



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

PHYSICS

9702/11

Paper 1 Multiple Choice

May/June 2012

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.

This document consists of **24** printed pages.



Data

speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion,

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

work done on/by a gas,

$$W = p\Delta V$$

gravitational potential,

$$\phi = -\frac{Gm}{r}$$

hydrostatic pressure,

$$p = \rho gh$$

pressure of an ideal gas,

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

simple harmonic motion,

$$a = -\omega^2 x$$

velocity of particle in s.h.m.,

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{x_0^2 - x^2}$$

electric potential,

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

capacitors in series,

$$1/C = 1/C_1 + 1/C_2 + \dots$$

capacitors in parallel,

$$C = C_1 + C_2 + \dots$$

energy of charged capacitor,

$$W = \frac{1}{2}QV$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

alternating current/voltage,

$$x = x_0 \sin \omega t$$

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

decay constant,

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

- 1 When a force F moves its point of application through a displacement s in the direction of the force, the work W done by the force is given by

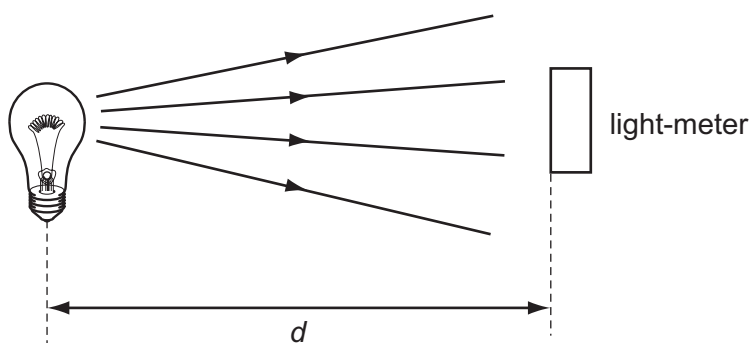
$$W = Fs.$$

How many vector quantities and scalar quantities does this equation contain?

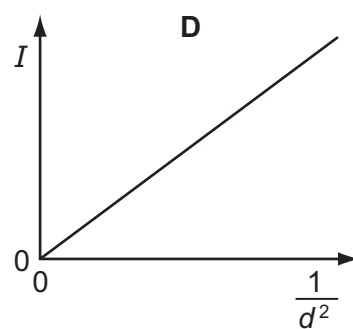
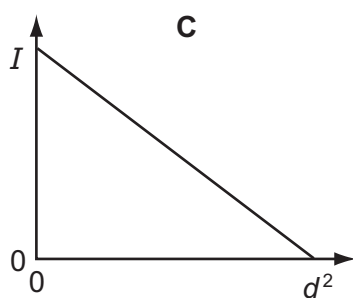
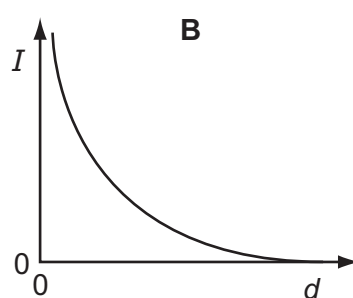
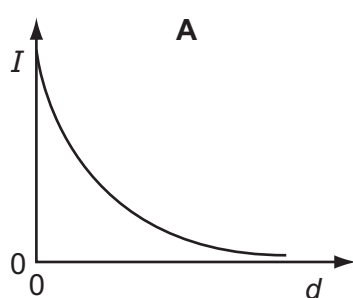
- A** one scalar quantity and two vector quantities
B one vector quantity and two scalar quantities
C three scalar quantities
D three vector quantities
- 2 What is a possible unit for the product VI , where V is the potential difference across a resistor and I is the current through the same resistor?
- A** newton per second (N s^{-1})
B newton second (Ns)
C newton metre (Nm)
D newton metre per second (Nm s^{-1})
- 3 What is a reasonable estimate of the average kinetic energy of an athlete during a 100 m race that takes 10 s?
- A** 40 J **B** 400 J **C** 4000 J **D** 40 000 J

Space for working

- 4 A light-meter measures the intensity I of the light falling on it. Theory suggests that I varies inversely as the square of the distance d .



Which graph of the results supports this theory?



Space for working

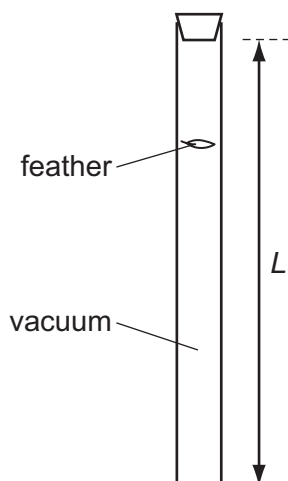
- 5 In an experiment, a radio-controlled car takes 2.50 ± 0.05 s to travel 40.0 ± 0.1 m.

What is the car's average speed and the uncertainty in this value?

- A $16 \pm 1 \text{ ms}^{-1}$
 - B $16.0 \pm 0.2 \text{ ms}^{-1}$
 - C $16.0 \pm 0.4 \text{ ms}^{-1}$
 - D $16.00 \pm 0.36 \text{ ms}^{-1}$
- 6 In an experiment to determine the acceleration of free fall using a falling body, what would lead to a value that is too large?
- A air resistance
 - B dimensions of the body are too large
 - C measured distance longer than true distance
 - D measured time longer than true time
- 7 Which feature of a graph allows acceleration to be determined?
- A the area under a displacement-time graph
 - B the area under a velocity-time graph
 - C the slope of a displacement-time graph
 - D the slope of a velocity-time graph

Space for working

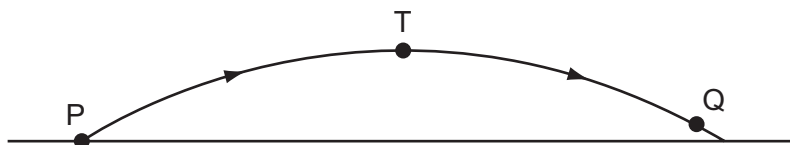
- 8 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length L .



The feather takes time T to fall from the top to the bottom of the tube.

How far will the feather have fallen from the top of the tube in time $0.50 T$?

- A** $0.13 L$ **B** $0.25 L$ **C** $0.38 L$ **D** $0.50 L$
- 9 In the absence of air resistance, a stone is thrown from P and follows a parabolic path in which the highest point reached is T. The stone reaches point Q just before landing.



The vertical component of acceleration of the stone is

- A** zero at T.
B larger at T than at Q.
C larger at Q than at T.
D the same at Q as at T.

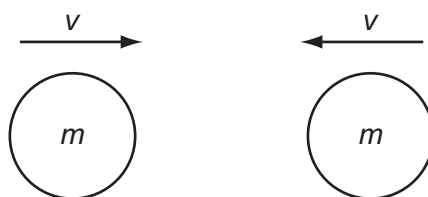
Space for working

10 Each option gives a correct word equation involving force.

Which option gives the definition of force?

- A force = energy divided by displacement
- B force = mass $\times$ acceleration
- C force = pressure $\times$ area
- D force = rate of change of momentum

11 Two similar spheres, each of mass m and travelling with speed v , are moving towards each other.



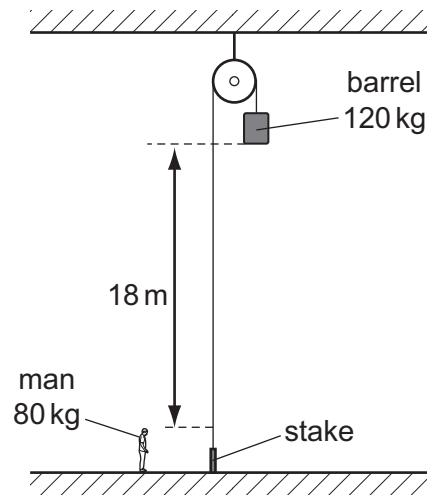
The spheres have a head-on elastic collision.

Which statement is correct?

- A The spheres stick together on impact.
- B The total kinetic energy after impact is mv^2 .
- C The total kinetic energy before impact is zero.
- D The total momentum before impact is $2mv$.

Space for working

- 12 The diagram shows a barrel suspended from a frictionless pulley on a building. The rope supporting the barrel goes over the pulley and is secured to a stake at the bottom of the building.



A man stands close to the stake. The bottom of the barrel is 18 m above the man's head. The mass of the barrel is 120 kg and the mass of the man is 80 kg.

The man keeps hold of the rope after untying it from the stake and is lifted upwards as the barrel falls.

What is the man's upward speed when his head is level with the bottom of the barrel? (Use $g = 10 \text{ m s}^{-2}$.)

- A** 6 m s^{-1} **B** 8 m s^{-1} **C** 13 m s^{-1} **D** 19 m s^{-1}

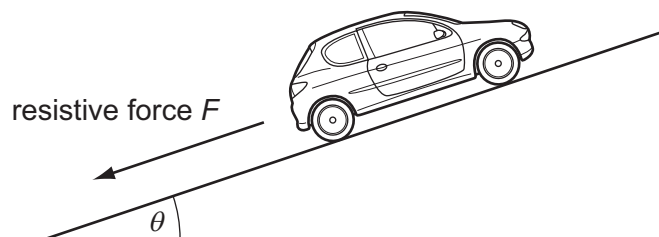
Space for working

- 13** A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which expression is equal to the upthrust on the block?

- A** $(p_b - p_t)A + W$
- B** $(p_b - p_t)$
- C** $(p_b - p_t)A$
- D** $(p_b - p_t)A - W$

- 14** A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F .

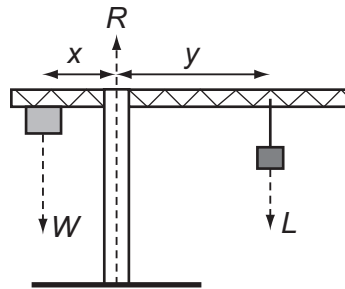


What force is needed to propel the car at this constant speed?

- A** $mg \cos \theta$
- B** $mg \sin \theta$
- C** $mg \cos \theta + F$
- D** $mg \sin \theta + F$

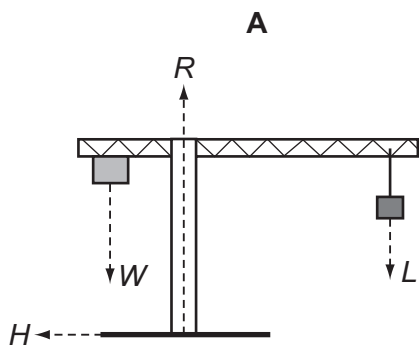
Space for working

15 The diagram shows a crane supporting a load L .

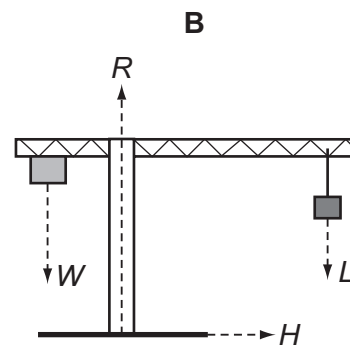


A mass provides a balancing load W . The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force R . The distance x does not change.

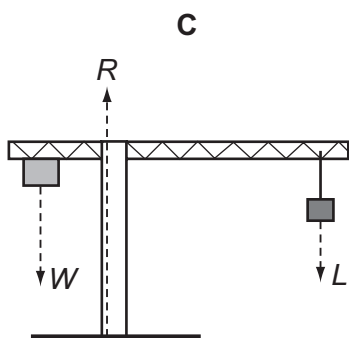
If the load is moved further out so that the distance y increases and the crane does not topple, which statement is correct?



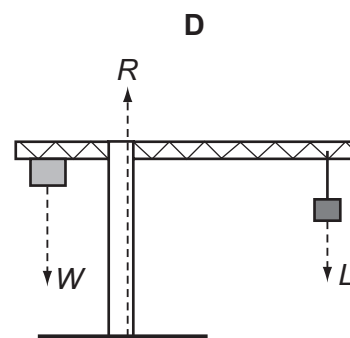
A horizontal force H acts on the base of the support column towards the left.



A horizontal force H acts on the base of the support column towards the right.



The reaction force R moves to the left.



The reaction force R moves to the right.

Space for working

- 16** A concrete cube of side 0.60 m and uniform density $2.0 \times 10^3 \text{ kg m}^{-3}$ is lifted 5.0 m vertically by a crane.

What is the change in potential energy of the cube?

- A** 2.2 kJ **B** 21 kJ **C** 59 kJ **D** 450 kJ

- 17** The force resisting the motion of a car is taken as being proportional to the square of the car's speed. The magnitude of the force at a speed of 20 m s^{-1} is 800 N.

What effective power is required from the car's engine to maintain a steady speed of 40 m s^{-1} ?

- A** 32 kW **B** 64 kW **C** 128 kW **D** 512 kW

- 18** The data below are taken from a test of a petrol engine for a motor car.

power output	150 kW
fuel consumption	20 litres per hour
energy content of fuel	40 MJ per litre

Which expression will evaluate the efficiency of the engine?

- A** $\frac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$
- B** $\frac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$
- C** $\frac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$
- D** $\frac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

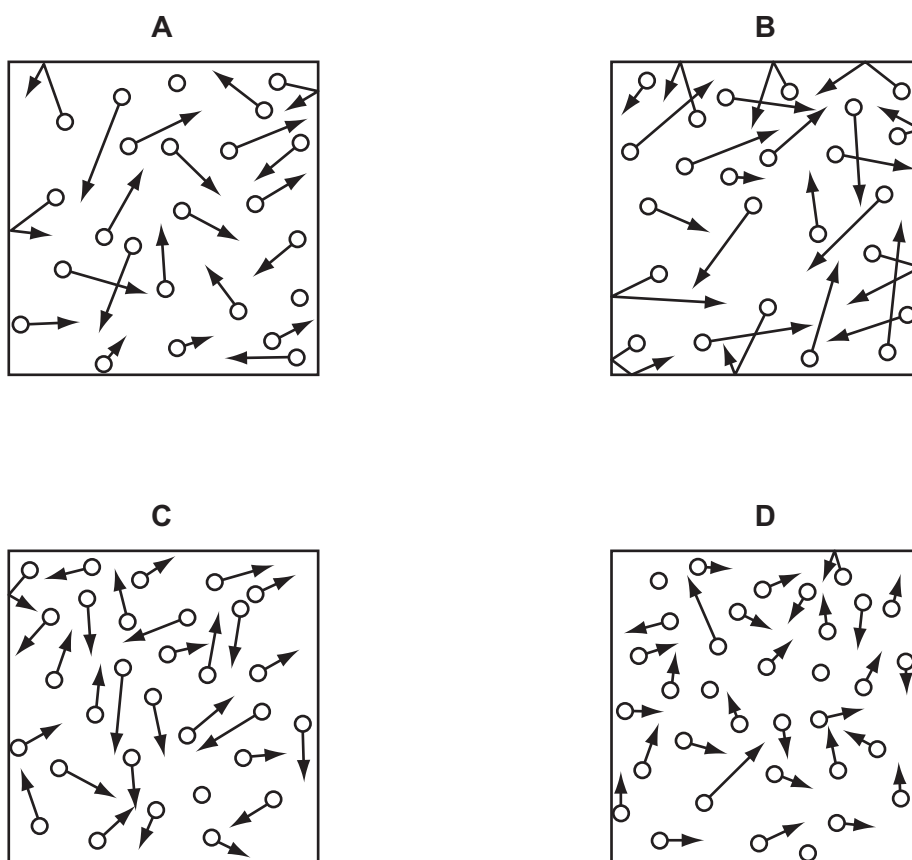
Space for working

19 What is the internal energy of an object?

- A It is the energy associated with the object's movement through space.
- B It is the energy associated with the random movement of the molecules in the object.
- C It is the energy due to the attractions between the molecules in the object.
- D It is the sum of all the microscopic potential and kinetic energies of the molecules in the object.

20 Each box shows identical molecules of a gas represented by circles with arrows to show the direction of travel and the speed of the molecule. A longer arrow represents a higher speed.

Which box contains a gas of the highest density and the lowest temperature?



Space for working

- 21** At room temperature, the density of liquid mercury is five times greater than the density of solid aluminium.

What is the reason for this?

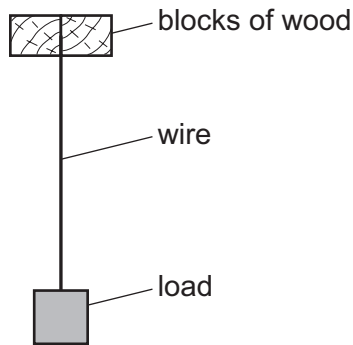
- A** Aluminium atoms are spaced widely apart.
 - B** Aluminium atoms move more freely than mercury atoms.
 - C** Atoms in a liquid take up less space than atoms in a solid.
 - D** Mercury atoms have greater mass than aluminium atoms.
- 22** When white sugar granules are heated, they melt. When the melt is cooled quickly, a brittle solid form of toffee is produced.

How does the structure of the sugar change?

- A** amorphous to polymeric
 - B** crystalline to amorphous
 - C** crystalline to polymeric
 - D** polymeric to amorphous
- 23** Which property of a metal wire depends on its Young modulus?
- A** ductility
 - B** elastic limit
 - C** spring constant
 - D** ultimate tensile stress

Space for working

- 24 The diagram shows a wire of diameter D and length L that is firmly clamped at one end between two blocks of wood. A load is applied to the wire which causes it to extend by an amount x .

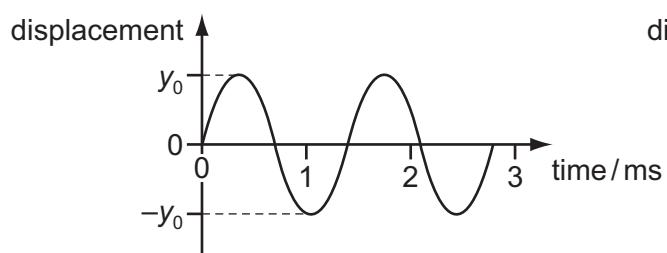


By how much would a wire of the same material, but of diameter $2D$ and length $3L$, extend when the same load is applied?

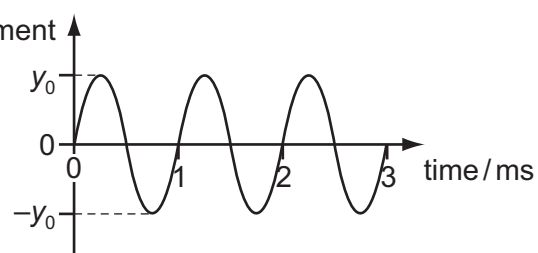
- A $\frac{2}{3}x$ B $\frac{3}{4}x$ C $\frac{4}{3}x$ D $\frac{3}{2}x$
- 25 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)?
- A elastic limit
B spring constant
C stress
D Young modulus

Space for working

26 Two waves E and G are shown. The waves have the same speed.



E

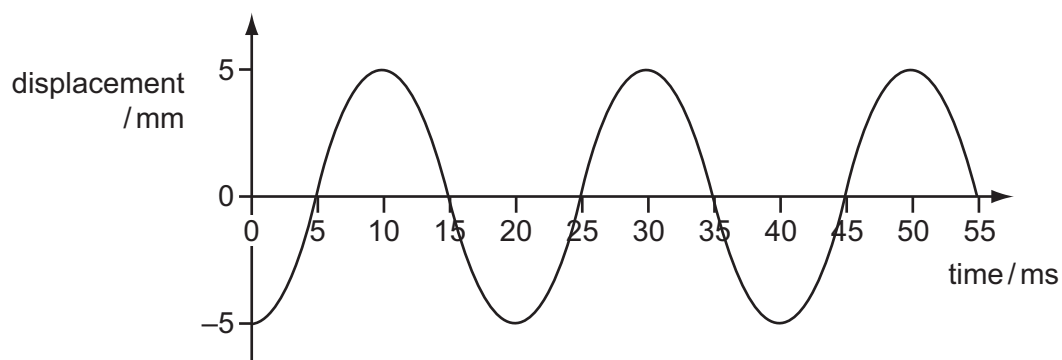


G

Which statement is correct?

- A Wave E has a greater amplitude than wave G.
- B Wave E has a greater intensity than wave G.
- C Wave E has a smaller frequency than wave G.
- D Wave E has a smaller wavelength than wave G.

27 The diagram shows a displacement-time graph for a progressive wave.

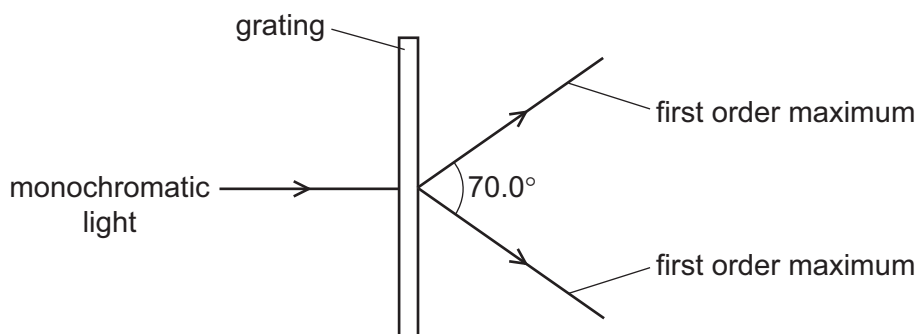


What are the amplitude and frequency of the wave?

	amplitude / mm	frequency / Hz
A	5	40
B	5	50
C	10	40
D	10	50

Space for working

- 28 Which observation indicates that sound waves are longitudinal?
- A Sound can be reflected from a solid surface.
 - B Sound cannot be polarised.
 - C Sound is diffracted around corners.
 - D Sound is refracted as it passes from hot air to cold air.
- 29 To produce a stationary wave, two waves must travel in opposite directions through the same space.
- Which statement about the properties of the two waves must also be true?
- A The waves must have equal frequency, but a different speed and wavelength.
 - B The waves must have equal speed, but a different wavelength and frequency.
 - C The waves must have equal speed, frequency and wavelength.
 - D The waves must have equal wavelength, but a different speed and frequency.
- 30 A diffraction grating is used to measure the wavelength of monochromatic light, as shown in the diagram.



The spacing of the slits in the grating is $1.00 \times 10^{-6} \text{ m}$. The angle between the first order diffraction maxima is 70.0° .

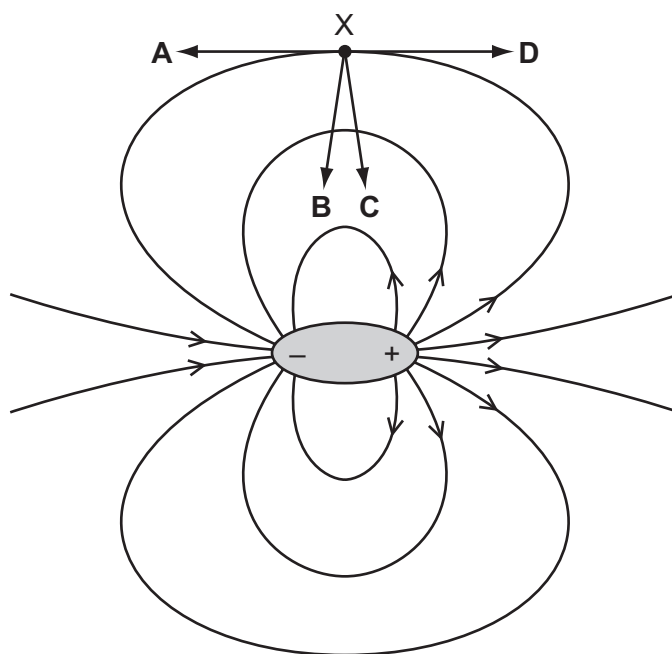
What is the wavelength of the light?

- A 287 nm B 470 nm C 574 nm D 940 nm

Space for working

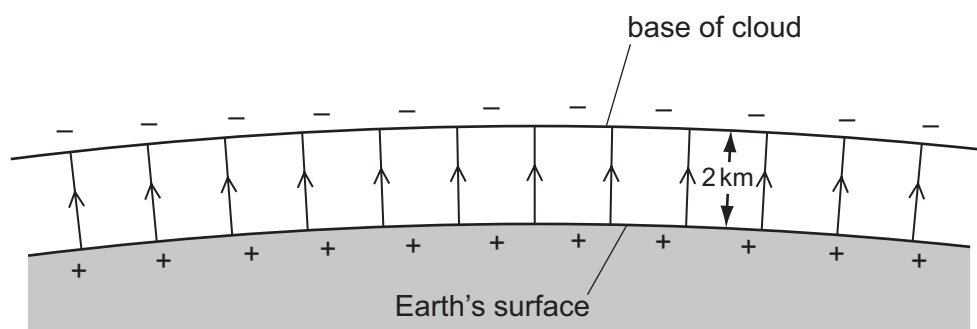
- 31 A dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of a dipole is shown below.

In which direction does the force act on an electron when at point X?



Space for working

- 32 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kNC^{-1} . The diagram shows the electric field between the base of a cloud and the Earth's surface.



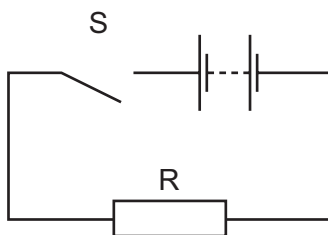
What is the minimum potential difference between the Earth and the base of a cloud, 2 km high, for lightning to occur?

- A** 12.5 MV **B** 25 MV **C** 50 MV **D** 100 MV
- 33 There is a current of 10 mA in a conductor for half an hour.
- How much charge passes a point in the conductor in this time?
- A** 0.3 C **B** 5 C **C** 18 C **D** 300 C
- 34 An iron wire has length 8.0 m and diameter 0.50 mm. The wire has resistance R .
- A second iron wire has length 2.0 m and diameter 1.0 mm.
- What is the resistance of the second wire?

- A** $\frac{R}{16}$ **B** $\frac{R}{8}$ **C** $\frac{R}{2}$ **D** R

Space for working

35 The diagram shows a simple circuit.

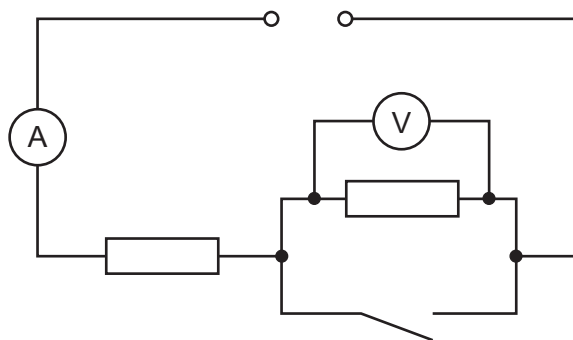


Which statement is correct?

- A** When switch S is closed, the electromotive force (e.m.f.) of the battery falls because work is done against the internal resistance of the battery.
- B** When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance R.
- C** When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.
- D** When switch S is closed, the potential difference across the battery falls because work is done against the resistance R.

Space for working

36 In the circuit below, the ammeter reading is I and the voltmeter reading is V .

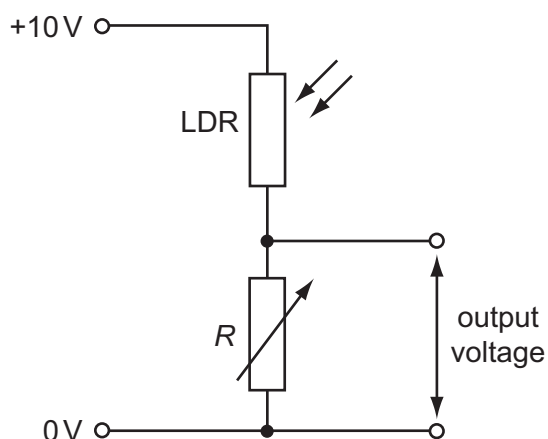


When the switch is closed, which row describes what happens to I and V ?

	I	V
A	decreases	decreases to zero
B	increases	decreases to zero
C	increases	stays the same
D	stays the same	increases

Space for working

- 37** A potential divider consists of a light-dependent resistor (LDR) in series with a variable resistor of resistance R . The resistance of the LDR decreases when the light level increases. The variable resistor can be set at either high resistance or low resistance.

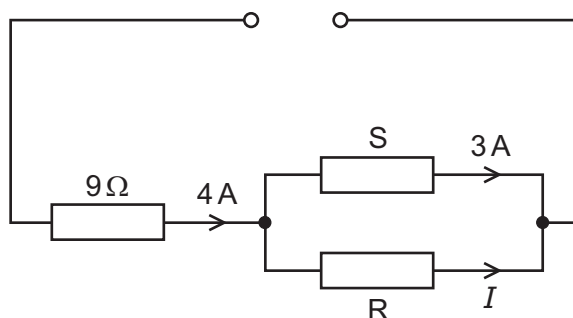


Which situation gives the largest output voltage?

	light level at LDR	R
A	high	high
B	high	low
C	low	high
D	low	low

Space for working

- 38 The circuit below has a current I in the resistor R .



What must be known in order to determine the value of I ?

- A e.m.f. of the power supply
 - B resistance of resistor S
 - C Kirchhoff's first law
 - D Kirchhoff's second law
- 39 An experiment in which α -particles were deflected by a gold foil produced new insights into the structure of the atom.

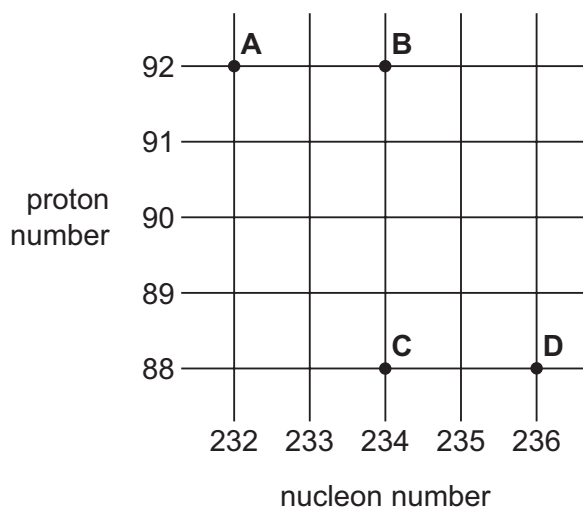
Which conclusion can be drawn from the results of the experiment?

- A Atomic nuclei occupy a very small fraction of the volume of an atom.
- B Electrons orbit the atomic nucleus.
- C Some atoms of the same element contain different numbers of neutrons.
- D The atomic nucleus contains protons and neutrons.

Space for working

- 40 Thorium-234 ($^{234}_{90}\text{Th}$) decays by β -emission into a daughter product which in turn decays by further β -emission into a granddaughter product.

Which letter in the diagram represents the granddaughter product?



Space for working



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$$1/R = 1/R_1 + 1/R_2 + \dots$$

alternating current/voltage,

$$x = x_0 \sin \omega t$$

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

decay constant,

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

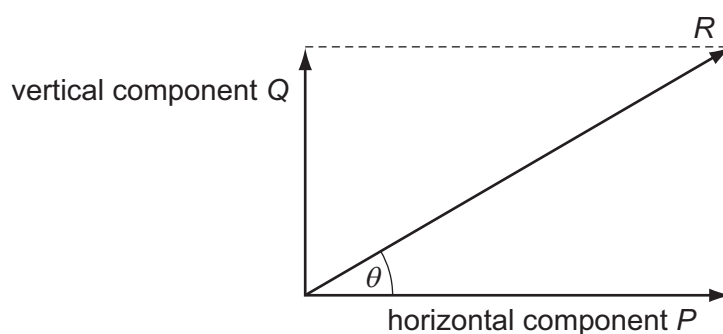
1 What is the unit watt in terms of SI base units?

- A Js^{-1} B $\text{m}^2\text{kg s}^{-1}$ C $\text{m}^2\text{kg s}^{-3}$ D Nms^{-1}

2 For which quantity is the magnitude a reasonable estimate?

- A frequency of a radio wave 500 pHz
 B mass of an atom 500 μg
 C the Young modulus of a metal 500 kPa
 D wavelength of green light 500 nm

3 A vector has magnitude R and perpendicular components P and Q , as shown in the diagram.



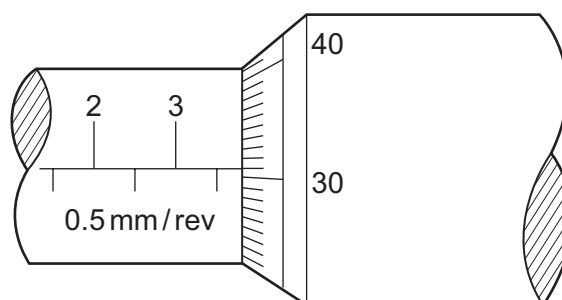
Which row correctly describes the perpendicular components?

	vertical component	horizontal component
A	Q	$R \sin \theta$
B	$R \cos \theta$	P
C	$R \cos \theta$	$R \sin \theta$
D	$R \sin \theta$	$R \cos \theta$

Space for working

- 4 The diameter of a cylindrical metal rod is measured using a micrometer screw gauge.

The diagram below shows an enlargement of the scale on the micrometer screw gauge when taking the measurement.



What is the cross-sectional area of the rod?

- A** 3.81 mm^2 **B** 11.4 mm^2 **C** 22.8 mm^2 **D** 45.6 mm^2
- 5 A mass is dropped from rest, and falls through a distance of 2.0 m in a vacuum. An observer records the time taken for the mass to fall through this distance using a manually operated stopwatch and repeats the measurements a further two times. The average result of these measured times, displayed in the table below, was used to determine a value for the acceleration of free fall. This was calculated to be 9.8 m s^{-2} .

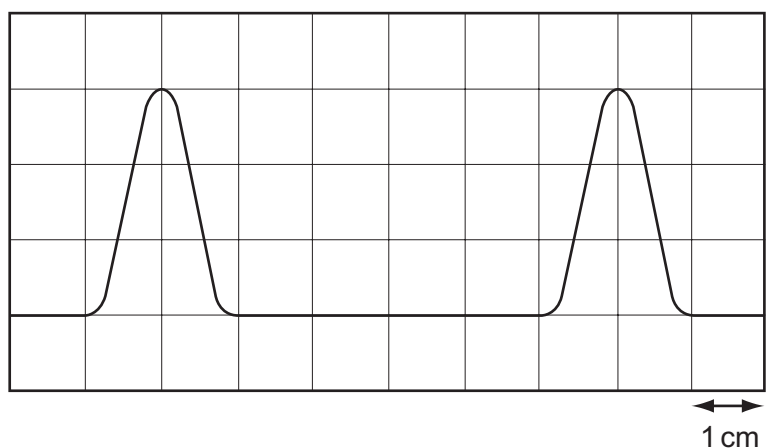
	first measurement	second measurement	third measurement	average
time/s	0.6	0.73	0.59	0.64

Which statement best relates to the experiment?

- A** The measurements are precise and accurate with no evidence of random errors.
- B** The measurements are not accurate and not always recorded to the degree of precision of the measuring device but the calculated experimental result is accurate.
- C** The measurements are not always recorded to the degree of precision of the measuring device but are accurate. Systematic errors may be present.
- D** The range of results shows that there were random errors made but the calculated value is correct so the experiment was successful.

Space for working

- 6 The diagram shows two complete pulses on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is $1 \mu\text{s cm}^{-1}$.

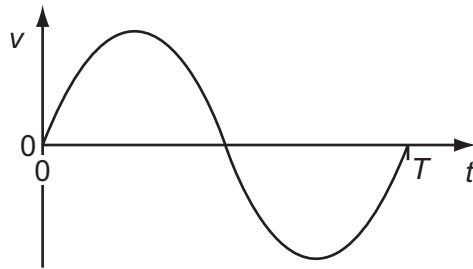


How long does each pulse last?

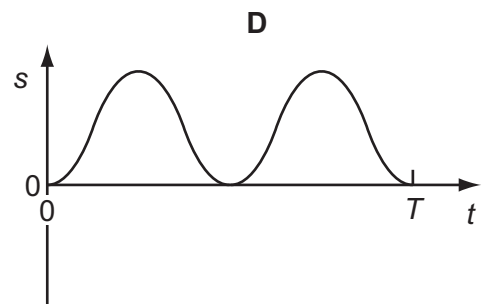
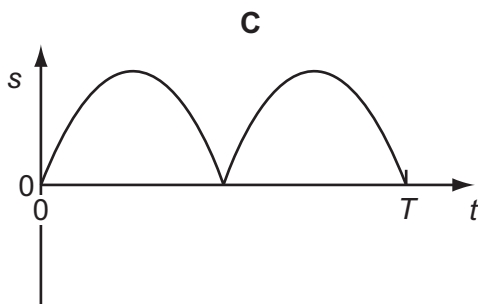
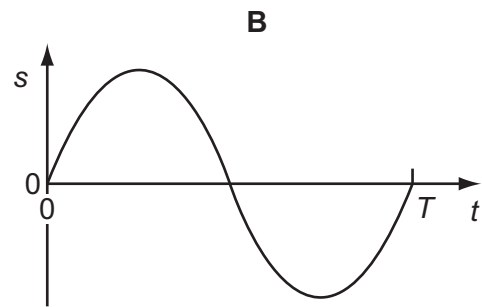
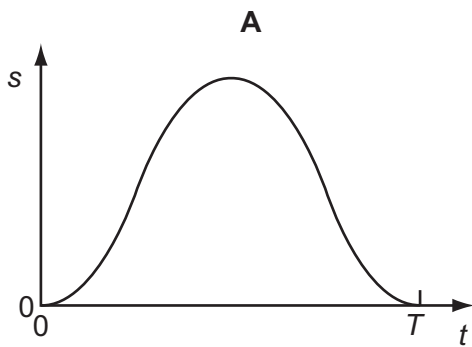
- A** $2 \mu\text{s}$ **B** $3 \mu\text{s}$ **C** $4 \mu\text{s}$ **D** $6 \mu\text{s}$

Space for working

- 7 The graph shows how the velocity v of an object moving in a straight line varies over time $t = 0$ to $t = T$.

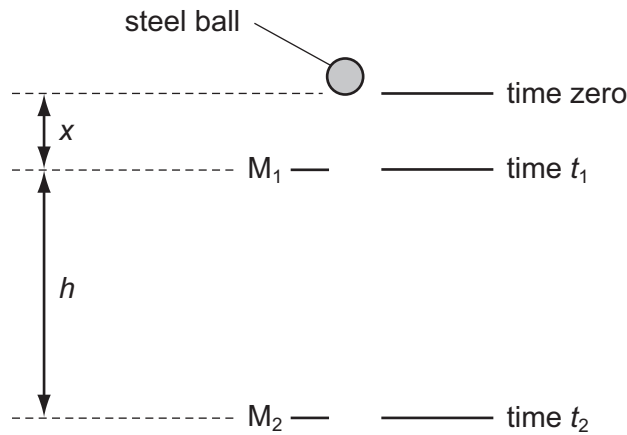


Which graph represents the displacement s of the object in the time $t = 0$ to $t = T$?



Space for working

- 8 Two markers M_1 and M_2 are set up a vertical distance h apart.



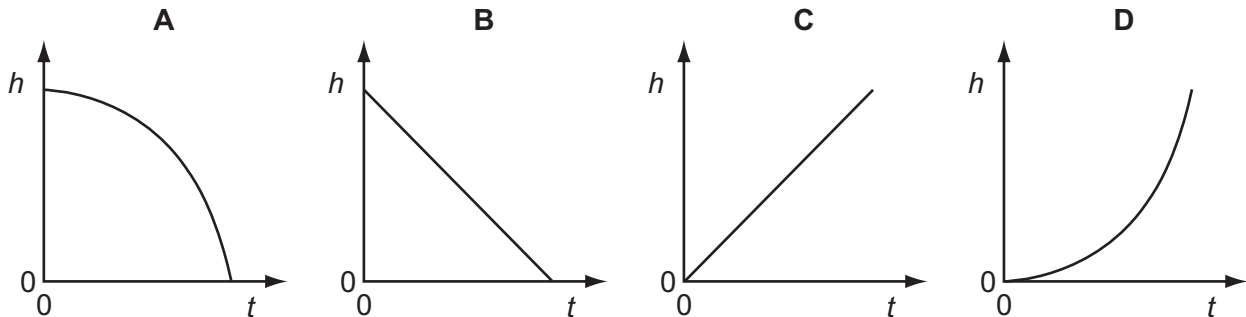
A steel ball is released at time zero from a point a distance x above M_1 . The ball reaches M_1 at time t_1 and reaches M_2 at time t_2 . The acceleration of the ball is constant.

Which expression gives the acceleration of the ball?

- A $\frac{2h}{t_2^2}$ B $\frac{2h}{(t_2 + t_1)}$ C $\frac{2h}{(t_2 - t_1)^2}$ D $\frac{2h}{(t_2^2 - t_1^2)}$

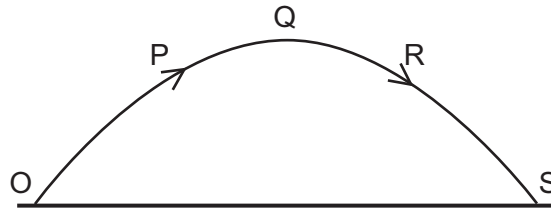
- 9 A brick is dislodged from a building and falls vertically under gravity.

Which graph best represents the variation of its height h above the ground with time t if air resistance is negligible?



Space for working

- 10 A projectile is launched at point O and follows the path OPQRS, as shown. Air resistance may be neglected.



Which statement is true for the projectile when it is at the highest point Q of its path?

- A The horizontal component of the projectile's acceleration is zero.
 - B The horizontal component of the projectile's velocity is zero.
 - C The kinetic energy of the projectile is zero.
 - D The momentum of the projectile is zero.
- 11 Which row correctly states whether momentum and kinetic energy are conserved in an inelastic collision in which there are no external forces?

	momentum	kinetic energy
A	conserved	conserved
B	conserved	not conserved
C	not conserved	conserved
D	not conserved	not conserved

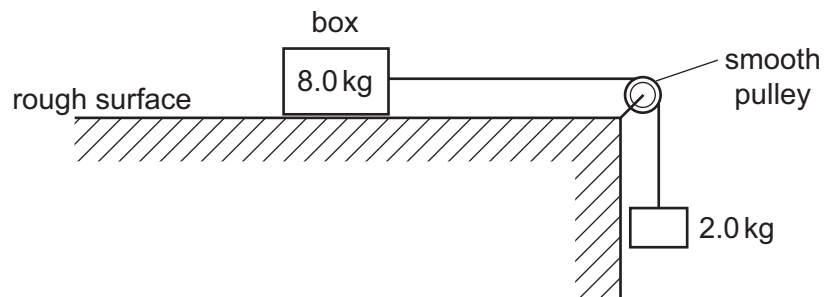
Space for working

- 12 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before collision. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below.



Which equation must be correct if the collision is perfectly elastic?

- A** $u_1 - u_2 = v_2 + v_1$
B $u_1 - u_2 = v_2 - v_1$
C $u_1 + u_2 = v_2 + v_1$
D $u_1 + u_2 = v_2 - v_1$
- 13 A box of mass 8.0 kg rests on a horizontal, rough surface. A string attached to the box passes over a smooth pulley and supports a 2.0 kg mass at its other end.



When the box is released, a frictional force of 6.0 N acts on it.

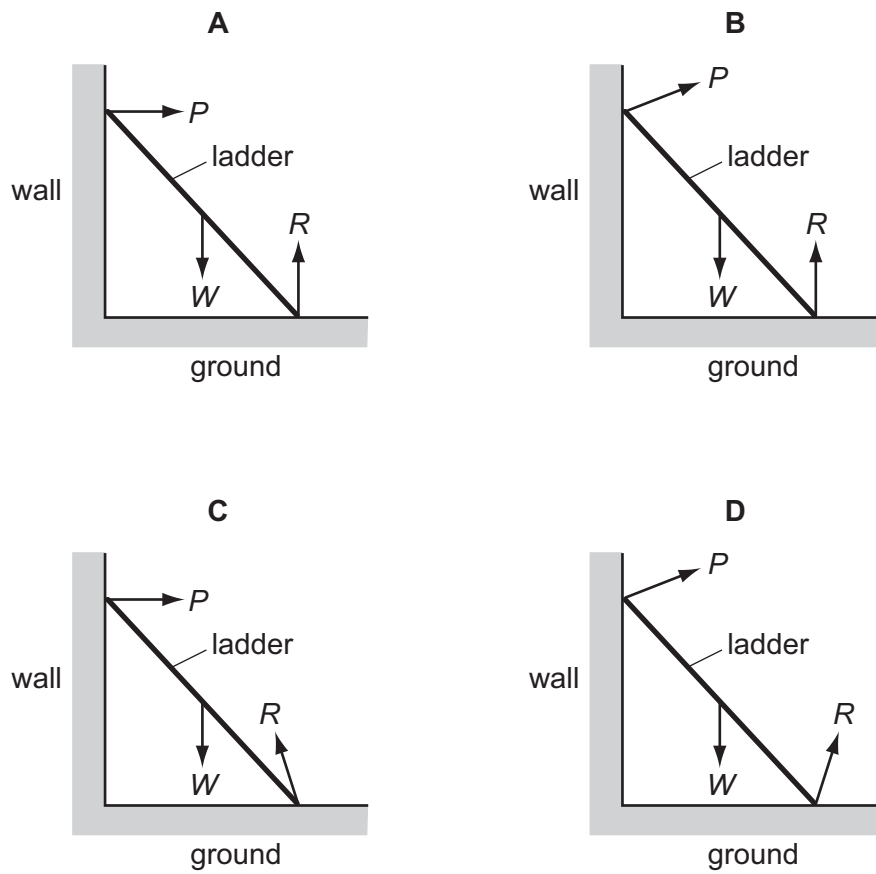
What is the acceleration of the box?

- A** 1.4 ms^{-2} **B** 1.7 ms^{-2} **C** 2.0 ms^{-2} **D** 2.5 ms^{-2}

Space for working

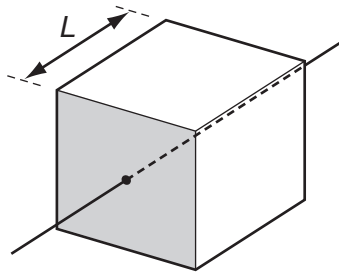
- 14** A ladder is positioned on icy (frictionless) ground and is leant against a rough wall. At the instant of release it begins to slide.

Which diagram correctly shows the directions of the forces P , W and R acting on the ladder as it begins to slide?

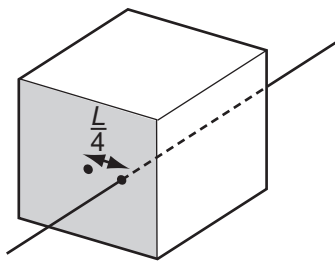


Space for working

- 15 The diagram shows a solid cube with weight W and sides of length L . It is supported by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.



The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



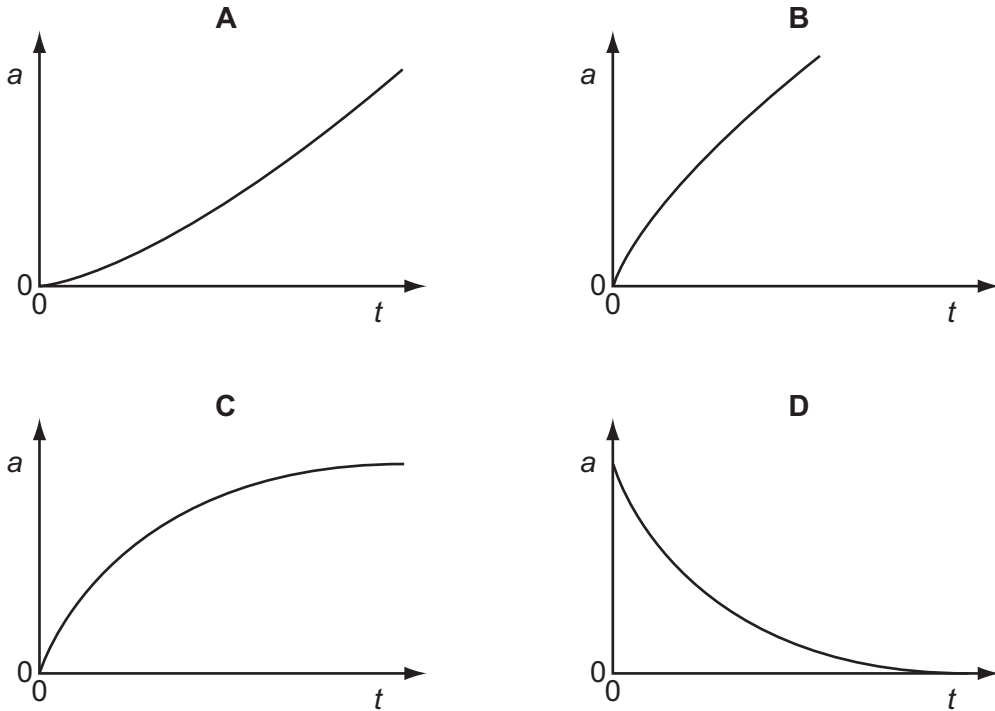
When viewing the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

- A $\frac{WL}{2}$ anticlockwise
- B $\frac{WL}{2}$ clockwise
- C $\frac{WL}{4}$ anticlockwise
- D $\frac{WL}{4}$ clockwise

Space for working

- 16 A sphere is released from rest in a viscous fluid.

Which graph represents the variation with time t of the acceleration a of the sphere?



- 17 Initially, four identical uniform blocks, each of mass m and thickness h , are spread on a table.

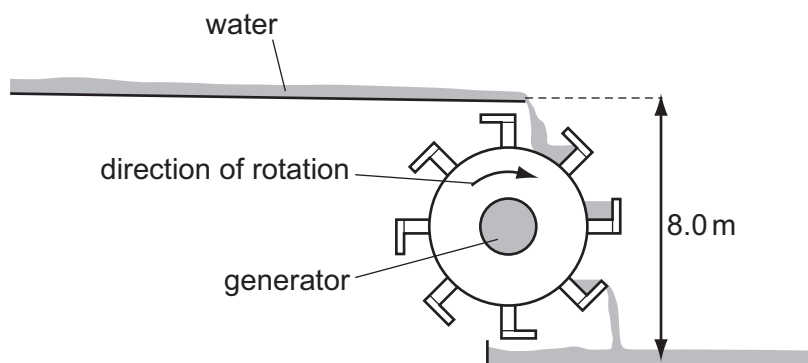


How much work is done on the blocks in stacking them on top of one another?

- A** $3 mgh$ **B** $6 mgh$ **C** $8 mgh$ **D** $10 mgh$

Space for working

- 18 The diagram shows the design of a water wheel which drives a generator to produce electrical energy. The flow rate of the water is 200 kg s^{-1} . The generator supplies a current of 32 A at a voltage of 230 V.



Ignoring any changes in kinetic energy of the water, what is the efficiency of the system?

- A** 14 % **B** 16 % **C** 22 % **D** 47 %
- 19 A car engine exerts an average force of 500 N in moving the car 1.0 km in 200 s.
- What is the average power developed by the engine?
- A** 2.5 W **B** 2.5 kW **C** 100 kW **D** 100 MW
- 20 A mass of gas enclosed in a cylinder by a piston is heated gently. At the same time, the piston is moved so that the pressure remains constant.
- As a result of this, what will **not** occur?
- A** The average velocity of the molecules will increase.
B The mean separation of the molecules will increase.
C The molecules will travel greater distances between collisions.
D The number of collisions per second of the molecules on the piston will increase.

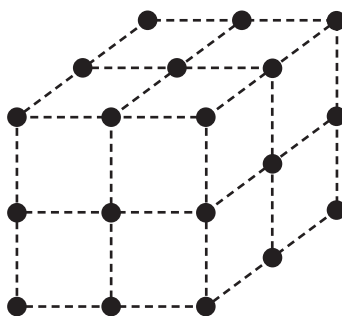
Space for working

- 21 In an experiment to demonstrate Brownian motion, a transparent container is filled with smoke particles suspended in air.

What can be seen when the contents of the container are strongly illuminated and viewed through a microscope?

- A air molecules that are colliding with smoke particles
- B air molecules that are moving in straight lines
- C smoke particles that are moving in random zigzag paths
- D smoke particles that are moving in straight lines

- 22 The diagram shows the arrangement of atoms in a particular crystal.



Each atom is at the corner of a cube.

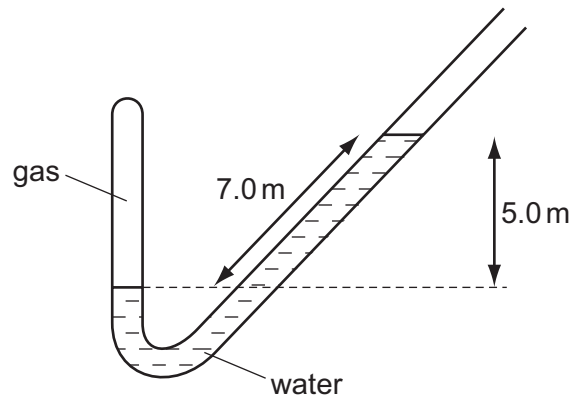
The mass of each atom is 3.5×10^{-25} kg. The density of the crystal is $9.2 \times 10^3 \text{ kg m}^{-3}$.

What is the shortest distance between the centres of two adjacent atoms?

- A $3.8 \times 10^{-29} \text{ m}$
- B $6.2 \times 10^{-15} \text{ m}$
- C $3.4 \times 10^{-10} \text{ m}$
- D $3.0 \times 10^{-9} \text{ m}$

Space for working

23 A pipe is closed at one end and contains gas, trapped by a column of water.



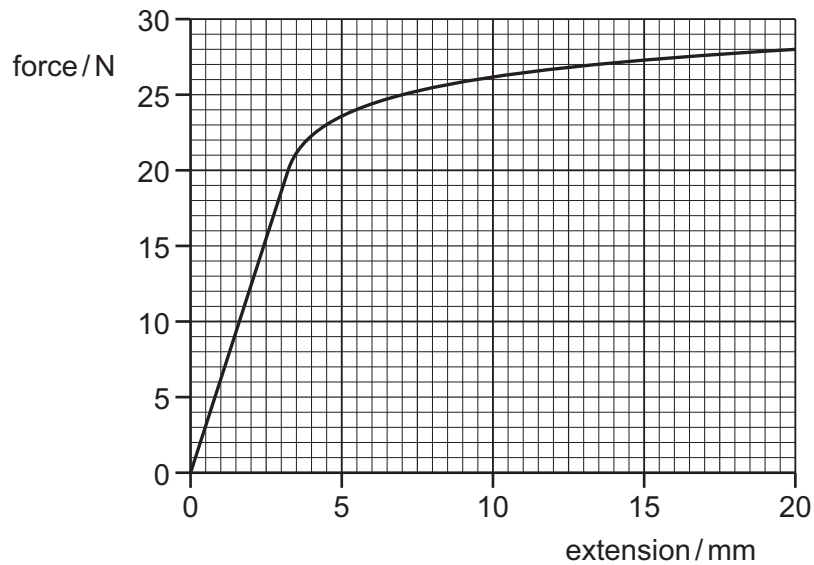
The atmospheric pressure is 1.0×10^5 Pa. The density of water is 1000 kg m^{-3} .

What is the pressure of the gas? (Use $g = 10 \text{ m s}^{-2}$.)

- A 0.3×10^5 Pa
- B 0.5×10^5 Pa
- C 1.5×10^5 Pa
- D 1.7×10^5 Pa

Space for working

24 The graph is a force-extension graph for a wire that is being stretched.



How much work needs to be done by the tensile force, to two significant figures, to cause an extension of 7.0 mm?

- A** 0.088 J **B** 0.12 J **C** 0.53 J **D** 120 J

25 A wire stretches 8 mm under a load of 60 N.

A second wire of the same material, with half the diameter and a quarter of the original length of the first wire, is stretched by the same load.

Assuming that Hooke's law is obeyed, what is the extension of this wire?

- A** 1 mm **B** 4 mm **C** 8 mm **D** 16 mm

Space for working

- 26 A surveyor's device emits a laser pulse.

What is the time taken for the pulse to travel from the device to a wall 150 m away, where it is reflected, and then return to the device?

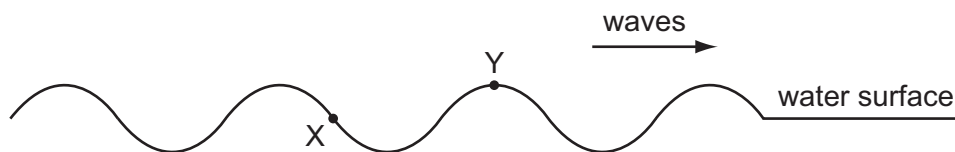
- A** 0.05 ns **B** 0.10 ns **C** 0.50 μs **D** 1.0 μs

- 27 The period of an electromagnetic wave is 1.0 ns.

What are the frequency and wavelength of the wave?

	frequency / Hz	wavelength / m
A	1.0	3.0×10^8
B	1.0×10^6	300
C	1.0×10^9	0.30
D	1.0×10^{12}	3.0×10^{-4}

- 28 X and Y are two points on the surface of water in a ripple tank. A source of waves of constant frequency begins to generate waves which then travel past X and Y, causing them to oscillate.



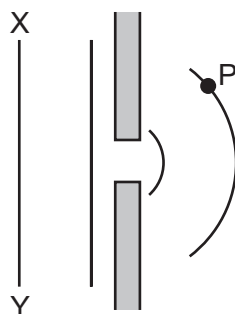
What is the phase difference between X and Y?

- A** 45° **B** 135° **C** 180° **D** 270°

Space for working

- 29 A monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.

The diagram illustrates successive wavefronts.



After what time will some portion of the wavefront XY reach point P?

- A $\frac{3\lambda}{2c}$ B $\frac{2\lambda}{c}$ C $\frac{3\lambda}{c}$ D $\frac{4\lambda}{c}$

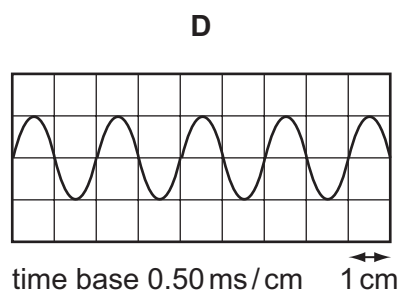
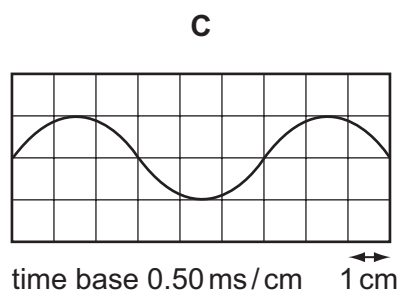
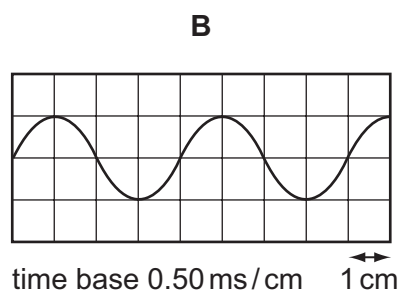
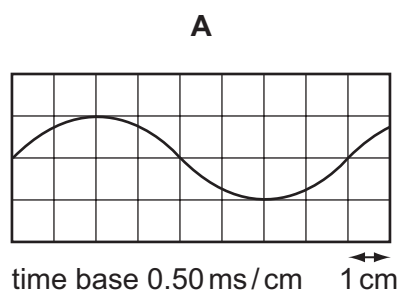
Space for working

- 30 A standing sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (c.r.o.) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the c.r.o. rises to a maximum at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

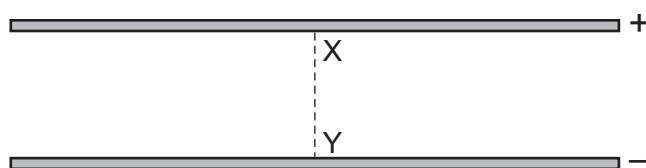
The distance between X and Y is 33 cm. The speed of sound in air is 330 m s^{-1} .

Which diagram represents the c.r.o. trace of the sound received at X?

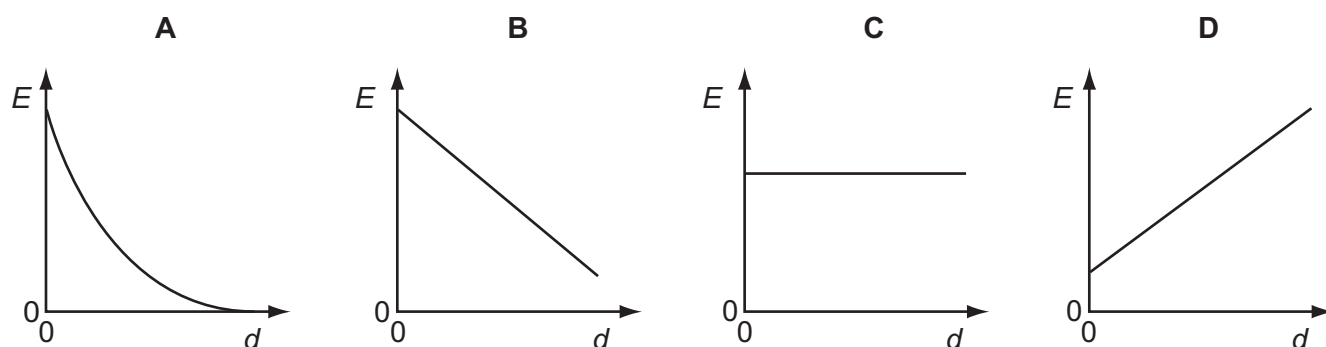


Space for working

- 31 An electric field exists in the space between two charged metal plates.



Which graph shows the variation of electric field strength E with distance d from X along the line XY?



- 32 When will 1 C of charge pass a point in an electrical circuit?

- A when 1 A moves through a potential difference of 1 V
- B when a power of 1 W is used for 1 s
- C when the current is 5 mA for 200 s
- D when the current is 10 A for 10 s

Space for working

- 33 Two copper wires of the same length but different diameters carry the same current.

Which statement about the flow of charged particles through the wires is correct?

- A Charged particles are provided by the power supply. Therefore the speed at which they travel depends only on the voltage of the supply.
- B The charged particles in both wires move with the same average speed because the current in both wires is the same.
- C The charged particles move faster through the wire with the larger diameter because there is a greater volume through which to flow.
- D The charged particles move faster through the wire with the smaller diameter because it has a larger potential difference applied to it.

- 34 A power cable X has resistance R and carries current I .

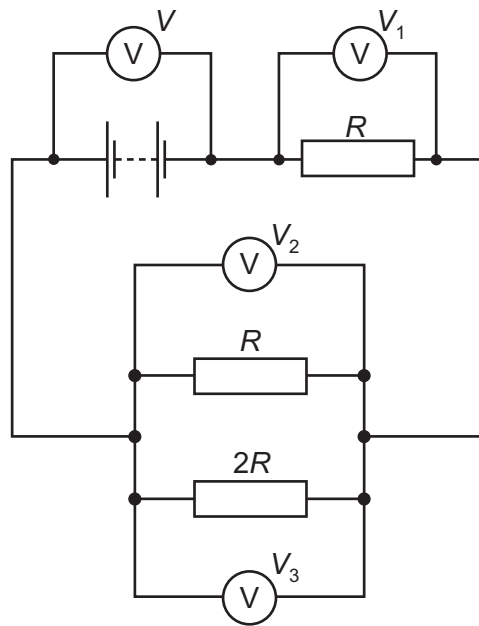
A second cable Y has resistance $2R$ and carries current $\frac{1}{2}I$.

What is the ratio $\frac{\text{power dissipated in Y}}{\text{power dissipated in X}}$?

- A $\frac{1}{4}$ B $\frac{1}{2}$ C 2 D 4

Space for working

35 The diagram shows a circuit with four voltmeter readings V , V_1 , V_2 and V_3 .

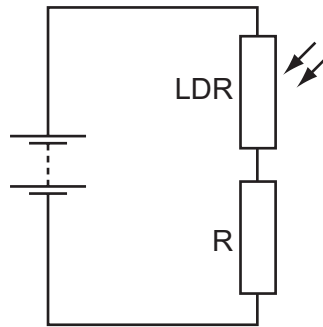


Which equation relating the voltmeter readings must be true?

- A $V = V_1 + V_2 + V_3$
- B $V + V_1 = V_2 + V_3$
- C $V_3 = 2(V_2)$
- D $V - V_1 = V_3$

Space for working

- 36 A light-dependent resistor (LDR) is connected in series with a resistor R and a battery.



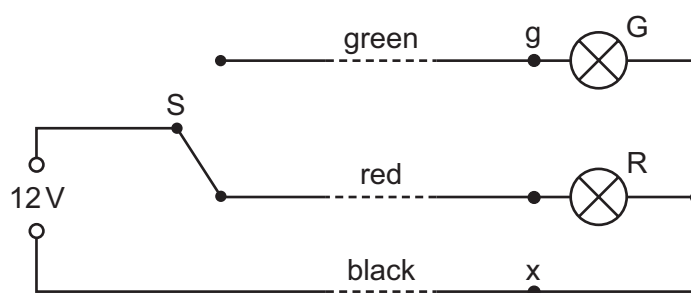
The resistance of the LDR is equal to the resistance of R when no light falls on the LDR.

When the light intensity falling on the LDR increases, which statement is correct?

- A** The current in R decreases.
- B** The current in the LDR decreases.
- C** The p.d. across R decreases.
- D** The p.d. across the LDR decreases.

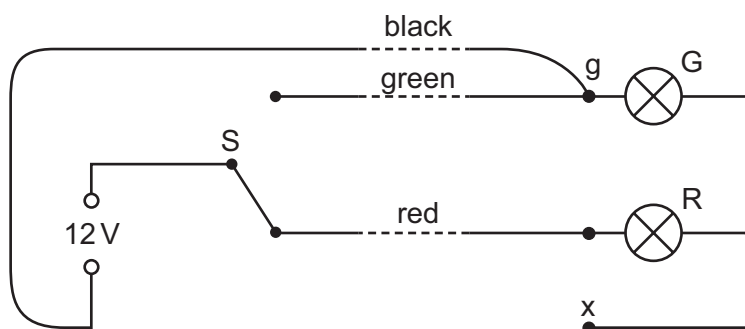
Space for working

- 37 The diagram shows the circuit for a signal to display a green or a red light. It is controlled by the switch S.



The signal is some way from S to which it is connected by a cable with green, red and black wires. At the signal, the green and red wires are connected to the corresponding lamp and the black wire is connected to a terminal x to provide a common return. The arrangement is shown correctly connected and with the switch set to illuminate the red lamp.

During maintenance, the wires at the signal are disconnected and, when reconnected, the black wire is connected in error to the green lamp (terminal g) instead of terminal x. The red wire is connected correctly to its lamp and connections at S remain as in the diagram.

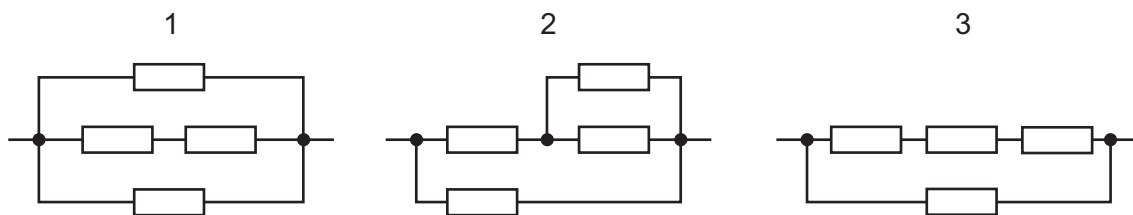


When the system is tested with the switch connection to the red wire, what does the signal show?

- A the green lamp illuminated normally
- B the red lamp illuminated normally
- C the red and green lamps both illuminated normally
- D the red and green lamps both illuminated dimly

Space for working

38 Four identical resistors are connected in the three networks below.



Which arrangement has the highest total resistance and which has the lowest?

	highest	lowest
A	1	2
B	1	3
C	3	1
D	3	2

Space for working

- 39 Nuclear decay is both spontaneous and random in nature.

Which row gives the correct experimental evidence for these properties?

	spontaneous nature of decay	random nature of decay
A	the decay rate is not affected by pressure	the decay rate is not affected by temperature
B	the decay rate is not affected by pressure	the rate at which radiation is received at a counter fluctuates
C	the decay rate is not affected by temperature	the decay rate is not affected by pressure
D	the rate at which radiation is received at a counter fluctuates	the decay rate is not affected by pressure

- 40 Radon $^{222}_{86}\text{Rn}$ is the start of a decay chain that forms bismuth $^{214}_{83}\text{Bi}$ by alpha and beta emission.

For the decay of each nucleus of radon, how many α -particles and β -particles are emitted?

	α -particles	β -particles
A	1	1
B	2	1
C	1	2
D	2	2

Space for working

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

PHYSICS

Paper 1 Multiple Choice

9702/13

May/June 2012

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)



READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.

This document consists of **24** printed pages.



Data

speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion,

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

work done on/by a gas,

$$W = p\Delta V$$

gravitational potential,

$$\phi = -\frac{Gm}{r}$$

hydrostatic pressure,

$$p = \rho gh$$

pressure of an ideal gas,

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

simple harmonic motion,

$$a = -\omega^2 x$$

velocity of particle in s.h.m.,

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{x_0^2 - x^2}$$

electric potential,

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

capacitors in series,

$$1/C = 1/C_1 + 1/C_2 + \dots$$

capacitors in parallel,

$$C = C_1 + C_2 + \dots$$

energy of charged capacitor,

$$W = \frac{1}{2}QV$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

alternating current/voltage,

$$x = x_0 \sin \omega t$$

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

decay constant,

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

- 1 What is a reasonable estimate of the average kinetic energy of an athlete during a 100 m race that takes 10 s?

A 40 J B 400 J C 4000 J D 40 000 J

- 2 When a force F moves its point of application through a displacement s in the direction of the force, the work W done by the force is given by

$$W = Fs.$$

How many vector quantities and scalar quantities does this equation contain?

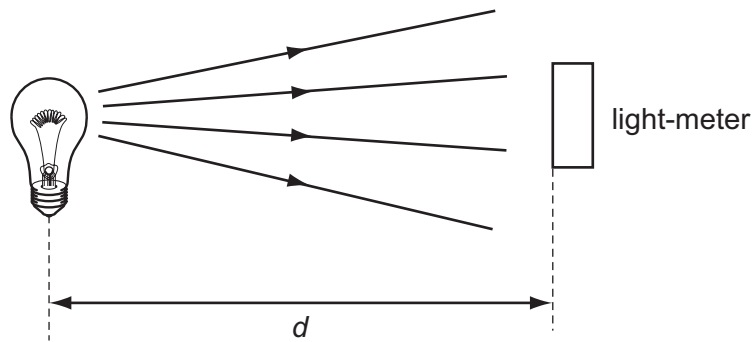
- A one scalar quantity and two vector quantities
B one vector quantity and two scalar quantities
C three scalar quantities
D three vector quantities
- 3 What is a possible unit for the product VI , where V is the potential difference across a resistor and I is the current through the same resistor?
- A newton per second (N s^{-1})
B newton second (N s)
C newton metre (N m)
D newton metre per second (N m s^{-1})
- 4 In an experiment, a radio-controlled car takes $2.50 \pm 0.05 \text{ s}$ to travel $40.0 \pm 0.1 \text{ m}$.

What is the car's average speed and the uncertainty in this value?

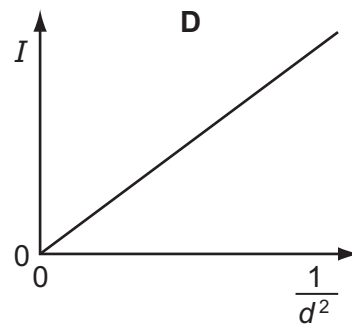
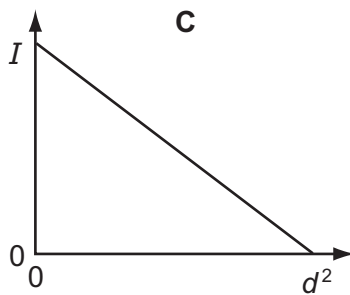
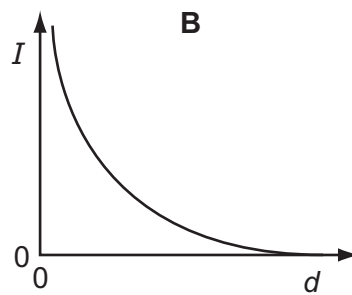
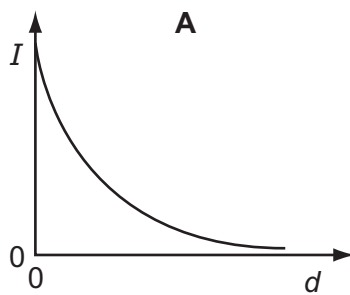
- A $16 \pm 1 \text{ m s}^{-1}$
B $16.0 \pm 0.2 \text{ m s}^{-1}$
C $16.0 \pm 0.4 \text{ m s}^{-1}$
D $16.00 \pm 0.36 \text{ m s}^{-1}$

Space for working

- 5 A light-meter measures the intensity I of the light falling on it. Theory suggests that I varies inversely as the square of the distance d .



Which graph of the results supports this theory?

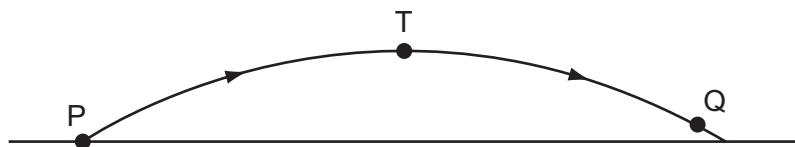


Space for working

- 6 Which feature of a graph allows acceleration to be determined?
- A the area under a displacement-time graph
 - B the area under a velocity-time graph
 - C the slope of a displacement-time graph
 - D the slope of a velocity-time graph
- 7 In an experiment to determine the acceleration of free fall using a falling body, what would lead to a value that is too large?
- A air resistance
 - B dimensions of the body are too large
 - C measured distance longer than true distance
 - D measured time longer than true time

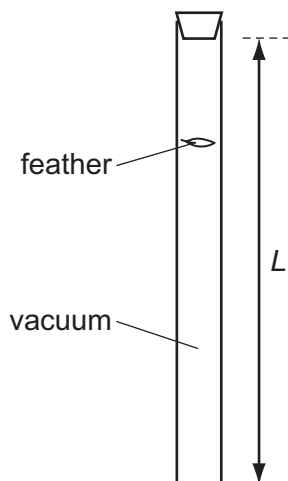
Space for working

- 8 In the absence of air resistance, a stone is thrown from P and follows a parabolic path in which the highest point reached is T. The stone reaches point Q just before landing.



The vertical component of acceleration of the stone is

- A zero at T.
 - B larger at T than at Q.
 - C larger at Q than at T.
 - D the same at Q as at T.
- 9 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length L .



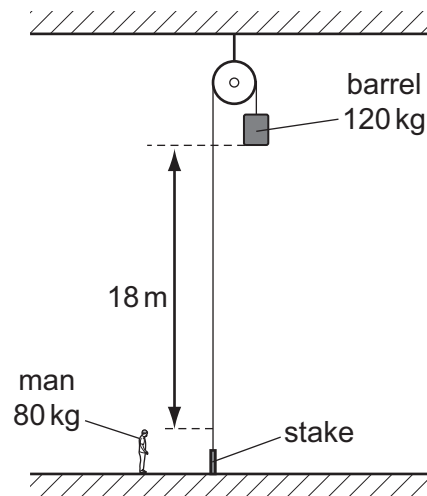
The feather takes time T to fall from the top to the bottom of the tube.

How far will the feather have fallen from the top of the tube in time $0.50 T$?

- A $0.13 L$
- B $0.25 L$
- C $0.38 L$
- D $0.50 L$

Space for working

- 10 The diagram shows a barrel suspended from a frictionless pulley on a building. The rope supporting the barrel goes over the pulley and is secured to a stake at the bottom of the building.



A man stands close to the stake. The bottom of the barrel is 18 m above the man's head. The mass of the barrel is 120 kg and the mass of the man is 80 kg.

The man keeps hold of the rope after untying it from the stake and is lifted upwards as the barrel falls.

What is the man's upward speed when his head is level with the bottom of the barrel? (Use $g = 10 \text{ m s}^{-2}$.)

- A** 6 m s^{-1} **B** 8 m s^{-1} **C** 13 m s^{-1} **D** 19 m s^{-1}

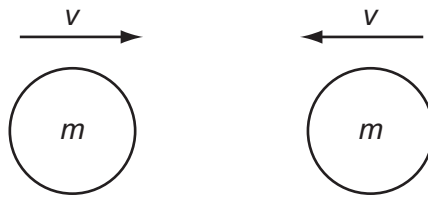
Space for working

11 Each option gives a correct word equation involving force.

Which option gives the definition of force?

- A force = energy divided by displacement
- B force = mass $\times$ acceleration
- C force = pressure $\times$ area
- D force = rate of change of momentum

12 Two similar spheres, each of mass m and travelling with speed v , are moving towards each other.



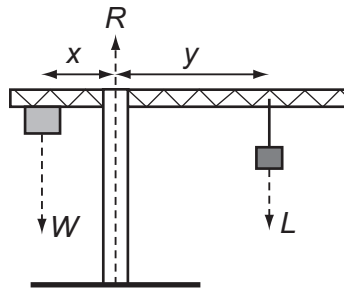
The spheres have a head-on elastic collision.

Which statement is correct?

- A The spheres stick together on impact.
- B The total kinetic energy after impact is mv^2 .
- C The total kinetic energy before impact is zero.
- D The total momentum before impact is $2mv$.

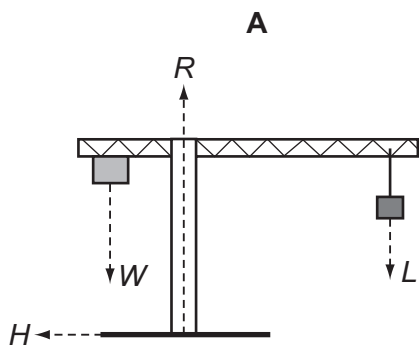
Space for working

13 The diagram shows a crane supporting a load L .

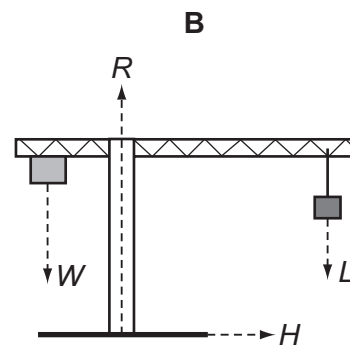


A mass provides a balancing load W . The position of the load is such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force R . The distance x does not change.

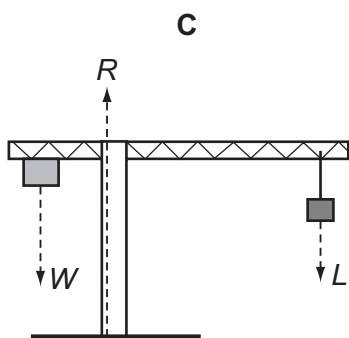
If the load is moved further out so that the distance y increases and the crane does not topple, which statement is correct?



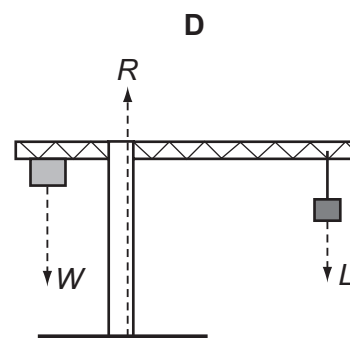
A horizontal force H acts on the base of the support column towards the left.



A horizontal force H acts on the base of the support column towards the right.



The reaction force R moves to the left.



The reaction force R moves to the right.

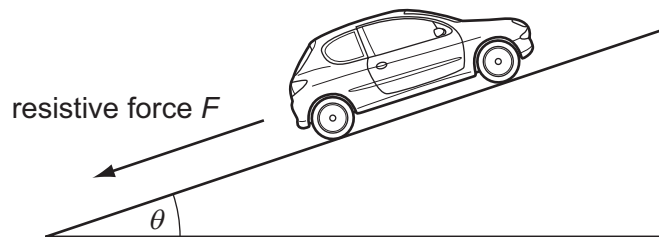
Space for working

- 14** A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which expression is equal to the upthrust on the block?

- A** $(p_b - p_t)A + W$
- B** $(p_b - p_t)$
- C** $(p_b - p_t)A$
- D** $(p_b - p_t)A - W$

- 15** A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F .



What force is needed to propel the car at this constant speed?

- A** $mg \cos \theta$
- B** $mg \sin \theta$
- C** $mg \cos \theta + F$
- D** $mg \sin \theta + F$

Space for working

- 16** The force resisting the motion of a car is taken as being proportional to the square of the car's speed. The magnitude of the force at a speed of 20 m s^{-1} is 800 N.

What effective power is required from the car's engine to maintain a steady speed of 40 m s^{-1} ?

- A** 32 kW **B** 64 kW **C** 128 kW **D** 512 kW

- 17** A concrete cube of side 0.60 m and uniform density $2.0 \times 10^3 \text{ kg m}^{-3}$ is lifted 5.0 m vertically by a crane.

What is the change in potential energy of the cube?

- A** 2.2 kJ **B** 21 kJ **C** 59 kJ **D** 450 kJ

- 18** What is the internal energy of an object?

- A** It is the energy associated with the object's movement through space.
B It is the energy associated with the random movement of the molecules in the object.
C It is the energy due to the attractions between the molecules in the object.
D It is the sum of all the microscopic potential and kinetic energies of the molecules in the object.

Space for working

19 The data below are taken from a test of a petrol engine for a motor car.

power output	150 kW
fuel consumption	20 litres per hour
energy content of fuel	40 MJ per litre

Which expression will evaluate the efficiency of the engine?

A $\frac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$

B $\frac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$

C $\frac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$

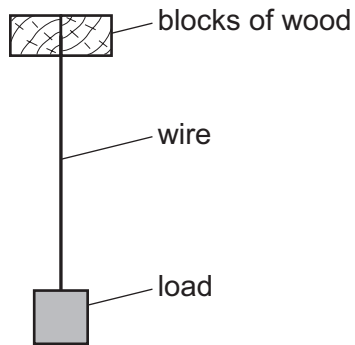
D $\frac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

20 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)?

- A elastic limit
- B spring constant
- C stress
- D Young modulus

Space for working

- 21 The diagram shows a wire of diameter D and length L that is firmly clamped at one end between two blocks of wood. A load is applied to the wire which causes it to extend by an amount x .



By how much would a wire of the same material, but of diameter $2D$ and length $3L$, extend when the same load is applied?

- A** $\frac{2}{3}x$ **B** $\frac{3}{4}x$ **C** $\frac{4}{3}x$ **D** $\frac{3}{2}x$
- 22 Which property of a metal wire depends on its Young modulus?
- A** ductility
B elastic limit
C spring constant
D ultimate tensile stress

Space for working

- 23** When white sugar granules are heated, they melt. When the melt is cooled quickly, a brittle solid form of toffee is produced.

How does the structure of the sugar change?

- A** amorphous to polymeric
 - B** crystalline to amorphous
 - C** crystalline to polymeric
 - D** polymeric to amorphous
- 24** At room temperature, the density of liquid mercury is five times greater than the density of solid aluminium.

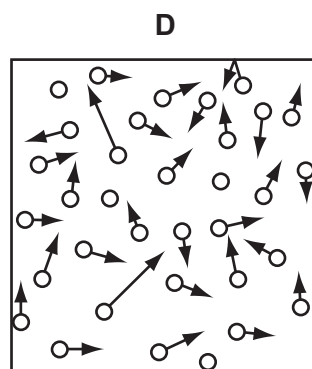
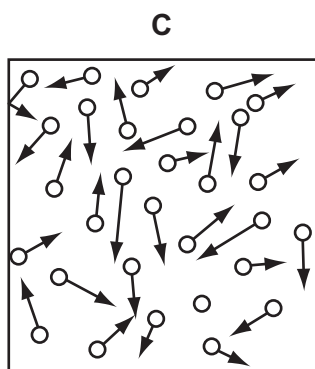
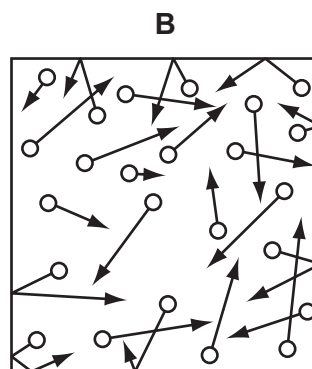
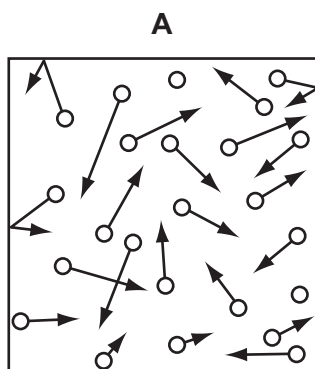
What is the reason for this?

- A** Aluminium atoms are spaced widely apart.
- B** Aluminium atoms move more freely than mercury atoms.
- C** Atoms in a liquid take up less space than atoms in a solid.
- D** Mercury atoms have greater mass than aluminium atoms.

Space for working

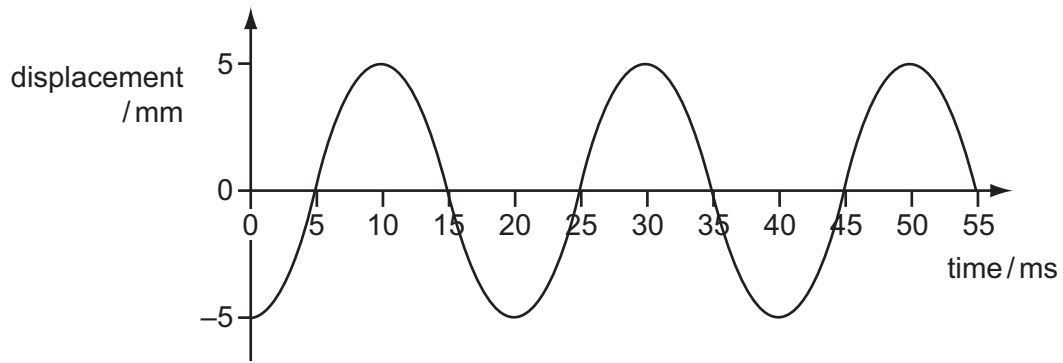
- 25 Each box shows identical molecules of a gas represented by circles with arrows to show the direction of travel and the speed of the molecule. A longer arrow represents a higher speed.

Which box contains a gas of the highest density and the lowest temperature?



Space for working

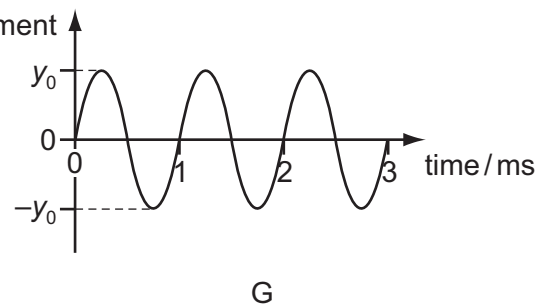
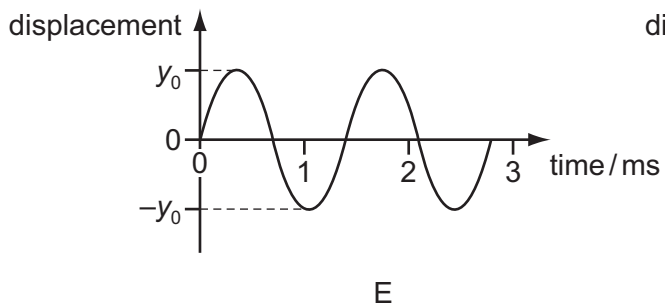
26 The diagram shows a displacement-time graph for a progressive wave.



What are the amplitude and frequency of the wave?

	amplitude / mm	frequency / Hz
A	5	40
B	5	50
C	10	40
D	10	50

27 Two waves E and G are shown. The waves have the same speed.

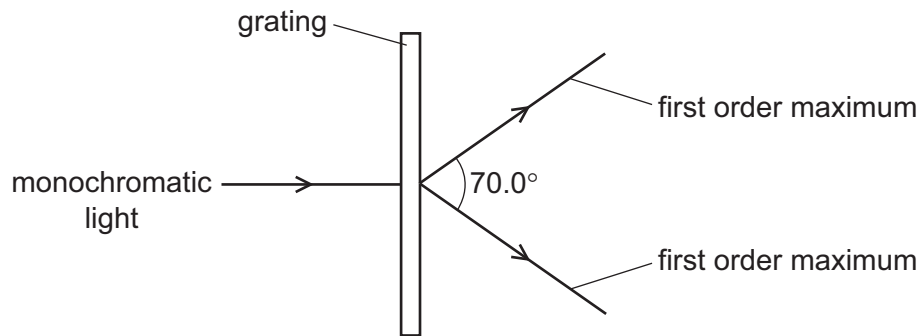


Which statement is correct?

- A** Wave E has a greater amplitude than wave G.
- B** Wave E has a greater intensity than wave G.
- C** Wave E has a smaller frequency than wave G.
- D** Wave E has a smaller wavelength than wave G.

Space for working

- 28 A diffraction grating is used to measure the wavelength of monochromatic light, as shown in the diagram.



The spacing of the slits in the grating is 1.00×10^{-6} m. The angle between the first order diffraction maxima is 70.0° .

What is the wavelength of the light?

- A** 287 nm **B** 470 nm **C** 574 nm **D** 940 nm
- 29 Which observation indicates that sound waves are longitudinal?
- A** Sound can be reflected from a solid surface.
- B** Sound cannot be polarised.
- C** Sound is diffracted around corners.
- D** Sound is refracted as it passes from hot air to cold air.

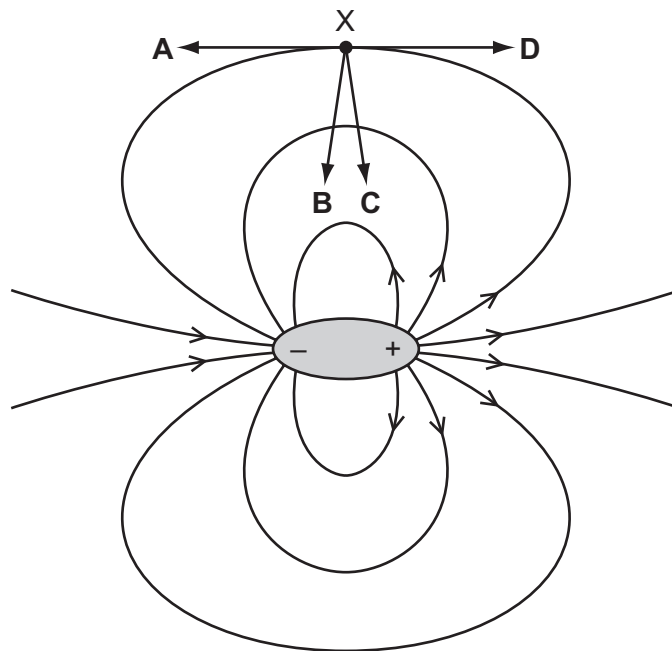
Space for working

- 30 To produce a stationary wave, two waves must travel in opposite directions through the same space.

Which statement about the properties of the two waves must also be true?

- A The waves must have equal frequency, but a different speed and wavelength.
 - B The waves must have equal speed, but a different wavelength and frequency.
 - C The waves must have equal speed, frequency and wavelength.
 - D The waves must have equal wavelength, but a different speed and frequency.
- 31 A dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of a dipole is shown below.

In which direction does the force act on an electron when at point X?



Space for working

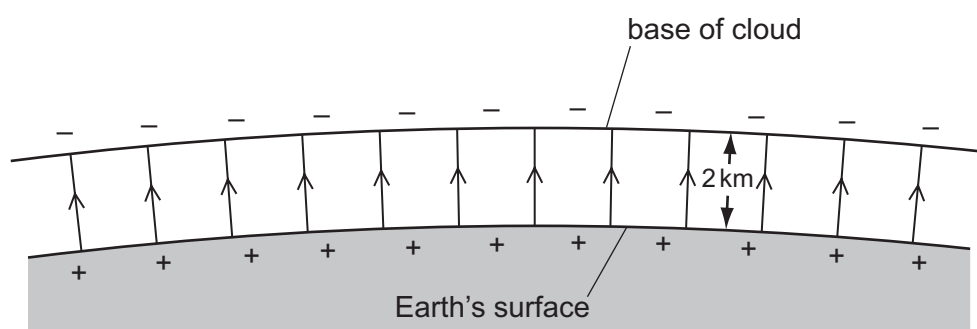
- 32 An iron wire has length 8.0 m and diameter 0.50 mm. The wire has resistance R .

A second iron wire has length 2.0 m and diameter 1.0 mm.

What is the resistance of the second wire?

- A $\frac{R}{16}$ B $\frac{R}{8}$ C $\frac{R}{2}$ D R

- 33 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kNC^{-1} . The diagram shows the electric field between the base of a cloud and the Earth's surface.



What is the minimum potential difference between the Earth and the base of a cloud, 2 km high, for lightning to occur?

- A 12.5 MV B 25 MV C 50 MV D 100 MV

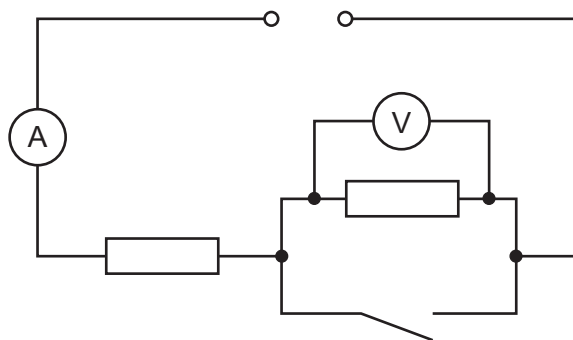
- 34 There is a current of 10 mA in a conductor for half an hour.

How much charge passes a point in the conductor in this time?

- A 0.3 C B 5 C C 18 C D 300 C

Space for working

35 In the circuit below, the ammeter reading is I and the voltmeter reading is V .

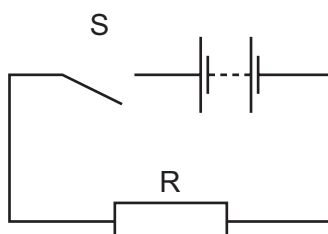


When the switch is closed, which row describes what happens to I and V ?

	I	V
A	decreases	decreases to zero
B	increases	decreases to zero
C	increases	stays the same
D	stays the same	increases

Space for working

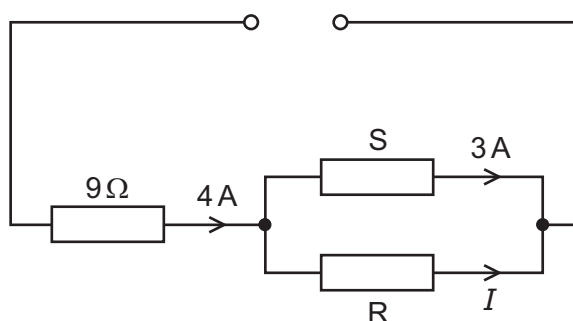
36 The diagram shows a simple circuit.



Which statement is correct?

- A** When switch S is closed, the electromotive force (e.m.f.) of the battery falls because work is done against the internal resistance of the battery.
- B** When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance R.
- C** When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.
- D** When switch S is closed, the potential difference across the battery falls because work is done against the resistance R.

37 The circuit below has a current I in the resistor R.

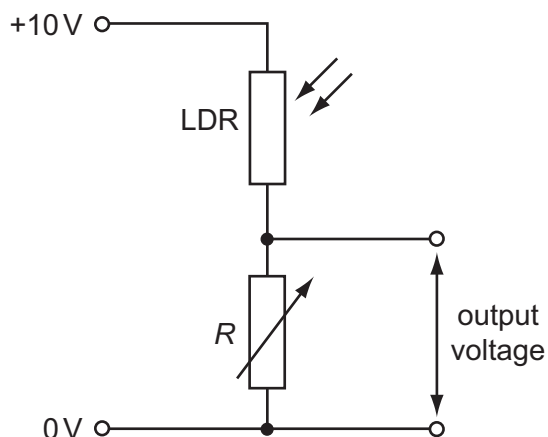


What must be known in order to determine the value of I ?

- A** e.m.f. of the power supply
- B** resistance of resistor S
- C** Kirchhoff's first law
- D** Kirchhoff's second law

Space for working

- 38 A potential divider consists of a light-dependent resistor (LDR) in series with a variable resistor of resistance R . The resistance of the LDR decreases when the light level increases. The variable resistor can be set at either high resistance or low resistance.



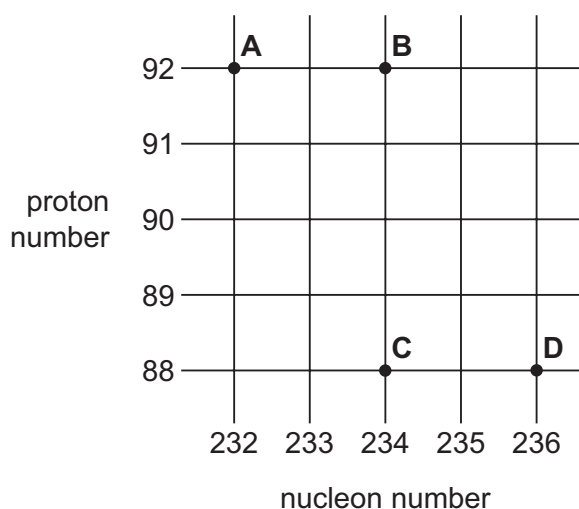
Which situation gives the largest output voltage?

	light level at LDR	R
A	high	high
B	high	low
C	low	high
D	low	low

Space for working

- 39 Thorium-234 ($^{234}_{90}\text{Th}$) decays by β -emission into a daughter product which in turn decays by further β -emission into a granddaughter product.

Which letter in the diagram represents the granddaughter product?



- 40 An experiment in which α -particles were deflected by a gold foil produced new insights into the structure of the atom.

Which conclusion can be drawn from the results of the experiment?

- A Atomic nuclei occupy a very small fraction of the volume of an atom.
- B Electrons orbit the atomic nucleus.
- C Some atoms of the same element contain different numbers of neutrons.
- D The atomic nucleus contains protons and neutrons.

Space for working