Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2020**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **20** pages. Blank pages are indicated.

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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	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\text{m F}^{-1})$
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 unit	$1\,\text{u} = 1.66 \times 10^{-27}\,\text{kg}$
rest mass of electron	$m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$
rest mass of proton	$m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$
molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
the Avogadro constant	$N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$g = 9.81\,\text{m s}^{-2}$

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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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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[Turn over

1 Which quantity is a physical quantity?

A atomic number

B efficiency

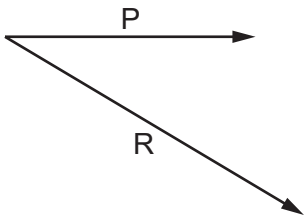
C number density of charge carriers

D strain

2 Which time interval is the shortest?

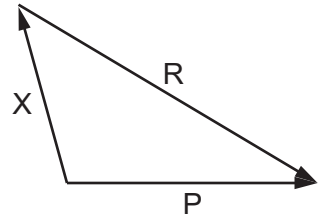
A 0.05 ms **B** 50 ns **C** 500 000 ps **D** 0.5 μs

3 P and R are coplanar vectors.

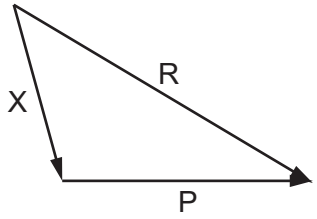


If X = P – R, which diagram best represents vector X?

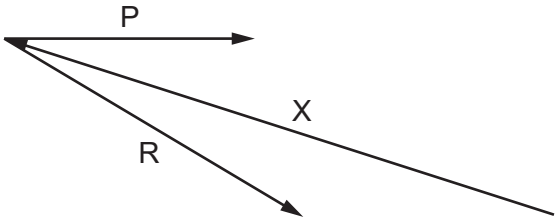
A



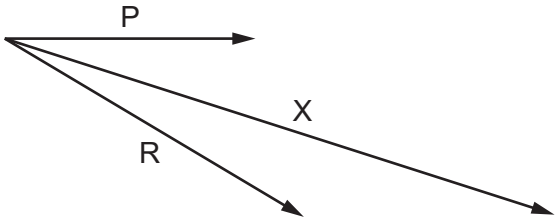
B



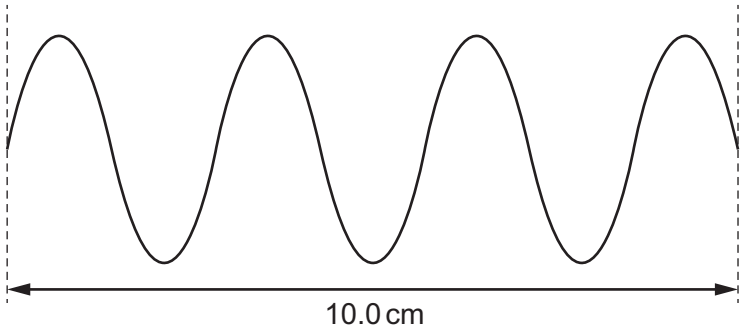
C



D



4 A student uses a cathode-ray oscilloscope (CRO) to measure the period of a signal. She sets the time-base of the CRO to $5\,\text{ms}\,\text{cm}^{-1}$ and observes the trace illustrated below. The trace has a length of 10.0 cm.



What is the period of the signal?

A $7.1 \times 10^{-6}\,\text{s}$ **B** $1.4 \times 10^{-5}\,\text{s}$ **C** $7.1 \times 10^{-3}\,\text{s}$ **D** $1.4 \times 10^{-2}\,\text{s}$

5 The diameter of a spherical golf ball is measured with calipers and found to be $(4.11 \pm 0.01)\,\text{cm}$.

The volume of a sphere is $V = \frac{1}{6}\pi d^3$, where d is the diameter of the sphere.

What is the volume of the golf ball?

A $(36.35 \pm 0.01)\,\text{cm}^3$

B $(36.35 \pm 0.03)\,\text{cm}^3$

C $(36.35 \pm 0.09)\,\text{cm}^3$

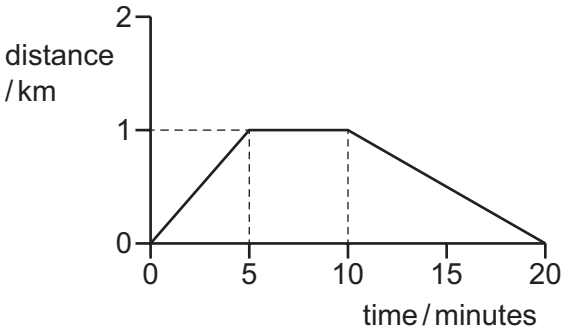
D $(36.4 \pm 0.3)\,\text{cm}^3$

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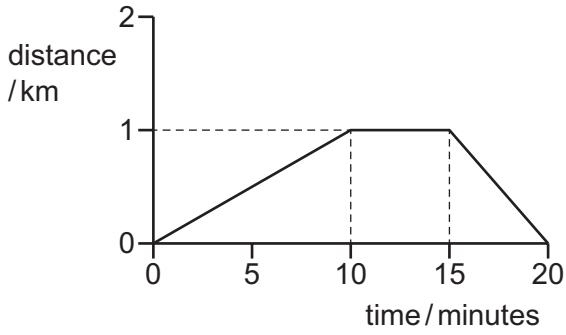
6 A student cycles uphill from home to a shop, taking 10 minutes. The student then spends 5 minutes in the shop, before cycling home downhill at twice the initial speed.

Which graph could show the variation with time of the distance travelled by the cyclist?

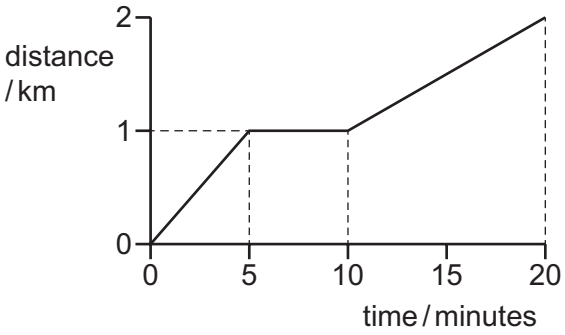
A



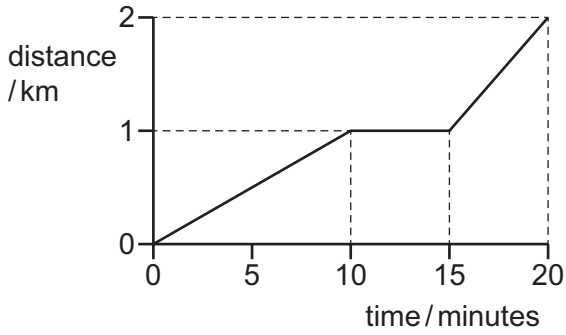
B



C

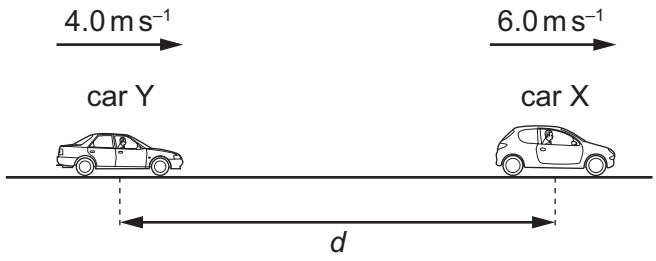


D



7 Two cars X and Y are travelling along the same straight road. Car X is travelling at a constant speed of $6.0\,m\,s^{-1}$. Car Y has a constant acceleration of $0.50\,m\,s^{-2}$.

At the instant shown, car X is a distance d ahead of car Y. Car Y is travelling at a speed of $4.0\,m\,s^{-1}$.



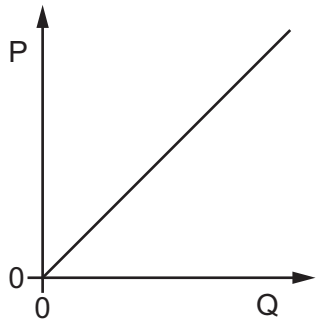
Car Y is level with car X after a time of 20 seconds.

What is the distance d?

A 40 m **B** 60 m **C** 180 m **D** 300 m

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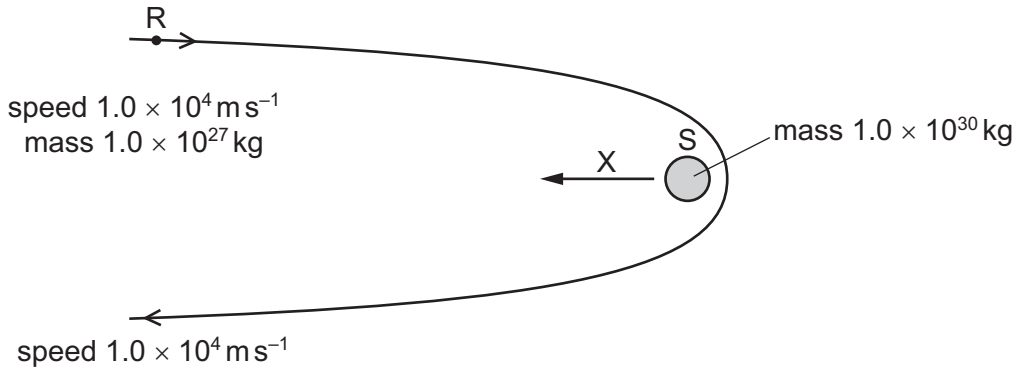
8 The graph shows how quantity P varies with quantity Q for an object falling in air for a long time in a uniform gravitational field.



What could be the identities of P and Q?

	P	Q
A	force of air resistance	acceleration
B	kinetic energy	time
C	potential energy	height
D	work done against air resistance	speed

9 A rock R of mass 1.0×10^{27} kg is a large distance from a star S and is travelling at a speed of $1.0 \times 10^{4}\,m\,s^{-1}$. The star has mass 1.0×10^{30} kg. The rock travels around the star on the path shown so that it reverses its direction of motion and, when finally again a large distance from the star, has the same speed as initially.



Which statement is correct?

A The change in the momentum of S is in the direction of arrow X.

B The change in the velocity of S is approximately $20\,m\,s^{-1}$.

C The magnitude of the change of momentum of R is 10^{3} times greater than the magnitude of the change of momentum of S.

D The momentum of R does not change.

10 The diagram shows the masses and velocities of two trolleys that are about to collide.



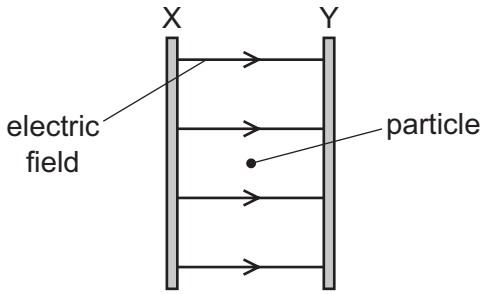
After the impact they move off together.

What is the kinetic energy lost in the collision?

A 4 J **B** 6 J **C** 12 J **D** 14 J

11 A particle is situated at rest between two metal plates X and Y.

A potential difference (p.d.) is then applied across the plates and produces the electric field shown.



The particle moves towards plate X when the p.d. is applied.

What could be the particle?

A alpha-particle

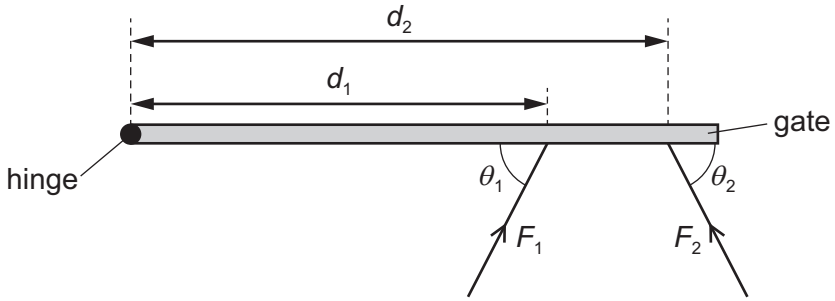
B electron

C neutron

D proton

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12 Two people push a vertical gate to open it. The forces exerted by the people on the gate are shown.



One person is distance d_1 from the gate's hinge and pushes with horizontal force F_1 at angle θ_1 to the gate.

The other person is at distance d_2 from the hinge and pushes with horizontal force F_2 at an angle θ_2 to the gate.

What is the total moment about the hinge due to forces F_1 and F_2?

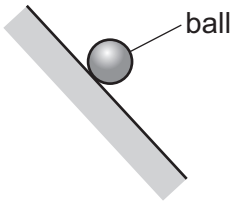
A $(d_1 \times F_1 \cos \theta_1) + (d_2 \times F_2 \cos \theta_2)$

B $(d_1 \times F_1 \sin \theta_1) + (d_2 \times F_2 \sin \theta_2)$

C $(d_1 \times F_1 \cos \theta_1) - (d_2 \times F_2 \cos \theta_2)$

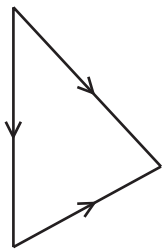
D $(d_1 \times F_1 \sin \theta_1) - (d_2 \times F_2 \sin \theta_2)$

13 A ball is rolling down a slope at a constant speed. The three forces acting on the ball are its weight, the contact force normal to the slope and friction.

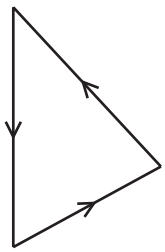


Which diagram could represent these three forces?

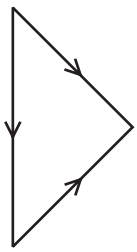
A



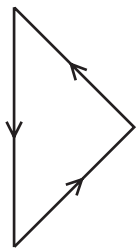
B



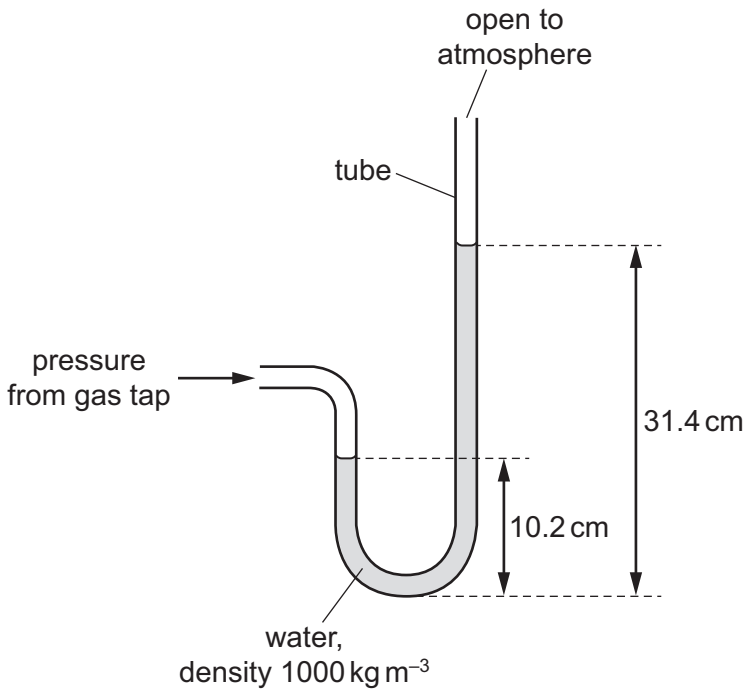
C



D



14 One end of a U-shaped tube is attached to a gas tap, with its other end open to the atmosphere. It contains water of density 1000 kg m^{-3} and the heights of both sides of the water column are shown.

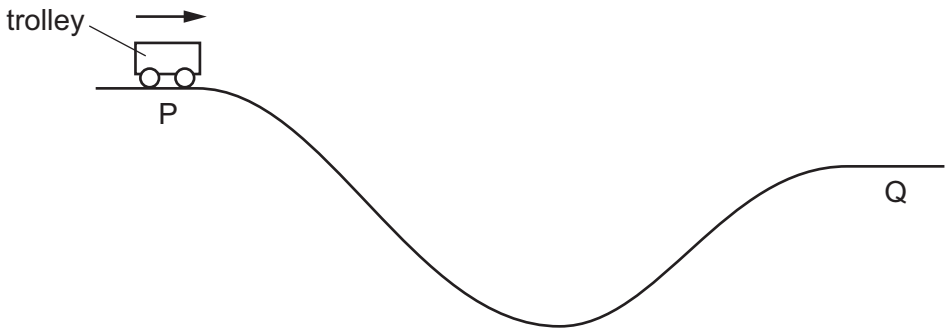


The atmospheric pressure is 101 kPa.

What is the pressure of the gas from the gas tap?

A 99 kPa **B** 100 kPa **C** 102 kPa **D** 103 kPa

15 A trolley runs from P to Q along a track. At Q its potential energy is 50 kJ less than at P.



At P, the kinetic energy of the trolley is 5 kJ. Between P and Q, the trolley does 10 kJ of work against friction.

What is the kinetic energy of the trolley at Q?

A 35 kJ **B** 45 kJ **C** 55 kJ **D** 65 kJ

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16 A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^5\,\text{kg s}^{-1}$. The water falls through a vertical height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

A 5.6% **B** 43% **C** 57% **D** 77%

17 Which amount of energy is **not** 2400 J?

A the decrease in gravitational potential energy of a mass of 60 kg when it moves vertically downwards through 40 m near the Earth's surface

B the energy transferred in 15 s by a machine of power 160 W

C the kinetic energy of a mass of 12 kg moving at a speed of $20\,\text{m s}^{-1}$

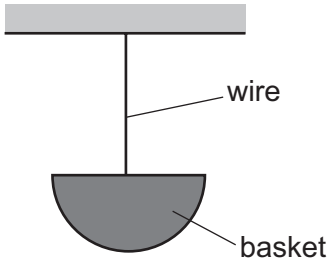
D the work done by a gas expanding against a constant external pressure of 120 kPa when its volume increases by $0.020\,\text{m}^3$

18 A train of mass 300 000 kg is accelerating at $0.80\,\text{m s}^{-2}$. At one instant, the speed of the train is $5.0\,\text{m s}^{-1}$ and the resistive force to its motion is 15 kN.

At this instant, what is the rate of increase of kinetic energy of the train?

A 0.075 MW **B** 1.2 MW **C** 1.3 MW **D** 3.8 MW

19 A wire of circular cross-section, which obeys Hooke's law, is used to suspend a basket as shown.



The Young modulus for the material of the wire is $2.5 \times 10^{11}\,\text{Pa}$.

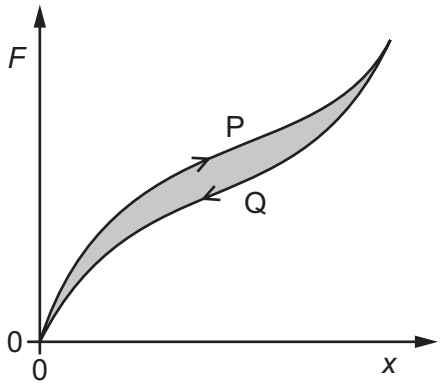
When a weight of 34 N is added to the basket, the strain in the wire increases by 6.0×10^{-5}.

What is the radius of the wire?

A $7.2 \times 10^{-7}\,\text{m}$ **B** $2.3 \times 10^{-6}\,\text{m}$ **C** $8.5 \times 10^{-4}\,\text{m}$ **D** $1.7 \times 10^{-3}\,\text{m}$

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20 An unstretched rubber cord is stretched by a force. The force F is plotted against the extension x. F is slowly increased from zero, causing the cord to extend along path P. F is then reduced back to zero along path Q.



What is represented by the shaded area?

A the elastic energy stored in the rubber cord

B the energy that causes plastic deformation

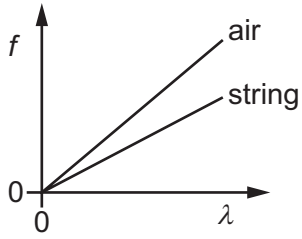
C the energy dissipated as heat

D the work done to extend the rubber cord

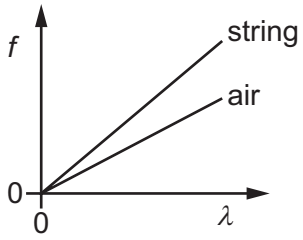
21 A guitar string vibrates to create a sound. The speed of the wave in the guitar string is always $440\,m\,s^{-1}$. The vibrating string creates a sound wave that moves in the air with a speed of $330\,m\,s^{-1}$.

Which graph shows the variation of frequency f with the wavelength λ for the waves in the string and in the air?

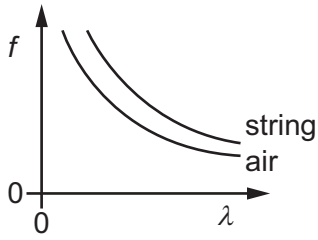
A



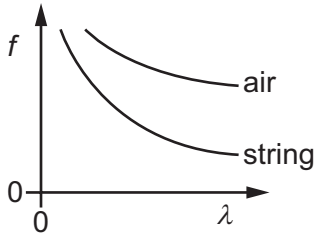
B



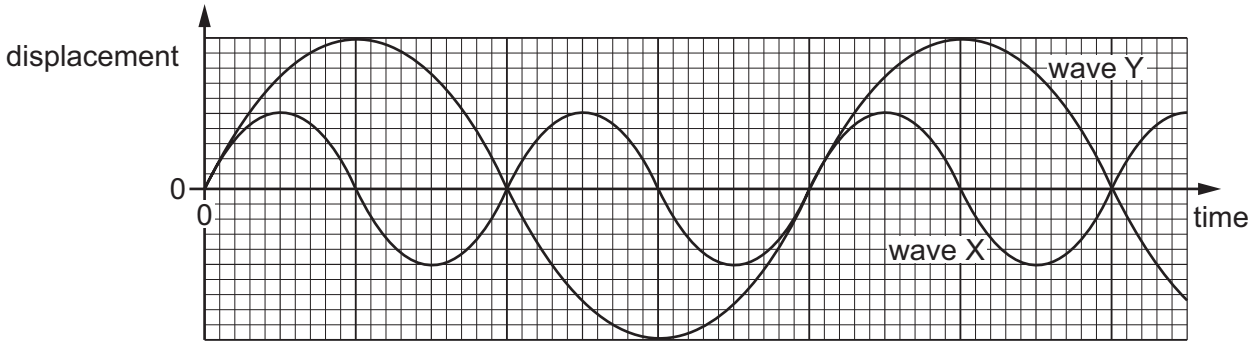
C



D



22 The graph shows the variation with time of displacement for two different waves X and Y.

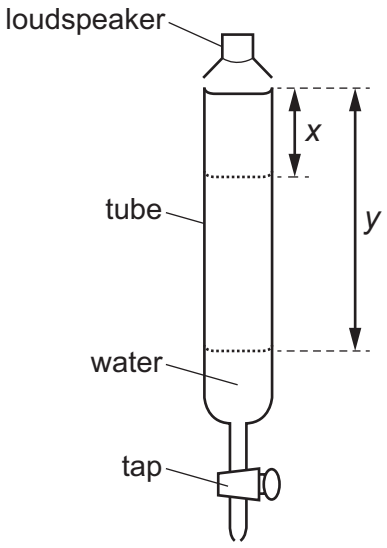


Wave X has frequency f and amplitude A.

What is the frequency and what is the amplitude of wave Y?

	frequency	amplitude
A	$\frac{1}{2}f$	$\frac{1}{2}A$
B	$\frac{1}{2}f$	$2A$
C	$2f$	$\frac{1}{2}A$
D	$2f$	$2A$

23 A loudspeaker emits a sound wave into a tube initially full of water.



A tap at the bottom of the tube is opened so that water slowly leaves the tube. For some lengths of the air column in the tube, the sound heard is much louder.

The first loud sound is heard when the air column in the tube has length x.

The next time that a loud sound is heard is when the air column in the tube has length y.

What is the wavelength of the sound wave from the loudspeaker?

A $2x$ **B** $4y$ **C** $2(y - x)$ **D** $4(y - x)$

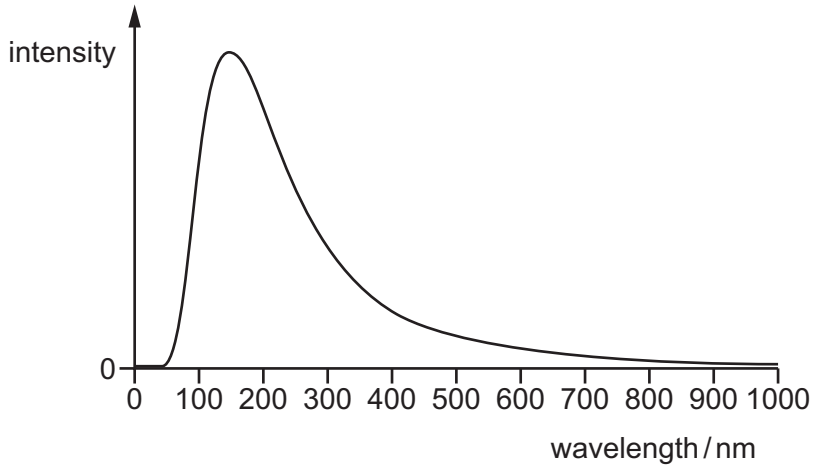
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24 A source of sound of frequency 1000 Hz directly approaches a stationary observer. The observer measures the frequency of the received sound to be 1500 Hz. The speed of sound in still air is $330\,m\,s^{-1}$.

What is the speed of the source of sound?

A $110\,m\,s^{-1}$ **B** $165\,m\,s^{-1}$ **C** $220\,m\,s^{-1}$ **D** $330\,m\,s^{-1}$

25 The graph shows how the intensity of electromagnetic radiation emitted from a distant star varies with wavelength.



In which region of the electromagnetic spectrum is the radiation of greatest intensity?

A infrared

B visible light

C ultraviolet

D X-ray

26 Which statement concerning a stationary wave is correct?

A All the particles between two adjacent nodes oscillate in phase.

B The amplitude of the stationary wave is equal to the amplitude of one of the waves creating it.

C The wavelength of the stationary wave is equal to the separation of two adjacent nodes.

D There is no displacement of a particle at an antinode at any time.

27 Which waves would best demonstrate diffraction through a doorway?

A sound waves

B ultraviolet waves

C visible light waves

D X-rays

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28 Two loudspeakers are placed near to each other and facing in the same direction.

A microphone connected to an oscilloscope is moved along a line some distance away from the loudspeakers, as shown.



Which statement about the waves emitted by the loudspeakers is **not** a necessary condition for the microphone to detect a fixed point along the line where there is no sound?

A The waves must be emitted in phase.

B The waves must be emitted with a similar amplitude.

C The waves must have the same frequency.

D The waves must have the same wavelength.

29 A parallel beam of white light passes through a diffraction grating. Orange light of wavelength 600 nm in the fourth-order diffraction maximum coincides with blue light in the fifth-order diffraction maximum.

What is the wavelength of the blue light?

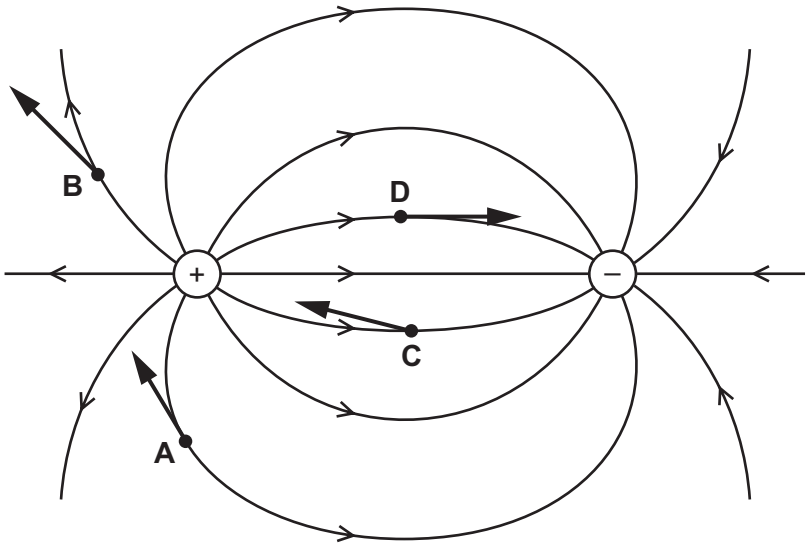
A 450 nm **B** 480 nm **C** 500 nm **D** 750 nm

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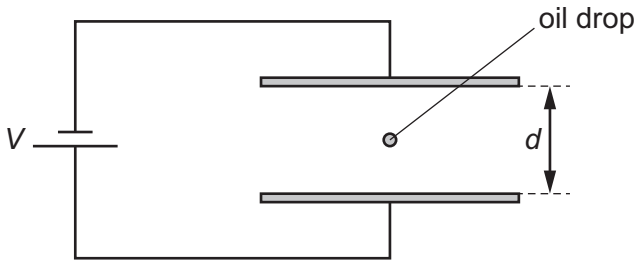
30 The diagram shows the electric field near a positively charged sphere and a negatively charged sphere.

Four electrons **A**, **B**, **C** and **D** are shown at different positions in the field.

On which electron is the direction of the force on the electron shown correctly?



31 An oil drop has mass m and charge q. The drop is held stationary in an electric field between two parallel horizontal plates, a distance d apart, as shown.



The potential difference between the plates is V and the acceleration of free fall is g.

What is the charge-to-mass ratio $\frac{q}{m}$ of the oil drop?

A $\frac{gd}{V}$ **B** $\frac{V}{dg}$ **C** $\frac{gV}{d}$ **D** $\frac{d}{Vg}$

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32 Free electrons flow along a copper wire X of radius 5.0×10^{-5} m with an average drift speed of $2.8 \times 10^{-2}\,\text{m s}^{-1}$. The current in the wire is 3.0 A.

There is a current of 2.0 A in a copper wire Y of radius 1.0×10^{-4} m.

What is the average drift speed of the free electrons in copper wire Y?

A $4.7 \times 10^{-3}\,\text{m s}^{-1}$

B $9.3 \times 10^{-3}\,\text{m s}^{-1}$

C $1.1 \times 10^{-2}\,\text{m s}^{-1}$

D $1.9 \times 10^{-2}\,\text{m s}^{-1}$

33 What is the definition of potential difference?

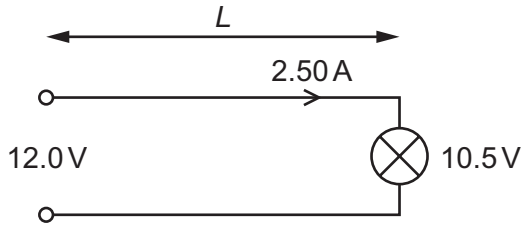
A power per unit current

B product of current and resistance

C product of electric field strength and distance

D work done per unit charge

34 A cable of length *L* consisting of two wires is used to connect a 12.0 V power supply of negligible internal resistance to a lamp, as shown.



The potential difference across the lamp is 10.5 V. The current in the wire is 2.50 A.

Each wire is made of metal of resistivity $1.70 \times 10^{-8}\,\Omega\text{m}$ and has a cross-sectional area of $6.00 \times 10^{-7}\,\text{m}^2$.

What is the length *L* of the cable?

A 10.6 m **B** 21.2 m **C** 29.4 m **D** 58.8 m

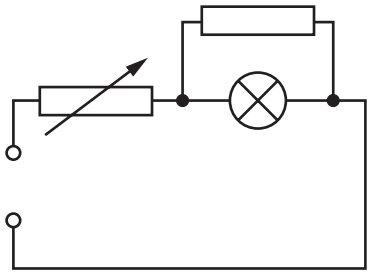
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35 In the circuits shown, the power supply has an electromotive force (e.m.f.) greater than the normal operating voltage of the lamp. The internal resistance of the power supply is negligible.

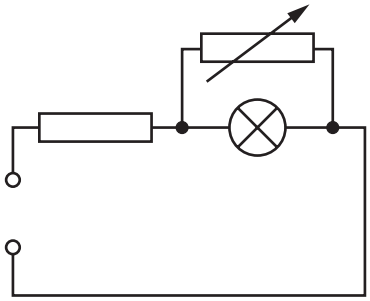
The resistance of the variable resistor is adjusted from zero to its maximum value.

In which circuit could the voltage across the lamp change from zero to its normal operating voltage and **not** exceed its normal operating voltage?

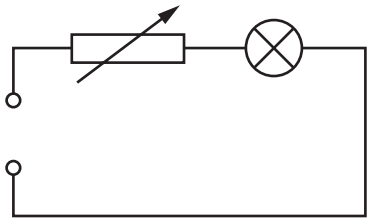
A



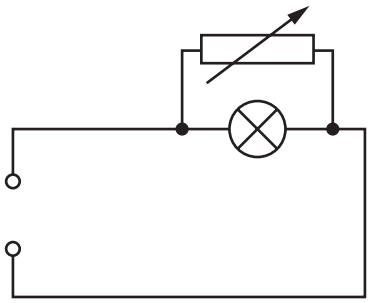
B



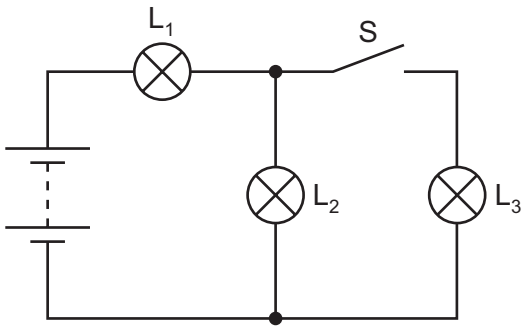
C



D



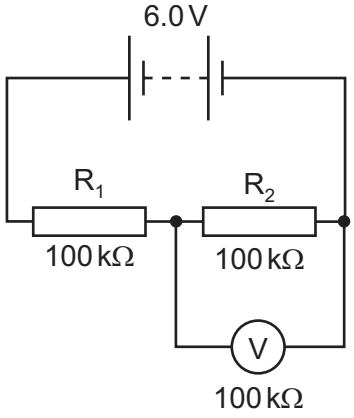
36 Three identical lamps L_1, L_2 and L_3 are connected to a battery with negligible internal resistance, as shown.



What happens to the brightness of lamps L_1 and L_2 when the switch S is closed?

	lamp L_1	lamp L_2
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

37 In the circuit shown, the 6.0 V battery has negligible internal resistance. Resistors R_1 and R_2 and the voltmeter each have a resistance of 100 kΩ.



What is the current in the resistor R_2?

A 20 μA **B** 30 μA **C** 40 μA **D** 60 μA

38 Which statement about two nuclei that are isotopes of the same element is correct?

A The nuclei each have the same acceleration when in the same uniform electric field.

B The nuclei each have the same number of neutrons.

C The nuclei each have the same number of nucleons.

D Uncharged atoms containing the nuclei each have the same number of electrons.

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39 In a nuclear physics experiment, a nucleus of $^{32}_{16}S$ collides with a nucleus of $^{94}_{42}Mo$. The nuclei combine together and immediately emit a single alpha-particle.

The nuclear reaction is shown.

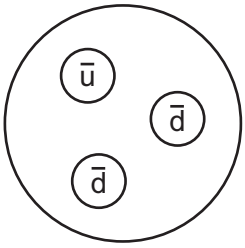
$$^{32}_{16}S + {}^{94}_{42}Mo \rightarrow X + \alpha$$

What is nucleus X?

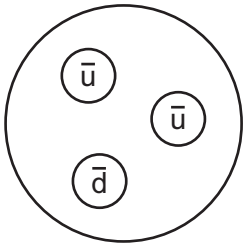
A $^{122}_{56}X$ **B** $^{124}_{54}X$ **C** $^{126}_{58}X$ **D** $^{126}_{59}X$

40 Which diagram represents the quark composition of an antineutron?

A



B



key

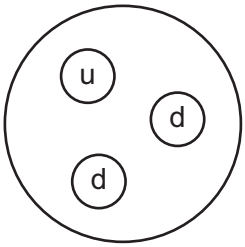
u up quark

d down quark

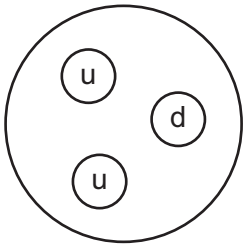
ū up antiquark

d̄ down antiquark

C



D



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PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2020**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

IB20 11_9702_12/3RP
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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	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$
	$\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\text{m F}^{-1}\right)$
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 unit	$1\,\text{u} = 1.66 \times 10^{-27}\,\text{kg}$
rest mass of electron	$m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$
rest mass of proton	$m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$
molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
the Avogadro constant	$N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$g = 9.81\,\text{m s}^{-2}$

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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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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[Turn over

1 A student uses the volume of a metal coin in order to determine the density of the metal.

What is **not** needed in order to determine an estimate of the volume of the coin?

A estimate of the diameter

B estimate of the mass

C estimate of the thickness

D use of the formula for the volume of a cylinder

2 The speed v of waves on a stretched wire is given by the equation

$$v = T^p \mu^q$$

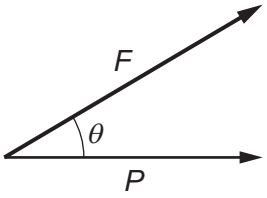
where T is the tension in the wire and μ is the mass per unit length of the wire.

What are the values of p and q?

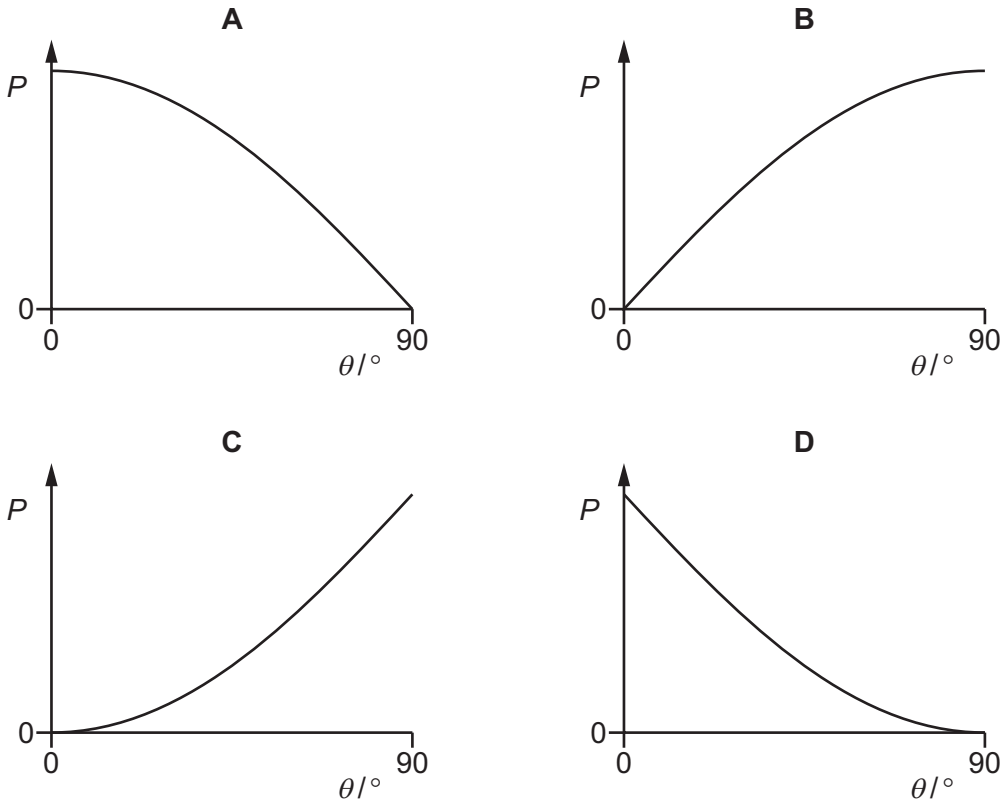
	p	q
A	$-\frac{1}{2}$	$-\frac{1}{2}$
B	$-\frac{1}{2}$	$\frac{1}{2}$
C	$\frac{1}{2}$	$-\frac{1}{2}$
D	$\frac{1}{2}$	$\frac{1}{2}$

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3 The diagram shows a force *F*. *P* is the horizontal component of *F*, at an angle θ to *F*.



Which graph best shows the variation with θ of the magnitude of *P*?



4 A student wishes to measure a distance of about 10 cm to a precision of 0.01 cm.

Which measuring instrument should be used?

A metre rule

B micrometer

C tape measure

D vernier calipers

5 A steel ball is dropped and falls through a vertical height h. The time t taken to fall is measured using light gates.

The results are given in the table.

h	$(4.05 \pm 0.01)\,\text{m}$
t	$(0.91 \pm 0.02)\,\text{s}$

The acceleration of free fall g is calculated using the equation shown.

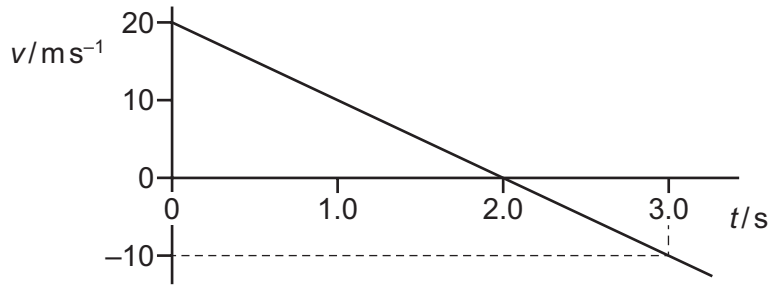
$$h = \tfrac{1}{2}gt^2$$

What is the percentage uncertainty in the value of g?

A 2.4% **B** 4.6% **C** 5.1% **D** 9.3%

6 A stone is thrown vertically upwards from a point X at time $t = 0$.

The variation with time t of the velocity v of the stone is shown.



What is the displacement of the stone from point X at time $t = 3.0\,\text{s}$?

A 15 m above X

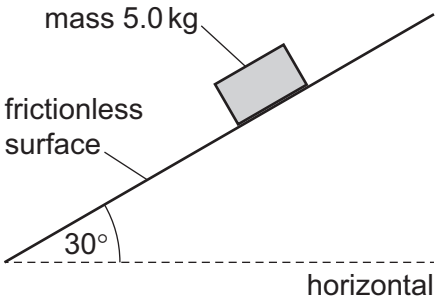
B 15 m below X

C 25 m above X

D 25 m below X

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7 A mass of 5.0 kg is released from rest on a frictionless surface inclined at 30° to the horizontal. Air resistance is negligible.



How far does the mass travel in a time of 0.80 s?

A 1.6 m **B** 2.0 m **C** 2.7 m **D** 3.1 m

8 What is **not** a statement of one of Newton's laws of motion?

A If body X exerts a force on body Y, body Y exerts an equal and opposite force on body X.

B If no resultant force acts on a body it has constant velocity.

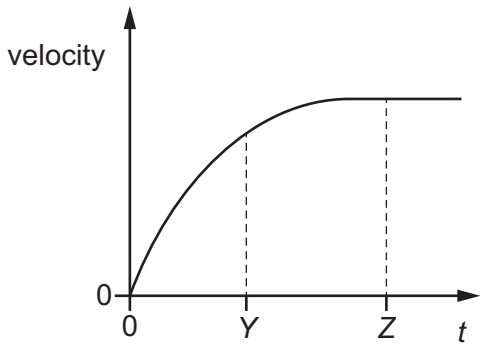
C The rate of change of momentum of a body is proportional to the resultant force acting on it and takes place in the direction of the force.

D The total momentum of a system of interacting bodies is constant if there is no external force.

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9 An object falls from a tall building.

The graph shows how the velocity of the object changes with time *t*.



The acceleration of free fall is *g*.

What describes the acceleration of the object at times $t = Y$ and $t = Z$?

	acceleration at $t = Y$	acceleration at $t = Z$
A	decreasing	*g*
B	decreasing	0
C	constant	*g*
D	constant	0

10 Two balls, one of mass 2*m* and one of mass *m*, collide.

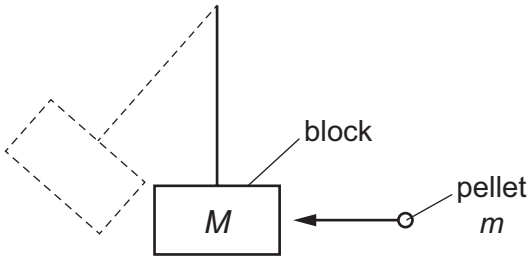
The diagrams show the initial and final velocities of the balls.

Which collision is **not** elastic?

	before collision	after collision
A	2*m* 4.0 m s^{-1} → *m* 1.0 m s^{-1} →	2*m* 2.0 m s^{-1} → *m* 5.0 m s^{-1} →
B	2*m* 6.0 m s^{-1} → *m* 3.0 m s^{-1} →	2*m* 4.0 m s^{-1} → *m* 7.0 m s^{-1} →
C	2*m* 8.0 m s^{-1} → *m* 2.0 m s^{-1} →	2*m* 5.0 m s^{-1} → *m* 8.0 m s^{-1} →
D	2*m* 10.0 m s^{-1} → *m* 4.0 m s^{-1} →	2*m* 6.0 m s^{-1} → *m* 12.0 m s^{-1} →

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11 The diagram shows a 'ballistic pendulum'.



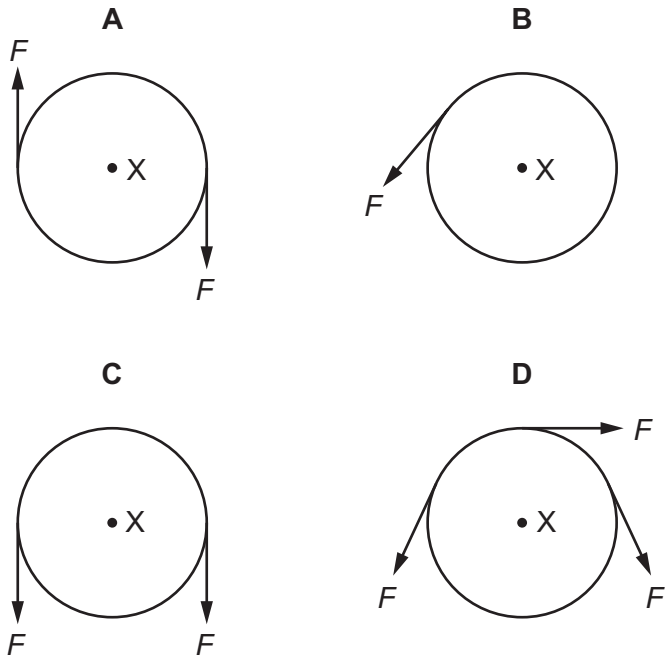
A pellet of mass m travelling at a speed u hits a stationary block of mass M. The pellet becomes embedded in the block and causes the block to move at a speed v immediately after the impact.

When a pellet of mass $2m$, travelling at a speed $2u$, hits a block of mass $2M$, what is the speed of the block immediately after the impact? (Neglect the small increase in the mass of the block as the pellet's mass is added during the collision.)

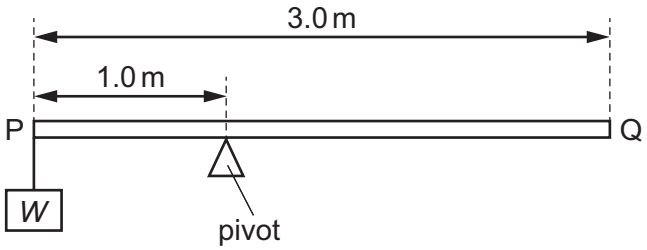
A v **B** $v\sqrt{2}$ **C** $2v$ **D** $4v$

12 A rigid circular disc of radius r has its centre at X. A number of forces of equal magnitude F act at the edge of the disc. All the forces are in the plane of the disc.

Which arrangement of forces provides a total moment of magnitude $2Fr$ about X?



13 The diagram shows a uniform beam PQ. The length of the beam is 3.0 m and its weight is 50 N. The beam is supported on a pivot 1.0 m from end P. A load of weight *W* is hung from end P. The beam is in equilibrium.



What is the value of *W*?

A 25 N **B** 50 N **C** 75 N **D** 100 N

14 In a high-wire circus act, a man of mass 85 kg is standing at rest at the midpoint of the wire.



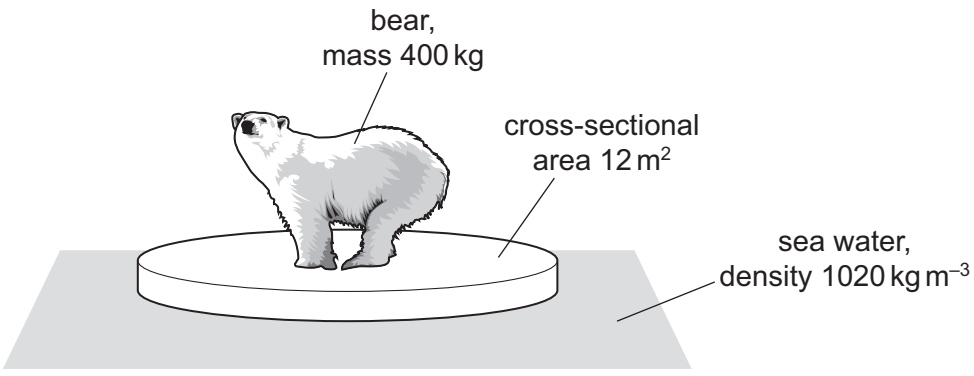
The wire on either side of the man is at an angle of 20° to the horizontal.

What is the tension *T* in the wire?

A 0.44 kN **B** 0.89 kN **C** 1.2 kN **D** 2.4 kN

15 A cylindrical block of ice of cross-sectional area 12 m^2 is floating, partially submerged, in the sea.

The density of the sea water is 1020 kg m^{-3}. A polar bear of mass 400 kg steps onto the block of ice.



The block of ice sinks a vertical distance *d*.

What is the value of *d*?

A 3.3 mm **B** 3.3 cm **C** 0.32 m **D** 3.1 m

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16 A ball is thrown vertically upwards. Air resistance is negligible.

Which statement is correct?

A By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.

B By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.

C The kinetic energy of the ball is greatest at the greatest height attained.

D The potential energy of the ball increases at a constant rate during its ascent.

17 A hammer with 10 J of kinetic energy hits a nail and pushes it 5.0 mm into a plank.

Both the hammer and nail come to rest after the collision.

What is the approximate average force that acts on the nail while it moves through 5.0 mm?

A 0.050 N **B** 2.0 N **C** 50 N **D** 2000 N

18 The change in gravitational potential energy ΔE of an object of mass m when moving through height Δh near the surface of the Earth is given by the equation shown.

$$\Delta E = mg\Delta h$$

Which equation is needed as part of the derivation of this expression?

A kinetic energy = $\frac{1}{2} \times$ mass $\times$ (speed)^2

B moment = force $\times$ distance

C weight = mass $\times$ acceleration of free fall

D work done = power $\times$ time

19 A racing car has an output power of 300 kW when travelling at a constant speed of 60 m s^{-1}.

What is the total resistive force acting on the car?

A 5 kN **B** 10 kN **C** 50 kN **D** 100 kN

20 A mass of 60.0 g is suspended from a spring and the distance from the bottom of the spring to the floor is measured to be 16.4 cm.

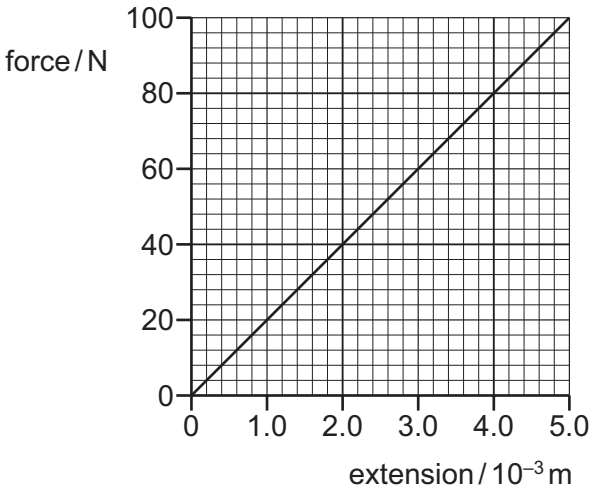
The mass is replaced with a 100.0 g mass and the distance from the bottom of the spring to the floor is now measured to be 12.6 cm. The spring obeys Hooke's law.

What is the spring constant of the spring?

A 1.05 N m^{-1} **B** 1.35 N m^{-1} **C** 10.3 N m^{-1} **D** 103 N m^{-1}

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21 The graph shows the force–extension graph for a wire.



The wire is already extended by a force of 60 N.

How much work is done to increase the extension of the wire by 2.0 mm?

A 0.040 J **B** 0.090 J **C** 0.16 J **D** 0.25 J

22 The speed v of waves in deep water is given by the equation

$$v^2 = \frac{g\lambda}{2\pi}$$

where λ is the wavelength of the waves and g is the acceleration of free fall.

A student measures the wavelength λ and the frequency f of a number of these waves.

Which graph should he plot to give a straight line through the origin?

A f^2 against λ

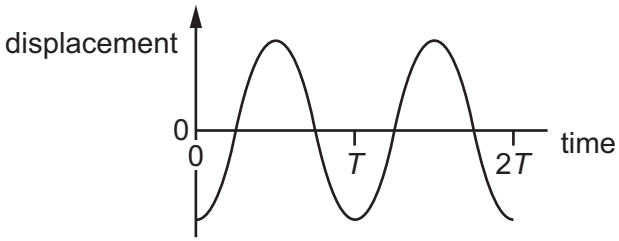
B f against λ^2

C f against $\frac{1}{\lambda}$

D f^2 against $\frac{1}{\lambda}$

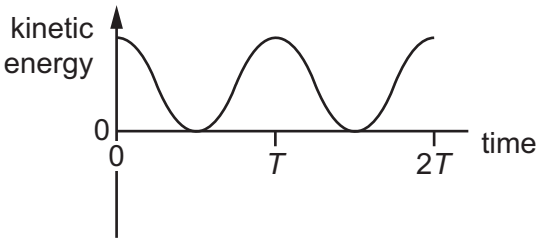
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23 When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.

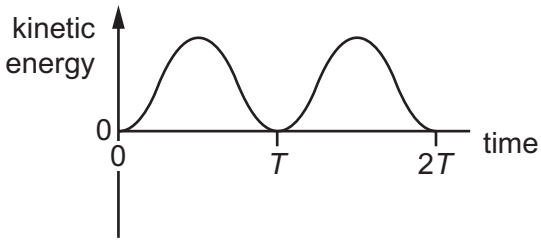


Which graph shows how the kinetic energy of the air particle varies with time?

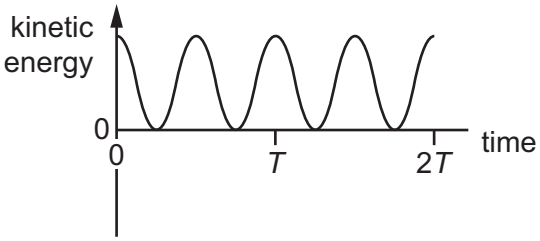
A



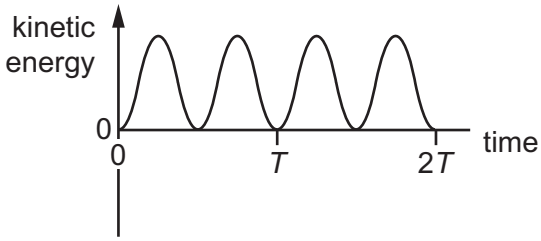
B



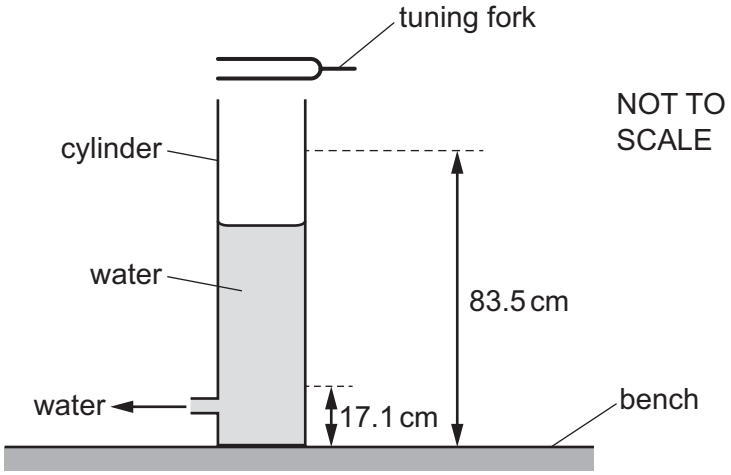
C



D



24 A vibrating tuning fork is held above a glass cylinder filled to the top with water. The water level is steadily lowered. A loud sound is first heard when the water level is 83.5 cm above the bench. The next loud sound is heard when the water level is 17.1 cm above the bench.



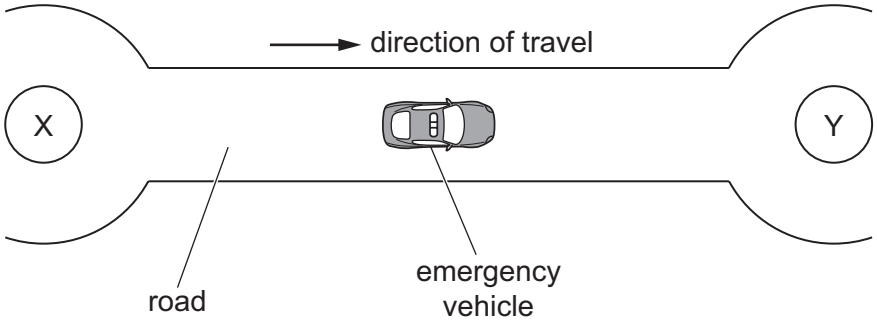
The speed of sound in air is 340 m s^{-1}.

What is the frequency of the tuning fork?

A 128 Hz **B** 256 Hz **C** 384 Hz **D** 512 Hz

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25 An emergency vehicle sounds its siren as it accelerates along a straight road between two points X and Y, as shown in the diagram.



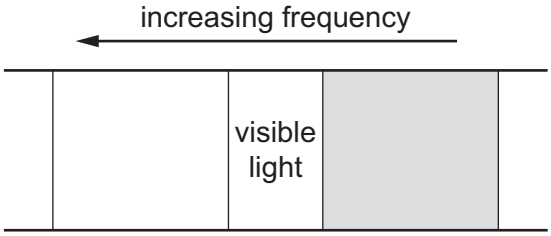
The frequency of the sound emitted by the siren is 750 Hz.

A person stands at X and another person stands at Y.

What describes the sounds heard by the people at X and at Y as the vehicle accelerates?

	sound heard by person at X	sound heard by person at Y
A	higher than 750 Hz, increasing in frequency	lower than 750 Hz, decreasing in frequency
B	higher than 750 Hz, decreasing in frequency	lower than 750 Hz, increasing in frequency
C	lower than 750 Hz, decreasing in frequency	higher than 750 Hz, increasing in frequency
D	lower than 750 Hz, increasing in frequency	higher than 750 Hz, decreasing in frequency

26 Part of the electromagnetic spectrum is shown.



What is the name of the shaded region and what is the order of magnitude of a wavelength of a wave from this region?

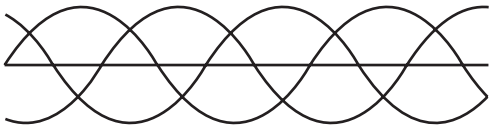
	name	wavelength / m
A	infrared	10^{-5}
B	infrared	10^{-8}
C	ultraviolet	10^{-5}
D	ultraviolet	10^{-8}

27 The three waves shown in each diagram have the same amplitude and frequency but different phase.

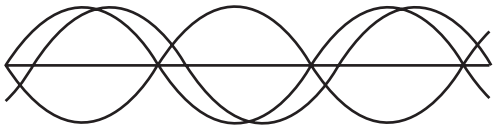
They are added together to give a resultant wave.

In which case is the resultant wave zero at this instant?

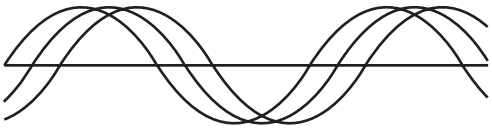
A



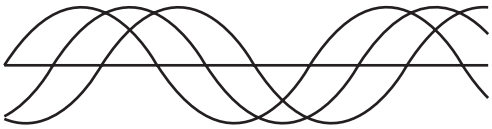
B



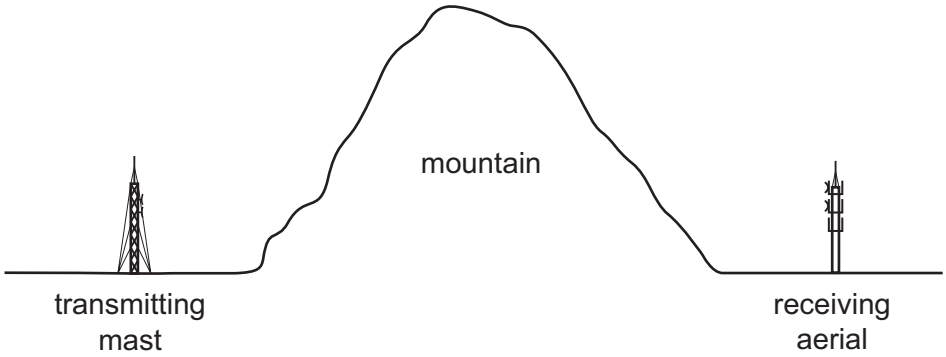
C



D



28 A transmitting mast sends out microwaves of wavelength 1.5 cm and radio waves of wavelength 1.5 km.



NOT TO SCALE

A receiving aerial behind a mountain can detect the radio waves but not the microwaves.

What is the reason for this?

A The radio waves are coherent but the microwaves are not.

B The radio waves are diffracted around the mountain but the microwaves are not.

C The radio waves are reflected by the mountain but the microwaves are not.

D The radio waves travel at the speed of light but the microwaves do not.

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29 An experiment is carried out to demonstrate double-slit interference using light of wavelength 500 nm. The distance between bright fringes in the interference pattern is 5 mm.

What are possible values for the distance between the slits and the screen, and the slit separation?

	slit–screen distance	slit separation
A	50 cm	0.5 mm
B	50 cm	5 mm
C	5 m	0.5 mm
D	5 m	5 mm

30 Light of a single frequency is incident on a diffraction grating. Seven bright spots are observed on a screen.

Which change will result in an increase in the number of bright spots observed?

A Increase the distance between the grating and the screen.

B Increase the frequency of the incident light.

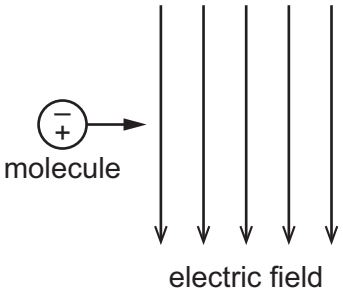
C Increase the intensity of the incident light.

D Increase the number of lines per metre in the grating.

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[Turn over

31 A molecule behaves as an electric 'dipole' consisting of two equal point charges of opposite sign, separated by a fixed distance. The molecule moves with constant horizontal velocity as it enters a vertical uniform electric field, as shown.

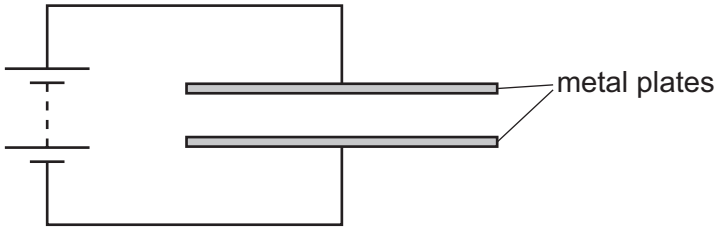


The positive and negative charges of the molecule enter the field at the same time.

What describes the effect of the electric field on the velocity of the molecule?

	horizontal component of velocity	vertical component of velocity
A	constant	increases
B	constant	zero
C	increases	increases
D	increases	zero

32 Two parallel metal plates are connected to a battery of negligible internal resistance.



One of the plates is slowly moved towards the other.

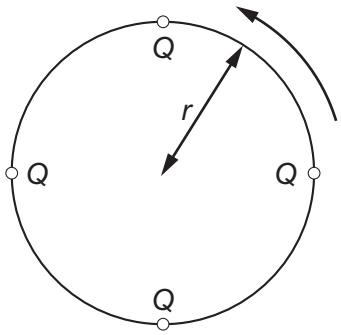
Which row is correct?

	electric field strength between the plates	potential difference between the plates
A	decreases	constant
B	increases	constant
C	decreases	increases
D	increases	increases

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33 Four point charges, each of charge Q, are placed on the edge of an insulating disc of radius r.

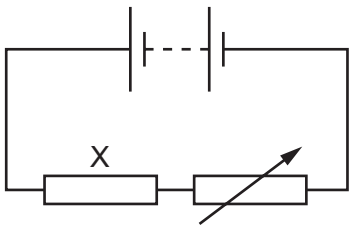
The disc rotates at a rate of n revolutions per unit time.



What is the equivalent electric current at the edge of the disc?

A $4Qn$ **B** $\frac{4Q}{n}$ **C** $8\pi rQn$ **D** $\frac{2Qn}{\pi r}$

34 In the circuit shown, a fixed resistor X is connected in series with a battery and a variable resistor.



The power dissipated in resistor X is 7.2 W when a current of 3.0 A passes through it.

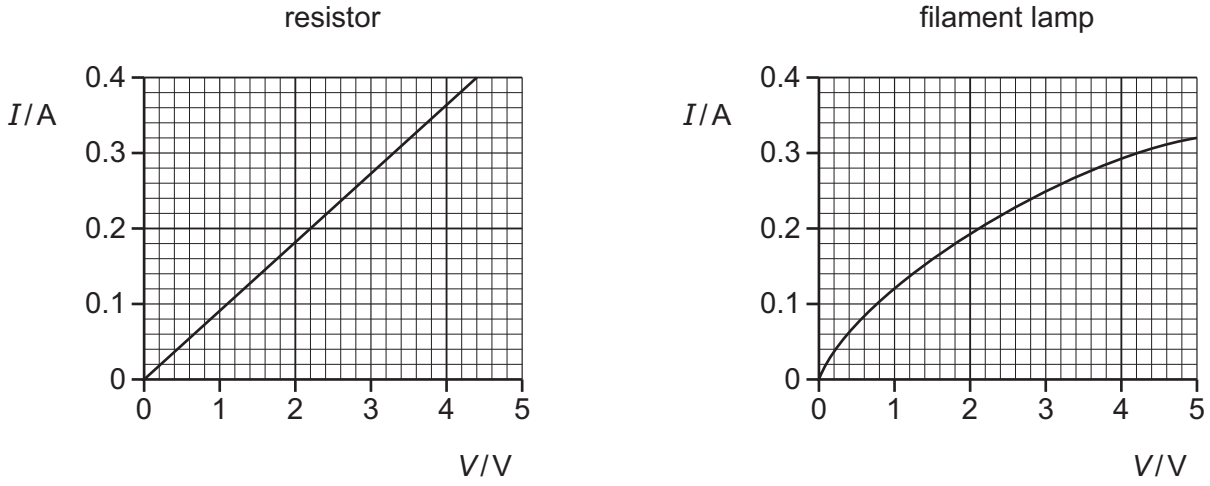
The variable resistor is adjusted so that the power dissipated in X increases by 50%.

What is the new current in the circuit?

A 2.4 A **B** 3.7 A **C** 4.5 A **D** 14 A

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35 A resistor and a filament lamp are connected in series with a power supply. The I–V characteristics of the resistor and of the lamp are shown below.

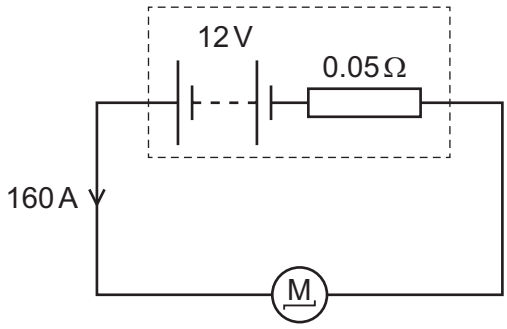


The potential difference (p.d.) across the resistor is 3.3 V.

What is the resistance of the lamp?

A 0.071 Ω **B** 4.2 Ω **C** 11 Ω **D** 14 Ω

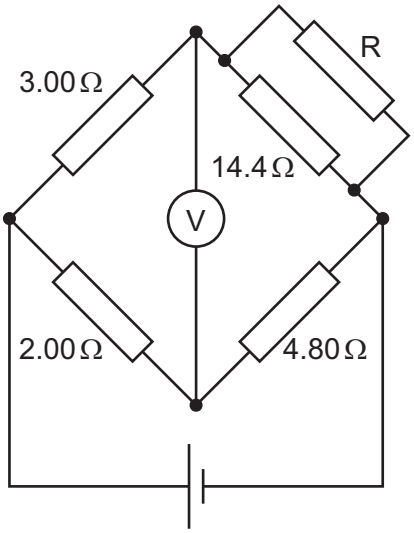
36 A car battery has an electromotive force (e.m.f.) of 12 V and an internal resistance of 0.05 Ω. The battery is connected to the starter motor of a car. The current in the motor is 160 A.



What is the terminal p.d. across the battery?

A 0 V **B** 4 V **C** 8 V **D** 12 V

37 A cell of negligible internal resistance is connected to a network of resistors and a voltmeter, as shown.

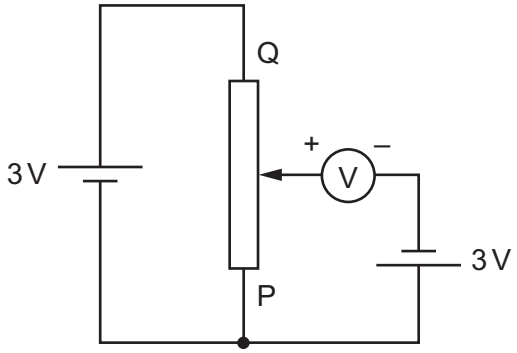


The reading on the voltmeter is zero.

What is the resistance of resistor R?

A 1.20 Ω **B** 1.80 Ω **C** 7.20 Ω **D** 14.4 Ω

38 A voltmeter is connected into a circuit with the polarity shown in the diagram.



The sliding contact is moved to end P of the potentiometer and then to end Q.

What are the two readings of the voltmeter?

	sliding contact at end P	sliding contact at end Q
A	0 V	3 V
B	0 V	6 V
C	3 V	3 V
D	3 V	6 V

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39 What is a conclusion from the alpha-particle scattering experiment?

A Protons and electrons have equal but opposite charges.

B Protons have a much larger mass than electrons.

C The nucleus contains most of the mass of the atom.

D The nucleus of an atom contains protons and neutrons.

40 Which particle is a hadron?

A electron

B neutrino

C positron

D proton

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PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2020**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **20** pages. Blank pages are indicated.

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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	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$
	$\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\text{m F}^{-1}\right)$
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 unit	$1\,\text{u} = 1.66 \times 10^{-27}\,\text{kg}$
rest mass of electron	$m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$
rest mass of proton	$m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$
molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
the Avogadro constant	$N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$g = 9.81\,\text{m s}^{-2}$

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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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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[Turn over

1 What is a reasonable estimate of the volume of a fully inflated standard football?

A $600\,cm^3$ **B** $6000\,cm^3$ **C** $60\,000\,cm^3$ **D** $600\,000\,cm^3$

2 What is **not** an SI base unit?

A coulomb

B kelvin

C kilogram

D second

3 Which two quantities are both vector quantities?

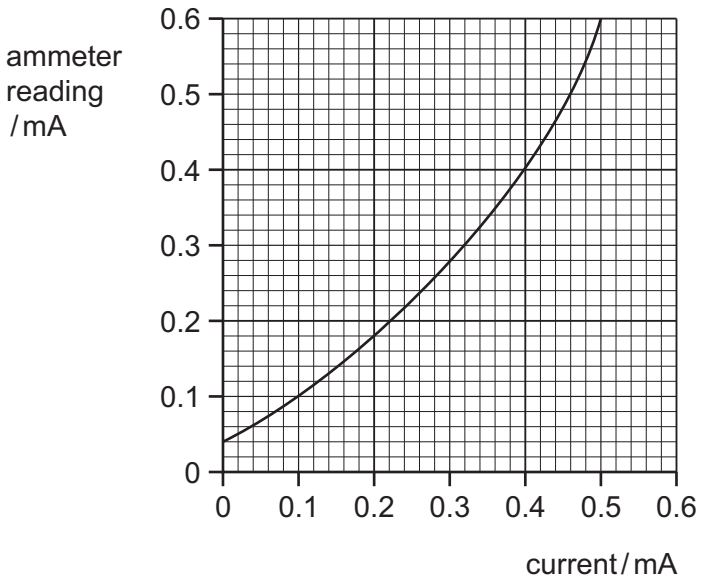
A displacement and distance

B force and momentum

C torque and time

D weight and pressure

4 A calibration curve is shown for an ammeter whose scale is inaccurate.



Two readings taken on the meter at different times during an experiment are 0.13 mA and 0.47 mA.

By how much did the current really increase between taking the two readings?

A 0.30 mA **B** 0.34 mA **C** 0.40 mA **D** 0.44 mA

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5 A student measures the length l and the period T of oscillation of a simple pendulum. He then uses the equation shown to calculate the acceleration of free fall g.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

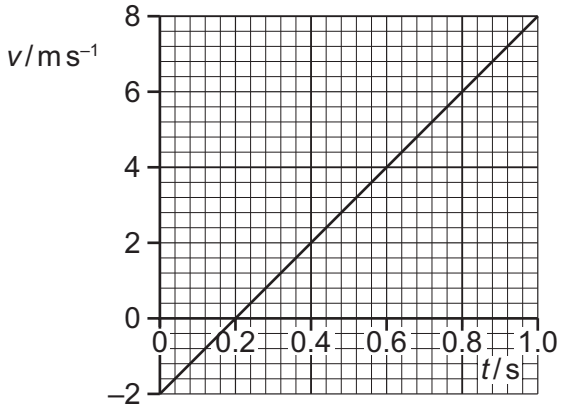
His measurements are shown.

l	$(87.3 \pm 0.2)\,\text{cm}$
T	$(1.9 \pm 0.05)\,\text{s}$

What is the percentage uncertainty in his calculated value of g?

A 2.4% **B** 2.9% **C** 5.5% **D** 7.2%

6 An object moves in a straight line. The graph shows the variation with time t of the velocity v of the object.



At time $t = 0$ the object is at point X.

What is the displacement of the object from point X at time $t = 0.80\,\text{s}$?

A 1.6 m **B** 1.8 m **C** 2.0 m **D** 3.2 m

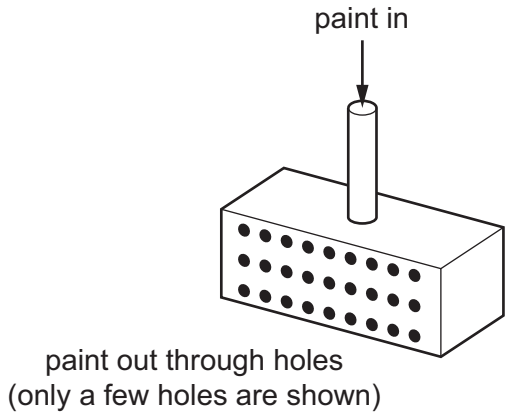
7 An object accelerates uniformly from rest to speed v. It then moves at constant speed v for a time of 8.0 s before decelerating uniformly to rest. The total time taken is 12.0 s, and the total distance travelled is 60 m.

What is the speed v?

A $3.0\,\text{m s}^{-1}$ **B** $5.0\,\text{m s}^{-1}$ **C** $6.0\,\text{m s}^{-1}$ **D** $15\,\text{m s}^{-1}$

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8 A device for spraying paint consists of a box with its axes horizontal and vertical. One of its vertical faces contains small holes. Paint is fed into the box under pressure via a vertical tube and exits through the holes as fine streams moving horizontally.



The paint is ejected at a speed of $2.5\,\text{m}\,\text{s}^{-1}$ through 400 holes, each of area $0.4\,\text{mm}^2$. The density of the paint is $900\,\text{kg}\,\text{m}^{-3}$.

What is the horizontal force required to hold the device stationary as it ejects the paint?

A 0.36 N **B** 0.90 N **C** 2.3 N **D** 900 N

9 A party balloon is filled with air and held stationary at a height of several metres above the ground. The balloon is then dropped in still air.

Which statement describes the motion of the balloon from the moment of release until just before it hits the floor?

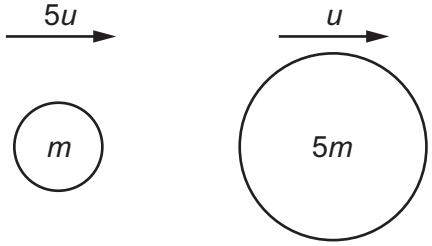
A The balloon decelerates continuously.

B The balloon falls at a constant speed and then decelerates.

C The balloon falls at a constant speed.

D The balloon initially accelerates and then reaches a constant speed.

10 An object of mass m travelling with speed $5u$ collides with, and sticks to, an object of mass $5m$ travelling in the same direction with speed u.



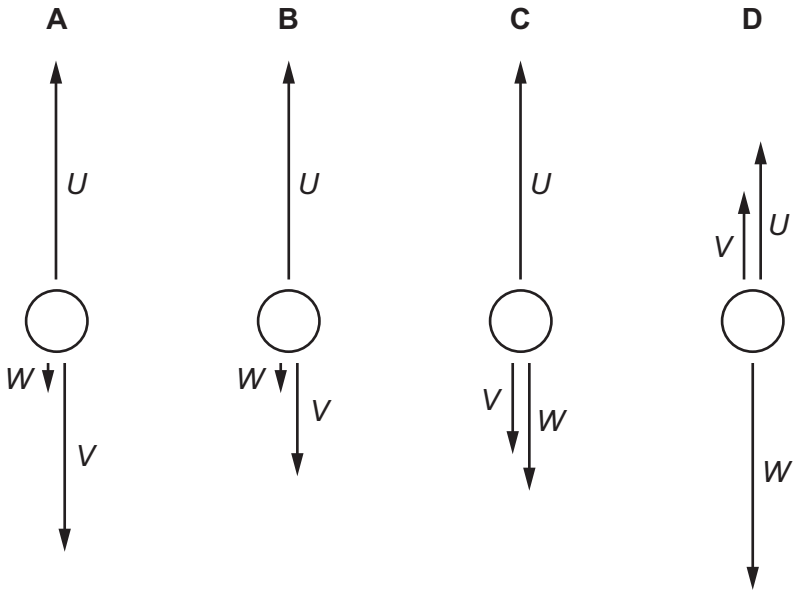
What is the speed with which the two objects travel together in the original direction?

A $\frac{3}{10}u$ **B** u **C** $\frac{6}{5}u$ **D** $\frac{10}{6}u$

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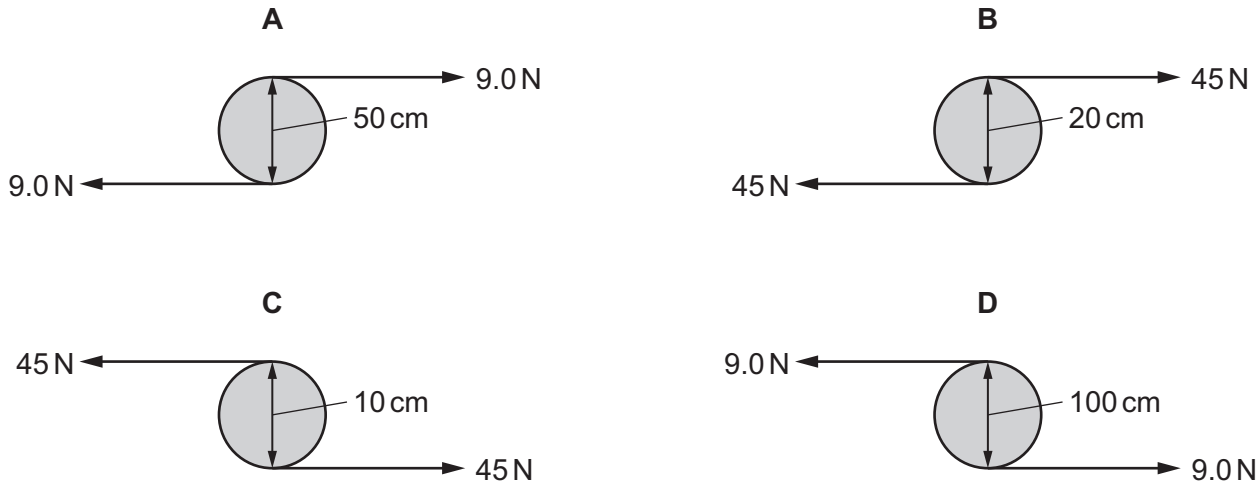
11 An air bubble is rising through a liquid at a constant speed. The forces on it are the upthrust *U*, the viscous drag *V* and its weight *W*.

Which diagram shows the directions and relative sizes of the forces?



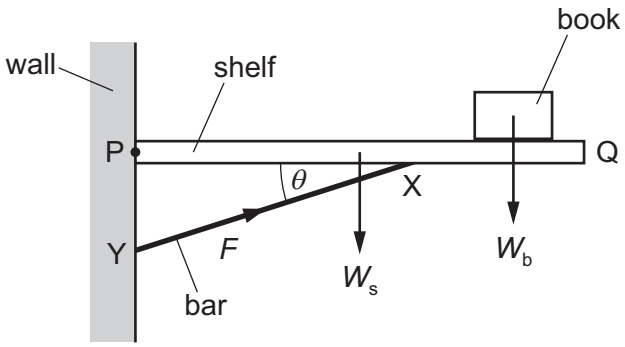
12 A couple applies a clockwise torque of 9.0 N m to a circular disc.

Which diagram shows this couple?



13 A shelf PQ is attached to a vertical wall at P and supports a book.

The shelf is held horizontal by a rigid bar XY, as shown.



The weight of the shelf is W_s and the weight of the book is W_b.

The bar is at an angle θ to the shelf and exerts a force F on the shelf.

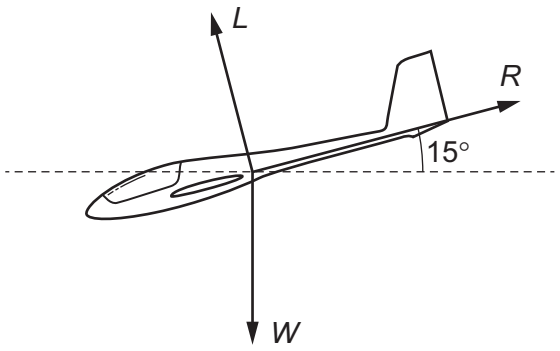
The shelf is in equilibrium.

What are the magnitudes of the horizontal and the vertical components of the force of the wall on the shelf at P?

	horizontal component	vertical component
A	$F \cos \theta$	$(W_s + W_b - F \cos \theta)$
B	$F \cos \theta$	$(W_s + W_b - F \sin \theta)$
C	$F \sin \theta$	$(W_s + W_b - F \cos \theta)$
D	$F \sin \theta$	$(W_s + W_b - F \sin \theta)$

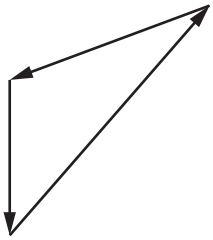
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14 A glider is descending at constant speed at an angle of 15° to the horizontal. The diagram shows the directions of the lift *L*, air resistance *R* and weight *W* acting on the glider.



Which vector triangle could represent the forces acting on the glider?

A



B



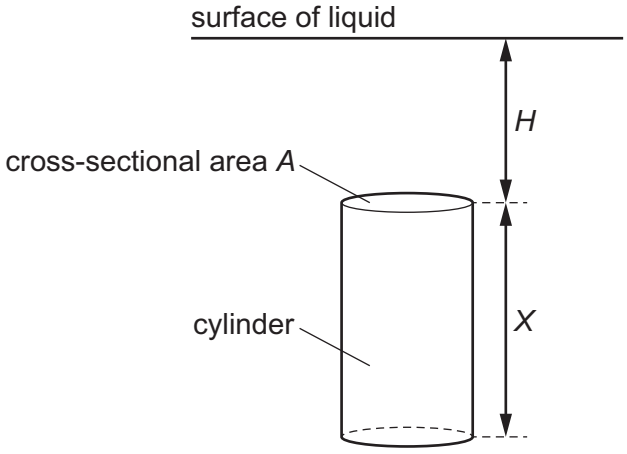
C



D



15 A solid cylinder of density ρ_C, cross-sectional area *A* and length *X* is submerged in a liquid of density ρ_L. The upper face of the cylinder is at a depth *H* below the surface of the liquid, as shown.



The acceleration of free fall is *g*.

Which expression gives the magnitude of the upthrust force acting on the cylinder?

A $\rho_C AHg$ **B** $\rho_C AXg$ **C** $\rho_L AHg$ **D** $\rho_L AXg$

16 A ball drops onto a horizontal surface and bounces elastically.

What happens to the kinetic energy of the ball during the very short time that it is in contact with the surface?

A Most of the kinetic energy is lost as heat and sound.

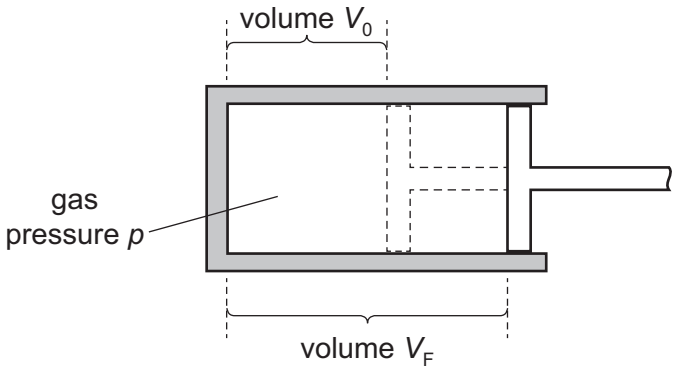
B The kinetic energy decreases to zero and then returns to its original value.

C The kinetic energy remains constant because it is an elastic collision.

D The kinetic energy remains constant in magnitude but changes direction.

17 Some gas in a cylinder is supplied with thermal energy q.

The gas does useful work in expanding at constant pressure p from volume V_0 to volume V_F, as shown.



Which expression gives the efficiency of this process?

A $\frac{pV_0}{q}$ **B** $\frac{V_F}{V_0 q}$ **C** $\frac{p(V_F - V_0)}{q}$ **D** $\frac{(V_F - V_0)}{V_0 q}$

18 An object of mass 0.30 kg is thrown vertically upwards from the ground with an initial velocity of $8.0\,m\,s^{-1}$. The object reaches a maximum height of 1.9 m.

How much work is done against air resistance as the object rises to its maximum height?

A 4.0 J **B** 5.6 J **C** 9.6 J **D** 15 J

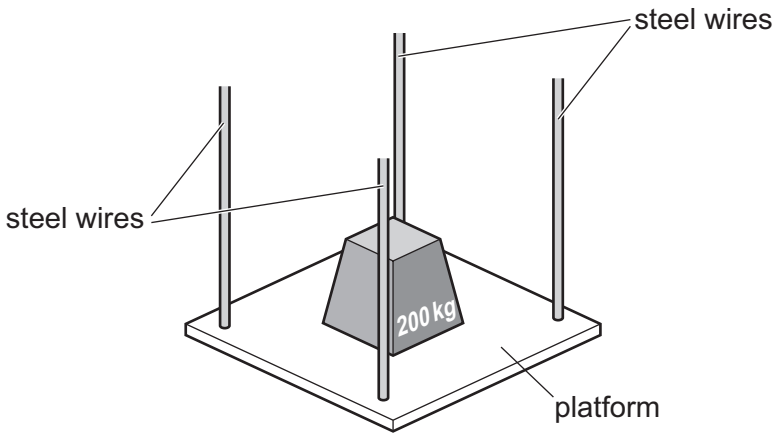
19 A water pump raises a mass of 27×10^3 kg of water through a vertical distance of 80 m in a time of 1.0 hour.

What is the average useful output power of the pump?

A 0.60 kW **B** 5.9 kW **C** 36 kW **D** 350 kW

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20 A platform is suspended by four steel wires. Each wire is 5.0 m long and has a diameter of 3.0 mm. The Young modulus of steel is 2.1×10^{11} Pa.



The wires obey Hooke's law when a load of mass 200 kg is placed on the platform.

How far will the platform descend because of the extension of the wires?

A 1.7×10^{-4} m **B** 4.1×10^{-4} m **C** 1.7×10^{-3} m **D** 6.6×10^{-3} m

21 A tensile force of 7.00 MN is applied to a sample of steel. This causes the sample to extend by 5.00 mm in the direction of the force. The sample obeys Hooke's law.

What is the work done to extend the sample?

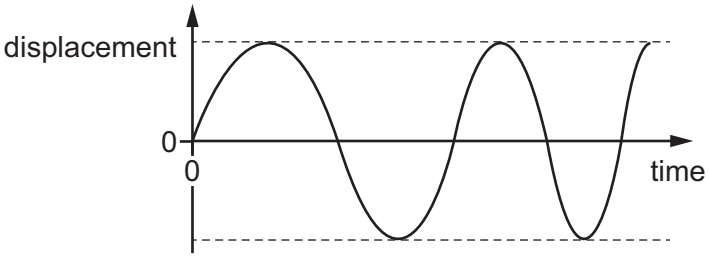
A 17.5 J **B** 35.0 J **C** 17.5 kJ **D** 35.0 kJ

22 Two waves X and Y have the same frequency. The amplitude of X is $1.5A_0$ and the amplitude of Y is $2.5A_0$. The waves meet at a point and superpose to form a resultant wave.

For the resultant wave, what is the ratio $\frac{\text{maximum possible intensity}}{\text{minimum possible intensity}}$?

A 1.7 **B** 2.8 **C** 4.0 **D** 16

23 The displacement–time graph for an air particle in the path of a sound wave is shown.



Which property of the sound wave must be increasing?

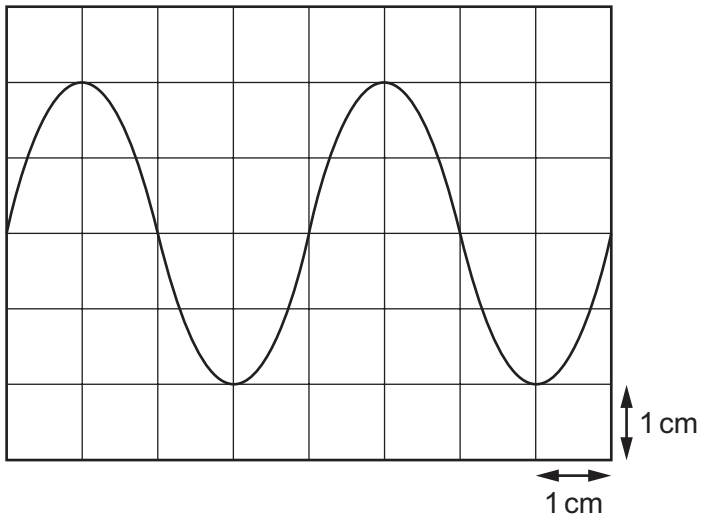
A amplitude

B frequency

C period

D speed

24 A sound wave is displayed on the screen of a cathode-ray oscilloscope (CRO) as shown.



The time-base of the CRO is set at 2.5 ms cm^{-1}.

What is the frequency of the sound wave?

A 50 Hz **B** 100 Hz **C** 200 Hz **D** 400 Hz

25 The horn of a train emits sound of frequency f_1. While the horn is sounding, the train moves directly towards a stationary person. The speed of the train is 0.20v, where v is the speed of sound.

The frequency of the sound heard by the person is f_2.

What is the ratio $\frac{f_1}{f_2}$?

A $\frac{0.80}{1}$ **B** $\frac{1}{1.2}$ **C** $\frac{1.2}{1}$ **D** $\frac{1}{0.80}$

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26 Two satellites in orbit around the Earth are at a constant distance of 100 km apart from each other.

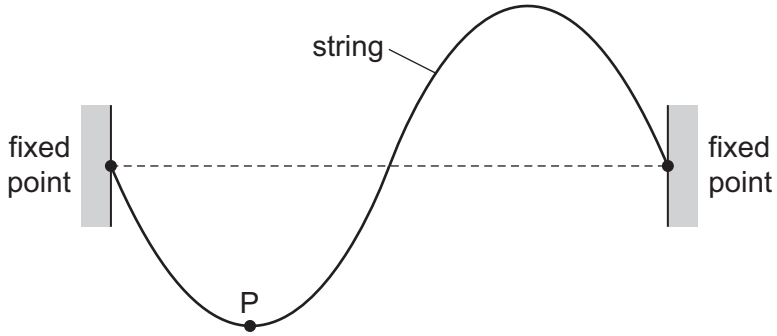
Satellite X transmits a microwave pulse towards satellite Y. The pulse takes time T to reach Y.

Satellite Y then transmits a pulse of visible light towards satellite X.

What is the time taken for the pulse of light to reach X?

A $10^{-5}\,T$ **B** $10^{-3}\,T$ **C** $10^{-2}\,T$ **D** T

27 A stationary wave is formed on a stretched string. The diagram illustrates the string at an instant of time when the displacement of the string is at its maximum.



The frequency of the wave is 250 Hz. Point P on the string has a vertical displacement of –1.0 mm.

What will be the vertical displacement of the point P after a time of 5.0 ms?

A –1.0 mm **B** zero **C** +0.5 mm **D** +1.0 mm

28 What is meant by *diffraction*?

A the change in observed frequency when a wave source moves relative to an observer

B the formation of nodes and antinodes by two progressive waves travelling in opposite directions

C the spreading of a wave around the edge of an obstacle

D the superposition of two waves when they meet

29 In a dark room, a small source of red light illuminates two slits that are 0.75 mm apart. A few metres beyond the slits, the light falls on a screen producing a series of equally spaced bright lines.

Which change would cause the distance between the bright lines on the screen to be reduced?

A Change the source for one emitting blue light.

B Reduce the distance between the light source and the slits.

C Reduce the distance between the slits to 0.55 mm.

D Reduce the intensity of the light source.

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30 Light of wavelength 5.30×10^{-7} m is incident normally on a diffraction grating. The first-order maximum is observed at an angle of 15.4° to the direction of the incident light.

What is the angle between the first-order and second-order diffraction maxima?

A 7.7° **B** 15.4° **C** 16.7° **D** 32.1°

31 A stationary particle is in an electric field.

The only force on the particle is that from the electric field.

In which case is the electric field strength 5.0×10^{5} V m^{-1}?

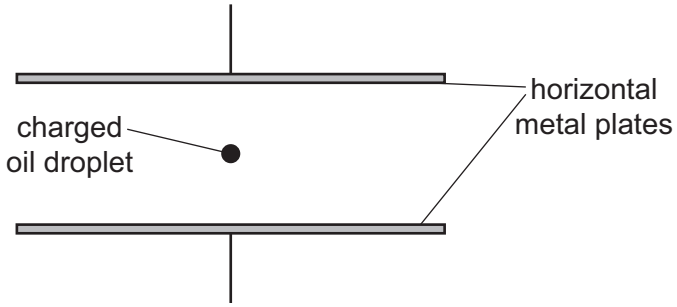
A a force of 1.6×10^{-14} N acting on an electron

B a force of 3.2×10^{-14} N acting on an alpha-particle

C a force of 8.0×10^{-14} N acting on an alpha-particle

D a force of 8.0×10^{-14} N acting on a proton

32 A constant potential difference is applied between two horizontal metal plates. A charged oil droplet is held stationary by the electric field between the plates.



As some of the oil evaporates, the droplet loses mass and starts to accelerate. Its charge remains constant.

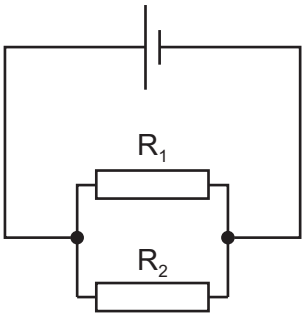
In which direction does the droplet accelerate, and which change needs to be made to the separation of the plates in order to stop this acceleration?

	direction of acceleration	separation of the plates
A	downwards	decrease
B	downwards	increase
C	upwards	decrease
D	upwards	increase

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33 Two resistors R_1 and R_2 are made from wire of the same material.

They are connected in parallel to each other in a circuit, as shown.



The diameter of R_2 is half the diameter of R_1.

The resistance of R_2 is three times the resistance of R_1.

What is the value of the ratio $\frac{\text{average drift speed of free electrons in } R_1}{\text{average drift speed of free electrons in } R_2}$?

A $\frac{3}{2}$ **B** $\frac{3}{4}$ **C** $\frac{1}{6}$ **D** $\frac{1}{12}$

34 A student describes potential difference as the energy transferred per unit charge.

Which statement about the energy transfer is correct?

A It is from electrical energy into other forms.

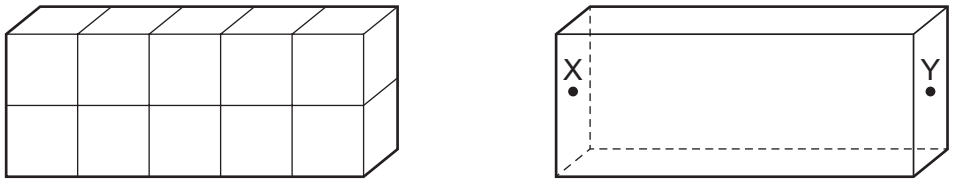
B It is from other forms into electrical energy.

C It only takes place inside a power supply.

D It only takes place inside resistors.

35 A metal cube has a resistance of 4.0 Ω between opposite faces.

Ten of these cubes are put together to make a cuboid of 1 × 2 × 5 cubes.



There is no extra resistance where the faces of the cubes touch each other.

What is the resistance of the cuboid when connected between faces X and Y?

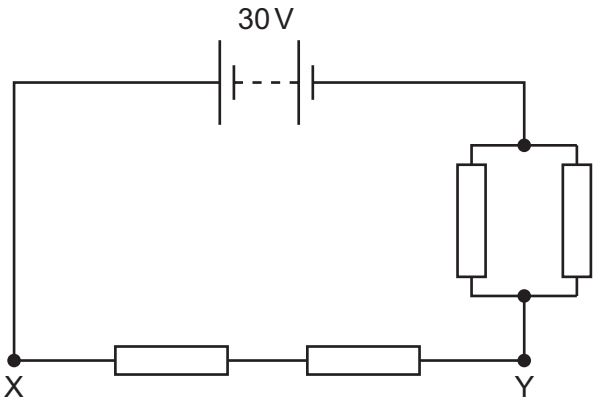
A 1.6 Ω **B** 2.0 Ω **C** 10 Ω **D** 40 Ω

36 A cell is connected to a fixed resistor. Over a long period of time, the internal resistance of the cell increases.

What is the effect of the increase in internal resistance on the electromotive force (e.m.f.) of the cell and on the power dissipated by the fixed resistor?

	e.m.f.	power dissipated
A	decreases	decreases
B	decreases	no change
C	no change	decreases
D	no change	no change

37 Four identical resistors are connected in a circuit, as shown.



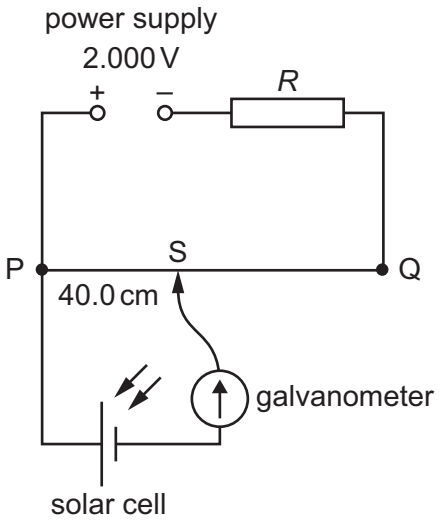
The battery has negligible internal resistance and an e.m.f. of 30 V.

What is the potential difference between the two points X and Y?

A 6.0 V **B** 15 V **C** 20 V **D** 24 V

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38 A power supply and a solar cell are compared using the potentiometer circuit shown.



The potentiometer wire PQ is 100.0 cm long and has a resistance of 5.00 Ω. The power supply has an e.m.f. of 2.000 V and the solar cell has an e.m.f. of 5.00 mV.

Which resistance *R* must be used so that the galvanometer reads zero when PS = 40.0 cm?

A 395 Ω **B** 405 Ω **C** 795 Ω **D** 805 Ω

39 The table contains data for four different nuclei P, Q, R and S.

nucleus	number of neutrons	nucleon number
P	5	10
Q	6	10
R	6	14
S	8	16

Which two nuclei are isotopes of the same element?

A P and Q **B** P and S **C** Q and R **D** R and S

40 Which particle is a fundamental particle?

A alpha-particle

B electron

C neutron

D proton

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