46) \) into fused quartz.

Which path will the refracted ray follow in the quartz?
A) A  B) B  C) C  D) D

5. As a periodic wave travels from one medium to another, which pair of the wave's characteristics do not change?
A) period and amplitude  
B) period and frequency  
C) amplitude and wavelength  
D) frequency and velocity

6. A ray of monochromatic light is traveling in flint glass. The ray strikes the flint glass-air interface at an angle of incidence greater than the critical angle for flint glass. Which diagram best represents the path of this light ray?
A)  
B)  
C)  
D)  

7. The absolute index of refraction for a substance is 2.0 ft light having a wavelength of \( 5.9 \times 10^{-7} \text{ meter} \). In this substance, what is the critical angle for light incident on a boundary with air?
A) 90°  B) 30.5°  C) 60°  D) 45°

8. A light ray traveling in air enters a second medium and its speed slows to \( 1.71 \times 10^8 \text{ meters per second} \). What is the absolute index of refraction of the second medium?
A) 1.75  B) 0.570  C) 1.00  D) 1.94

9. Compared to the wavelength of a wave of green light in air, the wavelength of this same wave of green light in Lucite is
A) less  
B) greater  
C) the same

10. What happens to the frequency and the speed of an electromagnetic wave as it passes from air into glass?
A) The frequency remains the same and the speed increases.  
B) The frequency remains the same and the speed decreases.  
C) The frequency decreases and the speed increases.  
D) The frequency increases and the speed decreases.
11. Which diagram best represents the behavior of a ray of monochromatic light in air incident on a block of crown glass?

A) Incident ray                      Normal
   Air                         Crown glass
   C) Incident ray                      Normal
   Air                         Crown glass
   D) Incident ray                      Normal
   Air                         Crown glass

B) Incident ray                      Normal
   Air                         Crown glass

12. The diagram below shows parallel rays of light incident on an irregular surface.

Which phenomenon of light is illustrated by the diagram?
A) diffuse reflection
B) refraction
C) regular reflection
D) diffraction

13. Orange light has a frequency of $5.0 \times 10^{14}$ hertz in a vacuum. What is the wavelength of this light?
A) $1.7 \times 10^{6}$ m
B) $1.5 \times 10^{23}$ m
C) $6.0 \times 10^{-7}$ m
D) $2.0 \times 10^{-15}$ m

14. In the diagram below, a monochromatic light ray is passing from medium $A$ into medium $B$. The angle of incidence $q$ is varied by moving the light source $S$.

When angle $\theta$ becomes the critical angle, the angle of refraction will be
A) $q$
B) 90°
C) 0°
D) greater than $q$, but less than 90°

15. A ray of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) in air is incident at an angle of 30° on a boundary with corn oil. What is the angle of refraction, to the nearest degree, for this light ray in the corn oil?
A) 20°
B) 6°
C) 30°
D) 47°

16. A ray of light ($\lambda = 5.9 \times 10^{-7}$ meter) traveling in air is incident on an interface with medium $X$ at an angle of 30°. The angle of refraction for the light ray in medium $X$ is 12°. Medium $X$ could be
A) diamond
B) corn oil
C) flint glass
D) alcohol

$N_{1}sin\theta_{1} = N_{2}sin\theta_{2}$
17. The diagram below shows white light being dispersed as it passes from air into a glass prism.

This phenomenon occurs because, in glass, each frequency of light has a different

A) intensity  
B) angle of incidence  
C) absolute index of refraction  
D) amplitude

18. A ray of monochromatic light traveling in air enters a rectangular glass block obliquely and strikes a plane mirror at the bottom. Then the ray travels back through the glass and strikes the air-glass interface. Which diagram below best represents the path of this light ray? [N represents the normal to the surface.]
22. The diagram below represents a ray of light being reflected from a plane mirror. Which letter indicates the angle of reflection?

A) 45°  B) 100°  C) 100°  D) 40°

20. The diagram below represents shallow water waves of constant wavelength passing through two small openings, A and B, in a barrier.

A) 1 A) 3 A) 2 A) 4

How much longer is the length of path AP than the length of path BP?

19. The diagram below represents shallow water waves of wavelength λ passing through two small openings, A and B, in a barrier.

D) 2 C) 5 B) 0 A) 0
23. The diagram below represents straight wave fronts passing from deep water into shallow water, with a change in speed and direction.

Which phenomenon is illustrated in the diagram? (A) refraction (B) interference (C) reflection

24. The change in the direction of a wave when it passes obliquely from one medium to another is called

(A) superposition (B) diffraction (C) refraction

25. The diagram below represents a light ray striking the boundary between air and glass.

What would be the angle between this light ray and its reflected ray? (A) 30° (B) 60° (C) 120° (D) 150°

26. A ray of light (f = 5.09 x 10^14 Hz) travels from zinc into diamond, the speed of the light is
(A) decreases (B) increases (C) remains the same

27. When a ray of white light is refracted and dispersed, the component color that has the greatest change in direction is
(A) orange (B) red (C) green (D) violet

28. As yellow light (f = 5.09 x 10^14 Hz) travels from zinc into diamond, the speed of the light is
(A) 1.1 x 10^8 m/s (B) 2.7 x 10^8 m/s (C) 3.0 x 10^8 m/s (D) 3.3 x 10^8 m/s

29. When a light wave enters a new medium and is refracted, there must be a change in the light wave's
(A) period (B) frequency (C) speed (D) wavelength

30. When a light wave enters a new medium and is refracted, the index of refraction of the new medium is
(A) 1.1 x 10^8 m/s (B) 2.7 x 10^8 m/s (C) 3.0 x 10^8 m/s (D) 3.3 x 10^8 m/s
1. The diagram below shows a ray of light passing from air into glass at an angle of incidence of $0^\circ$.

![Diagram of light passing from air into glass]

Which statement best describes the speed and direction of the light ray as it passes into the glass?

A) Neither speed nor direction changes.
B) Both speed and direction change.
C) Only direction changes.
D) Only speed changes.

2. In a certain material, a beam of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) has a speed of $2.25 \times 10^8$ meters per second. The material could be

A) crown glass
B) water
C) glycerol
D) flint glass

3. A beam of monochromatic light travels through flint glass, crown glass, Lucite, and water. The speed of the light beam is slowest in

A) Lucite
B) crown glass
C) water
D) flint glass

4. As shown in the diagram below, a beam of light can pass through the length of a curved glass fiber.

![Diagram of light passing through curved glass fiber]

This phenomenon is possible due to the effect of

A) polarization
B) diffraction
C) internal reflection
D) dispersion

35. As a monochromatic beam of light passes obliquely from flint glass into water, how do the characteristics of the beam of light change?

A) Its wavelength increases and it bends toward the normal.
B) Its wavelength decreases and its frequency decreases.
C) Its wavelength decreases and its frequency increases.
D) Its wavelength increases and it bends away from the normal.

36. Which diagram best represents the path of light rays passing through a glass prism?

A) ![Diagram A]
B) ![Diagram B]
C) ![Diagram C]
D) ![Diagram D]

37. What occurs when light passes from water into flint glass?

A) Its speed increases, its wavelength becomes longer, and its frequency decreases.
B) Its speed decreases, its wavelength becomes shorter, and its frequency increases.
C) Its speed decreases, its wavelength becomes shorter, and its frequency remains the same.
D) Its speed increases, its wavelength becomes longer, and its frequency remains the same.
18. The diagram below represents a transverse wave traveling to the right through a medium. Point A represents a particle of the medium.

In which direction will particle A move in the next instant of time?
1) down  3) right
2) up     4) left

19. A student strikes the top rope of a volleyball net, sending a single vibratory disturbance along the length of the net, as shown in the diagram below.

20. The diagram below represents a rope along which two pulses of equal amplitude, A, approach point P.

As the two pulses pass through point P, the maximum vertical displacement of the rope at point P will be
1) A  3) 0
2) 2A  4) A/2

Base your answers to questions 21 through 23 on the diagram below which represents a segment of a periodic wave traveling to the right in a steel spring.

21. What type of wave is illustrated by the diagram?
1) torsional  3) longitudinal
2) elliptical  4) transverse

22. If a wave crest passes line XY every 0.40 second, the frequency of the wave is
1) 1.0 Hz  3) 5.0 Hz
2) 2.5 Hz  4) 0.4 Hz

23. What is the wavelength of the wave?
1) 1.0 m  3) 2.5 m
2) 2.0 m  4) 0.4 m

24. An opera singer's voice is able to break a thin crystal glass if the singer's voice and the glass have the same natural
1) wavelength  3) amplitude
2) speed  4) frequency

25. Two waves having the same frequency and amplitude are traveling in the same medium. Maximum constructive interference occurs at points where the phase difference between the two superposed waves is
1) 0°  3) 180°
2) 90°  4) 270°
Base your answers to questions 29 and 30 on the information and diagram below.

A longitudinal wave moves to the right through a uniform medium, as shown below. Point A, B, C, D, and E represent the positions of particles of the medium.

29. Which diagram best represents the motion of the particle at position C as the wave moves to the right?
   1) 2) 3) 4)

30. The wavelength of this wave is equal to the distance between points
   1) A and B  2) A and C  3) B and C  4) B and E

31. As a longitudinal wave passes through a medium, the particles of the medium move
    1) parallel to the direction of wave travel
    2) in circles
    3) in ellipses
    4) perpendicular to the direction of wave travel

32. What is the frequency of a wave if its period is 0.25 second?
    1) 1.0 Hz  2) 0.25 Hz  3) 12 Hz  4) 4.0 Hz
38. A change in the speed of a wave as it enters a new medium produces a change in
A) wavelength  B) period
C) frequency  D) phase

39. As a wave is refracted, which characteristic of the wave will remain unchanged?
A) wavelength  B) velocity
C) frequency  D) direction

40. What happens to the speed and frequency of a light ray when it passes from air into water?
A) The speed decreases and the frequency increases.
B) The speed decreases and the frequency remains the same.
C) The speed increases and the frequency remains the same.
D) The speed increases and the frequency increases.

41. The diagram below represents a light ray reflecting from a plane mirror.

\[ \text{Light ray} \]
\[ \text{Plane mirror} \]

The angle of reflection for the light ray is
A) 50°  B) 65°  C) 35°  D) 25°

42. What is the speed of light \((f = 5.09 \times 10^{14} \text{ Hz})\) in flint glass?
A) \(1.81 \times 10^8 \text{ m/s}\)  B) \(1.97 \times 10^8 \text{ m/s}\)
C) \(3.00 \times 10^8 \text{ m/s}\)  D) \(4.98 \times 10^8 \text{ m/s}\)

43. A ray of monochromatic yellow light \((f = 5.09 \times 10^{14} \text{ Hz})\) passes from water through flint glass and into medium \(X\), as shown below.

\[ \text{Normal} \]
\[ \text{Water} \]
\[ \text{Flint glass} \]
\[ \text{Medium X} \]

The absolute index of refraction of medium \(X\) is
A) less than 1.33
B) greater than 1.33 and less than 1.52
C) greater than 1.52 and less than 1.66
D) equal to 1.66

44. Base your answer to the following question on the diagram and the information below.

Red light passing through a double slit is producing a stationary interference pattern on a screen as shown on the diagram.

\[ \text{Double-slit barrier} \]
\[ \text{Screen} \]

The interference pattern is produced because the light passing through the two slits is
A) diffracted  B) refracted
C) polarized  D) dispersed
15. In the diagram below, a ray of monochromatic light 
($\lambda = 5.9 \times 10^{-7}$ meter) reaches the boundary between medium $X$ and air and follows the path shown.

Normal

Air

Medium $X$

90°

49°

Which medium is most likely medium $X$?

A) flint glass  
B) diamond  
C) Lucite  
D) water