COMMACK HIGH SCHOOL

INTERNATIONAL BACCALAUREATE STANDARD LEVEL PHYSICS

SPRING 2019 SL REVIEW

PART B

May 2016 Papers 1, 2, 3 (in class)
May 2010 Paper 1 (in class)
May 2011 Paper 1 (in class)

NAME _____

TEACHER _____

The IB Data Booklet (Reference Tables) can be used on all portions of the exam.

Paper 1: 30 Multiple Choice – 45 minutes
NO CALCULATORS

Paper 2: 1 hour 15 minutes
Complete all parts .

Paper 3: 1 hour
Section A: Answer all questions.
Section B: .(The test booklet includes 4 options.)
Do Option B ONLY! Engineering Physics:
Rigid bodies and Rotational Dynamics
Thermodynamics.

- May 2016, 2017 and 2018 Exams follow the same exam format as the test you will take in May 2019.
- Please also note that the exams prior to 2016:
  - Contain some concepts that will not be on your exam
  - New concepts first tested in 2016 are missing.

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 1

Friday 6 May 2016 (morning)

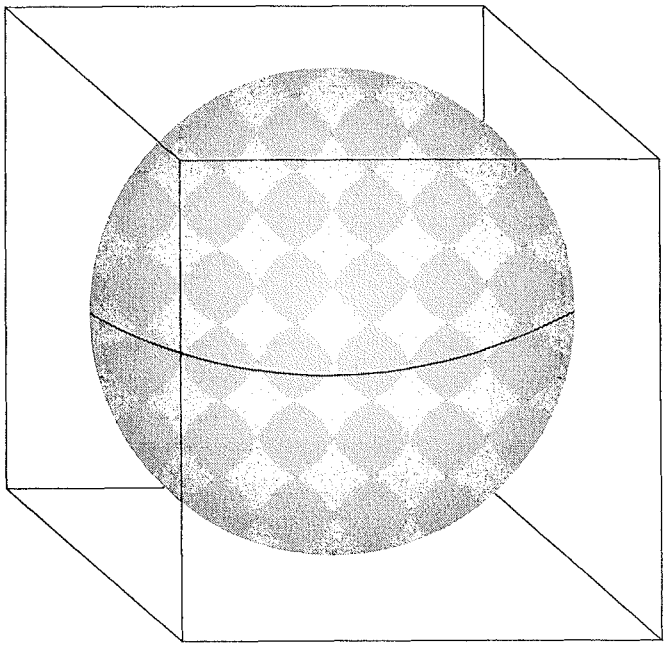
45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[30 marks]**.

2216–6504

1. A sphere fits inside a cube.



The length of the cube and the diameter of the sphere are $10.0 \pm 0.2\,\text{cm}$.

What is the ratio $\frac{\text{percentage uncertainty of the volume of the sphere}}{\text{percentage uncertainty of the volume of the cube}}$?

A. $\frac{3}{4\pi}$

B. 1

C. 2

D. 8

2. A swimming pool contains $18 \times 10^6\,\text{kg}$ of pure water. The molar mass of water is $18\,\text{g mol}^{-1}$. What is the correct estimate of the number of water molecules in the swimming pool?

A. 10^4

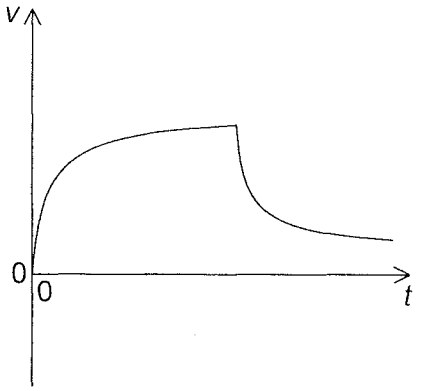
B. 10^{24}

C. 10^{25}

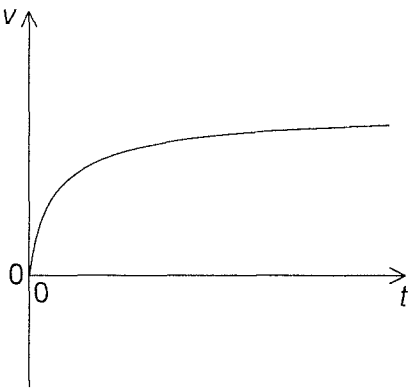
D. 10^{33}

3. An aircraft is moving horizontally. A parachutist leaves the aircraft and a few seconds later opens her parachute. Which graph shows the variation of the vertical speed v with time t for the parachutist from the time she leaves the aircraft until just before landing?

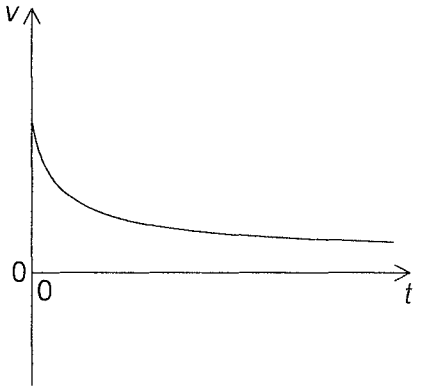
A.



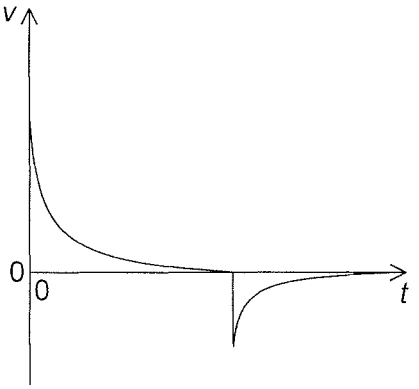
B.



C.



D.



4. An object of mass m rests on a horizontal plane. The angle θ that the plane makes with the horizontal is slowly increased from zero. When $\theta = \theta_0$, the object begins to slide. What are the coefficient of static friction μ_s and the normal reaction force N of the plane at $\theta = \theta_0$?

	μ_s	N
A.	$\sin \theta_0$	$mg \cos \theta_0$
B.	$\tan \theta_0$	$mg \sin \theta_0$
C.	$\sin \theta_0$	$mg \sin \theta_0$
D.	$\tan \theta_0$	$mg \cos \theta_0$

5. A stone is falling at a constant velocity vertically down a tube filled with oil. Which of the following statements about the energy changes of the stone during its motion are correct?

I. The gain in kinetic energy is less than the loss in gravitational potential energy.

II. The sum of kinetic and gravitational potential energy of the stone is constant.

III. The work done by the force of gravity has the same magnitude as the work done by friction.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

6. A spring of negligible mass and length l_0 hangs from a fixed point. When a mass m is attached to the free end of the spring, the length of the spring increases to l. The tension in the spring is equal to $k\Delta x$, where k is a constant and Δx is the extension of the spring. What is k?

A. $\frac{mg}{l_0}$

B. $\frac{mg}{l}$

C. $\frac{mg}{l - l_0}$

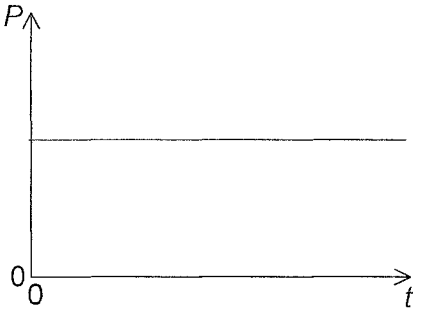
D. $\frac{mg}{l_0 - l}$

7. A ball with mass m moves horizontally with speed u. The ball hits a vertical wall and rebounds in the opposite direction with speed $v < u$. The duration of the collision is T. What are the magnitude of the average force exerted by the wall on the ball and the loss of kinetic energy of the ball?

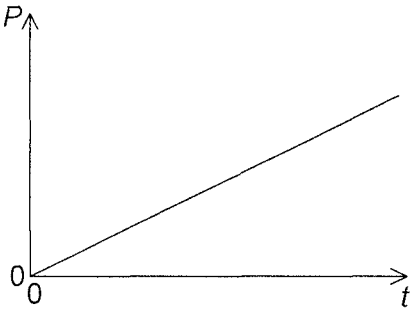
	Average force	Loss of kinetic energy
A.	$\frac{m(u+v)}{T}$	$\frac{m(u^2-v^2)}{2}$
B.	$\frac{m(u+v)}{T}$	$\frac{m(u-v)^2}{2}$
C.	$\frac{m(u-v)}{T}$	$\frac{m(u^2-v^2)}{2}$
D.	$\frac{m(u-v)}{T}$	$\frac{m(u-v)^2}{2}$

8. A train on a straight horizontal track moves from rest at constant acceleration. The horizontal forces on the train are the engine force and a resistive force which increases with speed. Which graph represents the variation with time t of the power P developed by the engine?

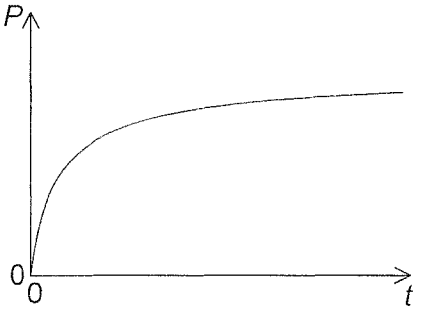
A.



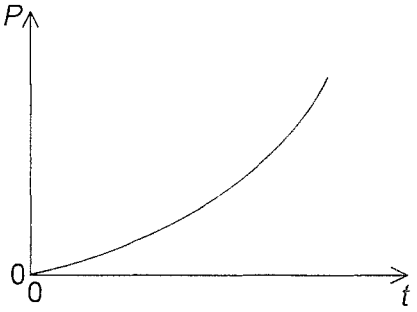
B.



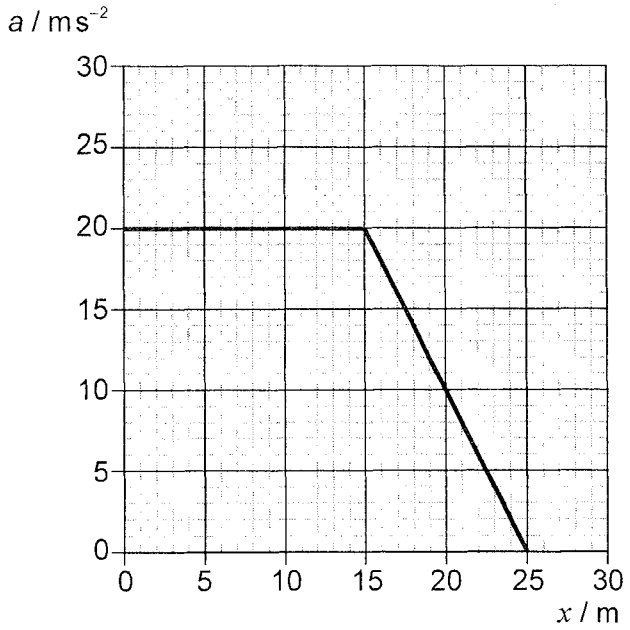
C.



D.



9. The graph shows how the acceleration a of an object varies with distance travelled x.



The mass of the object is 3.0 kg. What is the total work done on the object?

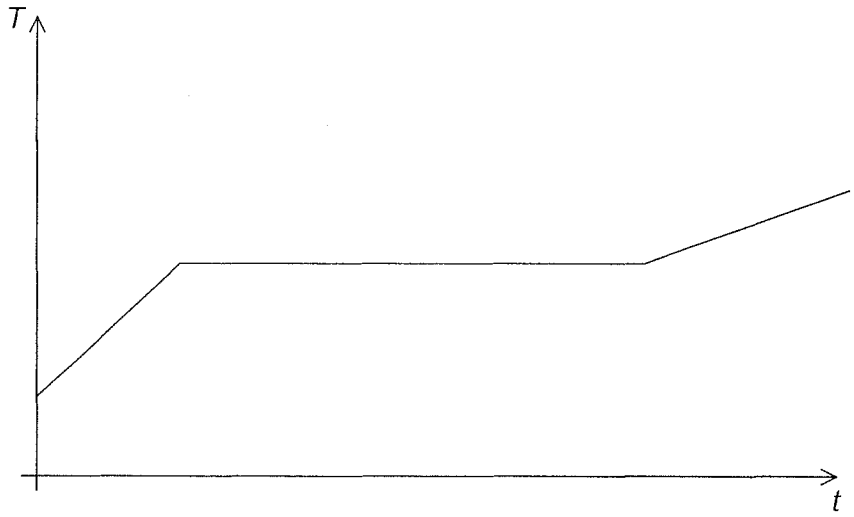
A. 300 J

B. 400 J

C. 1200 J

D. 1500 J

10. A substance is heated at constant power. The graph shows how the temperature T of the substance varies with time t as the state of the substance changes from liquid to gas.



What can be determined from the graph?

A. The specific heat capacity of the gas is smaller than the specific heat capacity of the liquid.

B. The specific heat capacity of the gas is larger than the specific heat capacity of the liquid.

C. The specific latent heat of fusion of the substance is less than its specific latent heat of vaporization.

D. The specific latent heat of fusion of the substance is larger than its specific latent heat of vaporization.

11. Which of the following is **not** an assumption of the kinetic model of ideal gases?

A. All particles in the gas have the same mass.

B. All particles in the gas have the same speed.

C. The duration of collisions between particles is very short.

D. Collisions with the walls of the container are elastic.

12. Under what conditions of density and pressure is a real gas best described by the equation of state for an ideal gas?

A. Low density and low pressure

B. Low density and high pressure

C. High density and low pressure

D. High density and high pressure

13. A point source emits sound waves of amplitude A. The sound intensity at a distance d from the source is I. What is the sound intensity at a distance $0.5d$ from the source when the source emits waves of amplitude $2A$?

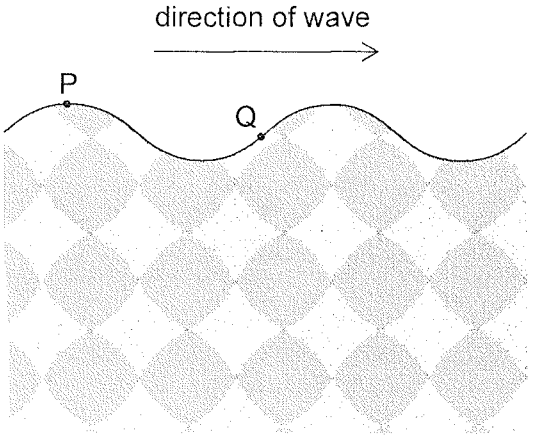
A. $16I$

B. $4I$

C. I

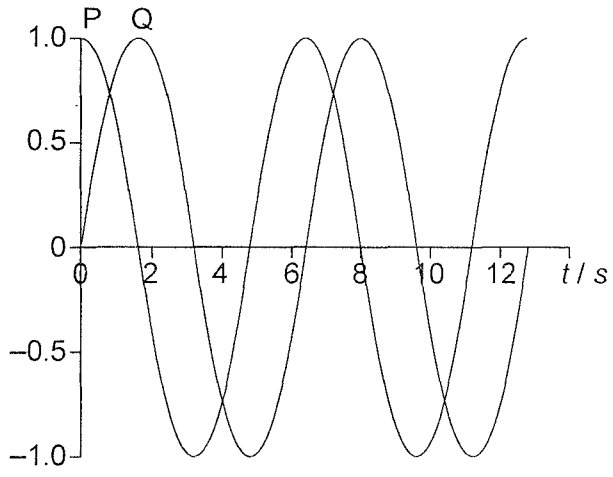
D. $\frac{1}{4}I$

14. A water wave moves on the surface of a lake. P and Q are two points on the water surface. The wave is travelling towards the right.

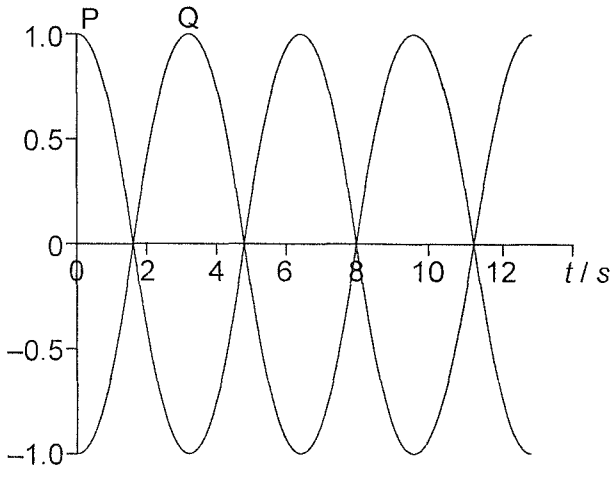


The diagram shows the wave at time $t = 0$. Which graph shows how the displacements of P and Q vary with t?

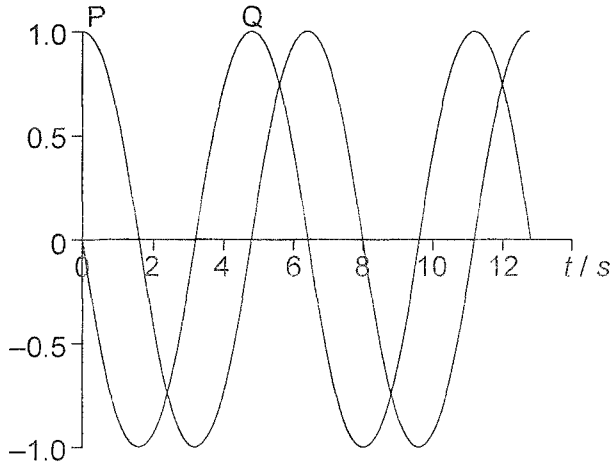
A.



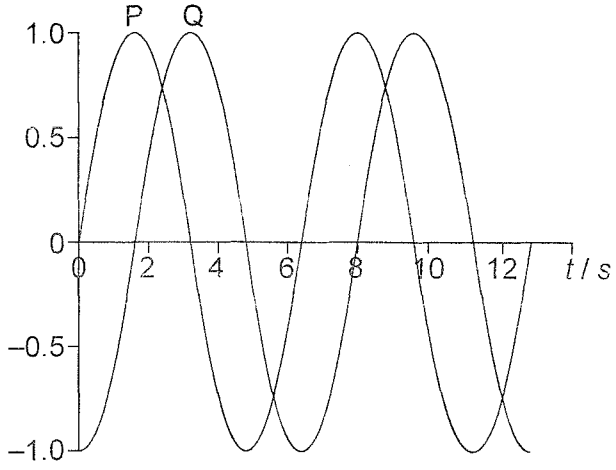
B.



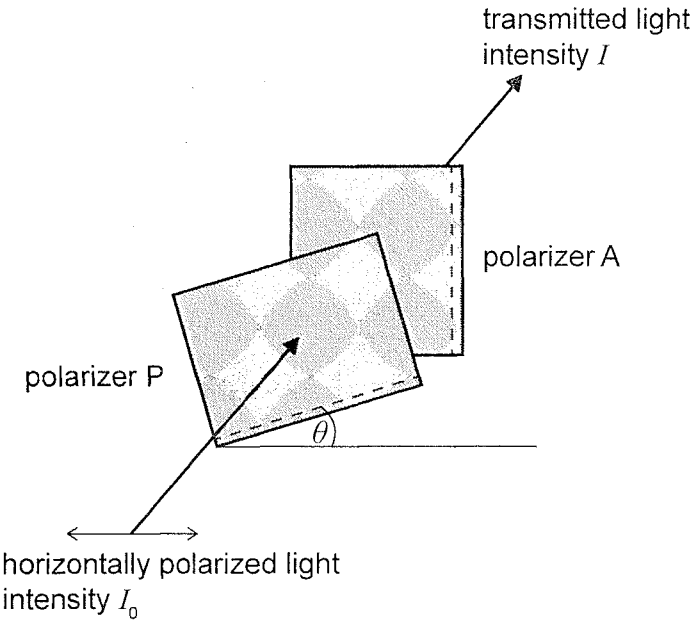
C.



D.

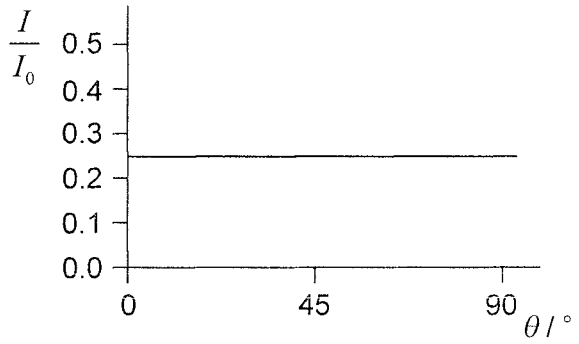


15. Horizontally polarized light of intensity I_0 enters a polarizer P whose polarization axis makes an angle of θ degrees with the horizontal. Light from P is then incident on a polarizer A with fixed vertical polarization axis.

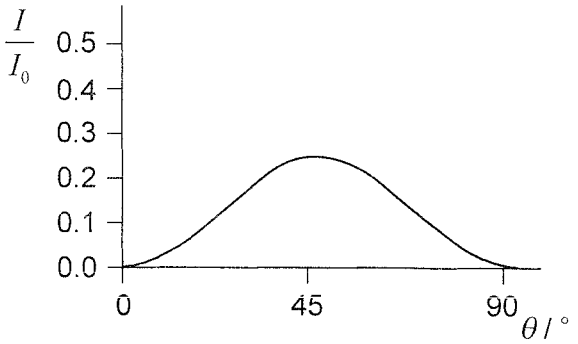


The angle θ is varied from 0 to 90 degrees. Which of the following represents the variation with θ of the intensity I of the light transmitted through A?

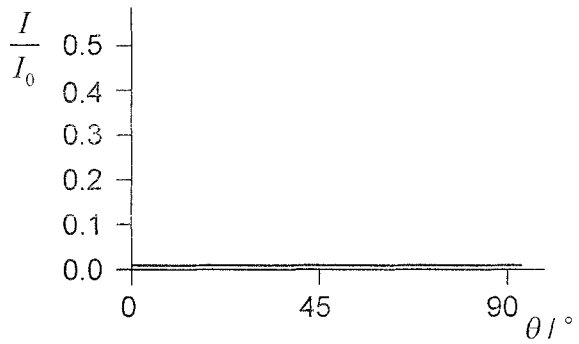
A.



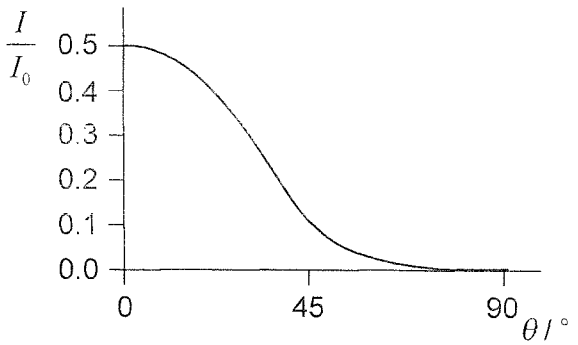
B.



C.



D.



16. A pipe of length L has two open ends. Another pipe of length L' has one open end and one closed end.

The frequency of the first harmonic of both pipes is the same. What is $\frac{L'}{L}$?

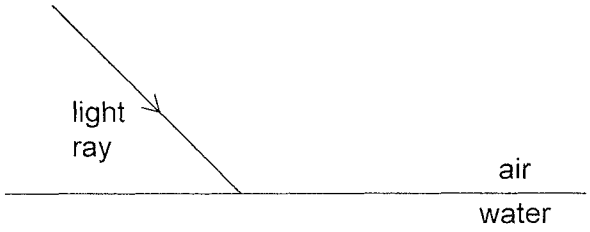
A. 2

B. $\frac{3}{2}$

C. 1

D. $\frac{1}{2}$

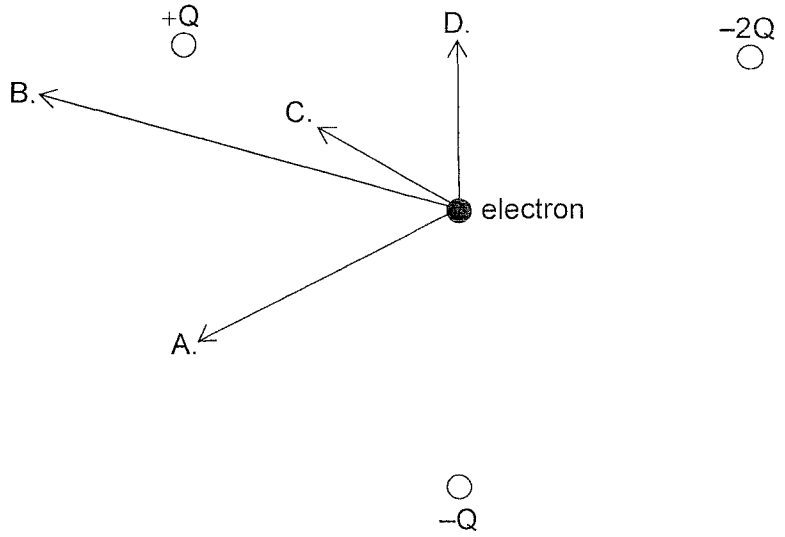
17. A light ray passes from air to water as shown.



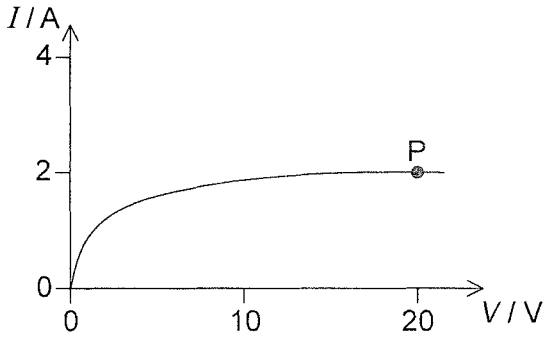
What are the change in the wavelength of the light wave and the change in the angle the ray makes with the normal to the surface?

	Wavelength	Angle with normal
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

18. Three fixed charges, +Q, –Q and –2Q, are at the vertices of an equilateral triangle. What is the resultant force on an electron at the centre of the triangle?



19. The graph shows the variation of current I in a device with potential difference V across it.



What is the resistance of the device at P?

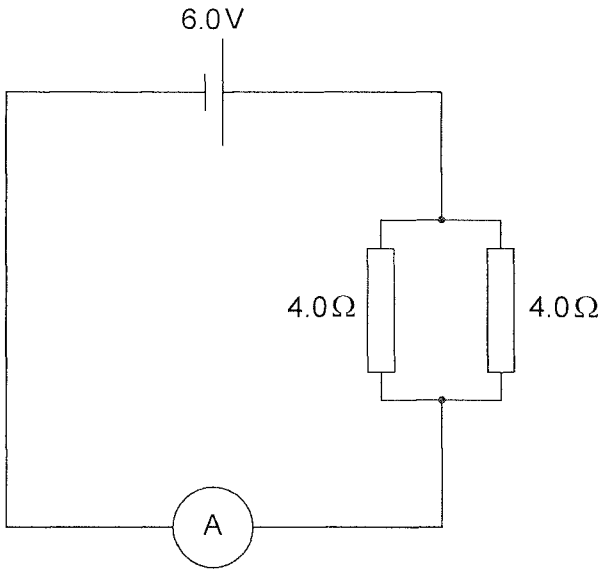
A. zero

B. 0.1 Ω

C. 10 Ω

D. infinite

20. A circuit consists of a cell of electromotive force (emf) 6.0 V and negligible internal resistance connected to two resistors of 4.0 Ω.



The resistance of the ammeter is 1.0 Ω. What is the reading of the ammeter?

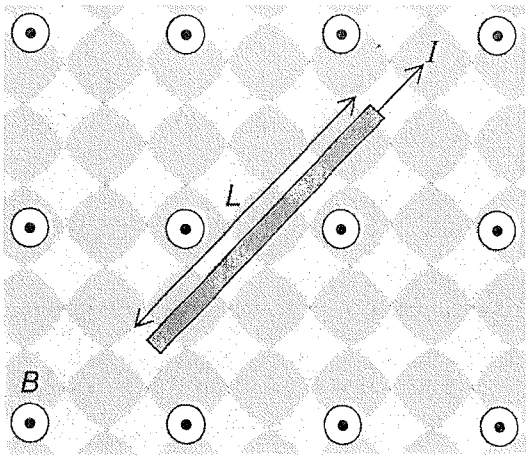
A. 2.0A

B. 3.0A

C. 4.5A

D. 6.0A

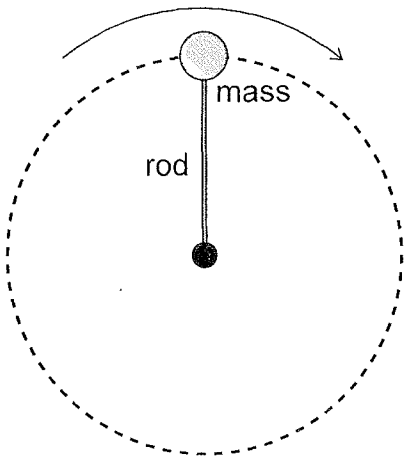
21. A wire carrying a current I is placed in a region of uniform magnetic field B, as shown in the diagram.



The direction of the field B is out of the page and the length of the wire is L. What is correct about the direction and magnitude of the force acting on the wire?

	Direction	Magnitude
A.	↘	equal to BIL
B.	↘	smaller than BIL
C.	↗	equal to BIL
D.	↗	smaller than BIL

22. A mass connected to one end of a rigid rod rotates at constant speed in a vertical plane about the other end of the rod.



The force exerted by the rod on the mass is

A. zero everywhere.

B. constant in magnitude.

C. always directed towards the centre.

D. a minimum at the top of the circular path.

23. Planet X has mass M and radius R. Planet Y has mass $2M$ and radius $3R$. The gravitational field strength at the surface of planet X is g. What is the gravitational field strength at the surface of planet Y?

A. $\frac{2}{9}g$

B. $\frac{2}{3}g$

C. $\frac{3}{2}g$

D. $\frac{9}{2}g$

24. A simple model of an atom has five energy levels. What is the maximum number of different frequencies in the emission spectrum of that atom?

A. 4

B. 6

C. 10

D. 25

25. Which of the following is the correct definition of the binding energy of a nucleus?

A. The product of the binding energy per nucleon and the nucleon number

B. The minimum work required to completely separate the nucleons from each other

C. The energy that keeps the nucleus together

D. The energy released during the emission of an alpha particle

26. Which of the following lists three fundamental forces in increasing order of strength?

A. electromagnetic, gravity, strong nuclear

B. weak nuclear, gravity, strong nuclear

C. gravity, weak nuclear, electromagnetic

D. electromagnetic, strong nuclear, gravity

27. For which reason were quarks first introduced?

A. To explain the existence of isotopes

B. To describe nuclear emission and absorption spectra

C. To account for patterns in properties of elementary particles

D. To account for the missing energy and momentum in beta decay

28. A solar panel has surface area $0.40\,m^2$ and efficiency 50 %. The average intensity of radiation reaching the surface of the panel is $0.25\,kW\,m^{-2}$. What is the average power output from an array of 10 of these solar panels?

A. 0.5 W

B. 5 W

C. 50 W

D. 500 W

29. What is the correct order of energy transformations in a coal power station?

A. thermal → chemical → kinetic → electrical

B. chemical → thermal → kinetic → electrical

C. chemical → kinetic → thermal → electrical

D. kinetic → chemical → electrical → thermal

30. A black body of surface $1.0\,m^2$ emits electromagnetic radiation of peak wavelength $2.90 \times 10^{-6}\,m$. Which of the following statements about the body are correct?

I. The temperature of the body is 1000 K.

II. The energy radiated by the body in one second is $5.7 \times 10^4\,J$.

III. The body is a perfect absorber of electromagnetic radiation.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Friday 6 May 2016 (morning)

1 hour 15 minutes

Candidate session number

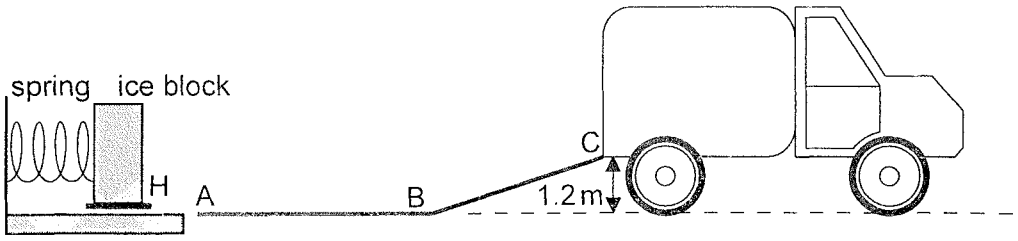
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

2216–6505

Answer **all** questions. Write your answers in the boxes provided.

1. A company designs a spring system for loading ice blocks onto a truck. The ice block is placed in a holder H in front of the spring and an electric motor compresses the spring by pushing H to the left. When the spring is released the ice block is accelerated towards a ramp ABC. When the spring is fully decompressed, the ice block loses contact with the spring at A. The mass of the ice block is 55 kg.



Assume that the surface of the ramp is frictionless and that the masses of the spring and the holder are negligible compared to the mass of the ice block.

(a) (i) The block arrives at C with a speed of $0.90\,m\,s^{-1}$. Show that the elastic energy stored in the spring is 670 J. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(ii) Calculate the speed of the block at A. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) Describe the motion of the block

(i) from A to B with reference to Newton's first law. [1]

. . . . . .

. . . . . .

(ii) from B to C with reference to Newton's second law. [2]

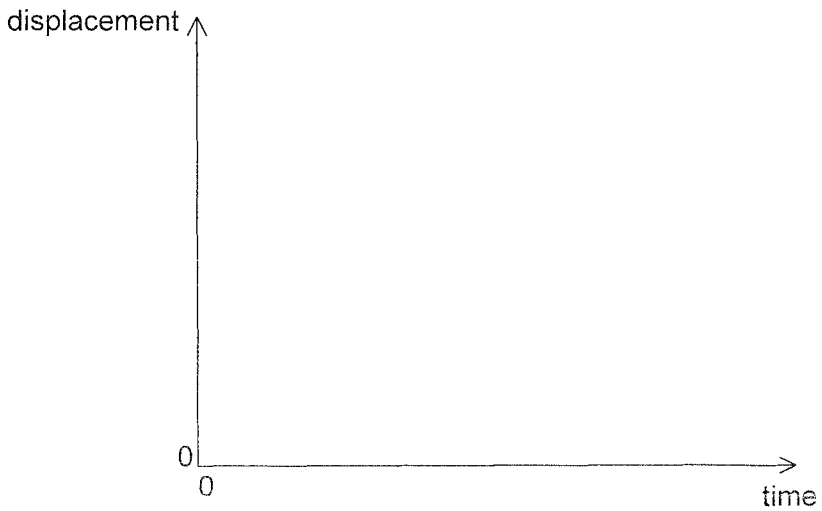
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) On the axes, sketch a graph to show how the displacement of the block varies with time from A to C. (You do not have to put numbers on the axes.) [2]



(This question continues on the following page)

(Question 1 continued)

(d) The spring decompression takes 0.42 s. Determine the average force that the spring exerts on the block. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(e) The electric motor is connected to a source of potential difference 120 V and draws a current of 6.8 A. The motor takes 1.5 s to compress the spring.

Estimate the efficiency of the motor. [2]

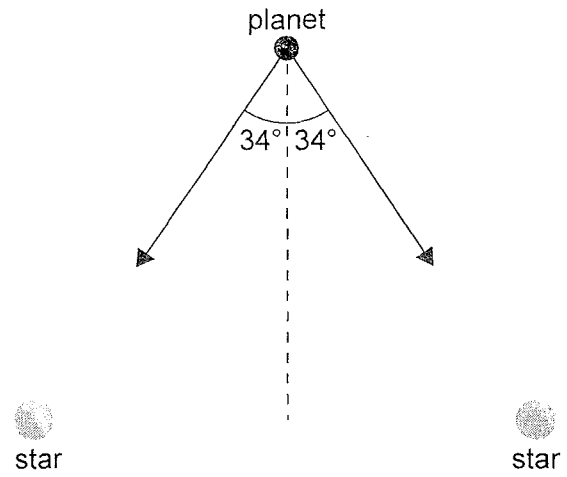
. . . . . .

. . . . . .

. . . . . .

. . . . . .

2. The two arrows in the diagram show the gravitational field strength vectors at the position of a planet due to each of two stars of equal mass M.



Each star has mass $M = 2.0 \times 10^{30}$ kg. The planet is at a distance of 6.0×10^{11} m from each star.

(a) Show that the gravitational field strength at the position of the planet due to **one** of the stars is $g = 3.7 \times 10^{-4}\,\text{N kg}^{-1}$. [1]

. . . . . .

. . . . . .

. . . . . .

(b) Calculate the magnitude of the resultant gravitational field strength at the position of the planet. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

3. In an experiment to determine the specific latent heat of fusion of ice, an ice cube is dropped into water that is contained in a well-insulated calorimeter of negligible specific heat capacity. The following data are available.

Mass of ice cube	= 25 g
Mass of water	= 350 g
Initial temperature of ice cube	= 0 °C
Initial temperature of water	= 18 °C
Final temperature of water	= 12 °C
Specific heat capacity of water	= 4200 $J kg^{-1} K^{-1}$

(a) Using the data, estimate the specific latent heat of fusion of ice. [4]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The experiment is repeated using the same mass of crushed ice.

Suggest the effect, if any, of crushing the ice on

(i) the final temperature of the water. [1]

. . . . . .

. . . . . .

(ii) the time it takes the water to reach its final temperature. [1]

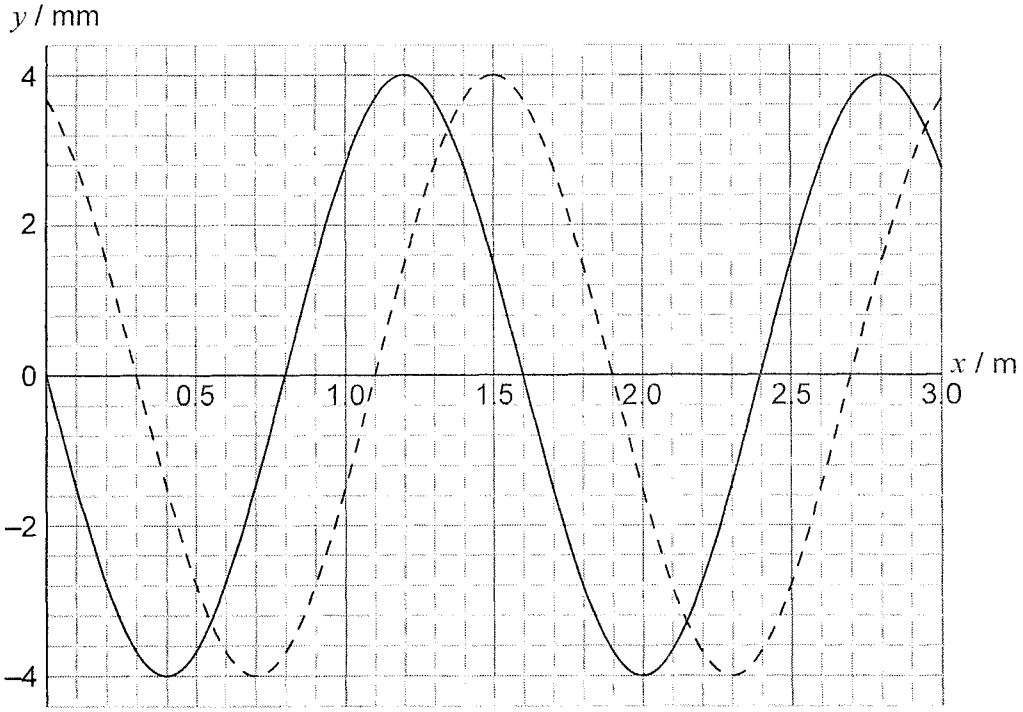
. . . . . .

. . . . . .

Please **do not** write on this page.

Answers written on this page
will not be marked.

4. A longitudinal wave is travelling in a medium from left to right. The graph shows the variation with distance x of the displacement y of the particles in the medium. The solid line and the dotted line show the displacement at $t = 0$ and $t = 0.882\,\text{ms}$, respectively.



The period of the wave is greater than 0.882 ms. A displacement to the right of the equilibrium position is positive.

(a) State what is meant by a longitudinal travelling wave. [1]

. . . . . .

. . . . . .

(b) Calculate, for this wave,

(i) the speed. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(ii) the frequency. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) The equilibrium position of a particle in the medium is at $x = 0.80\,\text{m}$. For this particle at $t = 0$, state and explain

(i) the direction of motion. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) whether the particle is at the centre of a compression or a rarefaction. [2]

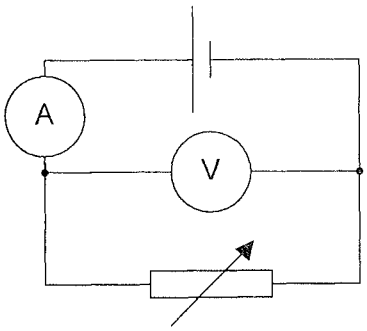
. . . . . .

. . . . . .

. . . . . .

. . . . . .

5. In an experiment a student constructs the circuit shown in the diagram. The ammeter and the voltmeter are assumed to be ideal.

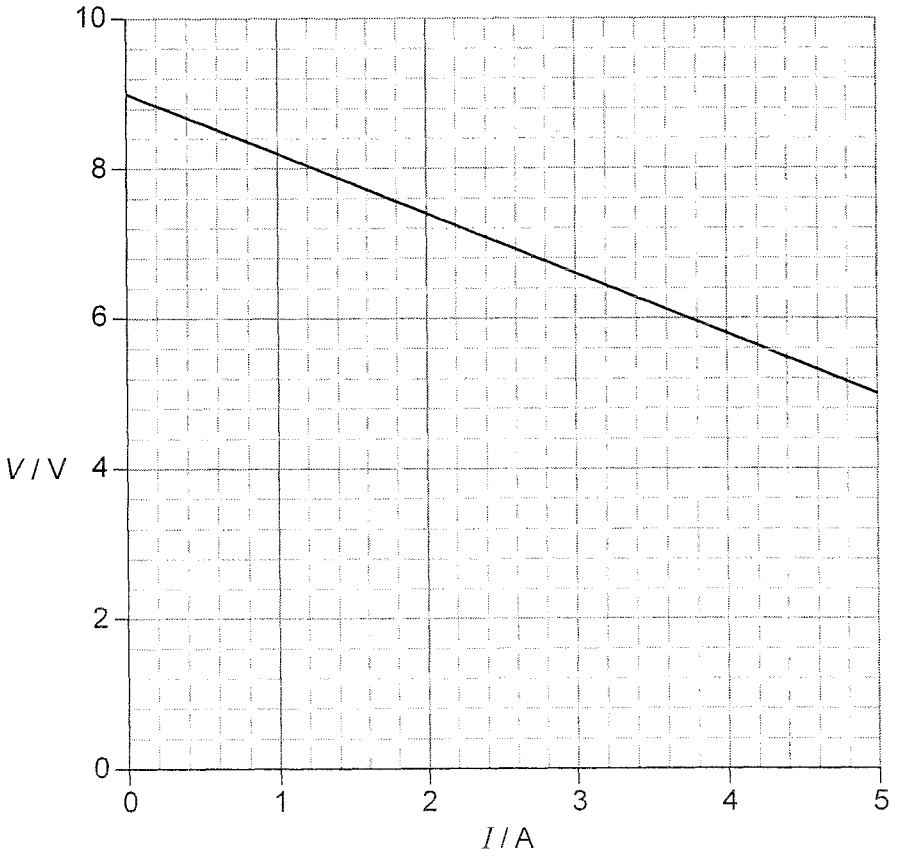


(a) State what is meant by an ideal voltmeter. [1]

. . . . . .

. . . . . .

(b) The student adjusts the variable resistor and takes readings from the ammeter and voltmeter. The graph shows the variation of the voltmeter reading V with the ammeter reading I.



(This question continues on the following page)

(Question 5 continued)

Use the graph to determine

(i) the electromotive force (emf) of the cell. [1]

. . . . . .

. . . . . .

(ii) the internal resistance of the cell. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) A connecting wire in the circuit has a radius of 1.2 mm and the current in it is 3.5 A. The number of electrons per unit volume of the wire is $2.4 \times 10^{28}\,m^{-3}$. Show that the drift speed of the electrons in the wire is $2.0 \times 10^{-4}\,m\,s^{-1}$. [1]

. . . . . .

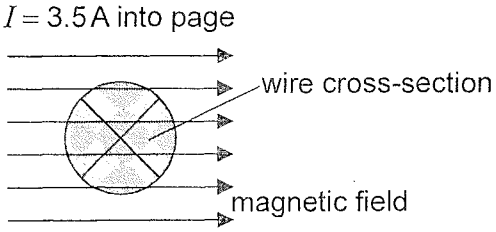
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 5 continued)

(d) The diagram shows a cross-sectional view of the connecting wire in (c).



The wire which carries a current of 3.5A into the page, is placed in a region of uniform magnetic field of flux density 0.25T. The field is directed at right angles to the wire.

Determine the magnitude **and** direction of the magnetic force on one of the charge carriers in the wire. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

6. (a) A nucleus of phosphorus-32 $\left({}^{32}_{15}\mathrm{P}\right)$ decays by beta minus (β^-) decay into a nucleus of sulfur-32 $\left({}^{32}_{16}\mathrm{S}\right)$. The binding energy per nucleon of ${}^{32}_{15}\mathrm{P}$ is 8.398 MeV and for ${}^{32}_{16}\mathrm{S}$ it is 8.450 MeV.

Determine the energy released in this decay. [2]

. . . . . .

. . . . . .

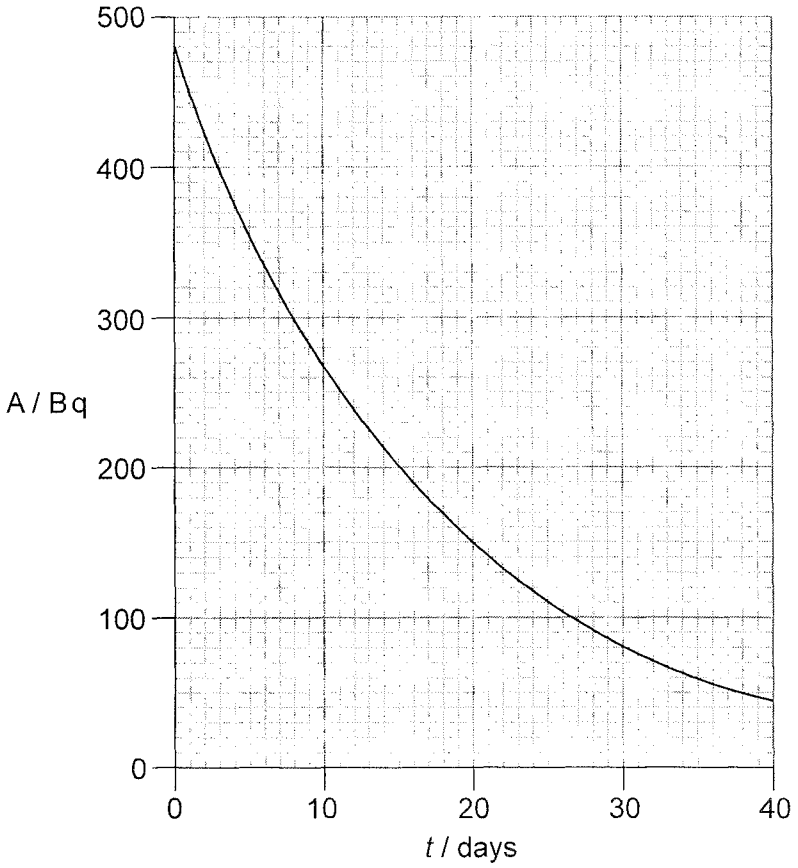
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 6 continued)

(b) The graph shows the variation with time t of the activity A of a sample containing phosphorus-32 $\left({}^{32}_{15}\mathrm{P}\right)$.



Determine the half-life of ${}^{32}_{15}\mathrm{P}$. [1]

. . . . . .

. . . . . .

(c) Quarks were hypothesized long before their existence was experimentally verified. Discuss the reasons why physicists developed a theory that involved quarks. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

7. The Sun has a radius of 7.0×10^8 m and is a distance 1.5×10^{11} m from Earth. The surface temperature of the Sun is 5800 K.

(a) Show that the intensity of the solar radiation incident on the upper atmosphere of the Earth is approximately $1400\,\text{W m}^{-2}$. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The albedo of the atmosphere is 0.30. Deduce that the average intensity over the entire surface of the Earth is $245\,\text{W m}^{-2}$. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Estimate the average surface temperature of the Earth. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Physics
Standard level
Paper 3

Monday 9 May 2016 (morning)

1 hour

Candidate session number

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer all of the questions from one of the options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

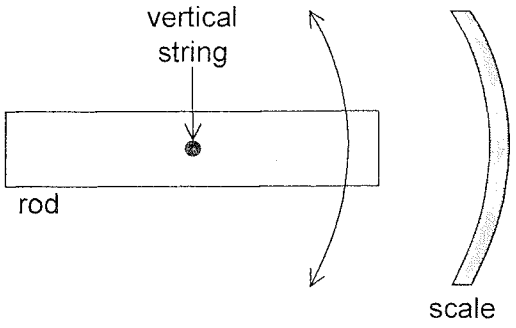
Option	Questions
Option A — Relativity	3 – 6
Option B — Engineering physics	7 – 8
Option C — Imaging	9 – 11
Option D — Astrophysics	12 – 14

2216 – 6506

Section A

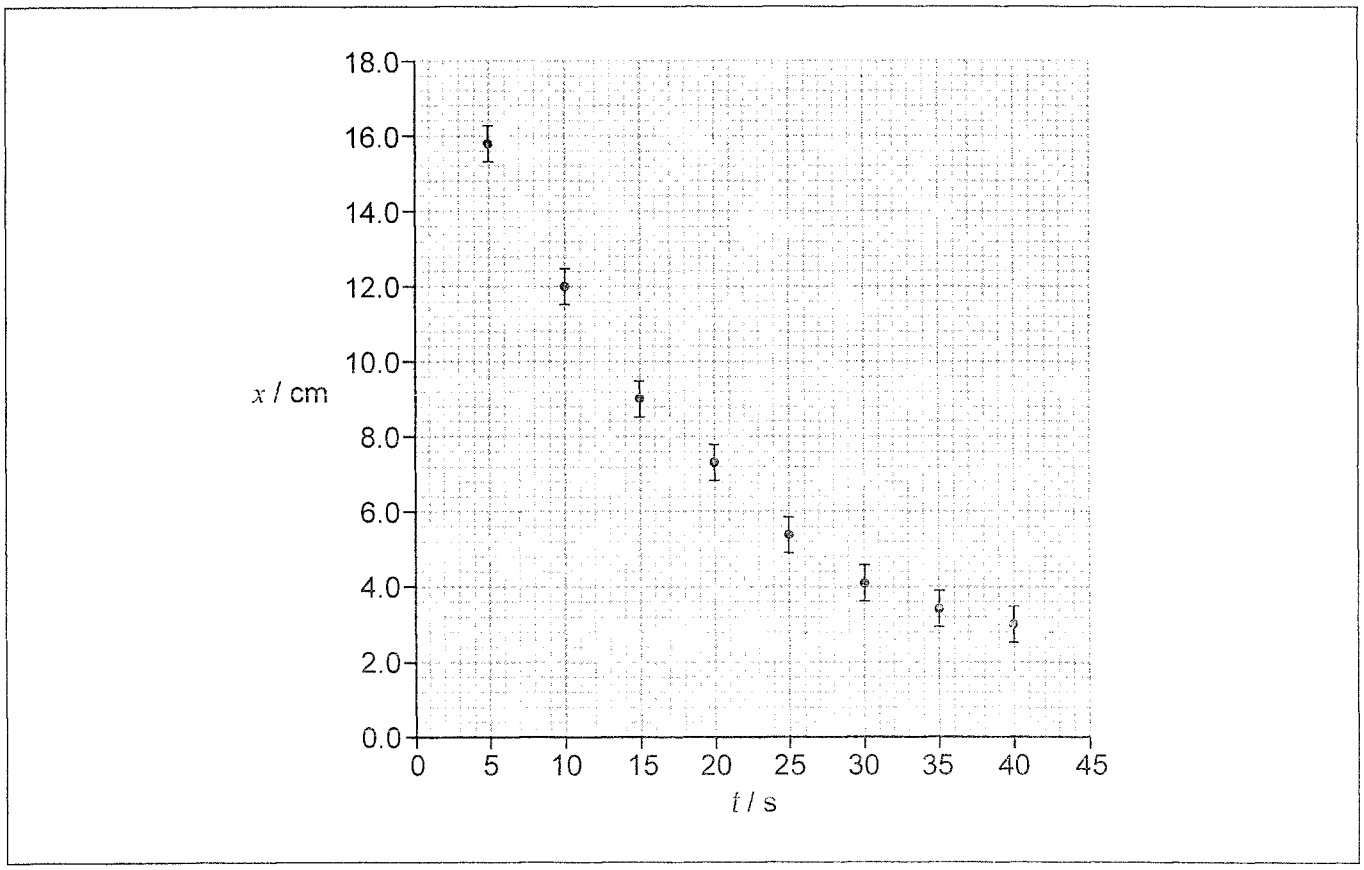
Answer **all** questions. Write your answers in the boxes provided.

1. A student investigates the oscillation of a horizontal rod hanging at the end of a vertical string. The diagram shows the view from above.



The student starts the rod oscillating and measures the largest displacement for each cycle of the oscillation on the scale and the time at which it occurs. The student begins to take measurements a few seconds after releasing the rod.

The graph shows the variation of displacement x with time t since the release of the rod. The uncertainty for t is negligible.



(a) On the graph above, draw the line of best fit for the data. [1]

(This question continues on the following page)

(Question 1 continued)

(b) Calculate the percentage uncertainty for the displacement when $t = 40\,\text{s}$. [2]

. . . . . .

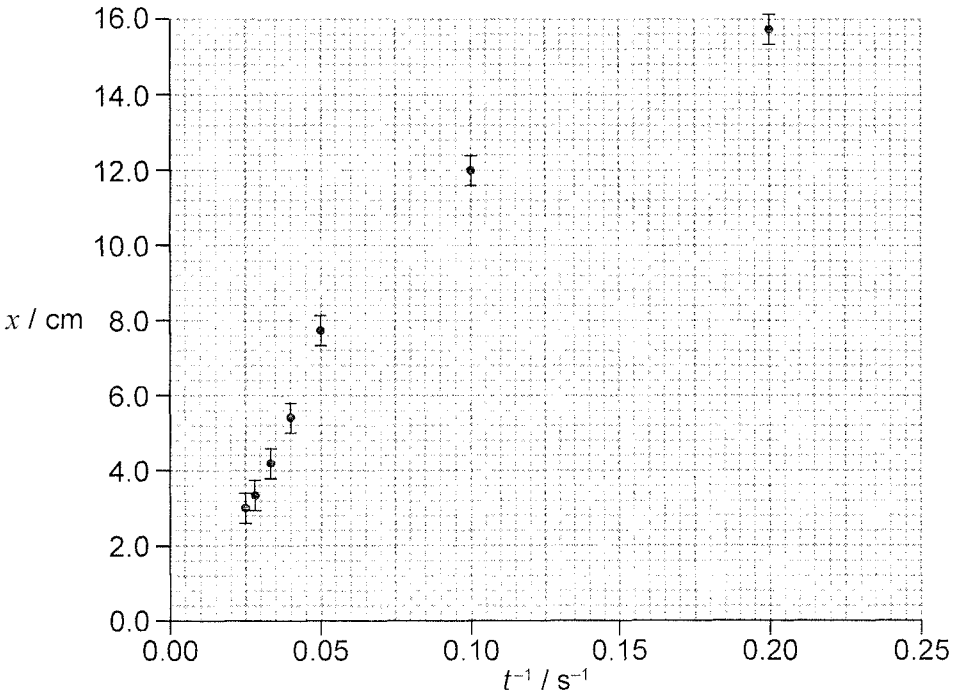
. . . . . .

. . . . . .

. . . . . .

(c) The student hypothesizes that the relationship between x and t is $x = \frac{a}{t}$ where a is a constant.

To test the hypothesis x is plotted against $\frac{1}{t}$ as shown in the graph.



(i) The data point corresponding to $t = 15\,\text{s}$ has not been plotted. Plot this point on the graph above. [1]

(ii) Suggest the range of values of t for which the hypothesis may be assumed to be correct. [2]

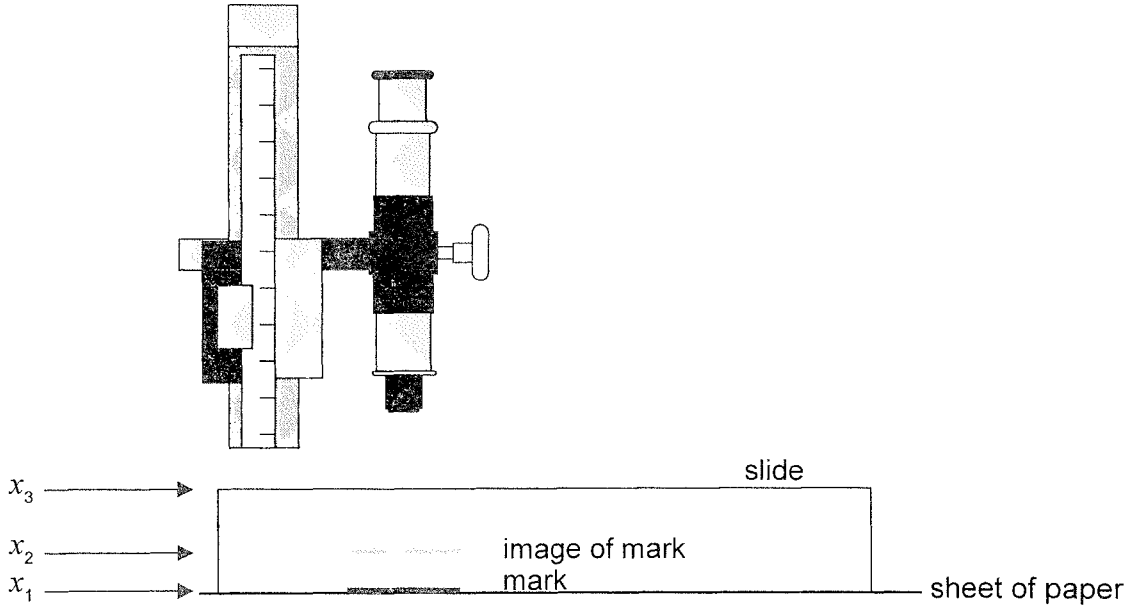
. . . . . .

. . . . . .

. . . . . .

2. A student measures the refractive index of the glass of a microscope slide.

He uses a travelling microscope to determine the position x_1 of a mark on a sheet of paper. He then places the slide over the mark and finds the position x_2 of the image of the mark when viewed through the slide. Finally, he uses the microscope to determine the position x_3 of the top of the slide.



The table shows the average results of a large number of repeated measurements.

	Average position of mark / mm
x_1	0.20 ±0.02
x_2	0.59 ±0.02
x_3	1.35 ±0.02

(a) The refractive index of the glass from which the slide is made is given by

$$\frac{x_3 - x_1}{x_3 - x_2}.$$

Determine

(i) the refractive index of the glass to the correct number of significant figures, ignoring any uncertainty. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(ii) the uncertainty of the value calculated in (a)(i). [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) After the experiment, the student finds that the travelling microscope is badly adjusted so that the measurement of each position is too large by 0.05 mm.

(i) State the name of this type of error. [1]

. . . . . .

(ii) Outline the effect that the error in (b)(i) will have on the calculated value of the refractive index of the glass. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(c) After correcting the adjustment of the travelling microscope, the student repeats the experiment using a glass block 10 times thicker than the original microscope slide. Explain the change, if any, to the calculated result for the refractive index and its uncertainty. [2]

. . . . . .

. . . . . .

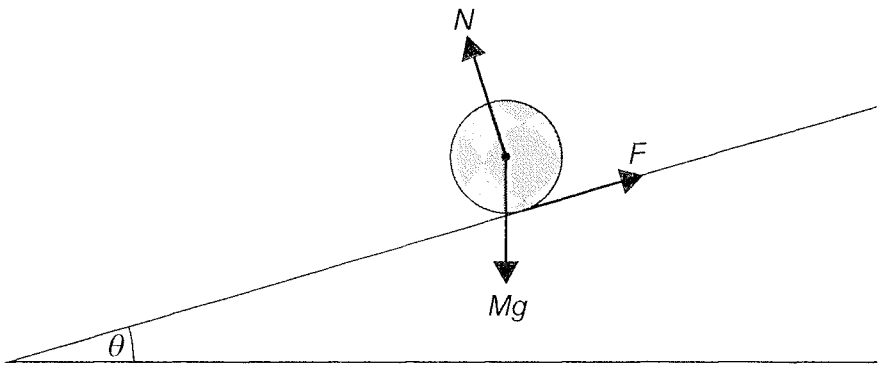
. . . . . .

. . . . . .

. . . . . .

Option B — Engineering physics

7. A solid cylinder of mass M and radius R rolls without slipping down a uniform slope. The slope makes an angle θ to the horizontal.



The diagram shows the three forces acting on the cylinder. N is the normal reaction force and F is the frictional force between the cylinder and the slope.

(a) State why F is the only force providing a torque about the axis of the cylinder. [1]

. . . . . .

. . . . . .

(b) (i) The moment of inertia of a cylinder about its axis is $I = \frac{1}{2}MR^2$. Show that, by applying Newton's laws of motion, the linear acceleration of the cylinder is $a = \frac{2}{3}g\sin\theta$. [4]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 7 continued)

(ii) Calculate, for $\theta = 30°$, the time it takes for the solid cylinder to travel 1.5 m along the slope. The cylinder starts from rest. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) A block of ice is placed on the slope beside the solid cylinder and both are released at the same time. The block of ice is the same mass as the solid cylinder and slides without friction.

At any given point on the slope, the speed of the block of ice is greater than the speed of the solid cylinder. Outline why, using the answer to (b)(i). [1]

. . . . . .

. . . . . .

. . . . . .

(d) The solid cylinder is replaced by a hollow cylinder of the same mass and radius. Suggest how this change will affect, if at all, the acceleration in (b)(i). [2]

. . . . . .

. . . . . .

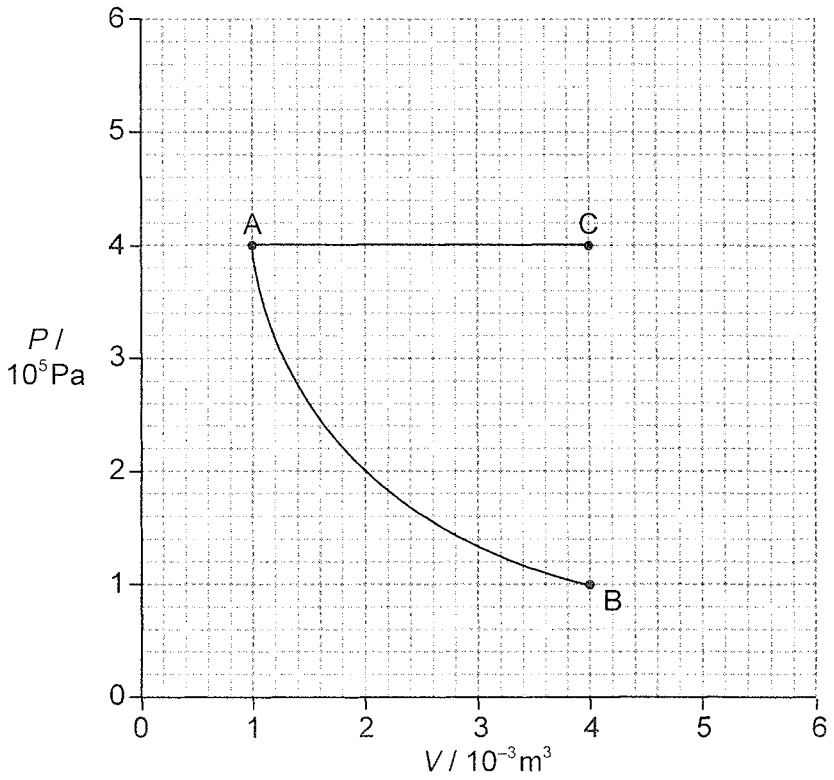
. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

8. A fixed mass of an ideal monatomic gas undergoes an isothermal change from A to B as shown.



The temperature at A is 350 K. An identical mass of the same ideal monatomic gas undergoes an isobaric change from A to C.

(a) (i) Calculate the temperature at C. [1]

. . . . . .

. . . . . .

(ii) Calculate the change in internal energy for AC. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 8 continued)

(iii) Determine the energy supplied to the gas during the change AC. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iv) On the graph, draw a line to represent an adiabatic expansion from A to a state of volume $4.0 \times 10^{-3}\,m^3$ (point D). [1]

(b) (i) State the change in entropy of a gas for the adiabatic expansion from A to D. [1]

. . . . . .

. . . . . .

(ii) Explain, with reference to the concept of disorder, why the entropy of the gas is greater at C than B. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

End of Option B

1. The best estimate for the time it takes light to cross the nucleus of the hydrogen atom is

   A. 10^{-23} s.

   B. 10^{-20} s.

   C. 10^{-15} s.

   D. 10^{-7} s.

2. The length of each side of a sugar cube is measured as 10 mm with an uncertainty of ± 2 mm. Which of the following is the absolute uncertainty in the volume of the sugar cube?

   A. $\pm 6\,\text{mm}^3$

   B. $\pm 8\,\text{mm}^3$

   C. $\pm 400\,\text{mm}^3$

   D. $\pm 600\,\text{mm}^3$

3. The time taken for a stone dropped from rest to fall vertically through 16 m is 2.0 s. Based on these measurements, what is the best estimate for the acceleration of free fall?

   A. $4.0\,\text{m s}^{-2}$

   B. $8.0\,\text{m s}^{-2}$

   C. $9.8\,\text{m s}^{-2}$

   D. $10\,\text{m s}^{-2}$

4. A wooden block is sliding down an inclined plane at constant speed. The magnitude of the frictional force between the block and the plane is equal to

   A. zero.

   B. the magnitude of the weight of the block.

   C. the magnitude of the component of weight of the block parallel to the plane.

   D. the magnitude of the component of the normal reaction parallel to the plane.

5. Which of the following is a correct statement of Newton's second law of motion?

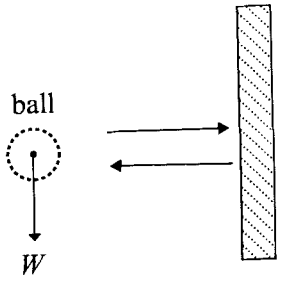
A. A force acting on a body is proportional to the mass of the body.

B. The rate of change of momentum of a body is equal to the net external force acting on the body.

C. The momentum of a body is proportional to the net external force acting on the body.

D. A force acting on a body is proportional to the acceleration of the body.

6. A ball of weight W is travelling horizontally towards a vertical wall. It strikes the wall and rebounds horizontally. The change in the magnitude of the momentum of the ball is Δp. Which of the following is the magnitude of the impulse that the ball imparts to the wall?



A. $W + \Delta p$

B. $W - \Delta p$

C. W

D. Δp

7. Two objects undergo an inelastic collision. Which of the following is correct in respect of both the conservation of momentum and the conservation of total energy of the system?

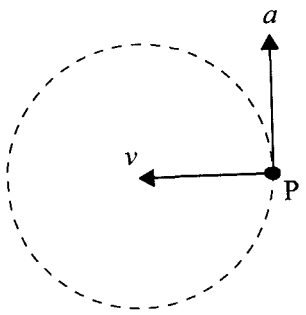
	Momentum	Total energy
A.	conserved	not conserved
B.	conserved	conserved
C.	not conserved	not conserved
D.	not conserved	conserved

Turn over

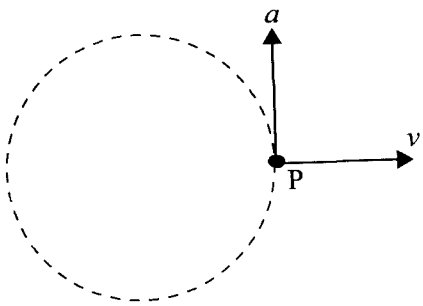
8. A particle P is moving anti-clockwise with constant speed in a horizontal circle.

Which diagram correctly shows the direction of the velocity v and acceleration a of the particle P in the position shown?

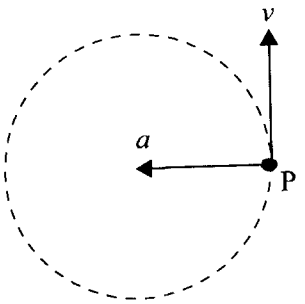
A.



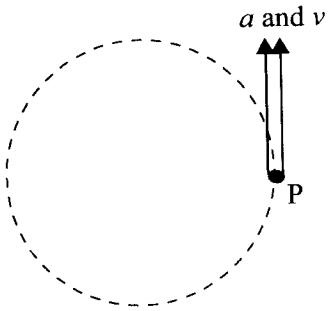
B.



C.



D.



9. Two objects are in thermal contact with each other. Which of the following will determine the direction of the transfer of thermal energy between the bodies?

A. The mass of each body

B. The area of contact between the bodies

C. The specific heat capacity of each body

D. The temperature of each body

10. The mole is defined as

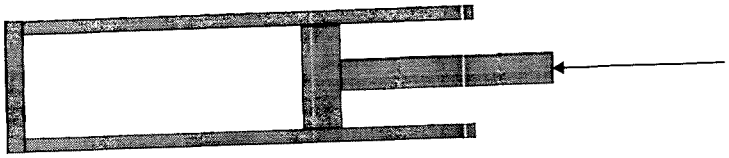
A. $\frac{1}{12}$ the mass of an atom of the isotope carbon-12.

B. the amount of a substance that contains as many elementary entities as the number of atoms in 12 g of the isotope carbon-12.

C. the mass of one atom of the isotope carbon-12.

D. the amount of a substance that contains as many nuclei as the number of nuclei in 12 g of the isotope carbon-12.

11. A gas is contained in a cylinder by a piston.



The gas is compressed rapidly by moving the piston in the direction shown. The best explanation for the resulting increase in temperature of the gas is that the molecules of the gas gain kinetic energy

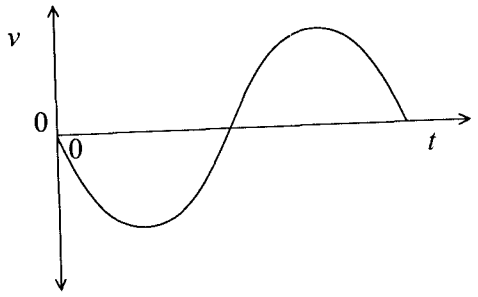
A. from the moving piston.

B. by colliding more frequently with each other.

C. by being pushed closer together.

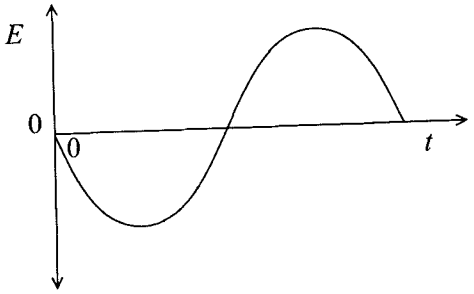
D. by colliding more frequently with the walls of the cylinder.

12. The graph shows how the velocity v of an object undergoing simple harmonic motion varies with time t for one complete period of oscillation.

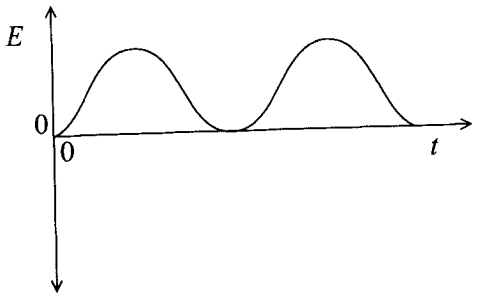


Which of the following sketch graphs best shows how the total energy E of the object varies with t?

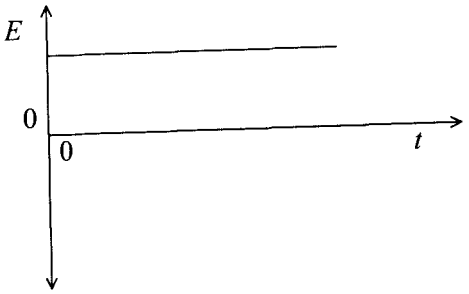
A.



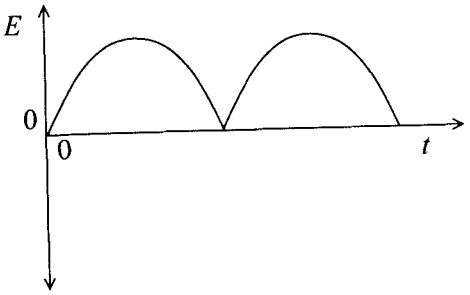
B.



C.



D.



13. A force that varies sinusoidally is applied to a system that is lightly damped. Which of the following must be true of the force for resonance to occur?

A. It must always be in anti-phase with the oscillations of the system.

B. Its direction must always be in the direction of motion of the oscillations of the system.

C. Its frequency must be equal to the frequency of oscillation of the system.

D. Its amplitude must be equal to the amplitude of oscillation of the system.

14. Which of the following is a value of wavelength that is found in the visible region of the electromagnetic spectrum?

A. 4×10^{-5} m

B. 4×10^{-7} m

C. 4×10^{-9} m

D. 4×10^{-11} m

15. Two waves meet at a point in space. Which of the following properties always add together?

A. Displacement

B. Amplitude

C. Speed

D. Frequency

16. A point charge of magnitude $2.0\,\mu C$ is moved between two points X and Y. Point X is at a potential of $+6.0\,V$ and point Y is at a potential of $+9.0\,V$. The gain in potential energy of the point charge is

A. $0.20\,\mu J$.

B. $1.5\,\mu J$.

C. $6.0\,\mu J$.

D. $30\,\mu J$.

17. A resistor of resistance $12\,\Omega$ is connected in series with a cell of negligible internal resistance. The power dissipated in the resistor is P. The resistor is replaced with a resistor of resistance $3.0\,\Omega$. What is the power dissipated in this resistor?

A. $0.25P$

B. P

C. $2.0P$

D. $4.0P$

18. The electromotive force (emf) of a cell is defined as

A. the power supplied by the cell per unit current from the cell.

B. the force that the cell provides to drive electrons round a circuit.

C. the energy supplied by the cell per unit current from the cell.

D. the potential difference across the terminals of the cell.

19. The weight of an object of mass 1 kg at the surface of Mars is about 4 N. The radius of Mars is about half the radius of Earth. Which of the following is the best estimate of the ratio below?

$$\frac{\text{mass of Mars}}{\text{mass of Earth}}$$

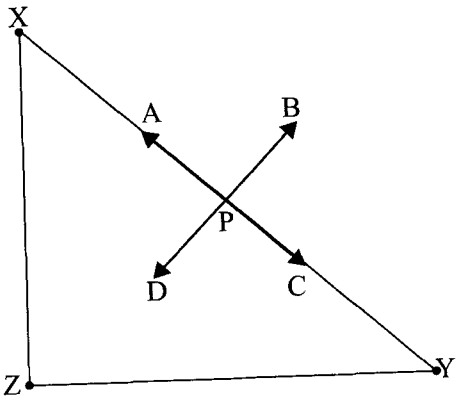
A. 0.1

B. 0.2

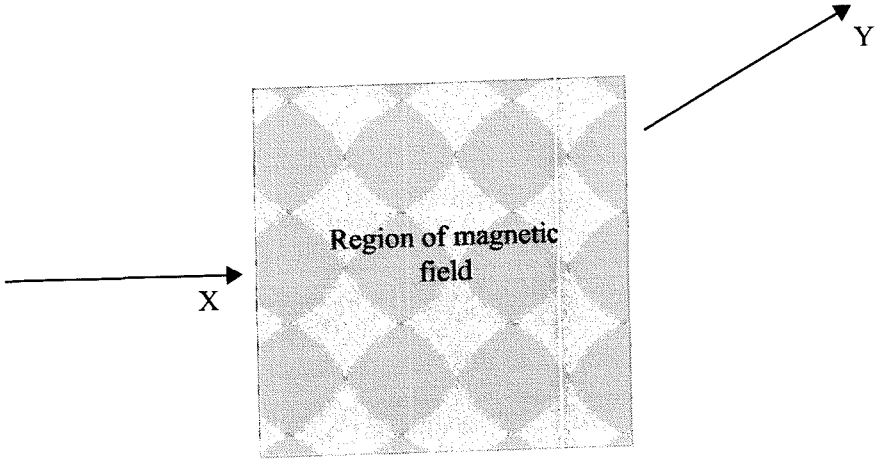
C. 5

D. 10

20. Three positive point charges of equal magnitude are held at the corners X, Y and Z of a right-angled triangle. The point P is at the midpoint of XY. Which of the arrows shows the direction of the electric field at point P?



21. An electron travelling in the direction shown by the arrow X, enters a region of uniform magnetic field. It leaves the region of field in the direction shown by the arrow Y.



The direction of the magnetic field is

A. in the direction of X.

B. into the plane of the paper.

C. in the opposite direction to X.

D. out of the plane of the paper.

22. Emission and absorption spectra provide evidence for

A. the nuclear model of the atom.

B. natural radioactivity.

C. the existence of isotopes.

D. the existence of atomic energy levels.

23. Which of the following is true in respect of both the Coulomb interaction and the strong interaction between nucleons in an atom?

	Coulomb interaction exists between	**Strong interaction exists between**
A.	protons only	neutrons only
B.	both protons and neutrons	neutrons only
C.	protons only	both protons and neutrons
D.	both protons and neutrons	both protons and neutrons

24. Which of the following correctly identifies the three particles emitted in the decay of the nucleus ${}^{45}_{20}\text{Ca}$ into a nucleus of ${}^{45}_{21}\text{Sc}$?

A. α, β^-, γ

B. $\beta^-, \gamma, \bar{\nu}$

C. $\alpha, \gamma, \bar{\nu}$

D. $\alpha, \beta^-, \bar{\nu}$

25. The nuclear reaction

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$$

is an example of

A. nuclear fission.

B. radioactive decay.

C. nuclear fusion.

D. artificial transmutation.

26. Degraded energy is energy that is

A. stored in the Earth's atmosphere.

B. available from non-renewable energy sources.

C. converted into work in a cyclical process.

D. no longer available for the performance of useful work.

27. Which of the following correctly describes both the role of the moderator and of the control rods in a nuclear reactor?

	Moderator	Control rods
A.	slows down the neutrons	maintain a constant rate of fission
B.	cools down the reactor	extract thermal energy
C.	cools down the reactor	maintain a constant rate of fission
D.	slows down the neutrons	extract thermal energy

28. Which of the following correctly shows the energy change in a photovoltaic cell and in a solar heating panel?

	Photovoltaic cell	Solar heating panel
A.	solar → electrical	solar → thermal
B.	electrical → thermal	solar → electrical
C.	solar → electrical	electrical → thermal
D.	electrical → thermal	solar → thermal

29. The albedo for the oceans is lower than that for glaciers. This is because, compared to ice, sea water

A. has a greater density.

B. has a greater specific heat capacity.

C. has a greater coefficient of volume expansion.

D. absorbs a greater amount of radiative power.

30. Which of the following is most likely to reduce the enhanced greenhouse effect?

A. Replace the use of gas powered stations with oil powered stations

B. Replace coal-fired power stations with nuclear power stations

C. Increase the use of all non-renewable energy sources

D. Decrease the efficiency of power production

1. Which of the following contains one fundamental and one derived unit?

A.	ampere	kilogram
B.	ampere	coulomb
C.	joule	newton
D.	joule	coulomb

2. The current I through a resistor is measured with a digital ammeter to be 0.10 A. The uncertainty in the calculated value of I^2 will be

A. 1%.

B. 2%.

C. 5%.

D. 20%.

3. A skydiver of mass 80 kg falls vertically with a constant speed of $50\,m\,s^{-1}$. The upward force acting on the skydiver is approximately

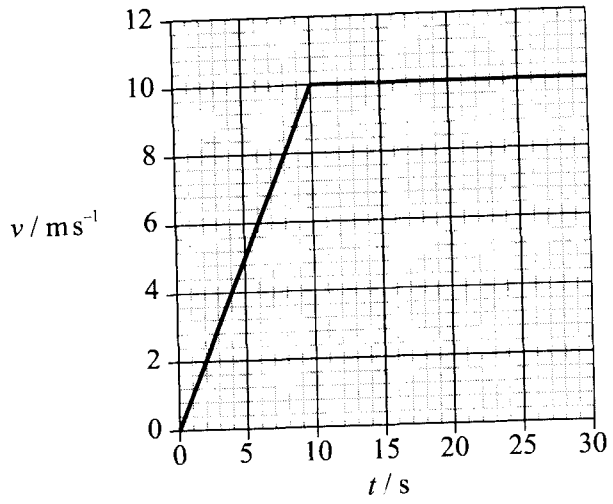
A. 0 N.

B. 80 N.

C. 800 N.

D. 4000 N.

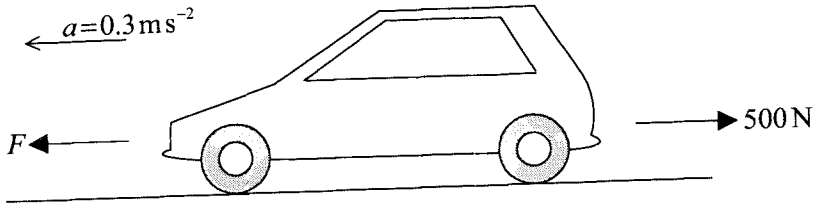
4. Joseph runs along a long straight track. The variation of his speed v with time t is shown below.



After 25 seconds Joseph has run 200 m. Which of the following is correct at 25 seconds?

	Instantaneous speed / ms^{-1}	Average speed / ms^{-1}
A.	$8 ms^{-1}$	$8 ms^{-1}$
B.	$8 ms^{-1}$	$10 ms^{-1}$
C.	$10 ms^{-1}$	$8 ms^{-1}$
D.	$10 ms^{-1}$	$10 ms^{-1}$

5. A car of mass 1000 kg accelerates on a straight, flat, horizontal road with an acceleration $a = 0.3\,\text{m s}^{-2}$. The driving force F on the car is opposed by a resistive force of 500 N.



The net (resultant) force on the car is

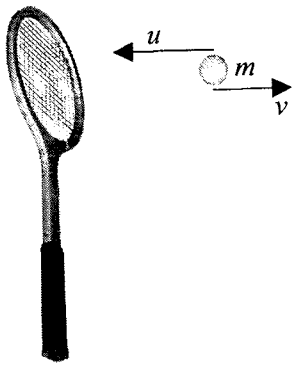
A. 200 N.

B. 300 N.

C. 500 N.

D. 800 N.

6. A tennis ball of mass m moving horizontally with speed u strikes a vertical tennis racket. The ball bounces back with a horizontal speed v.



The magnitude of the change in momentum of the ball is

A. $m(u+v)$.

B. $m(u-v)$.

C. $m(v-u)$.

D. zero.

7. A brother and sister take the same time to run up a set of steps. The sister has a greater mass than her brother. Which of the following is correct?

	Has done the most work	Has developed the greatest power
A.	brother	brother
B.	brother	sister
C.	sister	brother
D.	sister	sister

8. A nuclear power station produces 10 GW of electrical power. The power generated by the nuclear reactions in the core of the reactor is 25 GW. The efficiency of the power station is

A. 15%.

B. 35%.

C. 40%.

D. 60%.

9. A cyclist rides around a circular track at a uniform speed. Which of the following correctly gives the net horizontal force on the cyclist at any given instant of time?

	Net horizontal force along direction of motion	Net horizontal force normal to direction of motion
A.	zero	zero
B.	zero	non zero
C.	non zero	zero
D.	non zero	non zero

10. A solid piece of tungsten melts into liquid without a change in temperature. Which of the following is correct for the molecules in the liquid phase compared with the molecules in the solid phase?

	Kinetic energy	Potential energy
A.	same	greater
B.	same	same
C.	greater	greater
D.	greater	same

11. What is the mass of carbon-12 that contains the same number of atoms as 14 g of silicon-28?

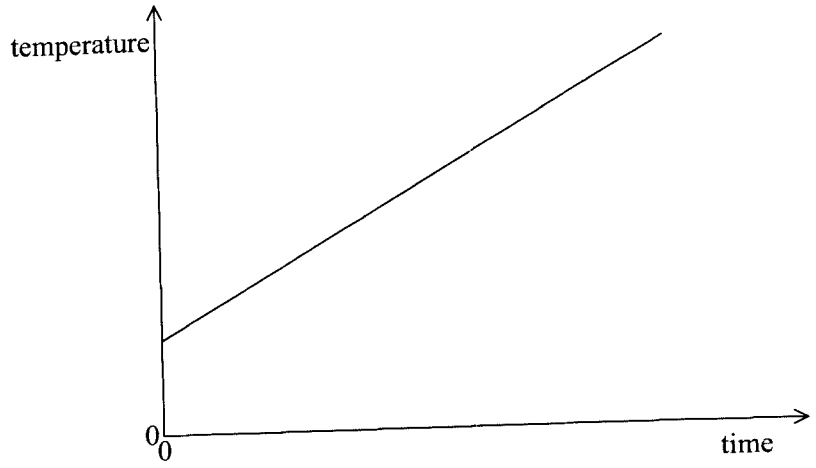
A. 6 g

B. 12 g

C. 14 g

D. 24 g

12. A heater of constant power heats a liquid of mass m and specific heat capacity c. The graph below shows how the temperature of the liquid varies with time.



The gradient of the graph is k and no energy is lost to the surroundings. What is the power of the heater?

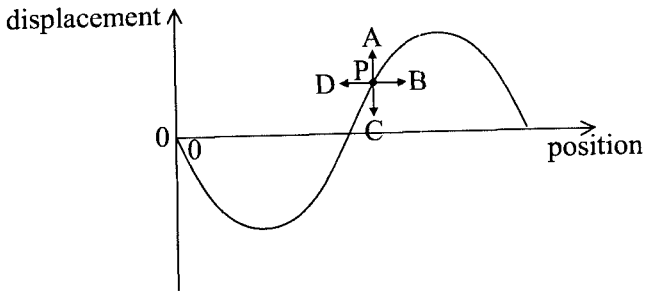
A. kmc

B. $\frac{k}{mc}$

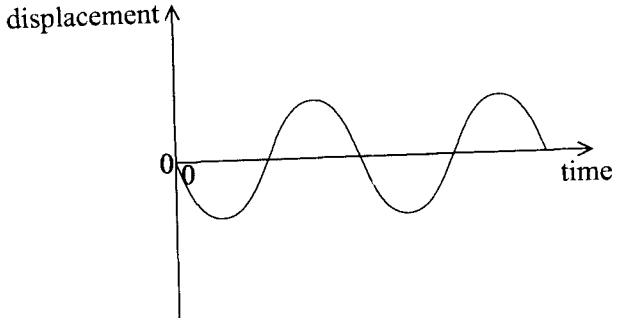
C. $\frac{mc}{k}$

D. $\frac{1}{kmc}$

13. A transverse wave travels from left to right. The diagram below shows how, at a particular instant of time, the displacement of particles in the medium varies with position. Which arrow represents the direction of the velocity of the particle marked P?

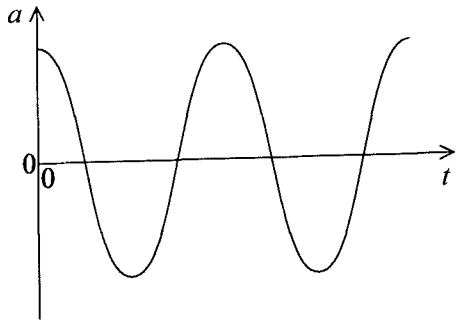


14. The graph shows how the displacement varies with time for an object undergoing simple harmonic motion.

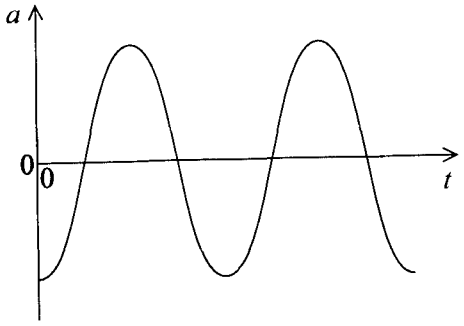


Which graph shows how the object's acceleration a varies with time t?

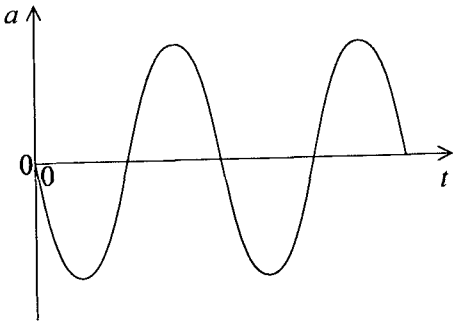
A.



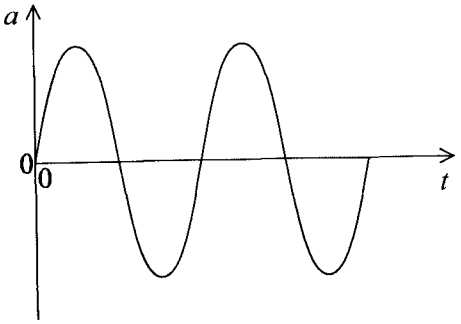
B.



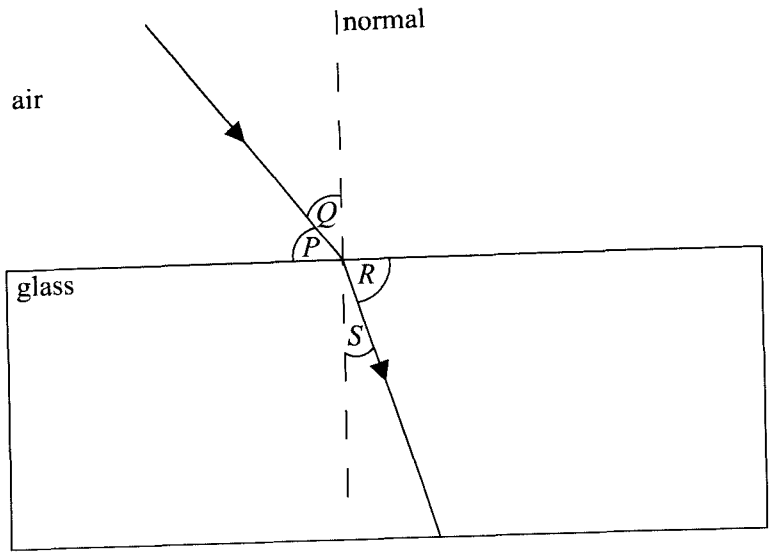
C.



D.



15. Light travels from air into glass as shown below.



What is the refractive index of glass?

A. $\frac{\sin P}{\sin S}$

B. $\frac{\sin Q}{\sin R}$

C. $\frac{\sin P}{\sin R}$

D. $\frac{\sin Q}{\sin S}$

16. Which of the following electromagnetic waves has a frequency **greater** than that of visible light?

A. Ultraviolet

B. Radio

C. Microwaves

D. Infrared

17. One electronvolt is equal to

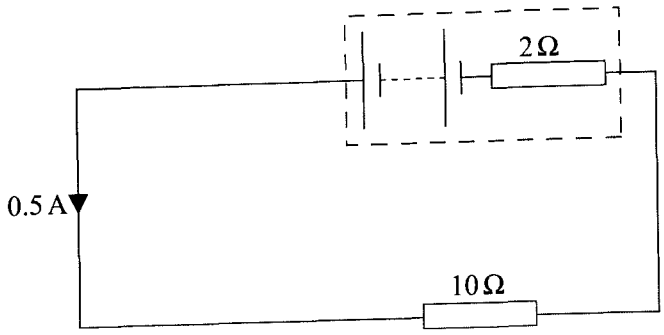
A. 1.6×10^{-19} C.

B. 1.6×10^{-19} J.

C. 1.6×10^{-19} V.

D. 1.6×10^{-19} W.

18. A battery of internal resistance 2 Ω is connected to an external resistance of 10 Ω. The current is 0.5 A.



What is the emf of the battery?

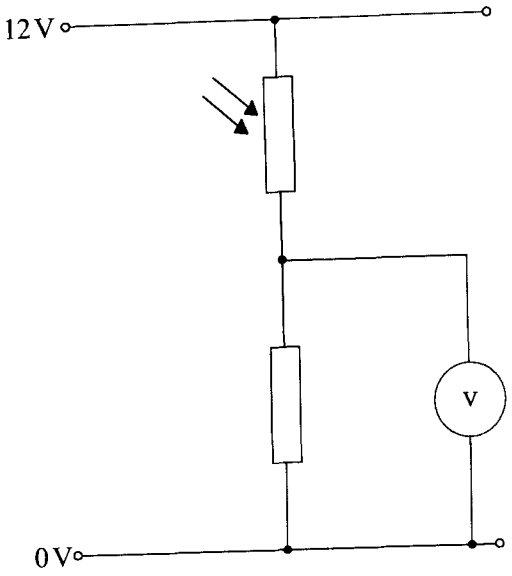
A. 1.0 V

B. 5.0 V

C. 6.0 V

D. 24.0 V

19. In the circuit below, which of the following will cause the greatest increase in the reading of the voltmeter?



A. An increase in temperature

B. An increase in light intensity

C. A decrease in temperature

D. A decrease in light intensity

20. A spherical planet of uniform density has three times the mass of the Earth and twice the average radius. The magnitude of the gravitational field strength at the surface of the Earth is g. What is the gravitational field strength at the surface of the planet?

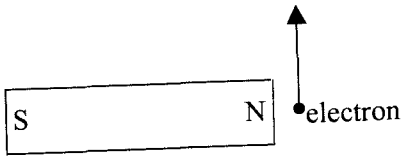
A. $6g$

B. $\frac{2}{3}g$

C. $\frac{3}{4}g$

D. $\frac{3}{2}g$

21. An electron passes the north pole of a bar magnet as shown below.



What is the direction of the magnetic force on the electron?

A. Into the page

B. Out of the page

C. To the left

D. To the right

22. Which of the following gives the correct number of protons and neutrons in a nucleus of carbon-14 $\left({}^{14}_{6}\mathrm{C}\right)$.

	Protons	Neutrons
A.	8	6
B.	6	8
C.	14	6
D.	6	14

23. A freshly prepared sample contains 4.0μg of iodine-131. After 24 days, 0.5μg of iodine-131 remain. The best estimate of the half-life of iodine-131 is

A. 8 days.

B. 12 days.

C. 24 days.

D. 72 days.

24. Which of the following causes the greatest number of ionizations as it passes through 1 cm of air? (The total energy of the ionizing radiation is the same.)

A. An alpha particle

B. A beta particle

C. A gamma-ray

D. An X-ray

25. What is the phenomenon that best explains why greenhouse gases absorb infrared radiation?

A. Resonance

B. Interference

C. Refraction

D. Diffraction

26. In which of the following places will the albedo be greatest?

A. A forest

B. A grassland

C. An ocean

D. A polar ice cap

27. A wind turbine produces a power P when the wind speed is v. Assuming that the efficiency of the turbine is constant, the best estimate for the power produced when the wind speed becomes $2v$ is

A. $2P$.

B. $4P$.

C. $6P$.

D. $8P$.

28. A spherical black body has absolute temperature T_1. The surroundings are kept at a lower absolute temperature T_2. What is the net power per unit area lost by the body?

A. σT_1^4

B. σT_2^4

C. $\sigma\left(T_1^4 - T_2^4\right)$

D. $\sigma\left(T_1^4 + T_2^4\right)$

29. The design of a nuclear power station includes an electrical generator. The function of the generator is to convert

A. nuclear energy to kinetic energy.

B. kinetic energy to thermal energy.

C. thermal energy to electrical energy.

D. kinetic energy to electrical energy.

30. What is the unit of surface heat capacity?

A. $\mathrm{J\,kg^{-1}K^{-1}}$

B. $\mathrm{JK^{-1}}$

C. $\mathrm{Jm^{-2}K^{-1}}$

D. $\mathrm{Jm^{-3}K^{-1}}$