34. A ball of mass m and momentum p has kinetic energy equal to which of the following?

(A) $\frac{1}{2}\frac{p^2}{m}$

(B) $\frac{p^2}{m}$

(C) $2\frac{p^2}{m}$

(D) $\frac{1}{2}\frac{m}{p^2}$

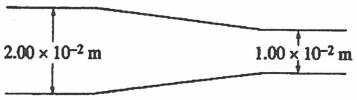
(E) $2\frac{m}{p^2}$

35. A simple pendulum consisting of a small object of mass m attached to a string of length ℓ has a period T. A pendulum with which of the following combinations of object mass and string length will also have period T?

	Object Mass	String Length
(A)	$m/2$	ℓ
(B)	m	$\ell/4$
(C)	$\sqrt{2}m$	$\ell/\sqrt{2}$
(D)	$2m$	4ℓ
(E)	$4m$	2ℓ

Item 36 was not scored.

Questions 37-38



Helium gas is flowing steadily through the pipe shown above. The diameter of the pipe at the left end is 2.00×10^{-2} m and at the right is 1.00×10^{-2} m. The flow is slow enough that the density of the gas remains essentially constant. The volume flow rate is $2.00 \times 10^{-3}\ \text{m}^3/\text{s}$.

37. The speed of the gas in the right end of the pipe is how many times the speed in the left end?

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

38. What is the speed of the gas in the left end of the pipe?

(A) 4×10^{-5} m/s

(B) 0.10 m/s

(C) 0.20 m/s

(D) $\frac{5}{\pi}$ m/s

(E) $\frac{20}{\pi}$ m/s

39. The pressure exerted on the bottom of a dam by the water in the reservoir created by the dam depends on the

(A) shape of the dam
(B) area of the dam
(C) depth of the water at the dam
(D) surface area of the reservoir
(E) shape of the bottom of the reservoir

40. A 3.0 kg block hanging from a spring scale is submerged in a beaker of water until the spring scale reads 20 N. What is the buoyant force on the block?

(A) 10 N
(B) 17 N
(C) 37 N
(D) 50 N
(E) It cannot be determined without knowing the dimensions of the block.

41. A planet of mass m orbits a star of mass M, where $m<<M$. The orbit is circular, its radius is r, and its period is T. True statements about the planet's orbit include which of the following?

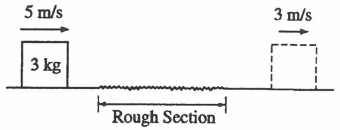
I. The orbital speed equals $\frac{2\pi r}{T}$.

II. The gravitational force equals $\frac{GMm}{r^2}$.

III. If the orbital radius r were greater, T would also be greater.

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

Questions 42-43



A block of mass 3 kg slides along a horizontal surface that has negligible friction except for one section, as shown above. The block arrives at the rough section with a speed of 5 m/s and leaves it 0.5 s later with a speed of 3 m/s.

42. What is the magnitude of the work done by the frictional force exerted on the block by the rough section of the surface?

(A) 24 J
(B) 16 J
(C) 8 J
(D) 6 J
(E) 3 J

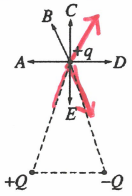
43. What is the magnitude of the average frictional force exerted on the block by the rough section of the surface?

(A) 30 N
(B) 12 N
(C) 4.5 N
(D) 4 N
(E) 3 N

44. An object attached to one end of a string moves in a circle at constant speed. Which of the following is correct?

(A) The object is accelerating as it moves.
(B) The object's velocity is the same as its speed.
(C) The object does not require a force to keep its state of circular motion.
(D) If the string breaks, the object will keep its circular motion.
(E) If the string breaks, the object will move radially away from the center of the circle.

tangentially



45. Three point charges, $+q$, $+Q$, and $-Q$, are fixed at the corners of an isosceles triangle in the plane of the page, as shown above. Which arrow in the figure represents the direction of the net electrostatic force on charge $+q$ due to the other two equal and opposite charges?

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

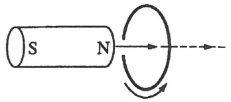
46. The magnetic flux for each turn of a 20-turn coil decreases from 0.30 T·m^2 to zero in 2 s. The emf induced in the coil is most nearly

(A) 2 V
(B) 3 V
(C) 6 V
(D) 9 V
(E) 12 V

$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t}$

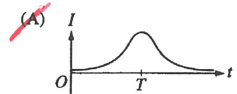
$= 20\left(\frac{.30}{2}\right)$

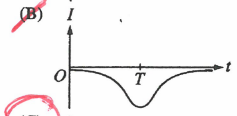
$10(.3)$

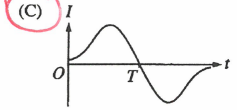


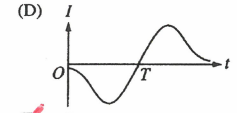
Direction of Positive Current

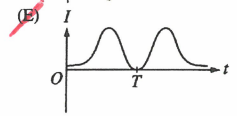
47. The magnet shown above is initially far away from the conducting loop and is moved at constant speed toward and completely through the loop. If T is the time at which the magnet is halfway through the loop, which of the following graphs best represents the induced current I in the loop as a function of time t?

(A)


(B)


(C)


(D)


(E)


enters dots in nature adds χ, UP thumb labeled as +

48. The index of refraction of air increases linearly with its density. A ray of light passes through an interface from vacuum into air. Statements that are true as the air is heated at constant pressure include which of the following?

I. The frequency of refracted light in the air decreases.
II. The wavelength of refracted light in the air decreases.
III. The speed of light in the air increases.

B

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

n ↑ w/ density

$PV = nRT$ (↑ ↑)

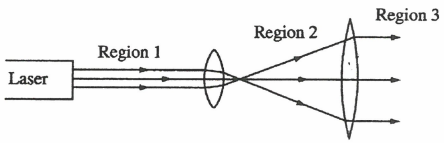
↑T ↑V

so ρ ↓

so n ↓

$v = \frac{c}{n}$ ↓ so λ ↑

$v = f\lambda$ so λ ↑



49. As shown above, two lenses are arranged so that a narrow laser beam of parallel rays spreads into a wider beam of parallel rays. If the lenses are interchanged, the light in region 3 will be a beam of

(A) parallel rays narrower than the beam in region 1
(B) parallel rays wider than the beam in region 1
(C) parallel rays about the same width as in region 1
(D) diverging rays
(E) converging rays

50. Traveling waves are generated on a string fixed at both ends. The string has a length L, a linear mass density μ, and a tension T. Which of the following will cause the wave speed to increase?

I. Using the same string but increasing the tension
II. Using a longer string with the same μ and T
III. Using a string with the same L and T but a smaller μ

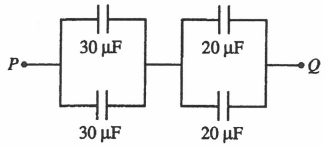
(A) I only
(B) II only
(C) III only
(D) I or II
(E) I or III

51. The wavelength of yellow sodium light in vacuum is approximately 6.0×10^{-7} m. The frequency of the light is most nearly

(A) 2.0×10^{-15} Hz
(B) 1.8 Hz
(C) 1.8×10^{2} Hz
(D) 1.7×10^{6} Hz
(E) 5.0×10^{14} Hz

52. When a voltage V is connected across a capacitor of capacitance C, charges of equal magnitude Q and opposite sign are on the plates, and the energy stored in the capacitor is U. If C is doubled and V is not changed, how are Q and U affected?

	Q	U
(A)	Halved	Halved
(B)	Halved	Quartered
(C)	Not changed	Not changed
(D)	Doubled	Doubled
(E)	Doubled	Quadrupled



53. In the diagram above, what is the equivalent capacitance between points P and Q?

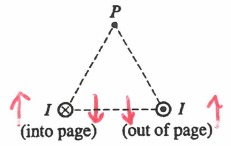
(A) 6 μF
(B) 24 μF
(C) 25 μF
(D) 50 μF
(E) 100 μF

54. Two skaters are initially at rest next to each other on frictionless ice. Skater A pushes on skater B. If skater A has greater mass than skater B, which of the following correctly relates the magnitudes of their momentums p and their kinetic energies K after the push?

(A) $p_A = p_B$ and $K_A < K_B$
(B) $p_A = p_B$ and $K_A = K_B$
(C) $p_A = p_B$ and $K_A > K_B$
(D) $p_A < p_B$ and $K_A < K_B$
(E) $p_A < p_B$ and $K_A = K_B$

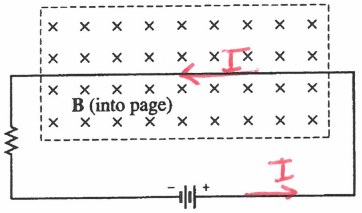
55. Which of the following is true of the conservation of momentum and kinetic energy?

(A) Momentum is conserved only in elastic collisions.
(B) Momentum is conserved only in inelastic collisions.
(C) Kinetic energy is conserved only in elastic collisions.
(D) Kinetic energy is conserved only in inelastic collisions.
(E) Both require the same conditions in order to be conserved.



56. Current I flows into and out of the page in two parallel, long, straight wires that are fixed at two vertices of an equilateral triangle, as shown above. The net magnetic field at the third vertex (point P) due to these currents is in which of the following directions?

(A) ↓
(B) ↑
(C) →
(D) ←
(E) None of the above



57. One section of wire in the circuit above lies in a region containing a magnetic field **B** directed into the page. The magnetic force on the section of wire is directed

(A) into the page
(B) toward the right
(C) toward the left
(D) toward the top of the page
(E) toward the bottom of the page

58. A student wants to determine experimentally, without disconnecting any wires in the circuit, the DC current moving through a copper wire. Which of the following items of laboratory equipment would be sufficient to make the necessary measurements for this determination?

(A) Magnetic field sensor only
(B) Magnetic field sensor and meterstick
(C) Bar magnet and meterstick
(D) Stopwatch and meterstick
(E) Voltmeter and ammeter

59. A force of constant magnitude F and fixed direction acts on an object of mass m that is initially at rest. If the force acts for a time interval Δt over a displacement Δx, what is the magnitude of the resultant change in the linear momentum of the object?

(A) $F\,\Delta t$
(B) $F\,\Delta x$
(C) $\frac{F\,\Delta t}{m}$
(D) $\frac{F\,\Delta x}{m}$
(E) $mF\,\Delta t$

60. A ball is thrown with an initial speed of 20 m/s at an angle of 60° to the ground. If air resistance is negligible, what is the ball's speed at the instant it reaches its maximum height from the ground?

(A) Zero
(B) 10 m/s
(C) 14 m/s
(D) 17 m/s
(E) 20 m/s

$K = hf - \phi$

61. The maximum energy of photoelectrons emitted from a metal surface depends on which of the following?

I. The intensity of the incident light
II. The frequency of the incident light
III. The work function of the metal

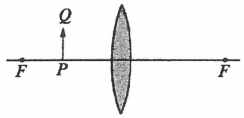
(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

62. For the hydrogen atom, how does the potential energy U of the atom change as the energy level n increases?

(A) The potential energy always increases.
(B) The potential energy always decreases.
(C) The potential energy increases, then decreases.
(D) The potential energy decreases, then increases.
(E) The potential energy does not change.

63. The present theory of the nature of light suggests that it

(A) is a wave only
(B) consists of particles only
(C) is a mixture of both waves and particles
(D) exhibits either wave or particle properties depending on the situation
(E) exhibits neither wave nor particle properties

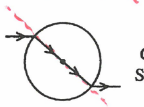


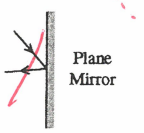
64. An object PQ is located to the left of a converging lens having focal points F, as shown in the figure above. The image formed by the lens is

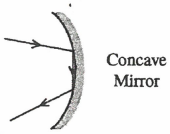
(A) real, inverted, and smaller than the object
(B) real, inverted, and larger than the object
(C) real, upright, and larger than the object
(D) virtual, upright, and larger than the object
(E) virtual, upright, and smaller than the object

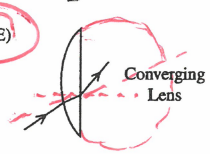
65. A student working with glass objects and silvered mirrors traces light rays in the laboratory. Which of the following ray tracings is drawn most correctly?

(A)


(B)


(C)


(D)


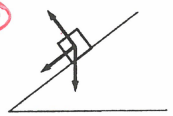
(E)


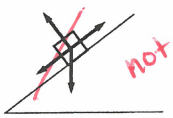
66. Young's double-slit experiment is performed with a pair of slits separated by a distance d. A screen is a distance L away from the slits, and the distance from the central maximum to the nth bright fringe is x. What is the wavelength of this light?

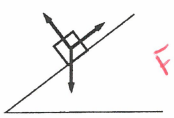
(A) $nxdL$
(B) $\frac{xd}{nL}$
(C) $\frac{nL}{xd}$
(D) $\frac{L}{nxd}$
(E) $\frac{nxd}{L}$

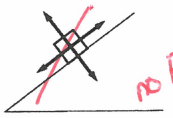
$\lambda = \frac{xd}{nL}$

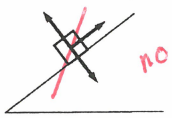
67. A box is given a sudden push up a ramp. Friction between the box and the ramp is not negligible. Which of the following diagrams best represents the directions of the actual forces acting on the box as it moves upward after the push?

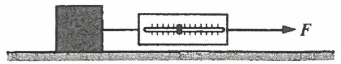
(A)


(B)


(C)


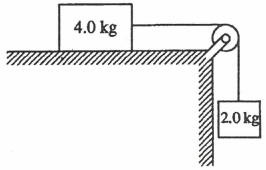
(D)


(E)




68. In a lab, a block weighing 80 N is attached to a spring scale, and both are pulled to the right on a horizontal surface, as shown above. Friction between the block and the surface is negligible. What is the acceleration of the block when the scale reads 32 N?

(A) 2.0 m/s^2
(B) 2.5 m/s^2
(C) 4.0 m/s^2
(D) 6.0 m/s^2
(E) 8.0 m/s^2



69. The system shown above is released from rest. If friction is negligible, the acceleration of the 4.0 kg block sliding on the table shown above is most nearly

(A) 0
(B) 1.7 m/s^2
(C) 3.3 m/s^2
(D) 5.0 m/s^2
(E) 10.0 m/s^2

70. A small car with mass m and speed $2v$ and a large car with mass $2m$ and speed v both travel the same circular section of an unbanked road. If the frictional force required to keep the small car on the road without skidding is F, then the frictional force required to keep the large car on the road without skidding is

(A) $4F$
(B) $2F$
(C) F
(D) $F/2$
(E) $F/4$