**Waves and Optics Version Whiskey Alfa Oscar**

**True/False**

*Indicate whether the statement is true or false.*

\_\_\_\_ 1. The incident angle is the angle formed between a barrier and the direction of wave propagation.

\_\_\_\_ 2. A point on a wave completes one cycle every 5 seconds. The frequency of this wave is 1/5 seconds.

\_\_\_\_ 3. The angle at which a light ray reflects off a smooth surface depends on its wavelength.

\_\_\_\_ 4. The *normal* with regard to reflection is perpendicular to the surface of a plane mirror.

\_\_\_\_ 5. A convex mirror forms a virtual, diminished, and upright image for all real objects regardless of the location of the object.

\_\_\_\_ 6. A concave mirror of focal length 10 cm forms an upright and diminished image of a real object placed at a distance of 5 cm from the mirror.

\_\_\_\_ 7. The angle at which a light ray reflects off a smooth surface depends on its wavelength.

\_\_\_\_ 8. The *normal* with regard to reflection is perpendicular to the surface of a plane mirror.

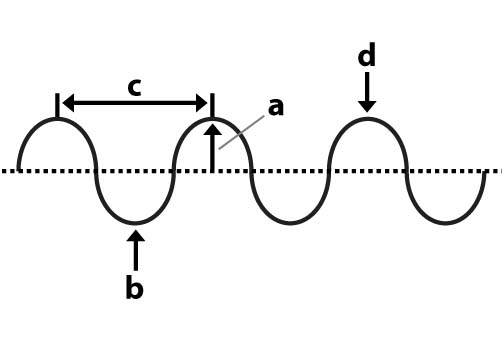
\_\_\_\_ 9. The virtual image produced by a plane mirror appears to be the same distance away from the mirror as the object itself.

\_\_\_\_ 10. The angle of incidence of a light ray on a concave mirror is the same as the angle of reflection of that light ray.

**Well that wasn’t so bad was it? Just kidding, the next question has a rather large diagram so the continues on the back side of this page. Best of luck!!!!**

**Multiple Choice**

*Identify the choice that best completes the statement or answers the question.*



\_\_\_\_ 11. In the diagram, the amplitude of the wave is shown by:

|  |  |  |  |
| --- | --- | --- | --- |
| a. | c | c. | b |
| b. | d | d. | a |

\_\_\_\_ 12. In the diagram, the crest of the wave is shown by:

|  |  |  |  |
| --- | --- | --- | --- |
| a. | c | c. | b |
| b. | d | d. | a |

\_\_\_\_ 13. In the diagram, the wavelength is shown by:

|  |  |  |  |
| --- | --- | --- | --- |
| a. | c | c. | b |
| b. | d | d. | a |

\_\_\_\_ 14. If wavelength is kept constant, which increases as the speed of a wave increases?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | period | c. | amplitude |
| b. | frequency | d. | phase |

\_\_\_\_ 15. Which shows the correct angle of reflection given the incident ray shown?

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 16. Tapping the surface of a pan of water generates 17.5 waves per second. If the wavelength of each wave is 45 cm, what is the speed of the waves?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 7.9 m/s | c. | 39 m/s |
| b. | 790 m/s | d. | 2.6 m/s |

\_\_\_\_ 17. A bell with a fundamental frequency of 880 Hz is moving toward an observer at 3.5 m/s. If the speed of sound is 343 m/s, what pitch would be heard by the observer?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 871 Hz | c. | 880 Hz |
| b. | 889 Hz | d. | 884 Hz |

\_\_\_\_ 18. A factory whistle blows at a frequency of 1216 HZ. What pitch will the passengers of a car moving at 28 m/s away from the whistle hear if the speed of sound is 343 m/s.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 1315 Hz | c. | 1188 Hz |
| b. | 1324 Hz | d. | 1117 Hz |

\_\_\_\_ 19. A fire engine is moving south at 35 m/s while blowing its siren at a frequency of 400 Hz. What pitch will the passengers in a car that has already passed the fire engine hear if the car is traveling north at 18 m/s? Use 343 m/s for the speed of sound.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 473 Hz | c. | 380 Hz |
| b. | 338 Hz | d. | 421 Hz |

\_\_\_\_ 20. Which of the following ray diagrams is correct?

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 21. What is the size and position of an image formed by a plane mirror?

|  |  |
| --- | --- |
| a. | same size, closer to the mirror |
| b. | same size, same distance away from the mirror |
| c. | enlarged, closer to the mirror |
| d. | reduced, farther from the mirror |

\_\_\_\_ 22. If di= do, then what is the meaning of the negative sign?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | the image is inverted | c. | the image is smaller |
| b. | the image is virtual | d. | the image is larger |

\_\_\_\_ 23. Under which conditions does a concave mirror produce an enlarged virtual image?

|  |  |
| --- | --- |
| a. | never |
| b. | when the object is farther away than the focal point |
| c. | when the object is farther away than the radius of curvature |
| d. | when the object is between the focal point and the mirror |

\_\_\_\_ 24. A concave mirror produces a smaller, inverted, real image. Which is true regarding the image distance?

|  |  |
| --- | --- |
| a. | It is between the radius of curvature and the focal point. |
| b. | It is closer to the mirror than the focal point. |
| c. | It is at the focal point. |
| d. | It is farther away than the radius of curvature. |

\_\_\_\_ 25. A concave mirror produces a larger, inverted, real image. Which is true regarding the image distance?

|  |  |
| --- | --- |
| a. | It is between the radius of curvature and the focal point. |
| b. | It is closer to the mirror than the focal point. |
| c. | It is at the focal point. |
| d. | It is farther away than the radius of curvature. |

\_\_\_\_ 26. The ratio of di to do for a certain mirror is 2.5. Which is true of an image produced by this mirror?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | It is 2.5 times larger and virtual. | c. | It is 2.5 times smaller and virtual. |
| b. | It is 2.5 times larger and real. | d. | It is 2.5 times larger and real. |

\_\_\_\_ 27. Which of the following ray diagrams is correct?

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 28. Which is formed by convergent rays?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | virtual image | c. | focal point |
| b. | real image | d. | object |

\_\_\_\_ 29. By definition, which has type of mirror has its edges curved toward the object?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | plane mirror | c. | convex mirror |
| b. | concave mirror | d. | spherical mirror |

\_\_\_\_ 30. Which type of mirror has its edges curved away from the object?

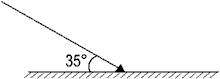
|  |  |  |  |
| --- | --- | --- | --- |
| a. | plane mirror | c. | convex mirror |
| b. | concave mirror | d. | spherical mirror |

\_\_\_\_ 31. Which type of image is produced by a convex mirror?

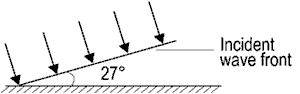
|  |  |  |  |
| --- | --- | --- | --- |
| a. | enlarged and real | c. | enlarged and virtual |
| b. | reduced and virtual | d. | reduced and real |

**Short Answer**

32. What is the angle of incidence of the ray shown below? (1)



33. What is the angle of reflection for the incident rays shown below? (1)



34. Besides a plane mirror, what type of mirror is used as a rear view mirror in cars and why? (2)

35. A lifeguard on a beach observes that waves have a speed of 2.60 m/s and a distance of 2.50 m between wave crests. What is the period of the wave motion? (3)

36. The graph below displays how displacement varies with time when a wave passes a fixed point at a speed of 12.0 m/s. Calculate the frequency and wavelength of the wave. (6, 3 for freq and3 for wave)



37. How fast should a car move toward you for the car’s horn to sound 2.88% higher in frequency than when the car is stationary? The speed of sound is 343 m/s. DON’T OVER THINK THIS!!!! (4)

38. A car moving at 16.0 m/s, passes an observer while its horn is pressed. Find the difference between the frequencies of sound heard when the car approaches and when it recedes from the stationary observer. The velocity of sound is 343 m/s and the frequency of the sound of the car’s horn is 583 Hz. This is only a level 3 so again, don’t over think this problem. (5)

39. A 5.0-cm real object is placed at a distance of 30.0 cm from a concave mirror of focal length 10.0 cm. Find the location and size of the image.(3)

40. What must be the minimum height of a plane mirror so that a boy of height 162 cm can view himself from head to toe? (1)

41. A light beam in air (n=1.0003) hits a sheet of crown glass (n=1.52) at an angle of 30 degrees. What is the angle the light beam will refract at?(3) FOR INDICES REFER TO PAGE 1

42. A block of unknown material is submerged in water. Light in the water is incident on the block at an angle of 31 degrees. The light then refracts at an angle of 27 degrees. What is the material of the block in the water? (3) FOR INDICES REFER TO PAGE 1

43. A beam of light strikes ethanol and refracts at a 90 degree angle. If that beam strikes at an angle of 57 degree’s what is the medium is travels through? (3) FOR INDICES REFER TO PAGE 1

44. Explain how surface waves can have characteristics of both longitudinal waves and transverse waves. (3)

45. BONUS!!!!!!! If 3 =3, 7=7 , 17 = 6 and 13= 2, what would 47 equal?

**Waves and Optics Final**

**Answer Section**

**TRUE/FALSE**

1. ANS: F

The incident angle is formed between a line perpendicular to the barrier and the direction of wave propagation.

PTS: 1 DIF: Bloom's Level 2 REF: p. 387

NAT: B.5

2. ANS: T

The frequency of a wave equals the inverse of the period of that wave.

PTS: 1 DIF: Bloom's Level 3 REF: pp. 383-384

NAT: B.6

3. ANS: F

The angle at which a light ray reflects off a smooth surface depends only on its angle of incidence.

PTS: 1 DIF: Bloom's Level 2 REF: p. 458

NAT: B.6

4. ANS: T

A normal is perpendicular to a surface.

PTS: 1 DIF: Bloom's Level 2 REF: p. 458

NAT: B.6

5. ANS: T

The focus of a convex mirror lies behind the mirror.

PTS: 1 DIF: Bloom's Level 1 REF: Page 473

OBJ: 17.2.2 Describe properties and uses of curved mirrors.

TOP: Describe properties and uses of curved mirrors. KEY: Convex mirror

MSC: 1 NOT: /T/ Correct! /F/ The focus of a convex mirror lies behind the mirror.

6. ANS: F

A concave mirror produces an upright, virtual, and magnified image of a real object placed between the focus and the mirror.

PTS: 1 DIF: Bloom's Level 1 REF: Page 473

OBJ: 17.2.3 Determine the locations and sizes of curved mirror images.

TOP: Determine the locations and sizes of curved mirror images.

KEY: Concave mirror MSC: 1

NOT: /T/ A concave mirror produces an upright but magnified image of a real object placed between the focus and the mirror. /F/ Correct!

7. ANS: F

The angle at which a light ray reflects off a smooth surface depends only on its angle of incidence.

PTS: 1 DIF: Bloom's Level 2 REF: p. 458

NAT: B.6

8. ANS: T

A normal is perpendicular to a surface.

PTS: 1 DIF: Bloom's Level 2 REF: p. 458

NAT: B.6

9. ANS: T

A virtual image produced by a plane mirror appears to be as far behind the plane mirror as the object is in front of it.

PTS: 1 DIF: Bloom's Level 2 REF: p. 461

NAT: B.6

10. ANS: T

The law of reflection states that the angle of incidence equals the angle of reflection.

PTS: 1 REF: p. 458 NAT: B.6

**MULTIPLE CHOICE**

11. ANS: A

The amplitude of a wave is half the height of the wave from crest to trough.

PTS: 1 DIF: Bloom's Level 2 REF: pp. 382-383

NAT: B.6

12. ANS: D

The crest of a wave is the top of the wave.

PTS: 1 DIF: Bloom's Level 2 REF: p. 383

NAT: B.6

13. ANS: B

The wavelength of a wave is the distance between successive crests.

PTS: 1 DIF: Bloom's Level 2 REF: p. 383

NAT: B.6

14. ANS: B

wave speed = 

PTS: 1 DIF: Bloom's Level 4 REF: p. 384

NAT: B.6

15. ANS: C

The angle of incidence equals the angle of reflection.

PTS: 1 DIF: Bloom's Level 4 REF: pp. 390-391

NAT: B.6

16. ANS: A



PTS: 1 DIF: Bloom's Level 3 REF: p. 384

NAT: UCP.3

17. ANS: B

The sound becomes higher in pitch as its source moves toward an observer.

PTS: 1 DIF: Bloom's Level 3 REF: pp. 407-408

NAT: UCP.3

18. ANS: D

The pitch of a sound decreases as an observer moves away from the sound source.

PTS: 1 DIF: Bloom's Level 3 REF: pp. 407-408

NAT: UCP.3

19. ANS: B

The observers are moving away from the sound source at 35 m/s + 18 m/s.



PTS: 1 DIF: Bloom's Level 3 REF: pp. 407-408

NAT: UCP.3

20. ANS: D

Use the laws of reflection.

|  |  |
| --- | --- |
|  | **Feedback** |
| **A** | A ray incident on the mirror passing through the focus must return parallel to its principal axis. |
| **B** | A ray incident on a mirror parallel to its principal axis does not reflect along the radius of curvature. |
| **C** | A ray pointing to the focus of a mirror does not reflect along the radius of curvature. |
| **D** | Correct! |

PTS: 1 DIF: Bloom's Level 2 REF: Page 465

OBJ: 17.2.1 Explain how concave and convex mirrors form images.

TOP: Explain how concave and convex mirrors form images. KEY: Concave mirror

MSC: 2

NOT: /a/ A ray incident on the mirror passing through the focus must return parallel to its principal axis. /b/ A ray incident on a mirror parallel to its principal axis does not reflect along the radius of curvature. /c/ A ray pointing to the focus of a mirror does not reflect along the radius of curvature. /d/ Correct!

21. ANS: B

A plane mirror produces images that are the same size and equidistant from the mirror as the object.

PTS: 1 DIF: Bloom's Level 3 REF: p. 473

NAT: B.6

22. ANS: B

The negative sign in the relationship  indicates the image is virtual.

PTS: 1 DIF: Bloom's Level 3 REF: p. 462

NAT: B.6

23. ANS: D

A concave mirror produces an enlarged virtual image when the object is between the focal point and the mirror.

PTS: 1 DIF: Bloom's Level 3 REF: p. 473

NAT: B.6

24. ANS: A

When an object is placed between the radius of curvature and the focal point of a concave mirror, the resulting image is reduced and inverted.

PTS: 1 DIF: Bloom's Level 3 REF: p. 473

NAT: B.6

25. ANS: D

When an object is placed farther from a concave mirror than the radius of curvature, the resulting image is larger, inverted, and real.

PTS: 1 DIF: Bloom's Level 3 REF: p. 473

NAT: B.6

26. ANS: A

When , the image is 2.5 times larger and virtual.

PTS: 1 DIF: Bloom's Level 3 REF: p. 468

NAT: B.6

27. ANS: A

Use the laws of reflection.

|  |  |
| --- | --- |
|  | **Feedback** |
| **A** | Correct! |
| **B** | A ray incident on a mirror passing through the focus of a mirror does not reflect back along the same line. |
| **C** | A ray must be incident through the focus of a mirror to reflect parallel to the principal axis. |
| **D** | A ray cannot pass through an opaque object like a mirror. |

PTS: 1 DIF: Bloom's Level 2 REF: Page 465

OBJ: 17.2.1 Explain how concave and convex mirrors form images.

TOP: Explain how concave and convex mirrors form images. KEY: Convex mirror

MSC: 2

NOT: /a/ Correct! /b/ A ray incident on a mirror passing through the focus of a mirror does not reflect back along the same line. /c/ A ray must be incident through the focus of a mirror to reflect parallel to the principal axis. /d/ A ray cannot pass through an opaque object like a mirror.

28. ANS: B

Real images are formed by convergent rays.

PTS: 1 DIF: Bloom's Level 2 REF: p. 465

NAT: B.6

29. ANS: B

The edges of a concave mirror are curved toward the object.

PTS: 1 DIF: Bloom's Level 2 REF: p. 464

NAT: B.6

30. ANS: C

The edges of a convex mirror are curved away from the object.

PTS: 1 DIF: Bloom's Level 2 REF: p. 471

NAT: B.6

31. ANS: B

A convex mirror always produces a reduced and virtual image.

PTS: 1 DIF: Bloom's Level 3 REF: p. 473

NAT: B.6

**SHORT ANSWER**

32. ANS:

55°

PTS: 1 DIF: Bloom's Level 1 REF: Page 458

OBJ: 17.1.1 Explain the law of reflection. TOP: Explain the law of reflection.

KEY: Angle of incidence MSC: 1

NOT: The angle of incidence is the angle made by the incident ray with the normal to the reflecting surface at the point of incidence.

33. ANS:

27°

PTS: 1 DIF: Bloom's Level 2 REF: Page 458

OBJ: 17.1.1 Explain the law of reflection. TOP: Explain the law of reflection.

KEY: Angle of incidence MSC: 2

NOT: The angle of incidence is the angle made by the incident ray with the normal to the reflecting surface at the point of incidence. The angle of reflection is equal to the angle of incidence. By simple geometry, it can be shown that the angle between the wavefront and the reflecting surface is the same as the angle of incidence.

34. ANS:

A convex mirror can be used as a rear view mirror, because it produces an upright image of objects regardless of position and offers a wide field of view.

PTS: 1 DIF: Bloom's Level 2 REF: Page 471

OBJ: 17.2.2 Describe properties and uses of curved mirrors.

TOP: Describe properties and uses of curved mirrors. KEY: Convex mirror

MSC: 3

NOT: Convex mirrors produce images that are smaller than the objects. This increases the field of view for observers.

**PROBLEM**

35. ANS:

0.962 s

PTS: 1 DIF: Bloom's Level 2 REF: Page 384

OBJ: 14.2.3 Relate wave speed, wavelength, and frequency.;

TOP: Relate wave speed, wavelength, and frequency.; KEY: Wavelength, Wave speed, Period

MSC: 3

NOT: Use the relationship between the wavelength and frequency of a wave. The period of a wave is the reciprocal of the frequency.

36. ANS:

Frequency = 0.400 Hz

Wavelength = 30.0 m

PTS: 1 DIF: Bloom's Level 3 REF: Page 381

OBJ: 14.2.3 Relate wave speed, wavelength, and frequency.;

TOP: Relate wave speed, wavelength, and frequency.;

KEY: Wave speed, Wavelength, Frequency MSC: 3

NOT: The graph can be used to find the time period of the wave. The reciprocal of time period is the frequency of the wave. The wavelength is equal to the velocity divided by the frequency.

37. ANS:

9.60 m/s

PTS: 1 DIF: Bloom's Level 3 REF: Page 403 | Page 407

OBJ: 15.1.3 Identify some applications of the Doppler effect.

TOP: Identify some applications of the Doppler effect. KEY: Doppler effect

MSC: 3

NOT: When a sound source moves toward you, the wavelength of the sound decreases. The apparent frequency is higher than the true frequency.

38. ANS:

54.5 Hz

PTS: 1 DIF: Bloom's Level 3 REF: Page 403 | Page 407

OBJ: 15.1.3 Identify some applications of the Doppler effect.

TOP: Identify some applications of the Doppler effect. KEY: Doppler effect

MSC: 3

NOT: When the sound source approaches an observer, the observer receives waves of a shorter wavelength. However, when the sound source recedes from the observer, the observer receives waves of a larger wavelength.

39. ANS:

A 2.5-cm image is formed 15 cm in front of the mirror.

PTS: 1 DIF: Bloom's Level 2 REF: Page 468

OBJ: 17.2.3 Determine the locations and sizes of curved mirror images.

TOP: Determine the locations and sizes of curved mirror images.

KEY: Concave mirror MSC: 2

NOT: Use the mirror formula to find the image distance and then calculate the magnification.

40. ANS:

81 cm

PTS: 1 DIF: Bloom's Level 1 REF: Page 462

OBJ: 17.1.3 Locate the images formed by plane mirrors.

TOP: Locate the images formed by plane mirrors. KEY: Plane mirror

MSC: 1

NOT: The minimum height of a plane mirror required for a boy to view himself from head to toe is half the boy's height.

41. ANS:

Solve for the angle associated with crown glass. Inverse function of 1.0003 x sin(30) / 1.52. Answer is 19.2 degrees

PTS: 1

42. ANS:

the index is 1.5 so something close to crown glass.

PTS: 1

43. ANS:

1.36 / sin 57 answer is 1.62 so flint gas

PTS: 1

**ESSAY**

44. ANS:

Surface waves, like deep water waves, have characteristics of longitudinal waves. The motion of a particle in the wave is parallel to the motion of the wave. This can be seen by an object on the surface approaching then retreating from an observer at the wave source. Waves on the surface also have characteristics of transverse waves because the surface of the water undulates, or rises and falls. This can be seen as an object on the surface of the water bobs up and down. The overall motion of particles in surface waves is to trace a circular path.

PTS: 1 DIF: Bloom's Level 5 REF: p. 382

NAT: B.6

45. ANS:

Maria is not correct. The law of reflection applies to all surfaces that are struck by light. The reason that rough-surfaced objects produce diffuse reflections is that there are many different points at which light rays hit the surface. Each ray strikes the surface at a different angle of incidence, so the angles of reflection are also all different. This produces scattering of light rather than one smooth reflected beam of light.

PTS: 1 DIF: Bloom's Level 6 REF: pp. 458-459

NAT: B.6