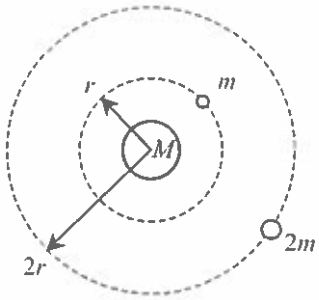
Questions 40–41

Two planets are observed orbiting a star. The star has a mass of M. The smaller planet has a mass of m and is orbiting at a radius of r. The larger planet has twice the mass, $2m$, of the smaller planet and is orbiting at twice the distance, $2r$, as measured from the center of the star.



40. What is the ratio of the force of gravity acting between the central star and planet m compared with the force of gravity acting between the central star and planet $2m$?

(A) $\frac{1}{4}$

(B) $\frac{1}{3}$

(C) $\frac{1}{1}$

(D) $\frac{2}{1}$

(E) $\frac{4}{1}$

41. Which statement is true?

(A) Planet m has a faster tangential speed and a longer orbital period, T.
(B) Planet m has a faster tangential speed and a shorter orbital period, T.
(C) Planet m has a slower tangential speed and a longer orbital period, T.
(D) Planet m has a slower tangential speed and a shorter orbital period, T.
(E) Both planets have the same orbital period, T.

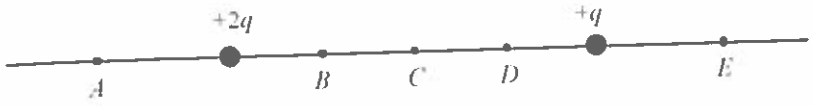
---

42. Two identical conducting spheres are initially separated. The left sphere has a negative 4-coulomb charge, and the right sphere has a positive 8-coulomb charge. The spheres are allowed to touch each other briefly, and then they are separated. Determine the charge on the left sphere.

(A) −4 C
(B) −2 C
(C) 0 C
(D) +2 C
(E) +4 C

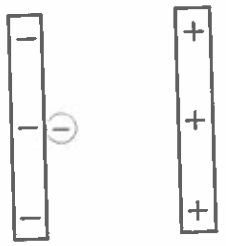
43. A proton and an electron are released from rest in the same uniform electric field. Assume the proton and electron do not interact with one another. How do the force and acceleration of the electron compare with that of the proton?

	Magnitude of Force	Direction of Force	Acceleration
(A)	Less	Same	Less
(B)	Less	Opposite	Less
(C)	Same	Same	Greater
(D)	Same	Opposite	Less
(E)	Same	Opposite	Greater



44. In the diagram above, two point charges, $+2q$ and $+q$, are held stationary. Determine the approximate location where the electric field is zero.

(A) A
(B) B
(C) C
(D) D
(E) E



45. Two charged plates have a potential difference, V, as shown in the diagram above. An electron with mass m and charge e is initially at the negative plate. The electron is accelerated through the potential difference and reaches a speed of v. The potential difference between the plates is doubled to $2V$. An electron accelerated through this potential difference will have a speed of

(A) $\frac{1}{2}v$
(B) v
(C) $\sqrt{2}\,v$
(D) $2v$
(E) $4v$

Questions 46–47

Two charged plates, each having a charge of 0.30 coulombs are separated by a distance of 10 centimeters. The plates have a potential difference of 6.0 volts.

46. Determine the magnitude of the electric field between the plates.

(A) 0.050 V/m
(B) 0.60 V/m
(C) 1.8 V/m
(D) 20 V/m
(E) 60 V/m

47. What is the capacitance of the charged plates?

(A) 0.050 F
(B) 0.60 F
(C) 1.8 F
(D) 20 F
(E) 60 F

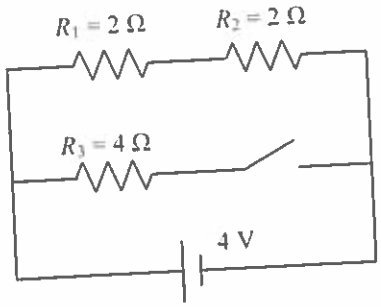
---

48. How does adding resistors in series affect total resistance, total current leaving the power source, and the total power consumed by the circuit?

	Resistance	Current	Power Consumed
(A)	Decreases	Decreases	Decreases
(B)	Decreases	Increases	Decreases
(C)	Decreases	Increases	Increases
(D)	Increases	Decreases	Decreases
(E)	Increases	Decreases	Increases

Questions 49–51

In the following diagram, the switch in the circuit below is initially open as shown.



49. What is the current flowing in the circuit initially, when the switch is open?

(A) 0.5 A
(B) 1.0 A
(C) 2.0 A
(D) 4.0 A
(E) 16.0 A

50. What is the total equivalent resistance of the circuit when the switch is closed?

(A) 1/2 Ω
(B) 3/4 Ω
(C) 4/3 Ω
(D) 2 Ω
(E) 4 Ω

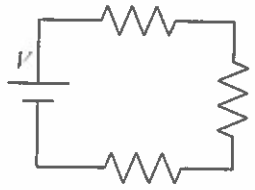
51. The resistors in the circuit above are actually lightbulbs. When the switch is closed, how is the brightness of lightbulb 1 (R_1) affected?

(A) The brightness is halved.
(B) The brightness doubles.
(C) The brightness is four times greater.
(D) The brightness is eight times greater.
(E) The brightness remains the same.

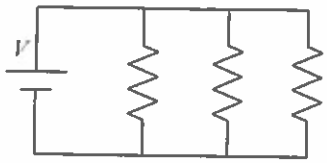
Questions 52–53

The circuits shown below all contain the same three identical resistors, each with resistance R, and the same identical battery with potential V.

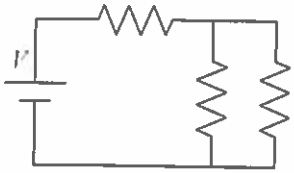
I



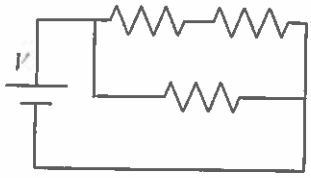
II



III



IV

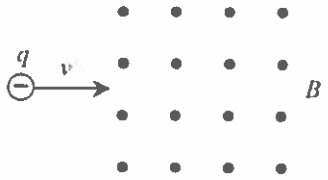


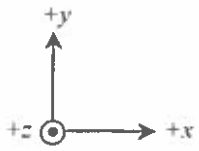
52. Which of the circuits will dissipate the most power?

(A) I only
(B) II only
(C) III only
(D) IV only
(E) They will each dissipate the same amount of power

53. Which of the circuits will have the same voltage, V, across each one of its resistors?

(A) I only
(B) II only
(C) III only
(D) I and II only
(E) III and IV only



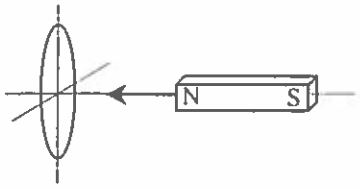


54. As shown in the diagram above, an electron with a charge of 1.6×10^{-19} coulombs is moving 1.0×10^{5} meters per second in the $+x$-direction. The electron enters a 2.0-tesla uniform magnetic field that is oriented in the $+z$-direction. What are the magnitude and direction of the force that acts on the electron at the instant it enters the magnetic field?

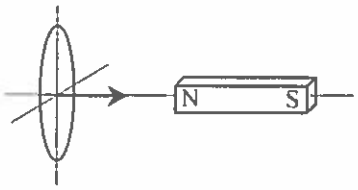
(A) 0.8×10^{-14} N, $+y$-direction
(B) 0.8×10^{-14} N, $-y$-direction
(C) 3.2×10^{-14} N, $+x$-direction
(D) 3.2×10^{-14} N, $+y$-direction
(E) 3.2×10^{-14} N, $-y$-direction

55. A loop of wire and a bar magnet are moving relative to one another. Which motion in the diagrams shown below will NOT induce a current in the loop?

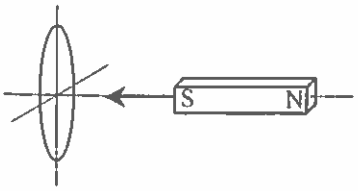
(A)



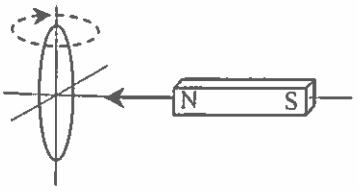
(B)



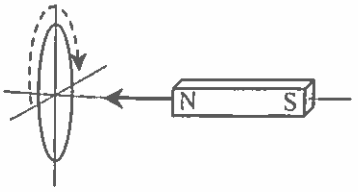
(C)



(D)



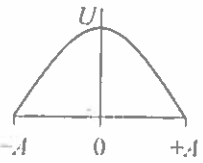
(E)

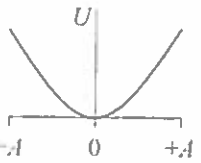


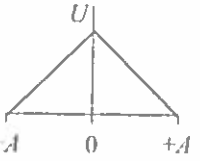
56. A mass m is attached to a spring and displaced from equilibrium. The mass is released, and the system begins to oscillate at frequency f. The mass is replaced with a new mass of $2m$ and is again displaced by the same amount. The new frequency of oscillation will be

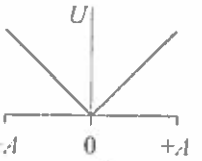
(A) $\frac{\sqrt{2}}{2}f$
(B) f
(C) $\sqrt{2}f$
(D) $2f$
(E) $4f$

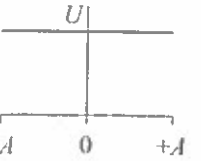
57. Which graph correctly depicts the potential energy, U, of a spring-mass system during an oscillation between a minimum amplitude of $-A$ and a maximum amplitude of $+A$?

(A)


(B)


(C)


(D)


(E)


58. When light enters a denser medium, its

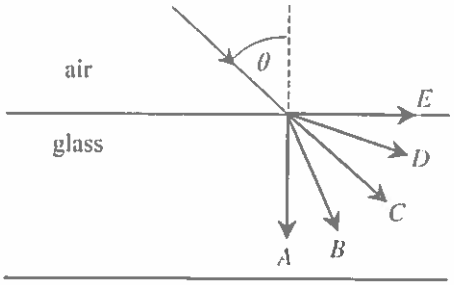
(A) speed decreases and its wavelength decreases
(B) speed decreases and its wavelength increases
(C) speed decreases but its wavelength remains constant
(D) speed increases and its wavelength decreases
(E) speed increases and its wavelength increases

59. During one complete cycle, a wave moves through

(A) 1/2 wavelength, 1 period, and 2 amplitudes
(B) 1/2 wavelength, 1 period, and 4 amplitudes
(C) 1 wavelength, 1 period, and 2 amplitudes
(D) 1 wavelength, 1 period, and 4 amplitudes
(E) 2 wavelengths, 1/2 period, and 2 amplitudes

60. A sound source is moving away from an observer. As compared with the actual wavelength and frequency of the waves, how would the observer describe the waves?

(A) They have shorter wavelengths and a lower frequency.
(B) They have shorter wavelengths and a higher frequency.
(C) They have shorter wavelengths and the same frequency.
(D) They have longer wavelengths and a lower frequency.
(E) They have longer wavelengths and a higher frequency.



61. In the diagram above, light moving in air enters a piece of glass at an angle of θ as measured from a normal drawn perpendicular to the surface of the glass. Which ray shows the path of the light in the glass?

(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) *E*

62. The image viewed by a pinhole camera is

(A) upright, smaller than the object, and real
(B) upright, larger than the object, and real
(C) inverted, smaller than the object, and real
(D) inverted, smaller than the object, and virtual
(E) inverted, larger than the object, and real

63. An object initially at a distance of $2f$ is moved away from the focal point, f, of a concave mirror, as shown in the diagram above. How is the image affected?

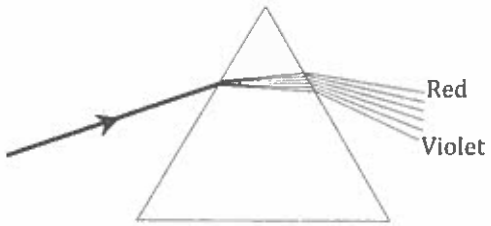
(A) The image size remains constant but moves away from the mirror.
(B) The image increases in size and moves away from the mirror.
(C) The image increases in size and moves toward the mirror.
(D) The image decreases in size and moves away from the mirror.
(E) The image decreases in size and moves toward the mirror.

64. Monochromatic light passes through two narrow slits and is projected onto a screen creating a double-slit interference pattern. Which of the following is true?

(A) The double-slit interference pattern is evidence that light has a wave characteristic.
(B) The path difference to the first maximum is equal to the wavelength.
(C) Increasing the separation between the two slits will compress the observed interference pattern.
(D) Increasing the wavelength will cause the maximums displayed on the screen to spread out.
(E) All of the above are true.

65. The bending of light caused by the change in the light wave's speed as it enters a new optical medium at an angle is called

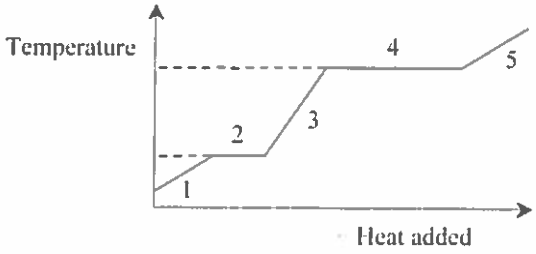
(A) refraction
(B) reflection
(C) diffraction
(D) interference
(E) polarization



66. Why does a prism disperse white light into the colors of the spectrum in the pattern shown in the diagram above?

(A) Violet light has more energy and therefore bends at a larger angle.
(B) The amplitude of violet light is greater, causing greater refraction.
(C) Each wavelength of light has a slightly different index of refraction.
(D) The red light travels a shorter distance and bends less.
(E) The violet light travels a longer distance and has more time to bend.

Questions 67–68 refer to the heating and cooling curve shown below.



67. Which statement is true regarding process 3 in the diagram above?

(A) The rate of temperature change is dependent on the specific heat capacity of the substance that is being heated.
(B) The rate of temperature change is dependent on the latent heat of fusion of the substance that is being heated.
(C) The rate of temperature change is dependent on the latent heat of vaporization of the substance that is being heated.
(D) The substance is in the solid phase and is expanding.
(E) The substance is in the gas phase and is expanding.

68. Which statement is true regarding process 4 in the diagram above?

(A) This occurs at the boiling point of the substance.
(B) Process 4 is dependent on the latent heat of vaporization.
(C) The temperature cannot rise until the phase change is completed.
(D) The process involves a liquid/gas phase change.
(E) All of the above are correct.

69. During a thermodynamic process, 400 joules of heat are added to a gas while 300 joules of work are done by the gas on its surroundings. Determine the change in internal energy.

(A) zero
(B) 100 J
(C) 300 J
(D) 400 J
(E) 700 J

70. An engine operates between 127°C and 227°C. Determine its theoretical efficiency.

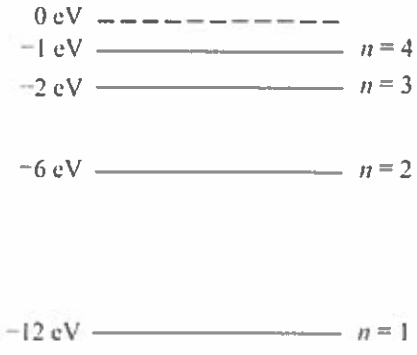
(A) 10%
(B) 20%
(C) 30%
(D) 40%
(E) 50%

71. The entropy of isolated systems

(A) is zero
(B) is one
(C) decreases
(D) remains constant
(E) increases

Questions 72–73

The energy level diagram below is for a large sample of atoms that are all identical. These atoms all contain one electron that is initially in the ground state. The sample is radiated with photons that all have 10-electron volts of energy.



72. Determine the energy of the excited electrons resulting from the absorption of the 10-electron volt photons.

(A) −1 eV
(B) −2 eV
(C) −6 eV
(D) −10 eV
(E) −12 eV

73. Shortly after the absorption, the atoms begin to emit photons spontaneously. What are all the possible energies of the emitted photons?

(A) 4 eV only
(B) 6 eV only
(C) 4 eV, 6 eV only
(D) 4 eV, 6 eV, and 10 eV only
(E) 4 eV, 6 eV, 10 eV, and 12 eV

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74. A radioactive sample with a half-life of 10 days is discovered to have 1/16 of its radioactive material remaining. How many days has the sample been experiencing radioactive decay?

(A) 20 days
(B) 30 days
(C) 40 days
(D) 60 days
(E) 120 days

75. Two spaceships approach each other. Spaceship *A* has a speed of 0.8*c* (80% of the speed of light). Spaceship *B* has a speed of 0.6*c* (60% of the speed of light). A passenger on spaceship *A* aims a laser at spaceship *B*. How fast does the laser light appear to be moving as observed by a passenger on spaceship *B*?

(A) 0.2*c*
(B) 0.6*c*
(C) 0.8*c*
(D) *c*
(E) 1.4*c*