The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Wednesday, June 21, 2000 — 9:15 a.m. to 12:15 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: ~~1~~ 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.

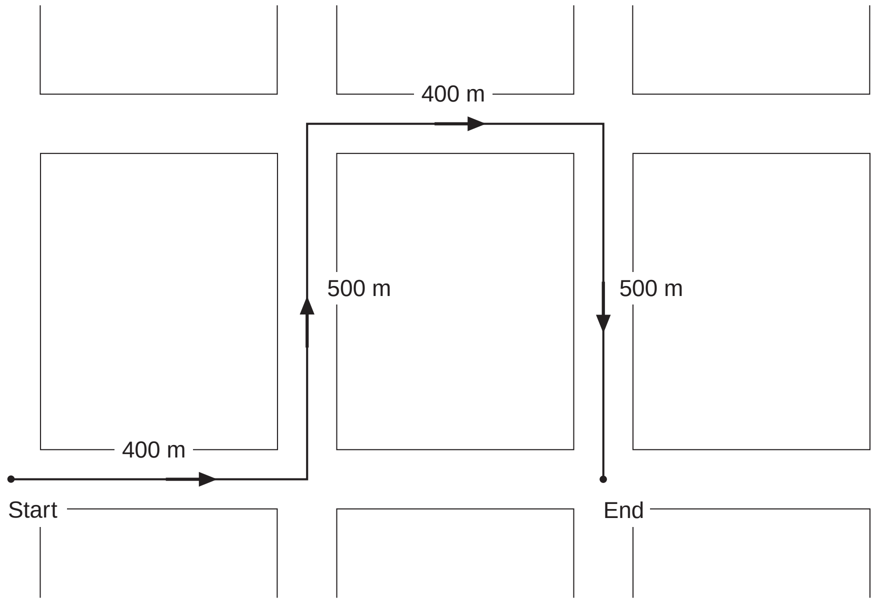
DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL YOU ARE TOLD TO DO SO.

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.

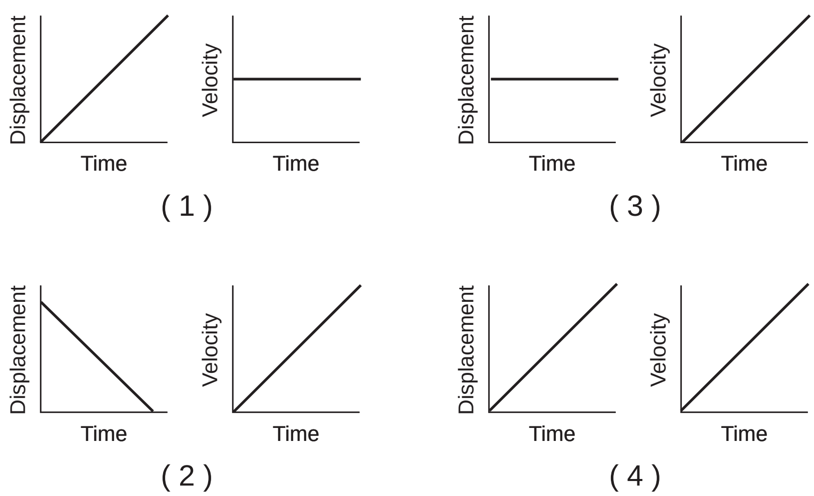
1 The map below shows the route traveled by a school bus.



What is the magnitude of the total displacement of the school bus from the start to the end of its trip?

(1) 400 m
(2) 500 m
(3) 800 m
(4) 1,800 m

2 Which pair of graphs represent the same motion?



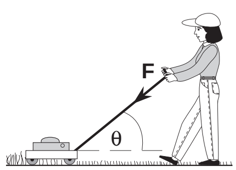
3 A runner starts from rest and accelerates uniformly to a speed of 8.0 meters per second in 4.0 seconds. The magnitude of the acceleration of the runner is

(1) 0.50 m/s^2 (3) 9.8 m/s^2
(2) 2.0 m/s^2 (4) 32 m/s^2

4 A cart moving across a level surface accelerates uniformly at 1.0 meter per $second^2$ for 2.0 seconds. What additional information is required to determine the distance traveled by the cart during this 2.0-second interval?

1 coefficient of friction between the cart and the surface
2 mass of the cart
3 net force acting on the cart
4 initial velocity of the cart

5 In the diagram below, a force, *F*, is applied to the handle of a lawnmower inclined at angle θ to the ground.



The magnitude of the horizontal component of force *F* depends on

1 the magnitude of force *F*, only
2 the measure of angle θ, only
3 both the magnitude of force *F* and the measure of angle θ
4 neither the magnitude of force *F* nor the measure of angle θ

6 Equilibrium exists in a system where three forces are acting concurrently on an object. If the system includes a 5.0-newton force due north and a 2.0-newton force due south, the third force must be

(1) 7.0 N south (3) 3.0 N south
(2) 7.0 N north (4) 3.0 N north

7 A ball is thrown straight up with a speed of 12 meters per second near the surface of Earth. What is the maximum height reached by the ball? [Neglect air friction.]

(1) 15 m (3) 1.2 m
(2) 7.3 m (4) 0.37 m

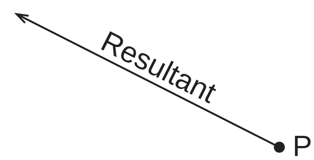
8 Which object weighs approximately 1 newton?

1 dime 3 physics student
2 paper clip 4 golf ball

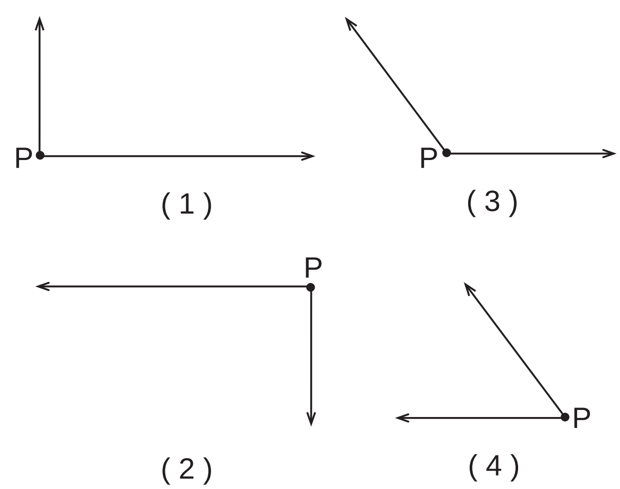
9 Which terms represent a vector quantity and its respective unit?

1 weight — kilogram
2 mass — kilogram
3 force — newton
4 momentum — newton

10 The vector below represents the resultant of two forces acting concurrently on an object at point *P*.



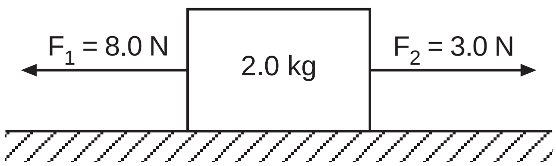
Which pair of vectors best represents two concurrent forces that combine to produce this resultant force vector?



11 Compared to 8 kilograms of feathers, 6 kilograms of lead has

1 less mass and less inertia
2 less mass and more inertia
3 more mass and less inertia
4 more mass and more inertia

12 Two forces are applied to a 2.0-kilogram block on a frictionless horizontal surface, as shown in the diagram below.



Frictionless surface

The acceleration of the block is

(1) 1.5 m/s^2 to the right
(2) 2.5 m/s^2 to the left
(3) 2.5 m/s^2 to the right
(4) 4.0 m/s^2 to the left

13 A 15-kilogram mass weighs 60. newtons on planet *X*. The mass is allowed to fall freely from rest near the surface of the planet. After falling for 6.0 seconds, the acceleration of the mass is

(1) 0.25 m/s^2
(2) 10. m/s^2
(3) 24 m/s^2
(4) 4.0 m/s^2

14 Sand is often placed on an icy road because the sand

1 decreases the coefficient of friction between the tires of a car and the road
2 increases the coefficient of friction between the tires of a car and the road
3 decreases the gravitational force on a car
4 increases the normal force of a car on the road

15 A 2.0-kilogram cart moving due east at 6.0 meters per second collides with a 3.0-kilogram cart moving due west. The carts stick together and come to rest after the collision. What was the initial speed of the 3.0-kilogram cart?

(1) 1.0 m/s
(2) 6.0 m/s
(3) 9.0 m/s
(4) 4.0 m/s

16 What is the momentum of a 1,200-kilogram car traveling at 15 meters per second due east?

(1) 80. kg•m/s due east
(2) 80. kg•m/s due west
(3) 1.8×10^4 kg•m/s due east
(4) 1.8×10^4 kg•m/s due west

17 A 2,400-kilogram car is traveling at a speed of 20. meters per second. Compared to the magnitude of the force required to stop the car in 12 seconds, the magnitude of the force required to stop the car in 6.0 seconds is

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

18 A student applies a 20.-newton force to move a crate at a constant speed of 4.0 meters per second across a rough floor. How much work is done by the student on the crate in 6.0 seconds?

(1) 80. J
(2) 120 J
(3) 240 J
(4) 480 J

19 The gravitational force of attraction between two objects would be increased by

1 doubling the mass of both objects, only
2 doubling the distance between the objects, only
3 doubling the mass of both objects and doubling the distance between the objects
4 doubling the mass of one object and doubling the distance between the objects

20 A 5.0×10^2-newton girl takes 10. seconds to run up two flights of stairs to a landing, a total of 5.0 meters vertically above her starting point. What power does the girl develop during her run?

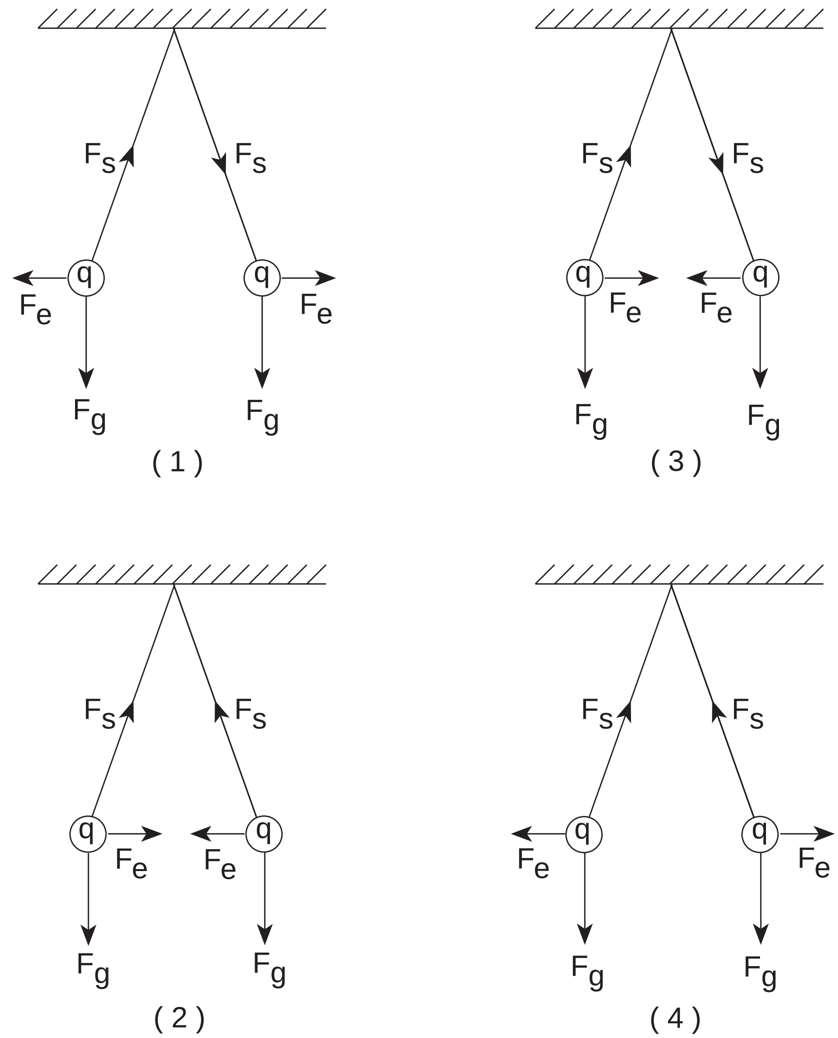
(1) 25 W
(2) 50. W
(3) 250 W
(4) 2,500 W

21 The kinetic energy of a 980-kilogram race car traveling at 90. meters per second is approximately

(1) 4.4×10^4 J
(2) 8.8×10^4 J
(3) 4.0×10^6 J
(4) 7.9×10^6 J

22 Two aluminum spheres of identical mass and identical charge q hang from strings of equal length. If the spheres are in equilibrium, which diagram best represents the direction of each force acting on the spheres?

Key
F_s = Force (tension) in string
F_e = Electrostatic force
F_g = Gravitational force



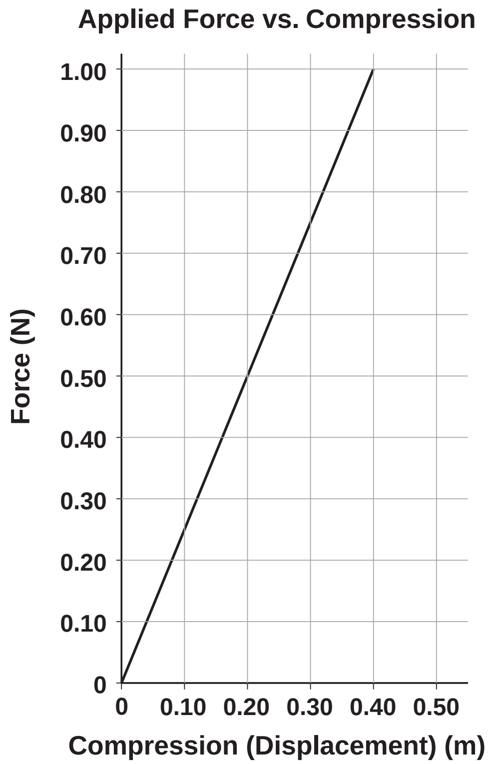
23 Moving 2.0 coulombs of charge a distance of 6.0 meters from point A to point B within an electric field requires a 5.0-newton force. What is the electric potential difference between points A and B?

(1) 60. V
(2) 30. V
(3) 15 V
(4) 2.5 V

24 A metal sphere having an excess of +5 elementary charges has a net electric charge of

(1) 1.6×10^{-19} C
(2) 8.0×10^{-19} C
(3) 5.0×10^{0} C
(4) 3.2×10^{19} C

25 The graph below represents the relationship between the force applied to a spring and the compression (displacement) of the spring.



What is the spring constant for this spring?

(1) 1.0 N/m
(2) 2.5 N/m
(3) 0.20 N/m
(4) 0.40 N/m

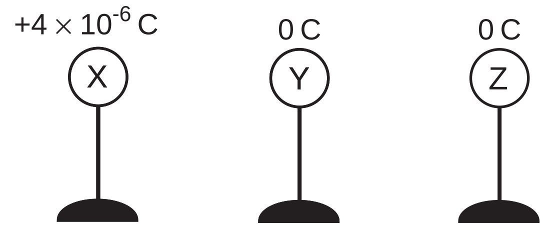
26 A lightning bolt transfers 6.0 coulombs of charge from a cloud to the ground in 2.0×10^{-3} second. What is the average current during this event?

(1) 1.2×10^{-2} A
(2) 3.0×10^{2} A
(3) 3.0×10^{3} A
(4) 1.2×10^{4} A

27 Conductivity in metallic solids is due to the presence of free

1 nuclei
2 protons
3 neutrons
4 electrons

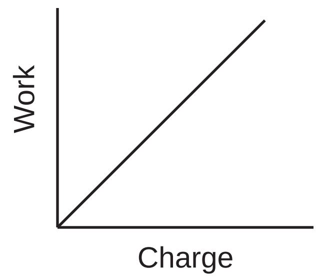
28 The diagram below shows the initial charge and position of three metal spheres, *X*, *Y*, and *Z*, on insulating stands.



Sphere *X* is brought into contact with sphere *Y* and then removed. Then sphere *Y* is brought into contact with sphere *Z* and removed. What is the charge on sphere *Z* after this procedure is completed?

(1) $+1 \times 10^{-6}$ C
(2) $+2 \times 10^{-6}$ C
(3) $+3 \times 10^{-6}$ C
(4) $+4 \times 10^{-6}$ C

29 In the diagram below, a student compresses the spring in a pop-up toy 0.020 meter.



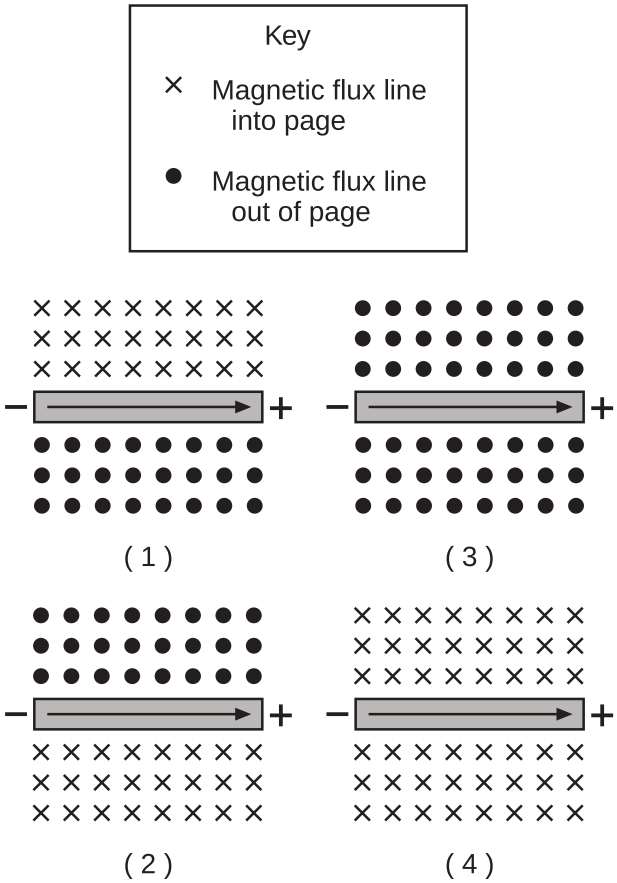
If the spring has a spring constant of 340 newtons per meter, how much energy is being stored in the spring?

(1) 0.068 J
(2) 0.14 J
(3) 3.4 J
(4) 6.8 J

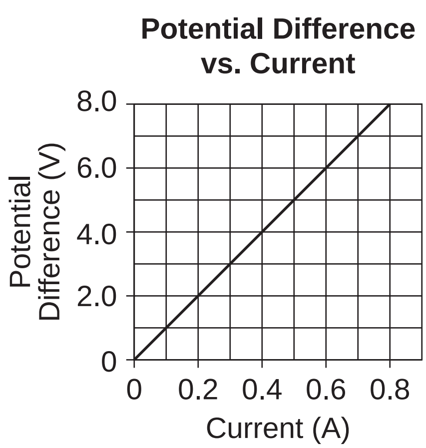
30 Gravitational field strength is to newtons per kilogram as electric field strength is to

1 coulombs per joule
2 coulombs per newton
3 joules per coulomb
4 newtons per coulomb

31 Which diagram best represents the magnetic field around a straight wire in which electrons are flowing from left to right?



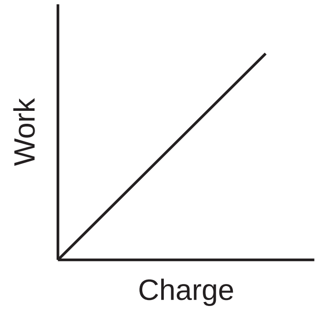
32 The graph below represents the relationship between the potential difference across a metal conductor and the current through the conductor at a constant temperature.



What is the resistance of the conductor?

(1) 1 Ω
(2) 0.01 Ω
(3) 0.1 Ω
(4) 10 Ω

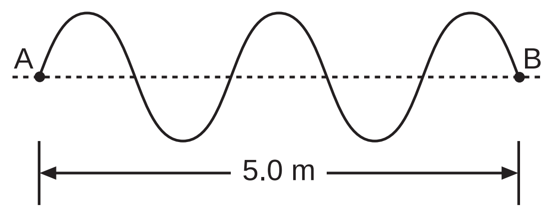
33 The graph below shows the relationship between the work done on a charged body in an electric field and the net charge on the body.



What does the slope of this graph represent?

1 power
2 potential difference
3 force
4 electric field intensity

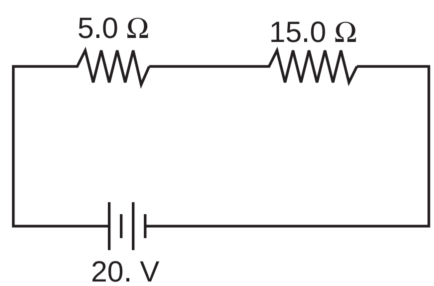
34 In the diagram below, the distance between points *A* and *B* on a wave is 5.0 meters.



The wavelength of this wave is

(1) 1.0 m
(2) 2.0 m
(3) 5.0 m
(4) 4.0 m

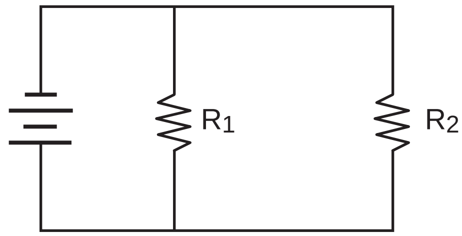
35 The diagram below shows two resistors connected in series to a 20.-volt battery.



If the current through the 5.0-ohm resistor is 1.0 ampere, the current through the 15.0-ohm resistor is

(1) 1.0 A
(2) 0.33 A
(3) 3.0 A
(4) 1.3 A

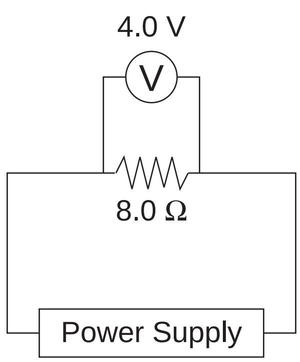
36 Resistors R_1 and R_2 have an equivalent resistance of 6 ohms when connected in the circuit shown below.



The resistance of R_1 could be

(1) 1 Ω (3) 8 Ω
(2) 5 Ω (4) 4 Ω

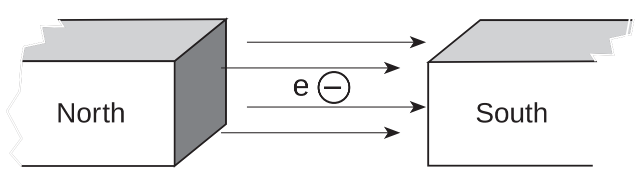
37 The diagram below represents an electric circuit.



The total amount of energy delivered to the resistor in 10. seconds is

(1) 3.2 J (3) 20. J
(2) 5.0 J (4) 320 J

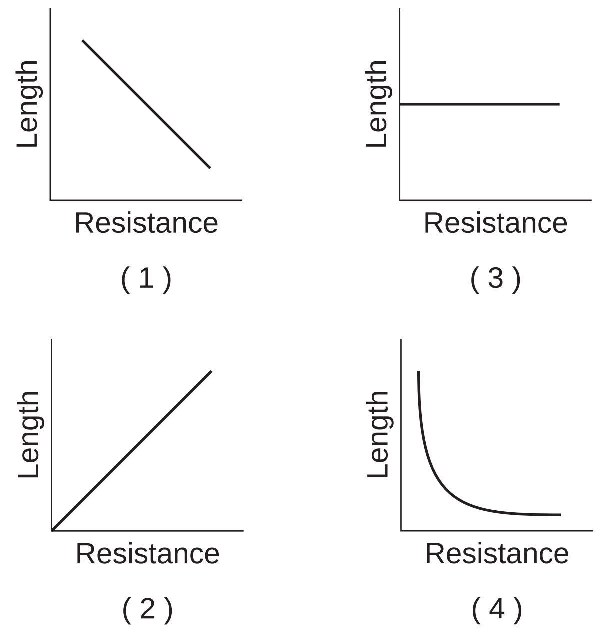
38 The diagram below shows an electron, *e*, located in a magnetic field.



There is *no* magnetic force on the electron when it moves

1 toward the right side of the page
2 toward the top of the page
3 into the page
4 out of the page

39 A copper wire is part of a complete circuit through which current flows. Which graph best represents the relationship between the wire's length and its resistance?



40 The heating element on an electric stove dissipates 4.0×10^2 watts of power when connected to a 120-volt source. What is the electrical resistance of this heating element?

(1) 0.028 Ω (3) 3.3 Ω
(2) 0.60 Ω (4) 36 Ω

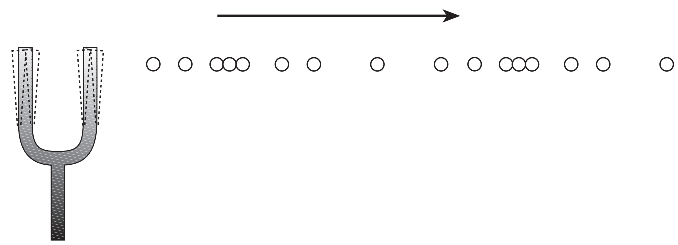
41 A monochromatic beam of light has a frequency of 6.5×10^{14} hertz. What color is the light?

1 yellow 3 violet
2 orange 4 blue

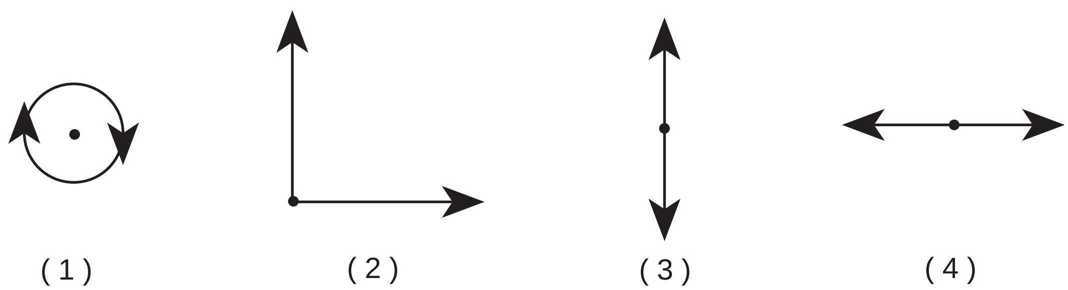
42 Two waves having the same amplitude and the same frequency pass simultaneously through a uniform medium. Maximum destructive interference occurs when the phase difference between the two waves is

(1) 0° (3) 180°
(2) 90° (4) 360°

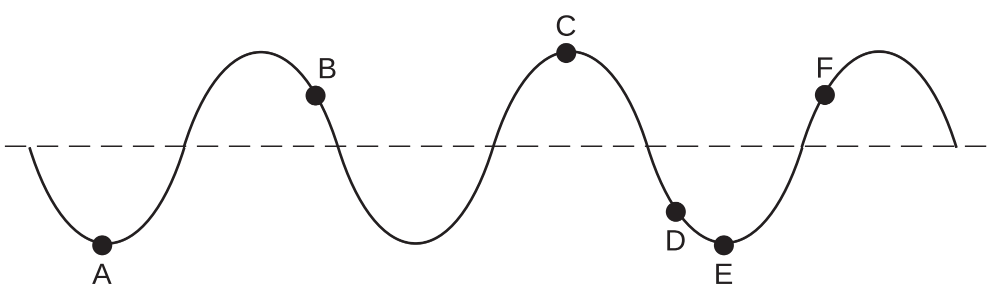
43 The diagram below shows a tuning fork vibrating in air. The dots represent air molecules as the sound wave moves toward the right.



Which diagram best represents the direction of motion of the air molecules?



44 The diagram below represents a wave traveling in a uniform medium.

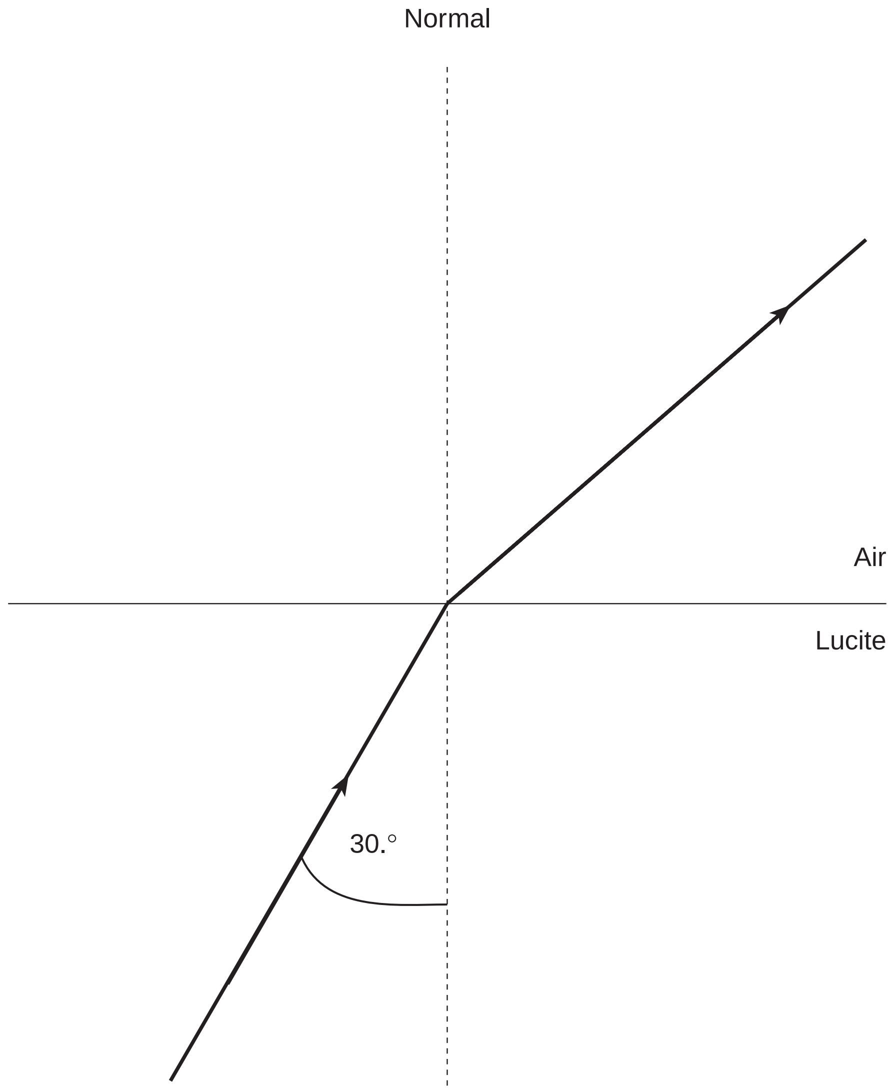


Which two points on the wave are in phase?

(1) *A* and *C*
(2) *A* and *E*
(3) *B* and *D*
(4) *B* and *F*

GO RIGHT ON TO THE NEXT PAGE.

Base your answers to questions 45 through 47 on the diagram below which represents a beam of monochromatic light ($\lambda = 5.9 \times 10^{-7}$ meter) traveling from Lucite into air.



(drawn to scale)

45 What is the measure of the angle of refraction? [Use a protractor or a mathematical calculation.]

(1) 19°
(2) 30.°
(3) 49°
(4) 60.°

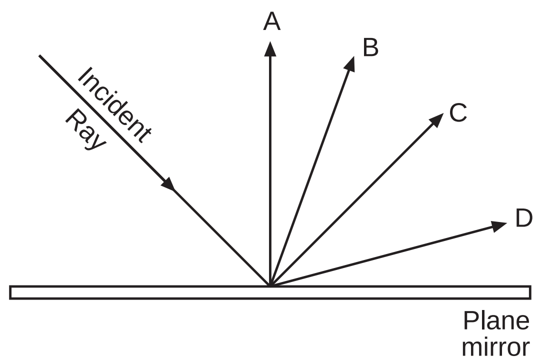
46 The speed of the light in Lucite is

(1) 1.5×10^8 m/s
(2) 2.0×10^8 m/s
(3) 3.0×10^8 m/s
(4) 4.5×10^8 m/s

47 The critical angle for the Lucite-air boundary is approximately

(1) 67°
(2) 48°
(3) 42°
(4) 33°

48 A light ray is incident on a plane mirror as shown in the diagram below.



Which ray best represents the reflected ray?

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

49 What occurs as a ray of light passes from air into water?

1 The ray must decrease in speed.
2 The ray must increase in speed.
3 The ray must decrease in frequency.
4 The ray must increase in frequency.

50 Which waves can be polarized?

1 light waves from an incandescent bulb
2 sound waves from a tuba
3 longitudinal waves
4 seismic waves (*P*-waves)

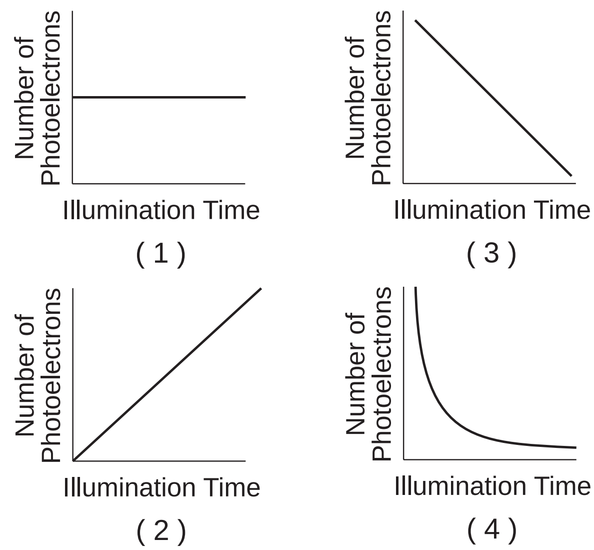
51 In which part of the electromagnetic spectrum does a photon have the greatest energy?

1 red 3 violet
2 infrared 4 ultraviolet

52 If all parts of a light beam have a constant phase relationship, with the same wavelength and frequency, the light beam is

1 monochromatic and coherent
2 monochromatic and incoherent
3 polychromatic and coherent
4 polychromatic and incoherent

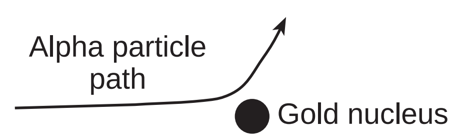
53 A beam of monochromatic light incident on a metal surface causes the emission of photoelectrons. The length of time that the surface is illuminated by this beam is varied, but the intensity of the beam is kept constant. Which graph best represents the relationship between the total number of photoelectrons emitted and the length of time of illumination?



54 What is the minimum energy required to excite a mercury atom initially in the ground state?

(1) 4.64 eV (3) 10.20 eV
(2) 5.74 eV (4) 10.38 eV

55 The diagram below represents the hyperbolic path of an alpha particle as it passes very near the nucleus of a gold atom.



The shape of the path is caused by the force between the

1 positively charged alpha particle and the neutral nucleus
2 positively charged alpha particle and the positively charged nucleus
3 negatively charged alpha particle and the neutral nucleus
4 negatively charged alpha particle and the positively charged nucleus

Part II

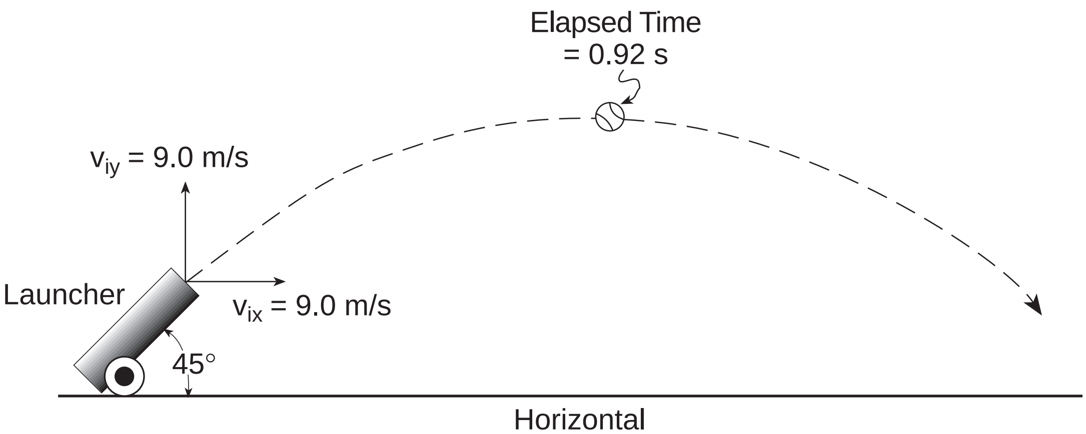
This part consists of six groups, each containing ten questions. Each group tests an optional area of the course. Choose two of these six groups. Be sure that you answer all ten questions in each group chosen. Record the answers to the questions in accordance with the directions on the front page of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

Group 1 — Motion in a Plane

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

Base your answers to questions 56 through 58 on the diagram and information below.

A machine launches a tennis ball at an angle of 45° with the horizontal, as shown. The ball has an initial vertical velocity of 9.0 meters per second and an initial horizontal velocity of 9.0 meters per second. The ball reaches its maximum height 0.92 second after its launch. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.]



56 The speed of the tennis ball as it leaves the launcher is approximately

(1) 4.5 m/s (3) 13 m/s
(2) 8.3 m/s (4) 18 m/s

57 The total horizontal distance traveled by the tennis ball during the entire time it is in the air is approximately

(1) 23 m (3) 8.3 m
(2) 17 m (4) 4.1 m

Note that question 58 has only three choices.

58 The speed at which the launcher fires tennis balls is constant, but the angle between the launcher and the horizontal can be varied. As the angle is decreased from 45° to 30.°, the range of the tennis balls

1 decreases
2 increases
3 remains the same

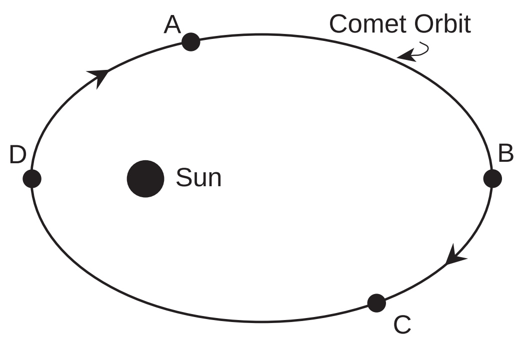
59 A 2-kilogram block is dropped from the roof of a tall building at the same time a 6-kilogram ball is thrown horizontally from the same height. Which statement best describes the motion of the block and the motion of the ball? [Neglect air resistance.]

1 The 2-kg block hits the ground first because it has no horizontal velocity.
2 The 6-kg ball hits the ground first because it has more mass.
3 The 6-kg ball hits the ground first because it is round.
4 The block and the ball hit the ground at the same time because they have the same vertical acceleration.

60 As a cart travels around a horizontal circular track, the cart *must* undergo a change in

1 velocity
2 inertia
3 speed
4 weight

Base your answers to questions 61 and 62 on the diagram below which represents the orbit of a comet about the Sun.



61 At which position in its orbit is the comet's speed greatest?

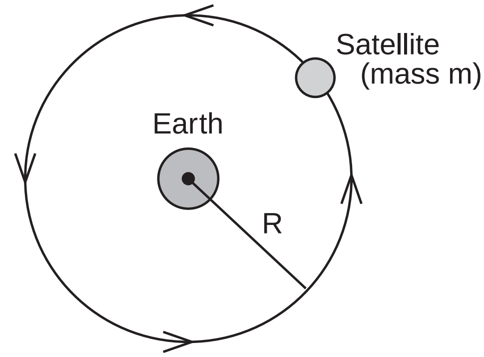
(1) *A*
(2) *B*
(3) *C*
(4) *D*

Note that question 62 has only three choices.

62 As the comet moves from point *A* to point *B*, its potential energy

1 decreases
2 increases
3 remains the same

63 The diagram below shows a satellite of mass m orbiting Earth in a circular path of radius R.



If centripetal force F_c is acting on the satellite, its speed is equal to

(1) $\sqrt{\frac{F_cR}{m}}$
(2) $\frac{F_cR}{m}$
(3) $\sqrt{\frac{F_cm}{R}}$
(4) F_cmR

64 A ball attached to a string is whirled at a constant speed of 2.0 meters per second in a horizontal circle of radius 0.50 meter. What is the magnitude of the ball's centripetal acceleration?

(1) 1.0 m/s^2
(2) 2.0 m/s^2
(3) 8.0 m/s^2
(4) 4.0 m/s^2

Note that question 65 has only three choices.

65 The symbols below are terms for Earth orbiting the Sun and a comet orbiting the Sun.

R_e = the mean radius of Earth's orbit
T_e = the period of Earth's orbit
R_c = the mean radius of the comet's orbit
T_c = the period of the comet's orbit

Compared to the value of $\frac{R_e^3}{T_e^2}$, the value of $\frac{R_c^3}{T_c^2}$ is

1 smaller
2 larger
3 the same

Group 2 — Internal Energy

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

66 Which substance remains a liquid over the *smallest* temperature range?

1 copper
2 silver
3 lead
4 iron

67 While orbiting Earth, the space shuttle has recorded temperatures ranging from 398 K to 118 K. These temperatures correspond to Celsius temperatures ranging from

(1) 125°C to – 391°C
(2) 125°C to –155°C
(3) 671°C to 391°C
(4) 671°C to 155°C

68 What is the total amount of energy needed to change the temperature of 0.20 kilogram of lead from 20.°C to 30.°C?

(1) 0.26 kJ
(2) 0.65 kJ
(3) 0.84 kJ
(4) 1.3 kJ

69 When a solid sample was heated, its temperature increased but it did not melt. Which statement best describes the changes in the average kinetic and potential energies of the molecules of the sample?

1 Potential energy decreased and kinetic energy remained the same.
2 Potential energy increased and kinetic energy remained the same.
3 Kinetic energy decreased and potential energy remained the same.
4 Kinetic energy increased and potential energy remained the same.

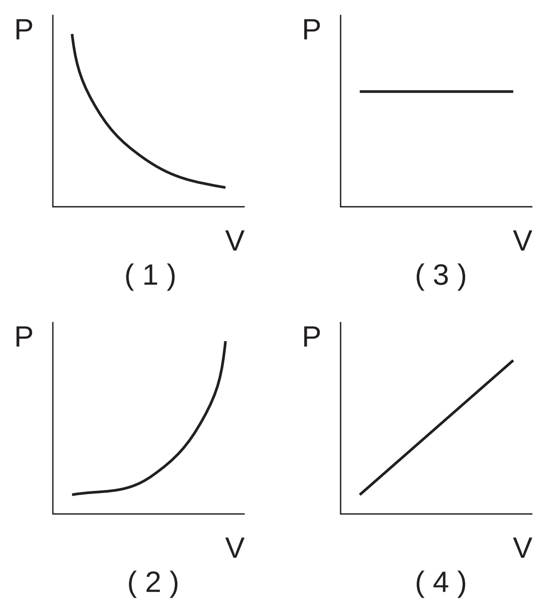
70 How are the boiling point of water and the melting point of ice affected by a decrease in pressure?

1 The boiling point of water increases, and the melting point of ice increases.
2 The boiling point of water increases, and the melting point of ice decreases.
3 The boiling point of water decreases, and the melting point of ice increases.
4 The boiling point of water decreases, and the melting point of ice decreases.

71 A 1.0-kilogram sample of water is boiling at 100.°C in an open container. If a 0.50-kilogram piece of lead at 300.°C is placed in the boiling water, how will the temperature of the two substances be affected?

1 The temperature of the water will decrease, and the temperature of the lead will remain the same.
2 The temperature of the water will increase, and the temperature of the lead will remain the same.
3 The temperature of the water will remain the same, and the temperature of the lead will decrease.
4 The temperature of the water will remain the same, and the temperature of the lead will increase.

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



73 A given mass of an ideal gas is enclosed in a rigid-walled container. If the Kelvin temperature of the gas is doubled, its pressure will be

1 halved
2 doubled
3 quartered
4 quadrupled

74 In a diesel engine, the piston compresses gases in a cylinder. Why does the temperature of the gases rise during this process?

1 Heat enters the cylinder from the surroundings.
2 Heat is expelled through the exhaust system.
3 Work is done on the surroundings by the gases.
4 Work is done by the piston on the gases.

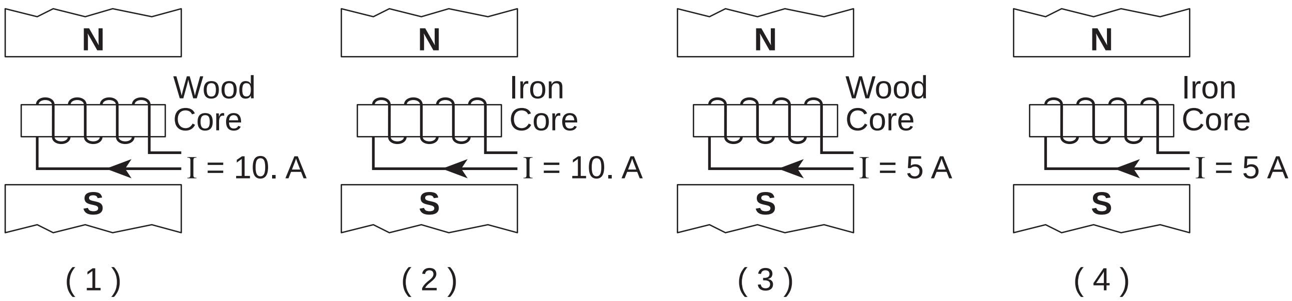
75 A commercial freezer vaporizes ammonia in its cooling coils to remove heat from an ice machine. How much ammonia at −33°C must be vaporized to remove 6,850 kilojoules of heat from the ice machine?

(1) 0.200 kg
(2) 5.00 kg
(3) 20.6 kg
(4) 1370 kg

Group 3 — Electromagnetic Applications

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

76 A student uses identical field magnets and coils of wire, as well as additional components, to make the electric motors shown in the diagrams below. Which combination of core and current through the coil of wire will produce the greatest torque on the motor's armature?



77 A simple electrical circuit contains a battery, a light bulb, and a properly connected ammeter. The ammeter has a very low internal resistance because it is connected in

1 parallel with the bulb to have little effect on the current through the bulb
2 parallel with the bulb to prevent current flow through the bulb
3 series with the bulb to have little effect on the current through the bulb
4 series with the bulb to prevent current flow through the bulb

78 Which expression is a unit of potential difference equivalent to a volt?

(1) $\dfrac{\text{tesla} \times \text{meter}}{\text{second}}$ (3) $\dfrac{\text{tesla} \times \text{meter}^2}{\text{second}}$

(2) $\dfrac{\text{tesla} \times \text{second}}{\text{meter}}$ (4) $\dfrac{\text{tesla} \times \text{second}}{\text{meter}^2}$

79 An operating electric motor has a back electromotive force because, in addition to acting as a motor, it acts as

1 a split-ring commutator
2 a transformer
3 an induction coil
4 a generator

80 In a mass spectrometer, the strength of the magnetic field is 1.0×10^{-1} tesla. Upon entering the chamber of the spectrometer, a positive ion traveling at 2.0×10^6 meters per second perpendicular to the magnetic field experiences a magnetic force having a magnitude of 3.2×10^{-14} newton. The charge on this positive ion is

(1) 6.4×10^{-21} C (3) 6.4×10^{-9} C
(2) 1.6×10^{-19} C (4) 1.6×10^{-9} C

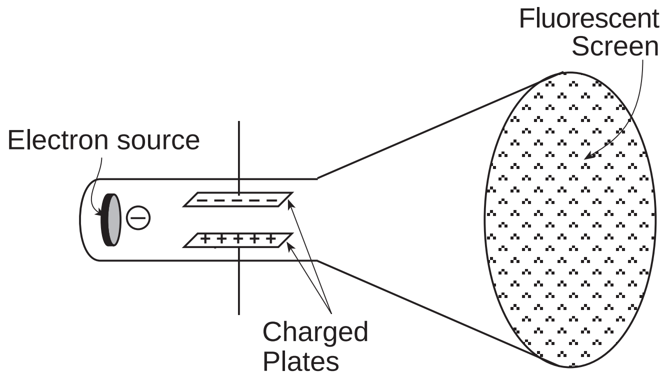
81 The Millikan oil drop experiment was designed to determine the

1 sign of the charge of an electron
2 mass of a proton
3 ratio of charge to mass of an electron
4 magnitude of the charge of an electron

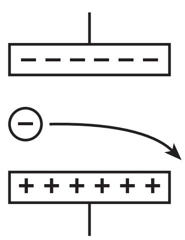
82 A transformer plugged into a 120-volt household electrical outlet is used to operate a doorbell at a potential difference of 12 volts. What is the ratio of the number of turns in the primary coil to the number of turns in the secondary coil of the transformer?

(1) 10:1 (3) 120:1
(2) 12:1 (4) 1440:1

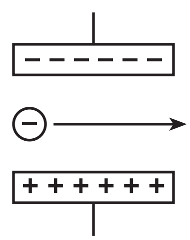
83 The diagram below shows an evacuated cathode ray tube consisting of a source of electrons at one end, a fluorescent screen at the other end, and a pair of oppositely charged parallel plates in between.



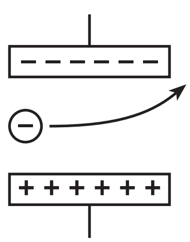
Which diagram best represents the motion of the electron beam in the tube as it passes between the oppositely charged plates?



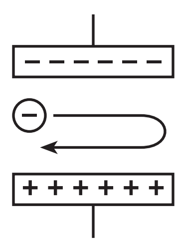
(1)



(3)

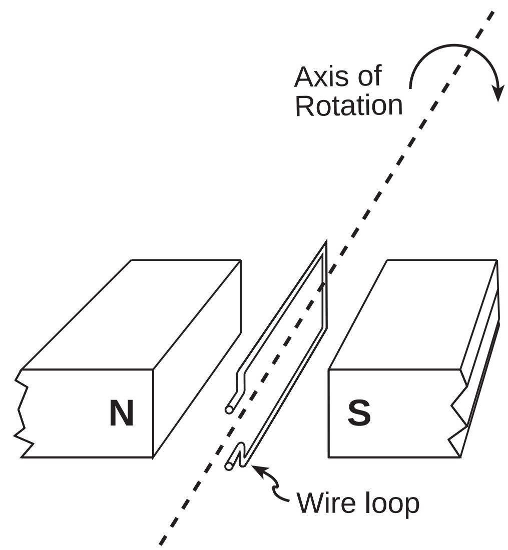


(2)



(4)

84 In the diagram below, a potential difference is induced in a rectangular wire loop as it is rotated at constant speed between two magnetic poles.



If the direction of the field is reversed and the speed of rotation is doubled, the magnitude of the maximum induced potential difference will be

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

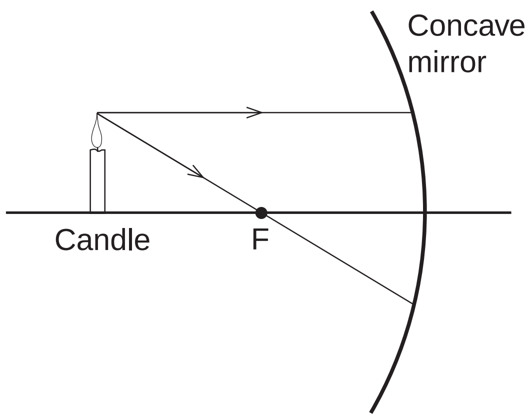
85 A 100% efficient transformer has 40. turns of wire in the primary coil and 80. turns of wire in the secondary coil. If 20. watts of power is supplied to the primary coil, the power developed in the secondary coil will be

(1) 10. W
(2) 20. W
(3) 80. W
(4) 160 W

Group 4 — Geometric Optics

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

86 A candle is located beyond the principal focus, F, of a concave spherical mirror. Two light rays originating from the same point on the candle are incident on the mirror, as shown in the diagram below.



After reflecting from the mirror, the light rays will

1 diverge to form a virtual image
2 diverge to form a real image
3 converge to form a virtual image
4 converge to form a real image

87 The radius of curvature of a spherical mirror is R. The focal length of this mirror is equal to

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

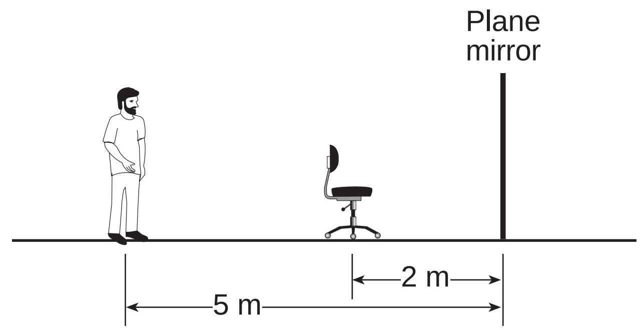
88 A candle is placed 0.24 meter in front of a converging mirror that has a focal length of 0.12 meter. How far from the mirror is the image of the candle located?

(1) 0.08 m
(2) 0.12 m
(3) 0.24 m
(4) 0.36 m

89 A converging lens forms a real image that is four times larger than the object. If the image distance is 0.16 meter, what is the object distance?

(1) 0.040 m
(2) 0.080 m
(3) 0.16 m
(4) 0.64 m

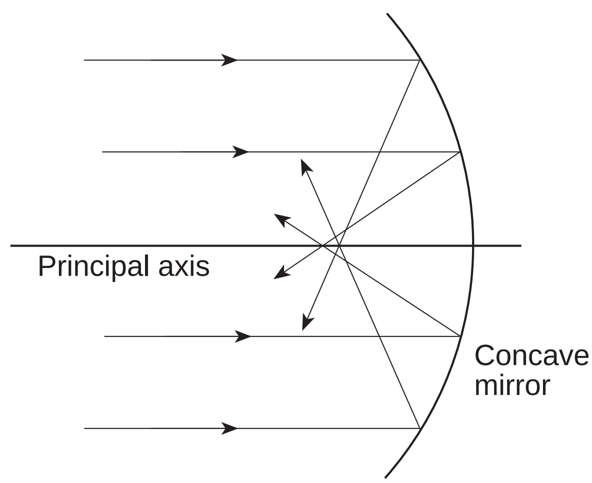
90 In the diagram below, a person is standing 5 meters from a plane mirror. The chair in front of the person is located 2 meters from the mirror.



What is the distance between the person and the image he observes of the chair?

(1) 7 m
(2) 2 m
(3) 3 m
(4) 10. m

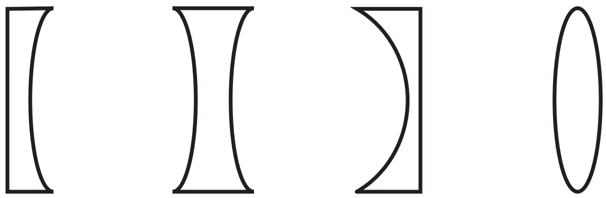
91 The diagram below shows parallel monochromatic incident light rays being reflected from a concave mirror.



The mirror fails to produce a sharp focal point as a result of

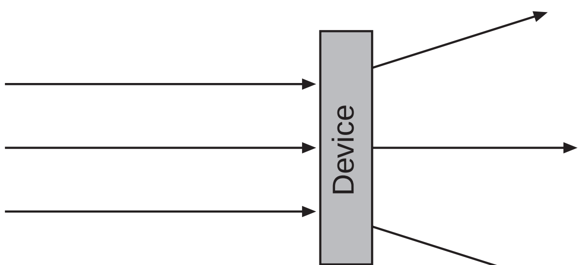
1 dispersion
2 diffuse reflection
3 spherical aberration
4 chromatic aberration

92 Which glass lens in air can produce an enlarged real image of an object?



(1) (2) (3) (4)

93 In the diagram below, parallel light rays in air diverge as a result of interacting with an optical device.



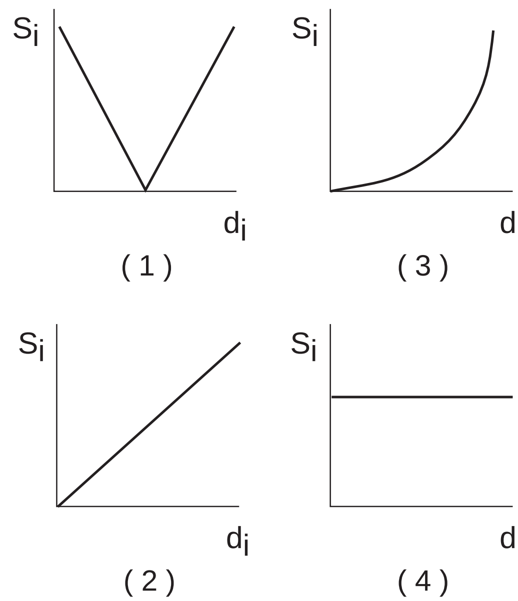
The device could be a

1 convex glass lens
2 rectangular glass block
3 plane mirror
4 concave glass lens

94 A person is standing in front of a diverging (convex) mirror. What type of image does the mirror form of the person?

1 erect, virtual, and smaller than the person
2 erect, virtual, and the same size as the person
3 erect, real, and smaller than the person
4 erect, real, and the same size as the person

95 Which graph best represents the relationship between image size (S_i) and image distance (d_i) for real images formed by a converging lens?



Group 5 — Solid State

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

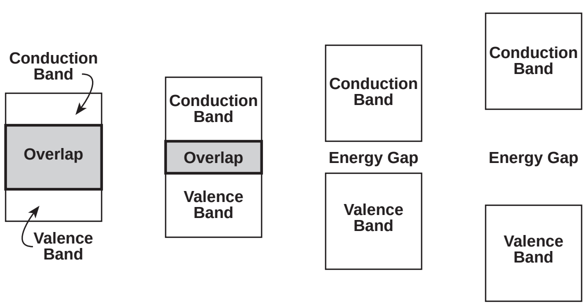
96 Which statement best explains how the resistivity of glass compares to the resistivity of copper?

1 Glass has a lower resistivity and is a poor conductor.
2 Glass has a lower resistivity and is a good conductor.
3 Glass has a higher resistivity and is a poor conductor.
4 Glass has a higher resistivity and is a good conductor.

97 Metals that are excellent conductors have valence electrons that are

1 difficult to dislodge and difficult to move through the crystal
2 difficult to dislodge but easy to move through the crystal
3 easy to dislodge but difficult to move through the crystal
4 easy to dislodge and easy to move through the crystal

98 Which energy band diagram best represents a semiconductor?



(1) (2) (3) (4)

99 Alternating current from a wall outlet can be converted to direct current by

1 an *N*-type semiconductor
2 a *P*-type semiconductor
3 an emitter
4 a diode

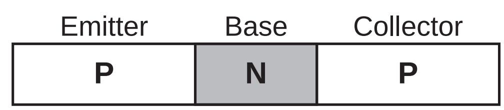
100 The table below lists the number of valence electrons for some elements.

Element	Number of Valence Electrons
antimony	5
silicon	4
germanium	4
aluminum	3

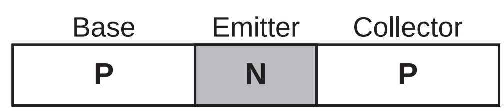
Which combination of elements could be used to make an *N*-type semiconductor?

1 antimony and silicon
2 silicon and germanium
3 germanium and aluminum
4 aluminum and antimony

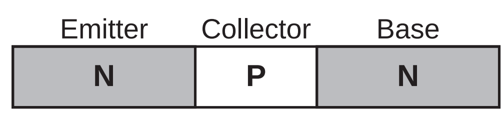
101 Which diagram below shows a correctly labeled *P–N–P* transistor?



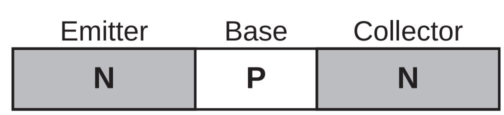
(1)



(2)

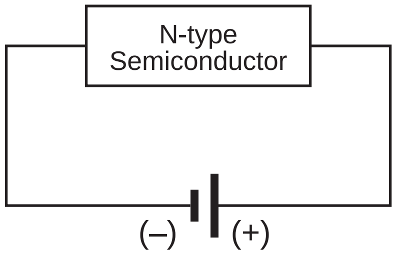


(3)



(4)

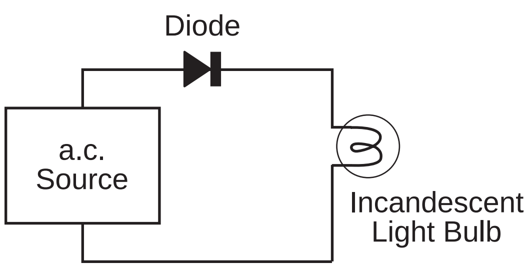
102 The diagram below represents an *N*-type semiconductor connected to a battery.



Which phrase best describes the majority charge carriers within the semiconductor?

1 electrons moving to the left
2 electrons moving to the right
3 holes moving to the left
4 holes moving to the right

103 In the circuit diagram below, a diode and an incandescent light bulb are connected in series with a source of alternating current having a frequency of 60 hertz.



How many times per second does a maximum current exist in the light bulb?

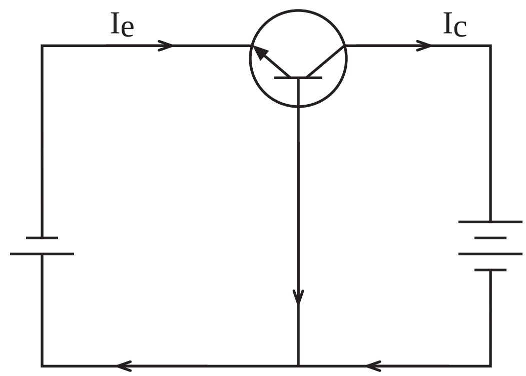
(1) 30
(2) 60
(3) 120
(4) 240

104 Which part of an *N–P–N* transistor is forward biased?

1 an integrated circuit
2 a parallel circuit
3 an emitter-base combination
4 a collector-base combination

Note that question 105 has only three choices.

105 The transistor shown in the circuit diagram below is being used as an amplifier.



When the emitter current (I_e) increases, the collector current (I_c)

1 decreases
2 increases
3 remains the same

Group 6 — Nuclear Energy

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

106 How much energy would be generated if a 1.0×10^{-3}-kilogram mass were completely converted to energy?

(1) 9.3×10^{-1} MeV
(2) 9.3×10^{2} MeV
(3) 9.0×10^{13} J
(4) 9.0×10^{16} J

107 One isotope of uranium is $^{238}_{92}U$. Any other isotope of uranium must have

(1) 92 protons
(2) 146 protons
(3) 92 neutrons
(4) 146 neutrons

108 A cyclotron is used in medical research to make radioisotopes. The primary function of a cyclotron is to

1 determine the mass of an atom
2 determine the half-life of a nuclide
3 accelerate neutrons
4 accelerate charged particles

109 As the nucleus of an unstable atom emits only gamma radiation, the nucleus must

1 gain energy
2 lose energy
3 lose protons
4 gain protons

110 In the reaction $^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + X$, particle X is a

1 positive electron
2 negative electron
3 proton
4 neutron

111 A 24-gram sample of a radioactive nuclide decayed to 3.0 grams of the nuclide in 36 minutes. How much of the original nuclide sample remained after the first 12 minutes?

(1) 12 g
(2) 2.0 g
(3) 6.0 g
(4) 8.0 g

112 A fusion reactor for commercial production of energy has *not* yet been developed. The best explanation for this situation is that fusion reactions

1 occur at extremely low temperatures
2 form highly radioactive products
3 require very high energies
4 need fuels unavailable on Earth

113 According to the Uranium Disintegration Series, how many beta particles are emitted when an atom of $^{218}_{84}Po$ decays to $^{206}_{82}Pb$?

(1) 7
(2) 6
(3) 3
(4) 4

114 In which nuclear equation does X represent a neutron?

(1) $^{3}_{1}H + {}^{1}_{1}H \rightarrow {}^{4}_{2}H + X$

(2) $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + {}^{1}_{1}H + X$

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

(4) $^{12}_{6}C + {}^{1}_{0}n \rightarrow {}^{13}_{7}N + X$

115 Which statement best describes what occurs when the control rods are inserted into a nuclear reactor?

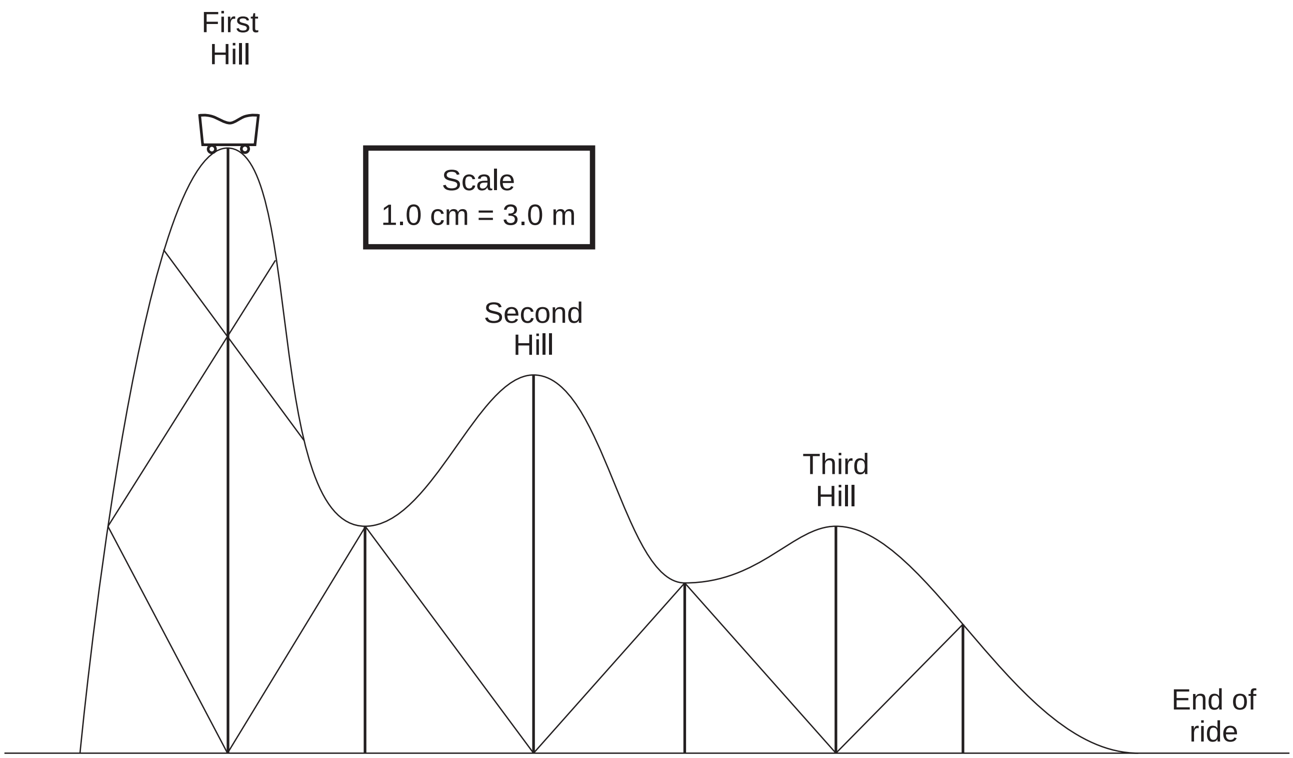
1 The number of fission reactions decreases because the control rods absorb neutrons.
2 The number of fission reactions decreases because the control rods absorb electrons.
3 The number of fission reactions increases because the control rods release neutrons.
4 The number of fission reactions increases because the control rods release electrons.

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 118 on the information and diagram below, which is drawn to a scale of 1.0 centimeter = 3.0 meters.

A 650-kilogram roller coaster car starts from rest at the top of the first hill of its track and glides freely. [Neglect friction.]



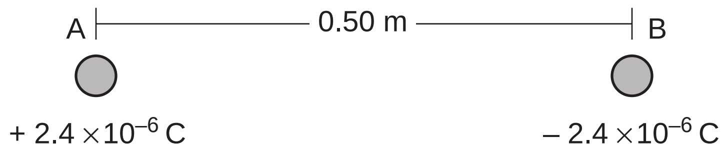
116 Using a metric ruler and the scale of 1.0 cm = 3.0 m, determine the height of the first hill. [1]

117 Determine the gravitational potential energy of the car at the top of the first hill. [Show all calculations, including the equation and substitution with units.] [2]

118 Using one or more complete sentences, compare the kinetic energy of the car at the top of the second hill to its kinetic energy at the top of the third hill. [1]

Base your answers to questions 119 through 121 on the information and diagram below.

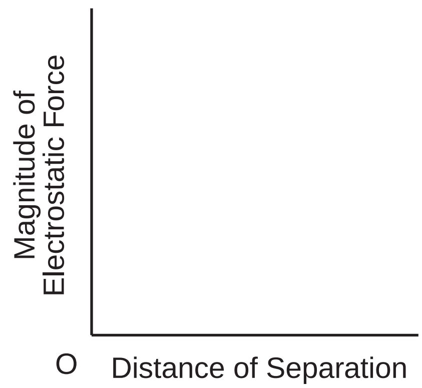
Two small charged spheres, *A* and *B*, are separated by a distance of 0.50 meter. The charge on sphere *A* is $+2.4 \times 10^{-6}$ coulomb and the charge on sphere *B* is -2.4×10^{-6} coulomb.



119 On the diagram *on your answer paper,* sketch *three* electric field lines to represent the electric field in the region between sphere *A* and sphere *B*. [Draw an arrowhead on each field line to show the proper direction.] [2]

120 Calculate the magnitude of the electrostatic force that sphere *A* exerts on sphere *B*. [Show all calculations, including the equation and substitution with units.] [2]

121 Using the axes *on your answer paper,* sketch the general shape of the graph that shows the relationship between the magnitude of the electrostatic force between the two charged spheres and the distance separating them. The charge on each sphere remains constant as the distance separating them is varied. The axes below are provided for practice purposes only. Be sure your final answer appears *on your answer paper.* [1]



Base your answers to questions 122 through 126 on the information and table below.

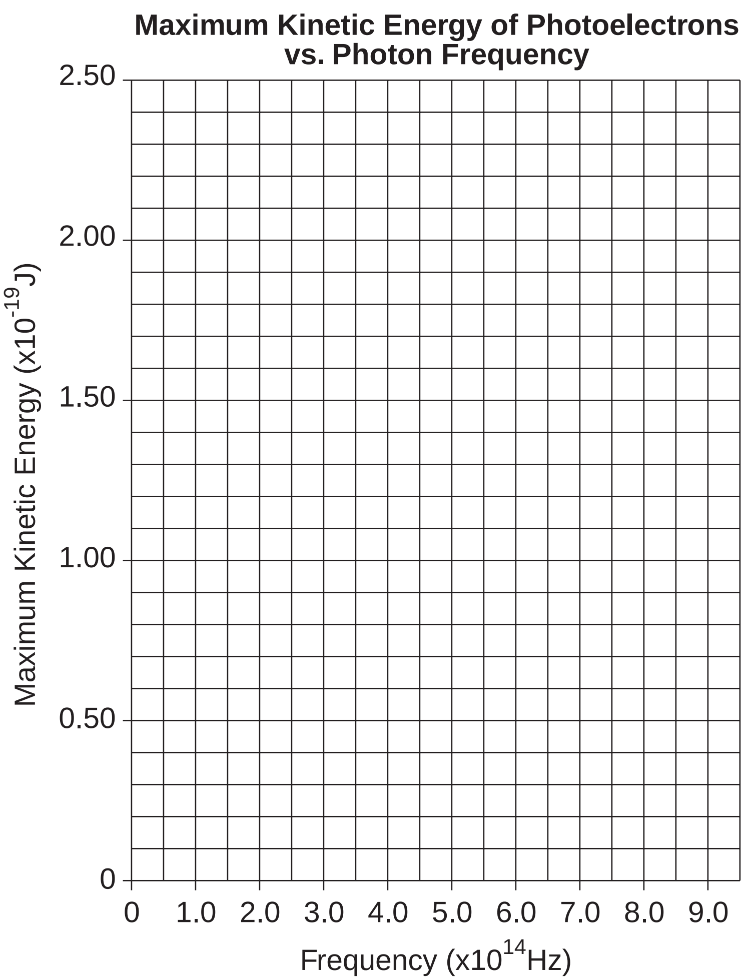
A photoemissive metal was illuminated successively by photons of various frequencies. The maximum kinetic energies of the emitted photoelectrons were measured and recorded in the table below.

FREQUENCY ($\times 10^{14}$ Hz)	MAXIMUM KINETIC ENERGY ($\times 10^{-19}$ J)
5.3	0.58
6.0	1.08
6.9	1.73
7.6	2.07

Using the information in the data table, construct a graph on the grid provided *on your answer paper*, following the directions below. The grid below is provided for practice purposes only. Be sure your final answer appears *on your answer paper*.

122 Plot the data points for maximum kinetic energy versus frequency. [1]

123 Draw the best-fit line. [1]



124 Using the graph, determine the threshold frequency of the metal. [1]

125 Determine the slope of the graph. [Show all calculations, including the equation and substitution with units.] [2]

126 Name the physical constant represented by the slope of a graph of maximum kinetic energy of photoelectrons versus photon frequency. [1]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Wednesday, June 21, 2000 — 9:15 a.m. to 12:15 p.m., only

ANSWER PAPER

Student . . . . Sex: ☐ Female ☐ Male

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	4	**53**	1	2	3	4
14	1	2	3	4	**34**	1	2	3	4	**54**	1	2	3	4
15	1	2	3	4	**35**	1	2	3	4	**55**	1	2	3	4
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	**42**
54	**64**	26	**41**
53	**63**	25	**40**
52	**63**	24	**40**
51	**62**	23	**39**
50	**61**	22	**38**
49	**60**	21	**37**
48	**59**	20	**36**
47	**58**	19	**35**
46	**58**	18	**35**
45	**57**	17	**34**
44	**56**	16	**33**
43	**55**	15	**32**
42	**54**	14	**31**
41	**54**	13	**31**
40	**53**	12	**29**
39	**52**	11	**26**
38	**51**	10	**24**
37	**50**	9	**21**
36	**49**	8	**19**
35	**49**	7	**17**
34	**48**	6	**14**
33	**47**	5	**12**
32	**46**	4	**10**
31	**45**	3	**7**
30	**44**	2	**5**
29	**44**	1	**2**
28	**43**	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	
59	1	2	3	4
60	1	2	3	4
61	1	2	3	4
62	1	2	3	
63	1	2	3	4
64	1	2	3	4
65	1	2	3	

Group 2
Internal Energy

66	1	2	3	4
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	4

Group 3
Electromagnetic Applications

76	1	2	3	4
77	1	2	3	4
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

Part III (15 credits)

Answer all questions in this part.

116 ____________________

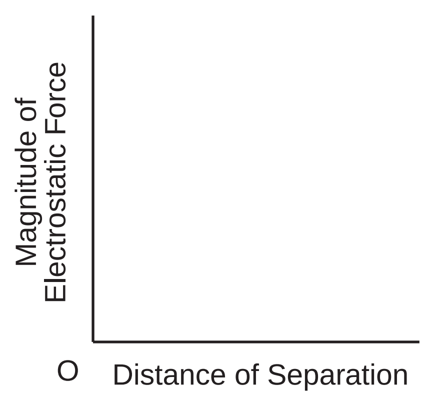
117

118 ____

119

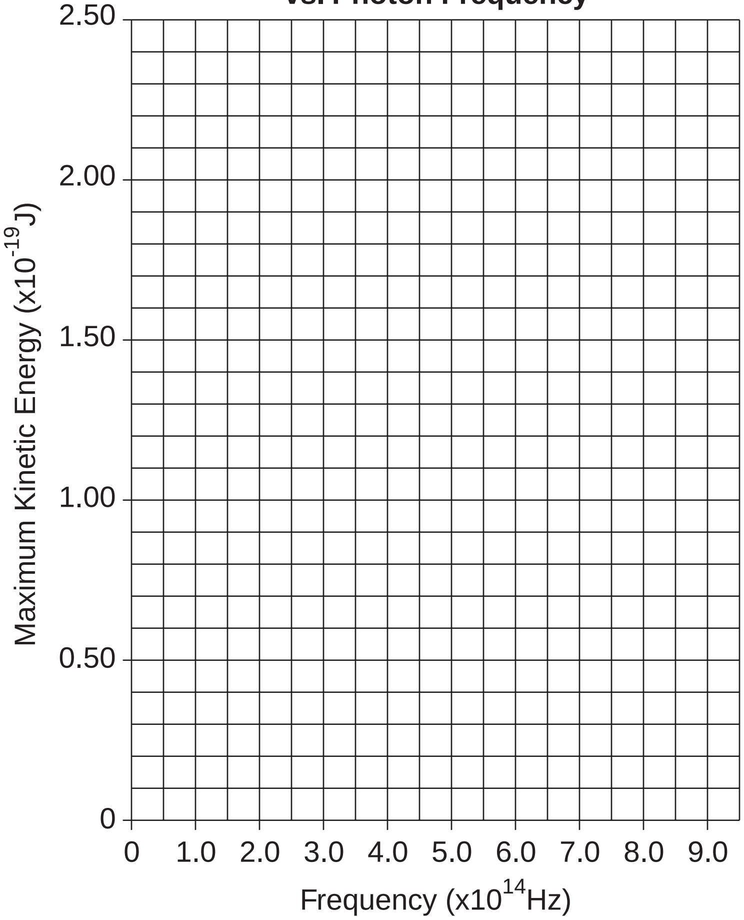
120

121



122–123

Maximum Kinetic Energy of Photoelectrons vs. Photon Frequency



124 ____________________

125

126 ____

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 117, 120, and 125.

- 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.

24 m ± 1 m

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

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

Examples of Acceptable Responses

$\varnothing PE = mg\varnothing h$

$\varnothing PE = (650 \text{ kg})(9.8 \text{ m/s}^2)(24 \text{ m})$

$\varnothing PE = 152,880 \text{ kg}\bullet\text{m}^2/\text{s}^2$

or

$\varnothing PE = 1.5 \times 10^5 \text{ J}$

Allow credit for an answer that is consistent with the student's answer to question 116.

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

Examples of Acceptable Responses

The kinetic energy of the car at the top of the second hill is less than the kinetic energy of the car at the top of the third hill.

or

The car's *KE* is less.

119 Allow a total of two credits.

- Allow one credit for three lines drawn from point *A* to point *B*. The lines may consist of one straight line and two curved lines or three curved lines.
- Allow one credit for three arrowheads, one on each line pointing in the direction of point *B*.
- Do not penalize a student for additional electric field lines with arrowheads drawn correctly.

Examples of Responses

[See the back of the Scoring Key for Part I]

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

Examples of Acceptable Responses

$$F = \frac{kq_1q_2}{r^2}$$

$$F = \frac{\left(9.0 \times 10^9 \frac{\text{N}\bullet\text{m}^2}{\text{C}^2}\right)(2.4 \times 10^{-6} \text{ C})(2.4 \times 10^{-6} \text{ C})}{(0.50 \text{ m})^2}$$

$$F = 0.21 \text{ N}$$

or

$$F = \frac{kq_1q_2}{r^2}$$

$$F = \frac{\left(9.0 \times 10^9 \frac{\text{N}\bullet\text{m}^2}{\text{C}^2}\right)(2.4 \times 10^{-6} \text{ C})^2}{(0.50 \text{ m})^2}$$

$$F = 2.1 \times 10^{-1} \text{ N}$$

Do not penalize a student for using the actual values for the charges and calculating a negative value for the force.

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

Group 2
Internal Energy

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

Group 3
Electromagnetic Applications

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

Group 4
Geometric Optics

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

Group 5
Solid State

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

Group 6
Nuclear Energy

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

FOR TEACHERS ONLY

P

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Wednesday, June 21, 2000 — 9:15 a.m. to 12:15 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	2	X	4	**21**	1	2	X	4	**41**	1	2	3	X
2	X	2	3	4	**22**	1	2	3	X	**42**	1	2	X	4
3	1	X	3	4	**23**	1	2	X	4	**43**	1	2	3	X
4	1	2	3	X	**24**	1	X	3	4	**44**	1	X	3	4
5	1	2	X	4	**25**	1	X	3	4	**45**	1	2	X	4
6	1	2	X	4	**26**	1	2	X	4	**46**	1	X	3	4
7	1	X	3	4	**27**	1	2	3	X	**47**	1	2	X	4
8	1	2	3	X	**28**	X	2	3	4	**48**	1	2	X	4
9	1	2	X	4	**29**	X	2	3	4	**49**	X	2	3	4
10	1	2	3	X	**30**	1	2	3	X	**50**	X	2	3	4
11	X	2	3	4	**31**	X	2	3	4	**51**	1	2	3	X
12	1	X	3	4	**32**	1	2	3	X	**52**	X	2	3	4
13	1	2	3	X	**33**	1	X	3	4	**53**	1	X	3	4
14	1	X	3	4	**34**	1	X	3	4	**54**	X	2	3	4
15	1	2	3	X	**35**	X	2	3	4	**55**	1	X	3	4
16	1	2	X	4	**36**	1	2	X	4					
17	1	X	3	4	**37**	1	2	X	4					
18	1	2	3	X	**38**	X	2	3	4					
19	X	2	3	4	**39**	1	X	3	4					
20	1	2	X	4	**40**	1	2	3	X					

Directions to the teacher:

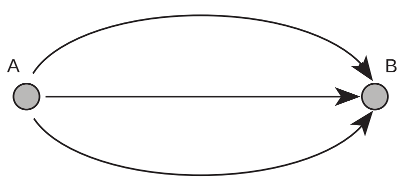
Use only *red* ink or *red* pencil in rating Regents examination papers. Do *not* correct the student's work by making insertions or changes of any kind.

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.

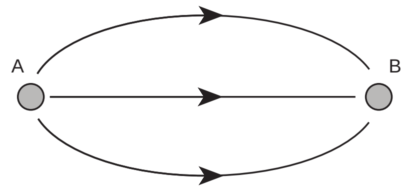
To facilitate scoring, the scoring key has been printed in the same format as the answer paper. The scoring key for **Part I and Part II** may be made into a scoring stencil by punching out the correct answers. Be sure that the stencil is aligned with the answer paper so that the holes correspond to 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]

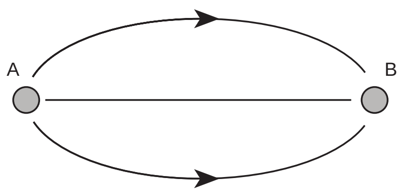
119 Examples of Two-Credit Responses



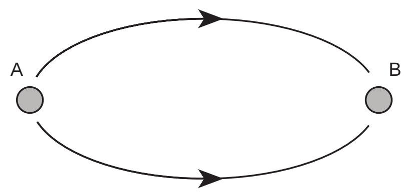
or

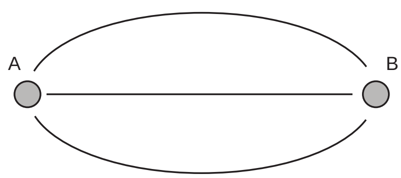


Examples of One-Credit Responses

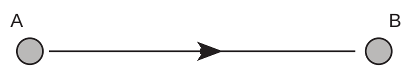


or



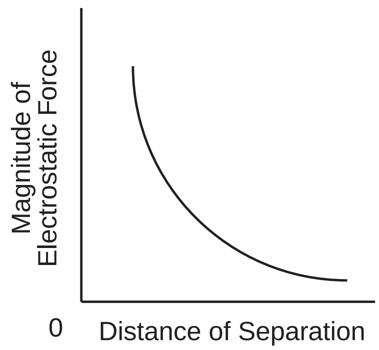


or



121 Allow one credit.

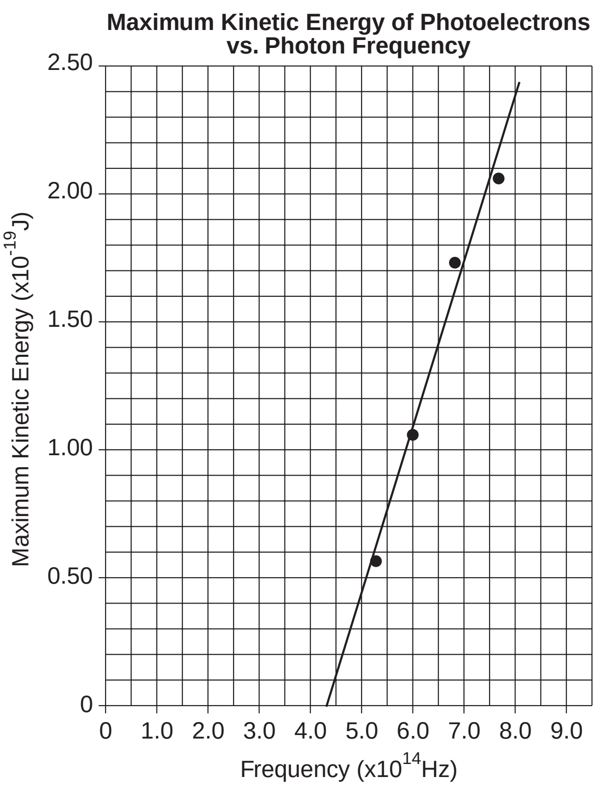
Example of Acceptable Response



Do not allow this credit if the curve intersects either axis.

Do not allow this credit if the sketch is a straight line.

122–123 Example of Acceptable Response



122 Allow one credit.

All points must be plotted accurately (±0.3 grid space).

123 Allow one credit.

The best-fit line must be straight. If one or more points are plotted incorrectly in question 122, but a best-fit straight line is drawn, allow this credit.

124 Allow one credit.

Example of Acceptable Response

4.4×10^{14} Hz $\pm 0.2 \times 10^{14}$ Hz

Allow credit for an answer that is consistent with the student's answer to question 123, that is, where the student's best-fit line intercepts the horizontal axis $\pm 0.2 \times 10^{14}$ Hz .

125 Allow a total of two credits. Refer to *Scoring Criteria for Calculations* in this scoring key. Allow credit for an answer that is consistent with the student's graph, *unless* the student receives no credits for questions 122 and 123. In that case, credit may be awarded if the student correctly calculates the slope using data in the table.

Note: The slope may be determined by direct substitution of data points *only* if the data values are on the best-fit line.

Examples of Acceptable Responses

These responses are based on the assumption that the best-fit line passes through these coordinates.

$$\text{slope} = \frac{\Delta KE_{\text{max}}}{\Delta f}$$

$$\text{slope} = \frac{2.4 \times 10^{-19}\ \text{J} - 0.4 \times 10^{-19}\ \text{J}}{8.0 \times 10^{14}\ \text{Hz} - 5.0 \times 10^{14}\ \text{Hz}}$$

$$\text{slope} = 6.7 \times 10^{-34}\ \text{J}\bullet\text{s}$$

or

$$\text{slope} = 0.67 \times 10^{-33}\ \text{J/Hz}$$

126 Allow one credit.

Planck's constant