The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Wednesday, June 20, 2001 — 1:15 to 4:15 p.m., only

The answer paper is stapled in the center of this examination booklet. Open the examination booklet, carefully remove the answer paper, and close the examination booklet. Then fill in the heading on your answer paper.

All of your answers are to be recorded on the separate answer paper. For each question in Part I and Part II, decide which of the choices given is the best answer. Then on the answer paper, in the row of numbers for that question, circle with pencil the number of the choice that you have selected. The sample below is an example of the first step in recording your answers.

SAMPLE: (1) 2 3 4

If you wish to change an answer, erase your first penciled circle and then circle with pencil the number of the answer you want. After you have completed the examination and you have decided that all of the circled answers represent your best judgment, signal a proctor and turn in all examination material except your answer paper. Then and only then, place an X in ink in each penciled circle. Be sure to mark only one answer with an X in ink for each question. No credit will be given for any question with two or more X's marked. The sample below indicates how your final choice should be marked with an X in ink.

SAMPLE: ⊗ 2 3 4

For questions in Part III, record your answers in accordance with the directions given in the examination booklet.

The *Reference Tables for Physics*, which you may need to answer some questions in this examination, are supplied separately. Be certain you have a copy of these reference tables before you begin the examination. You must also have access to a centimeter ruler and a protractor during this examination.

When you have completed the examination, you must sign the statement printed at the end of the answer paper, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer paper cannot be accepted if you fail to sign this declaration.

DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Part I

Answer all 55 questions in this part. [65]

Directions (1–55): For *each* statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answer on the separate answer paper in accordance with the directions on the front page of this booklet.

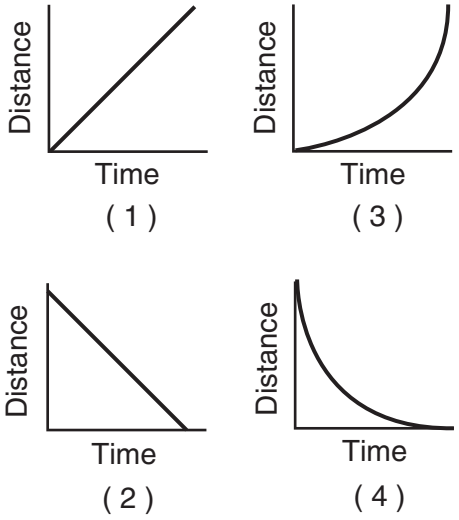
1 Which terms both represent scalar quantities?

(1) displacement and velocity
(2) distance and speed
(3) displacement and speed
(4) distance and velocity

2 A mass of one kilogram of nickels has a monetary value in United States dollars of approximately

(1) \$1.00
(2) \$0.10
(3) \$10.00
(4) \$1000.00

3 Which graph best represents the motion of an object whose speed is increasing?



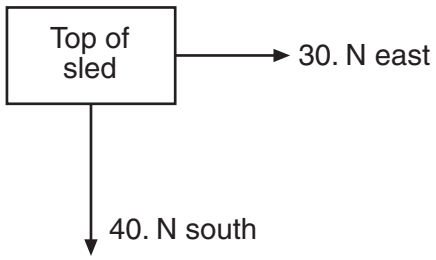
4 An astronaut weighs 500 newtons on Earth and 25 newtons on asteroid *X*. The acceleration due to gravity on asteroid *X* is approximately

(1) 1 m/s^2
(2) 2 m/s^2
(3) 0.2 m/s^2
(4) 0.5 m/s^2

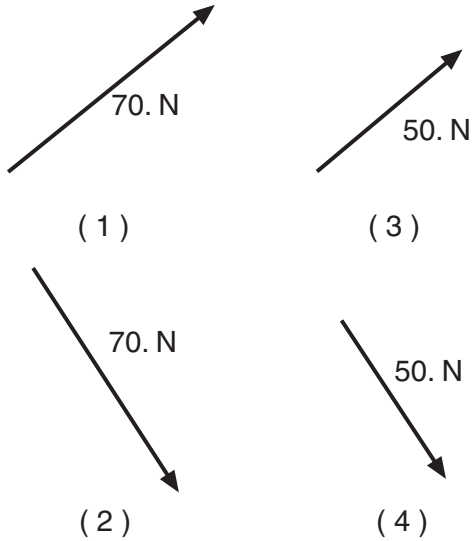
5 A car having an initial velocity of 12 meters per second east slows uniformly to 2 meters per second east in 4.0 seconds. The acceleration of the car during this 4.0-second interval is

(1) 2.5 m/s^2 west
(2) 2.5 m/s^2 east
(3) 6.0 m/s^2 west
(4) 6.0 m/s^2 east

6 Two students push on a sled. One pushes with a force of 30. newtons east and the other exerts a force of 40. newtons south, as shown in the top-view diagram below.



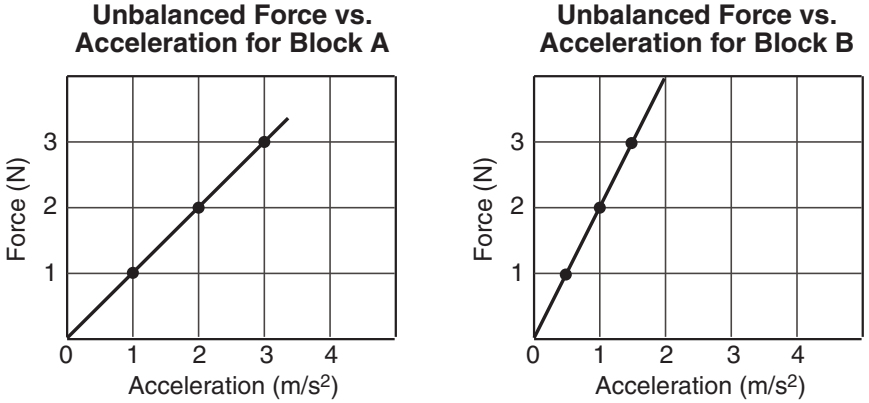
Which vector best represents the resultant of these two forces?



7 In an automobile collision, a 44-kilogram passenger moving at 15 meters per second is brought to rest by an air bag during a 0.10-second time interval. What is the magnitude of the average force exerted on the passenger during this time?

(1) 440 N
(2) 660 N
(3) 4400 N
(4) 6600 N

8 A series of unbalanced forces was applied to each of two blocks, *A* and *B*. The graphs below show the relationship between unbalanced force and acceleration for each block.



Compared to the mass of block *A*, the mass of block *B* is

(1) the same
(2) twice as great
(3) half as great
(4) four times as great

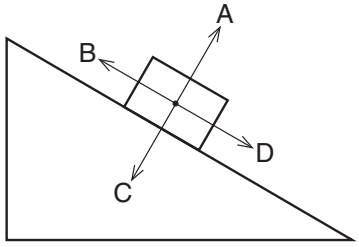
9 Two cars, *A* and *B*, are 400. meters apart. Car *A* travels due east at 30. meters per second on a collision course with car *B*, which travels due west at 20. meters per second. How much time elapses before the two cars collide?

(1) 8.0 s
(2) 13 s
(3) 20. s
(4) 40. s

10 A 50.-newton horizontal force is needed to keep an object weighing 500. newtons moving at a constant velocity of 2.0 meters per second across a horizontal surface. The magnitude of the frictional force acting on the object is

(1) 500. N
(2) 450. N
(3) 50. N
(4) 0 N

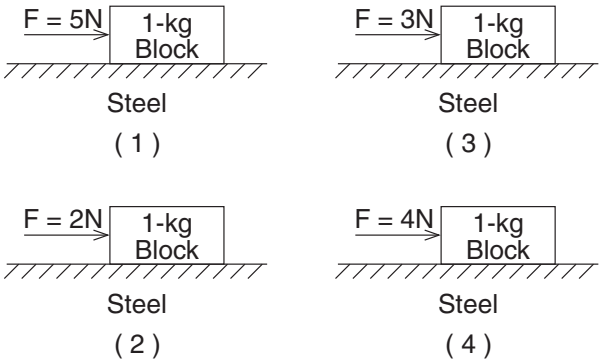
11 The diagram below represents a block sliding down an incline.



Which vector best represents the frictional force acting on the block?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

12 A different force is applied to each of four 1-kilogram blocks to slide them across a uniform steel surface at constant speed as shown below. In which diagram is the coefficient of friction between the block and steel *smallest*?



13 The magnitude of the momentum of an object is 64.0 kilogram•meter per second. If the velocity of the object is doubled, the magnitude of the momentum of the object will be

(1) 32.0 kg•m/s
(2) 64.0 kg•m/s
(3) 128 kg•m/s
(4) 256 kg•m/s

14 An airplane originally at rest on a runway accelerates uniformly at 6.0 meters per second^2 for 12 seconds. During this 12-second interval, the airplane travels a distance of approximately

(1) 72 m
(2) 220 m
(3) 430 m
(4) 860 m

15 Satellite *A* has a mass of 1.5×10^3 kilograms and is traveling east at 8.0×10^3 meters per second. Satellite *B* is traveling west at 6.0×10^3 meters per second. The satellites collide head-on and come to rest. What is the mass of satellite *B*?

(1) 2.7×10^3 kg
(2) 2.0×10^3 kg
(3) 1.5×10^3 kg
(4) 1.1×10^3 kg

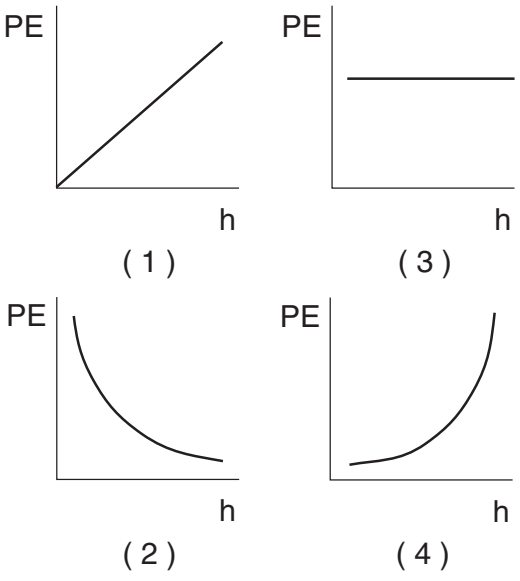
16 Which combination of units can be used to express work?

(1) $\frac{\text{newton} \cdot \text{second}}{\text{meter}}$
(2) $\frac{\text{newton} \cdot \text{meter}}{\text{second}}$
(3) newton/meter
(4) newton•meter

17 A 2000-watt motor working at full capacity can vertically lift a 400-newton weight at a constant speed of

(1) 2×10^3 m/s
(2) 50 m/s
(3) 5 m/s
(4) 0.2 m/s

18 Which graph best represents the relationship between gravitational potential energy (PE) and height (*h*) above the ground for an object near the surface of Earth?



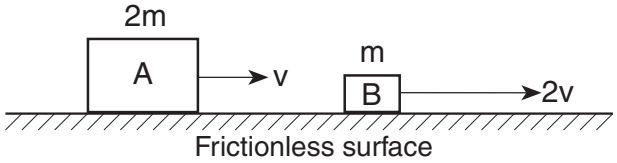
19 An alpha particle consists of two protons and two neutrons. The alpha particle's charge of +2 elementary charges is equivalent to

(1) 8.0×10^{-20} C
(2) 3.2×10^{-19} C
(3) 1.2×10^{19} C
(4) 3.2×10^{19} C

20 A 3.0-kilogram mass is attached to a spring having a spring constant of 30. newtons per meter. The mass is pulled 0.20 meter from the spring's equilibrium position and released. What is the maximum kinetic energy achieved by the mass-spring system?

(1) 2.4 J
(2) 1.5 J
(3) 1.2 J
(4) 0.60 J

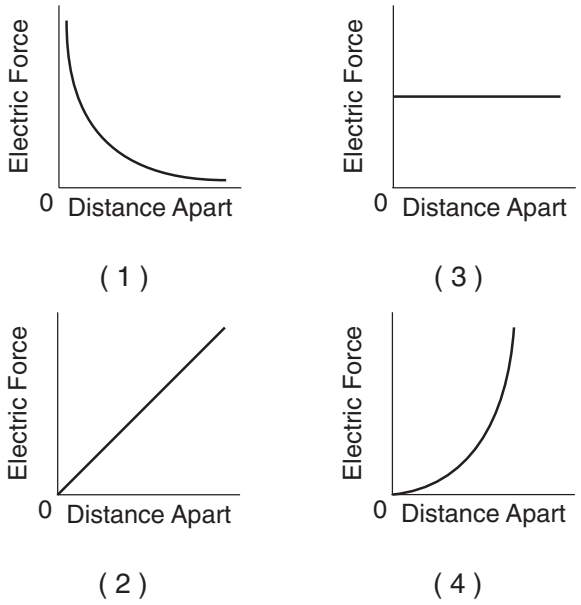
21 The diagram below shows block *A*, having mass $2m$ and speed v, and block *B* having mass m and speed $2v$.



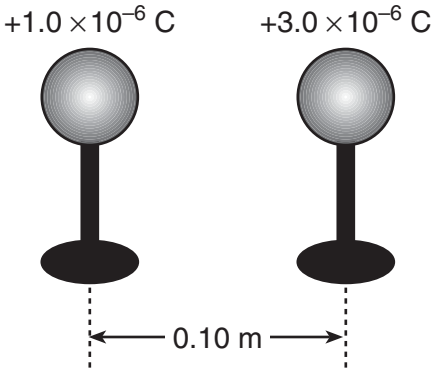
Compared to the kinetic energy of block *A*, the kinetic energy of block *B* is

(1) the same
(2) twice as great
(3) one-half as great
(4) four times as great

22 Two similar metal spheres possessing +1.0 coulomb of charge and –1.0 coulomb of charge, respectively, are brought toward each other. Which graph best represents the relationship between the magnitude of the electric force between the spheres and the distance between them?



23 The diagram below shows two metal spheres charged to $+1.0 \times 10^{-6}$ coulomb and $+3.0 \times 10^{-6}$ coulomb, respectively, on insulating stands separated by a distance of 0.10 meter.



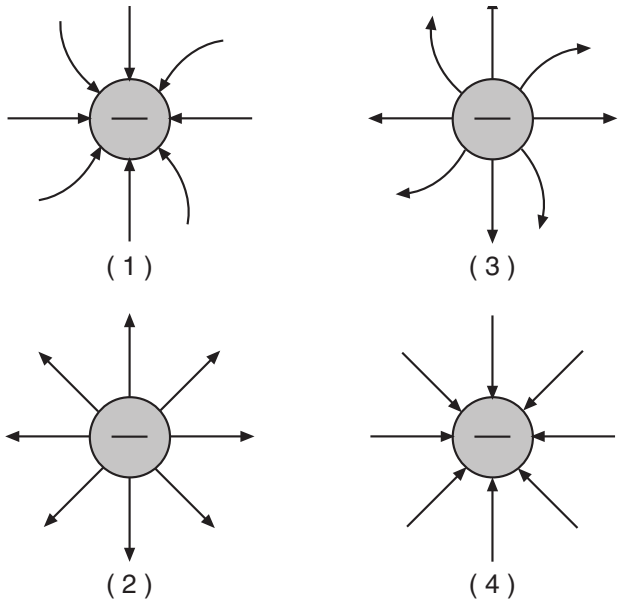
The spheres are touched together and then returned to their original positions. As a result, the magnitude of the electrostatic force between the spheres changes from 2.7 N to

(1) 1.4 N
(2) 1.8 N
(3) 3.6 N
(4) 14 N

24 An electrostatic force of 20. newtons is exerted on a charge of 8.0×10^{-2} coulomb at point P in an electric field. The magnitude of the electric field intensity at P is

(1) 4.0×10^{-3} N/C
(2) 1.6 N/C
(3) 20. N/C
(4) 2.5×10^{2} N/C

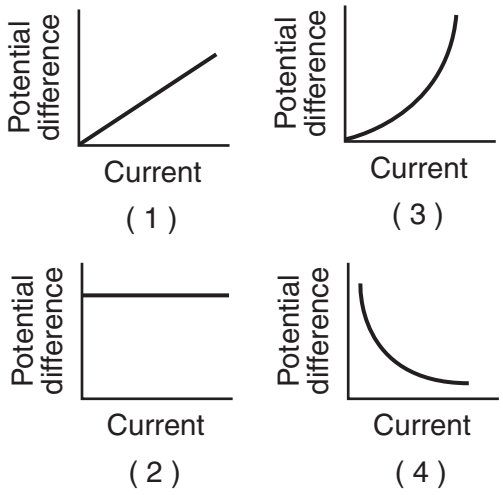
25 Which diagram best represents the electric field around a negatively charged conducting sphere?



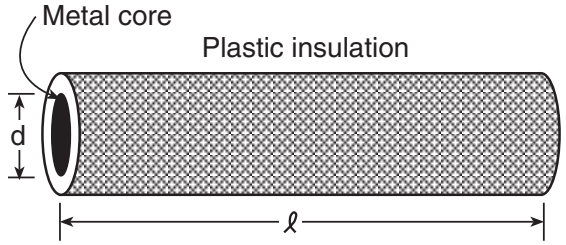
26 A 12-volt automobile battery has 8.4×10^{3} coulombs of electric charge. The amount of electrical energy stored in the battery is approximately

(1) 1.0×10^{5} J
(2) 8.4×10^{3} J
(3) 7.0×10^{2} J
(4) 1.4×10^{-3} J

27 Which graph best represents the relationship between potential difference across a metallic conductor and the resulting current through the conductor at a constant temperature?



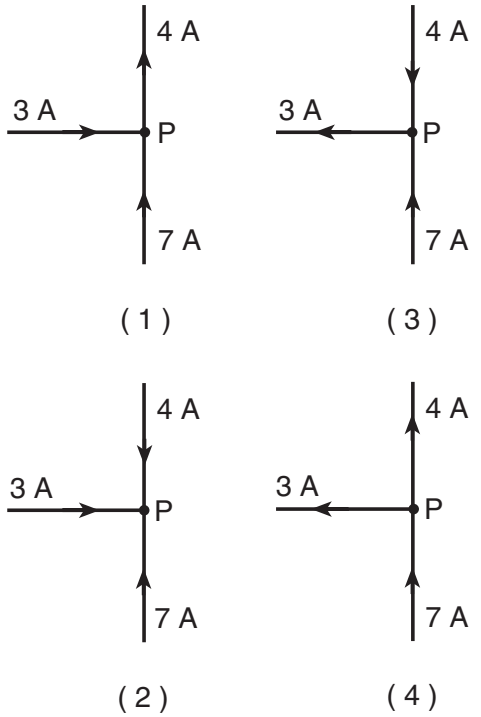
28 Plastic insulation surrounds a wire having diameter d and length ℓ as shown below.



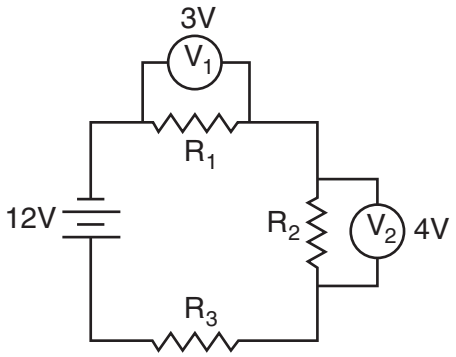
A decrease in the resistance of the wire would be produced by an increase in the

(1) thickness of the plastic insulation
(2) length ℓ of the wire
(3) diameter d of the wire
(4) temperature of the wire

29 Which diagram below correctly shows currents traveling near junction *P* in an electric circuit?



30 The diagram below shows three resistors, R_1, R_2, and R_3, connected to a 12-volt battery.



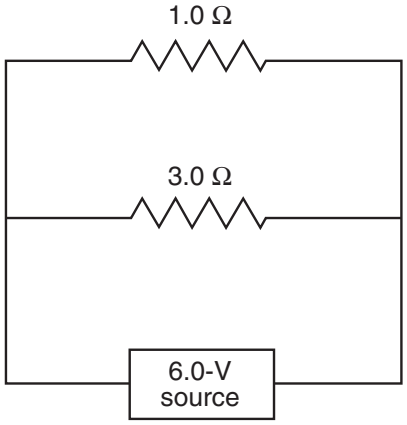
If voltmeter V_1 reads 3 volts and voltmeter V_2 reads 4 volts, what is the potential drop across resistor R_3?

(1) 12 V
(2) 5 V
(3) 0 V
(4) 4 V

31 A current of 3.0 amperes is flowing in a circuit. How much charge passes a given point in the circuit in 30. seconds?

(1) 0.10 C
(2) 10. C
(3) 33 C
(4) 90. C

Base your answers to questions 32 and 33 on the diagram below, which shows two resistors connected in parallel across a 6.0-volt source.



32 The equivalent resistance of the two resistors is

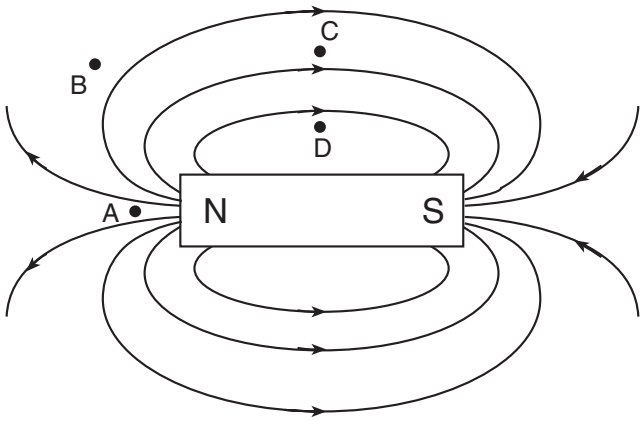
(1) 0.75
(2) 2.0
(3) 1.3
(4) 4.0

Note that question 33 has only three choices.

33 Compared to the power dissipated in the 1.0-ohm resistor, the power dissipated in the 3.0-ohm resistor is

(1) less
(2) greater
(3) the same

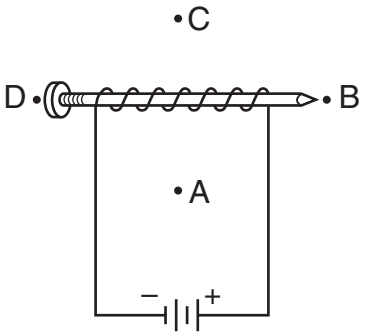
34 The diagram below represents the magnetic lines of force around a bar magnet.



At which point is the magnitude of the magnetic field strength of the bar magnet the greatest?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

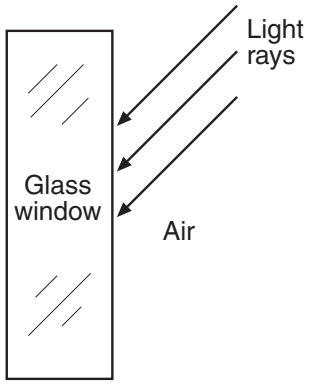
35 The diagram below shows an electromagnet made from a nail, a coil of insulated wire, and a battery.



The south pole of the electromagnet is located closest to point

(1) *A*
(2) *B*
(3) *C*
(4) *D*

36 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

(1) totally refracted
(2) totally reflected
(3) partially reflected and partially diffracted
(4) partially reflected and partially refracted

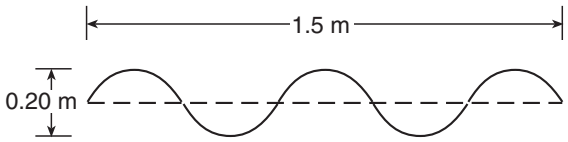
37 Which phrase best describes a periodic wave?

(1) a single pulse traveling at constant speed
(2) a series of pulses at irregular intervals
(3) a series of pulses at regular intervals
(4) a single pulse traveling at different speeds in the same medium

38 Which equation correctly relates the speed v, wavelength λ, and period T of a periodic wave?

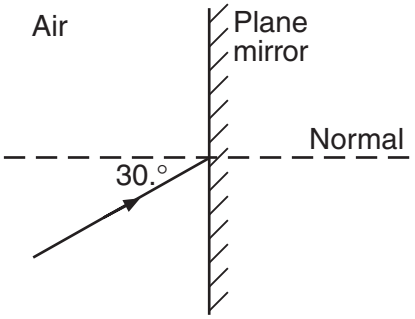
(1) $v = \frac{T}{\lambda}$
(2) $v = T\lambda$
(3) $v = \frac{\lambda}{T}$
(4) $v = \frac{\lambda^2}{T}$

39 What are the amplitude and wavelength of the wave shown below?



(1) amplitude = 0.10 m, wavelength = 0.30 m
(2) amplitude = 0.10 m, wavelength = 0.60 m
(3) amplitude = 0.20 m, wavelength = 0.30 m
(4) amplitude = 0.20 m, wavelength = 0.60 m

40 A ray of monochromatic light traveling in air is incident on a plane mirror at an angle of 30.°, as shown in the diagram below.



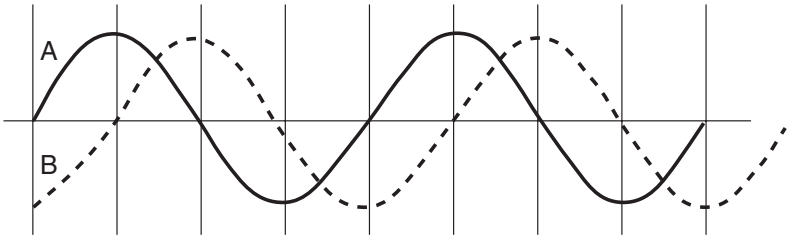
The angle of reflection for the light ray is

(1) 15°
(2) 30.°
(3) 60.°
(4) 90.°

41 What type of wave is sound traveling in water?

(1) torsional
(2) transverse
(3) elliptical
(4) longitudinal

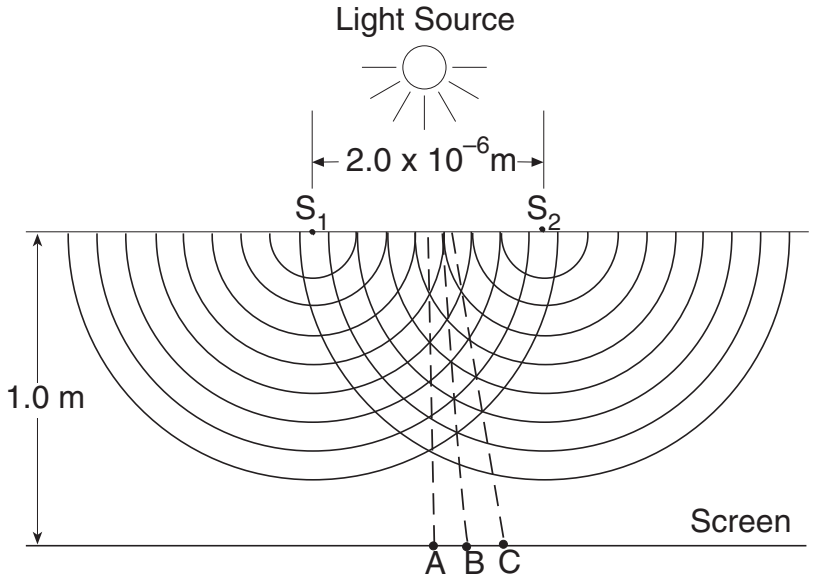
42 The diagram below shows two waves, *A* and *B*.



The phase difference between *A* and *B* is

(1) 0°
(2) 45°
(3) 90°
(4) 180°

43 The diagram below represents monochromatic light incident on a pair of slits, S_1 and S_2, that are separated by a distance of 2.0×10^{-6} meter. *A*, *B*, and *C* are adjacent antinodal areas that appear on a screen 1.0 meter from the slits. The distance from *A* to *B* is 0.34 meter.



(not drawn to scale)

What is the wavelength of the incident light?

(1) 6.8×10^{-7} m
(2) 5.9×10^{-6} m
(3) 1.7×10^{5} m
(4) 6.8×10^{7} m

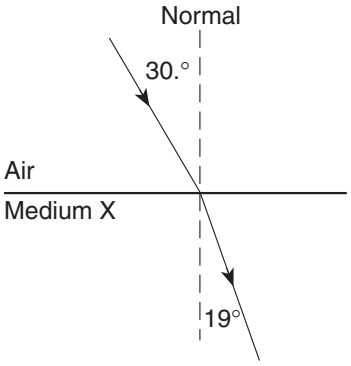
44 The hertz is a unit that describes the number of

(1) seconds it takes to complete one cycle of a wave
(2) cycles of a wave completed in one second
(3) points that are in phase along one meter of a wave
(4) points that are out of phase along one meter of a wave

45 As a wave travels between two points in a medium, the wave transfers

(1) energy, only
(2) mass, only
(3) both energy and mass
(4) neither energy nor mass

46 The diagram below shows a ray of light ($\lambda = 5.9 \times 10^{-7}$ meter) traveling from air into medium *X*.



If the angle of incidence is 30.° and the angle of refraction is 19°, medium *X* could be

(1) air
(2) alcohol
(3) Canada balsam
(4) glycerol

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

(1) Its wavelength decreases and its frequency decreases.
(2) Its wavelength decreases and its frequency increases.
(3) Its wavelength increases and it bends toward the normal.
(4) Its wavelength increases and it bends away from the normal.

48 Alpha particles were directed at a thin metal foil. Some particles were deflected into hyperbolic paths due to

(1) gravitational attraction
(2) electrostatic repulsion
(3) electrostatic attraction
(4) magnetic repulsion

49 The threshold frequency in a photoelectric experiment is most closely related to the

(1) brightness of the incident light
(2) thickness of the photoemissive metal
(3) area of the photoemissive metal
(4) work function of the photoemissive metal

50 The momentum of a photon is inversely proportional to the photon's

(1) frequency
(2) mass
(3) weight
(4) wavelength

51 The electron in a hydrogen atom drops from energy level $n = 2$ to energy level $n = 1$ by emitting a photon having an energy of approximately

(1) 5.4×10^{-19} J
(2) 1.6×10^{-18} J
(3) 2.2×10^{-18} J
(4) 7.4×10^{-18} J

52 In the currently accepted model of the atom, a fuzzy cloud around a hydrogen nucleus is used to represent the

(1) electron's actual path, which is not a circular orbit
(2) general region where the atom's proton is most probably located
(3) general region where the atom's electron is most probably located
(4) presence of water vapor in the atom

Note that questions 53 through 55 have only three choices.

53 A softball player leaves the batter's box, overruns first base by 3.0 meters, and then returns to first base. Compared to the total distance traveled by the player, the magnitude of the player's total displacement from the batter's box is

(1) smaller
(2) larger
(3) the same

54 The radius of Mars is approximately one-half the radius of Earth, and the mass of Mars is approximately one-tenth the mass of Earth. Compared to the acceleration due to gravity on the surface of Earth, the acceleration due to gravity on the surface of Mars is

(1) smaller
(2) larger
(3) the same

55 A mosquito flying over a highway strikes the windshield of a moving truck. Compared to the magnitude of the force of the truck on the mosquito during the collision, the magnitude of the force of the mosquito on the truck is

(1) smaller
(2) larger
(3) the same

Part II

This part consists of six groups, each containing ten questions. Each group tests an optional area of the course. Choose two of these six groups. Be sure that you answer all ten questions in each group chosen. Record the answers to the questions in accordance with the directions on the front page of this booklet. [20]

Group 1 — Motion in a Plane

If you choose this group, be sure to answer questions 56–65.

56 A football player kicks a ball with an initial velocity of 25 meters per second at an angle of 53° above the horizontal. The vertical component of the initial velocity of the ball is

(1) 25 m/s
(2) 20. m/s
(3) 15 m/s
(4) 10. m/s

57 A student throws a stone upward at an angle of 45°. Which statement best describes the stone at the highest point that it reaches?

(1) Its acceleration is zero.
(2) Its acceleration is at a maximum.
(3) Its potential energy is at a minimum.
(4) Its kinetic energy is at a minimum.

58 A red ball and a green ball are simultaneously thrown horizontally from the same height. The red ball has an initial speed of 40. meters per second and the green ball has an initial speed of 20. meters per second. Compared to the time it takes the red ball to reach the ground, the time it takes the green ball to reach the ground will be

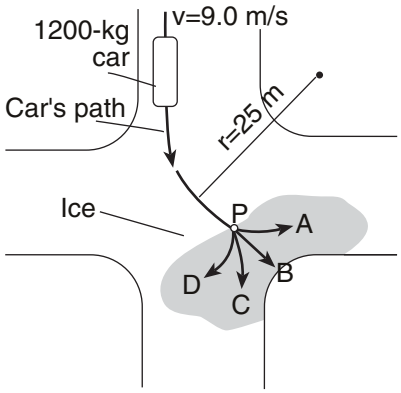
(1) the same
(2) twice as much
(3) half as much
(4) four times as much

59 A baseball player throws a ball horizontally. Which statement best describes the ball's motion after it is thrown? [Neglect the effect of friction.]

(1) Its vertical speed remains the same, and its horizontal speed increases.
(2) Its vertical speed remains the same, and its horizontal speed remains the same.
(3) Its vertical speed increases, and its horizontal speed increases.
(4) Its vertical speed increases, and its horizontal speed remains the same.

Base your answers to questions 60 and 61 on the information and diagram below.

A 1200-kilogram car traveling at a constant speed of 9.0 meters per second turns at an intersection. The car follows a horizontal circular path with a radius of 25 meters to point *P*.



60 The magnitude of the centripetal force acting on the car as it travels around the circular path is approximately

(1) 1.1×10^4 N
(2) 1.2×10^4 N
(3) 3.9×10^3 N
(4) 4.3×10^2 N

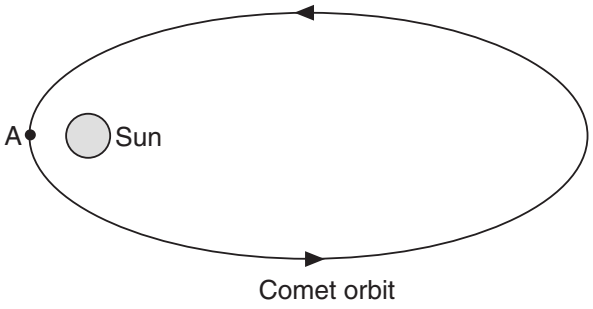
61 At point *P*, the car hits an area of ice and loses all frictional force on its tires. Which path does the car follow on the ice?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

62 An amusement park ride moves a rider at a constant speed of 14 meters per second in a horizontal circular path of radius 10. meters. What is the rider's centripetal acceleration in terms of g, the acceleration due to gravity?

(1) $1g$
(2) $2g$
(3) $3g$
(4) $0g$

63 The diagram below shows the elliptical orbit of a comet around the Sun. The comet's closest approach to the Sun is at point *A*.



Which statement best describes the comet's energy as it passes through point *A*?

(1) Its kinetic energy is at a minimum and its potential energy is at a minimum.
(2) Its kinetic energy is at a minimum and its potential energy is at a maximum.
(3) Its kinetic energy is at a maximum and its potential energy is at a minimum.
(4) Its kinetic energy is at a maximum and its potential energy is at a maximum.

64 The chart below gives the mass and orbital period of each of four satellites, *A*, *B*, *C*, and *D*, orbiting Earth in circular paths.

Satellite	Mass (kilograms)	Orbital Period (hours)
A	500	4
B	500	2
C	100	6
D	100	3

Which satellite is closest to Earth?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

65 The Moon's orbit is *not* classified as geosynchronous because

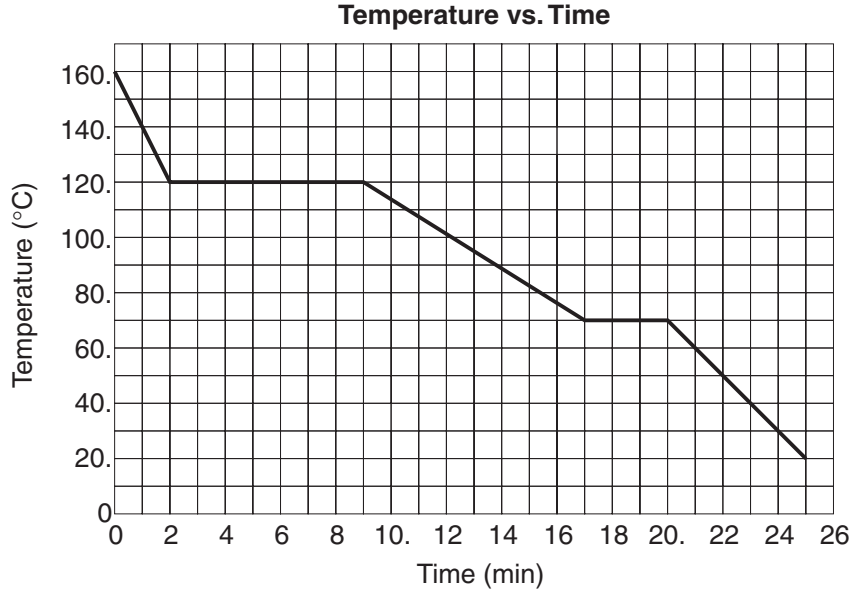
(1) the Moon's position over Earth's surface varies with time
(2) the Moon's mass is very large compared to the mass of all other Earth satellites
(3) the Moon is a natural satellite, rather than an artificial one
(4) the Moon always has the same half of its surface facing Earth

Group 2 — Internal Energy

If you choose this group, be sure to answer questions 66–75.

Base your answers to questions 66 and 67 on the graph and information below.

The graph below represents a cooling curve for 10. kilograms of a substance as it cools from a vapor at 160.°C to a solid at 20.°C. Energy is removed from the sample at a constant rate.



Note that question 66 has only three choices.

66 While the substance is cooling during the liquid phase, the average kinetic energy of the molecules of the substance

(1) decreases
(2) increases
(3) remains the same

67 The melting point of the substance is

(1) 0°C
(2) 70.°C
(3) 100.°C
(4) 120.°C

68 What is the change in temperature of a sample of water as it is heated from its freezing point to its boiling point at standard pressure?

(1) 373 K
(2) 273 K
(3) 212 K
(4) 100. K

69 Equal amounts of heat are applied to equal masses of four different substances initially at –10°C. Which substance has the largest change in temperature?

(1) aluminum
(2) ice
(3) iron
(4) alcohol

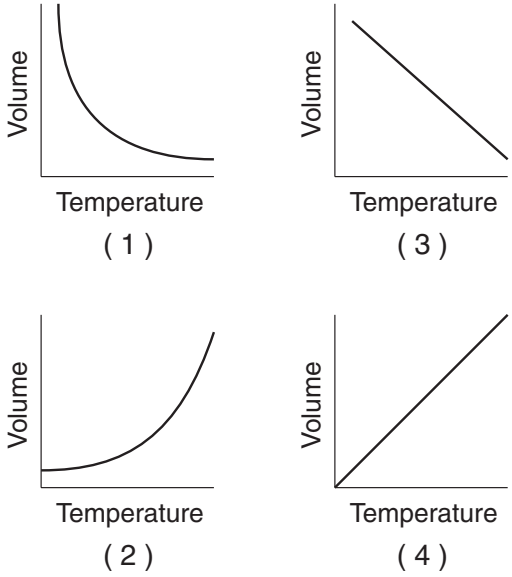
70 Why do some transportation agencies spread a mixture of sand and salt on icy roads in winter?

(1) Sand decreases the frictional force between vehicle tires and the road, and salt lowers the melting point of ice.
(2) Sand decreases the frictional force between vehicle tires and the road, and salt raises the melting point of ice.
(3) Sand increases the frictional force between vehicle tires and the road, and salt lowers the melting point of ice.
(4) Sand increases the frictional force between vehicle tires and the road, and salt raises the melting point of ice.

71 The air pressure inside an automobile tire is lower during cold weather than during warm weather. The lower air pressure is most likely due to

(1) an increase in molecular potential energy of the air molecules in the tire
(2) a decrease in the speed of the air molecules in the tire
(3) salt on the roads producing a decrease in tire volume
(4) cold air in the tire producing an increase in tire volume

72 Which graph best represents the relationship between volume and absolute temperature for a fixed mass of an ideal gas at constant pressure?



73 Heat will flow from a region of low temperature to a region of higher temperature if

(1) the specific heat of the cooler region is greater than the specific heat of the warmer region
(2) the temperature of the cooler region is near absolute zero
(3) work is done to produce the flow
(4) the cooler region is liquid and the warmer region is solid

74 What is the minimum heat required to change 5.0 kilograms of copper at 1083°C from a solid to a liquid?

(1) 0.20 kJ
(2) 0.39 kJ
(3) 41 kJ
(4) 1.0×10^3 kJ

Note that question 75 has only three choices.

75 When a box of beakers was dropped, the beakers broke into many pieces. Dropping the box a second time could *not* cause the pieces to reform into the original beakers because this would require entropy to

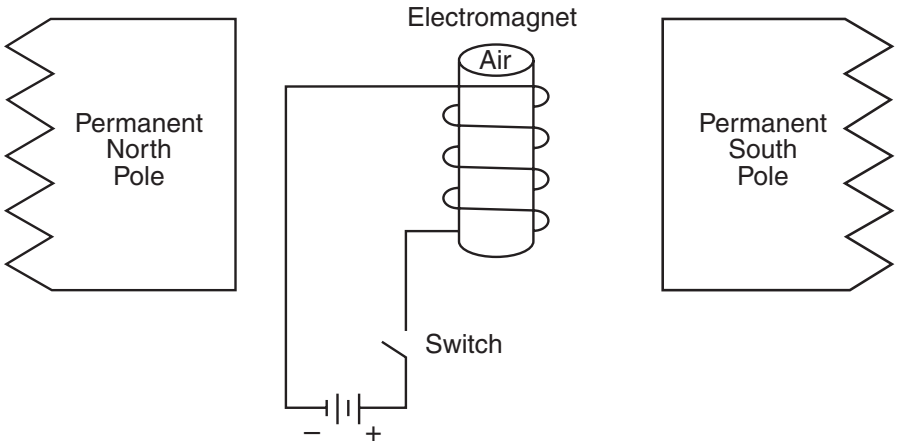
(1) decrease
(2) increase
(3) remain the same

Group 3 — Electromagnetic Applications

If you choose this group, be sure to answer questions 76–85.

Base your answers to questions 76 and 77 on the information and diagram below.

An electromagnet with an air core is located within the magnetic field between two permanent magnets.



76 At the instant the switch is closed and a current begins to flow through the coil of the electromagnet, the coil will experience

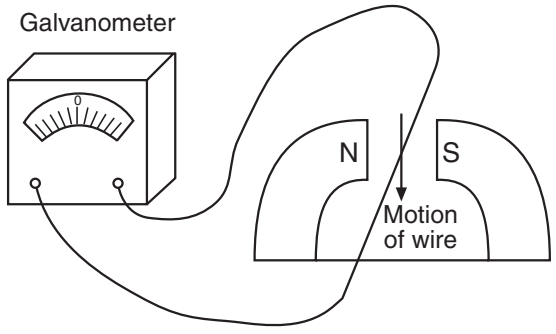
(1) no electromagnetic force
(2) a force directed out of the page
(3) a counterclockwise torque
(4) a clockwise torque

Note that question 77 has only three choices.

77 The air core of the electromagnet is replaced with an iron core. Compared to the strength of the magnetic field in the air core, the strength of the magnetic field in the iron core is

(1) less
(2) greater
(3) the same

78 The two ends of a wire are connected to a galvanometer, forming a complete electric circuit. The wire is then moved through a magnetic field, as shown in the diagram below.



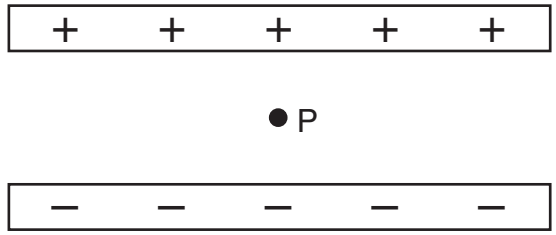
The galvanometer is being used to measure

(1) current
(2) potential difference
(3) temperature change
(4) resistance

79 Which device converts electrical energy into mechanical energy?

(1) motor
(2) generator
(3) source of emf
(4) thermocouple

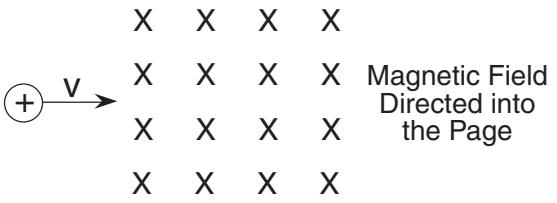
80 The diagram below shows a point, *P*, located midway between two oppositely charged parallel plates.



If an electron is introduced at point *P*, the electron will

(1) travel at constant speed toward the positively charged plate
(2) travel at constant speed toward the negatively charged plate
(3) accelerate toward the positively charged plate
(4) accelerate toward the negatively charged plate

81 The diagram below shows a proton moving with velocity v about to enter a uniform magnetic field directed into the page. As the proton moves in the magnetic field, the magnitude of the magnetic force on the proton is F.



If the proton were replaced by an alpha particle under the same conditions, the magnitude of the magnetic force on the alpha particle would be

(1) F
(2) $2F$
(3) $\frac{F}{2}$
(4) $4F$

82 The isotopes of an element can be separated using a

(1) cathode ray tube
(2) diffraction grating
(3) Geiger counter
(4) mass spectrometer

83 A potential difference of 12 volts is induced across a 0.20-meter-long straight wire as it is moved at a constant speed of 3.0 meters per second perpendicular to a uniform magnetic field. What is the strength of the magnetic field?

(1) 180 T
(2) 20. T
(3) 13 T
(4) 7.2 T

84 A step-down transformer used to run a toy train has an input of 120 volts to its primary coil. A potential difference of 12 volts is induced in the secondary coil, which carries a current of 12 amperes. If the transformer operates at 75% efficiency, what is the current in the primary coil?

(1) 0.90 A
(2) 1.6 A
(3) 90. A
(4) 160 A

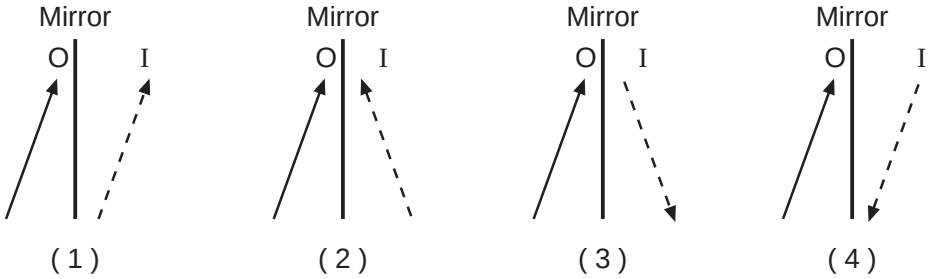
85 What is the origin of the light emitted by a laser?

(1) thermionic emission from an incandescent filament
(2) emission of mechanical waves from vibrating matter
(3) emission of photoelectrons from a photosensitive surface
(4) emission of photons from excited atoms

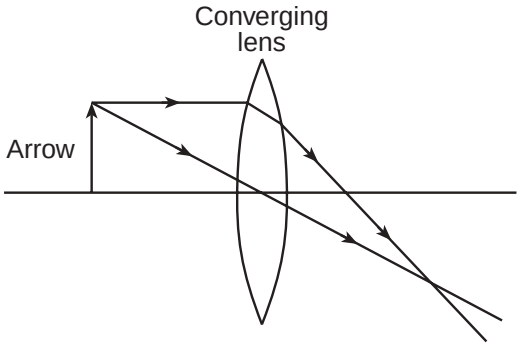
Group 4 — Geometric Optics

If you choose this group, be sure to answer questions 86–95.

86 Which diagram best represents image *I*, which is formed by placing object *O* in front of a plane mirror?



87 The diagram below shows an arrow placed in front of a converging lens.



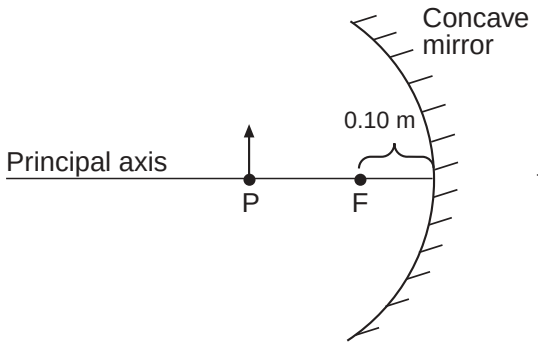
The lens forms an image of the arrow that is

(1) real and inverted
(2) real and erect
(3) virtual and inverted
(4) virtual and erect

88 Light rays from a candle flame are incident on a convex mirror. After reflecting from the mirror, these light rays

(1) converge and form a virtual image
(2) converge and form a real image
(3) diverge and form a virtual image
(4) diverge and form a real image

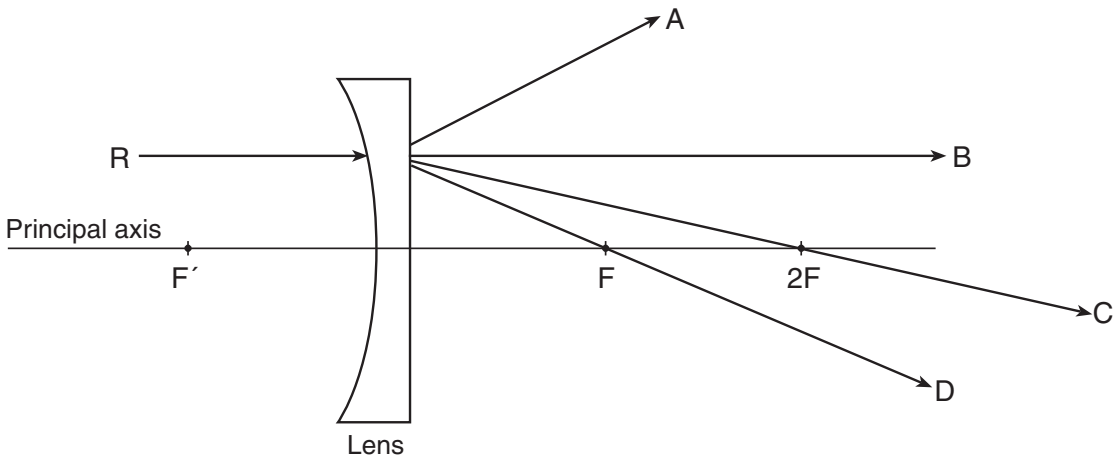
89 The diagram below shows an object located at point *P*, 0.25 meter from a concave spherical mirror with principal focus *F*. The focal length of the mirror is 0.10 meter.



How does the image change as the object is moved from point *P* toward point *F*?

(1) Its distance from the mirror decreases and the size of the image decreases.
(2) Its distance from the mirror decreases and the size of the image increases.
(3) Its distance from the mirror increases and the size of the image decreases.
(4) Its distance from the mirror increases and the size of the image increases.

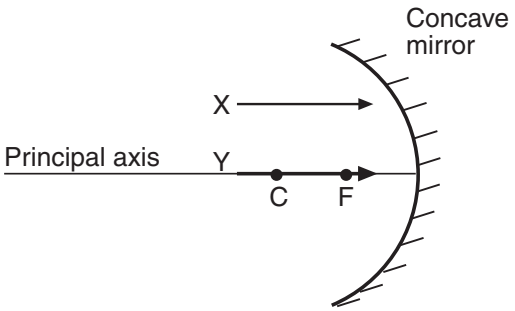
90 The diagram below shows light ray *R* incident on a glass lens in air.



Which ray best represents the path of light ray *R* after it passes through the lens?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

91 The diagram below shows two parallel light rays, *X* and *Y*, approaching a concave spherical mirror.



Which light will reflect through the mirror's center of curvature, *C*?

(1) ray *X*, only
(2) ray *Y*, only
(3) both ray *X* and ray *Y*
(4) neither ray *X* nor ray *Y*

92 Which optical devices in air can both form real images?

(1) concave mirror and convex lens
(2) concave mirror and concave lens
(3) plane mirror and convex lens
(4) plane mirror and concave lens

93 An object is located 0.15 meter from a converging lens with focal length 0.10 meter. How far from the lens is the image formed?

(1) 0.060 m
(2) 0.10 m
(3) 0.15 m
(4) 0.30 m

94 When a student 1.5 meters tall stands 5.0 meters in front of a lens, his image forms on a screen located 0.50 meter behind the lens. What is the height of the student's image?

(1) 0.015 m
(2) 0.15 m
(3) 1.5 m
(4) 15 m

95 Which phenomena cause chromatic aberration to occur when polychromatic light passes through a lens?

(1) diffraction and refraction
(2) diffraction and reflection
(3) dispersion and refraction
(4) dispersion and reflection

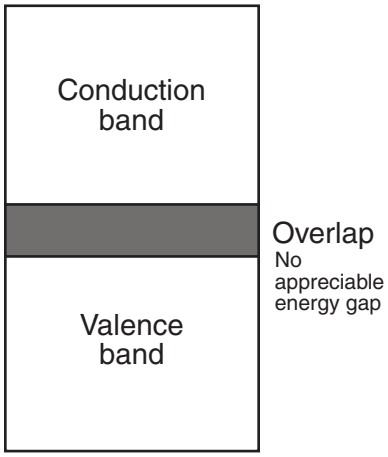
Group 5 — Solid State

If you choose this group, be sure to answer questions 96–105.

96 A material having extremely low conductivity would be classified as

(1) a conductor
(2) a semiconductor
(3) an insulator
(4) a metalloid

97 The diagram below represents the band model of a substance.



The substance is best classified as

(1) an insulator
(2) a semiconductor
(3) a conductor
(4) a nonmetal

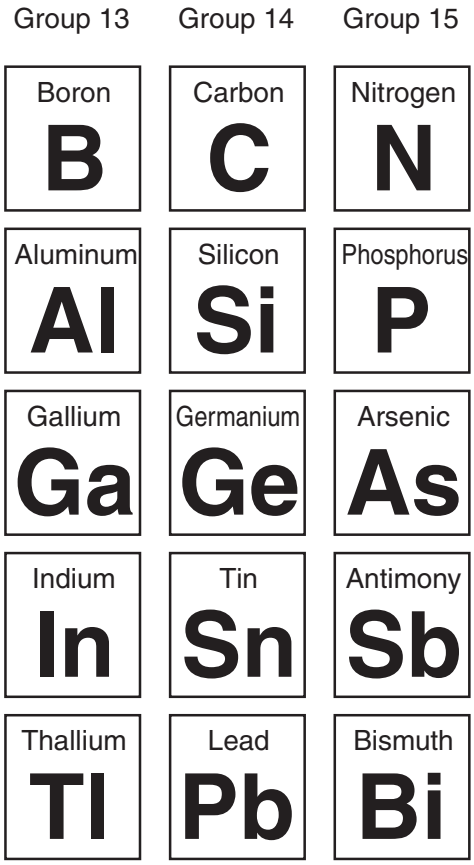
98 Magnetic-card door locks utilize many electronic components on one small piece of semiconductor material. This combination of components on a single chip is called

(1) a transistor
(2) an integrated circuit
(3) a printed circuit board
(4) a diode

99 The Band Model has replaced the Electron-sea Model of conduction because the Electron-sea Model

(1) only works for gases
(2) only works for liquids
(3) does not account for the conduction properties of metals
(4) does not account for the conduction properties of semiconductors

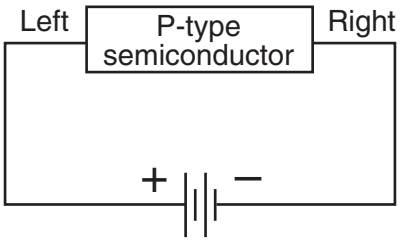
100 The diagram below shows a portion of the Periodic Table of the Elements.



Based on the information in this diagram, which three elements could all be used as doping agents to produce the holes of a *P*-type semiconductor?

(1) boron, aluminum, and gallium
(2) boron, carbon, and nitrogen
(3) thallium, germanium, and phosphorus
(4) nitrogen, phosphorus, and arsenic

101 The diagram below shows a circuit with a battery applying a potential difference across a *P*-type semiconductor.



The majority charge carriers in the semiconductor are

(1) negative electrons moving to the right
(2) negative electrons moving to the left
(3) positive holes moving to the right
(4) positive holes moving to the left

102 Which diagram best represents a diode?

(1) 

(3) 

(2) 

(4) 

103 In the *P*-*N* junction region of an operating diode, an electric field barrier is produced by free electrons in the

(1) *N*-type material crossing into the *P*-type material
(2) *N*-type material going away from the *P*-type material
(3) *P*-type material crossing into the *N*-type material
(4) *P*-type material going away from the *N*-type material

104 In a *P*-*N*-*P* transistor, what is the function of the two types of material?

(1) The *N*-type material functions as the base, and the *P*-type material is both emitter and collector.
(2) The *N*-type material functions as both base and emitter, and the *P*-type material is the collector.
(3) The *N*-type material functions as the emitter, and the *P*-type material is both base and collector.
(4) The *N*-type material functions as the collector, and the *P*-type material is both emitter and base.

Note that question 105 has only three choices.

105 As the temperature of a semiconductor increases, the number of holes in the valence band will

(1) decrease
(2) increase
(3) remain the same

Group 6 — Nuclear Energy

If you choose this group, be sure to answer questions 106–115.

106 Which nuclide has a mass number of 8?

(1) $^{6}_{2}\mathrm{He}$ (3) $^{15}_{7}\mathrm{N}$

(2) $^{8}_{4}\mathrm{Be}$ (4) $^{16}_{8}\mathrm{O}$

107 The binding energy of a uranium-235 nucleus is the energy equivalent of its

(1) total mass (3) critical mass
(2) mass number (4) mass defect

108 Which device is used to detect nuclear radiation?

(1) cyclotron
(2) Geiger counter
(3) linear accelerator
(4) Van de Graaff generator

109 When an atom of $^{238}_{92}\mathrm{U}$ decays to an atom of $^{206}_{82}\mathrm{Pb}$, the total number of alpha particles emitted is

(1) 5 (3) 8
(2) 6 (4) 14

110 A medical lab has a 16-gram sample of a radioactive isotope. After 6.0 hours, it is found that 12 grams of the sample have decayed. What is the half-life of the isotope?

(1) 6.0 hr (3) 3.0 hr
(2) 2.0 hr (4) 12.0 hr

111 The nuclear equation $^{30}_{15}\mathrm{P} \rightarrow {}^{30}_{14}\mathrm{Si} + {}^{0}_{+1}\mathrm{e}$ represents

(1) alpha bombardment
(2) electron capture
(3) neutron emission
(4) positron emission

112 In a nuclear reactor, one of the primary functions of the coolant is to

(1) promote overheating in the reactor core
(2) transfer thermal energy to a heat exchanger
(3) adjust the number of neutrons
(4) protect the reactor operators from radiation

113 Protons and neutrons are composed of smaller particles called

(1) quarks (3) alpha particles
(2) baryons (4) bosons

114 The equation below represents a fission reaction in a nuclear reactor.

$$^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 3{}^{1}_{0}\mathrm{n} + \text{energy}$$

Which product of this reaction must be absorbed by other $^{235}_{92}\mathrm{U}$ nuclei to sustain a chain reaction?

(1) $^{141}_{56}\mathrm{Ba}$ (3) $^{1}_{0}\mathrm{n}$

(2) $^{92}_{36}\mathrm{Kr}$ (4) energy

115 Which equation represents the process by which the Sun produces energy?

(1) $^{3}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + \mathrm{Q}$

(2) $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{138}_{56}\mathrm{Ba} + {}^{95}_{36}\mathrm{Kr} + 3{}^{1}_{0}\mathrm{n} + \mathrm{Q}$

(3) $^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e} + \mathrm{Q}$

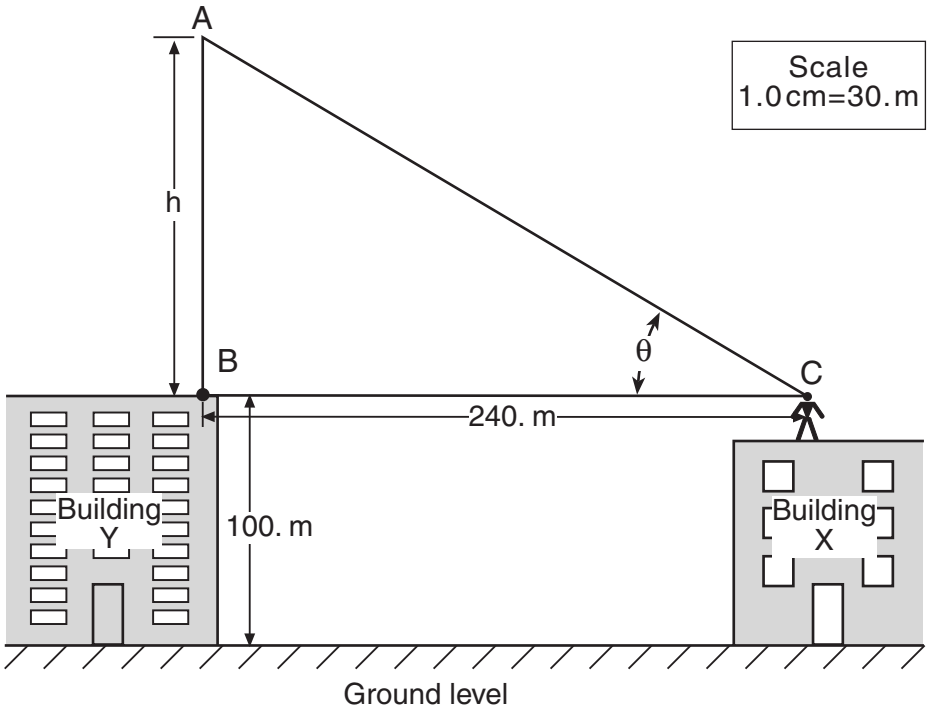
(4) $^{40}_{19}\mathrm{K} + {}^{0}_{-1}\mathrm{e} \rightarrow {}^{40}_{18}\mathrm{Ar} + \mathrm{Q}$

Part III

You must answer *all* questions in this part. Record your answers in the spaces provided on the separate answer paper. Pen or pencil may be used. [15]

Base your answers to questions 116 through 119 on the information and diagram below, which is drawn to a scale of 1.0 centimeter = 30. meters.

A student on building *X* is located 240. meters from the launch site *B* of a rocket on building *Y*. The rocket reaches its maximum altitude at point *A*. The student's eyes are level with the launch site on building *Y*.



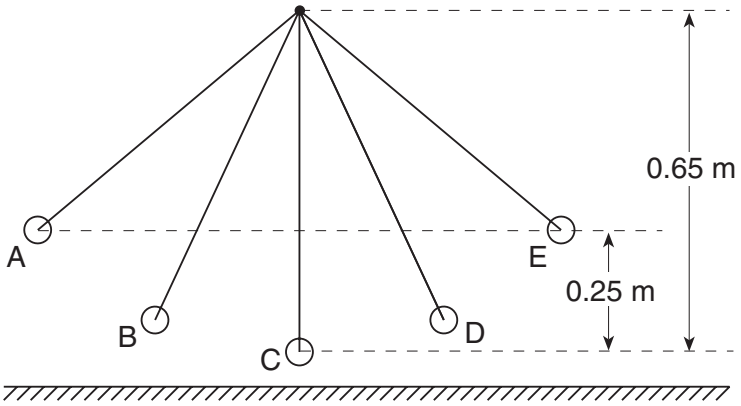
116 Using the scale diagram and a protractor, measure the angle of elevation, θ, of the rocket and record it to the *nearest degree*. [1]

117 Determine the height, h, of the rocket above the student's eye level. [1]

118 What is the total distance the rocket must fall from its maximum altitude to reach the ground? [1]

119 Determine how much time is required for the rocket to fall freely from point *A* back to ground level. [Show all calculations, including the equation and substitution with units.] [2]

120 A 0.65-meter-long pendulum consists of a 1.0-kilogram mass at the end of a string. The pendulum is released from rest at position *A*, 0.25 meter above its lowest point. The pendulum is timed at five positions, *A* through *E*.



Data Table

Position	Elapsed Time
A	0.00 s
B	0.20 s
C	0.40 s
D	0.60 s
E	0.80 s

Based on the information in the diagram and the data table, determine the period of the pendulum. [1]

Base your answers to questions 121 through 123 on the information below.

A 680-newton student runs up a flight of stairs 3.5 meters high in 11.4 seconds. The student takes 8.5 seconds to run up the same flight of stairs during a second trial.

121 Determine the work done by the 680-newton student in climbing the stairs. [Show all calculations, including the equation and substitution with units.] [2]

122 Determine the power developed by the student during the 11.4-second climb. [Show all calculations, including the equation and substitution with units.] [2]

123 Using one or more complete sentences, compare the power developed by the student climbing the stairs in 11.4 seconds to the power developed during the 8.5-second trial. [1]

Base your answers to questions 124 through 126 on the information below.

A 0.12-meter-long electromagnetic (radar) wave is emitted by a weather station and reflected from a nearby thunderstorm.

124 Determine the frequency of the radar wave. [Show all calculations, including the equation and substitution with units.] [2]

125 Using one or more complete sentences, define the Doppler effect. [1]

126 The thunderstorm is moving toward the weather station. Using one or more complete sentences, explain how the Doppler effect could have been used to determine the direction in which the storm is moving. [1]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Wednesday, June 20, 2001 — 1:15 to 4:15 p.m., only

ANSWER PAPER

Student . . . . . Sex: ☐ Male ☐ Female

Teacher . . . . . .

School . . . . . .

Record all of your answers on this answer paper in accordance with the instructions on the front page of the test booklet.

Part I (65 credits)

1	1	2	3	4	**21**	1	2	3	4	**41**	1	2	3	4
2	1	2	3	4	**22**	1	2	3	4	**42**	1	2	3	4
3	1	2	3	4	**23**	1	2	3	4	**43**	1	2	3	4
4	1	2	3	4	**24**	1	2	3	4	**44**	1	2	3	4
5	1	2	3	4	**25**	1	2	3	4	**45**	1	2	3	4
6	1	2	3	4	**26**	1	2	3	4	**46**	1	2	3	4
7	1	2	3	4	**27**	1	2	3	4	**47**	1	2	3	4
8	1	2	3	4	**28**	1	2	3	4	**48**	1	2	3	4
9	1	2	3	4	**29**	1	2	3	4	**49**	1	2	3	4
10	1	2	3	4	**30**	1	2	3	4	**50**	1	2	3	4
11	1	2	3	4	**31**	1	2	3	4	**51**	1	2	3	4
12	1	2	3	4	**32**	1	2	3	4	**52**	1	2	3	4
13	1	2	3	4	**33**	1	2	3		**53**	1	2	3	
14	1	2	3	4	**34**	1	2	3	4	**54**	1	2	3	
15	1	2	3	4	**35**	1	2	3	4	**55**	1	2	3	
16	1	2	3	4	**36**	1	2	3	4					
17	1	2	3	4	**37**	1	2	3	4					
18	1	2	3	4	**38**	1	2	3	4					
19	1	2	3	4	**39**	1	2	3	4					
20	1	2	3	4	**40**	1	2	3	4					

FOR TEACHER USE ONLY

Part I Score (Use table below) . . . . . .

Part II Score . . . . . .

Part III Score . . . . . .

Total Score . . . . . .

Rater's Initials: . . . . . .

PART I CREDITS

Directions to Teacher:

In the table below, draw a circle around the number of right answers and the adjacent number of credits. Then write the number of credits (not the number right) in the space provided above.

No. Right	Credits	No. Right	Credits
55	**65**	27	**45**
54	**64**	26	**44**
53	**64**	25	**43**
52	**63**	24	**43**
51	**62**	23	**42**
50	**61**	22	**41**
49	**61**	21	**41**
48	**60**	20	**40**
47	**59**	19	**39**
46	**59**	18	**38**
45	**58**	17	**38**
44	**57**	16	**37**
43	**56**	15	**36**
42	**56**	14	**36**
41	**55**	13	**35**
40	**54**	12	**32**
39	**54**	11	**30**
38	**53**	10	**27**
37	**52**	9	**24**
36	**51**	8	**22**
35	**51**	7	**19**
34	**50**	6	**16**
33	**49**	5	**13**
32	**48**	4	**11**
31	**48**	3	**8**
30	**47**	2	**5**
29	**46**	1	**3**
28	**46**	0	**0**

No. right . . . . . .

Part II (20 credits)

Answer the questions in only two of the six groups in this part. Be sure to mark the answers to the groups of questions you choose in accordance with the instructions on the front page of the test booklet. Leave blank the four groups of questions you do not choose to answer.

Group 1
Motion in a Plane

56	1	2	3	4
57	1	2	3	4
58	1	2	3	4
59	1	2	3	4
60	1	2	3	4
61	1	2	3	4
62	1	2	3	4
63	1	2	3	4
64	1	2	3	4
65	1	2	3	4

Group 2
Internal Energy

66	1	2	3	
67	1	2	3	4
68	1	2	3	4
69	1	2	3	4
70	1	2	3	4
71	1	2	3	4
72	1	2	3	4
73	1	2	3	4
74	1	2	3	4
75	1	2	3	

Group 3
Electromagnetic Applications

76	1	2	3	4
77	1	2	3	
78	1	2	3	4
79	1	2	3	4
80	1	2	3	4
81	1	2	3	4
82	1	2	3	4
83	1	2	3	4
84	1	2	3	4
85	1	2	3	4

Group 4
Geometric Optics

86	1	2	3	4
87	1	2	3	4
88	1	2	3	4
89	1	2	3	4
90	1	2	3	4
91	1	2	3	4
92	1	2	3	4
93	1	2	3	4
94	1	2	3	4
95	1	2	3	4

Group 5
Solid State

96	1	2	3	4
97	1	2	3	4
98	1	2	3	4
99	1	2	3	4
100	1	2	3	4
101	1	2	3	4
102	1	2	3	4
103	1	2	3	4
104	1	2	3	4
105	1	2	3	

Group 6
Nuclear Energy

106	1	2	3	4
107	1	2	3	4
108	1	2	3	4
109	1	2	3	4
110	1	2	3	4
111	1	2	3	4
112	1	2	3	4
113	1	2	3	4
114	1	2	3	4
115	1	2	3	4

FOR TEACHERS ONLY

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The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Wednesday, June 20, 2001—1:15 to 4:15 p.m., only

SCORING KEY

Part I

Refer to the table on the answer paper for the number of credits to be given on Part I.

Part I (65 credits)

1	1	X	3	4	21	1	X	3	4	41	1	2	3	X
2	1	2	X	4	22	X	2	3	4	42	1	2	X	4
3	1	2	X	4	23	1	2	X	4	43	X	2	3	4
4	1	2	3	X	24	1	2	3	X	44	1	X	3	4
5	X	2	3	4	25	1	2	3	X	45	X	2	3	4
6	1	2	3	X	26	X	2	3	4	46	1	2	X	4
7	1	2	3	X	27	X	2	3	4	47	1	2	3	X
8	1	X	3	4	28	1	2	X	4	48	1	X	3	4
9	X	2	3	4	29	1	2	3	X	49	1	2	3	X
10	1	2	X	4	30	1	X	3	4	50	1	2	3	X
11	1	X	3	4	31	1	2	3	X	51	1	X	3	4
12	1	X	3	4	32	X	2	3	4	52	1	2	X	4
13	1	2	X	4	33	X	2	3	4	53	X	2	3	
14	1	2	X	4	34	X	2	3	4	54	X	2	3	
15	1	X	3	4	35	1	2	3	X	55	1	2	X	
16	1	2	3	X	36	1	2	3	X					
17	1	2	X	4	37	1	2	X	4					
18	X	2	3	4	38	1	2	X	4					
19	1	X	3	4	39	1	X	3	4					
20	1	2	3	X	40	1	X	3	4					

Directions to the teacher:

Use only *red* ink or *red* pencil in rating Regents examination papers. Do *not* correct the student's work by making insertions or changes of any kind.

Scan each answer paper to make certain that the student has marked only one answer for each question. If a student has marked two or more answers with an X in ink, draw a red line through the row of numbers for that question to indicate that no credit is to be allowed for that question when the answer paper is scored.

To facilitate scoring, the scoring key has been printed in the same format as the answer paper. The scoring key for **Part I and Part II** may be made into a scoring stencil by punching out the correct answers. Be sure that the stencil is aligned with the answer paper so that the holes correspond to the correct answers. To aid in proper alignment, punch out the first and last item numbers in each part and place the stencil on the answer paper so that these item numbers appear through the appropriate holes.

[OVER]

Part II

Allow a total of 20 credits, one credit for each question, for only two of the six groups in this part. If more than two groups are answered, only the first two should be considered.

Group 1
Motion in a Plane

56	1	**X**	3	4
57	1	2	3	**X**
58	**X**	2	3	4
59	1	2	3	**X**
60	1	2	**X**	4
61	1	**X**	3	4
62	1	**X**	3	4
63	1	2	**X**	4
64	1	**X**	3	4
65	**X**	2	3	4

Group 2
Internal Energy

66	**X**	2	3	
67	1	**X**	3	4
68	1	2	3	**X**
69	1	2	**X**	4
70	1	2	**X**	4
71	1	**X**	3	4
72	1	2	3	**X**
73	1	2	**X**	4
74	1	2	3	**X**
75	**X**	2	3	

Group 3
Electromagnetic Applications

76	1	2	**X**	4
77	1	**X**	3	
78	**X**	2	3	4
79	**X**	2	3	4
80	1	2	**X**	4
81	1	**X**	3	4
82	1	2	3	**X**
83	1	**X**	3	4
84	1	**X**	3	4
85	1	2	3	**X**

Group 4
Geometric Optics

86	1	**X**	3	4
87	**X**	2	3	4
88	1	2	**X**	4
89	1	2	3	**X**
90	**X**	2	3	4
91	1	**X**	3	4
92	**X**	2	3	
93	1	2	3	**X**
94	1	**X**	3	4
95	1	2	**X**	4

Group 5
Solid State

96	1	2	**X**	4
97	1	2	**X**	4
98	1	**X**	3	4
99	1	2	3	**X**
100	**X**	2	3	4
101	1	2	**X**	4
102	1	2	3	**X**
103	**X**	2	3	4
104	**X**	2	3	4
105	1	**X**	3	

Group 6
Nuclear Energy

106	1	**X**	3	4
107	1	2	3	**X**
108	1	**X**	3	4
109	1	2	**X**	4
110	1	2	**X**	4
111	1	2	3	**X**
112	1	**X**	3	4
113	**X**	2	3	4
114	1	2	**X**	4
115	**X**	2	3	4

Part III (15 credits)

Please refer to the Department publication *Regents Examination in Physics: Rating Guide for Part III*. Teachers should become familiar with this guide before rating students' papers.

Scoring Criteria for Calculations

For each question requiring the student to *show all calculations, including the equation and substitution with units*, apply the following scoring criteria:

Allow a total of two credits for questions 119, 121, 122, and 124.

- Allow one credit for the equation and substitution of values with units. If the equation and/or substitution with units is not shown, do not allow this credit.
- Allow one credit for the correct answer (number and unit). If the number is given without the unit, do not allow this credit.
- Penalize a student only once per equation for omitting units.
- Allow full credit even if the answer is not expressed with the correct number of significant figures.

116 Allow one credit.

30.° ±2°

Do not penalize a student if the decimal point is missing and/or the degree sign is missing.

117 Allow one credit.

140 m ±20 m

If the number is given without the unit, do not allow this credit.

Allow credit for an answer that is consistent with the product of 240 m and the tangent of the angle given in the student's answer to question 116.

118 Allow one credit.

240 m

or

140 m + 100 m

If a number is given without a unit, do not allow this credit.

Allow credit for an answer that is consistent with the student's answer to question 117.

119 Allow a total of two credits. Refer to *Scoring Criteria for Calculations* in this scoring key.

Examples of Acceptable Responses

$\Delta s = v_i \Delta t + \frac{1}{2} a(\Delta t)^2$

$\Delta s = \frac{1}{2} a(\Delta t)^2$

$\Delta t = \sqrt{\frac{2\Delta s}{a}}$

$\Delta t = \sqrt{\frac{2 \cdot 240 \text{ m}}{9.8 \text{ m/s}^2}}$

$\Delta t = 7.0 \text{ s}$

or

$s = \frac{1}{2} at^2$ (from rest)

$t = \sqrt{\frac{2s}{a}}$

$t = \sqrt{\frac{2 \cdot 240 \text{ m}}{9.8 \text{ m/s}^2}}$

$t = 7 \text{ s}$

Allow credit for an answer that is consistent with the student's answer to question 118.

120 Allow one credit.

Examples of Acceptable Responses

1.60 s

or

1.6 second

If the number is given without the unit do not allow this credit.

121 Allow a total of two credits. Refer to *Scoring Criteria for Calculations* in this scoring key.

Examples of Acceptable Responses

$W = F\Delta s$

$W = (680\text{ N})(3.5\text{ m})$

$W = 2380\text{ N}\cdot\text{m}$

or

$W = 2400\text{ J}$

122 Allow a total of two credits. Refer to *Scoring Criteria for Calculations* in this scoring key.

Examples of Acceptable Responses

$P = \frac{W}{\Delta t}$

$P = \frac{2400\text{ J}}{11.4\text{ s}}$

$P = 210\text{ W}$

or

$P = \frac{W}{t}$

$P = \frac{2380\text{ J}}{11.4\text{ s}}$

$P = 208.8\text{ J/s}$

123 Allow one credit. To receive this credit, the response must be written in one or more complete sentences.

Examples of Acceptable Responses

The power developed during the 11.4-second trial is less than the power developed during the 8.5-second trial.

or

The power developed during the 11.4-second trial is less.

124 Allow a total of two credits. Refer to *Scoring Criteria for Calculations* in this scoring key.

Examples of Acceptable Responses

$v = f\lambda$

$f = \frac{v}{\lambda}$

$f = \frac{3.0\times10^8\text{ m/s}}{0.12\text{ m}} = 2.5\times10^9\text{ Hz}$

or

$c = f\lambda$

$f = \frac{c}{\lambda}$

$f = \frac{3.0\times10^8\text{ m/s}}{0.12\text{ m}} = 25\times10^8\text{ 1/s}$

125 Allow one credit. To receive this credit, the response must be written in one or more complete sentences.

Examples of Acceptable Responses

The Doppler effect is the variation in observed frequency when there is relative motion between a wave source and a receiver.

or

The Doppler effect is the variation in observed wavelength when there is relative motion between a wave source and a receiver.

or

The Doppler effect is the increase or decrease in wave frequency that results from the relative motion of a wave source and an observer.

126 Allow one credit. To receive this credit, the response must be written in one or more complete sentences.

Examples of Acceptable Responses

The wave reflected from the thunderstorm has a higher frequency than the wave emitted by the weather station.

or

The frequency of the reflected wave is greater than the emitted wave's frequency.

or

The wave reflected from the thunderstorm has a shorter wavelength than the wave emitted by the weather station.