The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Tuesday, January 22, 2002 — 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: ⊗ 2 3 4

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

The 2002 Edition of the *Reference Tables for Physical Setting/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 protractor during this examination.

Additional reference information which you may need to answer some of the questions in this examination is provided as the last page of this examination booklet.

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 What is the total displacement of a student who walks 3 blocks east, 2 blocks north, 1 block west, and then 2 blocks south?

(1) 0
(2) 2 blocks east
(3) 2 blocks west
(4) 8 blocks

2 Which measurement of an average classroom door is closest to 1 meter?

(1) thickness
(2) width
(3) height
(4) surface area

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

(1) 15 km/hr
(2) 30. km/hr
(3) 40. km/hr
(4) 60. km/hr

4 A skier starting from rest skis straight down a slope 50. meters long in 5.0 seconds. What is the magnitude of the acceleration of the skier?

(1) 20. m/s^2
(2) 9.8 m/s^2
(3) 5.0 m/s^2
(4) 4.0 m/s^2

5 An object falls freely from rest near the surface of Earth. What is the speed of the object after having fallen a distance at 4.90 meters?

(1) 4.90 m/s
(2) 9.80 m/s
(3) 24.0 m/s
(4) 96.1 m/s

6 Which two terms represent a vector quantity and the scalar quantity of the vector's magnitude, respectively?

(1) acceleration and velocity
(2) weight and force
(3) speed and time
(4) displacement and distance

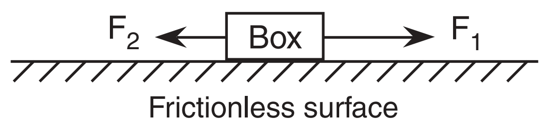
7 A 4.0-kilogram rock and a 1.0-kilogram stone fall freely from rest from a height of 100 meters. After they fall for 2.0 seconds, the ratio of the rock's speed to the stone's speed is

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

8 Two concurrent forces have a maximum resultant of 45 newtons and a minimum resultant of 5 newtons. What is the magnitude of each of these forces?

(1) 0 N and 45 N
(2) 5 N and 9 N
(3) 20. N and 25 N
(4) 0 N and 50. N

9 In the diagram below, a box is on a frictionless horizontal surface with forces F_1 and F_2 acting as shown.



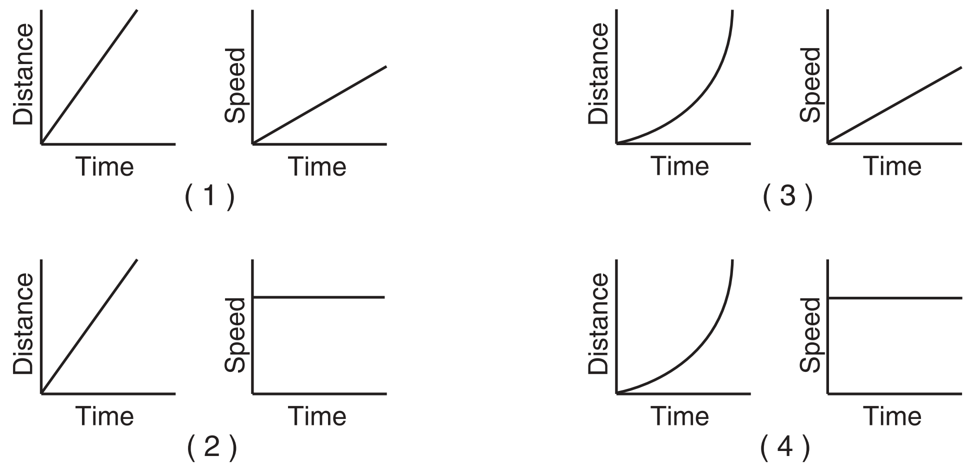
If the magnitude of F_1 is greater than the magnitude of F_2, then the box is

(1) moving at constant speed in the direction of F_1
(2) moving at constant speed in the direction of F_2
(3) accelerating in the direction of F_1
(4) accelerating in the direction of F_2

10 When a satellite is a distance R from the center of Earth, the force due to gravity on the satellite is F. What is the force due to gravity on the satellite when its distance from the center of Earth is $3R$?

(1) $\frac{F}{9}$
(2) $\frac{F}{3}$
(3) F
(4) $9F$

11 Which two graphs represent the motion of an object on which the net force is zero?



12 The table below lists the coefficients of kinetic friction for four materials sliding over steel.

Material	Coefficient of Kinetic Friction
aluminum	0.47
brass	0.44
copper	0.36
steel	0.57

A 10.-kilogram block of each of these materials is pulled horizontally across a steel floor at constant velocity. Which block requires the *smallest* applied force to keep it moving at constant velocity?

(1) aluminum
(2) brass
(3) copper
(4) steel

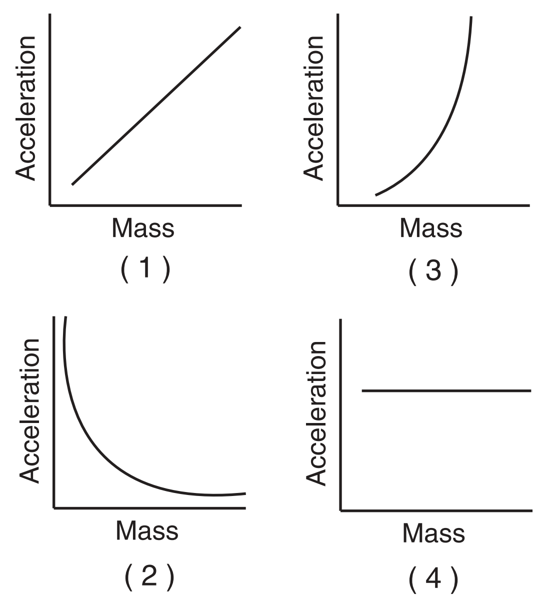
13 The magnitude of the force that a baseball bat exerts on a ball is 50. newtons. The magnitude of the force that the ball exerts on the bat is

(1) 5.0 N
(2) 10. N
(3) 50. N
(4) 250 N

14 A bullet traveling at 5.0×10^2 meters per second is brought to rest by an impulse of 50. newton•seconds. What is the mass of the bullet?

(1) 1.0×10^{-2} kg
(2) 1.0×10^{-1} kg
(3) 1.0×10^{1} kg
(4) 2.5×10^{4} kg

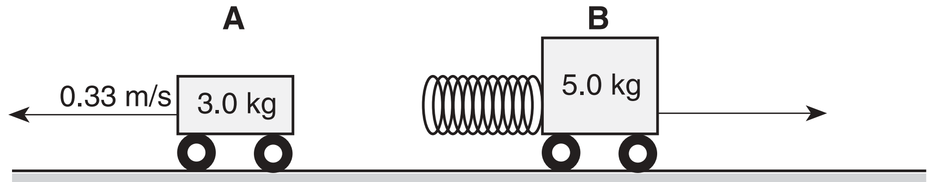
15 Which graph best represents the relationship between acceleration due to gravity and mass for objects near the surface of Earth? [Neglect air resistance.]



16 What is an essential characteristic of an object in equilibrium?

(1) zero velocity
(2) zero acceleration
(3) zero potential energy
(4) zero kinetic energy

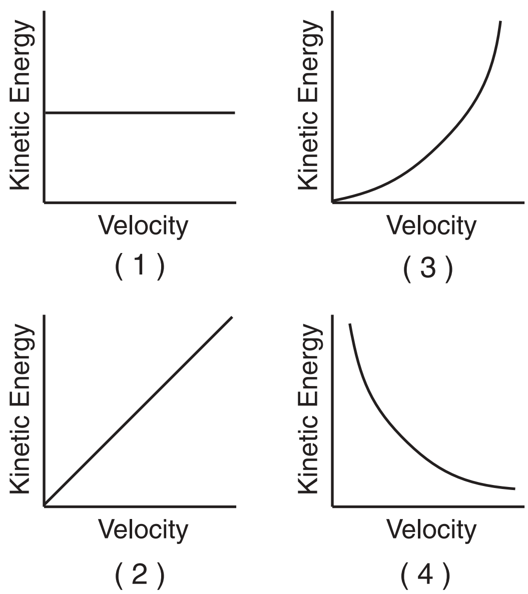
17 The diagram below shows two carts that were initially at rest on a horizontal, frictionless surface being pushed apart when a compressed spring attached to one of the carts is released. Cart *A* has a mass of 3.0 kilograms and cart *B* has a mass of 5.0 kilograms.



If the speed of cart *A* is 0.33 meter per second after the spring is released, what is the approximate speed of cart *B* after the spring is released?

(1) 0.12 m/s
(2) 0.20 m/s
(3) 0.33 m/s
(4) 0.55 m/s

18 Which graph best represents the relationship between the kinetic energy of a moving object and its velocity?



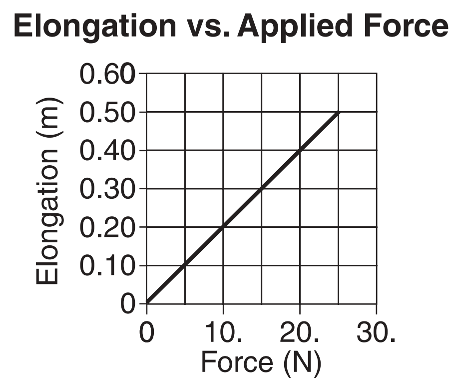
19 How much work is done on a downhill skier by an average braking force of 9.8×10^2 newtons to stop her in a distance of 10. meters?

(1) 1.0×10^1 J
(2) 9.8×10^1 J
(3) 1.0×10^3 J
(4) 9.8×10^3 J

20 A spring has a spring constant of 120 newtons per meter. How much potential energy is stored in the spring as it is stretched 0.20 meter?

(1) 2.4 J
(2) 4.8 J
(3) 12 J
(4) 24 J

21 The graph below shows the relationship between the elongation of a spring and the force applied to the spring causing it to stretch.



What is the spring constant for this spring?

(1) 0.020 N/m
(2) 2.0 N/m
(3) 25 N/m
(4) 50. N/m

22 Which quantity and unit are correctly paired?

(1) velocity — $\mathrm{m/s^2}$
(2) momentum — $\dfrac{\mathrm{kg \bullet m}}{\mathrm{s^2}}$
(3) energy — $\dfrac{\mathrm{kg \bullet m^2}}{\mathrm{s^2}}$
(4) work — kg/m

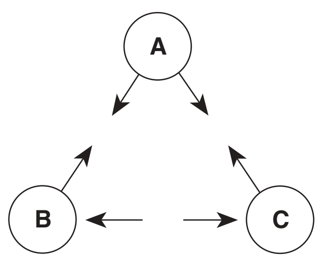
23 A 10.-newton force is required to move a 3.0-kilogram box at constant speed. How much power is required to move the box 8.0 meters in 2.0 seconds?

(1) 40. W
(2) 20. W
(3) 15 W
(4) 12 W

24 A 0.10-kilogram ball dropped vertically from a height of 1.00 meter above the floor bounces back to a height of 0.80 meter. The mechanical energy lost by the ball as it bounces is

(1) 0.080 J (3) 0.30 J
(2) 0.20 J (4) 0.78 J

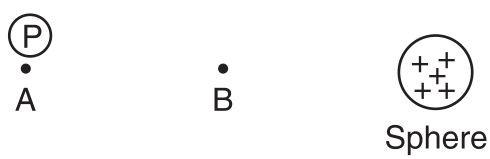
25 The diagram below shows the arrangement of three charged hollow metal spheres, *A*, *B*, and *C*. The arrows indicate the direction of the electric forces acting between the spheres. At least two of the spheres are positively charged.



Which sphere, if any, could be negatively charged?

(1) sphere *A* (3) sphere *C*
(2) sphere *B* (4) no sphere

26 The diagram below shows proton *P* located at point *A* near a positively charged sphere.



If 6.4×10^{-19} joule of work is required to move the proton from point *A* to point *B*, the potential difference between *A* and *B* is

(1) 6.4×10^{-19} V (3) 6.4 V
(2) 4.0×10^{-19} V (4) 4.0 V

27 An electrostatic force of magnitude *F* exists between two metal spheres having identical charge *q*. The distance between their centers is *r*. Which combination of changes would produce *no* change in the electrostatic force between the spheres?

(1) doubling *q* on one sphere while doubling *r*
(2) doubling *q* on both spheres while doubling *r*
(3) doubling *q* on one sphere while halving *r*
(4) doubling *q* on both spheres while halving *r*

28 What is the magnitude of the electrostatic force acting on an electron located in an electric field having a strength of 5.0×10^3 newtons per coulomb?

(1) 3.1×10^{22} N (3) 8.0×10^{-16} N
(2) 5.0×10^3 N (4) 3.2×10^{-23} N

29 A charge of 5.0 coulombs moves through a circuit in 0.50 second. The current in the circuit is

(1) 2.5 A (3) 7.0 A
(2) 5.0 A (4) 10. A

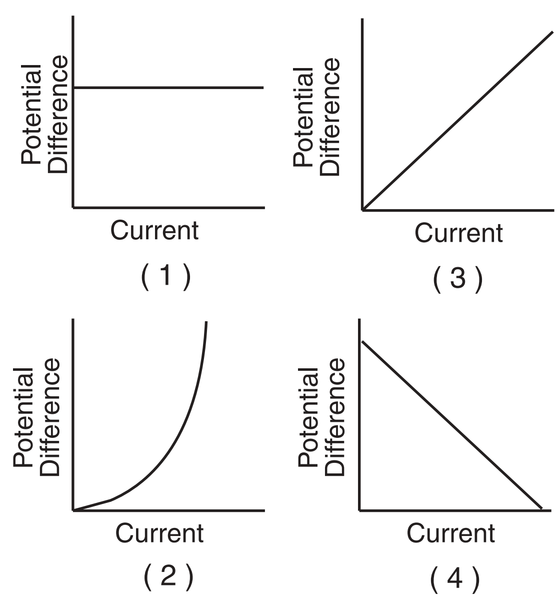
30 An operating electric iron draws a current of 5 amperes and has a resistance of 20 ohms. The amount of energy used by the iron in 40 seconds is

(1) 1×10^2 J (3) 4×10^3 J
(2) 5×10^2 J (4) 2×10^4 J

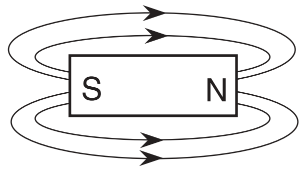
31 What is the net static electric charge on a metal sphere having an excess of +3 elementary charges?

(1) 1.60×10^{-19} C (3) 3.00×10^0 C
(2) 4.80×10^{-19} C (4) 4.80×10^{19} C

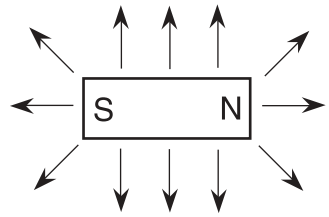
32 Which graph best represents the relationship between the potential difference across a conductor and the current through the conductor at constant temperature?



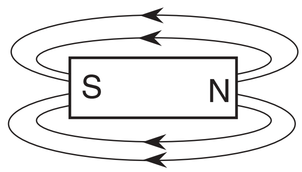
33 Which diagram below best represents the magnetic field near a bar magnet?



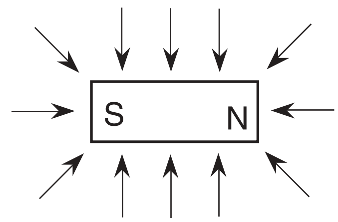
(1)



(3)

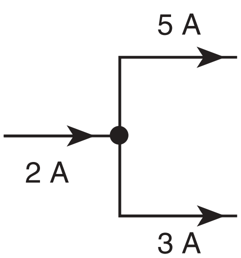


(2)

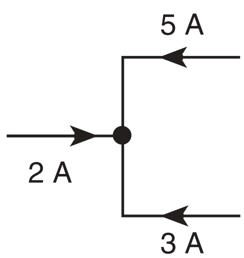


(4)

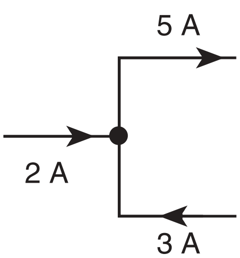
34 Which diagram shows correct current direction in a segment of an electric circuit?



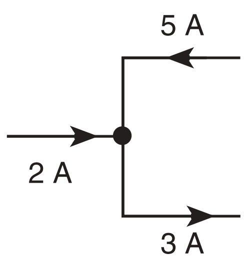
(1)



(3)



(2)

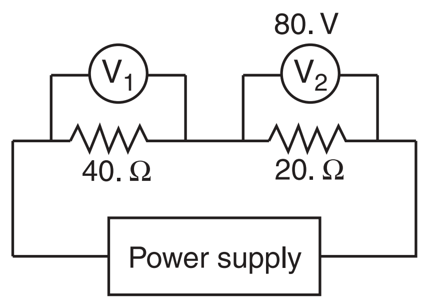


(4)

35 While operating at 120 volts, an electric toaster has a resistance of 15 ohms. The power used by the toaster is

(1) 8.0 W
(2) 120 W
(3) 960 W
(4) 1,800 W

36 In the circuit shown below, voltmeter V_2 reads 80. volts.



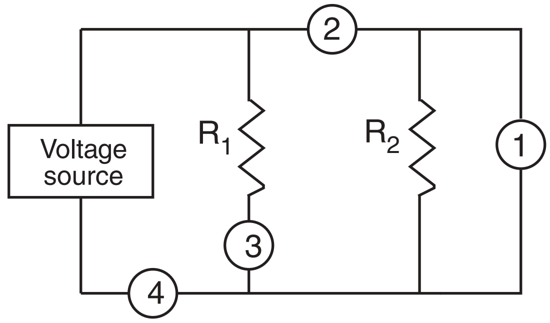
What is the reading of voltmeter V_1?

(1) 160 V
(2) 80. V
(3) 40. V
(4) 20. V

37 A physics student is given three 12-ohm resistors with instructions to create the circuit that would have the lowest possible resistance. The correct circuit would be a

(1) series circuit with an equivalent resistance of 36 Ω
(2) series circuit with an equivalent resistance of 4.0 Ω
(3) parallel circuit with an equivalent resistance of 36 Ω
(4) parallel circuit with an equivalent resistance of 4.0 Ω

38 Two resistors are connected to a source of voltage as shown in the diagram below.



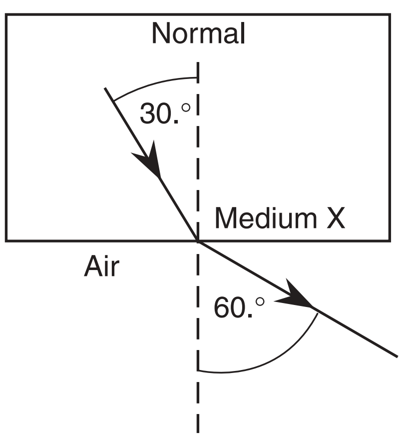
At which position should an ammeter be placed to measure the current passing only through resistor R_1?

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

39 Two points on a transverse wave that have the same magnitude of displacement from equilibrium are in phase if the points also have the

(1) same direction of displacement and the same direction of motion
(2) same direction of displacement and the opposite direction of motion
(3) opposite direction of displacement and the same direction of motion
(4) opposite direction of displacement and the opposite direction of motion

40 The diagram below shows a ray of light passing from medium *X* into air.



What is the absolute index of refraction of medium *X*?

(1) 0.500 (3) 1.73
(2) 2.00 (4) 0.577

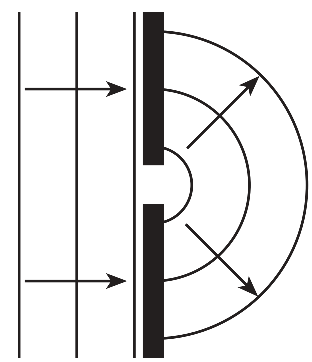
41 What is the frequency of a wave if its period is 0.25 second?

(1) 1.0 Hz (3) 12 Hz
(2) 0.25 Hz (4) 4.0 Hz

42 What occurs when light passes from water into flint glass?

(1) Its speed decreases, its wavelength becomes shorter, and its frequency remains the same.
(2) Its speed decreases, its wavelength becomes shorter, and its frequency increases.
(3) Its speed increases, its wavelength becomes longer, and its frequency remains the same.
(4) Its speed increases, its wavelength becomes longer, and its frequency decreases.

43 The diagram below shows straight wave fronts passing through an opening in a barrier.



This wave phenomenon is called

(1) reflection (3) polarizaton
(2) refraction (4) diffraction

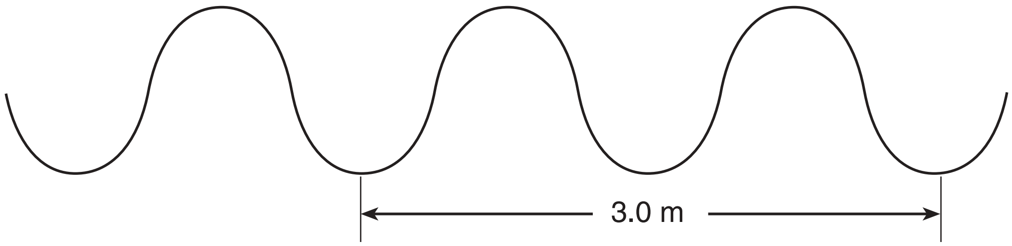
44 The speed of light in a material is 2.50×10^8 meters per second. What is the absolute index of refraction of the material?

(1) 1.20 (3) 7.50
(2) 2.50 (4) 0.833

45 An opera singer's voice is able to break a thin crystal glass when the singer's voice and the vibrating glass have the same

(1) frequency (3) amplitude
(2) speed (4) wavelength

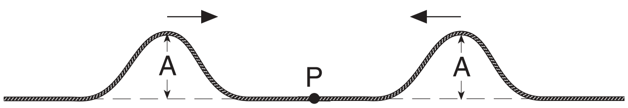
46 The periodic wave in the diagram below has a frequency of 40. hertz.



What is the speed of the wave?

(1) 13 m/s
(2) 27 m/s
(3) 60. m/s
(4) 120 m/s

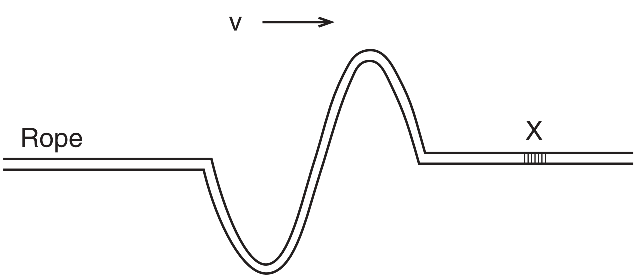
47 The diagram below represents a rope along which two pulses of equal amplitude, A, approach point P.



As the two pulses pass through point P, the maximum vertical displacement of the rope at point P will be

(1) A
(2) $2A$
(3) 0
(4) $\frac{A}{2}$

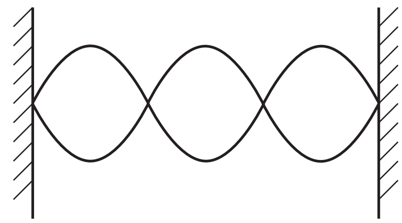
48 As shown in the diagram below, a transverse wave is moving with velocity v along a rope.



In which direction will segment X move as the wave passes through it?

(1) down, only
(2) up, only
(3) down, then up, then down
(4) up, then down, then up

49 How many nodes are represented in the standing wave diagram below?



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

50 Which phenomenon can *not* be exhibited by longitudinal waves?

(1) reflection
(2) refraction
(3) diffraction
(4) polarization

51 An electron in a hydrogen atom drops from the $n = 3$ energy level to the $n = 2$ energy level. The energy of the emitted photon is

(1) 1.51 eV
(2) 1.89 eV
(3) 3.40 eV
(4) 4.91 eV

52 What is the energy of a photon with a frequency of 5.00×10^{14} hertz?

(1) 3.32 eV
(2) 3.20×10^{-6} eV
(3) 3.00×10^{48} J
(4) 3.32×10^{-19} J

Note that questions 53 through 55 have only three choices.

53 If the diameter of a wire were decreased, its electrical resistance would

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

54 An astronomer on Earth studying light coming from a star notes that the observed light frequencies are lower than the actual emitted frequencies. The astronomer concludes that the distance between the star and Earth is

(1) decreasing
(2) increasing
(3) unchanging

55 Compared to the wavelength of red light, the wavelength of yellow light is

(1) shorter
(2) longer
(3) the same

Part II

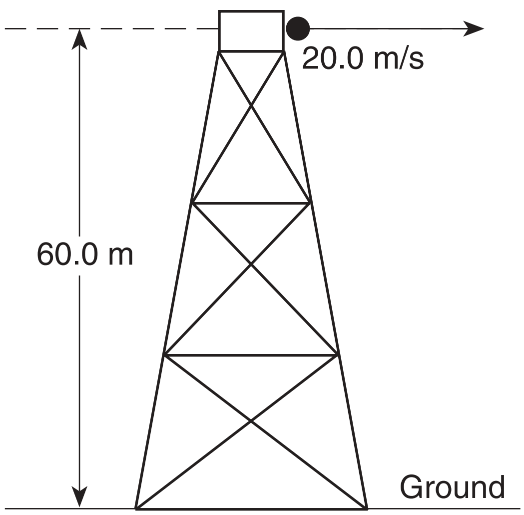
This part consists of six groups, each containing ten questions. Each group tests an optional area of the course. Choose two of these six groups. Be sure that you answer all ten questions in each group chosen. Record the answers to the questions in accordance with the directions on the front page of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

Group 1 — Motion in a Plane

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

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

A ball is thrown horizontally with an initial velocity of 20.0 meters per second from the top of a tower 60.0 meters high.



56 What is the initial vertical velocity of the ball?

(1) 0 m/s
(2) 9.81 m/s
(3) 20.0 m/s
(4) 60.0 m/s

57 What is the approximate total time required for the ball to reach the ground? [Neglect air resistance.]

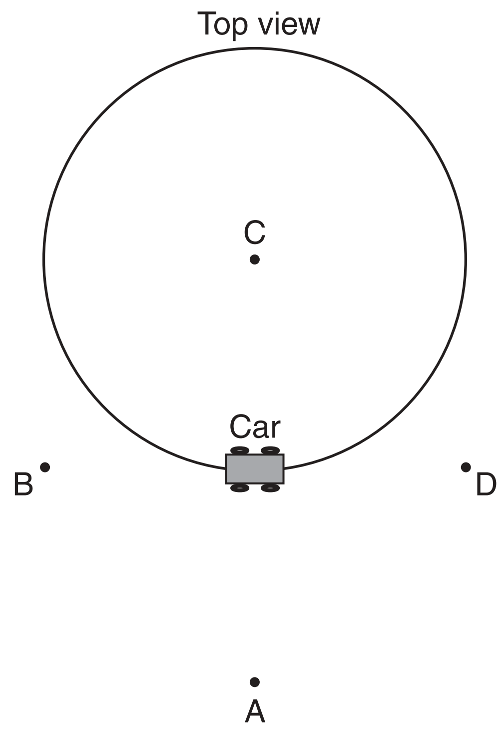
(1) 12.2 s
(2) 2.04 s
(3) 3.00 s
(4) 3.50 s

58 What is the horizontal velocity of the ball just before it reaches the ground? [Neglect air resistance.]

(1) 9.81 m/s
(2) 20.0 m/s
(3) 34.3 m/s
(4) 68.6 m/s

Base your answers to questions 59 and 60 on the information and diagram below.

A 60.-kilogram car travels clockwise in a horizontal circle of radius 10. meters at 5.0 meters per second.



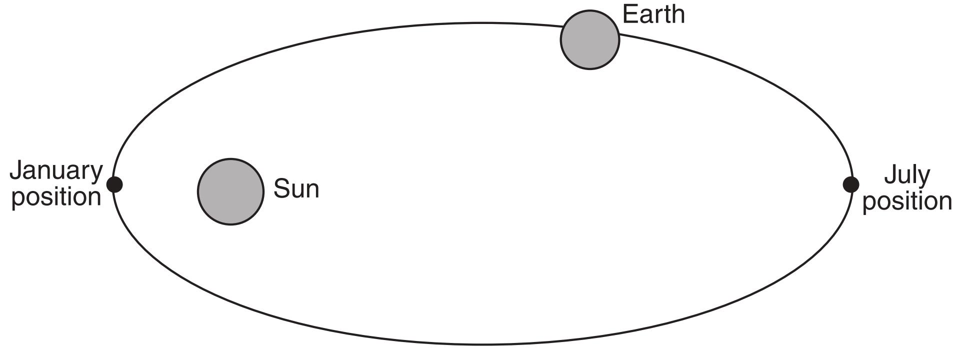
59 The centripetal acceleration of the car at the position shown is directed toward point

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

60 The magnitude of the centripetal force acting on the car is

(1) 590 N
(2) 150 N
(3) 30. N
(4) 2.5 N

61 The diagram below represents the path of Earth around the Sun.



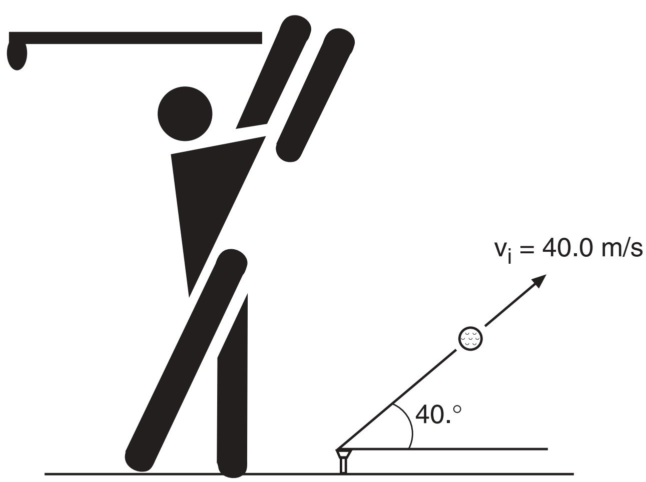
(not drawn to scale)

As Earth travels in its orbit from its January position to its July position, the potential energy of Earth

(1) decreases and its kinetic energy decreases
(2) decreases and its kinetic energy increases
(3) increases and its kinetic energy decreases
(4) increases and its kinetic energy increases

Base your answers to questions 62 and 63 on the information and diagram below

A golf ball leaves a golf club with an initial velocity of 40.0 meters per second at an angle of 40.° with the horizontal.



62 What is the vertical component of the golf ball's initial velocity?

(1) 25.7 m/s
(2) 30.6 m/s
(3) 40.0 m/s
(4) 61.3 m/s

63 What is the total horizontal distance traveled by the golf ball during the first 2.50 seconds of its flight?

(1) 100. m
(2) 76.6 m
(3) 64.3 m
(4) 40.0 m

64 What is the period of orbit of a communications satellite in geosynchronous orbit about Earth?

(1) 1 year
(2) 24 hours
(3) 12 hours
(4) 60 minutes

65 The table below gives information about the Moon and a satellite orbiting Earth.

R_m = mean radius of orbit of the Moon around Earth
R_s = mean radius of orbit of satellite around Earth
T_m = period of orbit of the Moon around Earth
T_s = period of orbit of satellite around Earth

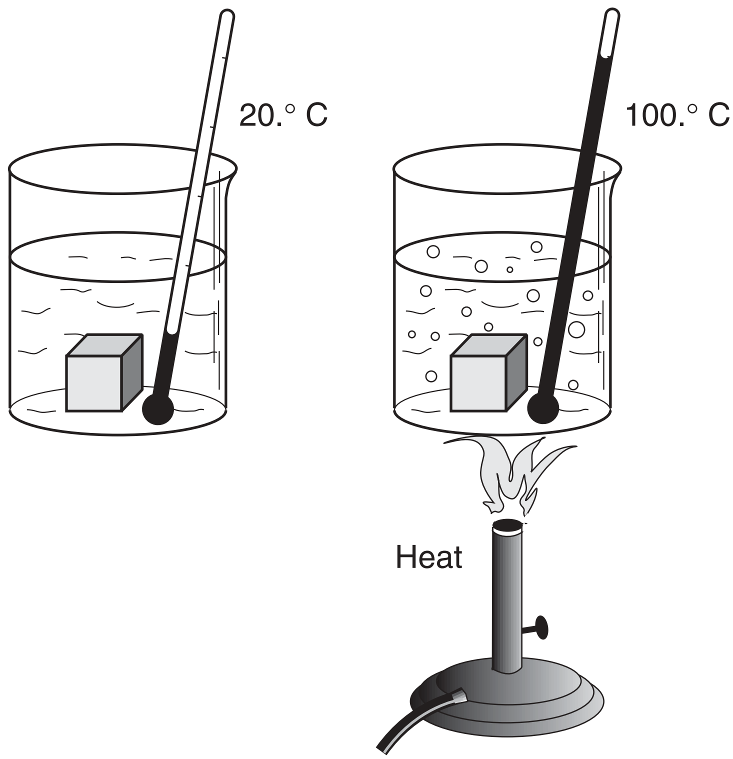
Which equation correctly relates these quantities?

(1) $R_m T_m = R_s T_s$
(2) $R_m T_s = R_s T_m$
(3) $\dfrac{R_m^{\,2}}{T_m} = \dfrac{R_s^{\,2}}{T_s}$
(4) $\dfrac{R_m^{\,3}}{T_m^{\,2}} = \dfrac{R_s^{\,3}}{T_s^{\,2}}$

Group 2 — Internal Energy

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

66 The diagram below represents an experiment in which a student placed a 0.030-kilogram lead cube in a beaker of water at 20.°C and then heated the beaker until the water began to boil.



The maximum amount of heat absorbed by the lead cube during the experiment was approximately

(1) 0.31 kJ
(2) 10. kJ
(3) 60. kJ
(4) 790 kJ

---

67 Absolute zero is best described as the temperature at which

(1) water freezes at standard pressure
(2) water is at its triple point
(3) the molecules of a substance have maximum kinetic energy
(4) the molecules of a substance have minimum kinetic energy

68 A temperature change of 20. Celsius degrees is equal to a temperature change of

(1) 20. Kelvins
(2) 120. Kelvins
(3) 253 Kelvins
(4) 293 Kelvins

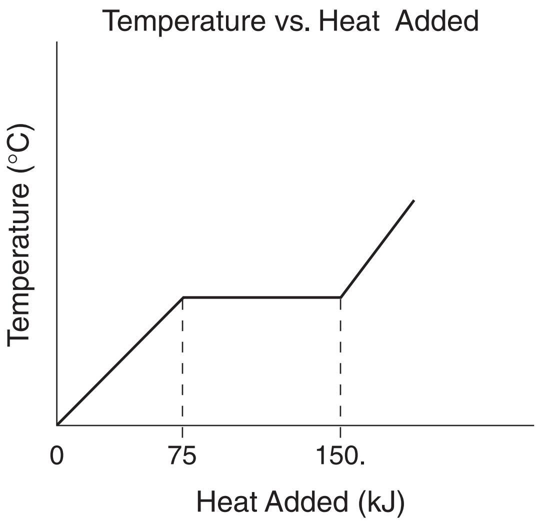
69 Heat will always flow from object *A* to object *B* if object *B* has a lower

(1) mass
(2) total energy
(3) temperature
(4) specific heat

70 Equal amounts of heat energy are given off by 1.0-kilogram samples of aluminum, iron, platinum, and zinc, all initially at 100.°C. Which sample has the greatest decrease in temperature?

(1) aluminum
(2) iron
(3) platinum
(4) zinc

71 The graph below shows the temperature of 3.0 kilograms of a pure substance initially in the solid phase as heat is added to it at a constant rate.



The substance is most likely

(1) alcohol
(2) silver
(3) copper
(4) lead

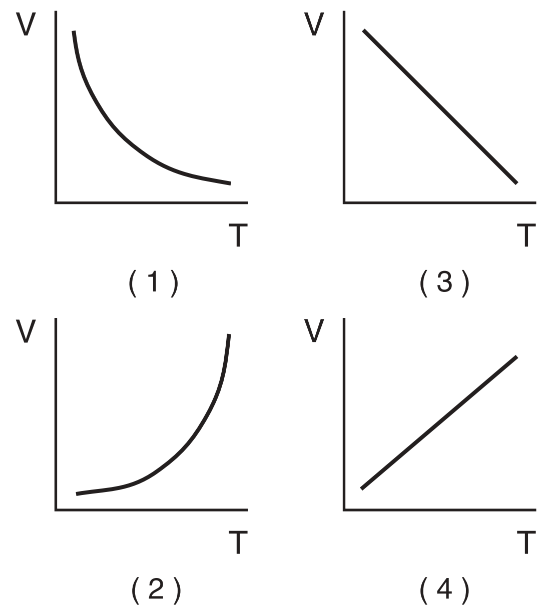
72 As a large quantity of salt is added to a container of boiling water, the water

(1) stops boiling because the boiling point decreases
(2) stops boiling because the boiling point increases
(3) boils faster because the boiling point decreases
(4) boils faster because the boiling point increases

73 The total effect of all the processes that occur in the universe is an increase in

(1) entropy
(2) temperature
(3) order
(4) energy

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



Note that question 75 has only three choices.

75 As the pressure of a fixed mass of gas is increased at constant temperature, the density of that gas

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

Group 3 — Electromagnetic Applications

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

76 If the current in an ammeter's coil is doubled, the resulting torque on the coil will be

(1) unchanged
(2) doubled
(3) halved
(4) quadrupled

77 An operating electric motor induces an EMF in the armature that opposes the applied potential difference. This phenomenon is an example of conservation of

(1) inertia
(2) electric charge
(3) momentum
(4) energy

78 The rate of thermionic emission from a surface increases as the surface's

(1) temperature decreases
(2) thickness decreases
(3) temperature increases
(4) thickness increases

79 An electron moves at 2.0×10^{6} meters per second perpendicular to a magnetic field having a flux density of 2.0 teslas. What is the magnitude of the magnetic force on the electron?

(1) 1.0×10^{-6} N
(2) 6.4×10^{-13} N
(3) 3.6×10^{-24} N
(4) 4.0×10^{6} N

80 The Millikan oil drop experiment determined the smallest unit of

(1) mass
(2) weight
(3) electric charge
(4) electric field strength

81 Which device transforms mechanical energy into electrical energy?

(1) generator
(2) motor
(3) transformer
(4) mass spectrometer

82 Power would most effectively be supplied to the primary coil of a step-up transformer by

(1) an ac generator
(2) a dc generator
(3) a battery
(4) an ac motor

83 The 200.-turn primary coil of a transformer is connected to a 120-volt line. How many turns must the secondary coil of the transformer have if it is to provide 240 volts? [Assume 100% efficiency.]

(1) 100
(2) 400
(3) 1,200
(4) 2,400

84 Which device is used in the ignition system of a car to induce a time-varying potential difference from the car's battery?

(1) electric motor
(2) electromagnet
(3) transistor
(4) induction coil

85 A helium-neon laser emits energy in the visible red region in the form of

(1) alpha particles
(2) gamma rays
(3) electrons
(4) photons

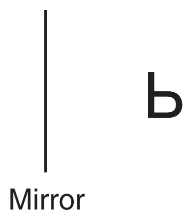
Group 4 — Geometric Optics

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

86 The diagram below shows the letter *P* in front of a plane mirror.

Which diagram best represents the image of *P* produced by the plane mirror?

(1)



(2)

(3)

(4)

87 A student stands 2.0 meters in front of a vertical plane mirror. As the student walks toward the mirror, the image

(1) decreases in size and remains virtual
(2) decreases in size and remains real
(3) remains the same size and remains virtual
(4) remains the same size and remains real

88 An incident light ray travels parallel to the principal axis of a concave spherical mirror. After reflecting from the mirror, the light ray will travel

(1) through the mirror's principal focus
(2) through the mirror's center of curvature
(3) parallel to the mirror's principal axis
(4) normal to the mirror's principal axis

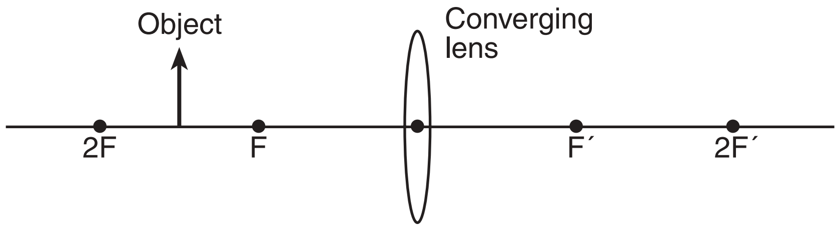
89 The focal length of a concave spherical mirror is 0.060 meter. What is the radius of curvature of the mirror?

(1) 0.060 m
(2) 0.12 m
(3) 8.3 m
(4) 17 m

90 An image that is 1.0×10^{-2} meter tall is formed on a screen behind a converging lens when an object 2.0 meters tall is placed 8.0 meters in front of the lens. What is the distance from the lens to the screen?

(1) 2.5×10^{-3} m
(2) 4.0×10^{-2} m
(3) 2.5×10^{-1} m
(4) 4.0×10^{-1} m

91 The diagram below shows an object placed between 1 and 2 focal lengths from a converging lens.



The image of the object produced by the lens is

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

---

92 The focal length of a lens is *not* dependent on the

(1) material from which the lens is made
(2) color of the light incident on the lens
(3) distance of an object from the lens
(4) shape or curvature of the lens

93 An object is placed 0.20 meter from a converging lens having a focal length of 0.040 meter. The distance of the image from the lens is

(1) 0.033 m
(2) 0.050 m
(3) 0.16 m
(4) 0.20 m

94 Images formed by diverging mirrors are always

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

95 Spherical aberration is a defect associated with

(1) spherical mirrors, only
(2) plane mirrors, only
(3) both spherical mirrors and lenses
(4) both plane mirrors and lenses

Group 5 — Solid State

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

96 The conductivity of a material is equivalent to

(1) its resistivity
(2) the square of its resistivity
(3) the reciprocal of its resistivity
(4) the square of the reciprocal of its resistivity

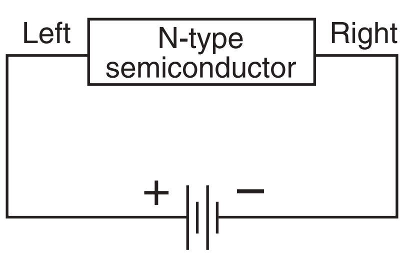
97 Which model most successfully explains conduction in solids?

(1) electron-cloud model
(2) electron-sea model
(3) band model
(4) doping model

98 As a donor material, arsenic provides a semiconducting material with extra

(1) electrons (3) protons
(2) holes (4) neutrons

99 The diagram below shows a circuit with a battery applying a potential difference across an *N*-type semiconductor.



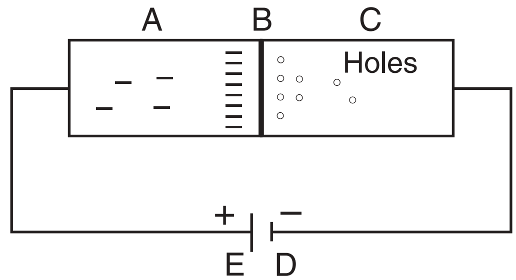
The majority charge carriers in the semiconductor are

(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

100 Pulsating direct current results when a *P-N* junction is connected to

(1) a battery
(2) an oscilloscope
(3) a source of direct current voltage
(4) a source of alternating current

Base your answers to questions 101 and 102 on the diagram below, which represents a silicon semiconductor.



101 In the diagram, *C* represents the

(1) *N*-type silicon (3) anode
(2) *P*-type silicon (4) diode

102 The *P-N* junction in the diagram is biased

(1) reverse (3) *A* to *E*
(2) forward (4) *C* to *D*

---

103 The primary source of holes in a *P-N-P* transistor is the

(1) *N*-type base (3) *N*-type emitter
(2) *P*-type base (4) *P*-type emitter

104 In a working transistor circuit, as the emitter-base current is increased, the collector current

(1) decreases a small amount
(2) decreases a large amount
(3) increases a small amount
(4) increases a large amount

Note that question 105 has only three choices.

105 An *N*-type semiconductor and a *P*-type semiconductor are joined to form a diode. Compared to the total number of electrons in the semiconductors before joining, the number of electrons in the diode is

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

Group 6 — Nuclear Energy

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

106 If nitrogen nuclei are bombarded with alpha particles they can be changed into oxygen nuclei. This phenomenon is known as

(1) nuclear fission
(2) nuclear fusion
(3) artificial transmutation
(4) particle scattering

107 One atomic mass unit is defined as

(1) the mass of an electron
(2) the mass of an alpha particle
(3) the mass of an atom of carbon-12
(4) $\frac{1}{12}$ the mass of an atom of carbon-12

108 According to the Uranium Disintegration Series, which nuclide is an isotope of lead (Pb)?

(1) $^{206}_{82}Pb$
(2) $^{214}_{83}Pb$
(3) $^{214}_{84}Pb$
(4) $^{222}_{86}Pb$

109 The nuclei of all the atoms in a single nuclide have

(1) the same number of neutrons and the same number of protons
(2) the same number of neutrons, but different numbers of protons
(3) different numbers of neutrons, but the same number of protons
(4) different numbers of neutrons and different numbers of protons

110 What occurs when an atom emits gamma radiation?

(1) The excited nucleus changes to a more stable state by absorbing a photon.
(2) The excited nucleus changes to a more stable state by emitting a photon.
(3) The stable nucleus changes to an excited state by emitting a photon.
(4) The stable nucleus changes to an excited state by absorbing a photon.

111 What particle is represented by *X* in the nuclear reaction $^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + X$?

(1) $^{0}_{-1}e$
(2) $^{1}_{1}H$
(3) $^{1}_{0}n$
(4) $^{2}_{1}H$

112 The half-life of a particular radioactive material is 6.0 hours. What fraction of a sample of the material would remain after 1 day?

(1) $\frac{1}{4}$
(2) $\frac{2}{3}$
(3) $\frac{3}{8}$
(4) $\frac{1}{16}$

113 Which device can be used to detect subatomic particles that exit nuclei?

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

114 In a nuclear reactor, which substance can be used as both the moderator and the coolant?

(1) cadmium
(2) boron
(3) water
(4) uranium

115 If the nucleus of an atom emits a positron, the atomic number of the atom will

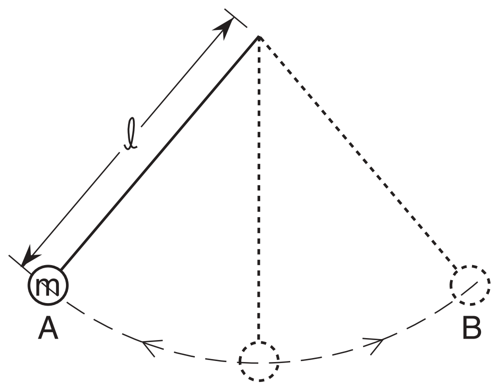
(1) decrease by one
(2) increase by one
(3) remain unchanged
(4) decrease by two

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]

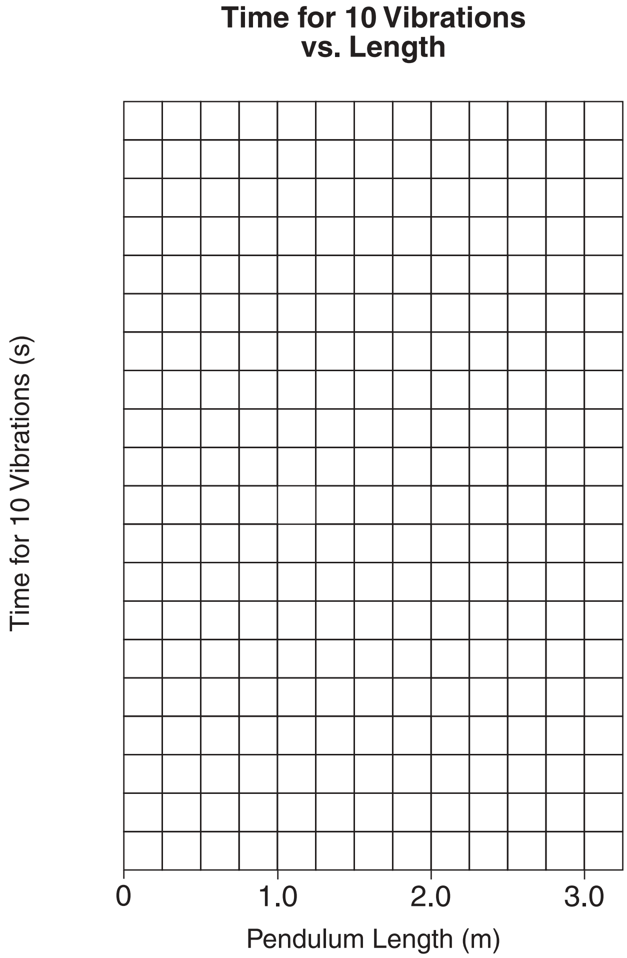
Base your answers to questions 116 through 119 on the information, diagram, and data table below.

The diagram shows a light string attached to mass *m* forming a pendulum of length ℓ. One complete vibration of the pendulum consists of mass *m* moving from position *A* to position *B* and back to position *A*. The data table shows the results of an experiment measuring the time for 10 complete vibrations of the pendulum for various pendulum lengths.



Pendulum Length (meters)	**Time for 10 Vibrations** (seconds)
0	0
0.2	9
0.5	14
1.0	20.
1.5	25
2.0	28
2.5	32

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.*



116 Mark an appropriate scale on the axis labeled "Time for 10 Vibrations." [1]

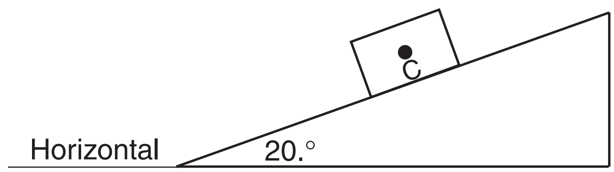
117 Plot the data points for time for 10 vibrations versus length. [1]

118 Draw the best-fit curve. [1]

119 Determine the period of the 1.0-meter pendulum. [1]

Base your answers to questions 120 through 122 on the information and diagram below. The diagram below is provided for practice purposes only. Be sure your final answer appears *on your answer paper*.

A 10.0-kilogram block slides at constant speed down a plane inclined at 20.° to the horizontal, as shown.



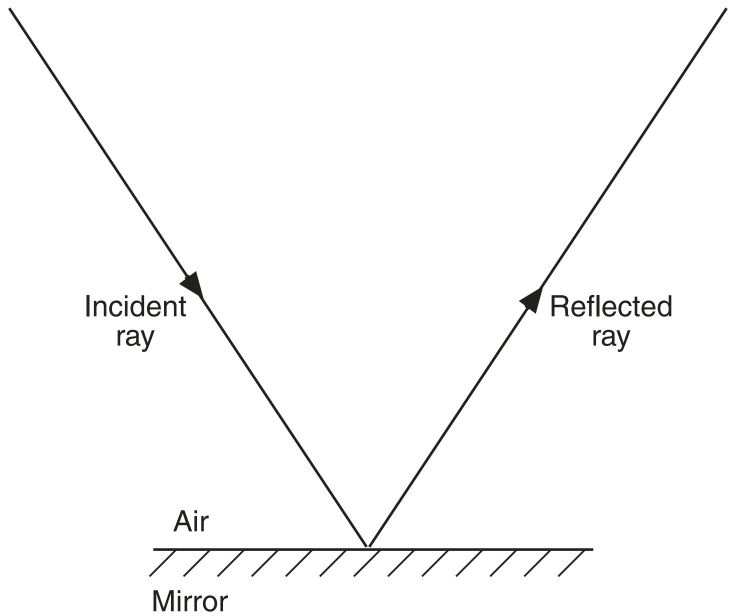
120 On the diagram *on your answer paper,* draw an arrow to represent and identify the direction of each of the *three* forces (weight, friction, normal force) acting on the block. Begin *each* arrow at point *C* and label *each* arrow with the force that it represents. [3]

121 Determine the weight of the block. [Show all calculations, including the equation and substitution with units.] [2]

122 In one or more complete sentences, describe the change in the motion of the block as the angle of inclination is increased to 30.°. [1]

Base your answers to questions 123 through 126 on the information and diagram below. The diagram below is provided for practice purposes only. Be sure your final answer appears *on your answer paper.*

A ray of monochromatic light of frequency 5.00×10^{14} hertz is incident on a mirror and reflected, as shown.



123 Using a protractor and ruler, construct and label the normal to the mirror at the point of incidence on the diagram *on your answer paper.* [1]

124 Using a protractor, measure the angle of incidence to the nearest degree and record the value *on your answer paper*. [1]

125 Determine the wavelength of the ray of light. [Show all calculations, including the equation and substitution with units.] [2]

126 What is the color of the ray of light? [1]

The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Tuesday, January 22, 2002 — 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	
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	**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	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	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	

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	

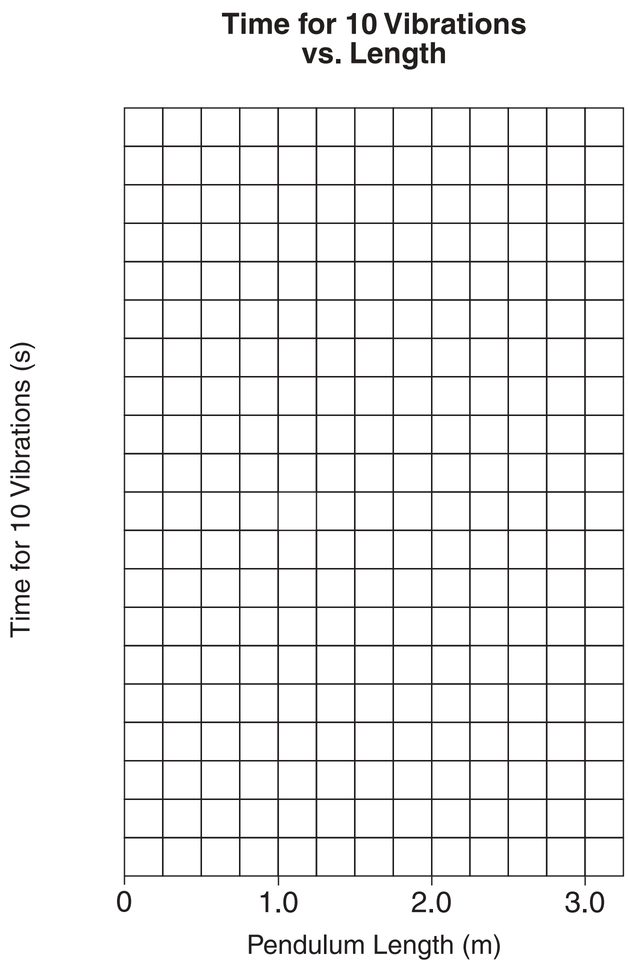
Group 6
Nuclear Energy

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)

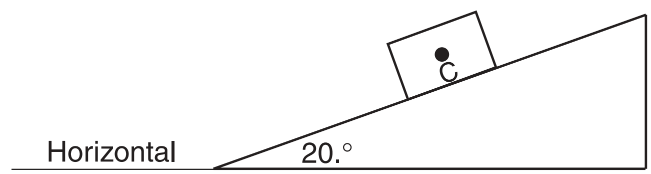
Answer all questions in this part.

116–118



119 ____________________

120



121

122 ____

____

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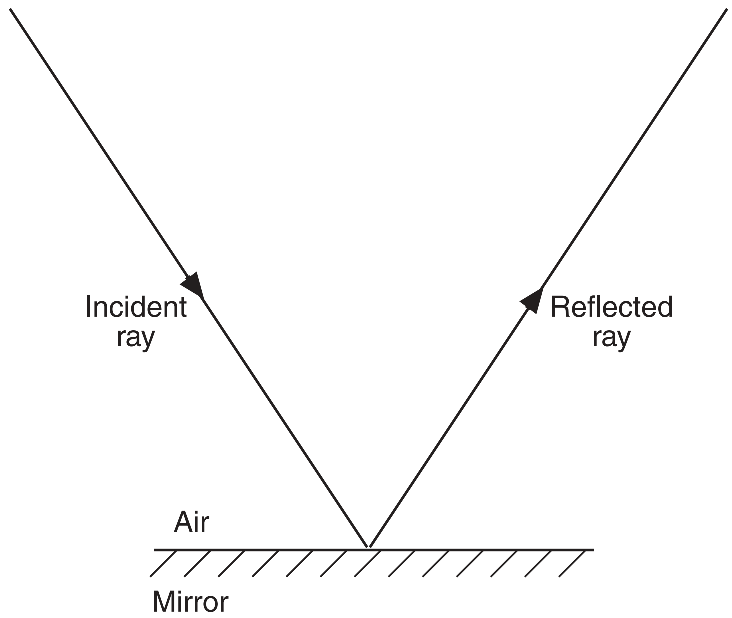
____

____

123



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124 __________

125

126 ______________________

I do hereby affirm, at the close of this examination, that I had no unlawful knowledge of the questions or answers prior to the examination and that I have neither given nor received assistance in answering any of the questions during the examination.

____

Signature

Additional Reference Information

Tear Here

VALUES OF TRIGONOMETRIC FUNCTIONS

Angle	Sine	Cosine	Angle	Sine	Cosine
5°	.0872	.9962	**50°**	.7660	.6428
10°	.1736	.9848	**55°**	.8192	.5736
15°	.2588	.9659	**60°**	.8660	.5000
20°	.3420	.9397	**65°**	.9063	.4226
25°	.4226	.9063	**70°**	.9397	.3420
30°	.5000	.8660	**75°**	.9659	.2588
35°	.5736	.8192	**80°**	.9848	.1736
40°	.6428	.7660	**85°**	.9962	.0872
45°	.7071	.7071	**90°**	1.0000	.0000

MOTION IN A PLANE

$$v_{iy} = v_i \sin\theta$$

$$v_{ix} = v_i \cos\theta$$

$$a_c = \frac{v^2}{r}$$

$$F_c = \frac{mv^2}{r}$$

a_c = centripetal acceleration
F_c = centripetal force
m = mass
r = radius
v = velocity
θ = angle

INTERNAL ENERGY

$$Q = mc\Delta T_C$$

$$Q_f = mH_f$$

$$Q_v = mH_v$$

c = specific heat
H_f = heat of fusion
H_v = heat of vaporization
m = mass
Q = amount of heat
T_C = Celsius temperature

HEAT CONSTANTS

		Specific Heat (average) (kJ/kg•C°)	*Melting Point* (°C)	*Boiling Point* (°C)	*Heat of Fusion* (kJ/kg)	*Heat of Vaporization* (kJ/kg)
Alcohol (ethyl)		2.43 (liq.)	–117	79	109	855
Aluminum		0.90 (sol.)	660	2467	396	10500
Ammonia		4.71 (liq.)	–78	–33	332	1370
Copper		0.39 (sol.)	1083	2567	205	4790
Iron		0.45 (sol.)	1535	2750	267	6290
Lead		0.13 (sol.)	328	1740	25	866
Mercury		0.14 (liq.)	–39	357	11	295
Platinum		0.13 (sol.)	1772	3827	101	229
Silver		0.24 (sol.)	962	2212	105	2370
Tungsten		0.13 (sol.)	3410	5660	192	4350
Water	ice	2.05 (sol.)	0	—	334	—
Water	water	4.19 (liq.)	—	100	—	2260
Water	steam	2.01 (gas)	—	—	—	—
Zinc		0.39 (sol.)	420	907	113	1770

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ELECTROMAGNETIC APPLICATIONS

$F = qvB$

$\dfrac{N_p}{N_s} = \dfrac{V_p}{V_s}$

$V_p I_p = V_s I_s$ (ideal)

B = flux density
F = force
I_p = current in primary coil
I_s = current in secondary coil
N_p = number of turns of primary coil
N_s = number of turns of secondary coil
q = charge
v = velocity
V_p = voltage of primary coil
V_s = voltage of secondary coil

GEOMETRIC OPTICS

$\dfrac{1}{d_o} + \dfrac{1}{d_i} = \dfrac{1}{f}$

$\dfrac{S_o}{S_i} = \dfrac{d_o}{d_i}$

d_i = image distance
d_o = object distance
f = focal length
S_i = image size
S_o = object size

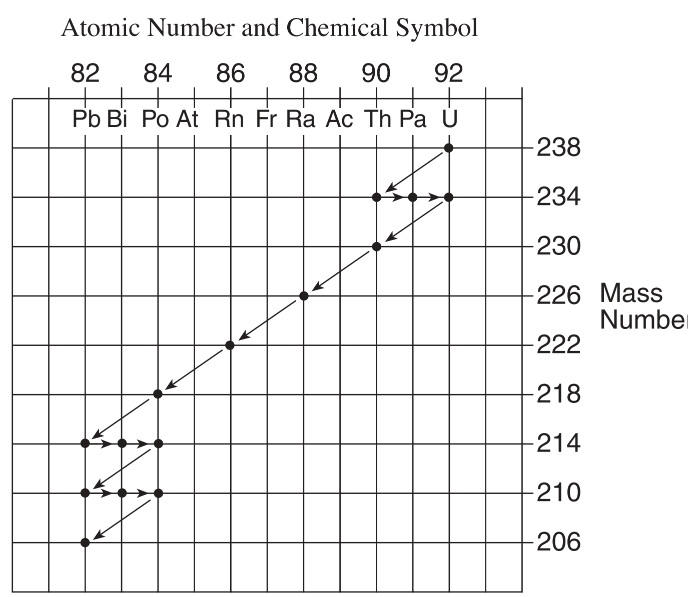
NUCLEAR ENERGY

$E = mc^2$

$m_f = \dfrac{m_i}{2^n}$

c = speed of light in a vacuum
E = energy
m = mass
n = number of half-lives

URANIUM DISINTEGRATION SERIES



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FOR TEACHERS ONLY

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The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICS

Tuesday, January 22, 2002 — 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	X	3	4	**21**	1	2	3	X	**41**	1	2	3	X
2	1	X	3	4	**22**	1	2	X	4	**42**	X	2	3	4
3	X	2	3	4	**23**	X	2	3	4	**43**	1	2	3	X
4	1	2	3	X	**24**	1	X	3	4	**44**	X	2	3	4
5	1	X	3	4	**25**	X	2	3	4	**45**	X	2	3	4
6	1	2	3	X	**26**	1	2	3	X	**46**	1	2	X	4
7	X	2	3	4	**27**	1	X	3	4	**47**	1	X	3	4
8	1	2	X	4	**28**	1	2	X	4	**48**	1	2	3	X
9	1	2	X	4	**29**	1	2	3	X	**49**	1	2	3	X
10	X	2	3	4	**30**	1	2	3	X	**50**	1	2	3	X
11	1	X	3	4	**31**	1	X	3	4	**51**	1	X	3	4
12	1	2	X	4	**32**	1	2	X	4	**52**	1	2	3	X
13	1	2	X	4	**33**	1	X	3	4	**53**	1	X	3	
14	1	X	3	4	**34**	1	X	3	4	**54**	1	X	3	
15	1	2	3	X	**35**	1	2	X	4	**55**	X	2	3	
16	1	X	3	4	**36**	X	2	3	4					
17	1	X	3	4	**37**	1	2	3	X					
18	1	2	X	4	**38**	1	2	X	4					
19	1	2	3	X	**39**	X	2	3	4					
20	X	2	3	4	**40**	1	2	X	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	X	2	3	4
57	1	2	3	X
58	1	X	3	4
59	1	2	X	4
60	1	X	3	4
61	1	2	X	4
62	X	2	3	4
63	1	X	3	4
64	1	X	3	4
65	1	2	3	X

Group 2
Internal Energy

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

Group 3
Electromagnetic Applications

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

Group 4
Geometric Optics

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

Group 5
Solid State

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

Group 6
Nuclear Energy

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

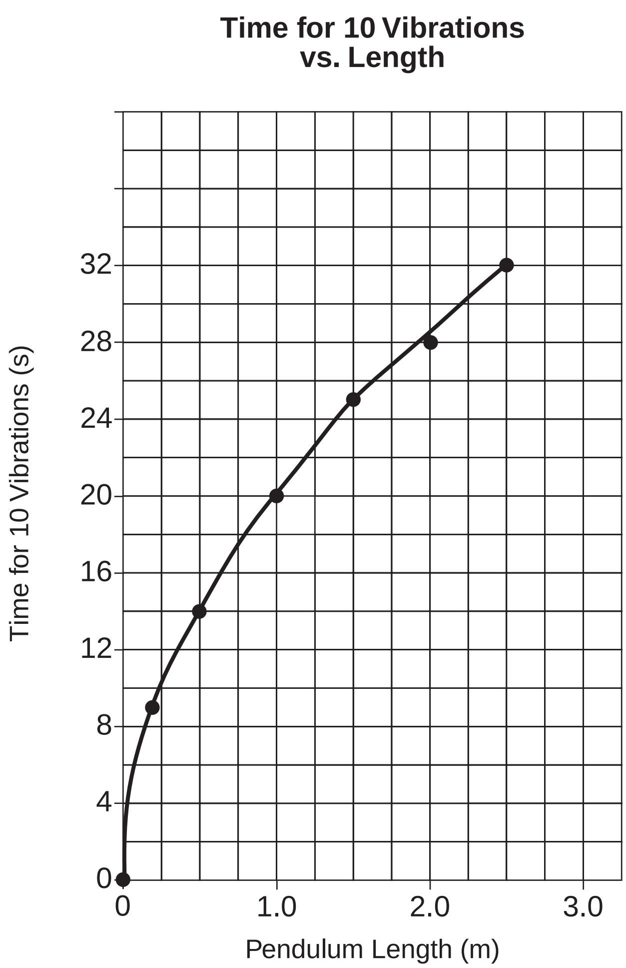
Scoring Criteria for Calculations

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 121 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.

116–118 Example of Acceptable Response



116 Allow 1 credit.

The scale must be linear and appropriate to receive this credit.

117 Allow 1 credit.

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

118 Allow 1 credit.

The best-fit line must be curved. If one or more points are plotted incorrectly in question 117, but a best-fit curve is drawn, allow this credit.

119 Allow 1 credit.

Examples of Acceptable Responses

2.0 s

or

2 seconds

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

120 Allow a total of 3 credits.

Example of Acceptable Response

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

If each of the three sketched forces meets all three of the following criteria, award a total of 3 credits.

- A line originating at point C and having the correct orientation
  - — weight: perpendicular to the horizontal
  - — friction: parallel to the incline
  - — normal force: perpendicular to the incline
- An arrowhead in the correct direction
  - — weight: directed towards the horizontal
  - — friction: directed up the incline
  - — normal force: directed away from the incline
- A label
  - — weight or F_g
  - — friction or F_f
  - — normal force or F_N

If each of the three sketched forces meets *at least two* of the three criteria, award a total of 2 credits.

If each of the three sketched forces meets *at least one* of the three criteria, award a total of 1 credit.

or

It two of the sketched forces meet all three criteria, award a total of 2 credits.

If one of the sketched forces meets all three criteria, award a total of 1 credit.

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

Examples of Acceptable Responses

$$g = \frac{F_g}{m}$$

$$F_g = mg$$

$$F_g = (10.0\ \text{kg})(9.81\ \text{m/s}^2)$$

$$F_g = 98.1\ \text{N}$$

or

$$w = mg$$

$$w = (10.0\ \text{kg})(9.81\ \text{m/s}^2)$$

$$w = 98\ \frac{\text{kg}\bullet\text{m}}{\text{s}^2}$$

122 Allow 1 credit. To receive this credit the response must be written in one or more complete sentences.

Examples of Acceptable Responses

The block would accelerate.
The speed of the block would increase.
The speed of the block would not be constant.

123 Allow 1 credit.

Example of Acceptable Response

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

Allow credit for a line making an angle of 90.° ± 2° with the mirror at the point where the rays meet at the mirror. Do not penalize the student if the line is solid and/or the label is missing.

124 Allow 1 credit.

34° ± 2°

Allow credit for an answer that is consistent with the student's answer to question 123.

125 Allow a total of 2 credits. Refer to *Scoring Criteria for Calculations* in this scoring key.

Examples of Acceptable Responses

$$v = f\lambda$$

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

$$\lambda = \frac{3.00 \times 10^8\ \text{m/s}}{5.00 \times 10^{14}\ \text{Hz}}$$

$$\lambda = 6.00 \times 10^{-7}\ \text{m}$$

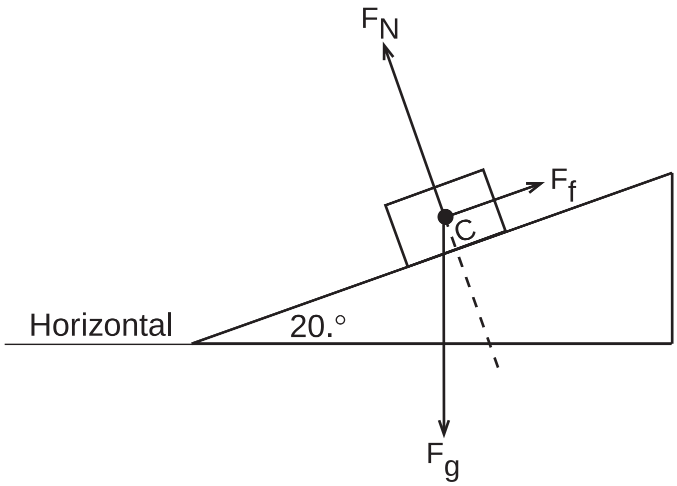
or

$$\lambda = 0.6 \times 10^{-6}\ \text{m}$$

126 Allow 1 credit.

orange

120 Example of Acceptable Response



123 Example of Acceptable Response