1. Which is a scalar quantity

   a) displacement   b) distance   c) force   d) acceleration

2. A group of bike riders took a 4.0 hour trip. During the first 3.0 hours, they traveled a total of 50 kilometers, but during the last hour they traveled only 10 kilometers. What was the group's average speed for the entire trip?

   a) $15\,\text{km/hr}$ b) $30\,\text{km/hr}$ c) $40\,\text{km/hr}$ d) $60\,\text{km/hr}$

3. A car accelerates uniformly from rest to a speed of 10 meters per second in 2 seconds. The acceleration of the car is

   a) $0.2\,\text{m/sec}^2$ b) $5\,\text{m/sec}^2$ c) $10\,\text{m/sec}^2$ d) $20\,\text{m/sec}^2$

4. An object starting from rest accelerates at a rate of 3.0 meters/seconds squared for 6.0 seconds. The velocity of the object at the end of this time is

   a) $0.50\,\text{m/s}$ b) $2.0\,\text{m/s}$ c) $3.0\,\text{m/s}$ d) $18\,\text{m/s}$

5. An object near the surface of planet X falls freely from rest and reaches a speed of 12.0 meters per second after it has fallen 14.4 meters. What is the acceleration due to gravity on planet X?

   a) $2.50\,\text{m/s}^2$ b) $5.00\,\text{m/s}^2$ c) $9.80\,\text{m/s}^2$ d) $10.0\,\text{m/s}^2$

6. A clam dropped by a sea gull takes 3.0 seconds to hit the ground. What is the sea gull's approximate height above the ground at the time the clam was dropped?

   a) $15\,\text{m}$ b) $30\,\text{m}$ c) $45\,\text{m}$ d) $90\,\text{m}$

7. A boat initially traveling at 10 meters per second accelerates uniformly at the rate of 5.0 meters per second^2 for 10 seconds. How far does the boat travel during this time?

   a) $50\,\text{m}$ b) $250\,\text{m}$ c) $350\,\text{m}$ d) $500\,\text{m}$

8. If an unbalanced force of 12 newtons acts on a 6-kilogram mass, the acceleration of the mass is

   a) $0.5\,\text{m/sec}^2$ b) $2\,\text{m/sec}^2$ c) $10\,\text{m/sec}^2$ d) $72\,\text{m/sec}^2$

9. As the unbalanced force exerted on an object is increased, the object's acceleration will

   a) decrease   b) increase   c) remain the same

10. Which unbalanced force acting on a 4.0-kilogram object will produce an acceleration of $8.0\,\text{m/sec}^2$?

    a) 32 newtons   b) 2.0 newtons   c) 0.50 newtons   d) 4 newtons

11. An unbalanced force of 2 newtons applied to a given mass produces an acceleration. If an unbalanced force of 1 newton is applied to the same mass, the acceleration produced will be

    a) the same   b) twice as much   c) one-half as much   d) four times as much

12. In the diagram shown, surface A of the wooden block has twice the area of surface B. If it takes F newtons to keep the block moving at constant speed across the table when it slides on surface A, what force is needed to keep the block moving at constant speed when it slides on surface B?

    a) F b) $2F$ c) $\frac{1}{2}F$ d) $4F$
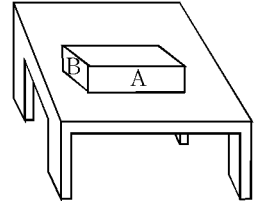
13. Four forces are acting on an object as shown in the diagram. If the object is moving with a constant velocity, the magnitude of force F must be

   a) 0 N   b) 20 N   c) 100 N   d) 40 N
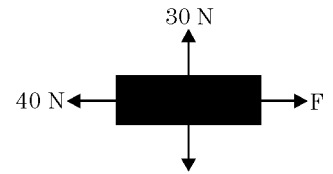
14. A box decelerates as it moves to the right along a horizontal surface, as shown in the diagram. Which vector best represents the force of friction on the box?

    a) ↓   b) ↑   c) $\longrightarrow$ d) $\longleftarrow$

15. Two forces are applied to a 2.0-kilogram block on a frictionless, horizontal surface, as shown in the diagram. The acceleration of the block is

    a) $5.0\,\mathrm{m/s^2}$ to the right   b) $5.0\,\mathrm{m/s^2}$ to the left

    c) $3.0\,\mathrm{m/s^2}$ to the right   d) $3.0\,\mathrm{m/s^2}$ to the left
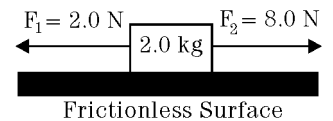
16. A 3.0-kilogram mass weighs 15 newtons at a given point in the Earth's gravitational field. What is the magnitude of the acceleration due to the gravity at this point?

    a) $45\,\mathrm{m/s^2}$ b) $9.8\,\mathrm{m/s^2}$ c) $5.0\,\mathrm{m/s^2}$ d) $0.20\,\mathrm{m/s^2}$

17. As shown in the diagram, an inflated balloon released from rest moves horizontally with velocity v. The velocity of the balloon is most likely caused by

    a) action-reaction   b) centripetal force

    c) gravitational attraction   d) rolling friction
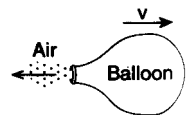
18. Within a vacuum, the property common to all electromagnetic waves is their
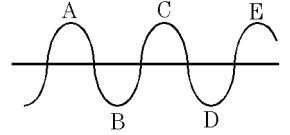
    a) amplitude   b) frequency   c) wavelength   d) velocity

19. Which characteristic is determined by the source of a wave and will not change when the wave passes into another medium?

    a) frequency   b) wavelength   c) velocity   d) amplitude

20. Periodic waves are being produced in a ripple tank. As the rate at which the waves are produced is increased, the wavelength of the waves will

    a) decrease   b) increase   c) remain the same

21. In the wave diagram shown, one wavelength is the distance from point A to which point?

    a) E b) B c) C d) D

22. Two waves have the same frequency in a medium. The wave with the greater energy has the greater

    a) amplitude   b) velocity   c) wavelength   d) period

23. If the velocity of a constant-frequency wave increases, the wavelength

    a) decreases   b) increases   c) remains the same

24. Water drips from a faucet at the rate of 150 drops in 120 seconds. What is the period?

    a) $0.80 \, \sec$ b) $1.3 \, \sec$ c) $75 \, \sec$ d) $300 \, \sec$

25. If the displacement of particles in a medium is parallel to the direction of travel of the wave, the wave is classified as
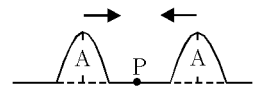
    a) electromagnetic   b) torsional   c) transverse   d) longitudinal

26. What is the period of a wave with a frequency of 2.0×10^2 hertz?

    a) $6.0 \times 10^{-10} \, \text{s}$ b) $2.0 \times 10^{-3} \, \text{s}$ c) $5.0 \times 10^{-3} \, \text{s}$ d) $1.5 \times 10^6 \, \text{s}$

27. The diagram shown represents a rope along which two pulses of equal amplitude, A, approach point P. When the two pulses meet at P, the vertical displacement of the rope at point P will be
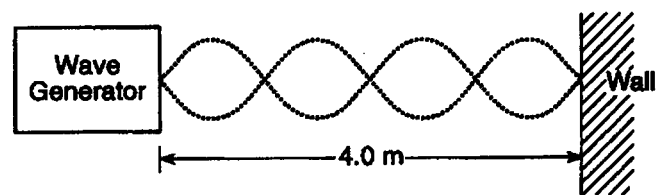
    a) A b) $2A$ c) 0 d) $\dfrac{A}{2}$

28. A wave generator located 4.0 meters from a reflecting wall produces a standing wave in a string, as shown in the diagram.

    If the speed of the wave is 10 meters per second, what is its frequency?

    a) $0.40 \, \text{Hz}$ b) $5.0 \, \text{Hz}$ c) $10 \, \text{Hz}$ d) $40 \, \text{Hz}$

29. A train sounding its whistle is moving rapidly away from an observer. The frequency the observer hears appears to

    a) decrease   b) increase   c) remain the same

30. A term often used to describe the frequency of a sound is

    a) amplitude   b) volume   c) pitch   d) tone

31. When the sound made by one tuning fork causes another tuning fork to vibrate, the principle demonstrated is

    a) reflection   b) refraction   c) interference   d) resonance

32. 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

    a) frequency   b) speed   c) amplitude   d) wavelength

33. The speed of sound in air on a day when the temperature is $20°$ C will be

    a) $316 \, \mathrm{m/sec}$ b) $330 \, \mathrm{m/sec}$ c) $344 \, \mathrm{m/sec}$ d) $358 \, \mathrm{m/sec}$

34. The loudness of a sound is dependent upon which wave property?

    a) wavelength   b) amplitude   c) frequency   d) pitch

35. A tuning fork of 256 vibrations per second is sounded in air at $20.0°$ C. The wavelength of the sound produced is

    a) $0.744 \, \mathrm{m}$ b) $1.34 \, \mathrm{m}$ c) $12.8 \, \mathrm{m}$ d) $344 \, \mathrm{m}$

36. In general, compared to the speed of sound through air, the speed of sound through liquids and solids is

    a) slower   b) faster   c) the same

37. Sound can *not* be transmitted through a

    a) gas   b) liquid   c) solid   d) vacuum

38. Light travels from medium A where its speed is 2.5×10^8 meters per second into medium B where its speed is 2.0×10^8 meters per second. Compared to the absolute index of refraction of medium A, the absolute index of refraction of medium B is

    a) less   b) greater   c) the same

39. A prism disperses white light, forming a spectrum. The best explanation for this phenomenon is that different frequencies of visible light

    a) move at different speeds in the prism

    b) are reflected inside the prism

    c) are absorbed inside the prism

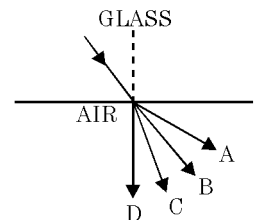   d) undergo constructive interference inside the prism

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

    a) Its speed decreases, its wavelength becomes smaller, and its frequency remains the same.

    b) Its speed decreases, its wavelength becomes smaller, and its frequency increases.

    c) Its speed increases, its wavelength becomes larger, and its frequency remains the same.

    d) Its speed increases, its wavelength becomes larger, and its frequency decreases.

41. The speed of light in a material is 2.5×10^8 meters per second. What is the absolute index of refraction of the material?

    a) 1.2   b) 2.5   c) 7.5   d) 0.83

42. The diagram shows a ray of light being refracted as it passes from air into glass. Which letter represents the angle of refraction for the light ray?

    a) A b) B c) C d) D
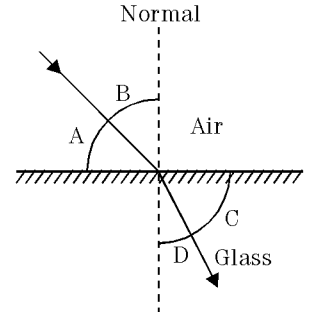
43. A ray of light emerges from a glass block into air as shown in the diagram. Which path would the light ray take?

    a) A b) B c) C d) D

44. Which diagram best illustrates wave refraction?

    a)   b)   c)   d)

45. The critical angle for a monochromatic light ray traveling from a dispersive material into air is 45°. What is the index of refraction for the material?

    a) 2.41   b) 1.71   c) 1.41   d) 0.707

46. Refraction of a wave is caused by a change in the wave's

    a) amplitude   b) frequency   c) speed   d) phase

47. In the diagram, a ray of light enters a transparent medium from air. If angle X is 45° and angle Y is 30°, what is the absolute index of refraction of the medium?

    a) 0.667   b) 0.707   c) 1.41   d) 1.50

48. The diagram shows a ray of light passing from medium X into air. What is the absolute index of refraction of medium X?

    a) 0.50   b) 2.0   c) 1.7   d) 0.58

49. A ray of light in air is incident on a block of Lucite at an angle of 60° from the normal. The angle of refraction of this ray in the Lucite is closest to

    a) 35°   b) 45°   c) 60°   d) 75°

50. If the critical angle for a substance is 44°, the index of refraction of the substances is equal to

   a) 1.0   b) 0.69   c) 1.4   d) 0.023

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

    What occurs as the light travels from alcohol into flint glass?
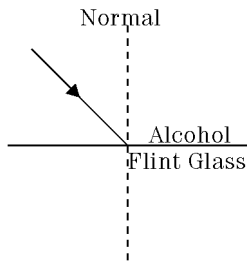
    a) The speed of the light decreases and the ray bends toward the normal.

    b) The speed of the light decreases and the ray bends away from the normal.

    c) The speed of the light increases and the ray bends toward the normal.

    d) The speed of the light increases and the ray bends away from the normal.

52. 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 the flint glass. Which diagram best represents the path of this light ray?
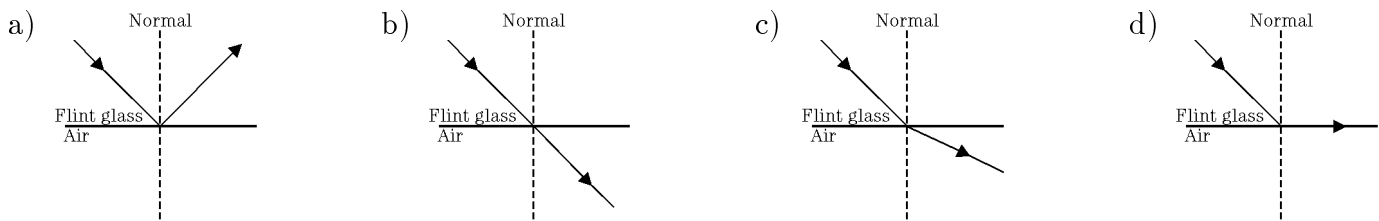
53. How does the speed of a mechanical wave change in a uniform rope if you increase the frequency?

    a) Speed increases   b) Speed decreases

    c) Speed remains the same   d) Speed depends on amplitude

54. As the tension in a spring increases, the speed _____ .

    a) increases   b) decreases   c) remains the same   d) accelerates

55. An observer hears a frequecy 3.75×10^5 Hz. The source frequency is 5.97×10^4 Hz. Which one of the following best describes the situation?

    a) The source is moving faster than the speed of sound.

    b) The separation between the source and the observer is increasing.

    c) The separation between the source and the observer is decreasing.

    d) The observer is stationary.

56. A fighter plane is travelling at $\frac{2}{3}$ the speed of sound and approaches a stationary observer. What is the ratio of f_o to f_s?

    a) $\frac{3}{1}$　　　　　　b) $\frac{2}{3}$　　　　　　c) $\frac{3}{2}$　　　　　　d) $\frac{1}{3}$

57. What fraction of the speed of sound must an object be travelling if a stationary observer detects a frequency 4.5 times higher than the source frequency?

    a) $\frac{9}{7}$　　　　　　b) $\frac{5}{7}$　　　　　　c) $\frac{7}{5}$　　　　　　d) $\frac{7}{9}$

58. An echo is heard 3.5 s later. What is the distance to the cliff is the air temperature is 0.0° C?

    a) 579 m　　　　　　b) 1159 m　　　　　　c) 290 m　　　　　　d) 680 m

59. A sonic boom is heard when _____ .

    a) an object makes a loud sound.

    b) two objects approach each other very quickly.

    c) an object travels slower than the local speed of sound.

    d) an object travels faster than the local speed of sound.

60. What electromagnetic wave carries with it the most energy?

    a) X-rays.　　　　　　b) Radio.　　　　　　c) Yellow light.　　　　　　d) Microwaves.

61. Which one of the following waves has the longest wavelength?

    a) Gamma rays　　　　　　b) Radio waves　　　　　　c) Infrared waves.　　　　　　d) Ultraviolet waves.

62. Light is traveling from water to Plexiglas, what is the largest possible angle of refraction?

    a) 61.7°

    c) 90.0°

    b) 28.3°

    d) total internal reflection occurs

63. In zircon, green light has a wavelength of 273 nm and index of refraction of 1.92. What is the wavlength of green light in air?

    a) 364 nm　　　　　　b) 273 nm　　　　　　c) 142 nm　　　　　　d) 524 nm

64. How many times faster does light travel in fused quartz than in diamond?

    a) 0.603　　　　　　b) 1.66　　　　　　c) 2.42　　　　　　d) 0.960

65. In which one of the following does light travel the fastest?

    a) Glycerin　　　　　　b) Zircon　　　　　　c) Plexiglas　　　　　　d) Ruby