Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

4633464165

PHYSICS **9702/12**

Paper 1 Multiple Choice **February/March 2016**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **17** printed pages and **3** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

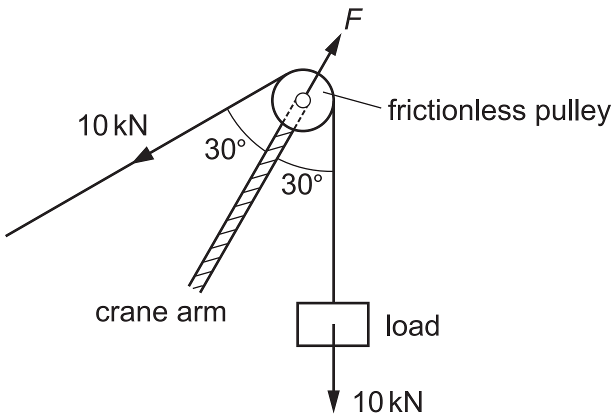
uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 The prefixes nano (n), micro (μ) and pico (p) are often used with units.

Which row shows their correct values?

	n	μ	p
A	10^{-6}	10^{-9}	10^{-12}
B	10^{-6}	10^{-12}	10^{-9}
C	10^{-9}	10^{-6}	10^{-12}
D	10^{-12}	10^{-9}	10^{-6}

2 A crane has an arm to which is attached a frictionless pulley. A cable passes over the pulley and supports a load of 10 kN as shown.



The crane arm exerts a force *F* on the pulley.

What is the value of *F*?

A 5.0 kN **B** 8.7 kN **C** 10 kN **D** 17 kN

3 The SI unit of specific heat capacity is $\mathrm{J\,kg^{-1}\,K^{-1}}$.

What is the unit of specific heat capacity expressed in SI base units?

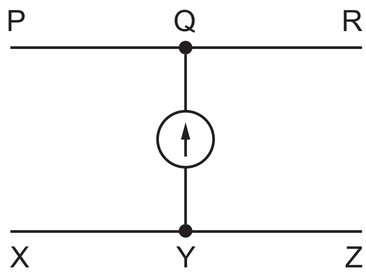
A $\mathrm{m\,s^{-2}\,K^{-1}}$ **B** $\mathrm{kg\,m\,s^{-1}\,K^{-1}}$ **C** $\mathrm{m^2\,s^{-2}\,K^{-1}}$ **D** $\mathrm{kg\,m^2\,s^{-1}\,K^{-1}}$

4 Quantity *X* has a fractional uncertainty of *x*. Quantity *Y* has a fractional uncertainty of *y*.

What is the fractional uncertainty in $\dfrac{X}{Y^2}$?

A $x + y$ **B** $x - y$ **C** $x + 2y$ **D** $x - 2y$

5 PQR and XYZ are wires in a circuit. A galvanometer connects Q and Y as a null indicator.



When the galvanometer reads zero, which statement is correct?

A The potential difference between Q and Y is infinite.

B The potential difference between Q and Y is zero.

C The resistance between Q and Y is infinite.

D The resistance between Q and Y is zero.

6 An object has an initial velocity *u* and an acceleration *a*. The object moves in a straight line through a displacement *s* and has final velocity *v*.

The above quantities are related by the equation shown.

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

Which condition **must** be satisfied in order for this equation to apply to the motion of the object?

A The direction of *a* is constant and the direction of *a* is the same as the direction of *s*.

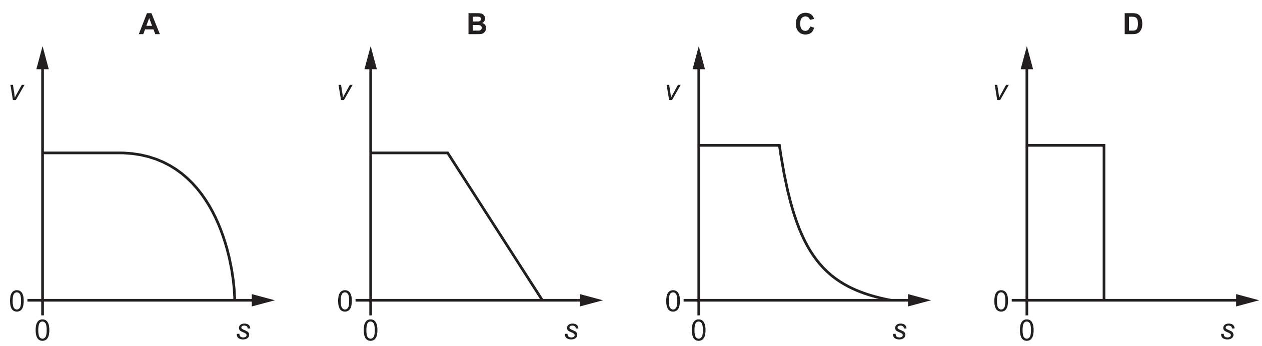
B The direction of *a* is constant and the direction of *a* is the same as the direction of *u*.

C The magnitude of *a* is constant and the direction of *a* is constant.

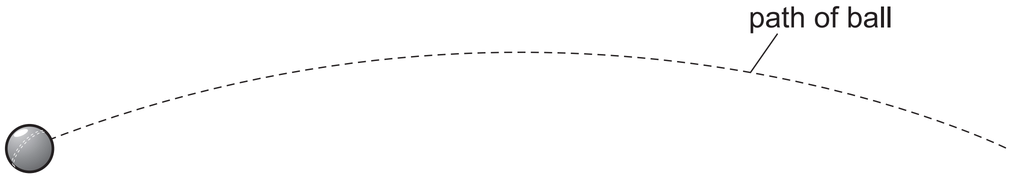
D The magnitude of *a* is constant and the direction of *a* is the same as the direction of *v*.

7 A car is travelling at constant velocity. Its brakes are then applied, causing uniform deceleration.

Which graph shows the variation with distance *s* of the velocity *v* of the car?



8 A ball is thrown across a flat field.



Which statement describes the motion of the ball, when the effects of air resistance are ignored?

A The ball lands with the same velocity at which it is thrown.

B The horizontal component of acceleration is constant throughout the motion.

C The horizontal and vertical components of acceleration are both zero at the highest point of the motion.

D The horizontal and vertical components of velocity are both zero at the highest point of the motion.

9 Which statement **defines** force?

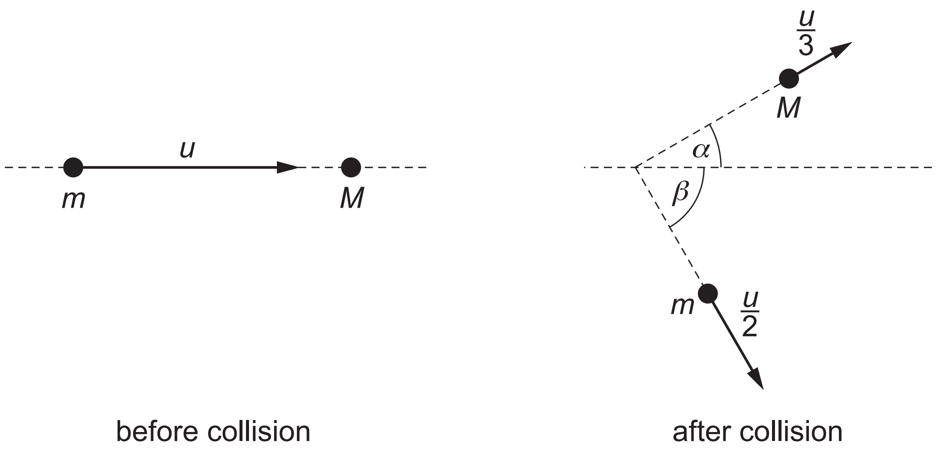
A When a force acts on a body that is free to move, the force is the product of the mass of the body and its acceleration.

B When a force acts on a body that is free to move, the force is the rate of change of momentum of the body.

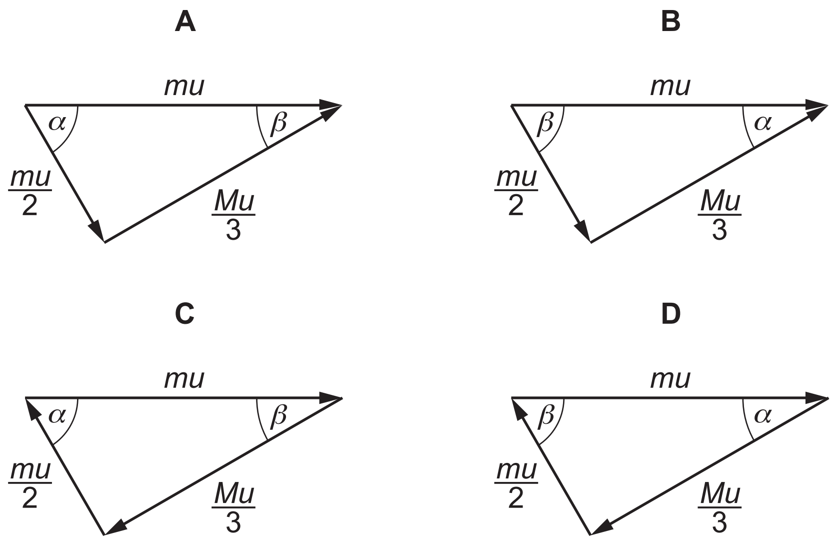
C When a force acts on a body that is free to move, the force is the work done by the force divided by the distance moved by the body.

D When a force acts on a lever and causes a moment, the force is the moment divided by the perpendicular distance of the force from the pivot.

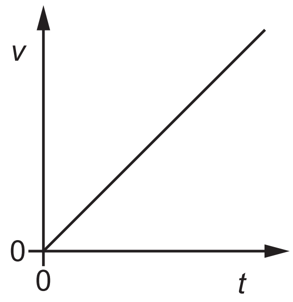
10 A particle of mass *m*, travelling with speed *u*, collides with a stationary particle of mass *M*. The velocities of the two particles before and after the collision are shown.



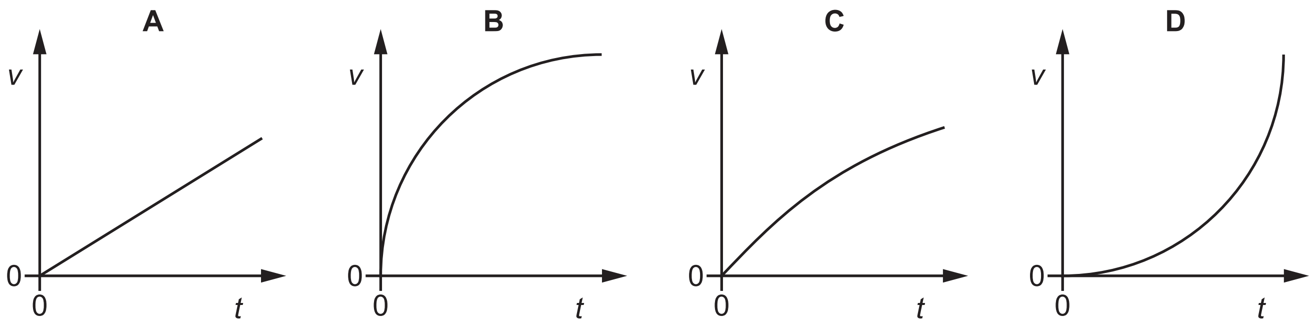
Which vector diagram correctly shows the momenta before and after the collision?



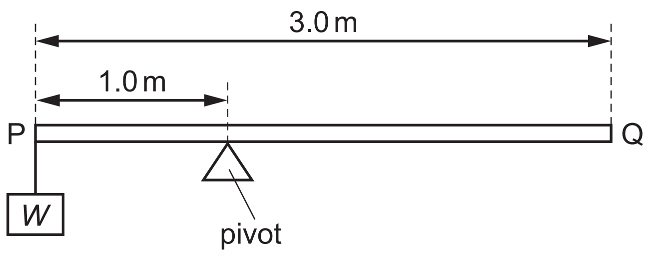
11 An object falls freely from rest in a vacuum. The graph shows the variation with time t of the velocity v of the object.



Which graph, using the same scales, represents the object falling in air?



12 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 and the beam is in equilibrium.

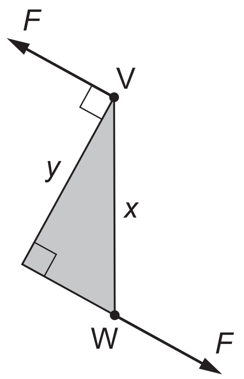


What is the value of W?

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

13 Two forces, each of magnitude F, act at points V and W on an object.

The two forces form a couple. The shape of the object is a right-angled triangle with sides of lengths x and y, as shown.



Which expression gives the torque exerted by the couple?

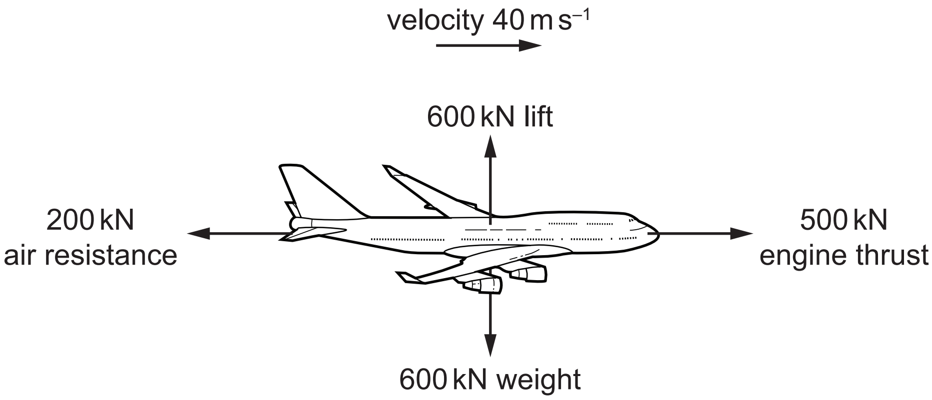
A Fx **B** Fy **C** $2Fx$ **D** $2Fy$

14 A giant squid of length 20.0 m is vertical in seawater, with the top of the squid at a depth of 8.00 m. The density of seawater is $1050\,\text{kg}\,\text{m}^{-3}$.

What is the difference in pressure between the top and the bottom of the squid?

A 82 000 Pa **B** 206 000 Pa **C** 288 000 Pa **D** 389 000 Pa

15 The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is $40\,\text{m}\,\text{s}^{-1}$.



At which rate is its kinetic energy increasing?

A 2.4 MW **B** 8.0 MW **C** 12 MW **D** 20 MW

16 A man is running in a straight line.

What is an approximate value of his kinetic energy?

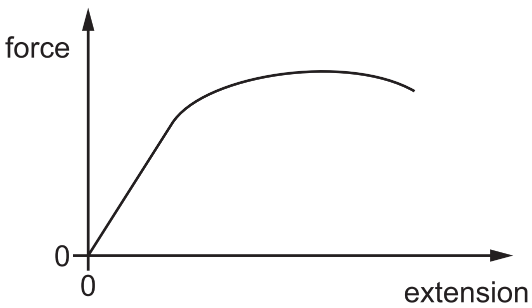
A 10 J **B** 100 J **C** 1000 J **D** 10 000 J

17 The pump of a water pumping system uses 2.0 kW of electrical power when raising water. The pumping system lifts 16 kg of water per second through a vertical height of 7.0 m.

What is the efficiency of the pumping system?

A 1.8% **B** 5.6% **C** 22% **D** 55%

18 A metal wire is stretched by a load. The force-extension graph is shown.



What is represented by the area under the whole graph?

A the change in gravitational potential energy of the wire

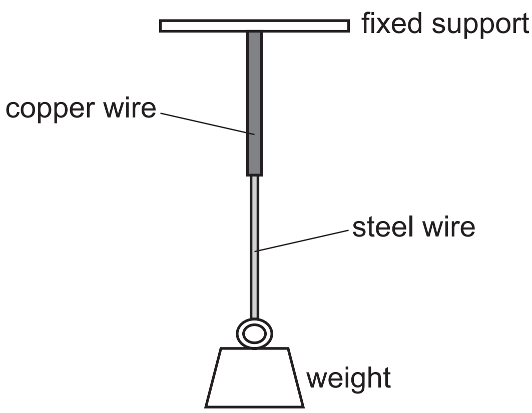
B the energy that would be released from the wire if the final load was removed

C the energy transferred into heat energy in the wire

D the work done in stretching the wire

19 The Young modulus of steel is twice that of copper.

A 50 cm length of copper wire of diameter 2.0 mm is joined to a 50 cm length of steel wire of diameter 1.0 mm, making a combination wire of length 1.0 m, as shown.



The combination wire is stretched by a weight added to its end. Both the copper and the steel wires obey Hooke's law.

What is the ratio $\dfrac{\text{extension of steel wire}}{\text{extension of copper wire}}$?

A 4 **B** 2 **C** 1 **D** 0.5

20 With which types of wave can the Doppler shift be observed?

A all types of wave

B light and sound waves only

C sound waves and water waves only

D sound waves only

21 A distant star is receding from the Earth with a speed of $1.40 \times 10^7\,\mathrm{m\,s^{-1}}$. It emits light of frequency $4.57 \times 10^{14}\,\mathrm{Hz}$. The speed of light is $3.00 \times 10^8\,\mathrm{m\,s^{-1}}$.

The Doppler effect formula can be used with light waves.

What will be the frequency of this light when detected on Earth?

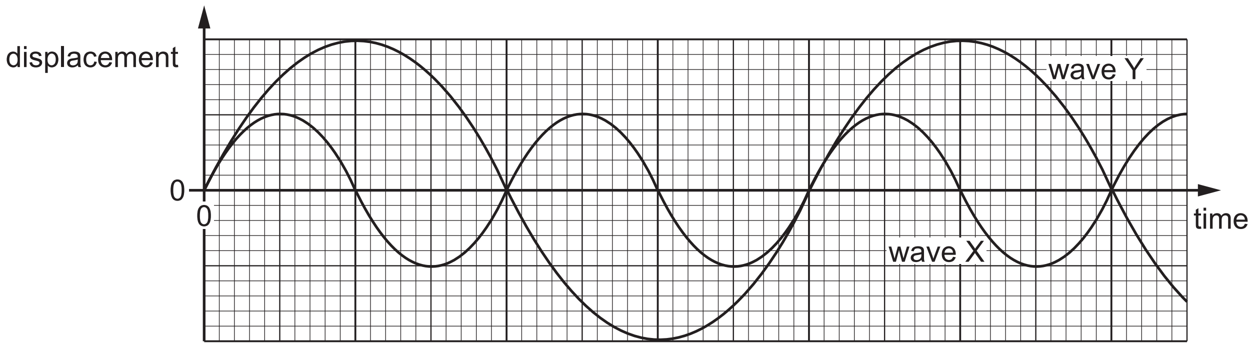
A $2.04 \times 10^{13}\,\mathrm{Hz}$

B $4.37 \times 10^{14}\,\mathrm{Hz}$

C $4.57 \times 10^{14}\,\mathrm{Hz}$

D $4.79 \times 10^{14}\,\mathrm{Hz}$

22 The graph shows the variation with time of the displacement of two separate 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	$2f$	$2A$

[Turn over

23 Diffraction is a term used to describe one aspect of wave behaviour.

What does diffraction make possible?

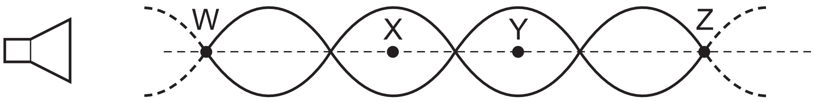
A the ability to hear around corners

B the ability to hear high frequency and low frequency sound waves

C the ability to hear loud and quiet sounds

D the ability to hear sound through a brick wall

24 The diagram represents the pattern of stationary waves formed by the superposition of sound waves from a loudspeaker and their reflection from a metal sheet (not shown).



W, X, Y and Z are four points on the line through the centre of these waves.

Which statement about these stationary waves is correct?

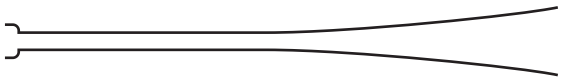
A An antinode is formed at the surface of the metal sheet.

B A node is a quarter of a wavelength from an adjacent antinode.

C The oscillations at X are in phase with those at Y.

D The air particles oscillate perpendicular to the line WZ.

25 A musical instrument called a bugle is a long tube with a mouthpiece at one end. The other end is open and flared, as shown.



A musician maintains stationary sound waves with a node at the mouthpiece and an antinode at the other end. The lowest frequency of sound that the bugle can produce is 92 Hz.

Which different frequencies of sound can be produced by the bugle?

A 92 Hz, 138 Hz, 184 Hz, 230 Hz, 276 Hz

B 92 Hz, 184 Hz, 276 Hz, 368 Hz, 460 Hz

C 92 Hz, 276 Hz, 460 Hz, 644 Hz, 828 Hz

D 92 Hz, 276 Hz, 828 Hz, 2484 Hz, 7452 Hz

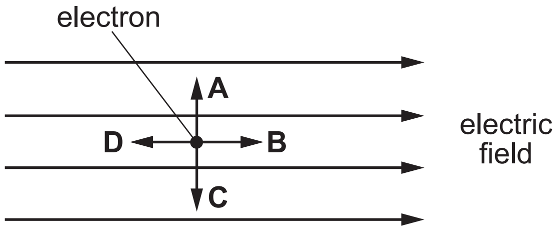
26 Monochromatic light of wavelength 5.30×10^{-7} m is incident normally on a diffraction grating. The first order maximum is observed at an angle of 15.4° to the direction of the incident light.

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

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

27 The diagram shows an electron in a uniform electric field.

In which direction will the field accelerate the electron?



28 The electric field strength at a certain distance from an isolated alpha particle is $3.0 \times 10^{7}\,\mathrm{N\,C^{-1}}$.

What is the force on an electron when at that distance from the alpha particle?

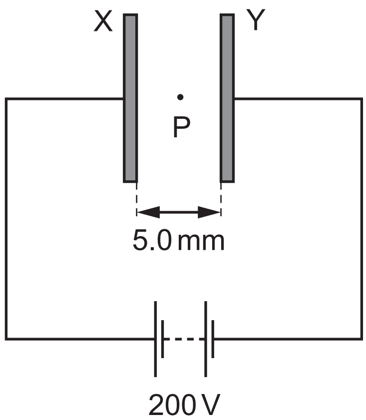
A $4.8 \times 10^{-12}\,\mathrm{N}$

B $9.6 \times 10^{-12}\,\mathrm{N}$

C $3.0 \times 10^{7}\,\mathrm{N}$

D $6.0 \times 10^{7}\,\mathrm{N}$

29 Two large parallel plates X and Y are placed a distance of 5.0 mm apart and connected to the terminals of a 200 V d.c. supply, as shown.



A small oil drop at P carries one excess electron.

What is the magnitude of the electrostatic force acting on the oil drop due to the electric field between the plates?

A $6.4 \times 10^{-15}\,\mathrm{N}$

B $6.4 \times 10^{-18}\,\mathrm{N}$

C $1.6 \times 10^{-19}\,\mathrm{N}$

D $4.0 \times 10^{-24}\,\mathrm{N}$

30 An electrical conductor has a resistance of 5.6 kΩ. A potential difference (p.d.) of 9.0 V is applied across its ends.

How many electrons pass a point in the conductor in one minute?

A 6.0×10^{20} **B** 1.0×10^{19} **C** 6.0×10^{17} **D** 1.0×10^{16}

31 A fixed resistor of resistance 12 Ω is connected to a battery. There is a current of 0.20 A in the resistor. The current is now doubled.

What is the new power dissipated in the resistor?

A 0.48 W **B** 0.96 W **C** 1.92 W **D** 4.8 W

32 Which **measurements** are taken in order to calculate the resistivity of the metal of a piece of wire?

A p.d., current, area, length

B p.d., current, diameter, length

C resistance, area, length

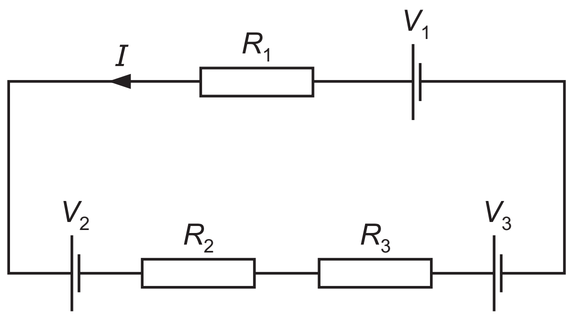
D resistance, length, radius

33 A 12 V battery is charged for 20 minutes by connecting it to a source of electromotive force (e.m.f.). The battery is supplied with 7.2×10^4 J of energy in this time.

How much charge flows through the battery?

A 5.0 C **B** 60 C **C** 100 C **D** 6000 C

34 Three cells with e.m.f.s V_1, V_2 and V_3, have negligible internal resistance. These cells are connected to three resistors with resistances R_1, R_2 and R_3, as shown.



The current in the circuit is I.

Which equation is correct?

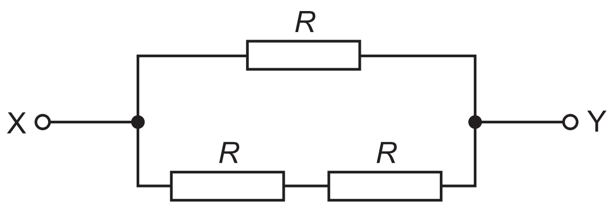
A $V_1 + V_2 + V_3 = I(R_1 + R_2 + R_3)$

B $V_1 + V_2 - V_3 = I(R_1 + R_2 + R_3)$

C $V_1 - V_2 + V_3 = I(R_1 + R_2 + R_3)$

D $V_1 - V_2 - V_3 = I(R_1 + R_2 + R_3)$

35 Three resistors, each of resistance R, are connected in a network, as shown.



The total resistance between points X and Y is $8.0\,\Omega$.

What is the value of R?

A $2.7\,\Omega$ **B** $4.0\,\Omega$ **C** $5.3\,\Omega$ **D** $12\,\Omega$

36 In deriving a formula for the combined resistance of three different resistors in series, Kirchhoff's laws are used.

Which physics principle is involved in this derivation?

A the conservation of charge

B the direction of the flow of charge is from negative to positive

C the potential difference across each resistor is the same

D the current varies in each resistor, in proportion to the resistor value

37 The battery of a car has an internal resistance of 0.10 Ω and an electromotive force of 12 V. When the battery is connected to the starter motor, the potential difference across the battery terminals is 7.0 V.

What is the current supplied to the starter motor?

A 50 A **B** 70 A **C** 120 A **D** 190 A

38 A sample of an isotope emits β^- particles.

The emitted β^- particles have a range of energies.

What must also be emitted?

A antineutrinos

B neutrinos

C antineutrons

D neutrons

39 A nucleus of magnesium decays into a nucleus of sodium by emitting a β^+ particle. The decay is represented by the equation shown.

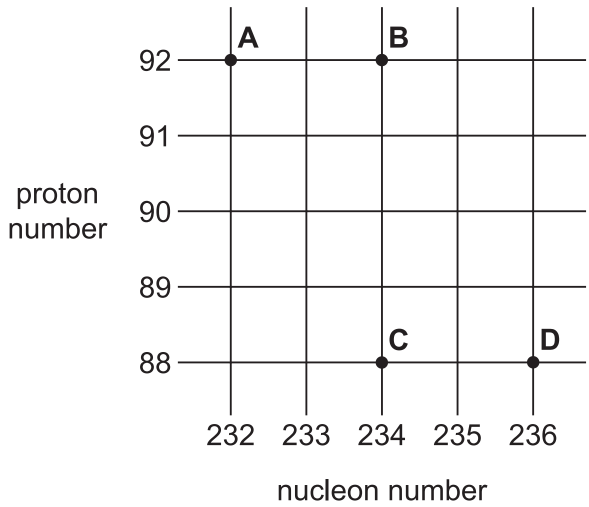
$$^{23}_{12}\mathrm{Mg} \rightarrow {}^{\mathrm{P}}_{\mathrm{Q}}\mathrm{Na} + {}^{0}_{+1}\beta$$

What are the values of P and Q?

	P	Q
A	22	11
B	22	13
C	23	11
D	23	13

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

Which letter in the diagram represents the granddaughter product?



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CAMBRIDGE International Examinations

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

1 Which expression has the same SI base units as pressure?

A $\dfrac{\text{force}}{\text{length} \times \text{speed}}$

B $\dfrac{\text{force}}{\text{length} \times \text{time}}$

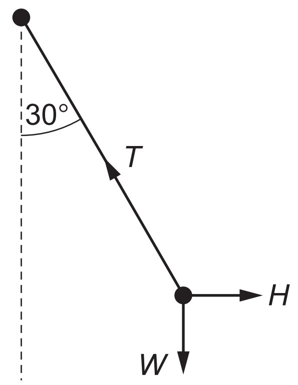
C $\dfrac{\text{mass}}{\text{length} \times (\text{time})^2}$

D $\dfrac{\text{mass} \times (\text{time})^2}{\text{length}}$

2 What is an approximate value for the speed of sound in air?

A $30\,\text{m}\,\text{s}^{-1}$ **B** $300\,\text{m}\,\text{s}^{-1}$ **C** $30\,000\,\text{m}\,\text{s}^{-1}$ **D** $300\,000\,000\,\text{m}\,\text{s}^{-1}$

3 A pendulum bob is held stationary by a horizontal force *H*. The three forces acting on the bob are shown in the diagram.



The tension in the string of the pendulum is *T*. The weight of the pendulum bob is *W*. The string is held at an angle of 30° to the vertical.

Which statement is correct?

A $H = T\cos 30$

B $T = H\sin 30$

C $W = T\sin 30$

D $W = T\cos 30$

4 A student is investigating an electrical signal using a cathode-ray oscilloscope (c.r.o).

The frequency of the signal is 50 kHz.

Which time-base setting on the oscilloscope should be used?

A $50\,\text{ms cm}^{-1}$ **B** $1\,\text{ms cm}^{-1}$ **C** $10\,\mu\text{s cm}^{-1}$ **D** $0.5\,\mu\text{s cm}^{-1}$

5 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

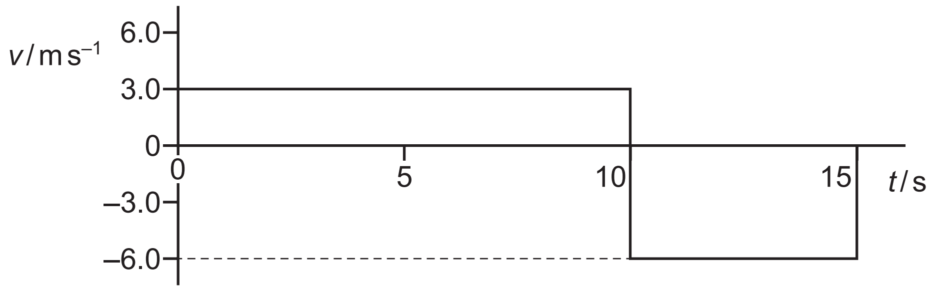
6 An aircraft, initially stationary on a runway, takes off with a speed of $85\,\text{km h}^{-1}$ in a distance of no more than 1.20 km.

What is the minimum constant acceleration necessary for the aircraft?

A $0.23\,\text{m s}^{-2}$ **B** $0.46\,\text{m s}^{-2}$ **C** $3.0\,\text{m s}^{-2}$ **D** $6.0\,\text{m s}^{-2}$

7 A radio-controlled toy car travels along a straight line for a time of 15 s.

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



What is the average velocity of the toy car for the journey shown by the graph?

A $-1.5\,\text{m s}^{-1}$ **B** $0.0\,\text{m s}^{-1}$ **C** $4.0\,\text{m s}^{-1}$ **D** $4.5\,\text{m s}^{-1}$

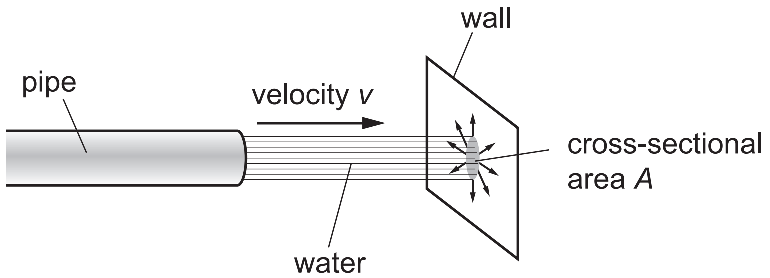
8 The acceleration of free fall on Pluto is $0.66\,\text{m s}^{-2}$.

An object weighs 6.0 N on Earth.

What would this object weigh on Pluto?

A 0.40 N **B** 0.93 N **C** 4.0 N **D** 39 N

9 Water flows out of a pipe and hits a wall.



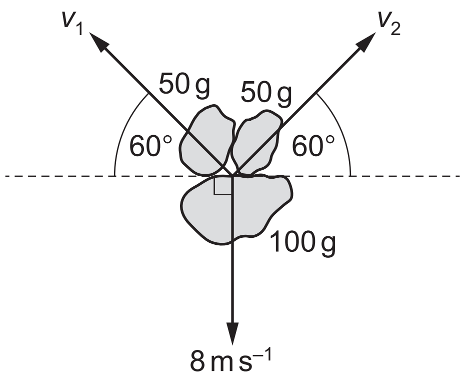
When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.

The density of the water is ρ. The water does not rebound from the wall.

What is the force exerted on the wall by the water?

A $\dfrac{\rho v}{A}$ **B** $\dfrac{\rho v^2}{A}$ **C** $\rho A v$ **D** $\rho A v^2$

10 A stationary firework explodes into three pieces. The masses and the velocities of the three pieces immediately after the explosion are shown.

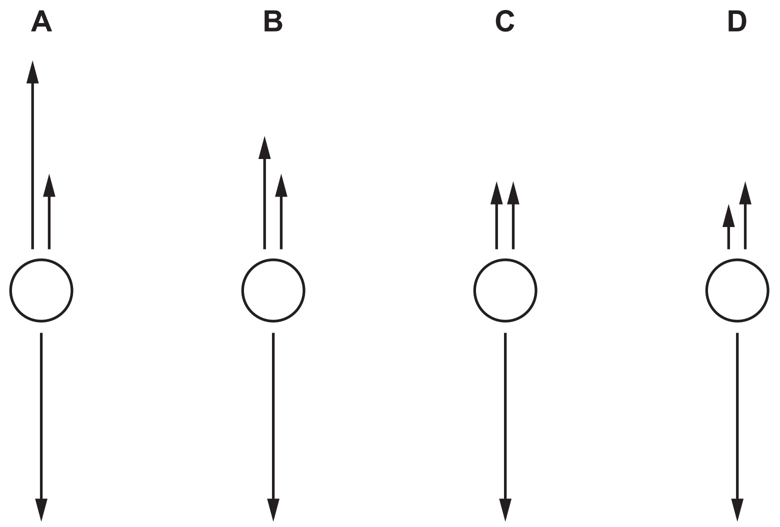


What are speed v_1 and speed v_2?

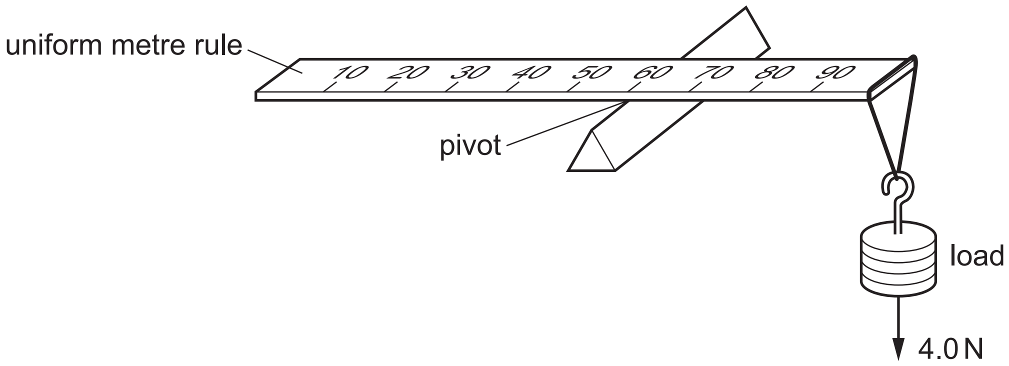
	v_1 / m s^{-1}	v_2 / m s^{-1}
A	4.0	4.0
B	9.2	9.2
C	14	14
D	16	16

11 A spherical object falls through water at constant speed. Three forces act on the object.

Which diagram, showing these three forces to scale, is correct?



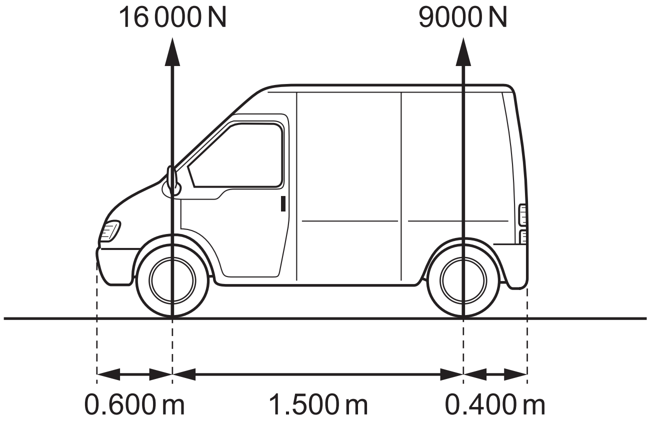
12 A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N load is suspended from one end, causing the rule to rotate about the pivot.



At the instant when the rule is horizontal, what is the resultant moment about the pivot?

A 0.0 N m **B** 1.4 N m **C** 1.6 N m **D** 1.8 N m

13 The vertical forces that the ground exerts on a stationary van are shown.

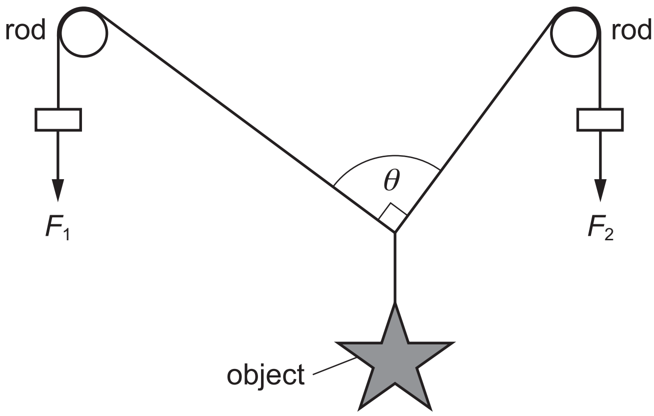


The van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

What is the horizontal distance of the van's centre of gravity from the front of the van?

A 0.540 m **B** 0.960 m **C** 1.14 m **D** 1.36 m

14 An object hangs by means of two cords around two rods, as shown.



The object is held in equilibrium by the forces F_1 and F_2. The object weighs 10 N. There is negligible friction between the rods and cords. Angle θ is 90°.

Which row of the table gives an angle θ of 90°?

	F_1 / N	F_2 / N
A	4.0	6.0
B	6.0	4.0
C	6.0	8.0
D	8.0	6.0

15 Which force is caused only by a pressure difference?

A friction

B upthrust

C viscous force

D weight

16 The total energy input E_{in} in a process is partly transferred to useful energy output U and partly transfered to energy that is wasted W.

What is the efficiency of the process?

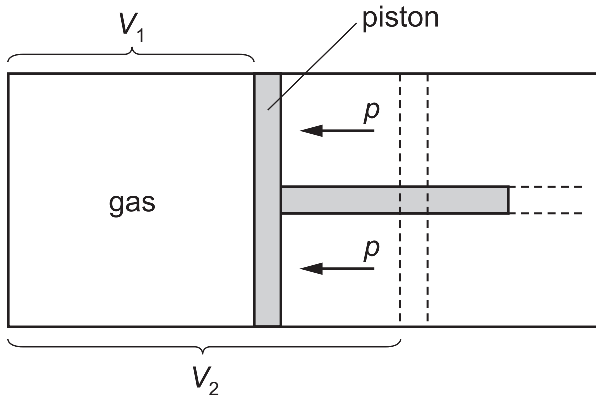
A $\dfrac{U}{E_{in}} \times 100\%$

B $\dfrac{W}{E_{in}} \times 100\%$

C $\dfrac{U}{W} \times 100\%$

D $\dfrac{U+W}{E_{in}} \times 100\%$

17 A gas is enclosed inside a cylinder which is fitted with a frictionless piston.

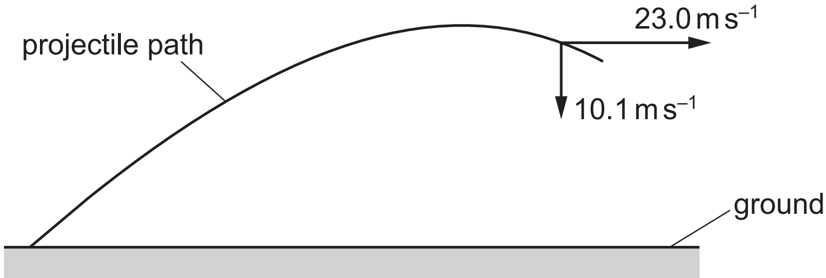


Initially, the gas has a volume V_1 and is in equilibrium with the external pressure p. The gas is then heated slowly so that it expands at constant pressure, pushing the piston back until the volume of the gas has increased to V_2.

How much work is done by the gas during this expansion?

A $p(V_2 - V_1)$ **B** $\frac{1}{2}p(V_2 - V_1)$ **C** $p(V_2 + V_1)$ **D** $\frac{1}{2}p(V_2 + V_1)$

18 A projectile is thrown at an angle to the ground.



At a certain time, the projectile has a horizontal velocity of 23.0 m s^{-1} and a vertical velocity of –10.1 m s^{-1}.

What is the speed of the projectile at this time?

A 12.9 m s^{-1} **B** 20.7 m s^{-1} **C** 25.1 m s^{-1} **D** 33.1 m s^{-1}

19 A car of mass 1400 kg is travelling on a straight, horizontal road at a constant speed of 25 m s^{-1}. The output power from the car's engine is 30 kW.

The car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

What is the output power of the car's engine when travelling up the slope?

A 12 kW **B** 31 kW **C** 42 kW **D** 65 kW

20 Two wires X and Y are made of different metals. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y.

The wires are extended with the same strain and obey Hooke's law.

What is the ratio $\dfrac{\text{tension in wire X}}{\text{tension in wire Y}}$?

A $\dfrac{1}{8}$ **B** $\dfrac{1}{2}$ **C** 1 **D** 8

21 A weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm. The column obeys Hooke's law when compressed.

How much energy is stored in the compressed column?

A 15 J **B** 30 J **C** 15 kJ **D** 30 kJ

22 What is the relationship between the amplitude of a wave and its intensity?

A amplitude $\propto$ intensity

B amplitude $\propto$ (intensity)^2

C amplitude $\propto \sqrt{\text{intensity}}$

D (amplitude)$^2 \propto \sqrt{\text{intensity}}$

23 Which statement about light waves and sound waves is correct?

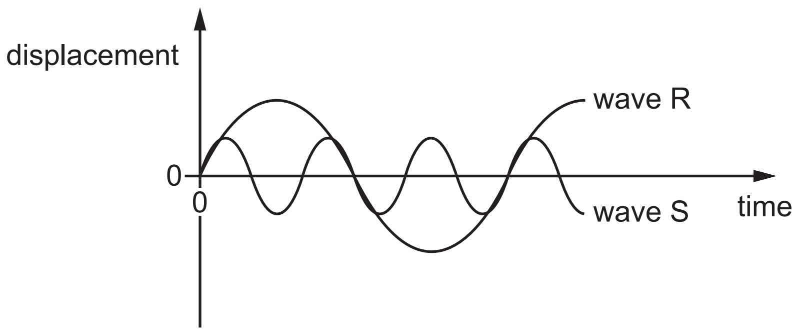
A Both light waves and sound waves show the Doppler effect.

B Light waves can be diffracted but sound waves cannot be diffracted.

C Sound waves are transverse waves and light waves are longitudinal waves.

D Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

24 The diagram shows two waves R and S.



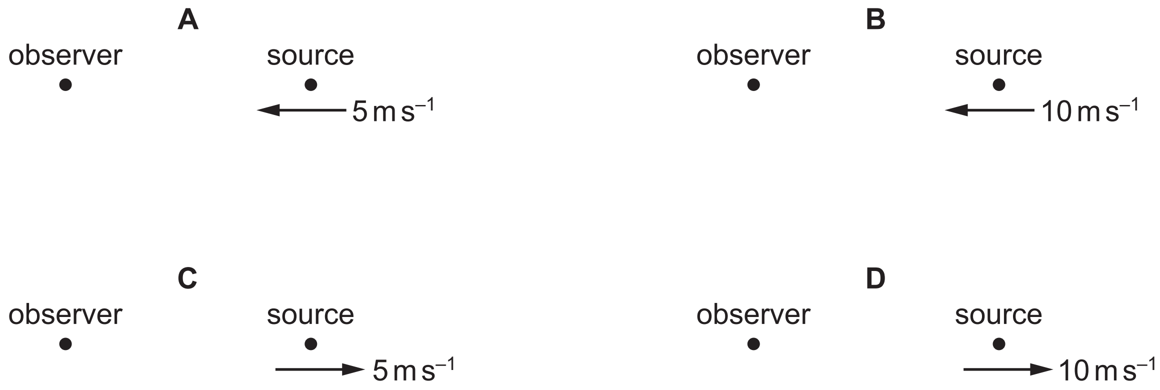
Wave R has an amplitude of 8 cm and a period of 30 ms.

What are the amplitude and the period of wave S?

	amplitude / cm	period / ms
A	2	10
B	2	90
C	4	10
D	4	90

25 A source of sound waves is travelling as shown.

In which situation would the stationary observer detect the largest decrease in the observed frequency?



26 M and N are two electromagnetic waves.

The ratio

$$\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5.$$

What could M and N be?

	M	N
A	microwaves	visible light
B	microwaves	γ-rays
C	γ-rays	microwaves
D	visible light	microwaves

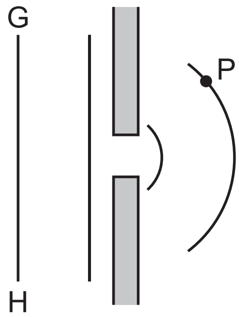
27 A progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

At an antinode, what could be the ratio $\dfrac{\text{displacement of the incident wave}}{\text{displacement of the reflected wave}}$ at any instant?

A –1 **B** 0 **C** 1 **D** 2

28 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 GH reach point P?

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

29 In an experiment to demonstrate two-source interference of light, a beam of light is split into two beams using two slits 0.50 mm apart. These two beams are incident on a laboratory wall at a distance of 4.0 m.

The wavelength of light is 550 nm.

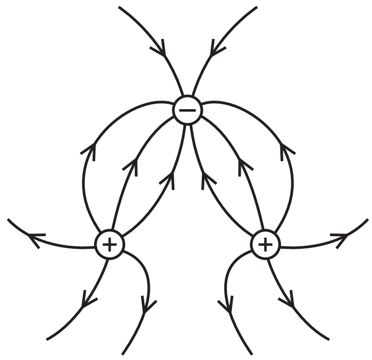
How far apart are two adjacent interference fringes that are formed on the laboratory wall?

A 0.22 mm **B** 0.44 mm **C** 2.2 mm **D** 4.4 mm

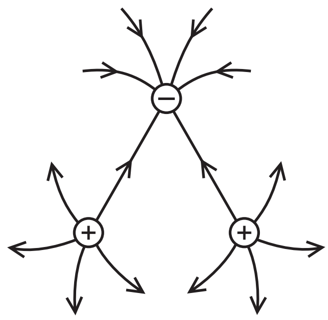
30 Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram best represents the electric field surrounding the charges?

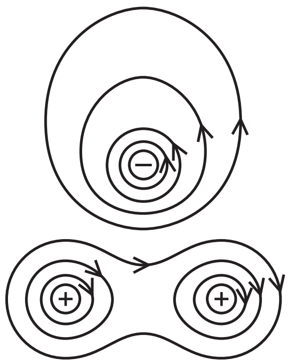
A



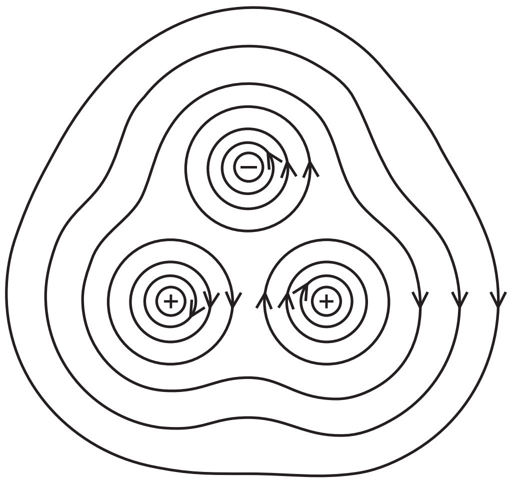
B



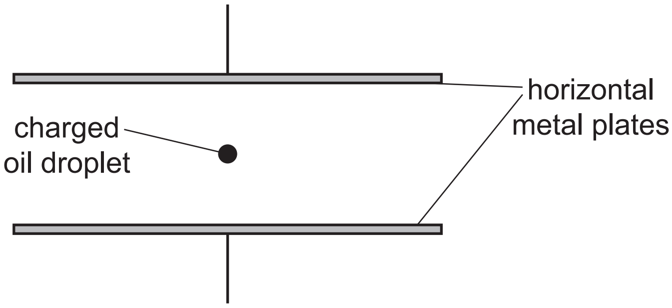
C



D



31 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

32 An electric current I is given in the list of formulae on page 3 as $I = Anvq$.

What do each of the symbols represent for an electric current in a metal wire?

	A	n	v	q
A	area of cross-section	number of free electrons	voltage	charge of each molecule
B	area of cross-section	number of free electrons per unit volume	average drift speed of electrons	charge of each electron
C	current	number of free electrons	average drift speed of electrons	charge of each molecule
D	current	number of free electrons per unit volume	voltage	charge of each electron

33 The potential difference across a resistor is 12 V. The current in the resistor is 2.0 A.

A charge of 4.0 C passes through the resistor.

What is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

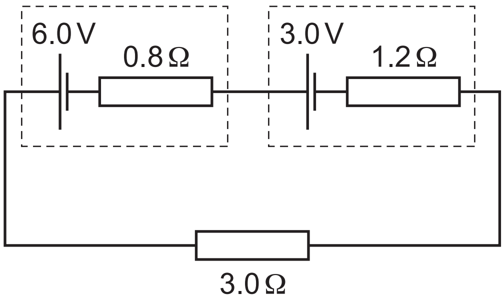
	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

34 A coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.

What is the total resistance between the two ends of the coil?

A $\dfrac{4N\rho D}{d^2}$ **B** $\dfrac{4N\rho d}{D^2}$ **C** $\dfrac{8N\rho D}{d^2}$ **D** $\dfrac{8N\rho d}{D^2}$

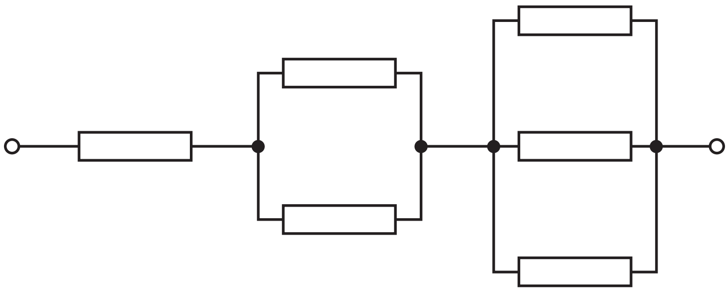
35 Two cells are connected to a load resistor of resistance 3.0 Ω. The electromotive force (e.m.f). and the internal resistance of each of the cells is shown.



What is the current in the load resistor?

A 0.60 A **B** 1.2 A **C** 1.8 A **D** 3.0 A

36 Six resistors, each of resistance R, are connected as shown.

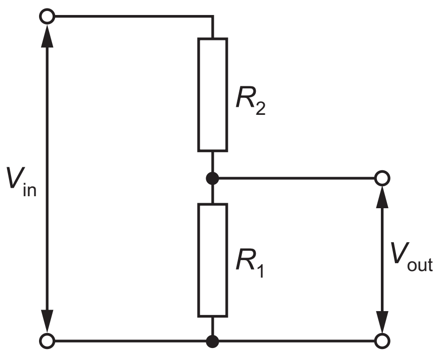


The combined resistance is $66\,\text{k}\Omega$.

What is the value of R?

A $11\,\text{k}\Omega$ **B** $18\,\text{k}\Omega$ **C** $22\,\text{k}\Omega$ **D** $36\,\text{k}\Omega$

37 A potential divider consists of two resistors of resistances R_1 and R_2 connected in series across a source of potential difference (p.d.) V_{in}. The p.d. across R_1 is V_{out}.



Which changes to R_1 and to R_2 will increase the value of V_{out}?

	R_1	R_2
A	doubled	doubled
B	doubled	halved
C	halved	doubled
D	halved	halved

38 Which row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

	α-particles	γ-rays
A	least ionizing	least penetrating
B	least penetrating	most ionizing
C	most ionizing	most penetrating
D	most penetrating	least ionizing

39 A nucleus of sodium-21, ${}^{21}_{11}\text{Na}$, decays to form a new nucleus containing 10 protons and 11 neutrons.

Which leptons are emitted from the sodium-21 nucleus during the decay?

A a positron and an antineutrino

B a positron and a neutrino

C an electron and an antineutrino

D an electron and a neutrino

40 A neutron decays to form a proton.

Which particle is **not** involved in the decay process?

A antineutrino

B down quark

C positron

D up quark

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **February/March 2018**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

IB18 03_9702_12/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which unit is equivalent to the coulomb?

A ampere per second

B joule per volt

C watt per ampere

D watt per volt

2 Which row shows a quantity and an **incorrect** unit?

	quantity	unit
A	efficiency	no unit
B	moment of force	N m^{-1}
C	momentum	N s
D	work done	J

3 Two forces of equal magnitude are represented by two coplanar vectors. One is directed towards the east and the other is directed towards the north.

What is the direction of a single force that will balance these two forces?

A towards the north-east

B towards the north-west

C towards the south-east

D towards the south-west

4 The density of paper is $800\,\text{kg m}^{-3}$. A typical sheet of paper has a width of 210 mm and a length of 300 mm.

The thickness of a pack of 500 sheets of paper is 50 mm.

What is the mass of a single sheet of paper?

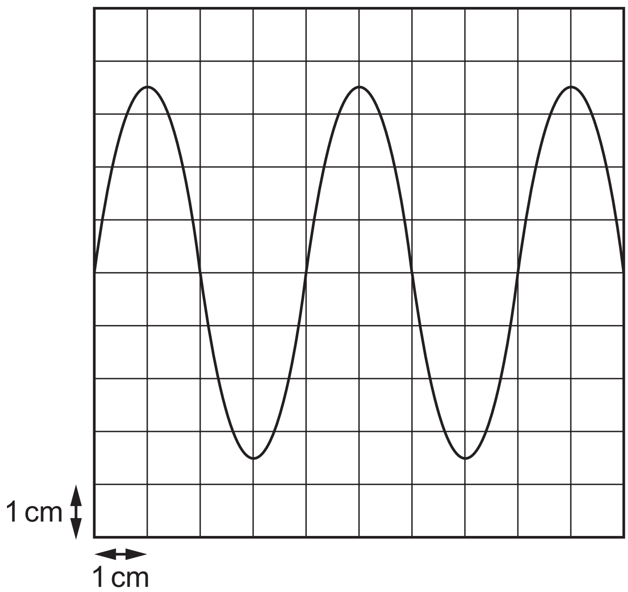
A 0.5 g **B** 5 g **C** 50 g **D** 500 g

5 A person calculates the potential difference across a wire by using the measurements shown.

Which measured quantity has the greatest contribution to the percentage uncertainty in the calculated potential difference?

	quantity	value	uncertainty
A	current / A	5.0	± 0.5
B	diameter of wire / mm	0.8	± 0.1
C	length of wire / m	150	± 5
D	resistivity of metal in wire / Ω m	1.6×10^{-8}	$\pm 0.2 \times 10^{-8}$

6 A cathode-ray oscilloscope (c.r.o.) is connected to an alternating voltage. The following trace is produced on the screen.



The oscilloscope time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 2 V cm^{-1}.

Which statement about the alternating voltage is correct?

A The amplitude is 3.5 cm.

B The frequency is 0.5 kHz.

C The period is 1 ms.

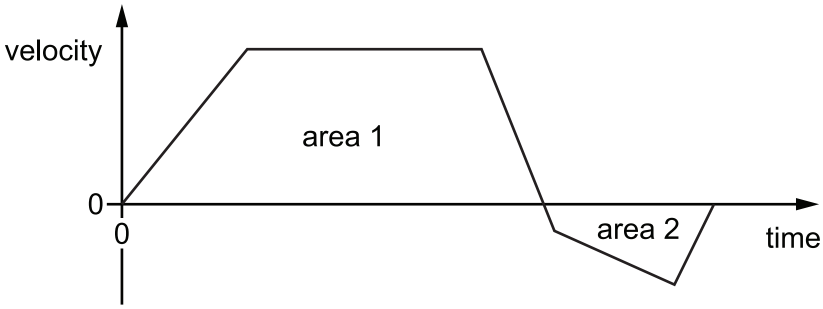
D The wavelength is 4 cm.

7 A stone of mass m is dropped from a tall building. There is significant air resistance. The acceleration of free fall is g.

When the stone is falling at a constant (terminal) velocity, which information is correct?

	magnitude of the acceleration of the stone	magnitude of the force of gravity on the stone	magnitude of the force of air resistance on the stone
A	g	zero	mg
B	zero	mg	mg
C	zero	zero	mg
D	zero	mg	zero

8 The velocity-time graph for an object is shown.



How can the total displacement of the object be determined?

A area 1 – area 2

B $\dfrac{(\text{area }1 + \text{area }2)}{2}$

C area 1 + area 2

D area 2 – area 1

9 A girl throws a ball vertically upwards. It takes a time of 3.20 s to return to her hand.

Assume air resistance is negligible.

What is the initial speed with which the ball is thrown?

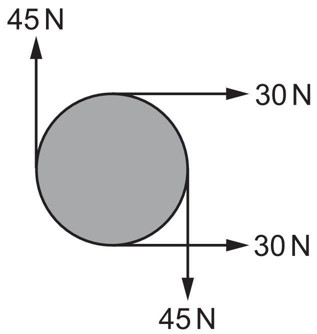
A $3.07\,\text{m}\,\text{s}^{-1}$ **B** $7.85\,\text{m}\,\text{s}^{-1}$ **C** $15.7\,\text{m}\,\text{s}^{-1}$ **D** $31.4\,\text{m}\,\text{s}^{-1}$

10 Steel pellets, each with a mass of 0.60 g, fall vertically onto a horizontal plate at a rate of 100 pellets per minute. They strike the plate with a velocity of $5.0\,m\,s^{-1}$ and rebound with a velocity of $4.0\,m\,s^{-1}$.

What is the average force exerted on the plate by the pellets?

A 0.0010 N **B** 0.0054 N **C** 0.0090 N **D** 0.54 N

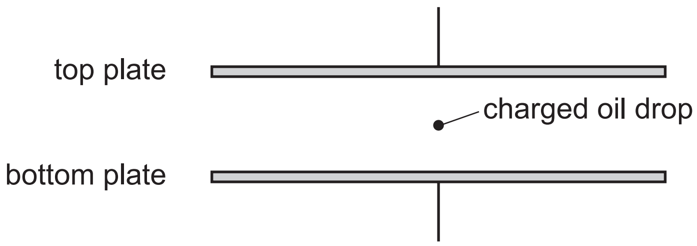
11 The diagram shows four forces applied to a circular object.



Which row describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

12 A charged oil drop is held stationary between two charged parallel plates.



Which forces act on the oil drop?

A both electric and gravitational

B electric only

C gravitational only

D neither electric nor gravitational

13 In which example is it **not** possible for the underlined body to be in equilibrium?

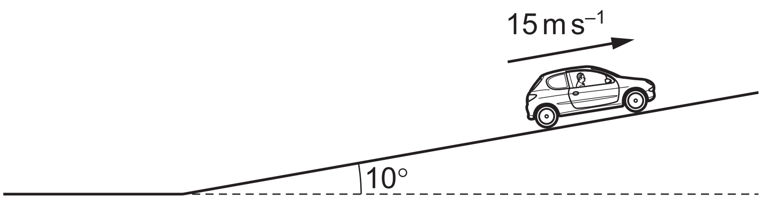
A An aeroplane climbs at a steady rate.

B An aeroplane tows a glider at a constant altitude.

C A speedboat changes direction at a constant speed.

D Two boats tow a ship into harbour.

14 A car of mass 1100 kg is travelling at a constant speed of $15\,\mathrm{m\,s^{-1}}$ up a slope inclined at 10° to the horizontal. The combined frictional forces acting on the car are directed down the slope and are equal to $\frac{W}{5}$, where W is the weight of the car.



What is the useful output power of the car's engine?

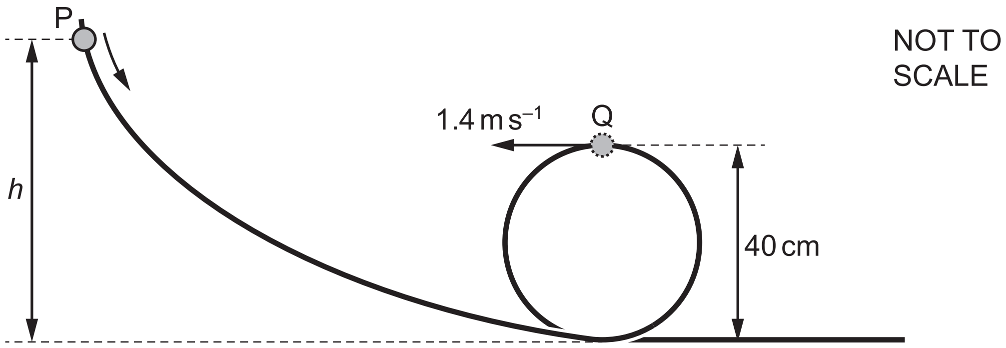
A 28 kW **B** 32 kW **C** 60 kW **D** 190 kW

15 An old-fashioned 60 W lamp converts 95% of its energy supply into heat. A 4.0 W modern lamp has the same power output of light as the old-fashioned lamp.

What is the efficiency of the modern lamp?

A 5.0% **B** 6.7% **C** 75% **D** 95%

16 A bead is released from rest at point P and slides along a wire, as shown.



The track loops around and forms a vertical circle of diameter 40 cm. At point Q, the bead has a speed of $1.4\,\mathrm{m\,s^{-1}}$.

Air resistance and friction on the wire are negligible.

What is the height *h* from which the bead is released?

A 0.30 m **B** 0.40 m **C** 0.50 m **D** 0.60 m

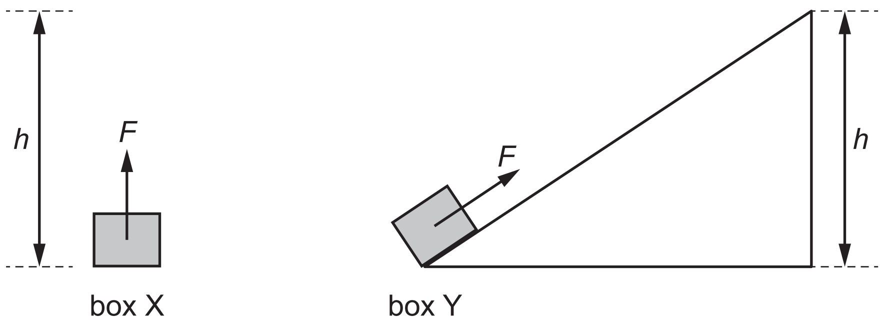
17 A small diesel engine uses a volume of $1.5 \times 10^4\,\mathrm{cm^3}$ of fuel per hour to produce a useful power output of 40 kW. It may be assumed that 34 kJ of energy is transferred to the engine when it uses $1.0\,\mathrm{cm^3}$ of fuel.

What is the rate of transfer from the engine of energy that is wasted?

A 102 kW **B** 142 kW **C** 182 kW **D** 470 kW

18 Two boxes X and Y have the same mass. Box X is lifted vertically through a height h by a force of magnitude F.

Box Y is pulled along a slope by a force of the same magnitude to reach the same height, as shown.



Which statement is correct?

A Both boxes gain the same amount of gravitational potential energy and the same amount of work is done by the two forces.

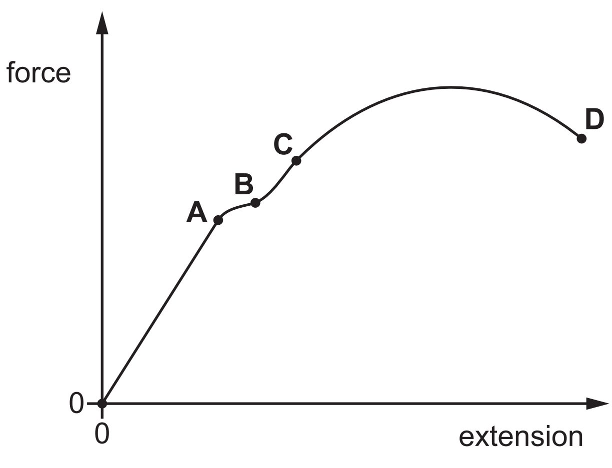
B Both boxes gain the same amount of gravitational potential energy but more work is done by the force acting on box Y than by the force acting on box X.

C Box Y gains less gravitational potential energy than box X because the weight of box Y is less than the weight of box X.

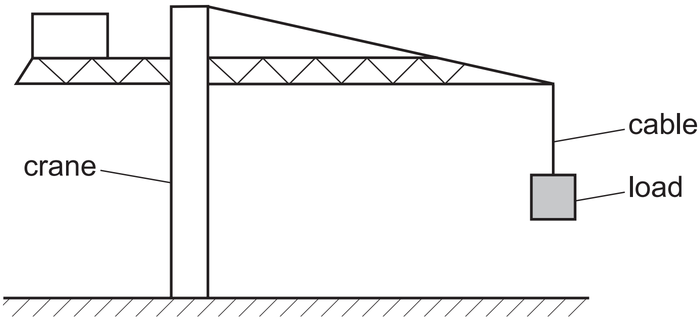
D Box Y gains more gravitational potential energy than box X as more work is done by the force acting on box Y than by the force acting on box X.

19 The force-extension graph of a metal wire is shown.

At which point on the graph does the metal wire stop obeying Hooke's law?



20 The diagram shows a large crane on a construction site lifting a cube-shaped load at a constant speed.



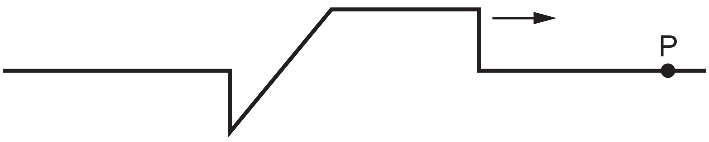
A model is made of the crane, its load and the cable supporting the load.

The material used for each part of the model is the same as that in the full-size crane, cable and load. The model is one tenth full-size in all linear dimensions.

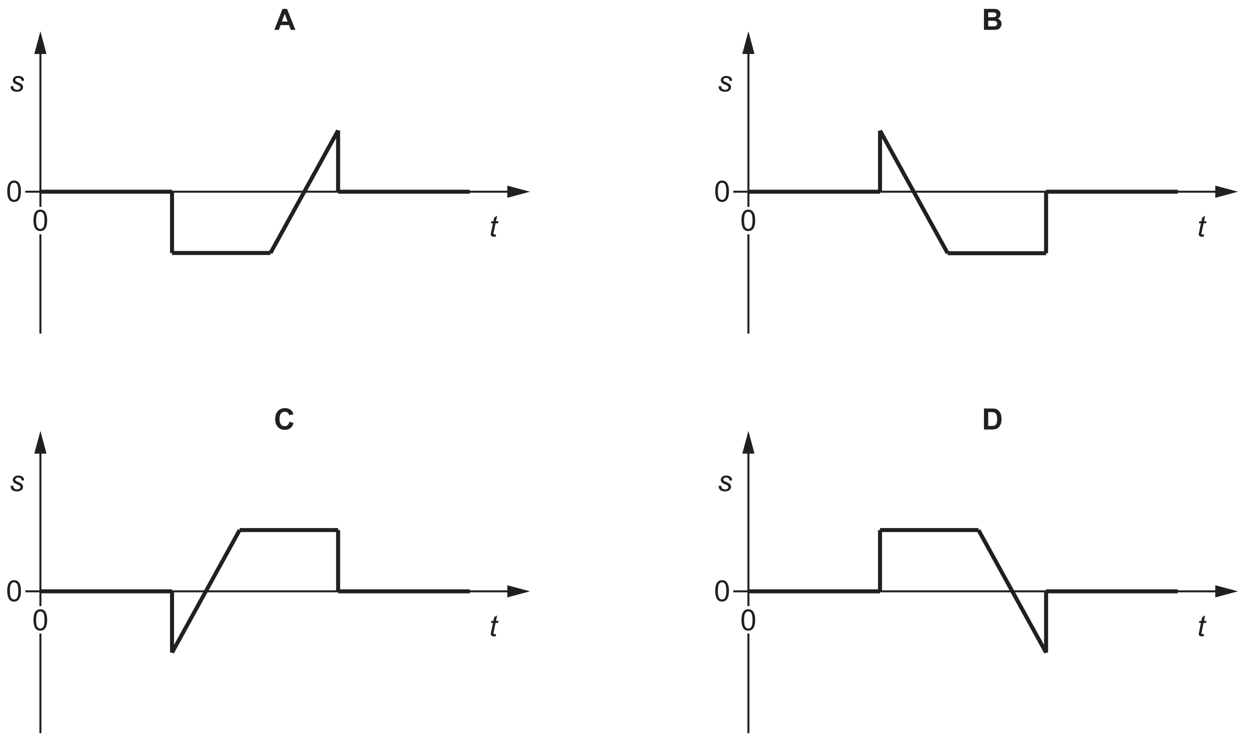
What is the ratio $\dfrac{\text{stress in the cable on the full-size crane}}{\text{stress in the cable on the model crane}}$?

A 0.1 **B** 1 **C** 10 **D** 100

21 A wave pulse moves along a stretched rope in the direction shown.

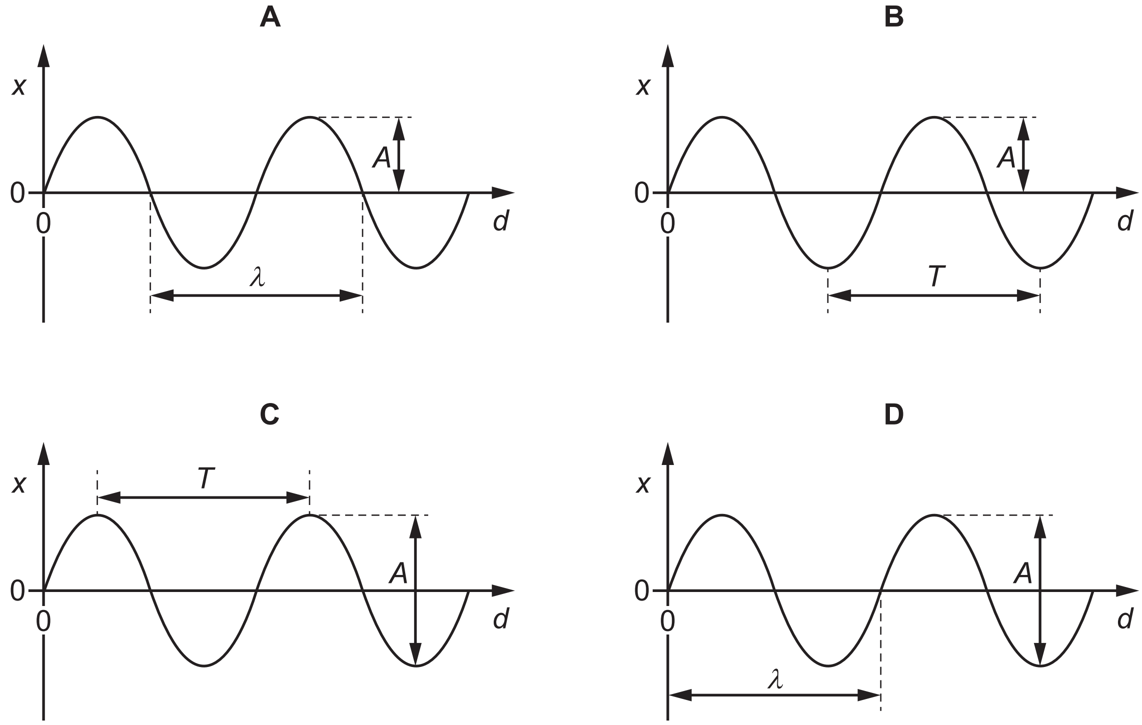


Which diagram shows the variation with time *t* of the displacement *s* of the particle P in the rope?



22 A wave has period T, wavelength λ and amplitude A. The wave is shown on a graph of displacement x against distance d.

Which graph is correctly labelled?



23 The table lists possible orders of magnitude of the wavelengths of some of the principal radiations of the electromagnetic spectrum.

Which row shows the correct orders of magnitude of the wavelengths?

	wavelength / m			
	microwaves	infra-red	ultraviolet	X-rays
A	10^{-6}	10^{-10}	10^{-12}	10^{-14}
B	10^{-4}	10^{-8}	10^{-10}	10^{-12}
C	10^{-2}	10^{-6}	10^{-8}	10^{-10}
D	10^{2}	10^{-4}	10^{-6}	10^{-8}

24 A vehicle carries a microwave transmitter that emits microwaves of a constant frequency. A stationary observer has a microwave receiver.

The vehicle moves directly towards the observer at constant speed. The observer detects microwaves of frequency F_o.

The vehicle then accelerates, still moving towards the observer, travels at higher steady speed for a time and then decelerates until it stops.

What is the variation in the frequency of the microwaves that are detected by the observer?

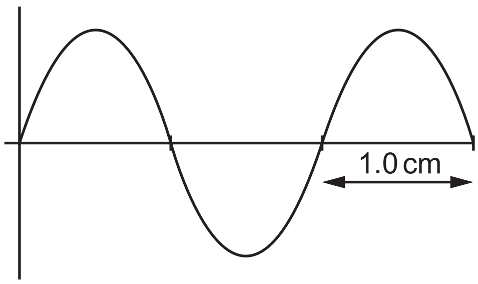
A The observed frequency will fall, then remain steady then return to the frequency F_o.

B The observed frequency will fall, then remain steady then rise to a higher frequency than F_o.

C The observed frequency will rise, then remain steady then fall to a lower frequency than F_o.

D The observed frequency will rise, then remain steady then return to the frequency F_o.

25 The diagram shows a cathode-ray oscilloscope display of an electromagnetic wave.



The time base setting is $0.20\,\mu s\,cm^{-1}$.

Which statement is correct?

A The frequency of the wave is 2.5 MHz and it lies in the microwave region of the electromagnetic spectrum.

B The frequency of the wave is 2.5 MHz and it lies in the radio-wave region of the electromagnetic spectrum.

C The frequency of the wave is 5.0 MHz and it lies in the microwave region of the electromagnetic spectrum.

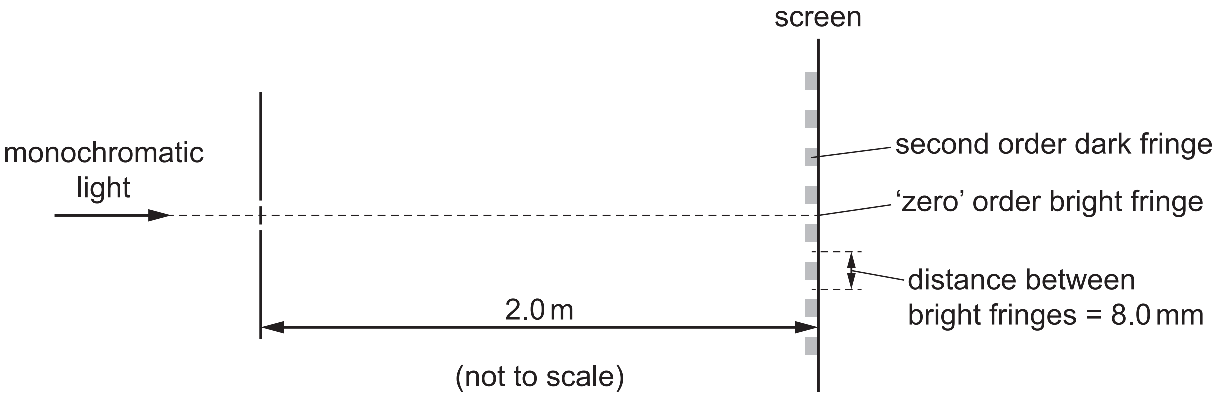
D The frequency of the wave is 5.0 MHz and it lies in the radio-wave region of the electromagnetic spectrum.

26 In a double-slit interference experiment, light of frequency 6.0×10^{14} Hz is incident on a pair of slits. Bright fringes that are 3.0 mm apart are observed on a screen some distance away.

What is the separation of the bright fringes when the frequency of the light is changed to 5.0×10^{14} Hz?

A 1.8 mm **B** 2.5 mm **C** 3.0 mm **D** 3.6 mm

27 Monochromatic light is incident on a pair of narrow slits a distance of 0.1 mm apart. A series of bright and dark fringes are observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference between the light waves from the two slits that meet at the second order dark fringe?

A 2.0×10^{-7} m

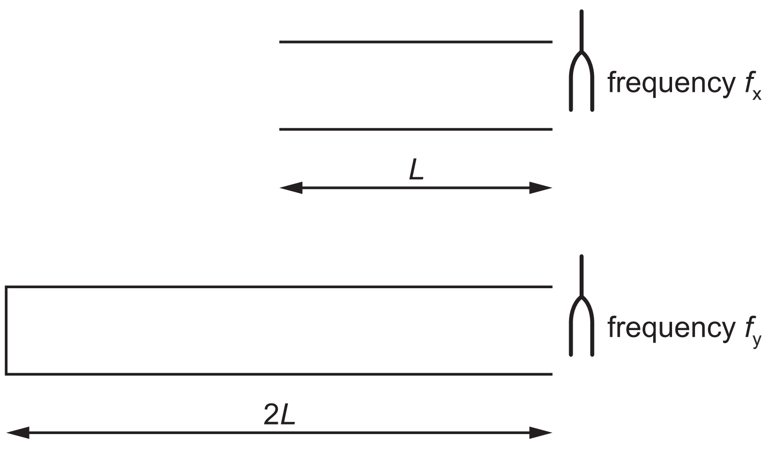
B 4.0×10^{-7} m

C 6.0×10^{-7} m

D 8.0×10^{-7} m

28 A tube of length L is open at both ends. A stationary wave is set up in this tube when a tuning fork vibrating with frequency f_x is held at one end. This is the lowest frequency of stationary wave that can be formed in this tube.

Another tube of length $2L$ is closed at one end. A stationary wave is set up in this tube when a tuning fork vibrating with frequency f_y is held at the open end. This is the lowest frequency of stationary wave that can be formed in this tube.



Assume the end correction for each tube is negligible.

Which equation is correct?

A $f_x = \frac{f_y}{4}$ **B** $f_x = \frac{f_y}{2}$ **C** $f_x = 2f_y$ **D** $f_x = 4f_y$

29 Which statement gives a condition that enables diffraction to occur?

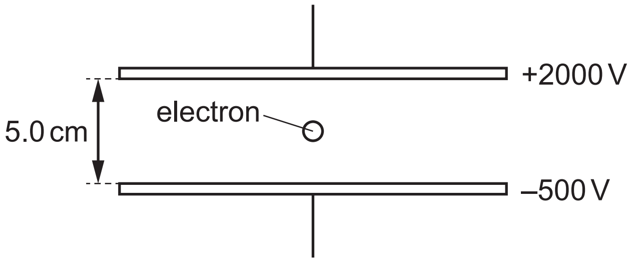
A A source of waves moves towards a stationary observer.

B A wave is partially blocked by an obstacle.

C Two coherent waves are superposed.

D Two waves of equal speed and frequency are travelling through the same part of a medium in opposite directions.

30 An electron passes into the space between two parallel plates that are 5.0 cm apart and which are maintained at electric potentials of +2000 V and –500 V, respectively.



What is the electric force on the electron?

A 1.6×10^{-15} N

B 4.8×10^{-15} N

C 6.4×10^{-15} N

D 8.0×10^{-15} N

31 Which statement about electric charges in a uniform electric field is **not** correct?

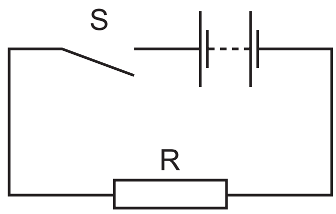
A Electric charges of the same magnitude, whether positive or negative, experience the same magnitude of force when placed in the same uniform electric field.

B The direction of the force on a positive charge placed in a uniform electric field is independent of the magnitude of the charge.

C The magnitude of the force on a positive charge placed in a uniform electric field is proportional to the magnitude of the electric field strength.

D The work done to move a positive charge a certain distance in a uniform electric field is independent of the direction of the movement.

32 The diagram shows a simple circuit.



Which statement is correct?

A When switch S is closed, the 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 of 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 of R.

33 A resistor has resistance R. When the potential difference across the resistor is V, the current in the resistor is I. The power dissipated in the resistor is P. Work W is done when charge Q flows through the resistor.

What is **not** a valid relationship between these variables?

A $I = \frac{P}{V}$ **B** $Q = \frac{W}{V}$ **C** $R = \frac{P}{I^2}$ **D** $R = \frac{V}{P}$

34 A wire of resistance $9.55\,\Omega$ has a diameter of 0.280 mm.

It is made of metal of resistivity $4.90 \times 10^{-7}\,\Omega\,\text{m}$.

What is the length of the wire?

A 1.20 m **B** 4.80 m **C** 19.0 m **D** 76.8 m

35 Charge carriers, each of charge q, move along a wire of fixed length. The number density of the charge carriers in the wire is n.

What is also required, for this wire, to determine the average drift velocity of the charge carriers in terms of n and q?

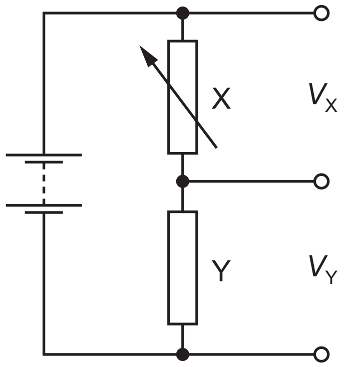
A current per unit of cross-sectional area

B potential difference per unit of length

C resistance and cross-sectional area

D resistivity and length

36 A potential divider circuit is constructed with one variable resistor X and one fixed resistor Y, as shown.

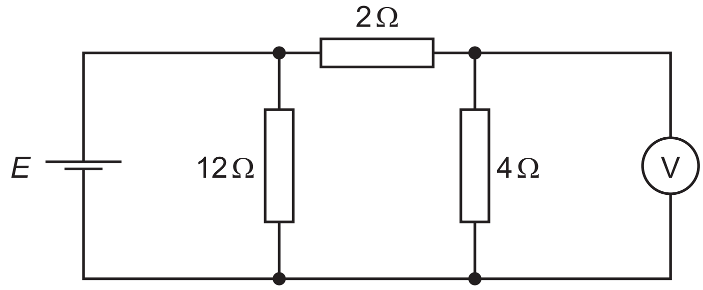


The potential difference across resistor X is V_X and the potential difference of resistor Y is V_Y.

As the resistance of X is increased, what happens to V_X and to V_Y?

	V_X	V_Y
A	falls	rises
B	falls	stays the same
C	rises	falls
D	rises	stays the same

37 A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.

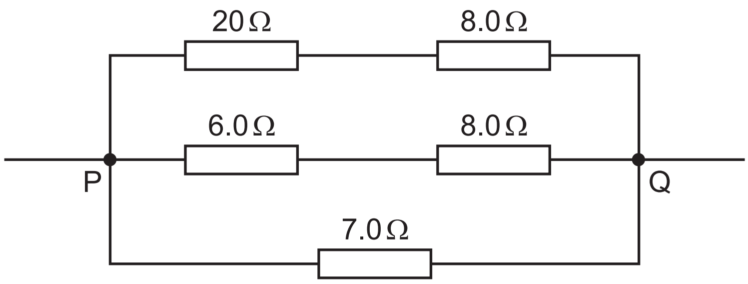


The voltmeter has a very high resistance and reads a potential difference V_{out}.

What is the ratio $\frac{V_{out}}{E}$?

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

38 Five resistors are connected as shown.

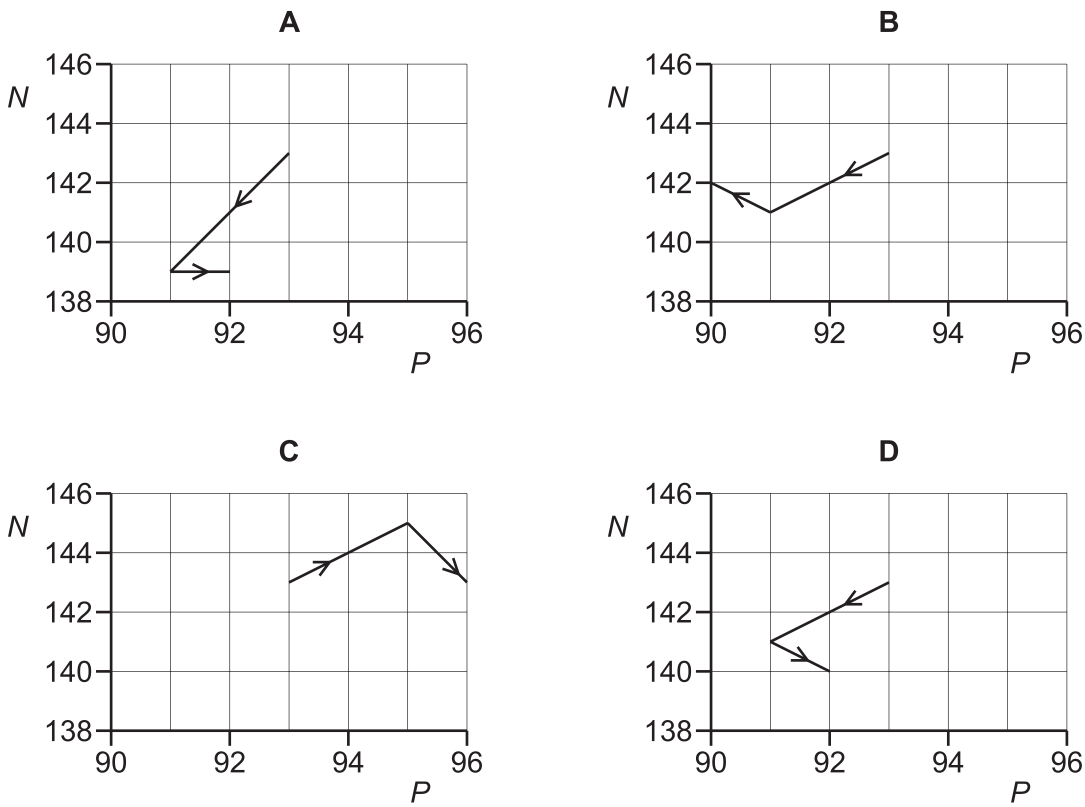


What is the total resistance between points P and Q?

A 0.25 Ω **B** 0.61 Ω **C** 4.0 Ω **D** 16 Ω

39 A nucleus of neptunium-236 contains 93 protons and 143 neutrons. This nucleus decays with the emission of an α-particle. The nucleus formed then emits a β^- particle.

Which diagram shows the changes in the number *P* of protons and the number *N* of neutrons in these nuclei?



40 An isolated neutron decays to produce a proton, a β^- particle and an antineutrino.

Which row gives the quark composition of the neutron and the proton and the type of force that gives rise to this reaction?

	quark composition		type of force
	neutron	proton	
A	down, down, up	down, up, up	strong interaction
B	down, down, up	down, up, up	weak interaction
C	down, up, up	down, down, up	strong interaction
D	down, up, up	down, down, up	weak interaction

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

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PHYSICS **9702/12**

Paper 1 Multiple Choice **February/March 2019**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

IB19 03_9702_12/4RP

Cambridge Assessment International Education

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^{\,2} - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 A wave has a frequency of 5 GHz.

What is the period of the wave?

A 200 ps

B 2 ns

C 20 ns

D 20 000 μs

2 At temperatures close to 0 K, the specific heat capacity c of a particular solid is given by $c = bT^3$, where T is the temperature and b is a constant, characteristic of the solid.
The SI unit of specific heat capacity is $\text{J kg}^{-1}\text{K}^{-1}$.

What is the unit of constant b, expressed in SI base units?

A $\text{m}^2\text{s}^{-2}\text{K}^{-3}$

B $\text{m}^2\text{s}^{-2}\text{K}^{-4}$

C $\text{kg m}^2\text{s}^{-2}\text{K}^{-3}$

D $\text{kg m}^2\text{s}^{-2}\text{K}^{-4}$

3 The speed of an aircraft in still air is 200 km h^{-1}. The wind blows from the west at a speed of 85.0 km h^{-1}.

In which direction must the pilot steer the aircraft in order to fly due north?

A 23.0° east of north

B 23.0° west of north

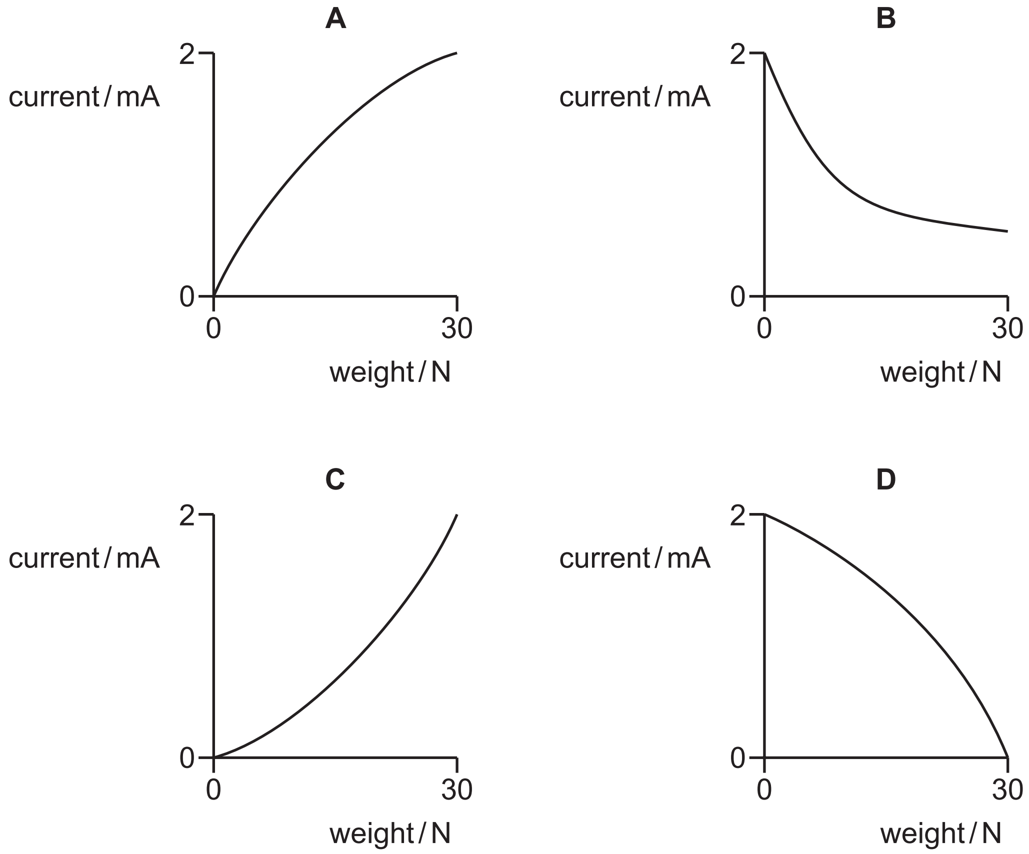
C 25.2° east of north

D 25.2° west of north

4 A digital balance is used to weigh ingredients in a laboratory. When a weight is applied to the digital balance, an electronic circuit generates a current which is then converted into a digital readout on the display.

The electronic circuit gives a current of 2.0 mA when a weight of 30 N is applied, and a current of 0.5 mA when a weight of 5 N is applied.

Which calibration curve could represent this circuit?



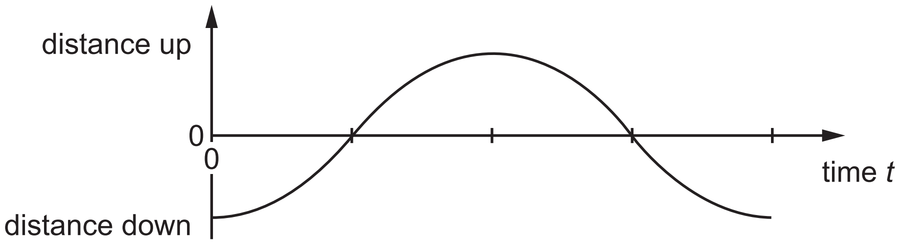
5 Four students measure a time interval that is known to be 1.734 s.

The measurement recorded by each student is shown.

Which measurement is the most accurate?

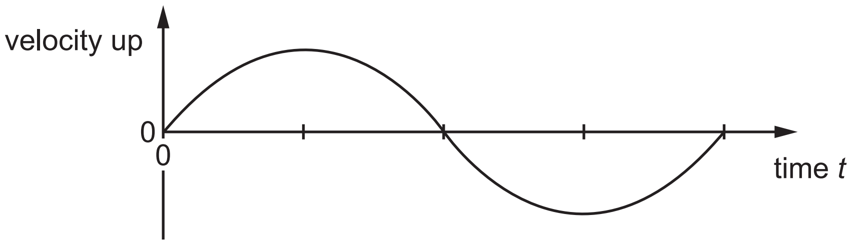
A 1 s **B** 1.7 s **C** 1.83 s **D** 1.604 s

6 A mass on the end of a spring bounces up and down as shown, after being released at time $t = 0$.

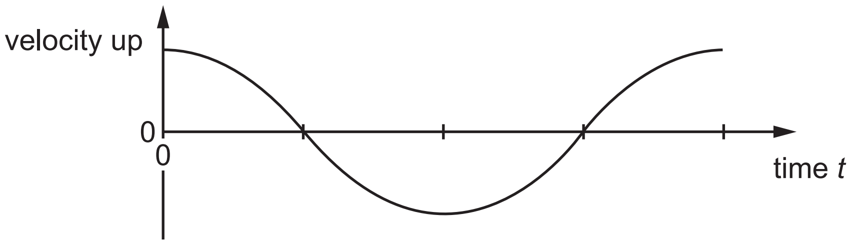


Which graph shows how the velocity varies with time?

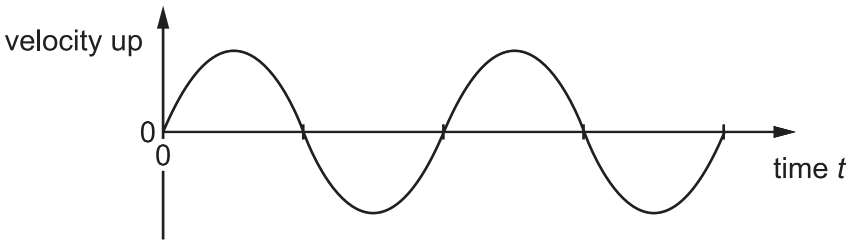
A



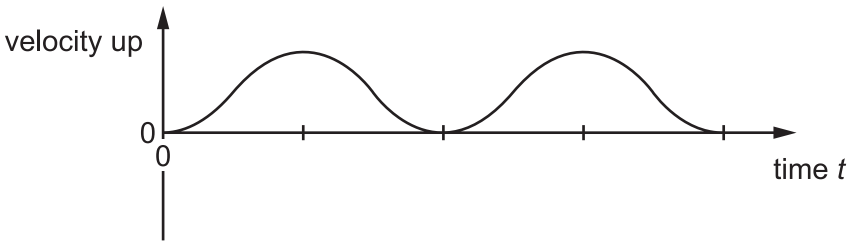
B



C



D



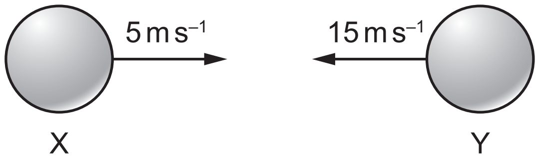
7 A stone is thrown vertically upwards from a point that is 12 m above the sea. It then falls into the sea below after 3.4 s.

Air resistance is negligible.

At which speed was the stone released when it was thrown?

A $3.5\,m\,s^{-1}$ **B** $6.6\,m\,s^{-1}$ **C** $13\,m\,s^{-1}$ **D** $20\,m\,s^{-1}$

8 Two balls X and Y are moving towards each other with speeds of $5\,m\,s^{-1}$ and $15\,m\,s^{-1}$ respectively.



They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of $7\,m\,s^{-1}$.

What is the speed and direction of ball X after the collision?

A $3\,m\,s^{-1}$ to the left

B $13\,m\,s^{-1}$ to the left

C $3\,m\,s^{-1}$ to the right

D $13\,m\,s^{-1}$ to the right

9 In the absence of air resistance, a ball thrown horizontally from a tower with velocity v, will land after time T seconds.

If, however, air resistance is taken into account, which statement is correct?

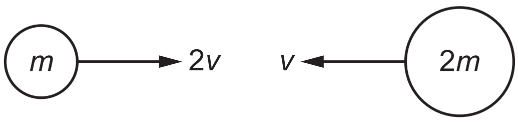
A The ball lands with a horizontal velocity less than v after more than T seconds.

B The ball lands with a horizontal velocity less than v after T seconds.

C The ball lands with a horizontal velocity v after more than T seconds.

D The ball lands with a horizontal velocity v after T seconds.

10 Two balls, of masses m and $2m$, travelling in a vacuum with initial velocities $2v$ and v respectively, collide with each other head-on, as shown.



After the collision, the ball of mass m rebounds to the left with velocity v.

What is the loss of kinetic energy in the collision?

A $\frac{3}{4}mv^2$ **B** $\frac{3}{2}mv^2$ **C** $\frac{9}{4}mv^2$ **D** $\frac{9}{2}mv^2$

11 A ball falls through a liquid at a constant speed. It is acted upon by three forces: an upthrust, a drag-force and its weight.

Which statement is correct?

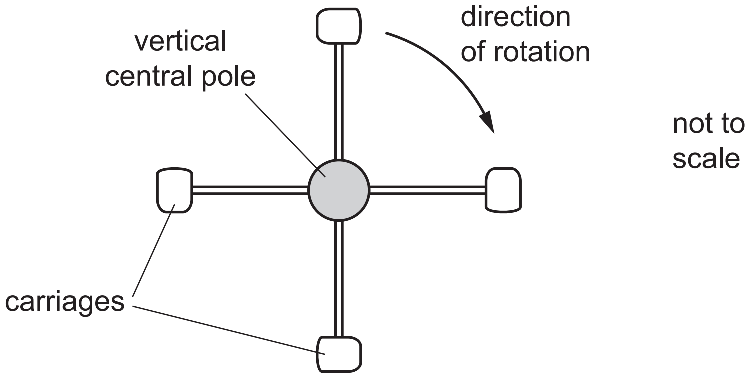
A The drag-force increases with increasing depth.

B The drag-force is equal to the sum of the upthrust and weight.

C The upthrust is constant with increasing depth.

D The weight is greater than the sum of the drag-force and the upthrust.

12 A fairground ride consists of four carriages connected to a central vertical pole, as shown in the following view from above.



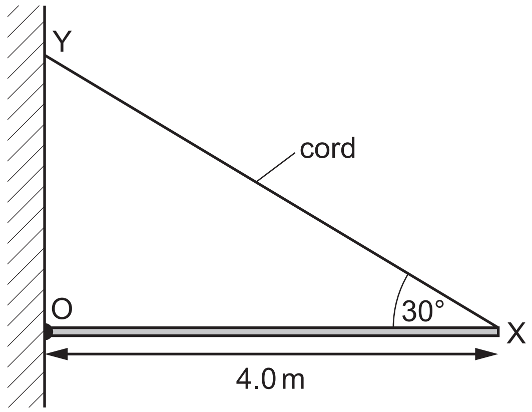
A motor rotates the central pole about its axis. This results in the four carriages each moving along a circular path.

The distance from the middle of each carriage to the centre of the pole is 3.20 m. When they are moving, each carriage experiences an air resistance force of 85.0 N. Assume that there are no other significant resistive forces.

Which torque does the motor need to apply to the pole to keep the system rotating at constant maximum speed?

A 5.44 N m **B** 272 N m **C** 544 N m **D** 1090 N m

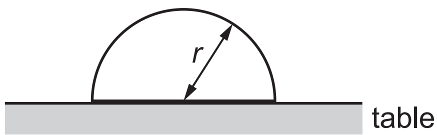
13 A uniform horizontal beam OX, 4.0 m long and weighing 100 N, is hinged at a wall at point O. It is supported by a cord XY which is attached to the wall at Y.



What is the tension in the cord?

A 50 N **B** 58 N **C** 86 N **D** 100 N

14 An object shaped as a hemisphere rests with its flat surface on a table. The object has radius r and density ρ.



The volume of a sphere is $\frac{4}{3}\pi r^3$.

Which average pressure does the object exert on the table?

A $\frac{1}{3}\rho r^2$ **B** $\frac{1}{3}\rho r^2 g$ **C** $\frac{2}{3}\rho r$ **D** $\frac{2}{3}\rho r g$

15 Which statement best represents the principle of conservation of energy?

A Energy cannot be used faster than it is created.

B The supply of energy is limited, so energy must be conserved.

C The total energy in a closed system is constant.

D The total energy input to a system is equal to the useful energy output.

16 A crane is being used to lift containers off a ship. One container has a mass of 14 000 kg and is being lifted vertically with a speed of $3.2\,\mathrm{m\,s^{-1}}$.

The electric motor being used to supply the power to lift the container is using a current of 240 A at a potential difference of 2200 V.

What is the efficiency of the system?

A 8.1% **B** 8.5% **C** 48% **D** 83%

17 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

What is the ratio $\dfrac{\text{power output}}{\text{power input}}$?

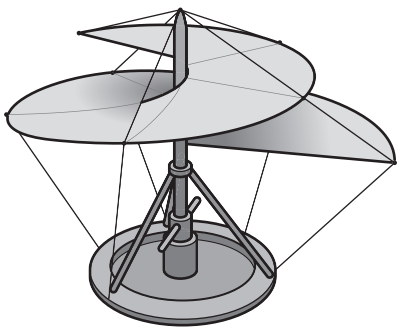
A $\dfrac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$

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

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

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

18 Leonardo da Vinci proposed a flying machine that would work like a screw to lift the pilot into the air. The 'screw' is rotated by the pilot.



The machine and the pilot together have a total mass of 120 kg.

Which useful output power must the pilot provide to move vertically upwards at a constant speed of 2.5 m s^{-1}?

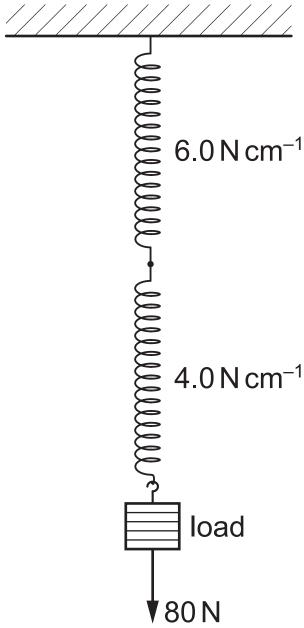
A 48 W **B** 300 W **C** 470 W **D** 2900 W

19 A metal wire, fixed at one end, has length l and cross-sectional area A. The wire extends a distance e when mass m is hung from the other end of the wire.

What is an expression for the Young Modulus E of the metal?

A $E = \dfrac{ml}{Ae}$ **B** $E = \dfrac{mgl}{Ae}$ **C** $E = \dfrac{me}{Al}$ **D** $E = \dfrac{mge}{Al}$

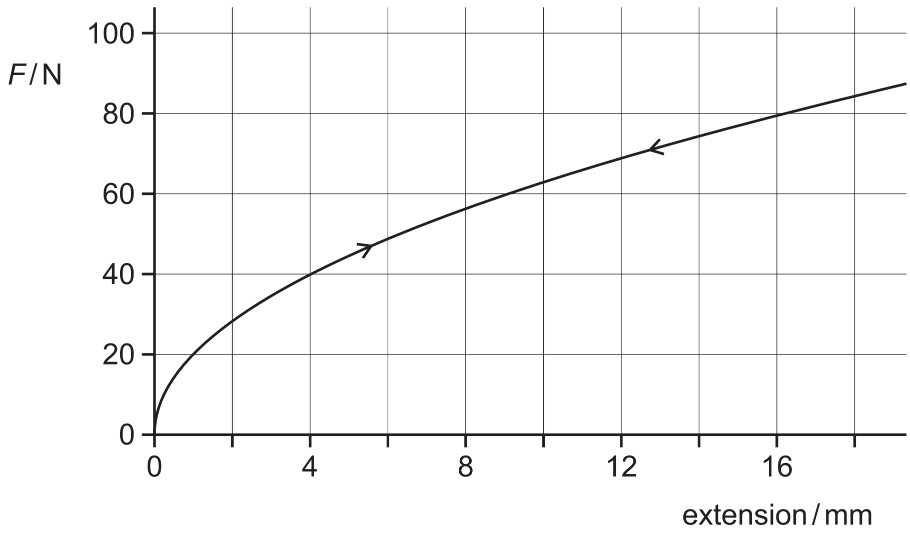
20 A spring has a spring constant of $6.0\,\text{N cm}^{-1}$. It is joined to another spring whose spring constant is $4.0\,\text{N cm}^{-1}$. A load of 80 N is suspended from this composite spring.



What is the extension of this composite spring?

A 8.0 cm **B** 16 cm **C** 17 cm **D** 33 cm

21 The graph shows the extension of a sample of a type of rubber as different loads *F* are applied and then gradually removed.

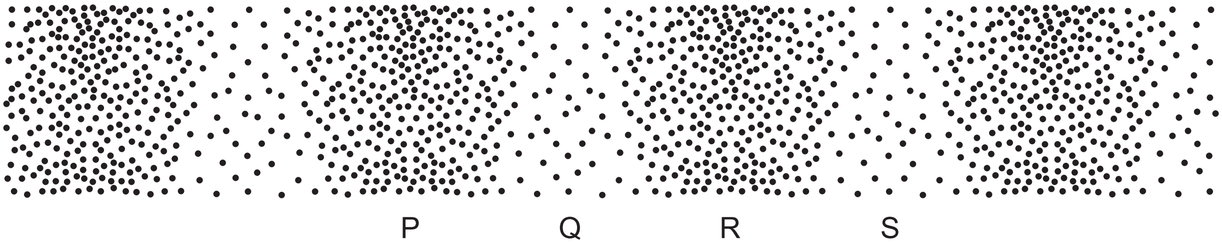


What is the best estimate of the strain energy in the rubber when a load of 80 N is applied?

A 0.40 J **B** 0.64 J **C** 0.88 J **D** 1.3 J

22 A sound wave passes through air.

The diagram shows the positions of the molecules of the air at one instant.

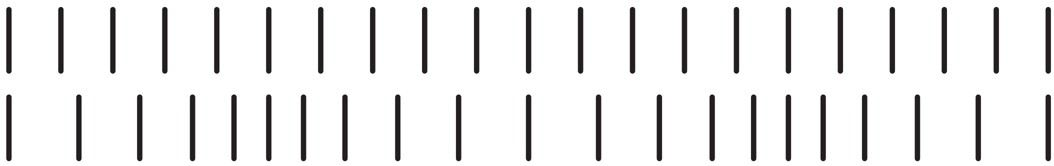


Which distance is equal to the wavelength of the wave?

A PQ **B** PS **C** QR **D** QS

23 The top row of bars represents a set of particles inside the Earth and at rest.

The lower row represents the same particles at one instant as a longitudinal wave passes from left to right through the Earth.



What should be measured to determine the amplitude of the oscillations of the particles in the lower row as the wave passes?

A half the maximum displacement of the particles from their position at rest

B half the maximum distance apart of the particles

C the maximum displacement of the particles from their position at rest

D the maximum distance apart of the particles

24 A straight tube is closed at one end and has a loudspeaker positioned at the open end. The frequency of the loudspeaker is initially very low and is increased slowly. A series of loudness maxima are heard. The stationary wave which gives the first maximum has a node at the closed end and an antinode at the open end. The frequency of the loudspeaker is f_1 when the first maximum is heard.

What is the frequency of the loudspeaker when the fourth maximum is heard?

A $\frac{7f_1}{4}$ **B** $2f_1$ **C** $4f_1$ **D** $7f_1$

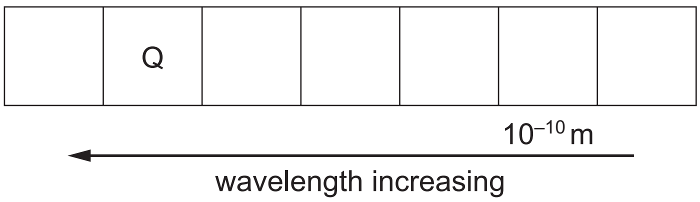
25 A buzzer emitting sound of frequency 846 Hz is attached to a string and rotated in a horizontal circle. The linear speed of the buzzer is $25.0\,\mathrm{m\,s^{-1}}$.

The speed of sound is $340\,\mathrm{m\,s^{-1}}$.

What is the maximum frequency heard by the observer?

A 783 Hz **B** 788 Hz **C** 908 Hz **D** 913 Hz

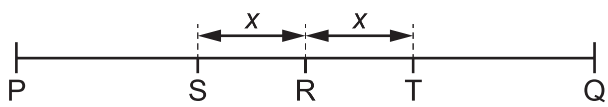
26 The diagram shows the principal regions of the electromagnetic spectrum, with some details labelled. The diagram is not to scale.



What is a typical order of magnitude of the wavelength of the radiation in region Q?

A 10^{-7} m **B** 10^{-5} m **C** 10^{-2} m **D** 10^{0} m

27 P and Q are fixed points at the end of a string. A transverse stationary wave of constant maximum amplitude is formed on the string.



P, R and Q are the only points on the string where nodes are formed. S and T are two points on the string at a distance x from R.

What is the relationship between points S and T?

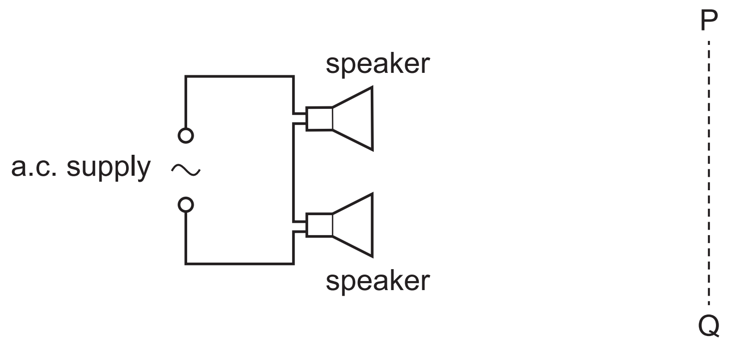
A the same amplitude and in phase

B different amplitudes and in phase

C the same amplitude and a phase difference of 180°

D different amplitudes and a phase difference of 180°

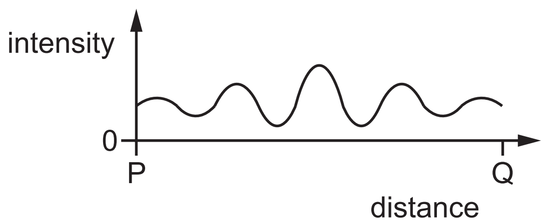
28 Two identical loudspeakers are connected in series to an a.c. supply, as shown.



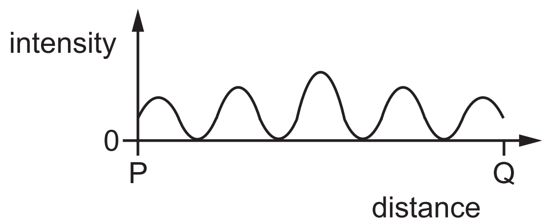
A microphone is moved along the line PQ.

Which graph best shows the variation with distance from P of the intensity of the sound detected by the microphone?

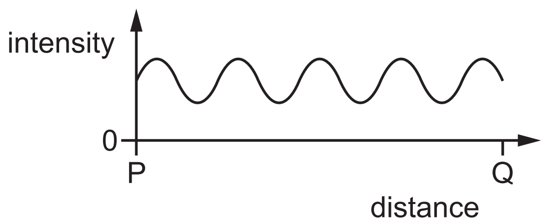
A



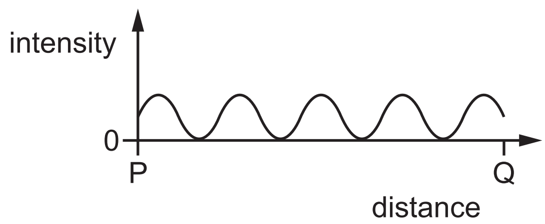
B



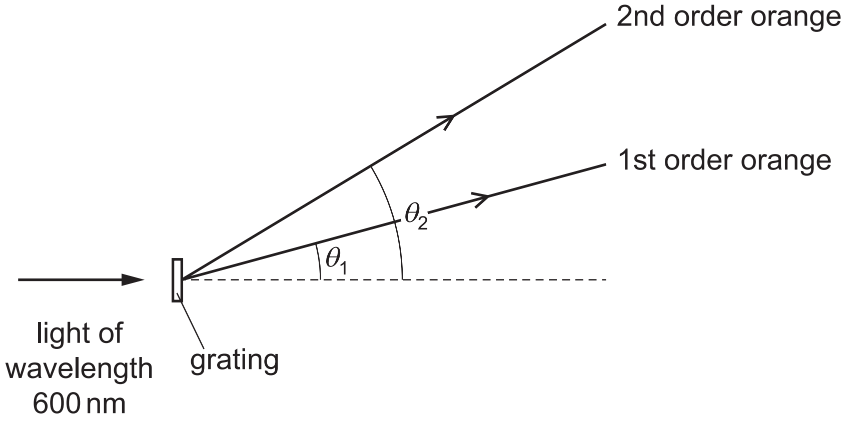
C



D



29 A diffraction grating experiment is set up using orange light of wavelength 600 nm. The grating has a slit separation of 2.00 μm.



What is the angular separation ($\theta_2 - \theta_1$) between the first and second order maxima of the orange light?

A 17.5° **B** 19.4° **C** 36.9° **D** 54.3°

30 Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V.

What is the electric field strength E at a point midway between the plates?

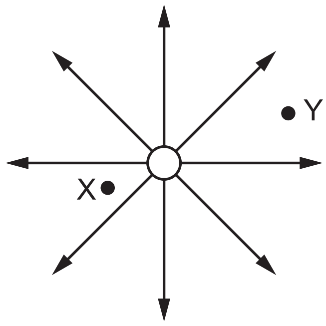
A $1.0 \times 10^4\,\mathrm{V\,m^{-1}}$ downwards

B $1.0 \times 10^4\,\mathrm{V\,m^{-1}}$ upwards

C $2.0 \times 10^4\,\mathrm{V\,m^{-1}}$ downwards

D $2.0 \times 10^4\,\mathrm{V\,m^{-1}}$ upwards

31 The diagram shows the electric field near a point charge and two electrons X and Y.



Which row describes the forces acting on X and on Y?

	direction of force	magnitude of force on X
A	radially inwards	less than force on Y
B	radially inwards	greater than force on Y
C	radially outwards	less than force on Y
D	radially outwards	greater than force on Y

32 The electric current in a wire may be calculated using the equation $I = Anvq$.

Which statement is **not** correct?

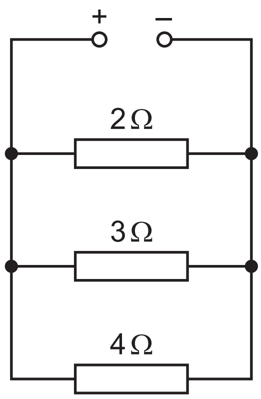
A *n* is the number of charge carriers per unit volume of the wire.

B *nA* is the number of charge carriers per unit length of the wire.

C *q* is the charge of each charge carrier.

D *v* is the velocity of each charge carrier.

33 Three resistors are connected in parallel across a power supply, as shown.

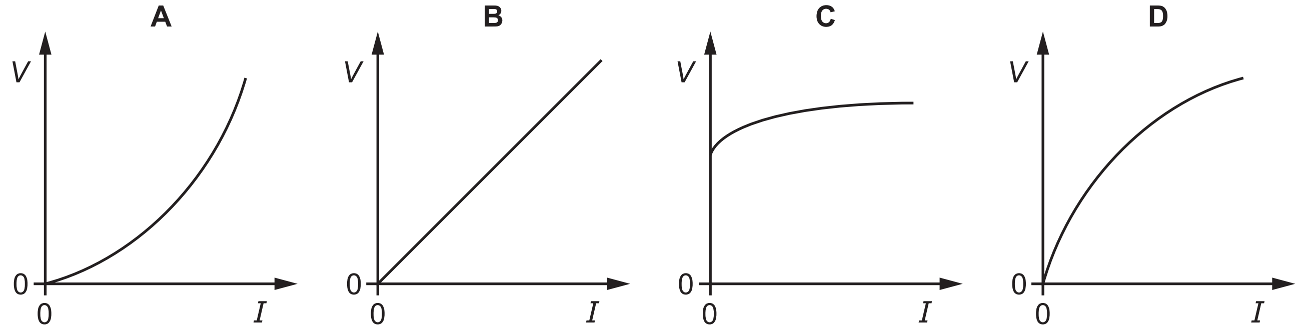


The power dissipated in each of the resistors of resistance 2Ω, 3Ω and 4Ω is P_2, P_3 and P_4 respectively.

What is the ratio $P_2 : P_3 : P_4$?

A 2 : 3 : 4 **B** 4 : 3 : 2 **C** 6 : 4 : 3 **D** 36 : 16 : 9

34 Which graph shows the variation with current I of the potential difference V of a filament lamp?



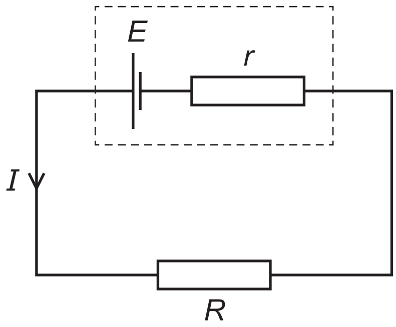
35 A wire of cross-sectional area $5.0 \times 10^{-6}\,\text{m}^2$ is made of a metal of resistivity $50 \times 10^{-8}\,\Omega\,\text{m}$.

The potential difference across the wire is 6.0 V and the current is 3.0 A.

What is the length of the wire?

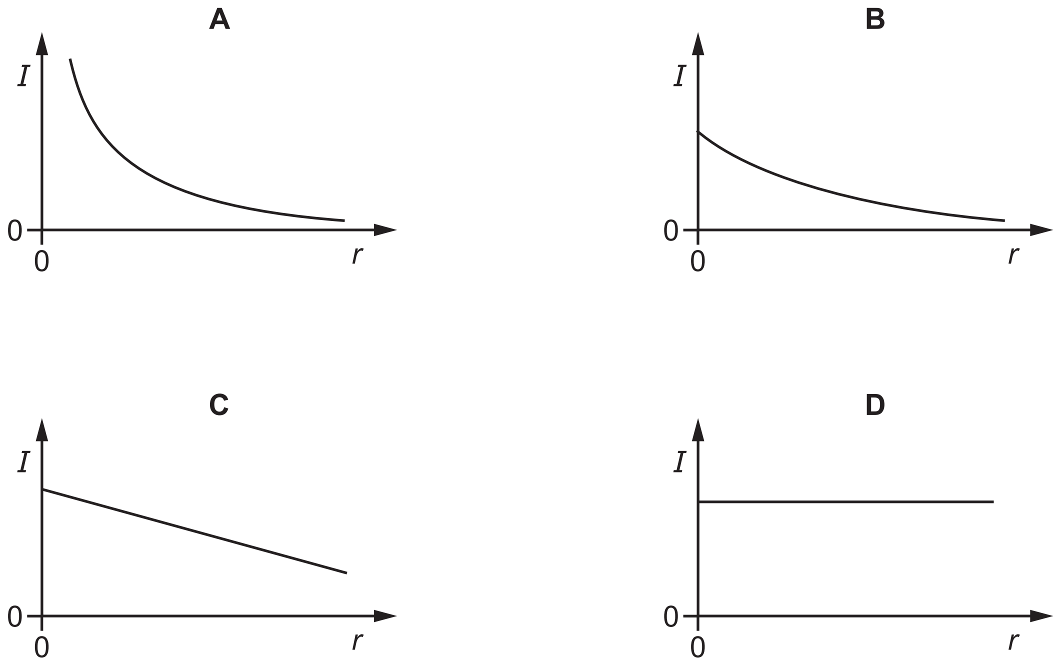
A 0.050 m **B** 0.20 m **C** 5.0 m **D** 20 m

36 A cell of internal resistance r and electromotive force (e.m.f.) E is connected in series with a resistor of resistance R.

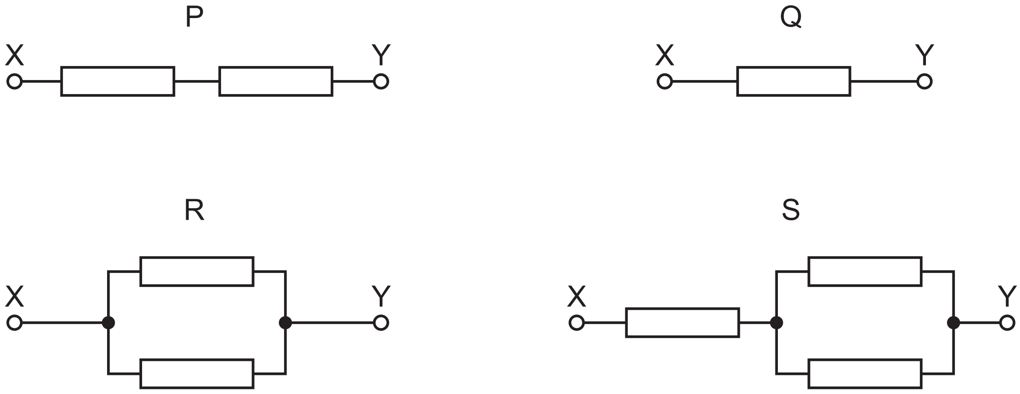


The resistance R and the e.m.f. E remain fixed. The internal resistance r of the cell changes over time.

Which graph best shows the variation of the current I in the circuit with the internal resistance r?



37 Identical resistors are connected in four combinations P, Q, R and S between terminals X and Y.



What is the order of decreasing combined resistance between X and Y (largest first)?

A P → S → Q → R

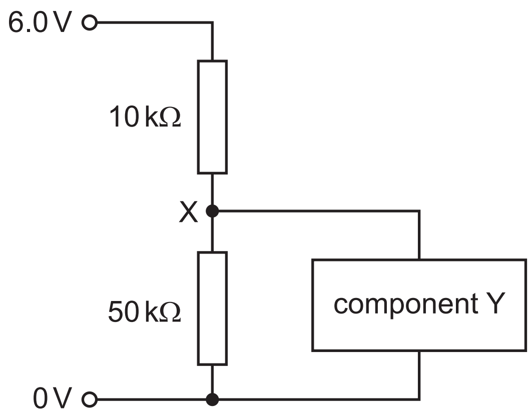
B P → S → R → Q

C Q → R → S → P

D S → P → Q → R

38 The circuit shown consists of two resistors of resistances 10 kΩ and 50 kΩ and a component Y.

A 6.0 V supply is provided. The electric potential of the bottom wire is 0 V.



The current in component Y is negligible.

What is the electric potential at junction X?

A 1.0 V **B** 1.2 V **C** 4.8 V **D** 5.0 V

39 A neutron ${}^{1}_{0}\text{n}$ is fired at a ${}^{235}_{92}\text{U}$ nucleus. The neutron is absorbed by the nucleus which then splits to form nuclei of ${}^{141}_{56}\text{Ba}$ and ${}^{92}_{36}\text{Kr}$.

What is the number of neutrons emitted when the ${}^{235}_{92}\text{U}$ nucleus splits?

A 0 **B** 1 **C** 2 **D** 3

40 Which word equation represents β^+ decay?

A proton $\rightarrow$ neutron + electron + electron antineutrino

B proton $\rightarrow$ neutron + electron + electron neutrino

C proton $\rightarrow$ neutron + positron + electron antineutrino

D proton $\rightarrow$ neutron + positron + electron neutrino

Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **February/March 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.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 The table shows some measurable quantities.

Which row gives the correct order of magnitude of the measurable quantity in the stated unit?

	measurable quantity	order of magnitude	unit
A	mass of a coin	10^{-4}	kg
B	thickness of a sheet of paper	10^{-2}	m
C	weight of an apple	10^{0}	N
D	temperature of a person's body	10^{1}	K

2 A byte (b) comprises 8 bits.

How many bits are there in 1 terabyte (1Tb)?

A 1×10^{9} **B** 8×10^{9} **C** 1×10^{12} **D** 8×10^{12}

3 Which pair of quantities contains both a scalar **and** a vector?

A acceleration and momentum

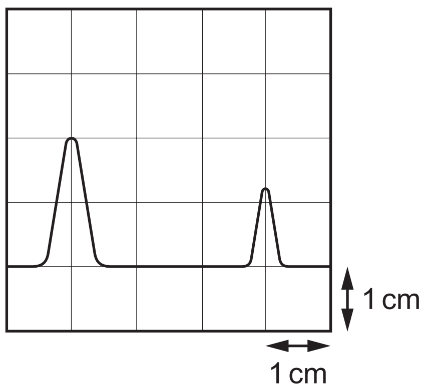
B charge and resistance

C kinetic energy and mass

D temperature and velocity

4 A transmitter emits a pulse of electromagnetic waves towards a reflector. The pulse is reflected and returns to the transmitter.

A detector is located at the transmitter. The emitted pulse and the reflected pulse are displayed on a cathode-ray oscilloscope (CRO) as shown.



The pulse takes 6.3 μs to travel from the transmitter to the reflector.

What is the time-base setting of the CRO?

A 2.1 μs cm^{-1} **B** 3.2 μs cm^{-1} **C** 4.2 μs cm^{-1} **D** 6.3 μs cm^{-1}

5 A micrometer is used to measure the diameters of two cylinders.

diameter of first cylinder = $(12.78 \pm 0.02)\,\text{mm}$

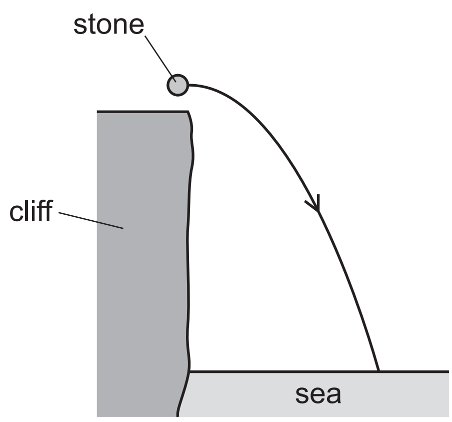
diameter of second cylinder = $(16.24 \pm 0.03)\,\text{mm}$

The difference in the diameters is calculated.

What is the uncertainty in this difference?

A 0.01 mm **B** 0.02 mm **C** 0.03 mm **D** 0.05 mm

6 A stone is thrown horizontally from the top of a cliff and falls into the sea below. Air resistance is negligible. The path of the stone is shown.



In which direction does the resultant force on the stone act during its fall?

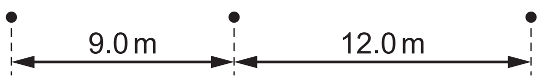
A horizontally to the right

B parallel to its velocity

C perpendicular to its velocity

D vertically downwards

7 A car moves with uniform acceleration along a straight road. Oil leaks from the car at the rate of one drop every two seconds. The diagram shows the distances between three successive oil drops on the road.



What is the acceleration of the car?

A $0.75\,\text{m}\,\text{s}^{-2}$ **B** $1.5\,\text{m}\,\text{s}^{-2}$ **C** $3.0\,\text{m}\,\text{s}^{-2}$ **D** $6.0\,\text{m}\,\text{s}^{-2}$

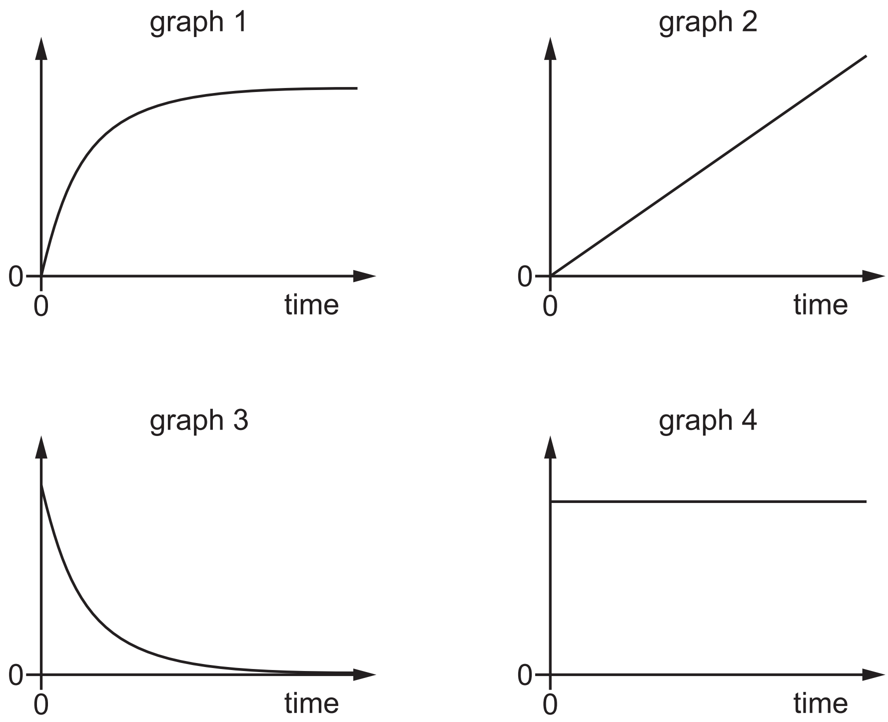
8 A person of mass 60 kg stands on accurate bathroom scales, placed on the floor of an elevator (lift) which operates in a tall building.

At a certain instant the bathroom scales read 58 kg.

Which row could give the person's direction of movement and type of motion?

	direction	motion
A	downwards	constant speed
B	downwards	slowing down
C	upwards	constant speed
D	upwards	slowing down

9 The diagram shows graphs of various quantities plotted against time for an object dropped from a stationary balloon high in the atmosphere.



Which statement could be correct?

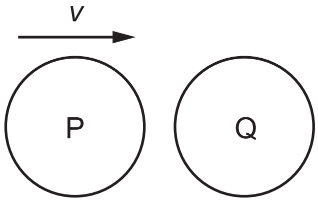
A Graph 1 is acceleration against time and graph 3 is resultant force against time.

B Graph 1 is acceleration against time and graph 4 is resultant force against time.

C Graph 3 is acceleration against time and graph 1 is velocity against time.

D Graph 3 is acceleration against time and graph 2 is velocity against time.

10 The diagram shows a particle P, travelling at speed v, about to collide with a stationary particle Q of the same mass. The collision is perfectly elastic.



Which statement describes the motion of P and of Q immediately after the collision?

A P and Q both travel in the same direction with speed $\frac{1}{2}v$.

B P comes to rest and Q acquires speed v.

C P rebounds with speed $\frac{1}{2}v$ and Q acquires speed $\frac{1}{2}v$.

D P rebounds with speed v and Q remains stationary.

11 A particle is in a uniform field. The particle experiences a force in the opposite direction to the field.

In which type of field is the particle, and on which property of the particle is the field acting?

	type of field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

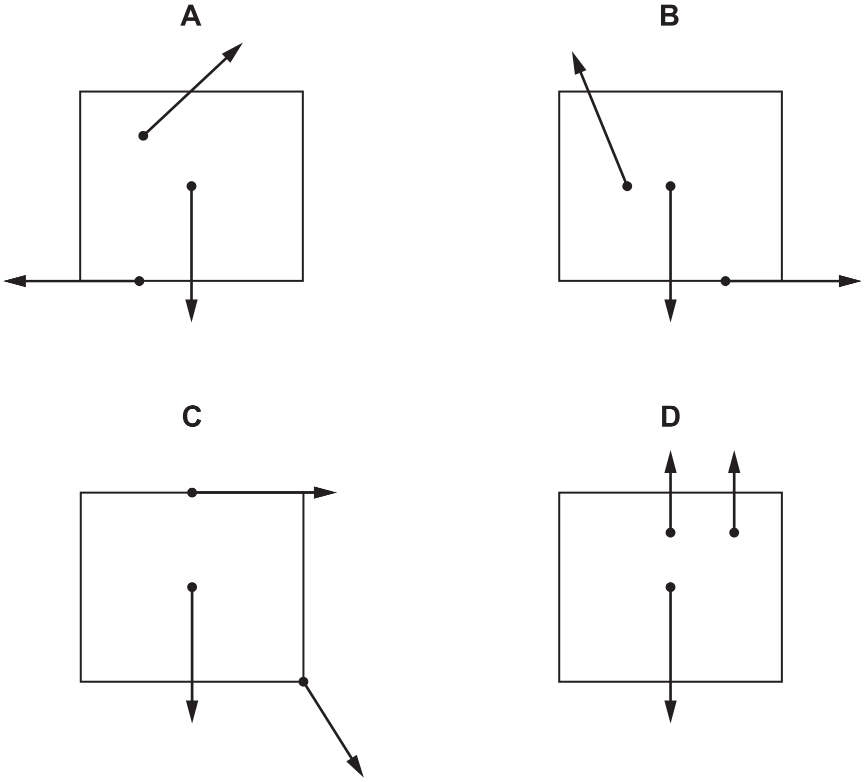
12 A uniform rod of weight 20 N and length 2.0 m is acted upon by two vertical forces, as shown.

What are the resultant force acting on the rod and the resultant moment about the centre of gravity of the rod?

	resultant force / N	resultant moment / N m
A	0	10
B	0	20
C	20	10
D	20	20

13 Three coplanar forces act on a block.

Which diagram shows the directions of the forces such that the block could be in equilibrium?



14 A cylinder contains a volume of $0.012\,m^3$ of gas at a pressure of $1.0 \times 10^5\,Pa$.

400 J of work is done **on** this gas, with its pressure remaining constant throughout.

What is the final volume of the gas?

A $0.0040\,m^3$ **B** $0.0080\,m^3$ **C** $0.016\,m^3$ **D** $0.020\,m^3$

15 A ball is thrown vertically upwards from the surface of the Earth.

Which statement describes the energy of the ball as it rises through the air?

A The kinetic energy of the ball decreases as the gravitational potential energy decreases.

B The kinetic energy of the ball decreases as the gravitational potential energy increases.

C The kinetic energy of the ball increases as the gravitational potential energy decreases.

D The total energy of the ball increases.

16 A sledge of mass 50 kg sits on a snowy surface. It is pulled horizontally for 10 m against a frictional force of 200 N, then it is pulled horizontally across ice for 10 m. There is no friction between the ice and the sledge. It is lifted up vertically by 1 m and finally carried back at a constant speed to where it started.

During which stage of its journey is most work done on the sledge?

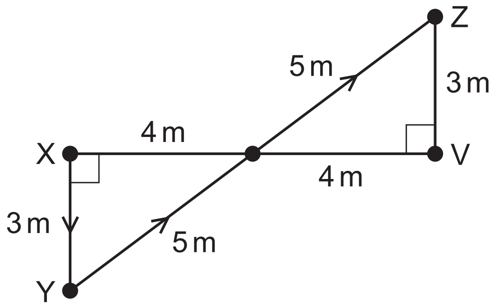
A being carried back 20 m at constant speed

B being lifted up 1 m

C being pulled 10 m across ice

D being pulled 10 m across snow

17 An object is moved in a vertical plane from X to Y, and then from Y to Z, as shown in the diagram.



The distances between various points are indicated on the diagram.

Lines XY and VZ are vertical.

The object weighs 20 N.

How much gravitational potential energy does the object gain by moving from X to Z?

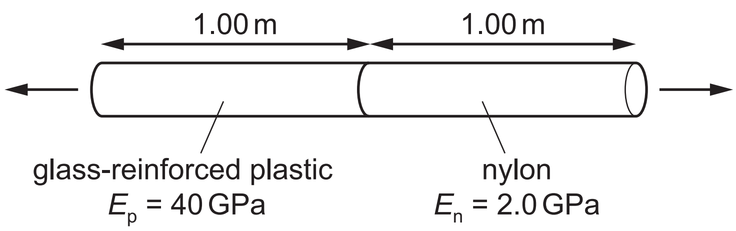
A 60 J **B** 120 J **C** 140 J **D** 260 J

18 A car travels at a constant speed of $25\,\text{m}\,\text{s}^{-1}$ up a slope. The wheels driven by the engine exert a forward force of 3000 N. The total force due to air resistance and friction is 2100 N. The weight of the car has a component down the slope of 900 N.

What is the rate at which thermal energy is dissipated?

A zero **B** 2.3×10^4 W **C** 5.3×10^4 W **D** 7.5×10^4 W

19 A composite rod is made by attaching a glass-reinforced plastic rod and a nylon rod end to end, as shown.



The rods have the same cross-sectional area and each rod is 1.00 m in length. The Young modulus E_p of the plastic is 40 GPa and the Young modulus E_n of the nylon is 2.0 GPa.

The composite rod will break when its total extension reaches 3.0 mm.

What is the greatest tensile stress that can be applied to the composite rod before it breaks?

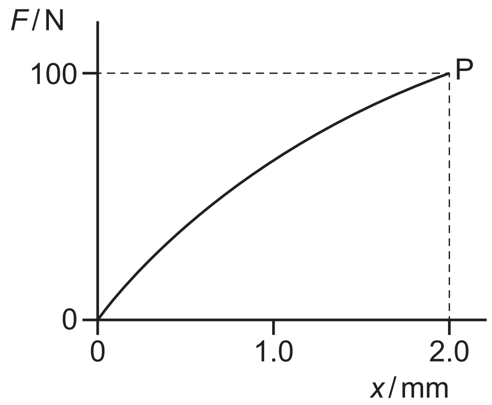
A 2.9×10^6 Pa

B 5.7×10^6 Pa

C 2.9×10^9 Pa

D 5.7×10^9 Pa

20 The graph shows the non-linear force–extension curve for a wire made from a new composite material.



What is the best estimate of the work done in stretching the wire to point P?

A 0.09 J **B** 0.10 J **C** 0.11 J **D** 0.20 J

21 A wave of frequency 15 Hz travels at 24 $m s^{-1}$ through a medium.

What is the phase difference between two points 2.0 m apart?

A There is no phase difference.

B They are out of phase by a quarter of a cycle.

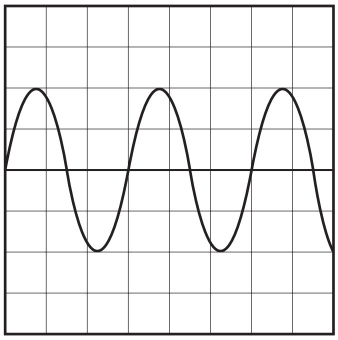
C They are out of phase by half a cycle.

D They are out of phase by 0.80 of a cycle.

22 Which row describes a longitudinal wave and a medium through which it can travel?

	direction of oscillation of the medium compared with the direction of propagation of wave energy	medium
A	parallel	air
B	parallel	vacuum
C	perpendicular	air
D	perpendicular	vacuum

23 A sound wave is displayed on the screen of a cathode-ray oscilloscope, as shown.



The time-base setting is 0.50 ms per division.

What is the frequency of the sound wave?

A 500 Hz **B** 670 Hz **C** 1000 Hz **D** 1300 Hz

24 An observer is situated at the top of a tall tower. An aeroplane emitting sound at a frequency of 1000 Hz approaches the observer at a speed of $165\,m\,s^{-1}$.

The speed of sound is $330\,m\,s^{-1}$.

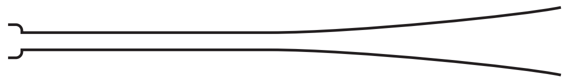
What is the frequency of the sound received by the observer?

A 330 Hz **B** 667 Hz **C** 1000 Hz **D** 2000 Hz

25 What is the order of magnitude of the wavelengths of microwaves and X-rays?

	wavelength of microwaves / m	wavelength of X-rays / m
A	10^{-6}	10^{3}
B	10^{-2}	10^{3}
C	10^{-6}	10^{-10}
D	10^{-2}	10^{-10}

26 A musical instrument is made using a long tube with a mouthpiece at one end. The other end is open and flared, as shown.



A musician maintains stationary sound waves with a node at the mouthpiece and an antinode at the other end. The lowest frequency of sound that the instrument can produce is 92 Hz.

Which different frequencies of sound can be produced by the instrument?

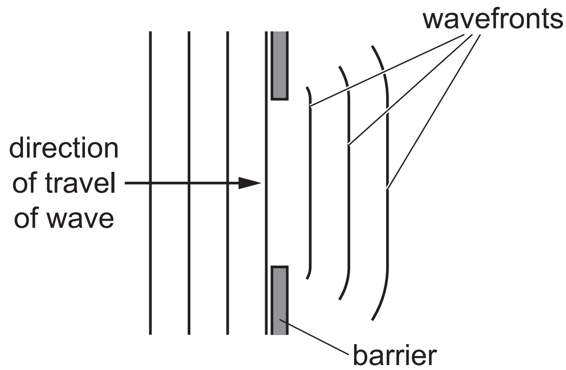
A 92 Hz, 138 Hz, 184 Hz, 230 Hz

B 92 Hz, 184 Hz, 276 Hz, 368 Hz

C 92 Hz, 276 Hz, 460 Hz, 644 Hz

D 92 Hz, 276 Hz, 828 Hz, 1288 Hz

27 A water wave passes through a gap between two barriers. The wavefronts spread out as shown.



What is the name of this phenomenon?

A coherence

B diffraction

C interference

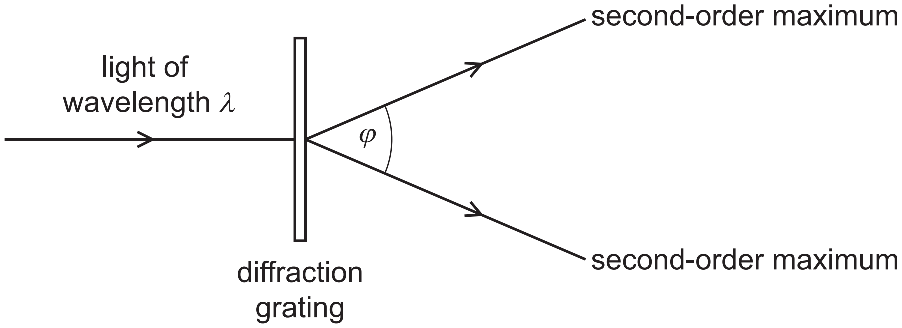
D superposition

28 The table shows four possible combinations of values for the laser wavelength, slit separation and slit-screen distance in a two-slit interference experiment to show the interference of visible light on a white screen.

Which combination will result in visible fringes being observed?

	laser wavelength / nm	slit separation / mm	slit-screen distance / m
A	200	0.10	5.0
B	200	100	1.0
C	600	0.10	5.0
D	600	100	1.0

29 Light of wavelength λ is incident normally on a diffraction grating, as shown.



The angle between the two second-order maxima is φ.

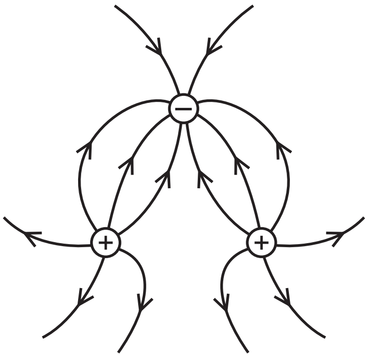
Which expression gives the spacing of the lines on the diffraction grating?

A $\dfrac{\lambda}{\sin\varphi}$ **B** $\dfrac{\lambda}{\sin(\varphi/2)}$ **C** $\dfrac{2\lambda}{\sin\varphi}$ **D** $\dfrac{2\lambda}{\sin(\varphi/2)}$

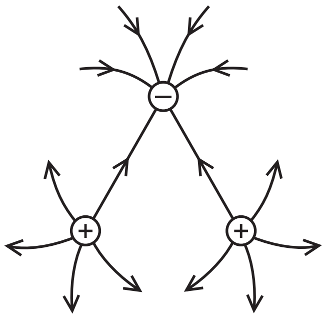
30 Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram represents the electric field surrounding the charges?

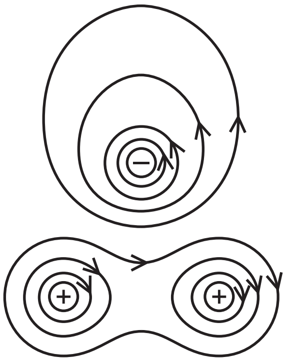
A



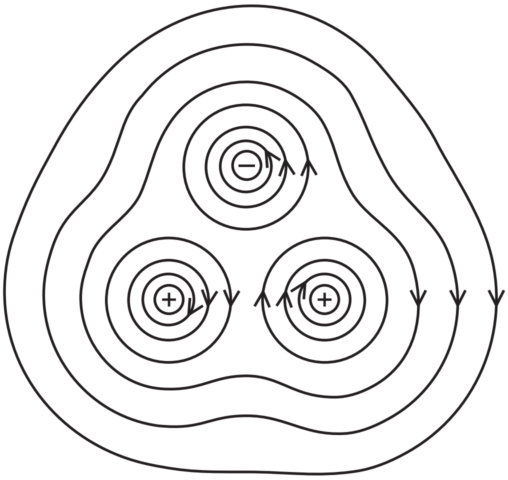
B



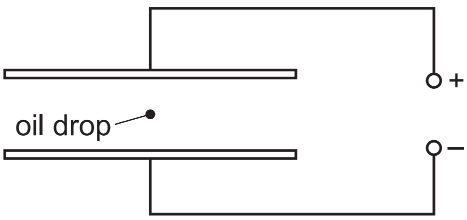
C



D



31 A negatively charged oil drop is held stationary, equidistant between two plates connected to a high voltage supply, as shown.



Which change would **not** increase the upward electrical force on the drop?

A decreasing the distance between the plates whilst keeping the drop equidistant from them

B increasing the amount of negative charge on the drop

C increasing the supply voltage

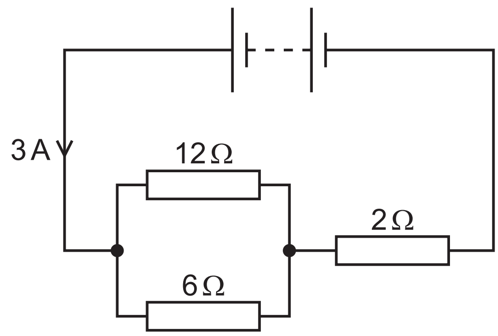
D moving the drop closer to the positive plate

32 Electrons move in a vacuum from one metal plate to another metal plate. As a result of this, there is an electric current of 48 μA between the two plates.

How many electrons are emitted by the first plate in a time of 5.0 minutes?

A 1.4×10^4 **B** 1.5×10^{15} **C** 1.8×10^{16} **D** 9.0×10^{16}

33 A battery is connected to three resistors of resistances 12 Ω, 6 Ω and 2 Ω, as shown.



The current from the battery is 3 A.

What is the value of the ratio $\dfrac{\text{power dissipated in the resistor of resistance } 6\,\Omega}{\text{power dissipated in the resistor of resistance } 2\,\Omega}$?

A $\dfrac{1}{3}$ **B** $\dfrac{4}{3}$ **C** $\dfrac{2}{1}$ **D** $\dfrac{3}{1}$

34 A manufacturer recommends that the longer the extension cord you use with an electric drill, the bigger the cross-sectional area of the cord should be.

What is a reason for this recommendation?

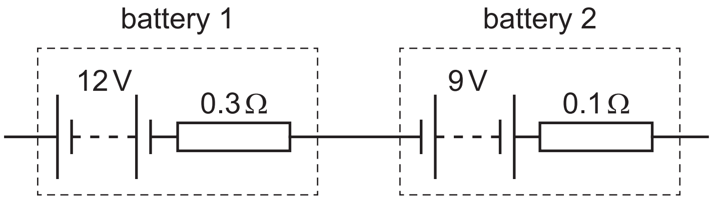
A Resistance is inversely proportional to both the length and the cross-sectional area.

B Resistance is inversely proportional to the length and directly proportional to the cross-sectional area.

C Resistance is proportional to both the length and the cross-sectional area.

D Resistance is proportional to the length and inversely proportional to the cross-sectional area.

35 Two batteries are connected together, as shown.



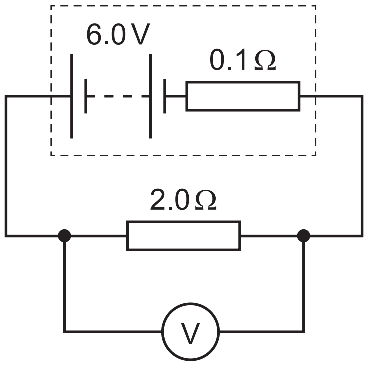
Battery 1 has electromotive force (e.m.f.) 12 V and internal resistance 0.3 Ω.

Battery 2 has e.m.f. 9 V and internal resistance 0.1 Ω.

What are the e.m.f. and the internal resistance of a single battery that has the same effect as the combination?

	e.m.f. / V	internal resistance / Ω
A	3	0.2
B	3	0.4
C	21	0.2
D	21	0.4

36 The diagram shows a circuit.

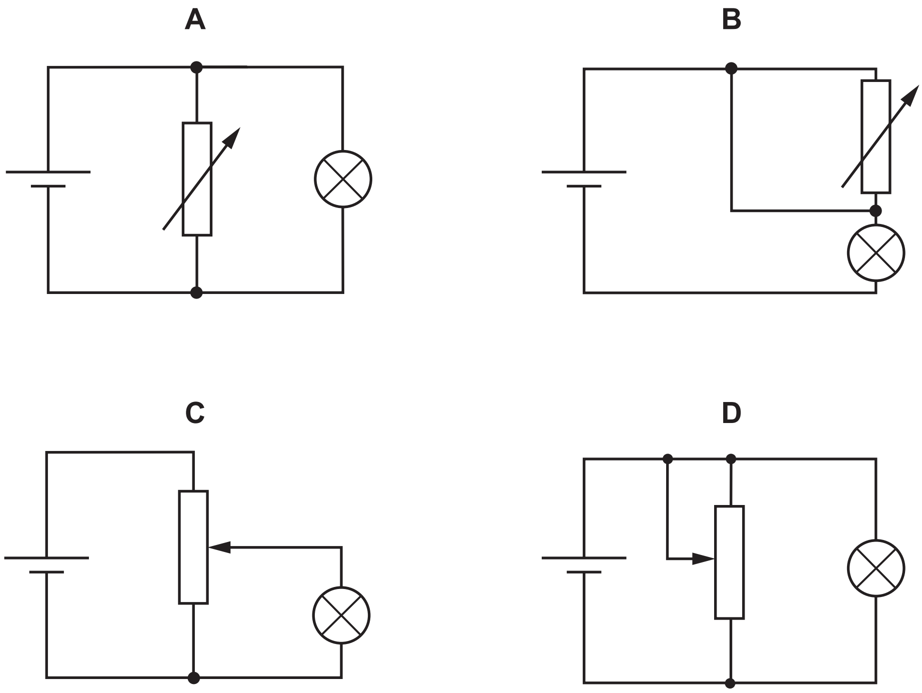


What is the reading on the voltmeter?

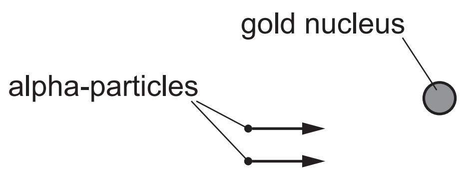
A 0.3 V **B** 5.7 V **C** 6.0 V **D** 6.3 V

37 In the circuits shown, the cell has negligible internal resistance.

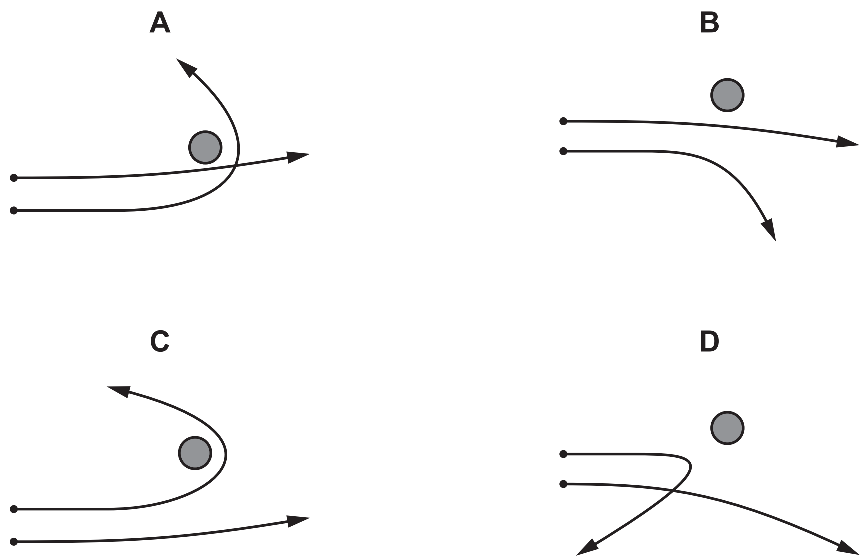
Which diagram shows a potential divider circuit that can vary the potential difference (p.d.) across the lamp?



38 Two alpha-particles with the same kinetic energy are moving towards, and are then deflected by, a gold nucleus.



Which diagram could show the paths of the two alpha-particles?



39 The equation represents the decay of a nucleus X to a nucleus Y.

$$^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + p + q$$

What are particles p and q?

	p	q
A	β^- particle	neutron
B	β^- particle	proton
C	β^+ particle	antineutrino
D	β^+ particle	neutrino

40 Which row gives the correct type and quark composition for the named particle?

	particle	type	quark composition
A	neutron	hadron	u u d
B	neutron	lepton	u d d
C	proton	hadron	u u d
D	proton	lepton	u d d

key
u = up quark
d = down quark

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **February/March 2021**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 9 9 4 3 9 7 5 7 2 3 *

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

IB21 03_9702_12/2RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate for the density of sand?

A $2 \times 10^2\,\text{g cm}^{-3}$

B $2 \times 10^3\,\text{g cm}^{-3}$

C $2 \times 10^1\,\text{kg m}^{-3}$

D $2 \times 10^3\,\text{kg m}^{-3}$

2 Which physical quantity could have units of $\text{N s}^2\,\text{m}^{-1}$?

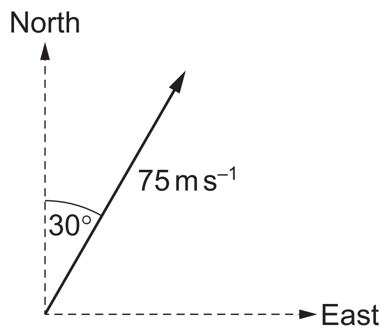
A acceleration

B force

C mass

D momentum

3 A velocity vector is shown.



What are the components of the velocity vector in the northerly and in the easterly directions?

	component of vector in northerly direction / m s^{-1}	component of vector in easterly direction / m s^{-1}
A	38	38
B	38	65
C	65	38
D	65	65

4 A micrometer screw gauge is used to measure the diameter of a copper wire.

The reading with the wire in position is shown in diagram 1. The wire is removed and the jaws of the micrometer are closed. The new reading is shown in diagram 2.

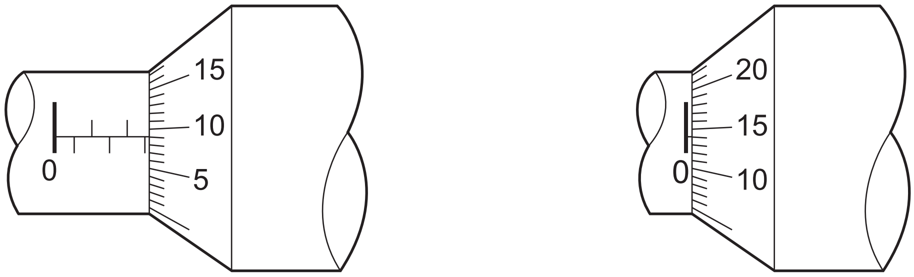


diagram 1 diagram 2

What is the diameter of the wire?

A 1.95 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

5 A student measures the current and the potential difference for a resistor in a circuit.

current = (50.00 ± 0.01) mA

potential difference = (500.0 ± 0.1) mV

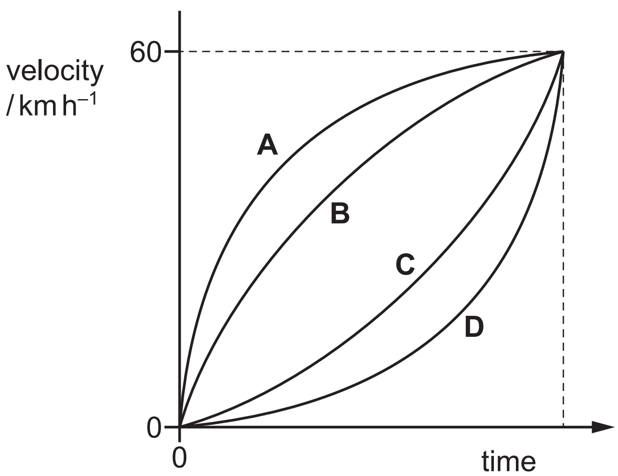
The measurements are used to calculate the resistance of the resistor.

What is the percentage uncertainty in the calculated resistance?

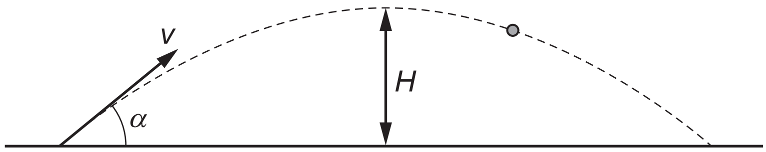
A 0.0002% **B** 0.0004% **C** 0.02% **D** 0.04%

6 Four cars, **A**, **B**, **C** and **D**, move from rest in a straight line. The cars take the same time to accelerate to a velocity of 60 km h^{-1}. Their velocity–time graphs are shown.

Which car reaches a velocity of 60 km h^{-1} in the shortest distance?



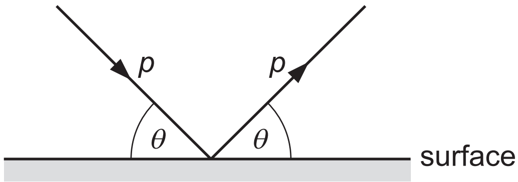
7 A cannon fires a cannonball with an initial speed v at an angle α to the horizontal.



Which equation is correct for the maximum height H reached?

A $H = \dfrac{v\sin\alpha}{2g}$ **B** $H = \dfrac{g\sin\alpha}{2v}$ **C** $H = \dfrac{(v\sin\alpha)^2}{2g}$ **D** $H = \dfrac{g^2\sin\alpha}{2v}$

8 A ball strikes a horizontal surface with momentum p at an angle θ to the surface, as shown.



The ball rebounds with the same magnitude of momentum at an angle θ to the surface.

The ball is in contact with the surface for time t.

What is the magnitude of the average resultant force acting on the ball during the collision?

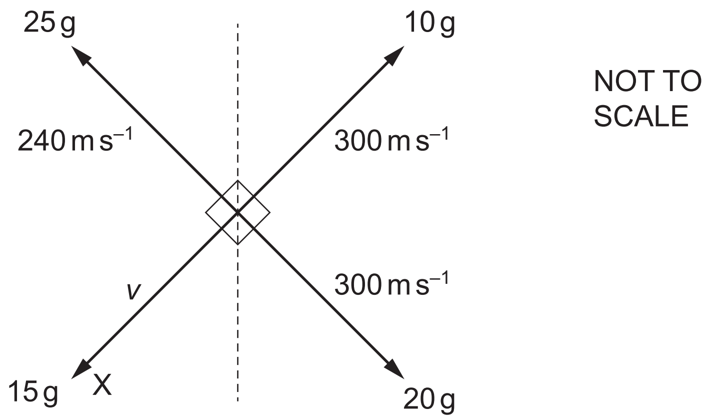
A zero **B** $\dfrac{2p}{t}$ **C** $\dfrac{2p\cos\theta}{t}$ **D** $\dfrac{2p\sin\theta}{t}$

9 A skydiver, who is falling vertically through the air, opens his parachute.

Which row describes the velocity of the skydiver immediately after he opens his parachute?

	direction of velocity	magnitude of velocity
A	downwards	decreases
B	downwards	increases
C	upwards	decreases
D	upwards	increases

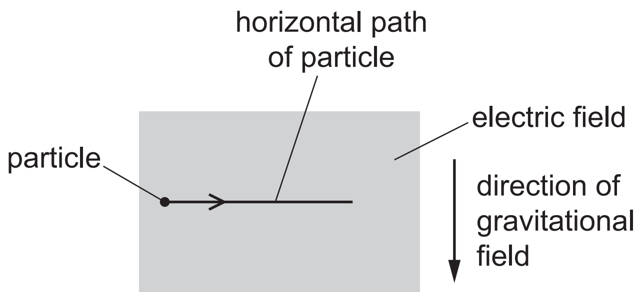
10 A stationary firework explodes into four fragments which travel in different directions in a horizontal plane. The diagram shows the velocity and mass of each fragment.



What is the speed v of fragment X?

A 200 m s^{-1} **B** 240 m s^{-1} **C** 300 m s^{-1} **D** 360 m s^{-1}

11 A particle with mass moves in a horizontal straight line through a uniform electric field in a vacuum. The electric field is vertical.



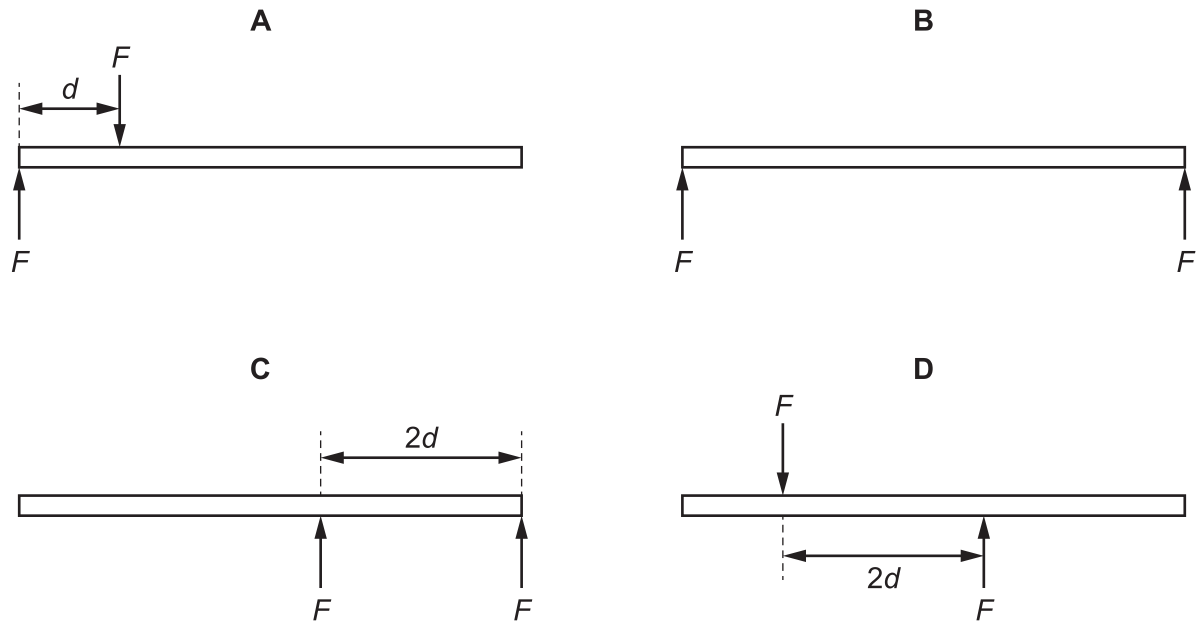
There is a significant gravitational effect on the motion of the particle.

What could be the direction of the electric field and the sign of the charge, if any, on the particle?

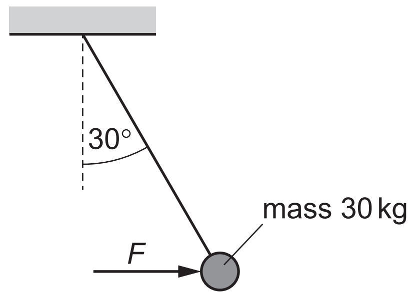
	electric field direction	sign of charge
A	downwards	negative
B	downwards	positive
C	upwards	negative
D	upwards	no charge

12 Two parallel forces, each of magnitude F, act on a rod of length $5d$.

Which diagram shows the positions of the two forces that will produce the largest torque on the rod?



13 A mass of 30 kg is suspended from the end of a wire. A horizontal force F acts on the mass so that it is in equilibrium, with the wire at an angle of 30° to the vertical, as shown.

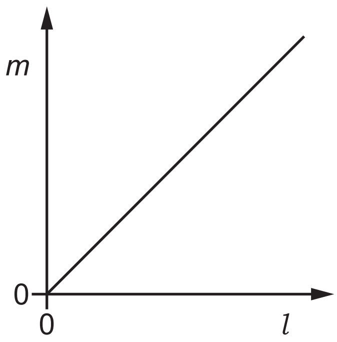


What is the magnitude of F?

A 17 N **B** 150 N **C** 170 N **D** 510 N

14 A balance is used to measure the mass m of a number of cylindrical metal rods of length l. All the metal rods have the same radius r.

The graph shows the variation with l of m.



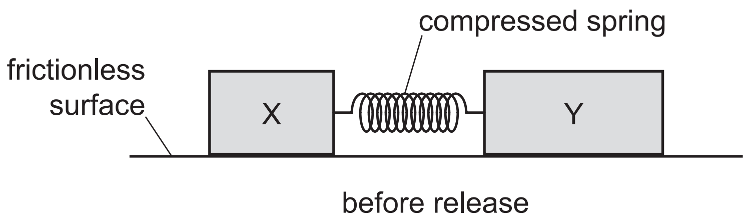
The gradient of the graph is G.

Which expression gives the density of the metal?

A $\dfrac{G}{2\pi r}$ **B** $G2\pi r$ **C** $\dfrac{G}{\pi r^2}$ **D** $G\pi r^2$

15 Two blocks, X and Y, are on a horizontal frictionless surface. The mass of block Y is greater than that of block X. Block Y has a spring attached to its end.

The blocks are pushed together so that the spring is compressed between them and the blocks are held stationary as shown.



When released, the blocks move in opposite directions.

Which statement is correct?

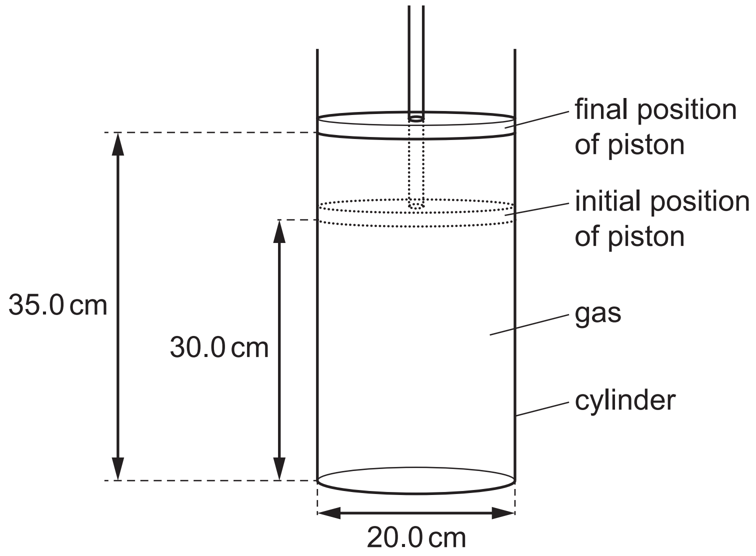
A After release, the kinetic energy of block X must equal the kinetic energy of block Y.

B After release, the sum of the kinetic energies of the blocks is equal to zero.

C The total energy of the spring and blocks immediately before release is zero.

D The total energy of the spring and blocks is equal to the energy needed to bring the blocks together.

16 A gas is contained in a cylinder by a movable piston.



The cylinder has a circular cross-section of diameter 20.0 cm.

The pressure of the gas is 102 Pa and the piston is initially 30.0 cm from the base of the cylinder.

The gas is heated causing the piston to move up so that it is 35.0 cm from the base. The pressure of the gas remains constant.

How much work does the gas do in moving the piston?

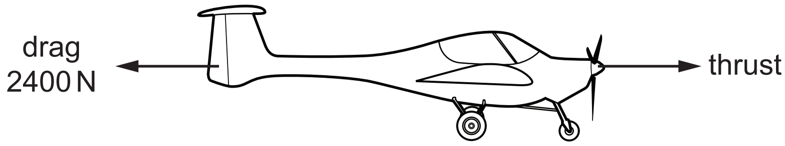
A 0.160 J **B** 0.641 J **C** 1.12 J **D** 4.49 J

17 An egg of mass 25 g falls vertically downwards from the surface of a table which is 900 mm above the ground. Air resistance is negligible.

What is the kinetic energy of the egg when it hits the ground?

A 0.023 J **B** 0.22 J **C** 23 J **D** 220 J

18 An aircraft travels at a constant velocity of $90\,\mathrm{m\,s^{-1}}$ in horizontal flight. The diagram shows the horizontal forces acting on the aircraft.



The mass of the aircraft is 2000 kg.

What is the power produced by the thrust force?

A 1.8×10^5 W **B** 2.2×10^5 W **C** 1.8×10^6 W **D** 2.0×10^6 W

19 Which expression is equal to the stress on a wire?

A $\dfrac{\text{extension}}{\text{original length}}$

B $\dfrac{\text{force}}{\text{cross-sectional area}}$

C $\dfrac{\text{force}}{\text{extension}}$

D $\dfrac{\text{Young modulus}}{\text{original length}}$

20 A wire is stretched by applying increasing values of force F. For each value of force applied, the extension x is recorded. A force–extension graph is plotted from the data obtained.

Which statement about the area under the graph **must** be correct?

A It can be calculated as $\frac{1}{2}Fx$.

B It is the elastic potential energy stored in the stretched sample.

C It is the work done in stretching the sample.

D It would be the same for any wire of the same material.

21 A progressive radio wave in a vacuum has a frequency of 75 MHz.

What is the phase difference between two points on the wave that are 50 cm apart from each other?

A 23° **B** 45° **C** 90° **D** 180°

22 Which statement is correct for longitudinal waves but **not** correct for transverse waves?

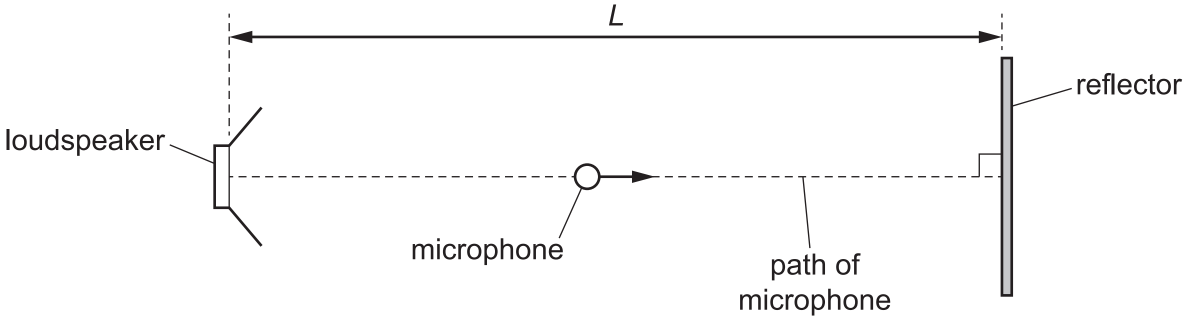
A They can form stationary waves.

B They can only travel through a medium.

C They can transfer energy in the direction of travel.

D They consist of peaks and troughs.

23 A loudspeaker emitting a sound wave of a single frequency is placed a distance L from a reflecting surface, as shown.



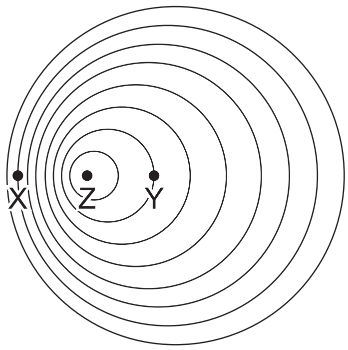
A stationary wave is formed with an antinode at the loudspeaker. A microphone is moved from the loudspeaker to the reflector.

Before the microphone reaches the reflector, it detects four points where the sound intensity is a minimum.

What is the wavelength of the sound wave?

A $\frac{2L}{9}$ **B** $\frac{2L}{8}$ **C** $\frac{4L}{9}$ **D** $\frac{4L}{8}$

24 A source of sound of frequency F at point Z is moving at a steady speed. The pattern of the emitted wavefronts is shown.



Which row describes the frequencies of the sound heard by stationary observers at X and Y?

	frequency heard at X	frequency heard at Y
A	$<F$	$<F$
B	$<F$	$>F$
C	$>F$	$<F$
D	$>F$	$>F$

25 What is **not** a possible value for the wavelength of the named electromagnetic waves when it is travelling in a vacuum?

	electromagnetic wave	wavelength / m
A	γ-rays	3×10^{-13}
B	X-rays	3×10^{-10}
C	infrared	3×10^{-6}
D	microwaves	3×10^{-5}

26 Two waves, P and Q, meet at a point X and superpose.

Initially, the two waves meet at X in phase (zero phase difference) so that the resultant wave has an amplitude of 14.0 cm at that point.

The phase difference between the two waves is then changed so that they meet at X with a phase difference of 180°. The resultant wave now has an amplitude of 4.0 cm at X.

What is the amplitude of one of the waves at point X?

A 2.0 cm **B** 5.0 cm **C** 10 cm **D** 18 cm

27 A water wave is diffracted as it passes through a gap between two barriers in a ripple tank. The wave is observed to 'spread out' as it moves through the gap.

Which two factors both affect the amount of diffraction observed?

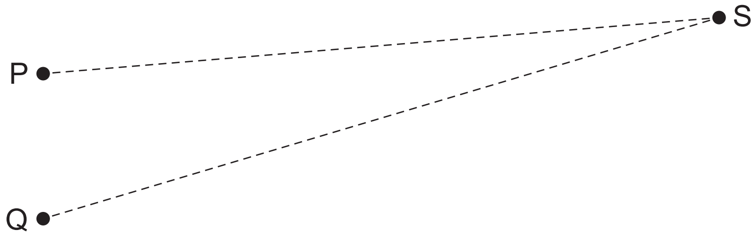
A the amplitude and frequency of the incident wave

B the amplitude of the incident wave and the width of the gap

C the wavelength and amplitude of the incident wave

D the wavelength of the incident wave and the width of the gap

28 Two sources of microwaves P and Q produce coherent waves with a phase difference of 180°. The waves have the same wavelength λ.

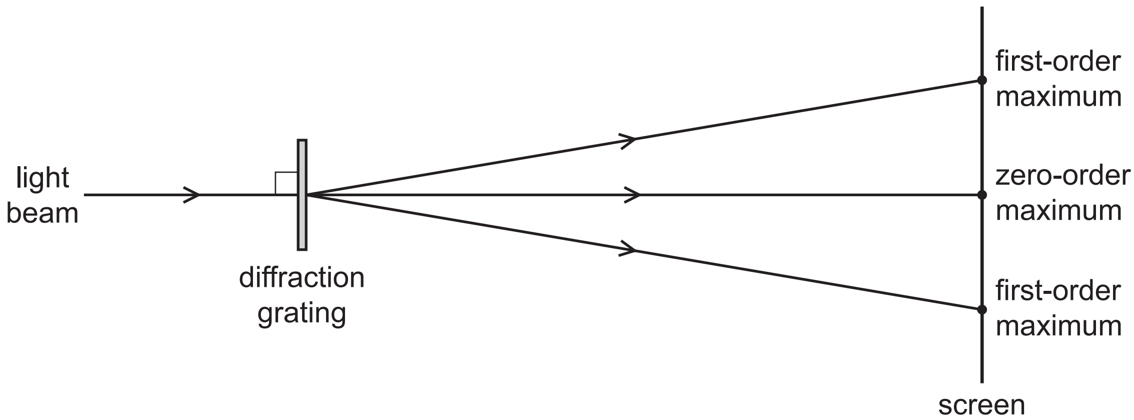


At the point S there is a minimum in the interference pattern produced by waves from the two sources. The distance (QS – PS) is called the path difference.

Which expression could represent the path difference?

A $\frac{\lambda}{4}$ **B** $\frac{\lambda}{2}$ **C** λ **D** $\frac{3\lambda}{2}$

29 A beam of red laser light of wavelength 633 nm is incident normally on a diffraction grating with 600 lines per mm.



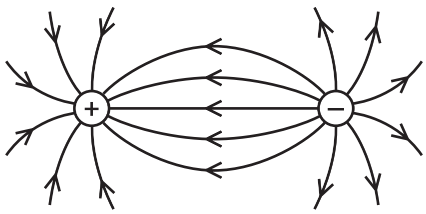
The beam of red light is now replaced by a beam of blue laser light of wavelength 445 nm. A replacement diffraction grating is used so that the first-order maximum of the blue light appears at the same position on the screen as the first-order maximum of the red light from the original laser.

How many lines per mm are there in the replacement diffraction grating?

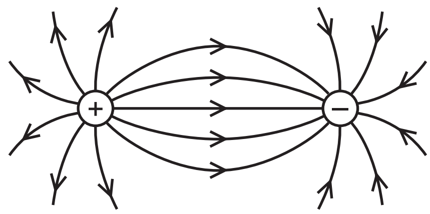
A $420\,mm^{-1}$ **B** $470\,mm^{-1}$ **C** $600\,mm^{-1}$ **D** $850\,mm^{-1}$

30 Which diagram best represents the field lines in the electric field produced by a combination of one point positive charge and one point negative charge?

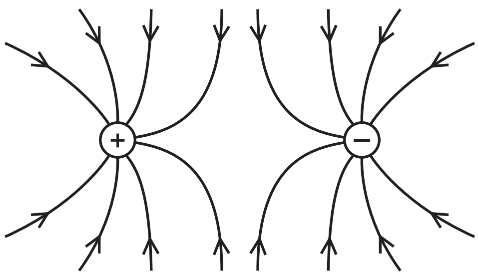
A



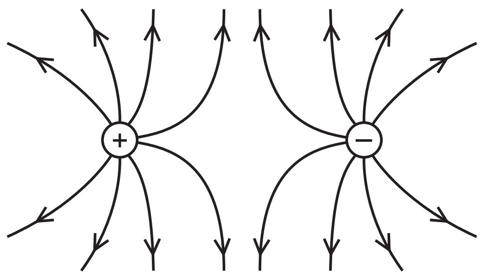
B



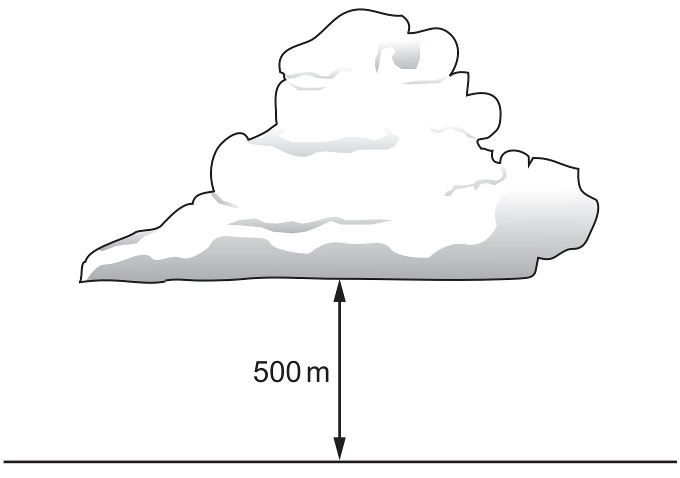
C



D



31 The diagram shows a thundercloud whose base is 500 m above the ground.



The potential difference between the base of the cloud and the ground is 200 MV. A raindrop with a charge of 4.0×10^{-12} C is in the region between the cloud and the ground.

What is the electrical force on the raindrop?

A 1.6×10^{-6} N **B** 8.0×10^{-4} N **C** 1.6×10^{-3} N **D** 0.40 N

32 The current I in a metal wire is given by the equation

$$I = Anvq.$$

What does the symbol n represent?

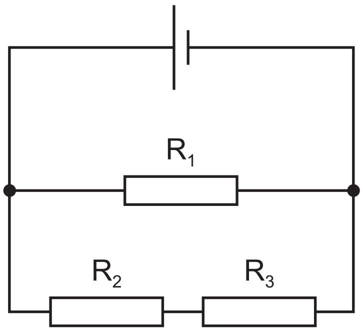
A the number of charge carriers in the wire

B the number of charge carriers per unit cross-sectional area of the wire

C the number of charge carriers per unit length of the wire

D the number of charge carriers per unit volume of the wire

33 A cell of negligible internal resistance is connected to resistors R_1, R_2 and R_3, as shown. The cell provides power to the circuit and power is dissipated in the resistors.



Which word equation **must** be correct?

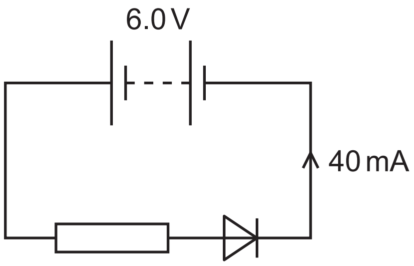
A power dissipated in R_1 = power dissipated in R_2 + power dissipated in R_3

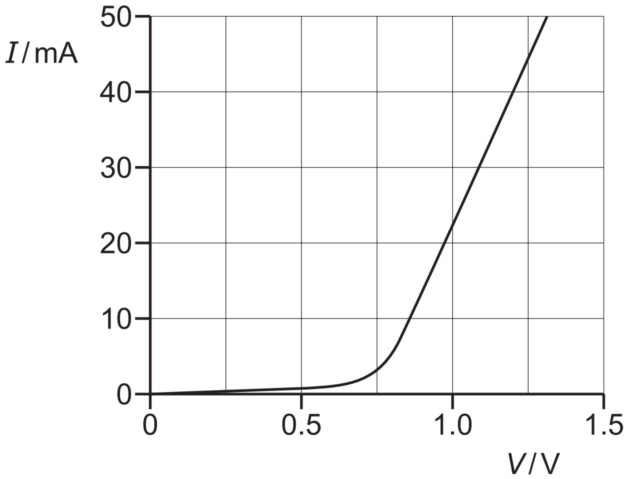
B power dissipated in R_2 = power dissipated in R_3

C power output of cell = power dissipated in R_1 + power dissipated in R_2 + power dissipated in R_3

D power output of cell = power dissipated in R_1

34 A fixed resistor and a diode are connected in series to a battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance. The graph shows the variation with potential difference (p.d.) V of the current I for the diode.





The current in the diode is 40 mA.

What is the resistance of the fixed resistor?

A 30 Ω **B** 120 Ω **C** 150 Ω **D** 180 Ω

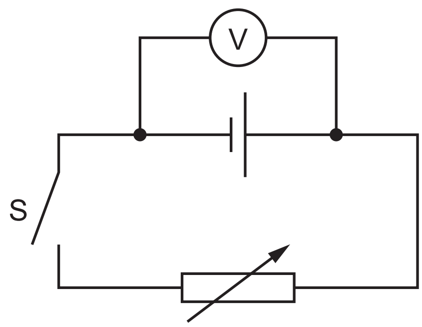
35 An electrical cable consists of seven strands of copper wire, each of diameter 0.30 mm, connected in parallel.

The resistivity of copper is 1.72×10^{-8} Ω m. The current in the cable is 13 A.

What is the potential difference (p.d.) between two points on the cable a distance of 1.0 m apart?

A 0.0045 V **B** 0.11 V **C** 0.45 V **D** 3.2 V

36 A cell that has internal resistance is connected to a switch S and a variable resistor. A voltmeter is connected between the terminals of the cell, as shown.

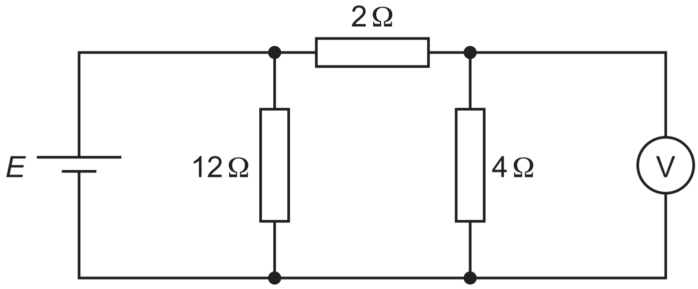


When switch S is open, the voltmeter reads 1.5 V. The switch is then closed and the variable resistor is adjusted to have a resistance of 4.0 Ω. The voltmeter now reads 0.75 V.

What is the internal resistance of the cell?

A 1.0 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 8.0 Ω

37 A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.

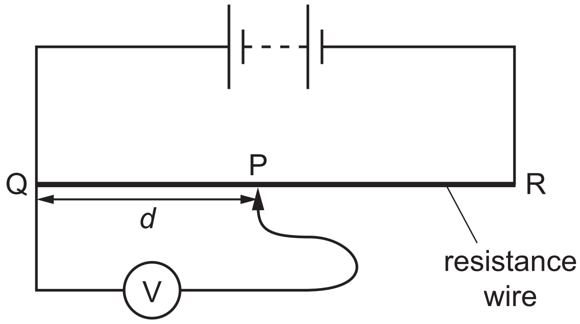


The voltmeter has a very high resistance and reads a potential difference V_{out}.

What is the ratio $\frac{V_{out}}{E}$?

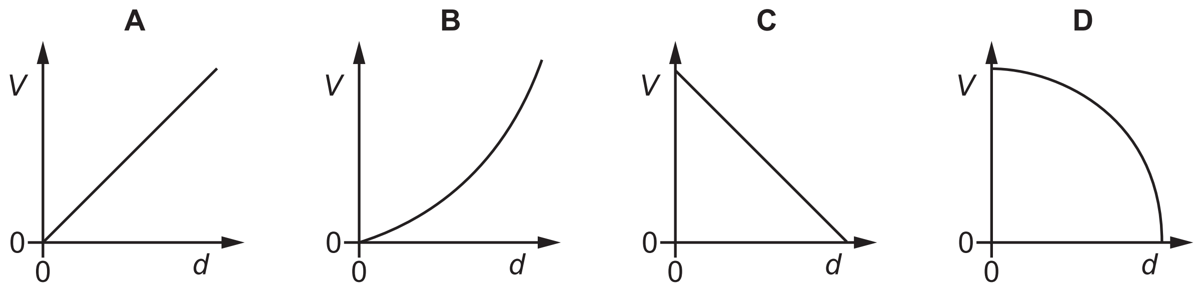
A $\frac{1}{6}$ **B** $\frac{1}{3}$ **C** $\frac{1}{2}$ **D** $\frac{2}{3}$

38 A battery is connected to a potentiometer. The potentiometer consists of a uniform resistance wire and a sliding contact P.



The potential difference (p.d.) V between the sliding contact P and end Q of the wire is measured using a voltmeter. The sliding contact P is moved from end Q to end R of the wire. Sliding contact P is distance d from Q.

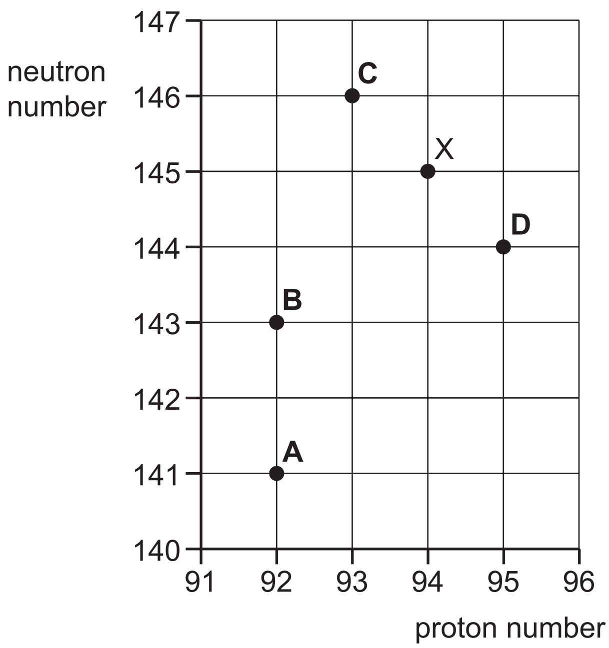
Which graph shows the variation with distance d of the p.d. V?



39 The figure shows part of a chart of nuclides where neutron number is plotted against proton number.

An unstable nuclide X decays by emitting an α-particle.

Which nuclide is formed by the decay of nuclide X?



40 The nuclei of common isotopes of hydrogen, helium, lithium and beryllium are shown.

Which nucleus contains equal numbers of up and down quarks?

A ${}^{1}_{1}H$ **B** ${}^{4}_{2}He$ **C** ${}^{7}_{3}Li$ **D** ${}^{9}_{4}Be$

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Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **February/March 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

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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.
- Any rough working should be done on this question paper.

This document has **16** pages.

Data

acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$
speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \tfrac{1}{2}at^2$
	$v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_\mathrm{o} = \dfrac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 What could **not** be a measurement of a physical quantity?

A $10\,\mathrm{K}$ **B** $11\,\mathrm{J\,N^{-1}\,m^{-1}}$ **C** $17\,\mathrm{Pa\,m^{3}\,N^{-1}}$ **D** $25\,\mathrm{T\,m}$

2 A computer memory stick is labelled as having a storage capacity of 128 GB.

The letter B stands for byte, which is a unit.

What is the equivalent storage capacity?

A $1.28 \times 10^{8}\,\mathrm{B}$

B $1.28 \times 10^{11}\,\mathrm{B}$

C $1.28 \times 10^{14}\,\mathrm{B}$

D $1.28 \times 10^{17}\,\mathrm{B}$

3 A man of mass 75.2 kg uses a set of weighing scales to measure his mass three times. He obtains the following readings.

	mass / kg
reading 1	80.2
reading 2	80.1
reading 3	80.2

Which statement describes the precision and accuracy of the weighing scales?

A not precise to ± 0.1 kg and accurate to ± 0.1 kg

B not precise to ± 0.1 kg and not accurate to ± 0.1 kg

C precise to ± 0.1 kg and accurate to ± 0.1 kg

D precise to ± 0.1 kg and not accurate to ± 0.1 kg

4 Which statement about scalar and vector quantities is correct?

A A scalar quantity has direction but not magnitude.

B A scalar quantity has magnitude but not direction.

C A vector quantity has direction but not magnitude.

D A vector quantity has magnitude but not direction.

5 How can the acceleration of an object be determined?

A from the area under a displacement–time graph

B from the area under a velocity–time graph

C from the gradient of a displacement–time graph

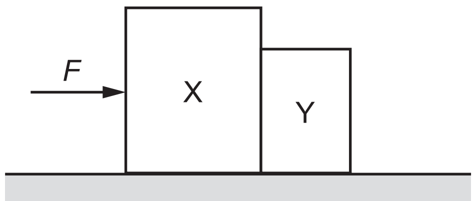
D from the gradient of a velocity–time graph

6 A sprinter takes a time of 11.0 s to run a 100 m race. She first accelerates uniformly from rest, reaching a speed of $10\,m\,s^{-1}$. She then runs at a constant speed of $10\,m\,s^{-1}$ until the finish line.

What is the uniform acceleration of the sprinter for the first part of the race?

A $0.5\,m\,s^{-2}$ **B** $0.91\,m\,s^{-2}$ **C** $1.7\,m\,s^{-2}$ **D** $5.0\,m\,s^{-2}$

7 A single horizontal force *F* is applied to a block X which is in contact with a separate block Y, as shown.



The blocks remain in contact as they accelerate along a horizontal frictionless surface. Air resistance is negligible. X has a greater mass than Y.

Which statement is correct?

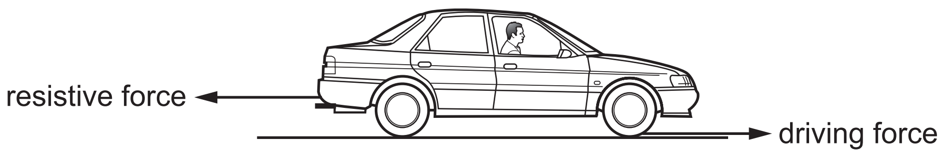
A The acceleration of X is equal to force *F* divided by the mass of X.

B The force that X exerts on Y is equal to *F*.

C The force that X exerts on Y is less than *F*.

D The force that X exerts on Y is less than the force that Y exerts on X.

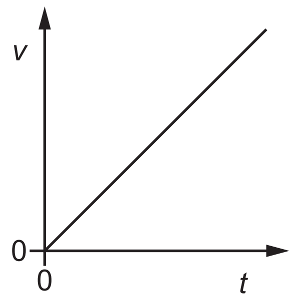
8 A car of mass 750 kg has a horizontal driving force of 2.0 kN acting on it. It has a forward horizontal acceleration of $2.0\,m\,s^{-2}$.



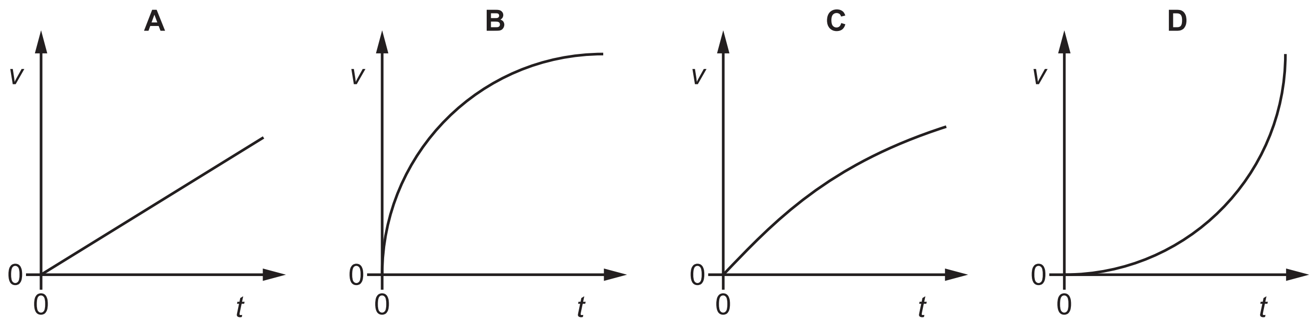
What is the resistive force acting horizontally?

A 0.50 kN **B** 1.5 kN **C** 2.0 kN **D** 3.5 kN

9 An object falls freely from rest in a vacuum. The graph shows the variation with time t of the velocity v of the object.



Which graph, **using the same scales**, represents the object falling in air?

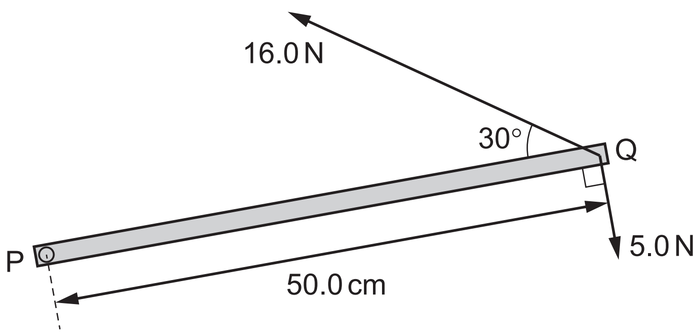


10 A rock of mass $2m$, travelling in deep space at velocity v, explodes into two parts of equal mass, one of which is then stationary.

What is the kinetic energy of the moving part after the explosion?

A $\frac{1}{2}mv^2$ **B** mv^2 **C** $\frac{3}{2}mv^2$ **D** $2mv^2$

11 A horizontal metal bar PQ of length 50.0 cm is hinged at end P. The diagram shows the metal bar viewed from above.

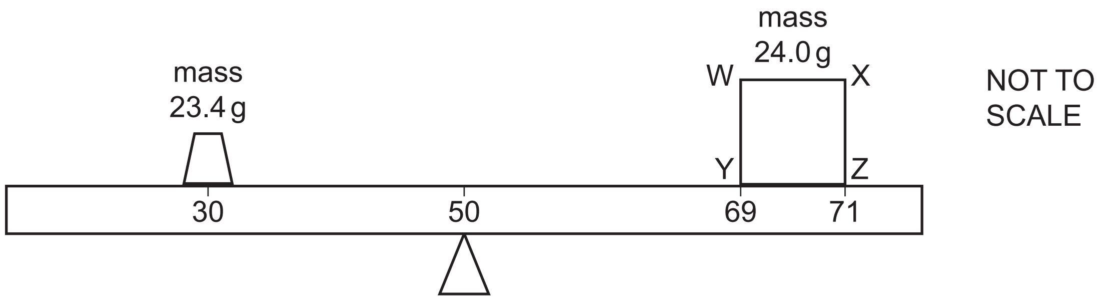


Two forces of 16.0 N and 5.0 N are in the horizontal plane and act on end Q, as shown.

What is the resultant moment about P due to the two forces?

A 1.5 N m **B** 4.4 N m **C** 6.5 N m **D** 9.4 N m

12 A cube WXZY has sides of length 2.0 cm and mass 24.0 g. The cube rests on a metre rule of negligible mass. The geometrical centre of the cube is vertically above the 70.0 cm mark on the scale of the rule.



The cube has a non-uniform density so that its centre of gravity is **not** at its geometrical centre. The centre of gravity of the cube is in the plane of the diagram.

The rule rests on a pivot at the 50.0 cm mark. A mass of 23.4 g is placed vertically above the 30.0 cm mark. The rule is horizontal and in equilibrium.

What can be determined about the position of the centre of gravity of the cube?

A It must be somewhere along a horizontal line that is 0.5 cm from line WX.

B It must be somewhere along a horizontal line that is 0.5 cm from line YZ.

C It must be somewhere along a vertical line that is 0.5 cm from line WY.

D It must be somewhere along a vertical line that is 0.5 cm from line XZ.

13 A rigid sphere is held at rest on the sea bed. When the sphere is released, it rises to the surface of the sea. The seawater has a uniform density.

Which statement about the sphere, from its release until it reaches the surface, is correct?

A The sphere always moves with constant acceleration.

B The sphere always moves with constant velocity.

C The upthrust on the sphere always decreases.

D The upthrust on the sphere is always constant.

14 What is a unit for density?

A $\mathrm{N\,m^{-3}}$ **B** $\mathrm{g\,mm^{-1}}$ **C** $\mathrm{kg\,cm^{-2}}$ **D** $\mathrm{\mu g\,mm^{-3}}$

15 The total energy input E_{in} in a process is partly transferred to useful energy output U and partly transferred to energy that is wasted W.

What is the efficiency of the process?

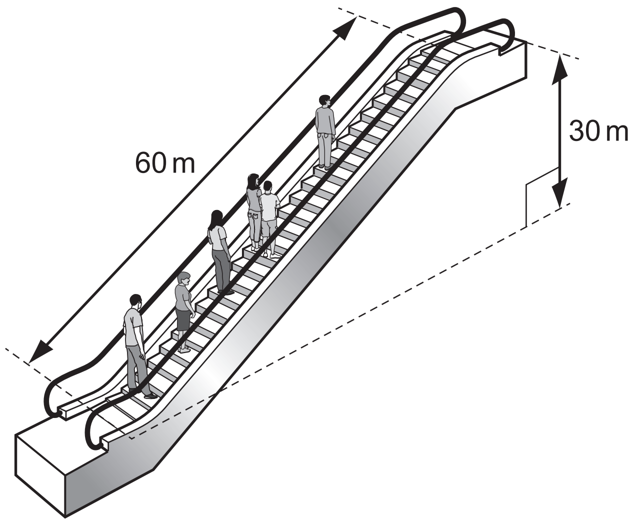
A $\dfrac{U}{E_{in}} \times 100\%$

B $\dfrac{W}{E_{in}} \times 100\%$

C $\dfrac{U}{W} \times 100\%$

D $\dfrac{U+W}{E_{in}} \times 100\%$

16 An escalator is 60 m long and lifts passengers through a vertical height of 30 m, as shown.



To drive the escalator against the forces of friction when there are no passengers requires a power of 2.0 kW.

The escalator is used by passengers of average mass 60 kg and the power to overcome friction remains constant.

How much power is required to drive the escalator when it is carrying 20 passengers and is travelling at $0.75\,\text{m}\,\text{s}^{-1}$?

A 4.4 kW **B** 6.4 kW **C** 8.8 kW **D** 10.8 kW

17 A rock of mass 40 kg is released from rest from a height of 20 m above the surface of a planet.

The rock has a kinetic energy of 32 kJ when it hits the surface of the planet. The planet does not have an atmosphere.

What is the weight of the rock on the surface of the planet?

A 1.6 N **B** 390 N **C** 1.6 kN **D** 64 kN

18 A metal wire is stretched. The wire obeys Hooke's law.

Which quantity has a value that does **not** change?

A extension

B strain

C stress

D Young modulus

19 An object is stretched until it reaches the elastic limit.

Which statement must describe the stress on the object when it is at the elastic limit?

A It is the maximum stress for which the object obeys Hooke's law.

B It is the maximum stress that can be applied to the object before it has elastic deformation.

C It is the maximum stress that can be applied to the object before it has plastic deformation.

D It is the maximum stress the object can withstand before it breaks.

20 Which statement about progressive waves is correct?

A They are always transverse waves.

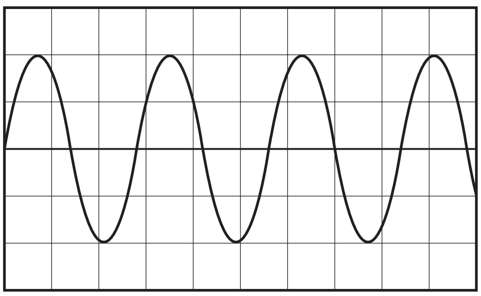
B They can exist in solids but not liquids.

C They decrease in frequency as their speed increases.

D They transfer energy away from their source.

21 A cathode-ray oscilloscope (CRO) is used to determine the frequency of a sound wave.

The diagram shows the waveform on the screen.

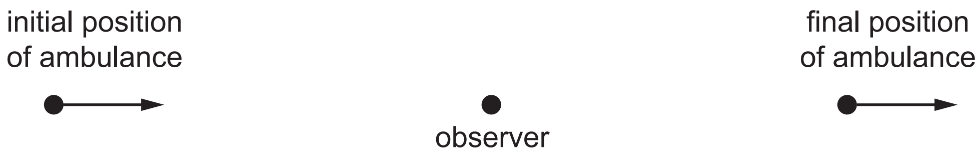


The time-base setting is $5.0\,\text{ms}\,\text{div}^{-1}$.

What is the best estimate of the frequency of the sound wave?

A 50 Hz **B** 71 Hz **C** 100 Hz **D** 143 Hz

22 The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is $330\,\mathrm{m\,s^{-1}}$. The ambulance is travelling with a constant velocity of $25\,\mathrm{m\,s^{-1}}$ towards an observer. The ambulance passes, and then moves away from the observer with no change in velocity.



Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

A 49 Hz **B** 84 Hz **C** 91 Hz **D** 98 Hz

23 Brief pulses of red, blue and green light are emitted from the Sun at the same time.

The pulses travel the same distance to reach Mars. Assume that the pulses travel in a vacuum for the full duration of their journey.

In which order would these pulses of light arrive at Mars?

A all arrive at the same time

B blue first, then green, then red

C red first, then blue, then green

D red first, then green, then blue

24 Two coherent progressive waves from different sources meet at a point.

Which condition **must** be satisfied for there to be zero resultant amplitude at the point where the waves meet?

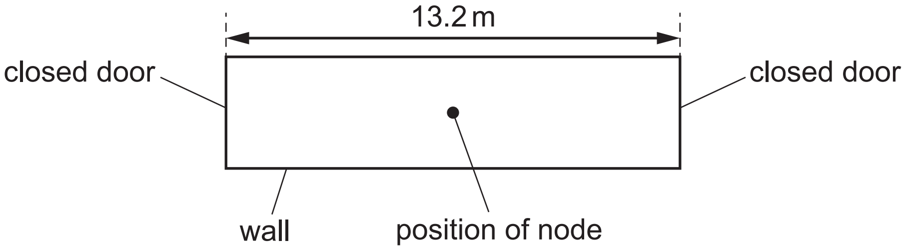
A The two waves must be emitted from their sources with the same intensity.

B The two waves must be in phase with each other at the point.

C The two waves must be travelling in opposite directions.

D The two waves must have the same amplitude at the point.

25 A corridor is 13.2 m long and has closed doors that reflect sound at both ends. The speed of sound in the air in the corridor is 330 m s^{-1}.



What is the lowest frequency of sound that could create a stationary wave in the corridor with a node halfway along it?

A 0.040 Hz **B** 13 Hz **C** 25 Hz **D** 50 Hz

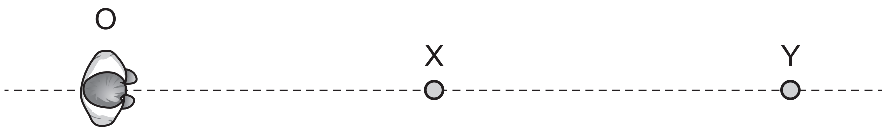
26 Water waves of wavelength λ are formed in a ripple tank. The waves are diffracted as they pass through a narrow gap of width d (d is greater than λ).

Which gap width and which wavelength will cause the largest decrease in the amount of diffraction?

	gap width	wavelength
A	$\frac{1}{2}d$	$\frac{1}{2}\lambda$
B	$\frac{1}{2}d$	2λ
C	$2d$	$\frac{1}{2}\lambda$
D	$2d$	2λ

27 Two loudspeakers X and Y emit sound waves that are in phase and of wavelength 0.75 m.

An observer O is able to stand anywhere on a straight line that passes through X and Y, as shown. The observer stands at a point where the sound waves from X and Y meet in phase.



What could be the distances OY and XY?

	distance OY / m	distance XY / m
A	1.25	3.50
B	2.00	2.75
C	2.75	2.00
D	3.25	1.50

28 Light of a single wavelength is incident normally on a diffraction grating.

The resulting diffraction pattern is displayed on a screen.

Which change makes the first orders of intensity maxima further apart from each other on the screen?

A placing the screen closer to the diffraction grating

B using a diffraction grating with less separation between adjacent slits

C using a diffraction grating with more slits but keeping the same separation between adjacent slits

D using light with a shorter wavelength

29 For a current-carrying wire, the current can be calculated using the equation shown.

$$I = Anvq$$

What is the meaning of n?

A the number of charge carriers in the wire

B the number of charge carriers multiplied by the volume of the wire

C the number of charge carriers per unit length of the wire

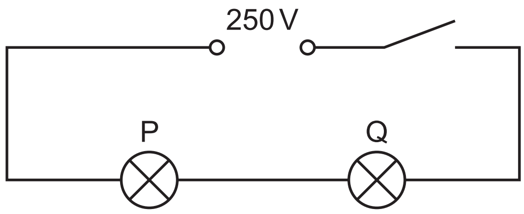
D the number of charge carriers per unit volume of the wire

30 The number of free electrons passing a point in a wire in 24 hours is 6.0×10^{23}.

What is the average current in the wire?

A 6.3 pA **B** 1.1 A **C** 67 A **D** 4.0 kA

31 In the circuit shown, lamp P is rated 250 V, 50 W and lamp Q is rated 250 V, 200 W. The two lamps are connected in series to a 250 V power supply.



Assume that the resistance of each lamp remains constant.

Which statement most accurately describes what happens when the switch is closed?

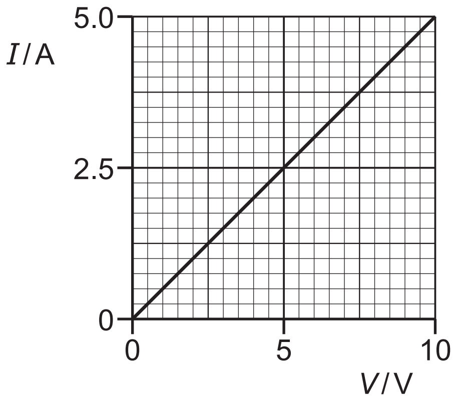
A Lamp P emits four times as much power as lamp Q.

B Lamp P emits twice as much power as lamp Q.

C Lamp Q emits four times as much power as lamp P.

D Lamp Q emits twice as much power as lamp P.

32 A piece of wire has a length of 0.80 m and a diameter of 5.0×10^{-4} m. The I–V characteristic of the wire is shown.



What is the resistivity of the metal from which the wire is made?

A $1.2 \times 10^{-7}\,\Omega\,\text{m}$

B $1.6 \times 10^{-7}\,\Omega\,\text{m}$

C $4.9 \times 10^{-7}\,\Omega\,\text{m}$

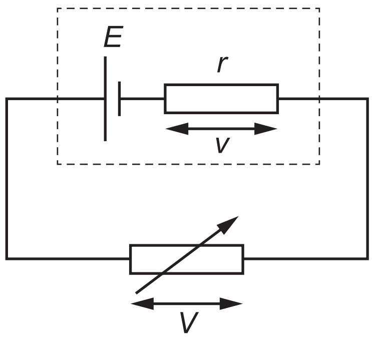
D $2.0 \times 10^{-6}\,\Omega\,\text{m}$

33 Ten cells, each of electromotive force (e.m.f.) 1.5 V, are connected together, as shown.

What is the combined e.m.f. between terminals X and Y?

A 8 V **B** 9 V **C** 12 V **D** 15 V

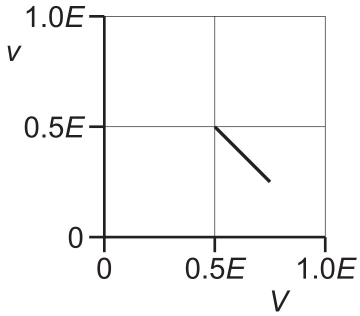
34 A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor, as shown.



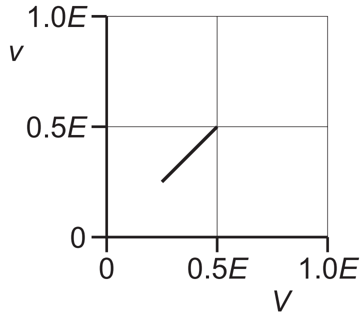
The resistance of the variable resistor is gradually increased from r to $3r$.

Which graph shows the variation of the potential difference (p.d.) v across the internal resistance with the p.d. V across the variable resistor?

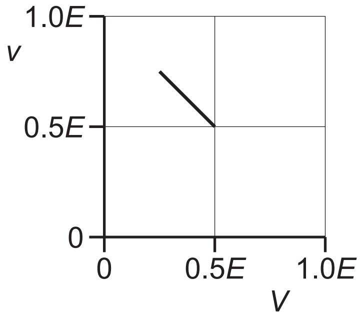
A



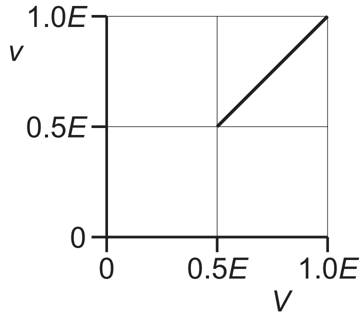
B



C



D

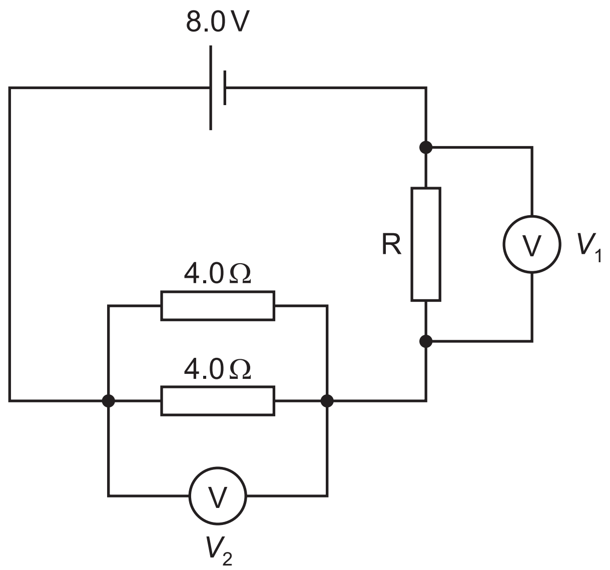


35 Each of Kirchhoff's two laws presumes that some quantity is conserved.

Which row states Kirchhoff's **first** law and names the quantity that is conserved?

	statement	quantity
A	the algebraic sum of currents into a junction is zero	charge
B	the algebraic sum of currents into a junction is zero	energy
C	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	charge
D	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	energy

36 A cell has an electromotive force (e.m.f.) of 8.0 V and negligible internal resistance. The cell forms part of a circuit, as shown.

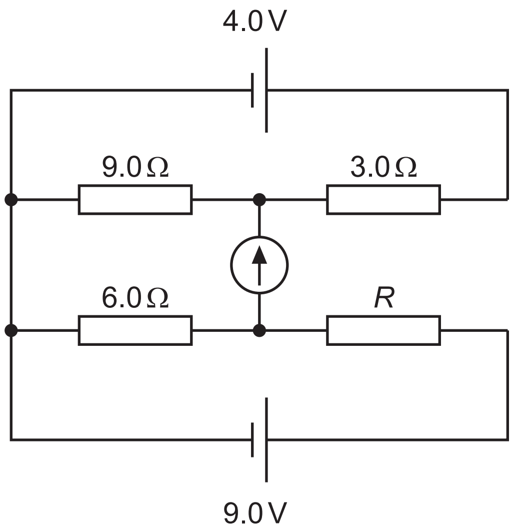


The reading V_1 is 4.0 V and the reading V_2 is also 4.0 V.

What is the resistance of resistor R?

A 0.50 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 8.0 Ω

37 In the circuit shown, the cells have negligible internal resistance and the reading on the galvanometer is zero.



What is the value of resistor R?

A 2.0 Ω **B** 6.0 Ω **C** 12 Ω **D** 18 Ω

38 When α-particles are directed at gold leaf:

1 almost all α-particles pass through without deflection

2 a few α-particles are deviated through large angles.

What are the reasons for these effects?

	1	2
A	most α-particles have enough energy to pass right through the gold leaf	gold is very dense so a few low energy α-particles bounce back from the gold surface
B	most α-particles miss all gold atoms	a few α-particles bounce off gold atoms
C	the gold nucleus is very small so most α-particles miss all nuclei	occasionally the path of an α-particle is close to a nucleus
D	the positive charge in an atom is not concentrated enough to deflect an α-particle	occasionally an α-particle experiences many small deflections in the same direction

39 A nucleus X is radioactive and decays into a nucleus Y.

X and Y are isotopes of the same element.

Which combination of particles could have been emitted during the decay process?

A 1 α-particle and 1 β^- particle

B 1 α-particle and 2 β^- particles

C 2 α-particles and 1 β^- particle

D 2 α-particles and 2 β^- particles

40 A positively charged meson consists of a quark and an antiquark.

What could be the quark and antiquark?

A charm and antiup

B down and antitop

C strange and antibottom

D up and antistrange

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2016**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **18** printed pages and **2** blank pages.

IB16 06_9702_11/3RP

CAMBRIDGE International Examinations

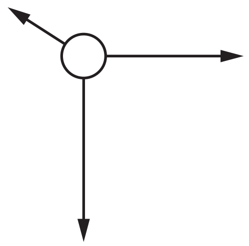
Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

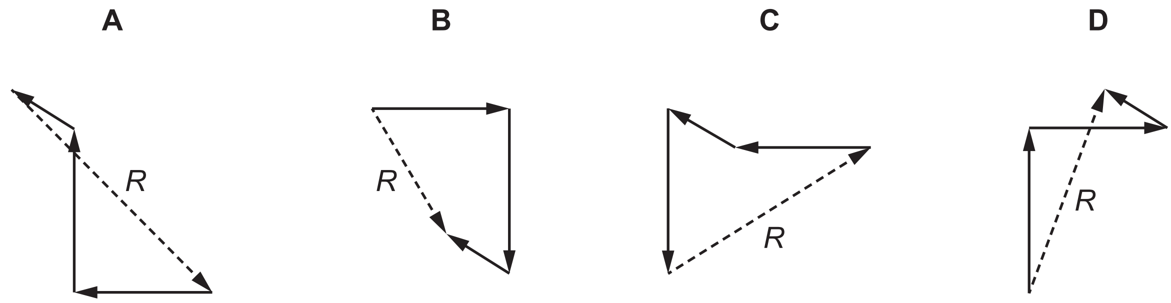
Formulae

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Three wires each exert a horizontal force on a vertical pole, as shown.



Which vector diagram shows the resultant force R acting on the pole?



2 Which pair of quantities do **not** have the same SI base units?

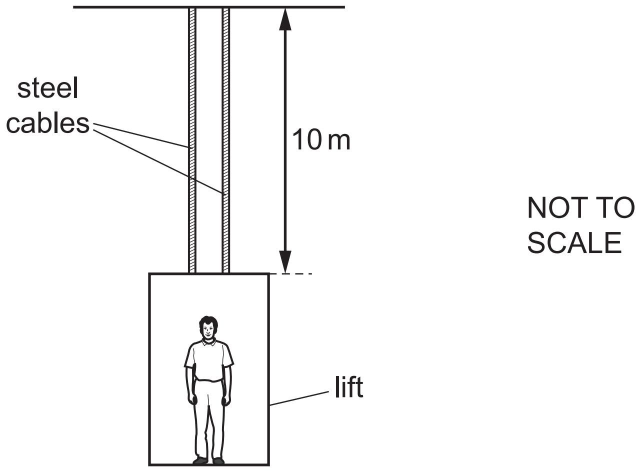
A electromotive force and electric potential difference

B pressure and stress

C spring constant and moment of a force

D torque and work

3 A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.



The cables extend by 1 mm when a man of mass 80 kg steps into the lift.

What is the best estimate of the value of the Young modulus of the steel?

A $2 \times 10^{10}\,\text{N m}^{-2}$

B $4 \times 10^{10}\,\text{N m}^{-2}$

C $2 \times 10^{11}\,\text{N m}^{-2}$

D $4 \times 10^{11}\,\text{N m}^{-2}$

4 When performing an experiment, a student should minimise the uncertainty of any measurement.

In which case is the student reducing the systematic error in a measurement?

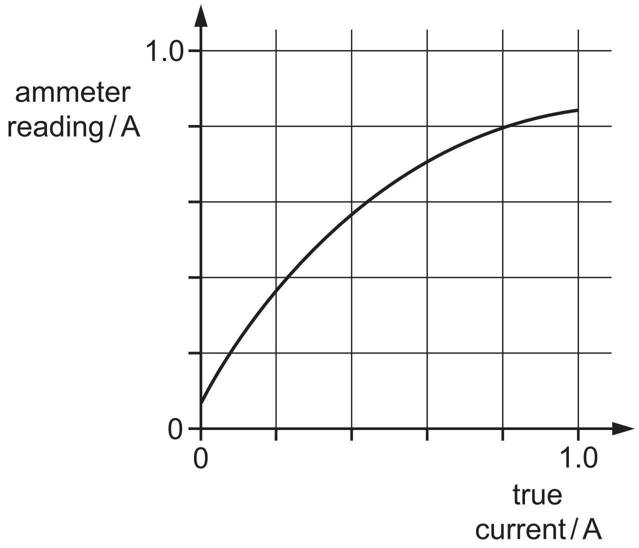
A adjusting a voltmeter needle pointer to the zero position before using it to measure a potential difference

B measuring the diameter of a wire at several points and orientations

C measuring the mass of 100 paperclips to determine the mass of one paperclip

D timing 20 oscillations of a mass on a spring to determine the period of one oscillation

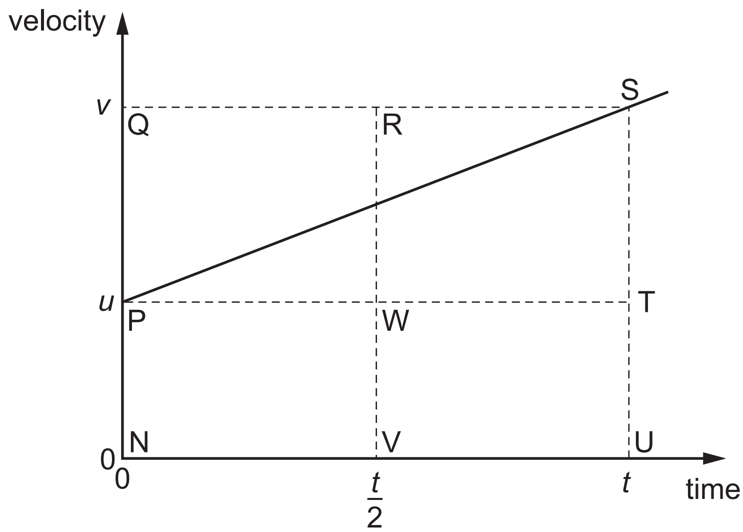
5 A calibration graph is produced for a faulty ammeter.



Which ammeter reading will be nearest to the true current?

A 0.2 A **B** 0.4 A **C** 0.6 A **D** 0.8 A

6 A car accelerates uniformly from velocity u to velocity v in time t.



On the graph, which area equals the distance travelled by the car in time t?

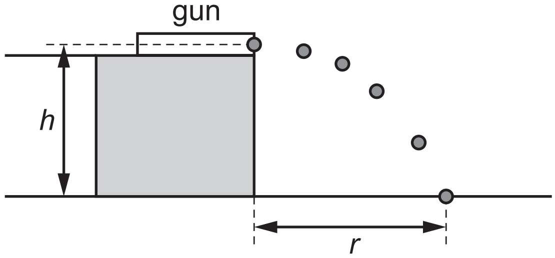
A NPTU + PQST

B NPWV + VRSU

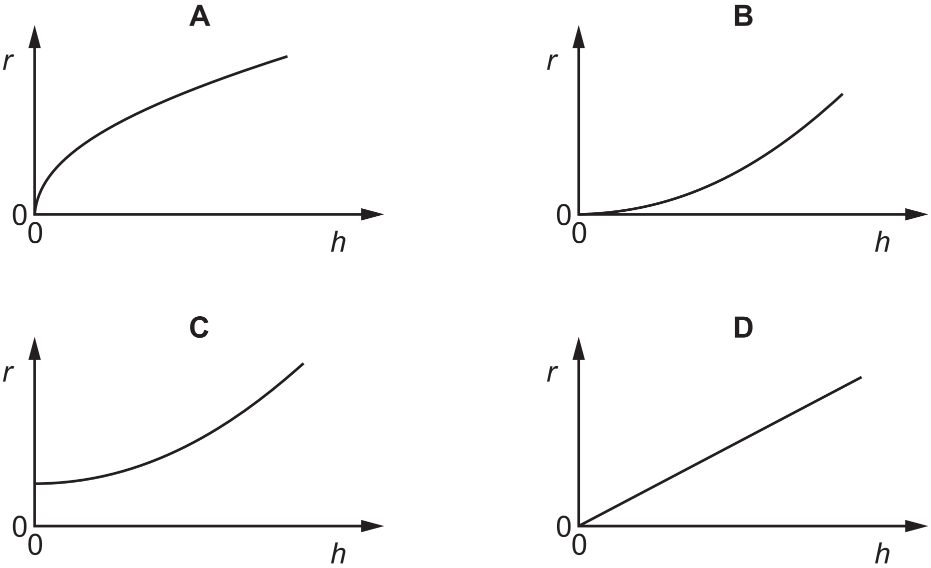
C NPWV + WRST

D PST + PQS

7 A student uses a spring gun to launch a steel ball with a constant horizontal velocity. He varies the height h of the gun and measures the horizontal displacement r of the ball when it hits the ground.



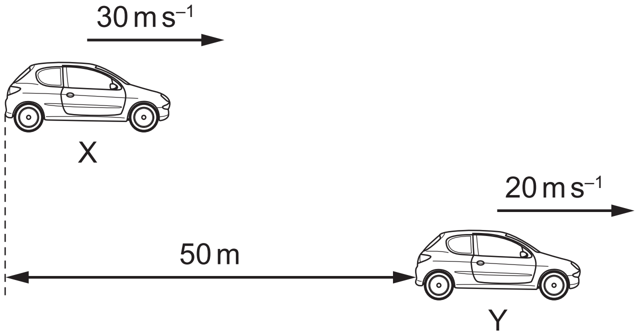
Which graph shows the variation with height h of the horizontal displacement r?



8 Two cars X and Y are positioned as shown at time $t = 0$.

They are travelling in the same direction.

X is 50 m behind Y and has a constant velocity of $30\,\mathrm{m\,s^{-1}}$. Y has a constant velocity of $20\,\mathrm{m\,s^{-1}}$.



What is the value of t when X is level with Y?

A 1.0 s **B** 1.7 s **C** 2.5 s **D** 5.0 s

9 Which statement about a perfectly elastic collision between two bodies in an isolated system is correct?

A Both total kinetic energy and total momentum are conserved.

B Total kinetic energy is conserved, but total momentum is not conserved.

C Total momentum is conserved, but total kinetic energy is not conserved.

D Neither total kinetic energy nor total momentum is conserved.

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

The collision is perfectly elastic. Which equation must be correct?

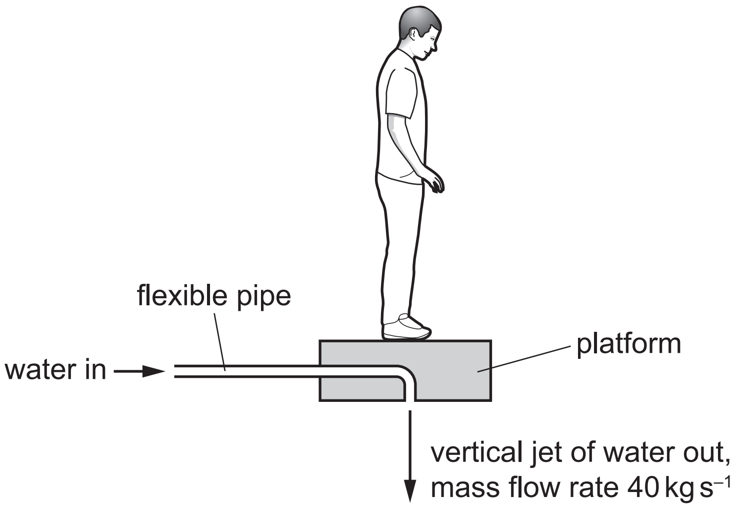
A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

11 The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



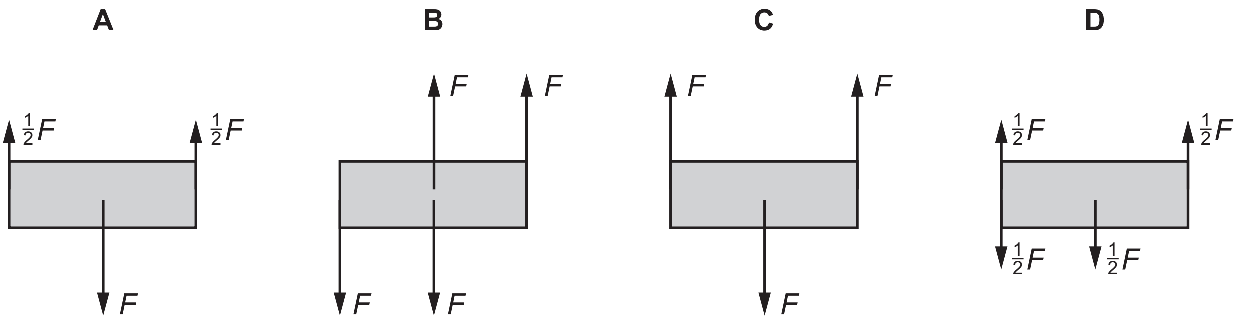
The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

What is the speed of the water leaving the platform?

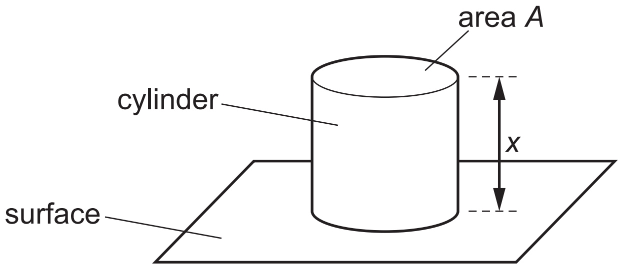
A 2.4 m s^{-1} **B** 6.9 m s^{-1} **C** 24 m s^{-1} **D** 47 m s^{-1}

12 Forces are applied to a rigid body. The forces all act in the same plane.

In which diagram is the body in equilibrium?



13 A solid metal cylinder stands on a horizontal surface, as shown.

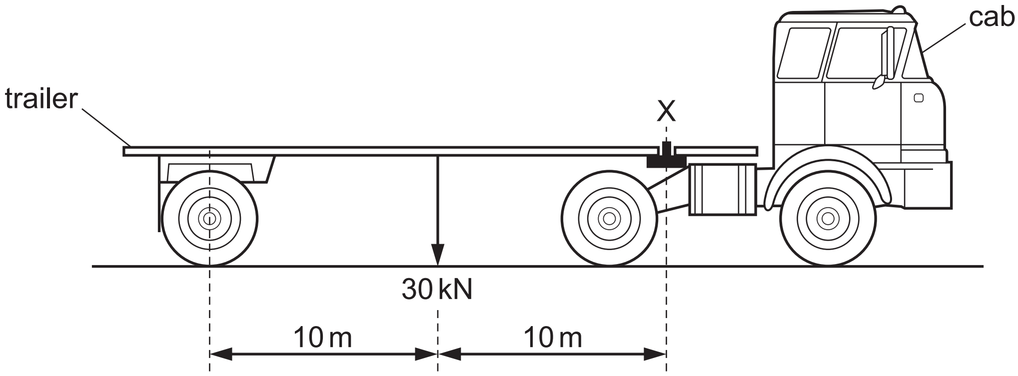


The cylinder has length x and cross-sectional area A. The cylinder exerts a pressure p on the surface. The acceleration of free fall is g.

Which expression gives the density of the metal of the cylinder?

A $\frac{gx}{p}$ **B** $\frac{p}{gx}$ **C** $\frac{gx}{pA}$ **D** $\frac{pA}{gx}$

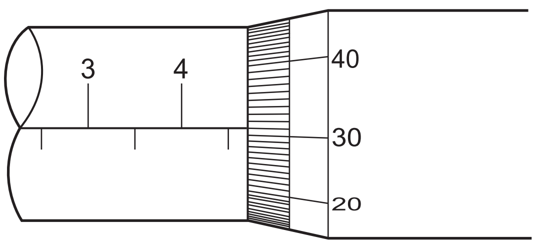
14 A trailer of weight 30 kN is attached to a cab at X, as shown in the diagram.



What is the upward force exerted at X by the cab on the trailer?

A 3 kN **B** 15 kN **C** 30 kN **D** 60 kN

15 The diameter of a solid metal sphere is measured using a micrometer screw gauge. The diagram shows an enlargement of the shaft of the micrometer screw gauge when taking the measurement.



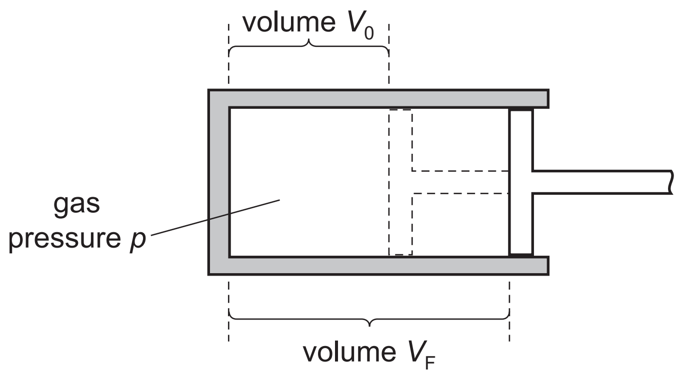
The mass of the sphere is 0.450 g.

What is the density of the metal used to make the sphere?

A 965 kg m^{-3} **B** 1340 kg m^{-3} **C** 7720 kg m^{-3} **D** 10 700 kg m^{-3}

16 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 change?

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

17 The power P required to move an object through a medium at constant speed depends on the speed v and the resistive force F acting on the object.

The resistive force F also depends on the speed v.

Which row shows a possible relationship between speed v, resistive force F and power P?

	resistive force F	power P
A	proportional to v	constant
B	proportional to v	proportional to v
C	proportional to v^2	proportional to v^2
D	proportional to v^2	proportional to v^3

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

A the decrease in gravitational potential energy of a body of mass 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 body of mass 12 kg moving at a speed of 20 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 m^3

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

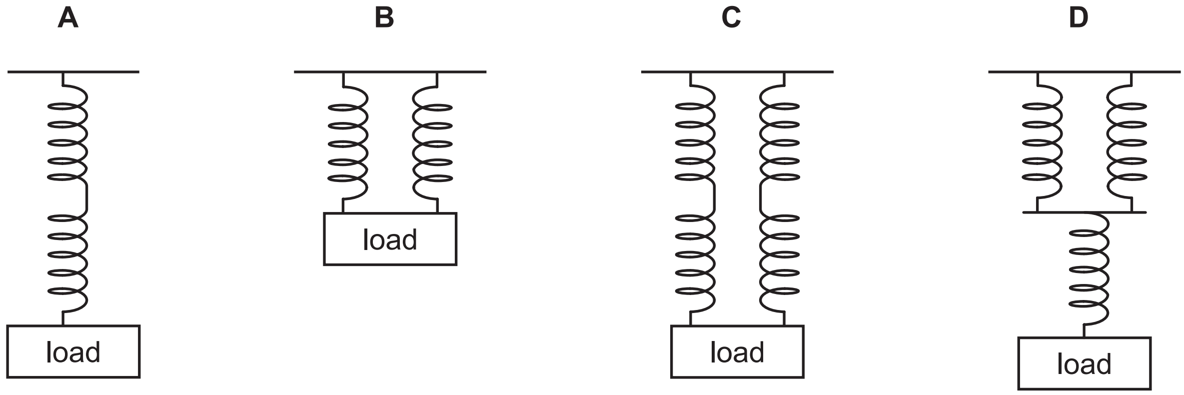
Both the hammer and nail come to rest after the collision.

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

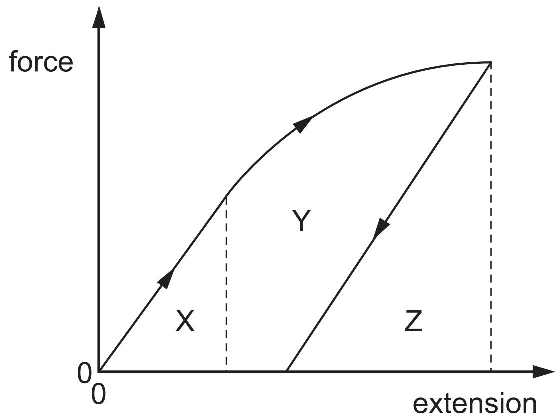
A 0.050 N **B** 2.0 N **C** 50 N **D** 2000 N

20 A number of identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



21 A sample of material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below.



Which area represents the net work done on the sample?

A X **B** X + Y **C** Y + Z **D** Z

22 Two sound waves have frequencies of 250 Hz and 300 Hz. The speed of sound is 340 m s^{-1}.

What is the difference between the wavelengths of the two waves?

A 0.23 m **B** 1.1 m **C** 1.4 m **D** 6.8 m

23 Which electromagnetic waves have the wavelengths of 10^{-2} m, 10^{-5} m, 10^{-10} m and 10^{-13} m?

	10^{-2} m	10^{-5} m	10^{-10} m	10^{-13} m
A	infra-red	microwaves	visible light	X-rays
B	microwaves	infra-red	X-rays	gamma rays
C	microwaves	visible light	ultraviolet	gamma rays
D	radio waves	microwaves	ultraviolet	X-rays

24 Which statement concerning a stationary wave is correct?

A All the particles between two successive 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.

25 Continuous water waves are diffracted through a gap in a barrier in a ripple tank.

Which change will cause the diffraction of the waves to increase?

A increasing the frequency of the waves

B increasing the width of the gap

C reducing the wavelength of the waves

D reducing the width of the gap

26 A parallel beam of light of wavelength 450 nm is incident normally on a diffraction grating which has 300 lines / mm.

What is the total number of intensity maxima observed?

A 7 **B** 8 **C** 14 **D** 15

27 Fringes of separation x are observed on a screen 1.00 m from a double slit that is illuminated by yellow light of wavelength 600 nm.

At which distance from the slits would fringes of the same separation x be observed when using blue light of wavelength 400 nm?

A 0.33 m **B** 0.67 m **C** 0.75 m **D** 1.50 m

28 A charged particle is moving in a uniform electric field.

For the motion of the particle due to the field, which quantity has a constant non-zero value?

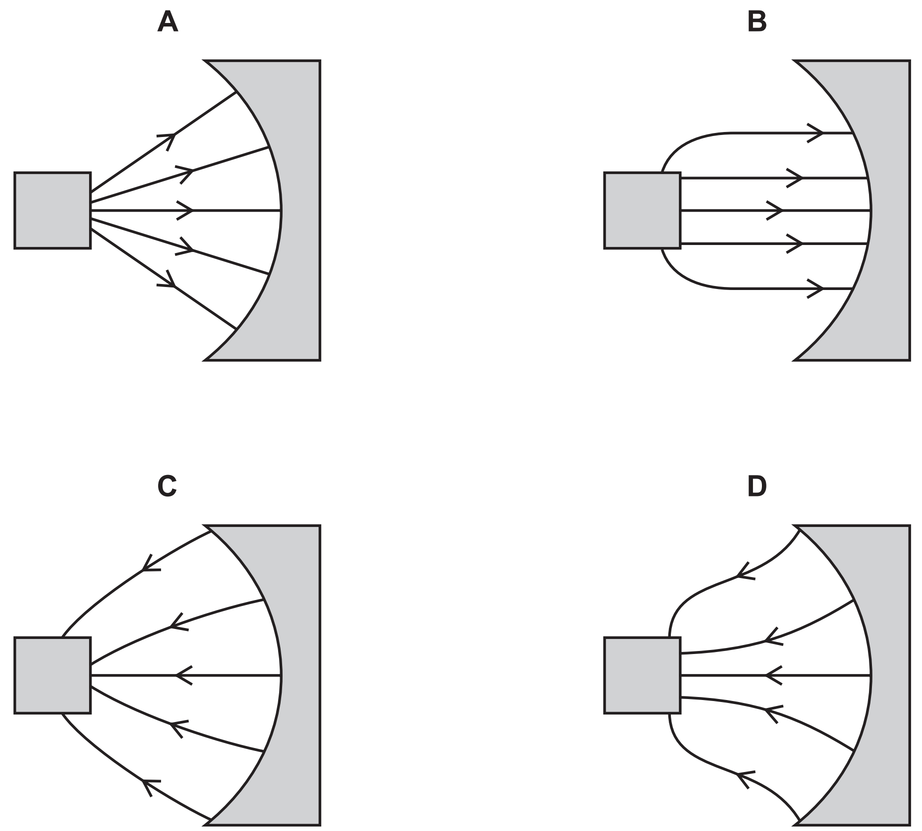
A acceleration

B displacement

C rate of change of acceleration

D velocity

29 Which diagram could represent the electric field lines between two oppositely charged conducting surfaces?



30 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

A the current in the resistor and the potential difference across the resistor

B the resistance of the resistor and the current in the resistor

C the total charge passing through the resistor and the potential difference across the resistor

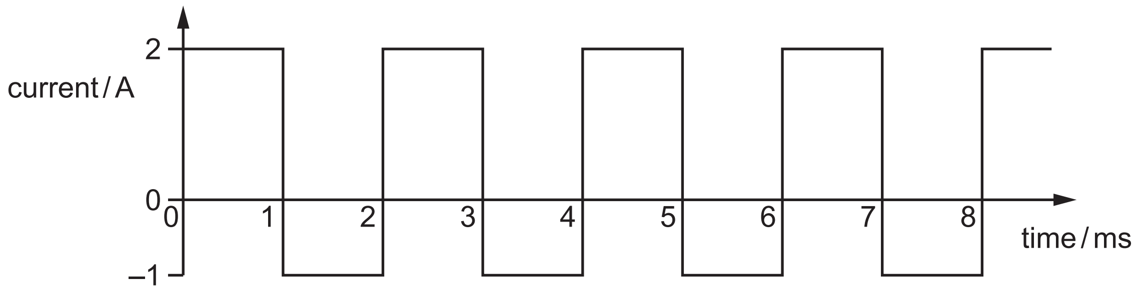
D the total charge passing through the resistor and the resistance of the resistor

31 Two copper wires of equal length are connected in parallel. A potential difference is applied across the ends of this parallel arrangement. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

What is the value of the ratio $\frac{\text{current in S}}{\text{current in T}}$?

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

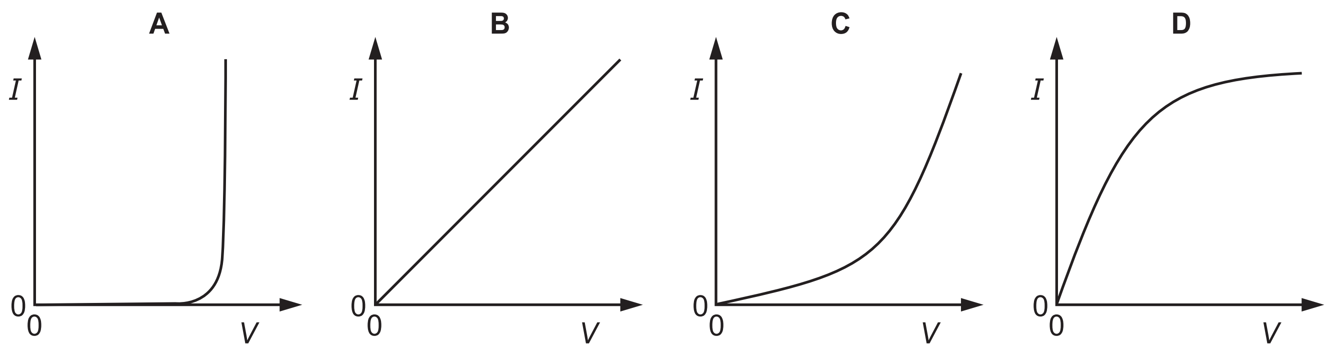
32 A 100 Ω resistor conducts a current with changing direction and magnitude, as shown.



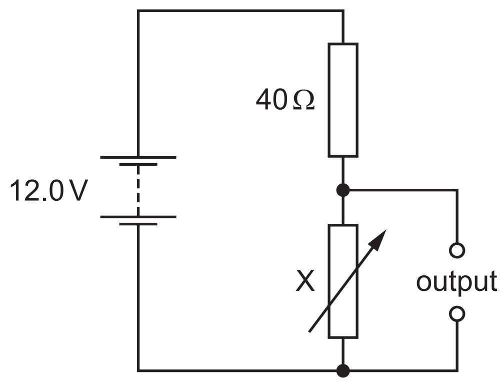
What is the mean power dissipated in the resistor?

A 100 W **B** 150 W **C** 250 W **D** 400 W

33 Which graph shows the I–V characteristic of a filament lamp?



34 In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0 Ω to 500 Ω. The e.m.f. of the battery is 12.0 V. It has negligible internal resistance.



What is the maximum range of values of potential difference across the output?

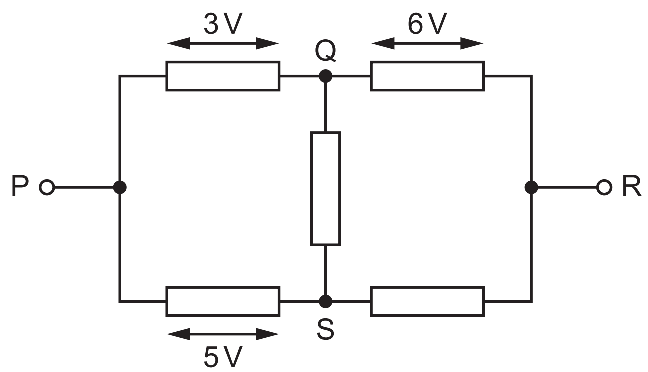
A 1.3 V to 11.1 V

B 1.3 V to 12.0 V

C 1.5 V to 11.1 V

D 1.5 V to 12.0 V

35 There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3 V.

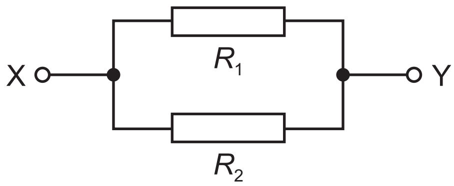
The p.d. between Q and R is 6 V.

The p.d. between P and S is 5 V.

Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2 V	4 V
B	2 V	10 V
C	3 V	4 V
D	3 V	10 V

36 Two resistors of resistances R_1 and R_2 are connected in parallel.



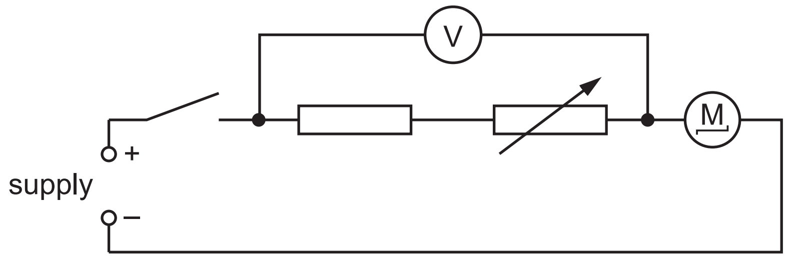
What is the combined resistance between X and Y?

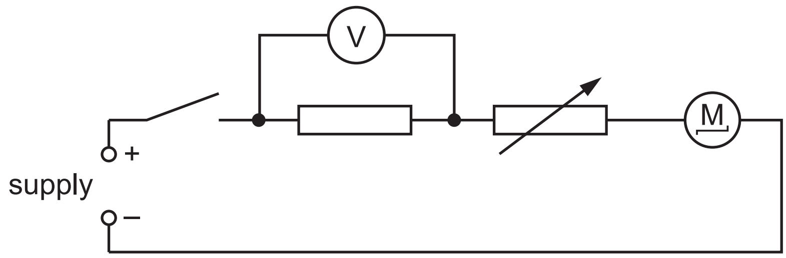
A $R_1 + R_2$ **B** $\dfrac{R_1 R_2}{R_1 + R_2}$ **C** $\dfrac{R_1 + R_2}{R_1 R_2}$ **D** $\dfrac{R_1}{R_2}$

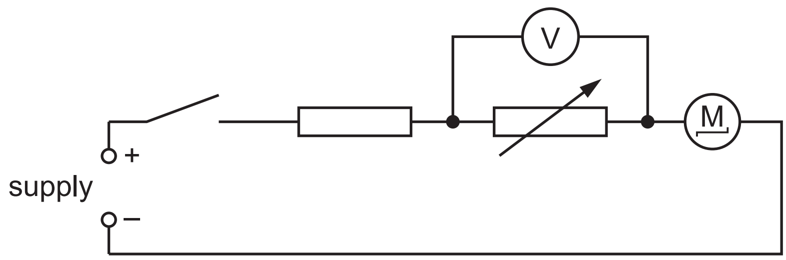
37 A voltmeter is used to monitor the operation of an electric motor. The motor speed is controlled by a variable resistor. A fixed resistor is used to limit the speed.

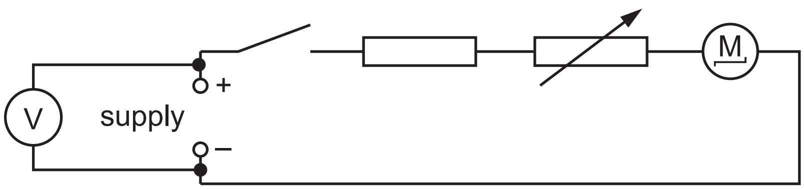
The current in the motor is gradually changed.

In which circuit is the voltmeter reading proportional to the current in the motor?

A


B


C


D


38 Which statement describes β^- decay in terms of a simple quark model?

A A down quark changes to an up quark and emits an electron and an electron antineutrino.

B A down quark changes to an up quark and emits a positron and an electron neutrino.

C An up quark changes to a down quark and emits an electron and an electron antineutrino.

D An up quark changes to a down quark and emits a positron and an electron neutrino.

39 Which word equation represents β^+ decay?

A proton $\rightarrow$ neutron + electron + electron antineutrino

B proton $\rightarrow$ neutron + electron + electron neutrino

C proton $\rightarrow$ neutron + positron + electron antineutrino

D proton $\rightarrow$ neutron + positron + electron neutrino

40 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?

A A tiny proportion of the alpha-particles are deflected through large angles.

B Slower alpha-particles are deflected through larger angles.

C The kinetic energies of the deflected alpha-particles are unchanged.

D The number of alpha-particles deflected depends on the thickness of the foil.

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PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2016**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **21** printed pages and **3** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_{\mathrm{e}} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_{\mathrm{p}} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_{\mathrm{A}} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 Which quantity with its unit is correct?

A acceleration of a bicycle = $1.4\,\mathrm{m\,s^{-1}}$

B electric current in a lamp = $0.25\,\mathrm{A\,s^{-1}}$

C electric potential difference across a battery = $8.0\,\mathrm{J\,C^{-1}}$

D kinetic energy of a car = $4500\,\mathrm{N\,m^{-1}}$

2 The luminosity L of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

r is the radius of the star,

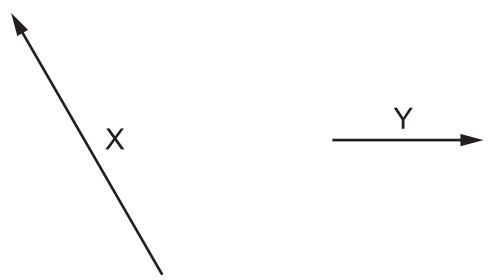
T is the temperature of the star,

σ is a constant with units $\mathrm{W\,m^{-2}\,K^{-4}}$.

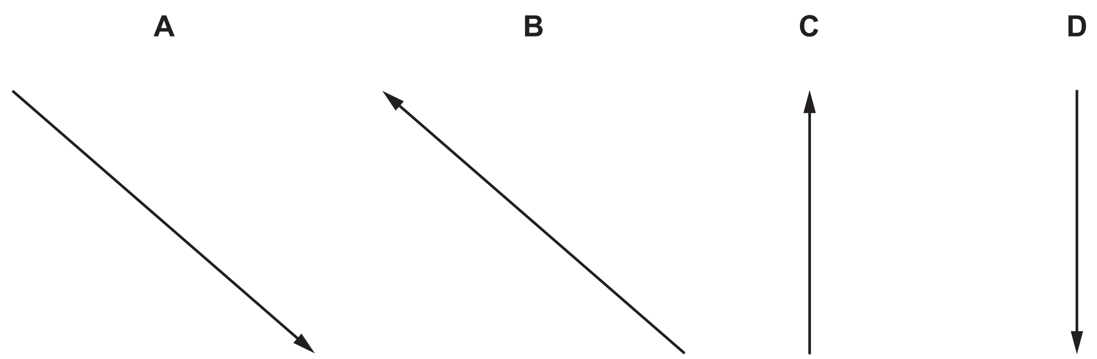
What are the SI base units of L?

A $\mathrm{kg\,m^2\,s^{-1}}$ **B** $\mathrm{kg\,m^2\,s^{-2}}$ **C** $\mathrm{kg\,m^2\,s^{-3}}$ **D** $\mathrm{kg\,m^2\,s^{-4}}$

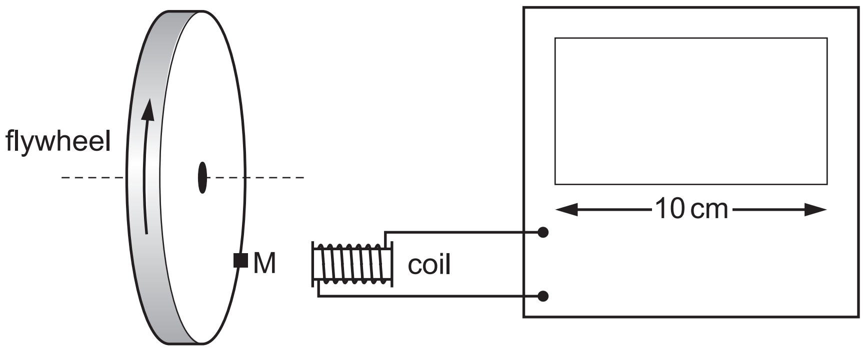
3 The diagram shows two vectors X and Y, drawn to scale.



If X = Y – Z, which diagram best represents the vector Z?



4 The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.



The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at 3000 revolutions per minute.

Which time-base setting will display clearly separate pulses on the screen?

A $1\,\text{s}\,\text{cm}^{-1}$ **B** $10\,\text{ms}\,\text{cm}^{-1}$ **C** $100\,\mu\text{s}\,\text{cm}^{-1}$ **D** $1\,\mu\text{s}\,\text{cm}^{-1}$

5 A student determines the density ρ of steel by taking measurements from a steel wire.

mass $m = 6.2 \pm 0.1\,\text{g}$

length $l = 25.0 \pm 0.1\,\text{cm}$

diameter $d = 2.00 \pm 0.01\,\text{mm}$

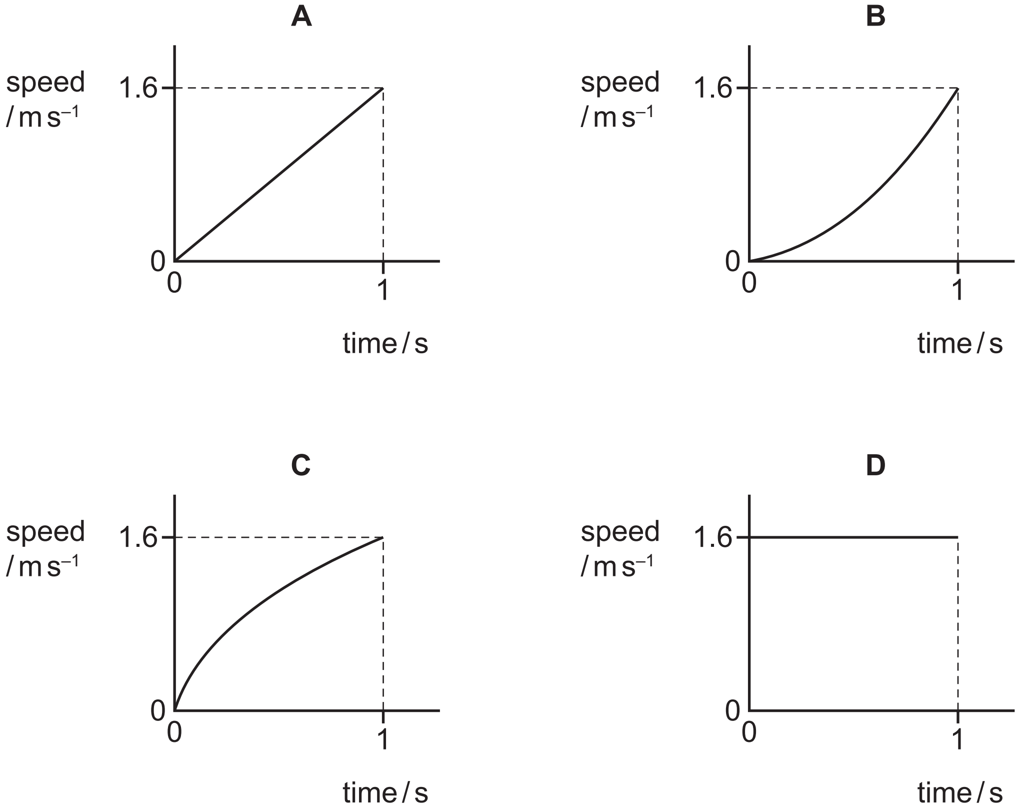
He uses the equation $\rho = \dfrac{4m}{\pi d^2 l}$.

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

A 1.1% **B** 1.8% **C** 2.5% **D** 3.0%

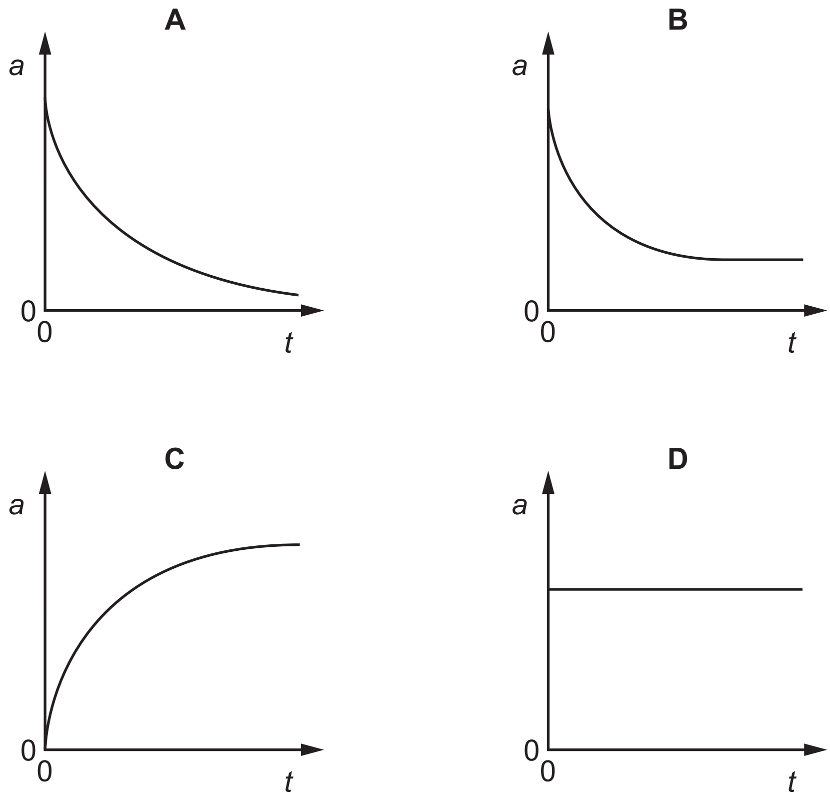
6 The acceleration of free fall on the Moon is $1.6\,m\,s^{-2}$. The Moon has no atmosphere. An astronaut standing on the surface of the Moon drops a feather.

Which graph shows the variation with time of the speed of the feather during the first second of its fall?

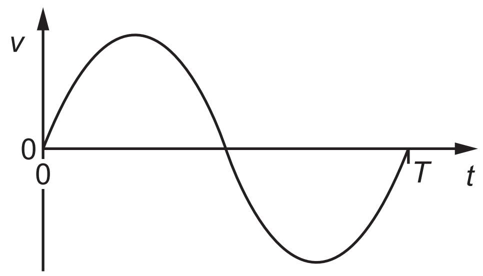


7 A tennis ball is released from rest at the top of a tall building.

Which graph best represents the variation with time t of the acceleration a of the ball as it falls, assuming that the effect of air resistance is **not** negligible?

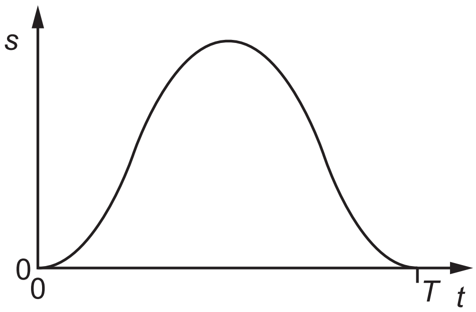


8 The graph shows how the velocity v of an object moving in a straight line varies with time t from $t = 0$ to $t = T$.

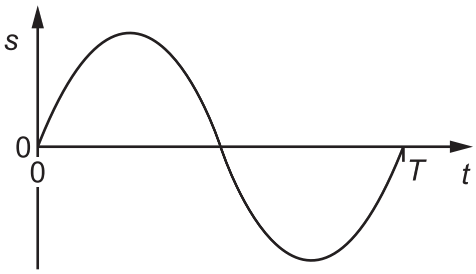


Which graph represents the displacement s of the object in the time $t = 0$ to $t = T$?

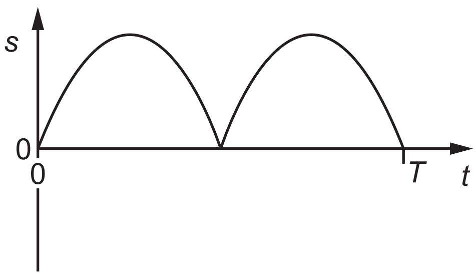
A



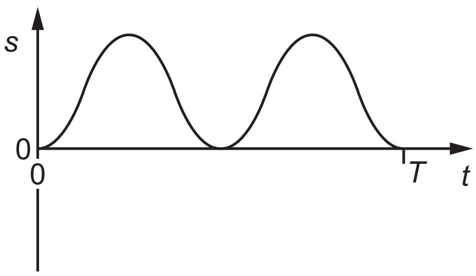
B



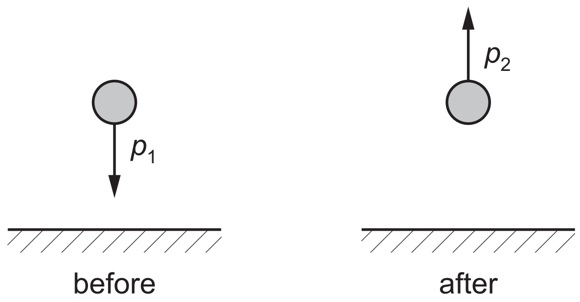
C



D



9 A ball falls vertically onto horizontal ground and rebounds, as shown.

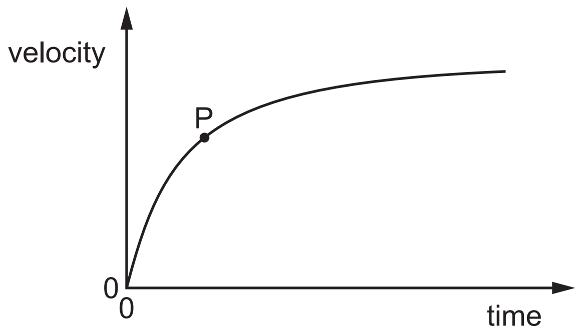


The ball has momentum p_1 downwards just before hitting the ground. After rebounding, the ball leaves the ground with momentum p_2 upwards. The ball is in contact with the ground for 0.020 s. During this time interval, an average resultant force of 25 N acts on the ball.

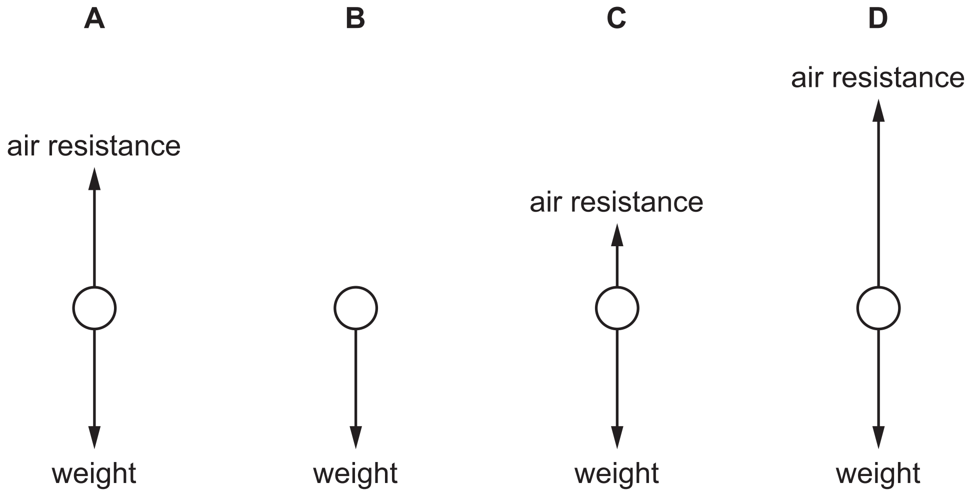
What is a possible combination of values for p_1 and p_2?

	p_1 / kg m s^{-1}	p_2 / kg m s^{-1}
A	0.15	0.65
B	0.20	0.30
C	0.30	0.20
D	0.65	0.15

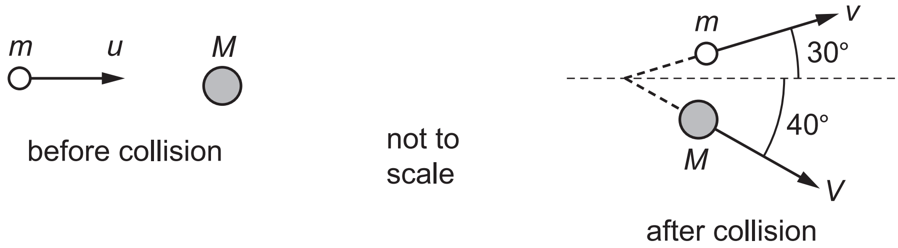
10 A sphere falls from rest through the air. The graph shows the variation with time of the sphere's velocity.



Which diagram shows the forces acting on the sphere when it is at the velocity corresponding to point P on the graph?



11 A ball of mass m travelling at velocity u collides with a stationary ball of mass M. After collision the two balls travel at velocities v and V respectively, in the directions shown.

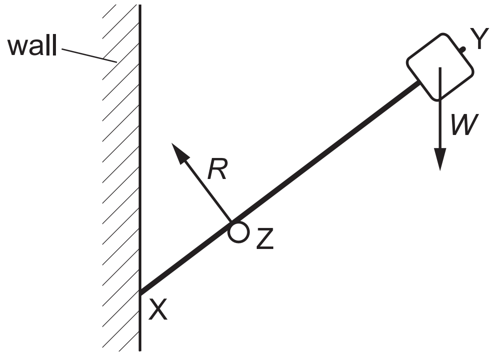


A student writes three equations relating to the collision.

Which row in the table indicates the correct and incorrect equations?

	$mu = MV + mv$	$mv \sin 30° = MV \sin 40°$	$mu = mv \cos 30° + MV \cos 40°$
A	correct	correct	correct
B	incorrect	correct	incorrect
C	correct	incorrect	incorrect
D	incorrect	correct	correct

12 A light rigid rod XY has an object of weight W fixed at one end. The rod is in equilibrium, resting on a roller at Z and a vertical wall at X. The roller exerts a force R on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces R and W.



What is the direction of the force on the rod at X?

13 In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of

1200 kg of oil of density 1100 $kg\,m^{-3}$,

1500 kg of oil of density 860 $kg\,m^{-3}$,

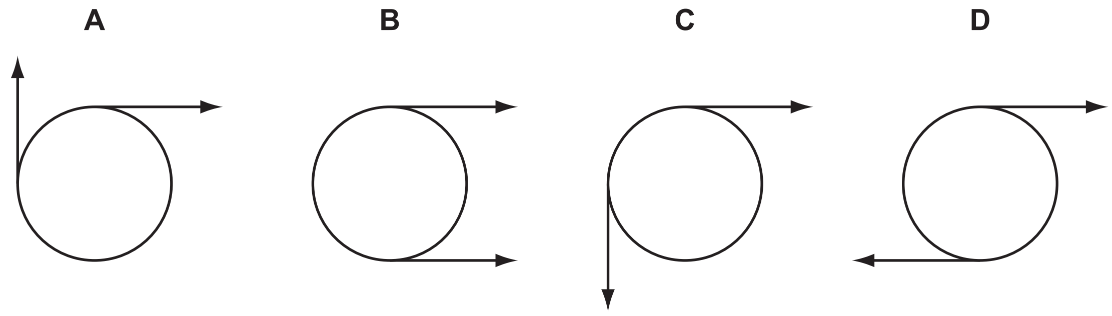
4000 kg of oil of density 910 $kg\,m^{-3}$.

What is the density of the mixture?

A 927 $kg\,m^{-3}$ **B** 957 $kg\,m^{-3}$ **C** 1010 $kg\,m^{-3}$ **D** 1080 $kg\,m^{-3}$

14 Two coplanar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?



15 The density of air on the Earth decreases almost linearly with height from 1.22 $kg\,m^{-3}$ at sea level to 0.74 $kg\,m^{-3}$ at an altitude of 5000 m.

Atmospheric pressure at the Earth's surface on a particular day is 100 000 Pa. The value of *g* between the Earth's surface and an altitude of 5000 m can be considered to have a constant value of 9.7 $m\,s^{-2}$.

What will be the atmospheric pressure at an altitude of 5000 m?

A 36 000 Pa **B** 48 000 Pa **C** 52 000 Pa **D** 59 000 Pa

16 A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

A Gravitational potential energy is converted into kinetic energy of the air.

B Gravitational potential energy is converted into kinetic energy of the parachutist.

C Gravitational potential energy is converted into thermal energy of the air.

D Gravitational potential energy is converted into thermal energy of the parachutist.

17 A boy on a bicycle starts from rest and rolls down a hill inclined at 30° to the horizontal.

The boy and bicycle have a combined mass of 25 kg.

There is a frictional force of 30 N, which is independent of the velocity of the bicycle.

What is the kinetic energy of the boy and the bicycle after rolling 20 m down the slope?

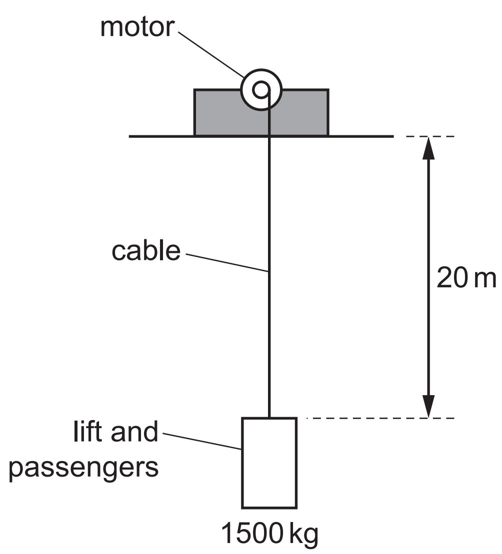
A 1850 J **B** 2450 J **C** 3050 J **D** 3640 J

18 An escalator in an underground station has 250 people standing on it and is moving with a velocity of 4.3 m s^{-1}. The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40°.

What is the minimum power required to lift these people?

A 54 kW **B** 64 kW **C** 530 kW **D** 630 kW

19 An electric motor operating a lift has an output power of 20 kW.



The lift and passengers have a combined mass of 1500 kg. The motor raises the lift through a distance of 20 m.

How long does it take?

A 6 s **B** 15 s **C** 30 s **D** 60 s

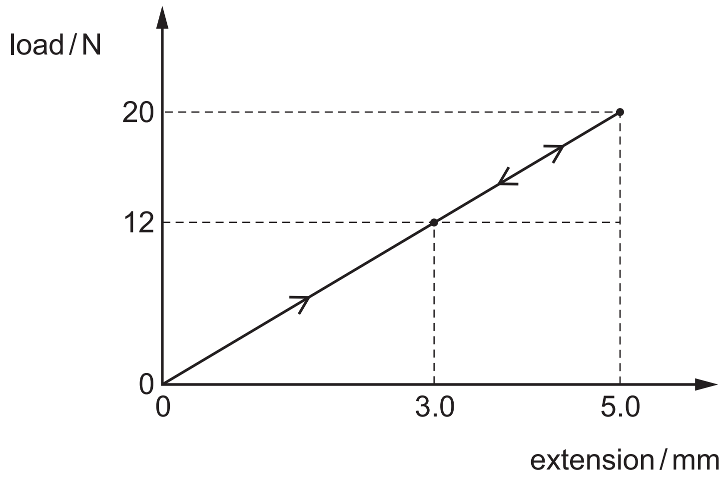
20 A spring balance consists of a spring of length 20.0 cm with a hook attached.

When a fish of mass 3.0 kg is suspended from the hook, the new length of the spring is 27.0 cm.

What is the spring constant of the spring?

A 4.2 N m^{-1} **B** 43 N m^{-1} **C** 110 N m^{-1} **D** 420 N m^{-1}

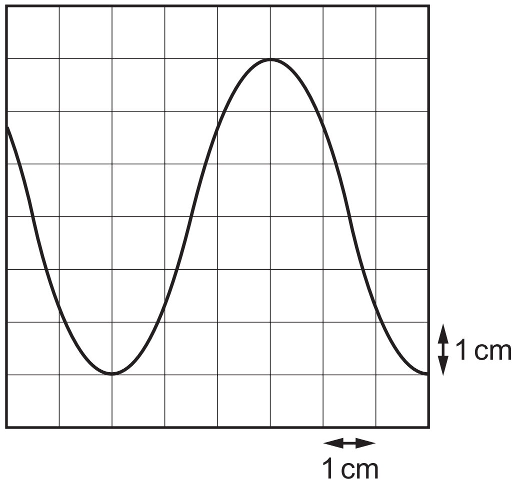
21 A metal wire is attached at one end to a fixed point and a load is hung from the other end so that the wire hangs vertically. The load is increased from zero to 20 N. This causes the wire to extend elastically by 5.0 mm. The load is then reduced to 12 N and the extension decreases to 3.0 mm.



How much strain energy is released during the unloading process?

A 0.8×10^{-2} J **B** 1.8×10^{-2} J **C** 2.4×10^{-2} J **D** 3.2×10^{-2} J

22 A microphone connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.) is placed in front of a loudspeaker. The trace on the screen of the c.r.o. is shown.



The time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 0.2 mV cm^{-1}.

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the c.r.o.?

	frequency / Hz	amplitude / mV
A	330	0.6
B	330	1.2
C	670	0.6
D	670	1.2

23 A source of sound of frequency 1000 Hz moves away from a stationary observer at a speed of 30.0 m s^{-1}. The speed of sound is 330 m s^{-1}.

What is the frequency of the sound heard by the observer?

A 909 Hz **B** 917 Hz **C** 1090 Hz **D** 1100 Hz

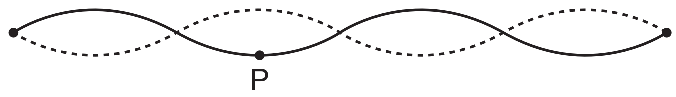
24 Each of the principal radiations of the electromagnetic spectrum has a range of wavelengths.

Which wavelength is correctly linked to its radiation?

	wavelength / m	radiation
A	10^{-9}	gamma ray
B	10^{-5}	microwave
C	10^{-8}	ultraviolet
D	10^{-14}	X-ray

25 A stationary wave is set up on a stretched string.

The diagram shows the string at two instants of time when it has maximum displacement.



The oscillations of point P on the string have amplitude A.

What is the distance moved by P from the position shown in the diagram after half a time period of the wave?

A 0 **B** A **C** $2A$ **D** $4A$

26 Which statement is an example of the diffraction of light?

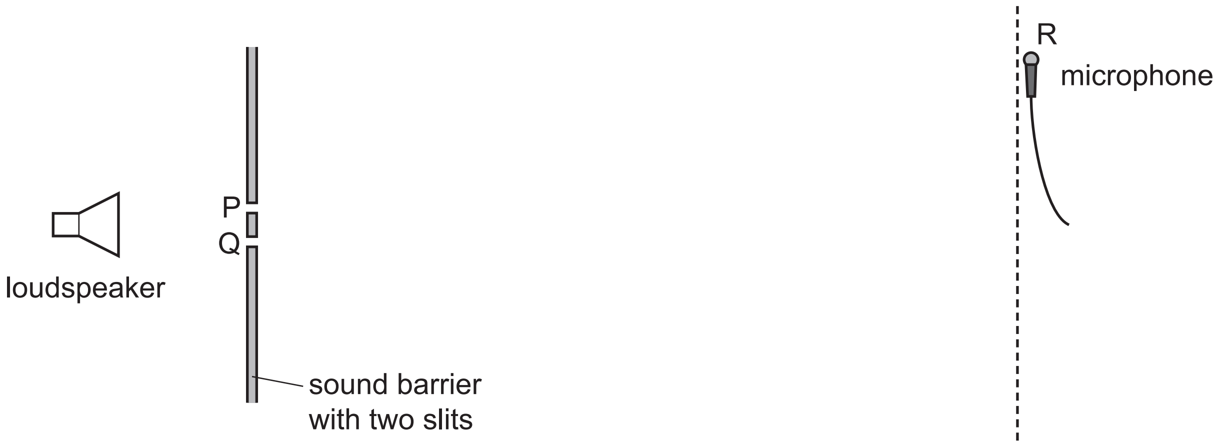
A the addition of the amplitudes of two beams of light which are in phase

B the change in direction of a beam of light when passing from air into water

C the separation of a beam of white light into a spectrum of colours using a prism

D the spreading of a beam of light as it passes through a small hole

27 Sound waves of wavelength λ are emitted by a loudspeaker and pass through two slits P and Q. Two sound waves from the slits meet at R.



What is the condition for an intensity maximum (loud sound) to be detected by a microphone at R?

A The amplitudes of the two waves at R must be the same.

B The distance PQ must be smaller than the wavelength λ.

C The two waves from the slits must have travelled the same distance to R.

D The two waves must be in phase at R.

28 Coherent light passes through a double slit, producing bright and dark fringes on a screen placed parallel to the plane of the double slit. The intensity of the light from each of the slits is initially the same.

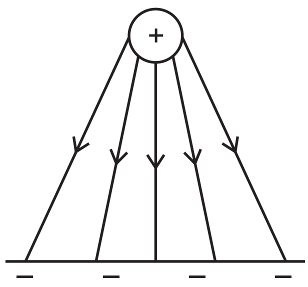
The intensity of the light passing through one of the slits in the double slit is now increased. The frequency of the light remains constant.

What is the effect on the appearance of the fringes on the screen?

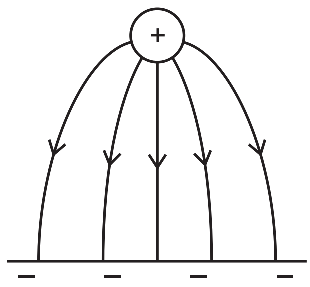
	separation of fringes	maximum intensity of dark fringes
A	decreases	no change
B	increases	greater
C	no change	greater
D	no change	no change

29 Which diagram shows the pattern of the electric field between a positively charged metal sphere and a negatively charged metal plate?

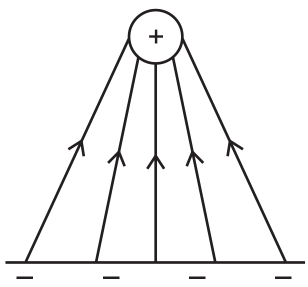
A



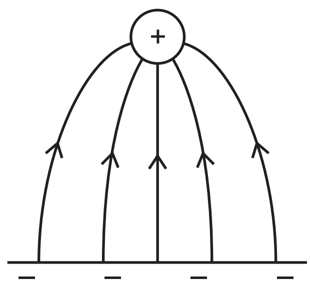
B



C



D



30 Before a thunderstorm, the hairs on your head sometimes stand on end.

A hair with mass 0.50 mg and charge 1.0 pC is supported by a force due to an electric field. Ignore any forces other than the weight of the hair and the electric force.

What is the electric field strength?

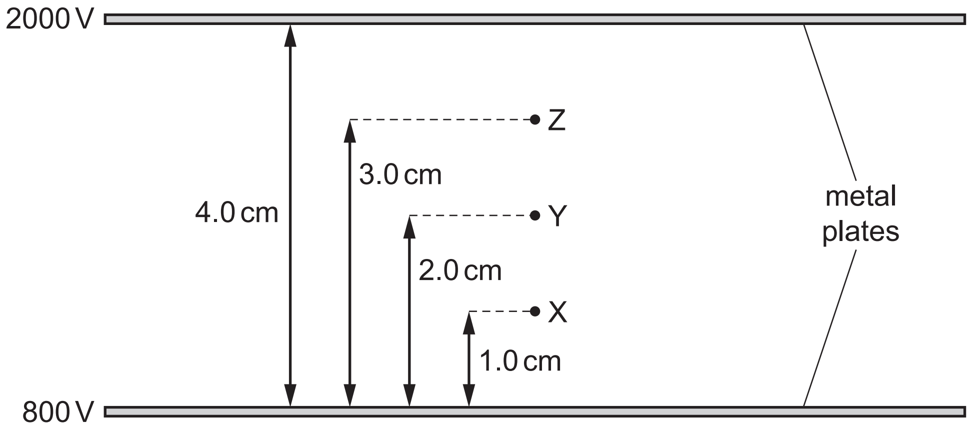
A $4.9 \times 10^{3}\,\mathrm{N\,C^{-1}}$

B $4.9 \times 10^{5}\,\mathrm{N\,C^{-1}}$

C $4.9 \times 10^{6}\,\mathrm{N\,C^{-1}}$

D $4.9 \times 10^{9}\,\mathrm{N\,C^{-1}}$

31 Two parallel metal plates, 4.0 cm apart, are at electric potentials of 800 V and 2000 V. Points X, Y and Z are situated in the space between the plates at distances of 1.0 cm, 2.0 cm and 3.0 cm from the lower plate.

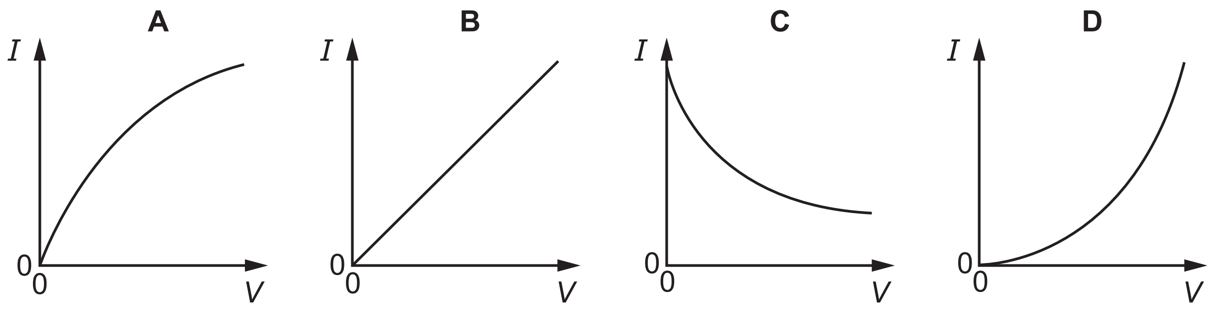


What is the electric field strength, in $\mathrm{V\,m^{-1}}$, at X, Y and Z?

	X	Y	Z
A	300	600	900
B	1100	1400	1700
C	3.0×10^{4}	3.0×10^{4}	3.0×10^{4}
D	5.0×10^{4}	5.0×10^{4}	5.0×10^{4}

32 The potential difference V across a filament lamp is slowly raised from zero to its normal operating value.

Which graph represents the variation with V of the current I in the lamp?



33 Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

A Both lamps light at less than their normal brightness.

B Both lamps light at their normal brightness.

C Only the 240 V lamp lights.

D The 10 V lamp blows.

34 Which equation is used to define resistance?

A energy = $(\text{current})^2 \times$ resistance $\times$ time

B potential difference = current $\times$ resistance

C power = $(\text{current})^2 \times$ resistance

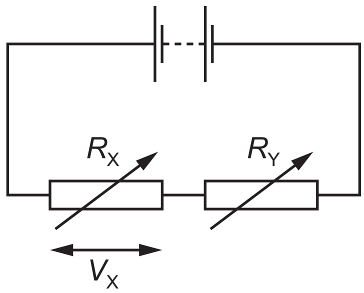
D resistivity = resistance $\times$ area $\div$ length

35 The charge that a fully charged 12 V car battery can supply is 100 kC. The starter motor of the car requires a current of 200 A for an average period of 2.0 s. The battery does not recharge because of a fault.

What is the maximum number of times the starter motor of the car can be used?

A 21 **B** 25 **C** 42 **D** 250

36 A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



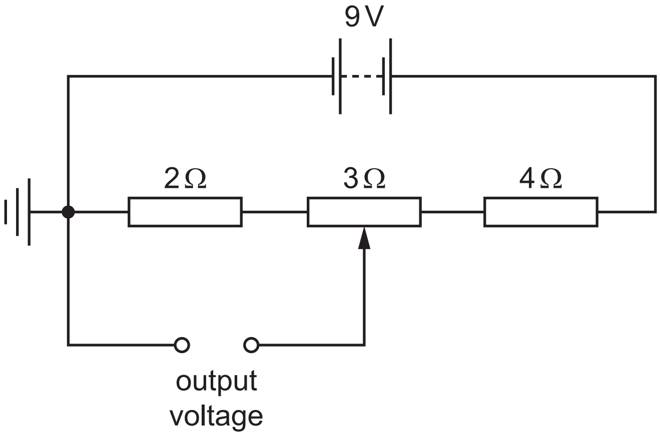
The variable resistors have resistances R_X and R_Y.
V_X is the potential difference across resistance R_X.

R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

37 In the circuit shown, contact may be made at any point along the 3 Ω resistor (potentiometer).



The battery has e.m.f. 9 V and negligible internal resistance.

What is the maximum range of the output voltage?

A 0–2 V **B** 0–5 V **C** 2–3 V **D** 2–5 V

38 The gold nucleus $^{185}_{79}Au$ undergoes alpha decay.

What are the nucleon number and proton number of the nucleus formed by this decay?

	nucleon number	proton number
A	183	79
B	183	77
C	181	77
D	181	75

39 Which row gives the correct classification of protons, electrons and neutrinos?

	protons	electrons	neutrinos
A	hadrons	leptons	hadrons
B	hadrons	leptons	leptons
C	leptons	hadrons	hadrons
D	leptons	hadrons	leptons

40 Which equation represents β^+ decay?

A neutron $\rightarrow$ proton + positron + antineutrino

B neutron $\rightarrow$ proton + positron + neutrino

C proton $\rightarrow$ neutron + positron + antineutrino

D proton $\rightarrow$ neutron + positron + neutrino

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2016**

1 hour 15 minutes

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

6375742808

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **20** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which list contains only SI base units?

A ampere, kelvin, joule, gram

B kilogram, newton, metre, ampere

C metre, coulomb, second, kelvin

D second, kelvin, ampere, kilogram

2 The stress σ needed to fracture a particular solid is given by the equation

$$\sigma = k\sqrt{\frac{\gamma E}{d}}$$

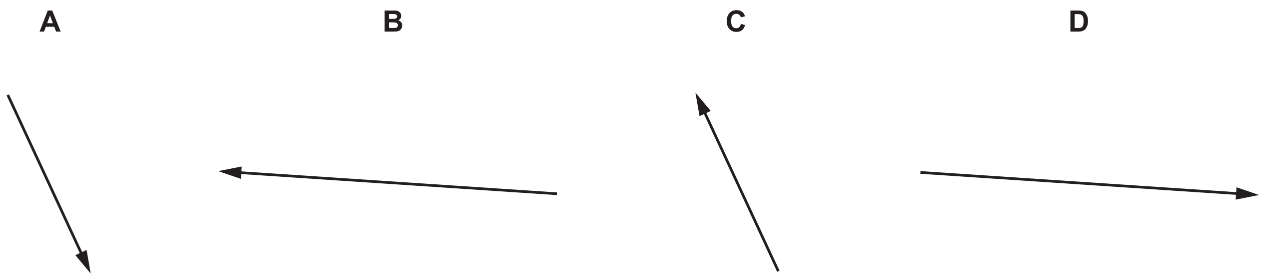
where E is the Young modulus, d is the distance between planes of atoms, and k is a constant with no units.

What are the SI base units of γ?

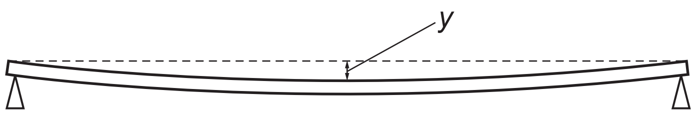
A $\mathrm{kg\,m\,s^{-2}}$ **B** $\mathrm{kg\,s^{-2}}$ **C** $\mathrm{kg\,m\,s^{-1}}$ **D** $\mathrm{kg\,s^{-1}}$

3 Vectors P and Q are drawn to scale.

Which diagram represents the vector (P – Q)?



4 A metre rule is supported horizontally by two pivots as shown.



The vertical displacement y at the centre of the rule is given by the equation

$$y = \frac{kML^3}{wt^3}$$

where

k is a constant,

L is the distance between the pivots,

M is the mass of the rule,

t is the thickness of the rule and

w is the width of the rule.

In an experiment, the following results are obtained:

$L = (80.0 \pm 0.2)\,\text{cm}$

$M = (60 \pm 1)\,\text{g}$

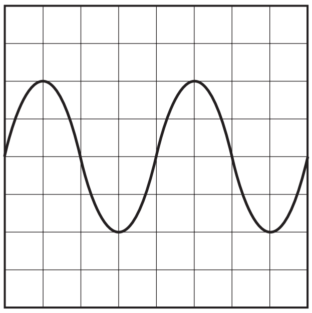
$t = (6.0 \pm 0.1)\,\text{mm}$

$w = (23.0 \pm 0.5)\,\text{mm}$.

Which measurement contributes most to the uncertainty in the calculated value of y?

A L **B** M **C** t **D** w

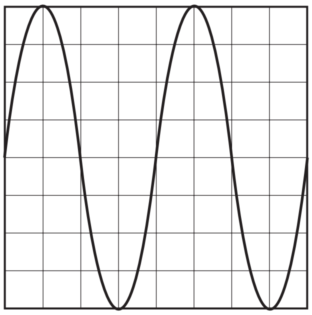
5 The following trace is seen on the screen of a cathode-ray oscilloscope.



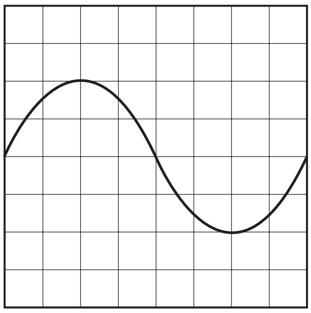
The setting of the time-base is then changed from $10\,ms\,cm^{-1}$ to $20\,ms\,cm^{-1}$ and the Y-plate sensitivity remains constant.

Which trace is now seen on the screen?

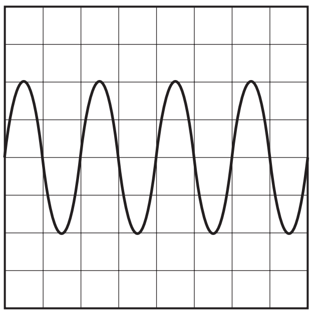
A



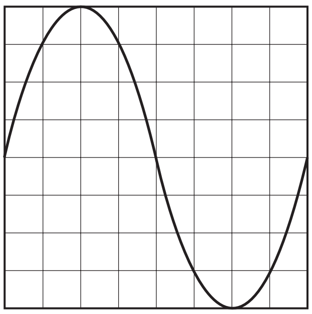
B



C

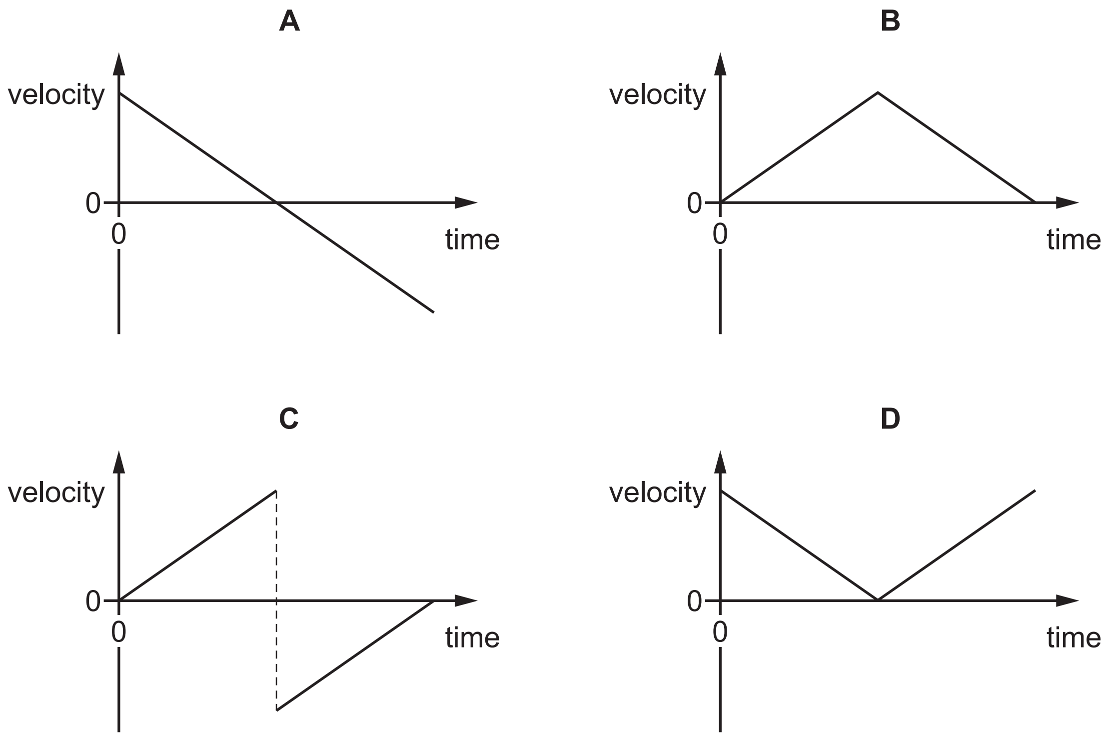


D

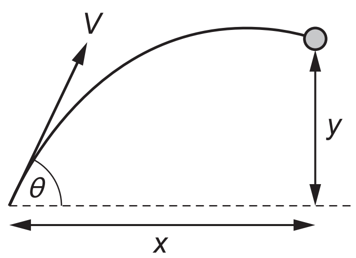


6 A ball rolls in a straight line up a ramp and then back down the ramp along its original path.

Which graph shows the variation with time of the ball's velocity?



7 A ball is thrown with velocity V at an angle θ to the horizontal.

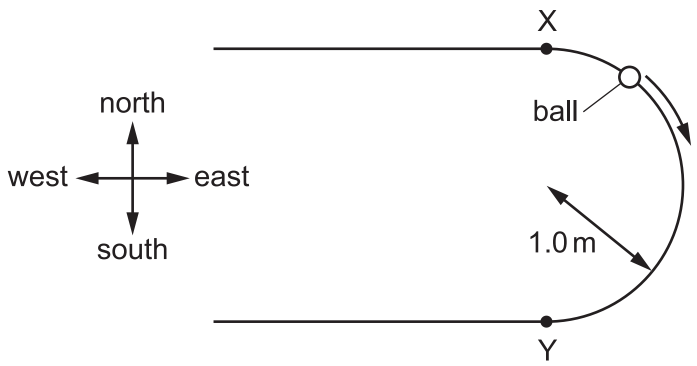


The acceleration of free fall is g. Assume that air resistance is negligible.

What are the horizontal displacement x and the vertical displacement y after time t?

	x	y
A	$Vt\cos\theta$	$Vt\sin\theta + \frac{1}{2}gt^2$
B	$Vt\cos\theta$	$Vt\sin\theta - \frac{1}{2}gt^2$
C	$Vt\sin\theta$	$Vt\cos\theta + \frac{1}{2}gt^2$
D	$Vt\sin\theta$	$Vt\cos\theta - \frac{1}{2}gt^2$

8 A ball travels from point X to point Y around a semi-circular track of radius 1.0 m as shown.



What is the displacement of the ball from X to Y?

A 2.0 m

B 2.0 m due south

C 3.1 m

D 3.1 m due south

9 Which row in the table gives the quantities that are conserved in a perfectly elastic collision between two gas molecules?

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

10 Two equal masses travel towards each other on a frictionless track at speeds of $60\,\text{cm}\,\text{s}^{-1}$ and $30\,\text{cm}\,\text{s}^{-1}$. They stick together on impact.

What is the speed of the masses after impact?

A $15\,\text{cm}\,\text{s}^{-1}$ **B** $20\,\text{cm}\,\text{s}^{-1}$ **C** $30\,\text{cm}\,\text{s}^{-1}$ **D** $45\,\text{cm}\,\text{s}^{-1}$

11 The IKAROS satellite has mass 320 kg and moves through space using a solar sail of area 20 m^2. The average solar wind pressure is 1.0×10^{-5} N m^{-2}.

What is the acceleration of the satellite caused by the solar wind?

A 3.1×10^{-8} m s^{-2}

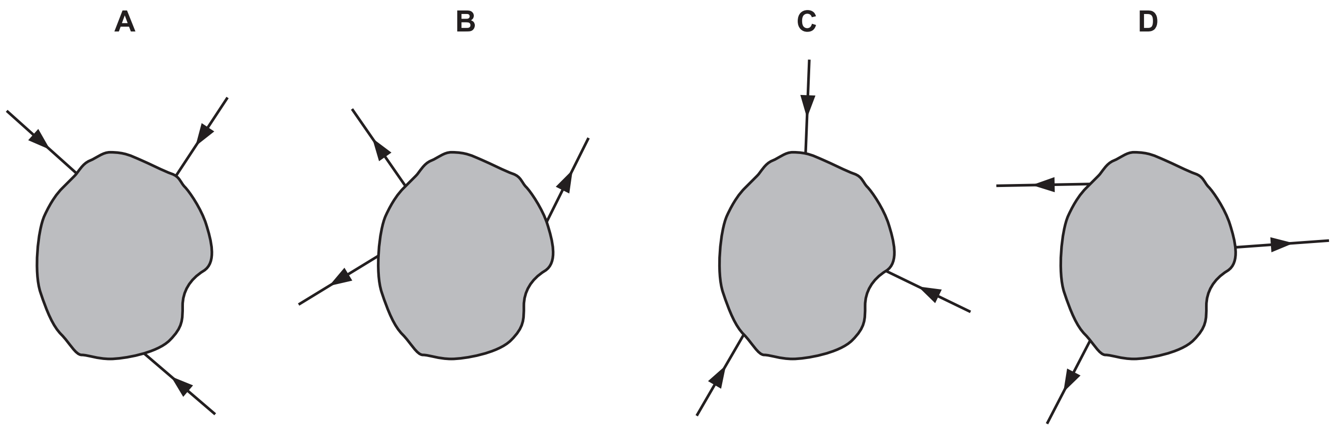
B 6.3×10^{-7} m s^{-2}

C 3.2×10^{-3} m s^{-2}

D 6.4×10^{-2} m s^{-2}

12 Three coplanar forces act on an object in the directions shown.

In which diagram could the object be in equilibrium?



13 What is the centre of gravity of an object?

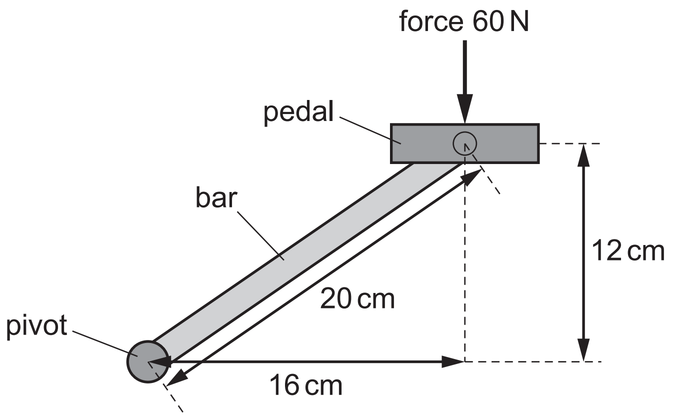
A the geometrical centre of the object

B the point at which the weight of the object may be considered to act

C the point on the object about which there is a zero net torque

D the point where gravity acts on the object

14 A bicycle pedal is connected to a pivot by a metal bar, as shown.



The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

A 7.2 N m **B** 9.6 N m **C** 12 N m **D** 1200 N m

15 For a change in depth Δh in a liquid of density ρ, the change in pressure Δp is given by $\Delta p = \Delta h \rho g$ where g is the acceleration of free fall.

What is the equation, or principle of physics, used in the derivation of this formula?

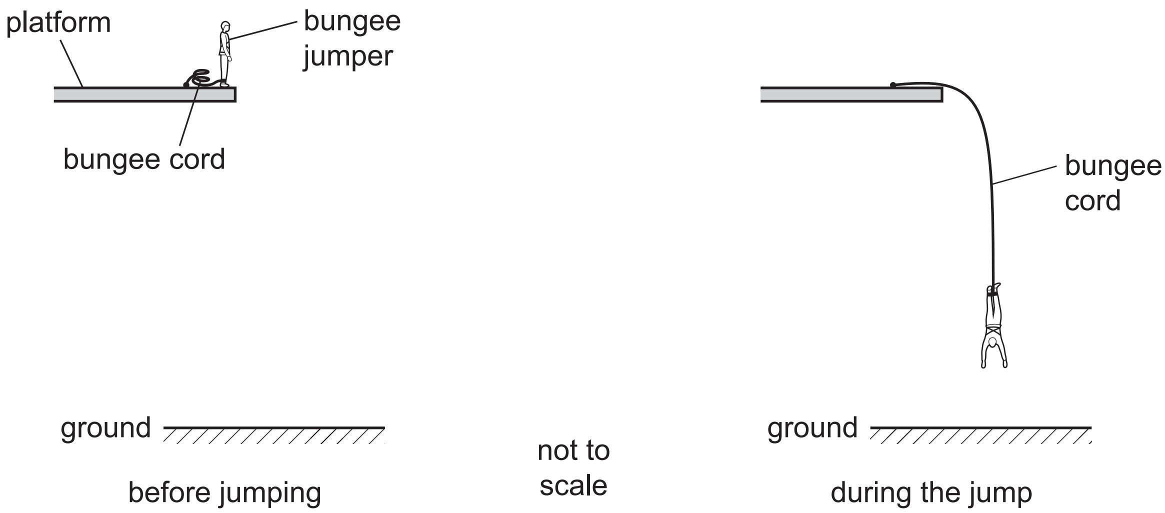
A atmospheric pressure decreases with height

B change in gravitational potential energy = mass $\times$ $g\Delta h$

C $\rho = \dfrac{\text{mass}}{\text{volume}}$

D the density of a fluid increases with depth

16 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



When the jumper makes the jump, his initial gravitational potential energy is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

A on the platform before the jump

B on the way down before the cord has started to extend

C on the way down as he decelerates

D at the bottom of the jump when he is stationary

17 An object of mass 0.30 kg is thrown vertically upwards from the ground with an initial velocity of $8.0\,\mathrm{m\,s^{-1}}$. 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?

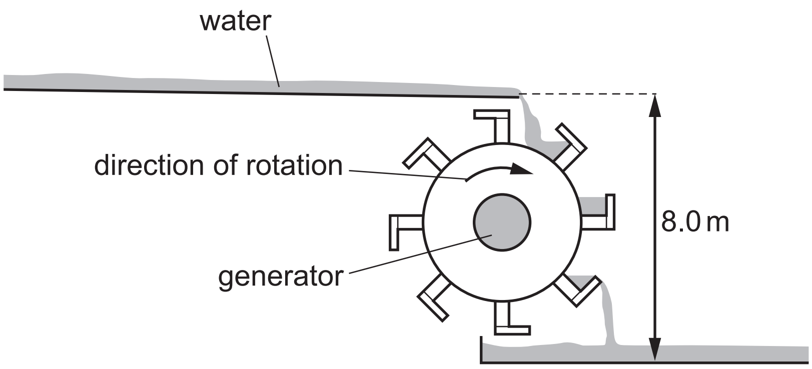
A 4.0 J **B** 5.6 J **C** 9.6 J **D** 15 J

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

What is the total resistive force acting on the car?

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

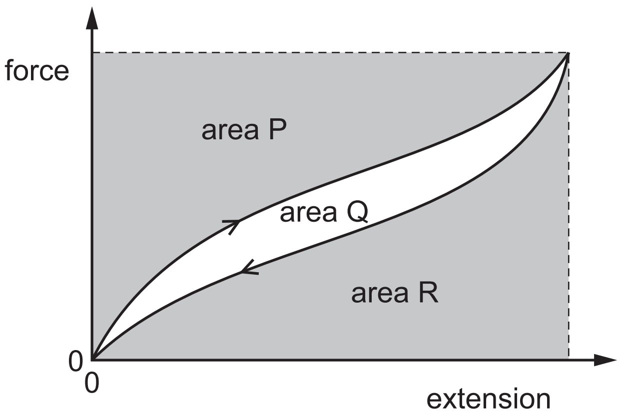
19 The diagram shows the design of a water wheel which drives a generator to produce electrical power. The flow rate of the water is 200 kg s^{-1}. The generator supplies a current of 32 A at a voltage of 230 V.



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

A 14% **B** 16% **C** 22% **D** 47%

20 The diagram shows the force-extension graph for a sample of material. The sample is stretched and then returns to its original length.



Which area represents the work done to stretch the sample?

A P + Q **B** P only **C** Q + R **D** R only

21 A metal wire of cross-sectional area 0.20 mm^2 hangs vertically from a fixed point. A load of 84 N is then attached to the lower end of the wire. The wire obeys Hooke's law and increases in length by 0.30%.

What is the Young modulus of the metal of the wire?

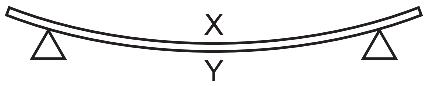
A 1.4×10^5 Pa

B 1.4×10^8 Pa

C 1.4×10^9 Pa

D 1.4×10^{11} Pa

22 The diagram shows a beam supported on two pivots.



Which statement describes the state of the top surface X and of the bottom surface Y?

A Both X and Y are in compression.

B Both X and Y are in tension.

C X is in compression and Y is in tension.

D X is in tension and Y is in compression.

23 A beam of red laser light has length 1.0 m.

What is the order of magnitude of the number of wavelengths of the red light in 1.0 m?

A 10^4 **B** 10^6 **C** 10^8 **D** 10^{10}

24 When a car travelling with constant velocity passes a stationary observer, the observer hears a change in the frequency of the sound emitted by the car.

Which statement is correct?

A The change in frequency is greater as the car moves away than as it approaches.

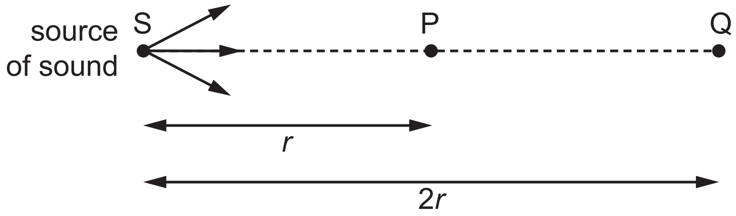
B The greater the speed of the car, the greater the change in observed frequency.

C The observed frequency is lower as the car moves towards the observer and higher as the car moves away from the observer.

D The volume of the sound heard by the observer does not change as the car approaches.

25 The intensity I of sound is inversely proportional to the square of the distance x from the source of the sound. This can be represented as

$$I \propto \frac{1}{x^2}.$$



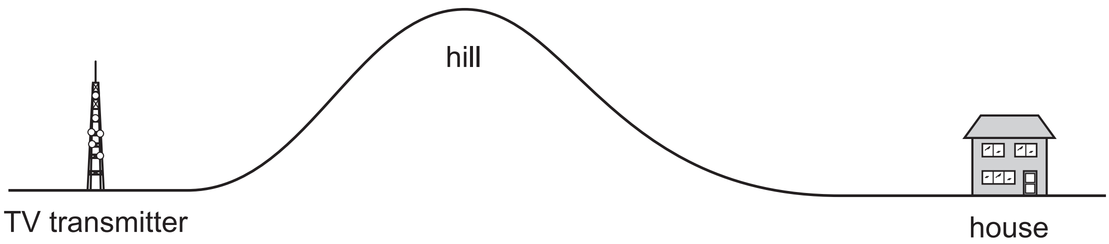
Air molecules at point P, a distance r from the source S, oscillate with amplitude 8.0 μm.

Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

26 A hill separates a television (TV) transmitter from a house. The transmitter cannot be seen from the house. However, the house has good TV reception.



By which wave effect at the hill could the TV signal reach the house?

A coherence

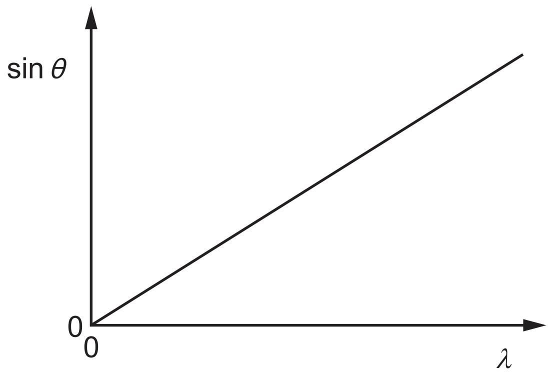
B diffraction

C interference

D reflection

27 A diffraction grating with N lines per metre is used to deflect light of various wavelengths λ.

The graph shows a relation between the deflection angle θ and λ for different wavelengths in the n^{th} order interference pattern.



What is the gradient of the graph?

A Nn **B** $\frac{N}{n}$ **C** $\frac{n}{N}$ **D** $\frac{1}{Nn}$

28 Which wave phenomenon is **not** needed to explain the pattern of observable fringes produced by a double slit experiment?

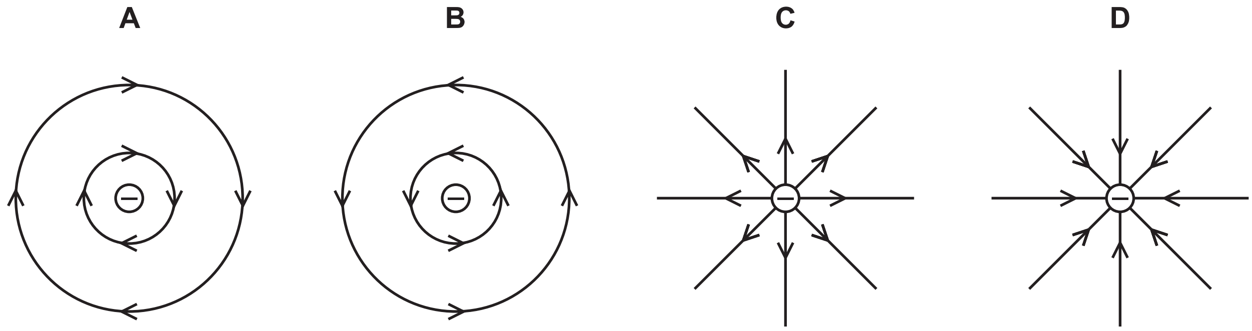
A coherence

B diffraction

C interference

D reflection

29 Which diagram shows the electric field pattern of an isolated negative point charge?



30 An electron is in an electric field of strength $5 \times 10^4\,\mathrm{V\,m^{-1}}$. The field is the only influence on the electron.

The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

A the force on the electron

B the momentum of the electron

C the kinetic energy of the electron

D the speed of the electron

31 In an electrolyte, the electric current is carried by charged particles (ions) in solution.

What is **not** a possible value for the charge on an ion in solution?

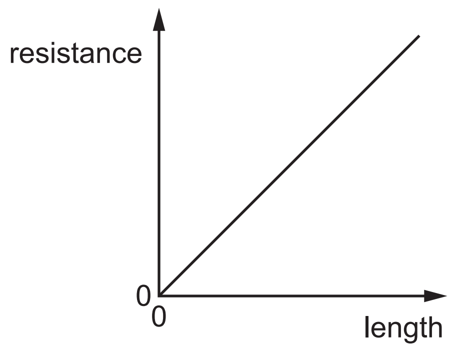
A $-4.8 \times 10^{-19}\,\mathrm{C}$

B $+1.6 \times 10^{-19}\,\mathrm{C}$

C $+3.2 \times 10^{-19}\,\mathrm{C}$

D $+4.0 \times 10^{-19}\,\mathrm{C}$

32 The graph shows the variation with length of the resistance of a uniform metal wire.



The gradient of the graph is G.
The wire has cross-sectional area A.

Which expression could be used to calculate the resistivity of the metal of the wire?

A $G \times A$ **B** $\dfrac{G}{A}$ **C** $\dfrac{A}{G}$ **D** $G \times A^2$

33 What describes the electric potential difference between two points in a wire that carries a current?

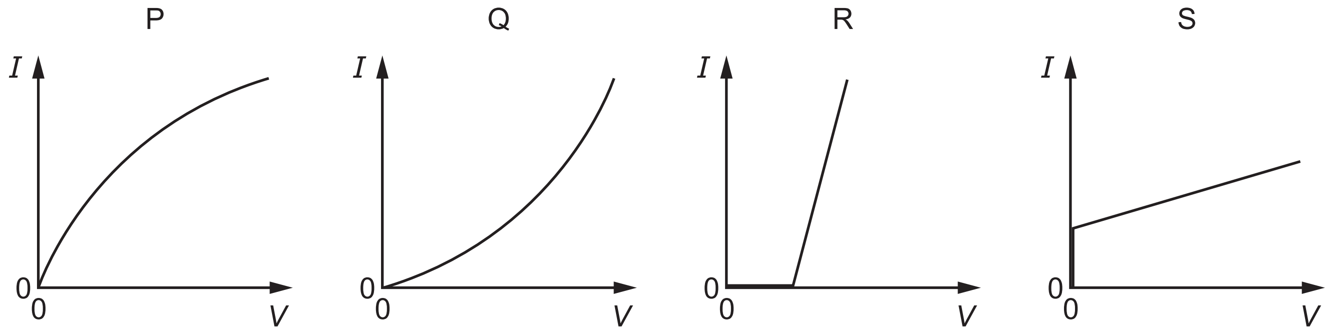
A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

D the ratio of the power dissipated between the points to the charge moved

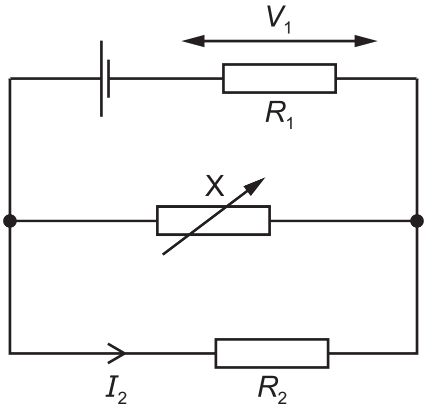
34 The graphs show possible current-voltage (I-V) characteristics for a filament lamp and for a semiconductor diode.



Which row in the table best specifies the correct I-V graphs for the lamp and for the diode?

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

35 A circuit contains a cell, two resistors of resistances R_1 and R_2 and a variable resistor X. The cell has negligible internal resistance.



V_1 is the potential difference across the resistor of resistance R_1.

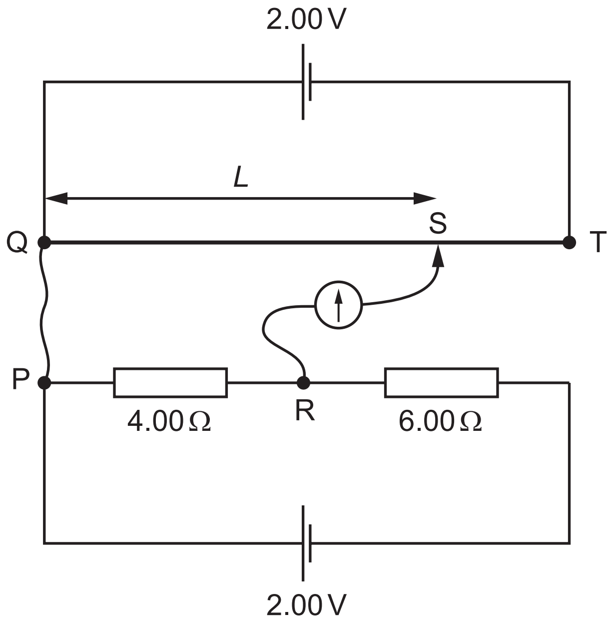
I_2 is the current through the resistor of resistance R_2.

The resistance of X is reduced.

What is the effect on V_1 and I_2?

	V_1	I_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

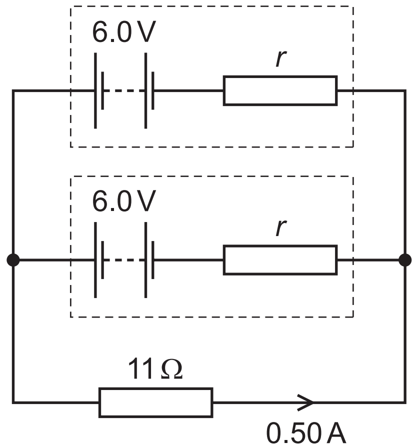
36 A 100 cm potentiometer wire QT is connected in series with a 2.00 V cell. Another circuit, consisting of a 2.00 V cell in series with resistors of resistance 4.00 Ω and 6.00 Ω, is set up alongside the potentiometer. Connections PQ and RS are then made so that the potential difference (p.d.) across the 4.00 Ω resistor is balanced against the p.d. across a length *L* of potentiometer wire. Both cells have negligible internal resistance.



What is the balance length *L*?

A 0 cm **B** 40 cm **C** 60 cm **D** 100 cm

37 Two identical batteries each have e.m.f. 6.0 V and internal resistance *r*. The batteries are connected to an external resistor of resistance 11 Ω, as shown.



The current in the external resistor is 0.50 A.

What is the internal resistance *r* of each battery?

A 1.0 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 6.5 Ω

38 A nitrogen-13 nucleus $^{13}_{7}N$ undergoes beta decay.

In the equations below, ν and $\bar{\nu}$ represent a neutrino and antineutrino respectively and γ represents a photon of gamma radiation.

Which equation represents this decay?

A $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^{-} + \bar{\nu} + \gamma$

B $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^{-} + \nu + \gamma$

C $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^{+} + \bar{\nu} + \gamma$

D $^{13}_{7}N \rightarrow {}^{13}_{6}C + \beta^{+} + \nu + \gamma$

39 Radon $^{222}_{86}Rn$ is the start of a decay chain that forms bismuth $^{214}_{83}Bi$ by α and β^{-} 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

40 The magnitude of the charge on the proton may be regarded as +1 unit. On this basis, the charges on the up (u) quark, down (d) quark and their antiquarks ($\bar{u}$ and $\bar{d}$) are not whole units.

Which row in the table shows the correct values for the charges on the u, d, $\bar{u}$ and $\bar{d}$ quarks?

	u	d	$\bar{u}$	$\bar{d}$
A	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$
B	$-\frac{2}{3}$	$+\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$
C	$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$
D	$-\frac{2}{3}$	$+\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$

Cambridge International AS & A Level

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PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2017**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

IB17 06_9702_11_VI_BLU/FP

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Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 A student creates a table to show reasonable estimates of some physical quantities.

Which row is **not** a reasonable estimate?

	quantity	value
A	current in a fan heater	12 A
B	mass of an adult person	70 kg
C	speed of an Olympic sprint runner	$10\,\mathrm{m\,s^{-1}}$
D	water pressure at the bottom of a garden pond	10^6 Pa

2 A particle travels in a straight line with speed v.

The particle slows down and changes direction. The new speed of the particle is $\frac{v}{2}$.

The new velocity has a component of $\frac{v}{4}$ in the same direction as the initial path of the particle.

Through which angle has the particle turned?

A 27° **B** 30° **C** 45° **D** 60°

3 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ of the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no units.

What is the value of n?

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

4 The values of displacement, velocity and acceleration of a vehicle can be deduced from graphs representing its motion. Often the areas under these graphs, or the gradients of the graphs, are used.

What would **not** give a value for a displacement, a velocity or an acceleration?

A area under a velocity-time graph

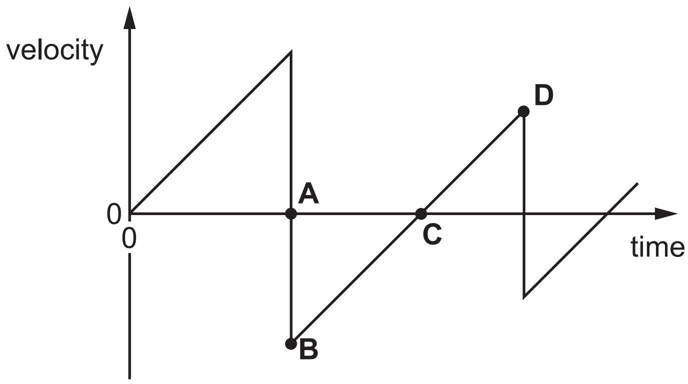
B gradient of a displacement-time graph

C gradient of a velocity-time graph

D gradient of an acceleration-time graph

5 A ball is released from rest above a hard, horizontal surface. The graph shows how the velocity of the bouncing ball varies with time.

At which point on the graph does the ball reach its maximum height after the first bounce?



6 A ball is kicked upwards at an angle of 45° to horizontal ground. After a short flight, the ball returns to the ground.

It may be assumed that air resistance is negligible.

What is **never** zero during the flight of the ball?

A the horizontal component of the ball's acceleration

B the horizontal component of the ball's velocity

C the vertical component of the ball's momentum

D the vertical component of the ball's velocity

7 The mass of a rocket-propelled truck is approximately equal to the mass of the fuel in its tank. The fuel is ignited and the truck is propelled along horizontal tracks by a constant force. The effect of air resistance is negligible.

During a test run the fuel is consumed at a constant rate.

Which statement describes the acceleration of the truck during the test run?

A The acceleration of the truck decreases as the fuel is consumed.

B The acceleration of the truck increases as the fuel is consumed.

C The acceleration of the truck remains constant.

D The acceleration of the truck is zero and the truck moves at a constant velocity.

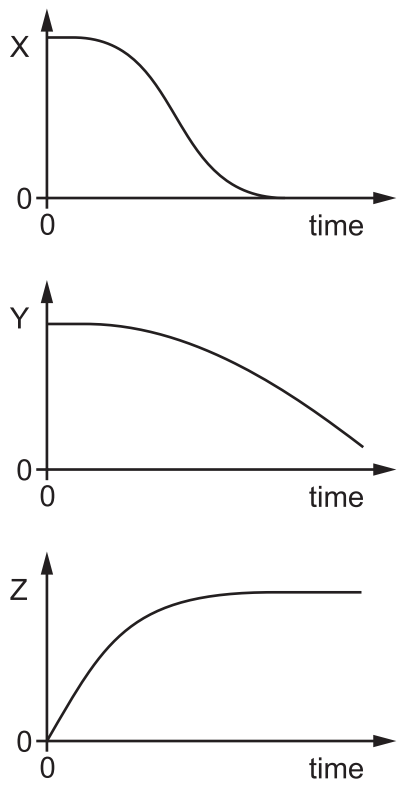
8 An object is dropped at time $t = 0$ from a high building. Air resistance is significant.

Three graphs are plotted against time.

the height of the object above the ground

the speed of the object

the magnitude of the resultant force on the object



What are the quantities X, Y and Z?

	height of the object above the ground	speed of the object	magnitude of the resultant force on the object
A	X	Y	Z
B	X	Z	Y
C	Y	Z	X
D	Z	Y	X

9 A student attempts to find the density ρ of aluminium by taking measurements of a rectangular sheet.

mass m = 51.6 ± 0.1 g

length l = 100.0 ± 0.1 cm

width w = 10.0 ± 0.1 cm

thickness t = 0.20 ± 0.01 mm

He uses the equation $\rho = \dfrac{m}{wlt}$ to calculate the density.

What is the calculated value of density with its uncertainty?

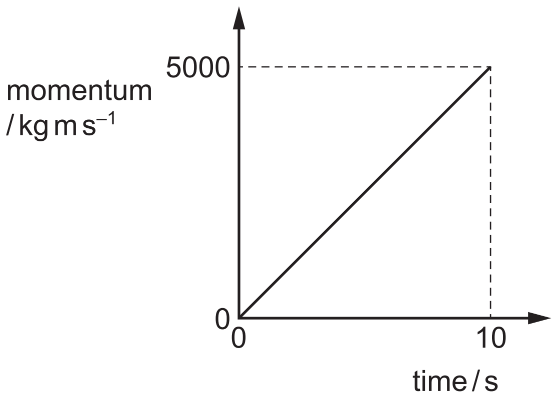
A $0.26 \pm 0.01\,\mathrm{g\,cm^{-3}}$

B $0.26 \pm 0.02\,\mathrm{g\,cm^{-3}}$

C $2.6 \pm 0.1\,\mathrm{g\,cm^{-3}}$

D $2.6 \pm 0.2\,\mathrm{g\,cm^{-3}}$

10 The graph shows how the momentum of a motorcycle changes with time.



What is the resultant force on the motorcycle?

A 500 N **B** 5000 N **C** 25 000 N **D** 50 000 N

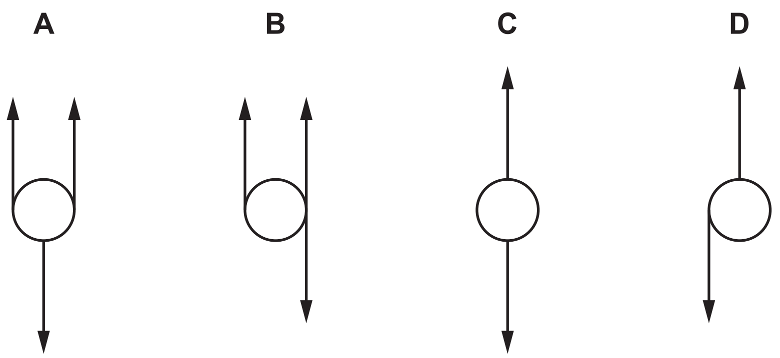
11 A particle with mass and charge is moving from left to right in a uniform gravitational field and a uniform electric field. The gravitational field is downwards. The gravitational force and the electric force on this particle act in opposite directions.

What could be the sign of the charge on the particle and the direction of the electric field?

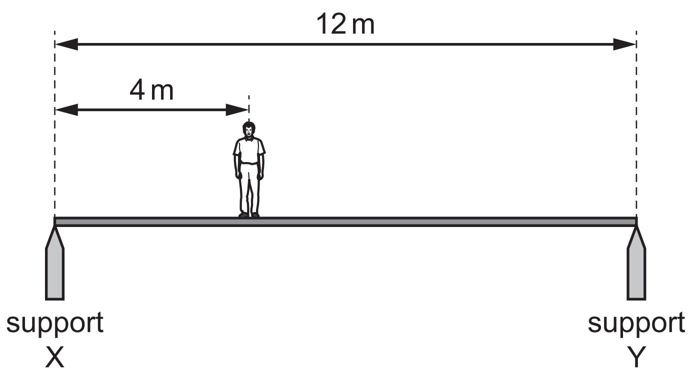
	sign of charge	direction of electric field
A	negative	down
B	negative	up
C	positive	left
D	positive	right

12 A sphere is acted upon by various forces, all of the same magnitude.

Which system of forces provides a resultant torque but zero resultant force on the sphere?



13 A uniform horizontal footbridge is 12 m long and weighs 4000 N. It rests on two supports X and Y as shown.



A man of weight 600 N is a distance of 4 m from support X.

What is the upward force on the footbridge from support X?

A 2200 N **B** 2300 N **C** 2400 N **D** 2600 N

14 A metal block has a mass of 750 g. 60% of the mass is magnesium and the remainder is copper.

The density of magnesium is 1.7 g cm^{-3}.

The density of copper is 9.0 g cm^{-3}.

What is the density of the block?

A 2.5 g cm^{-3} **B** 4.6 g cm^{-3} **C** 5.4 g cm^{-3} **D** 10.7 g cm^{-3}

15 A man climbs slowly at a steady speed to the top of a ladder.

What is the **main** energy transfer taking place for the man as he climbs?

A chemical potential to gravitational potential

B chemical potential to kinetic

C kinetic to gravitational potential

D thermal (heat) to kinetic

16 During an interval of time, fuel supplies energy X to a car.

Some of this energy is converted into kinetic energy as the car accelerates.

The rest of the energy Y is lost as thermal energy.

What is the efficiency of the car?

A $\dfrac{X}{X-Y}$ **B** $\dfrac{Y}{X-Y}$ **C** $\dfrac{X-Y}{X}$ **D** $\dfrac{X-Y}{Y}$

17 A railway engine accelerates a train of total mass 800 tonnes (1 tonne = 1000 kg) from rest to a speed of 50 m s^{-1}.

How much useful work must be done on the train to reach this speed?

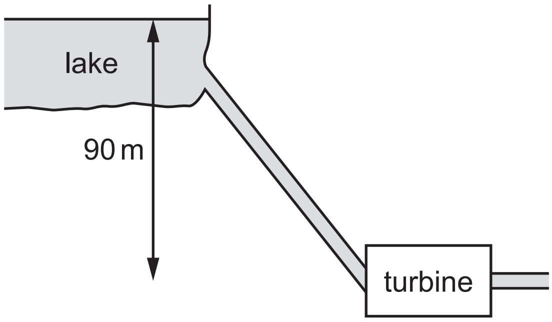
A 1.0×10^6 J **B** 2.0×10^6 J **C** 1.0×10^9 J **D** 2.0×10^9 J

18 A mass is raised vertically. In time t, the increase in its gravitational potential energy is E_p and the increase in its kinetic energy is E_k.

What is the average power input to the mass?

A $(E_p - E_k)t$ **B** $(E_p + E_k)t$ **C** $\dfrac{E_p - E_k}{t}$ **D** $\dfrac{E_p + E_k}{t}$

19 Water flows from a lake into a turbine that is a vertical distance of 90 m below the lake, as shown.



The mass flow rate of the water is $2400\,\text{kg}\,\text{min}^{-1}$. The turbine has an efficiency of 75%.

What is the output power of the turbine?

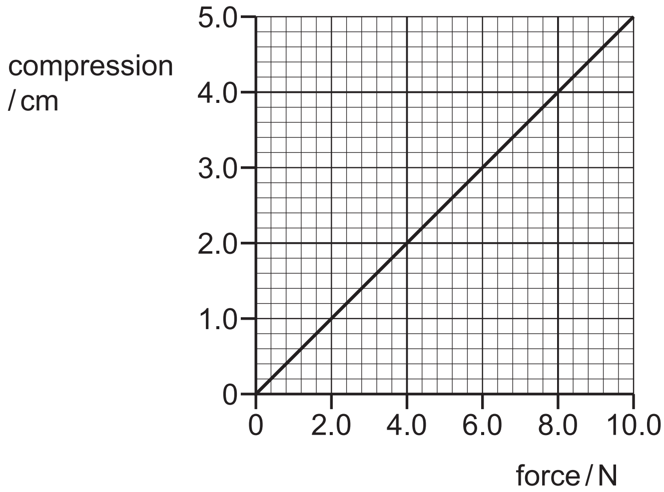
A 26 kW **B** 35 kW **C** 1.6 MW **D** 2.1 MW

20 A wire of diameter d and length l hangs vertically from a fixed point. The wire is extended by hanging a mass M on its end. The Young modulus of the wire is E. The acceleration of free fall is g.

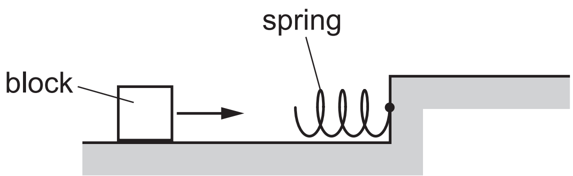
Which equation is used to determine the extension x of the wire?

A $x = \dfrac{Ml}{\pi d^2 E}$ **B** $x = \dfrac{Mgl}{\pi d^2 E}$ **C** $x = \dfrac{4Mgl}{\pi d E}$ **D** $x = \dfrac{4Mgl}{\pi d^2 E}$

21 The variation of the compression of a spring with the force applied to it is shown in the graph.



A block slides along a horizontal frictionless surface towards the spring, as shown.



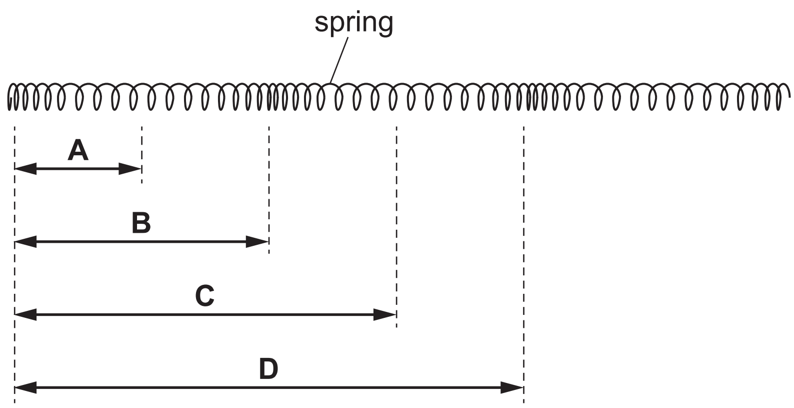
The block is brought to rest by the spring. When the spring reaches a compression of 4.0 cm, all of the kinetic energy of the block is transferred to the elastic potential energy of the spring.

What is the kinetic energy of the block when it first makes contact with the spring?

A 0.16 J **B** 0.32 J **C** 16 J **D** 32 J

22 A longitudinal wave travels through a long spring. The spring is shown at one instant.

What is the wavelength of the wave?

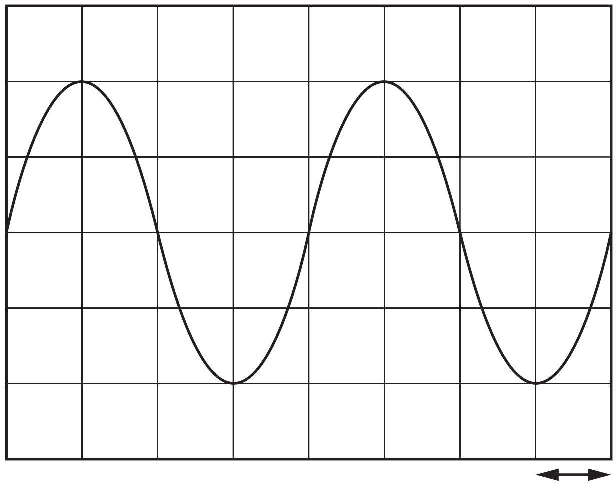


23 A sound wave has a frequency of 2500 Hz and a speed of 1500 $m s^{-1}$.

What is the shortest distance from a point of maximum pressure in the wave to a point of minimum pressure?

A 0.15 m **B** 0.30 m **C** 0.60 m **D** 1.20 m

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



The time-base of the c.r.o. 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 A car travelling in a straight line at a speed of 30 $m s^{-1}$ passes near a stationary observer while sounding its horn. The true frequency of sound from the horn is 400 Hz.

The speed of sound in air is 336 $m s^{-1}$.

What is the change in the frequency of the sound heard by the observer as the car passes?

A 39 Hz **B** 66 Hz **C** 72 Hz **D** 78 Hz

26 Which list shows electromagnetic waves in order of increasing frequency?

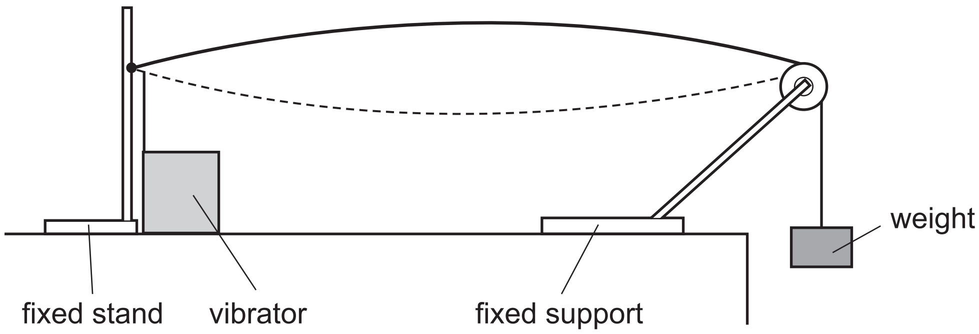
A radio waves → gamma rays → ultraviolet → infra-red

B radio waves → infra-red → ultraviolet → gamma rays

C ultraviolet → gamma rays → radio waves → infra-red

D ultraviolet → infra-red → radio waves → gamma rays

27 The diagram shows a steel wire clamped at one end. The other end is attached to a weight hanging over a pulley.



A vibrator is attached to the wire near the clamped end. A stationary wave with one loop is produced. The frequency of the vibrator is f.

Which frequency should be used to produce a stationary wave with two loops?

A $\frac{f}{4}$ **B** $\frac{f}{2}$ **C** $2f$ **D** $4f$

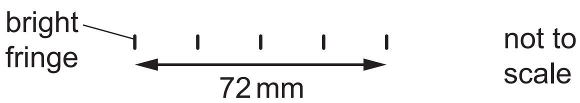
28 A parallel beam of light of wavelength 600 nm is incident normally on a diffraction grating. The grating has 300 lines per millimetre.

What is the total number of intensity maxima from the grating?

A 1 **B** 3 **C** 11 **D** 13

29 A pattern of interference fringes is produced using a red laser, a double slit and a screen. The screen is 3.5 m from the double slit. The light from the laser has a wavelength of 640 nm.

The pattern of fringes is shown.

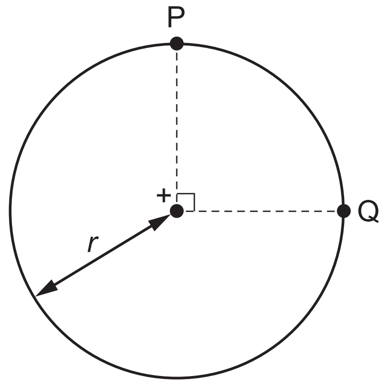


What is the separation of the slits?

A 1.2×10^{-4} m **B** 1.6×10^{-4} m **C** 3.1×10^{-5} m **D** 3.3×10^{-9} m

30 The diagram shows two points P and Q which lie 90° apart on a circle of radius r.

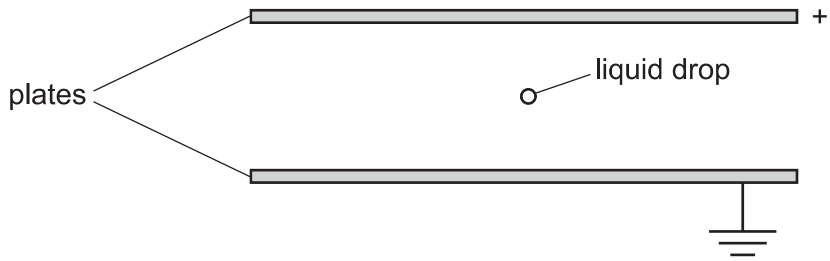
A positive point charge at the centre of the circle creates an electric field of magnitude E at both P and Q.



Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\dfrac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

31 The diagram shows two parallel horizontal metal plates. The top plate is positively charged and the bottom plate is earthed.



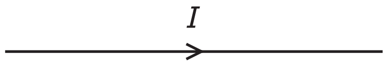
A small charged liquid drop, midway between the plates, is held in equilibrium by the combination of its weight and the electric force acting on it.

The acceleration of free fall is g and the electric field strength is E.

What is the polarity of the charge on the drop, and the ratio of charge to mass of the drop?

	polarity	$\dfrac{\text{charge}}{\text{mass}}$
A	negative	$\dfrac{E}{g}$
B	negative	$\dfrac{g}{E}$
C	positive	$\dfrac{E}{g}$
D	positive	$\dfrac{g}{E}$

32 The diagram shows the symbol for a wire carrying a current I.



What does this current represent?

A the charge flowing past a point in the wire per unit time

B the number of electrons flowing past a point in the wire per unit time

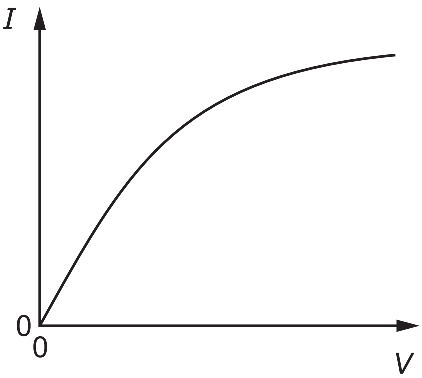
C the number of positive ions flowing past a point in the wire per unit time

D the number of protons flowing past a point in the wire per unit time

33 Which values of current and resistance will produce a rate of energy transfer of 16 J s^{-1}?

	current / A	resistance / Ω
A	1	4
B	2	8
C	4	1
D	16	1

34 Which component has the I-V graph shown?



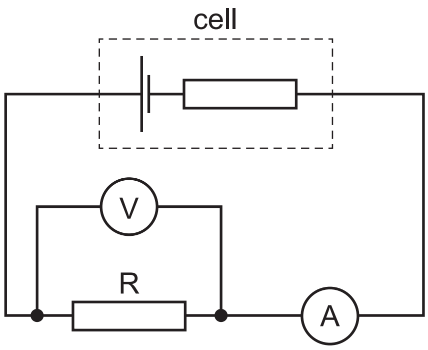
A filament lamp

B metallic conductor at constant temperature

C resistor of fixed resistance

D semiconductor diode

35 The circuit shown includes a cell of constant internal resistance and an external resistor R.



A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	increases	decreases
D	increases	stays the same

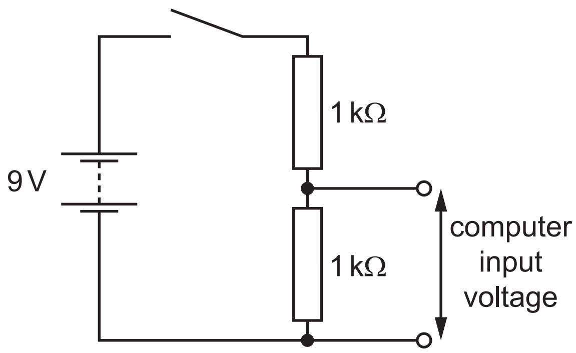
36 A computer is used to detect the change of position of a switch.

To detect the change of position, the computer requires a potential difference (p.d.) of 0 V to its input at one switch position and a p.d. of between 5 V and 7 V at the other switch position.

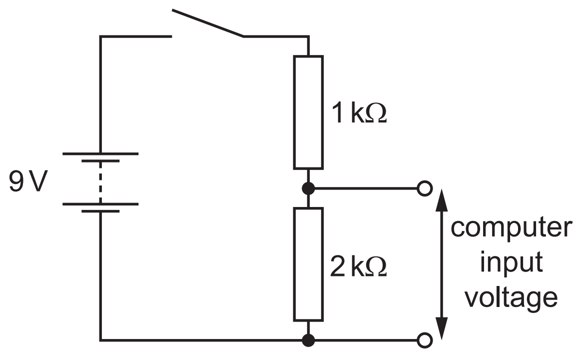
For each of the circuits, assume the battery has negligible internal resistance.

Which circuit provides an input voltage to the computer that enables it to detect the change of position of the switch?

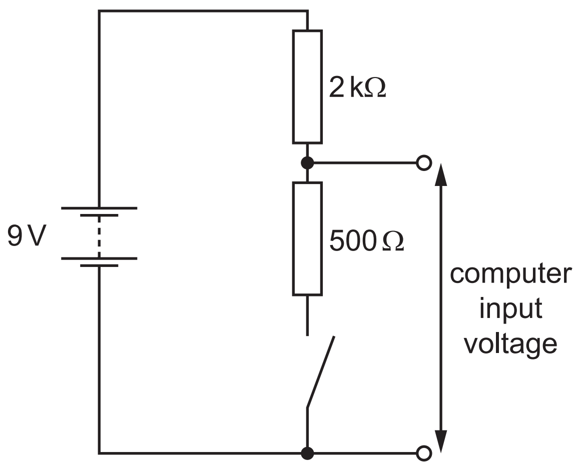
A



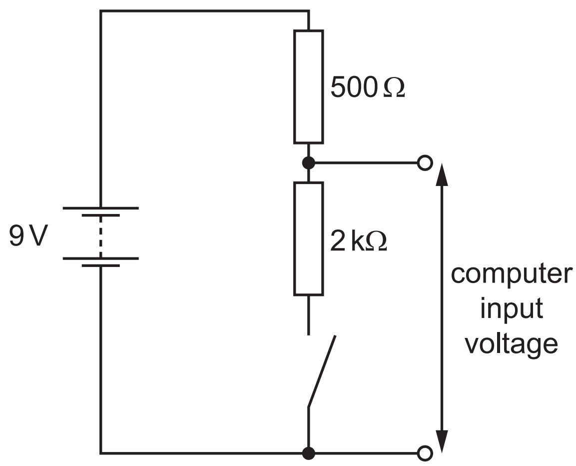
B



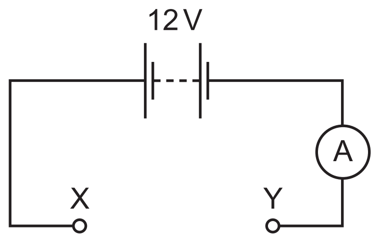
C



D

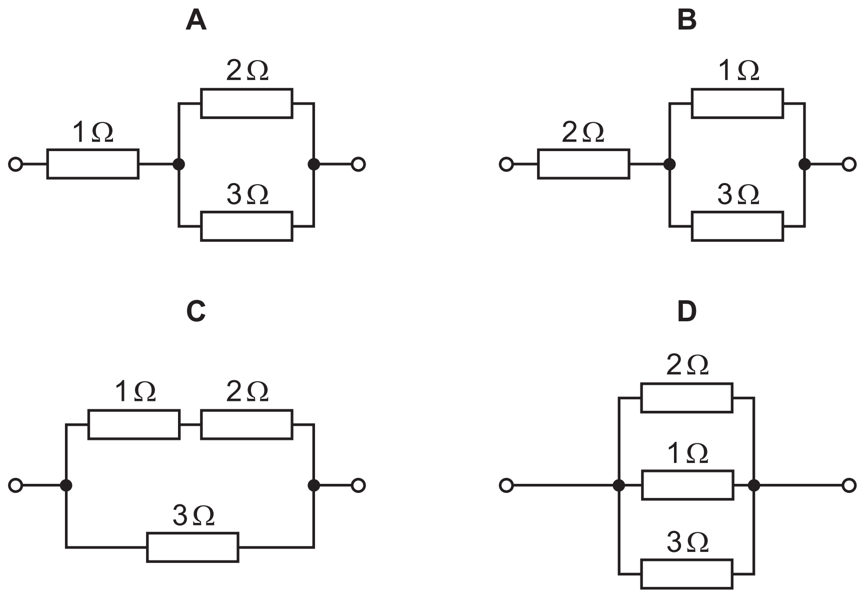


37 In the circuit shown, the battery and ammeter have negligible resistance.



The following combinations of resistors are each separately placed between the terminals X and Y of the circuit.

Which combination would give an ammeter reading of 8 A?



38 The table lists the nucleon number and the proton number of various nuclei. The nuclei are represented by the letters L to T.

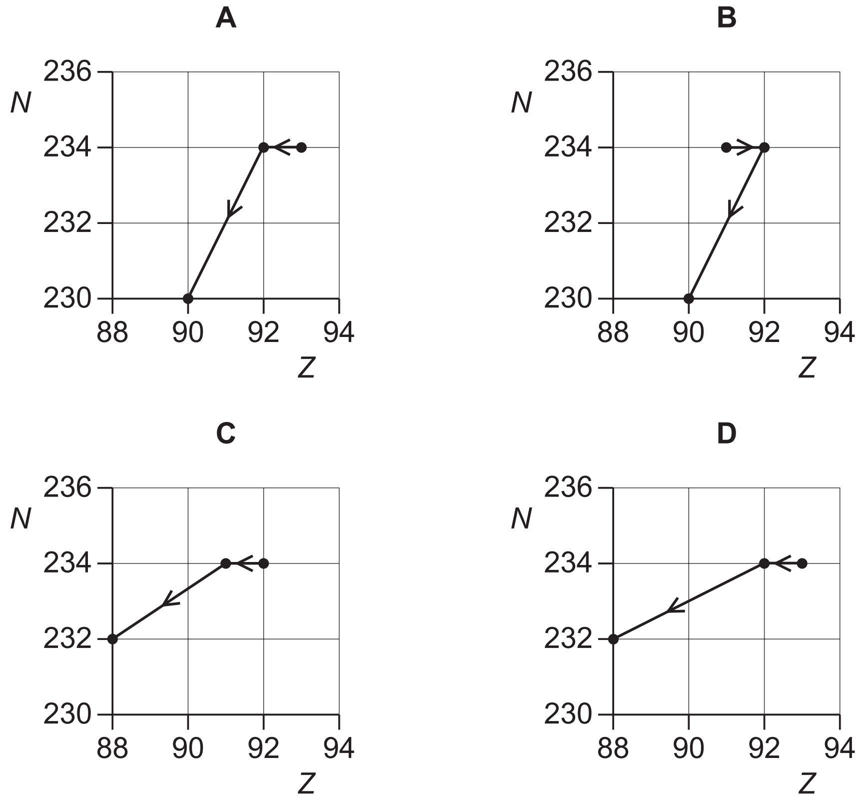
nucleus	nucleon number	proton number
L	227	89
M	226	89
N	225	89
O	227	90
P	226	90
Q	225	90
R	227	91
S	226	91
T	225	91

Which row in the following table correctly shows three nuclei of the same element, and three nuclei that have the same number of neutrons?

	same element	same number of neutrons
A	L M N	R P N
B	M P S	R S T
C	O P Q	M P S
D	R P N	O P Q

39 A radioactive nucleus is formed by β^- decay. This nucleus then decays by α-emission.

Which graph of nucleon number *N* plotted against proton number *Z* shows the β^- decay followed by the α-emission?



40 What are the structures of the proton and of the neutron in terms of quarks?

	proton		neutron	
	up quark	down quark	up quark	down quark
A	1	1	2	2
B	1	2	2	1
C	2	1	1	2
D	2	2	1	1

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2017**

1 hour 15 minutes

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

* 1 3 1 5 2 5 3 7 1 0 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **18** printed pages and **2** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

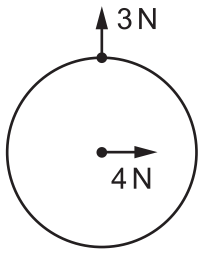
Formulae

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	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

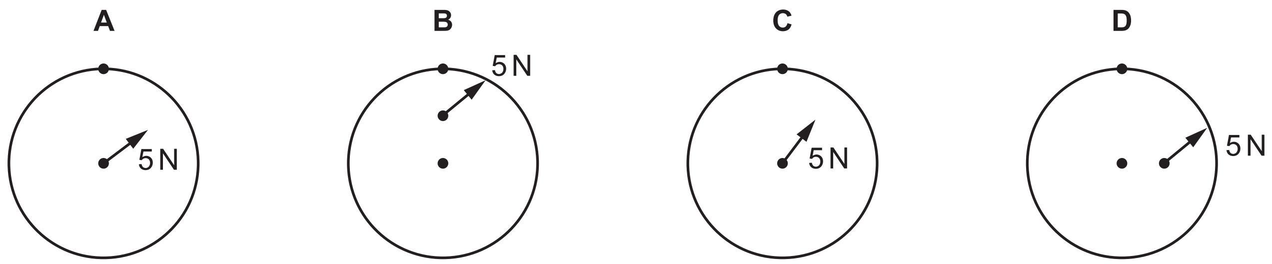
1 What is the approximate average speed of a winning female Olympic athlete running a 100 m race?

A $6\,m\,s^{-1}$ **B** $9\,m\,s^{-1}$ **C** $12\,m\,s^{-1}$ **D** $15\,m\,s^{-1}$

2 Two forces act on a circular disc as shown.



Which diagram shows the line of action of the resultant force?



3 What correctly expresses the volt in terms of SI base units?

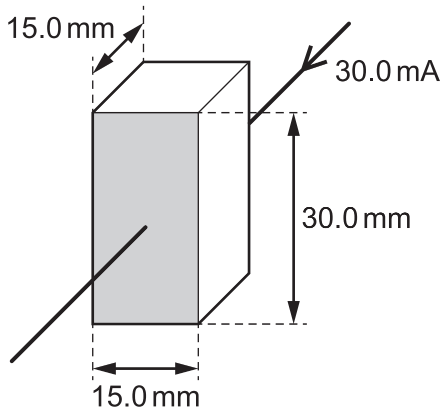
A $A\,\Omega$

B $W\,A^{-1}$

C $kg\,m^2\,s^{-1}\,A^{-1}$

D $kg\,m^2\,s^{-3}\,A^{-1}$

4 The current in a block of semiconductor is 30.0 mA when there is a potential difference (p.d.) of 10.0 V across it. The dimensions of the block and the direction of the current in it are as shown.



The electrical meters used are accurate to ± 0.1 mA and ± 0.1 V. The dimensions of the block are accurate to ± 0.2 mm.

What is the resistivity of the semiconductor?

A 10.0 ± 0.2 Ω m

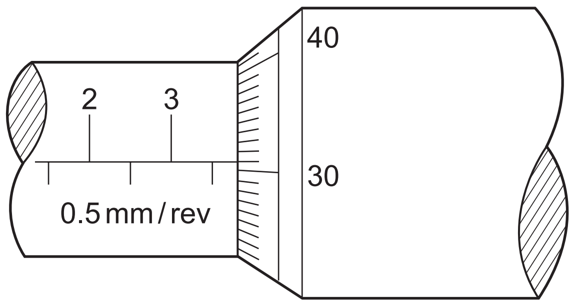
B 10.0 ± 0.3 Ω m

C 10.0 ± 0.5 Ω m

D 10.0 ± 0.8 Ω m

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

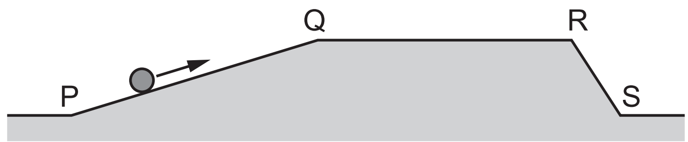
The diagram below shows an enlargement of the scale on the micrometer screw gauge when taking the measurement.



What is the cross-sectional area of the rod?

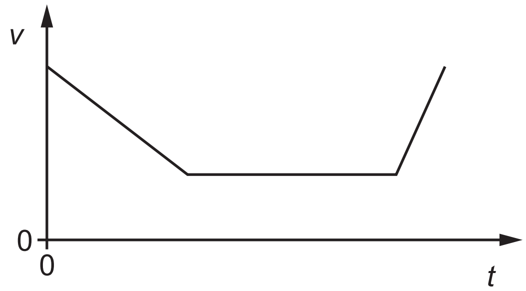
A 3.81 mm^2 **B** 11.4 mm^2 **C** 22.8 mm^2 **D** 45.6 mm^2

6 A ball is set in motion at P on a frictionless surface. It moves up slope PQ, along the horizontal surface QR and finally descends slope RS.

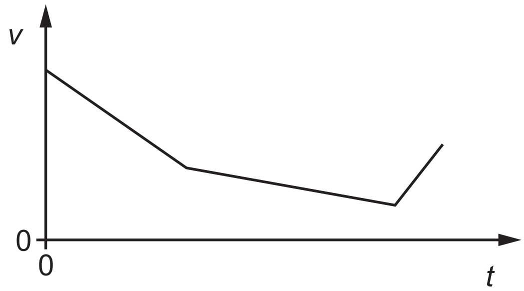


Which graph could represent the variation with time *t* of the ball's speed *v* as the ball moves from P to S?

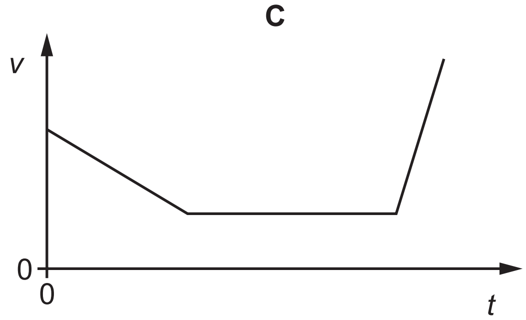
A



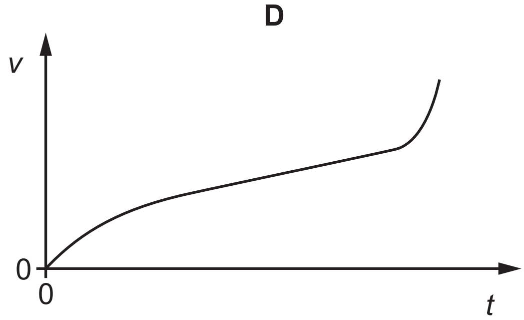
B



C



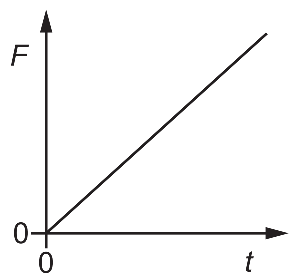
D



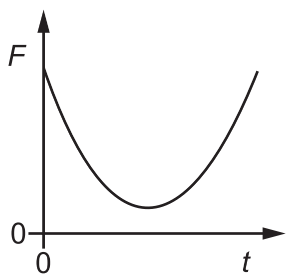
7 A rubber ball is dropped onto a table and bounces back up. The table exerts a force *F* on the ball.

Which graph best shows the variation with time *t* of the force *F* for the short time that the ball is in contact with the table?

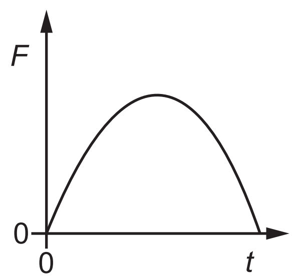
A



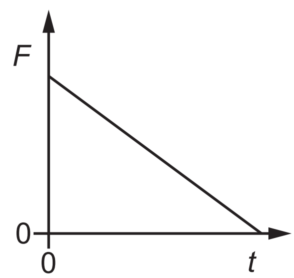
B



C



D



8 A golf ball of mass m is dropped onto a hard surface from a height h_1 and rebounds to a height h_2.

The momentum of the golf ball just as it reaches the surface is different from its momentum just as it leaves the surface.

What is the total change in the momentum of the golf ball between these two instants? (Ignore air resistance.)

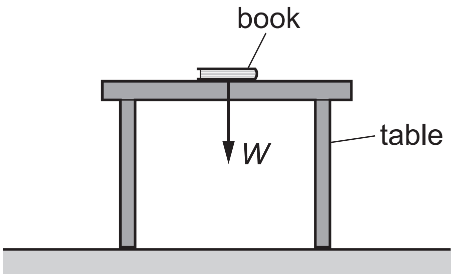
A $m\sqrt{2gh_1} - m\sqrt{2gh_2}$

B $m\sqrt{2gh_1} + m\sqrt{2gh_2}$

C $m\sqrt{2g(h_1 - h_2)}$

D $m\sqrt{2g(h_1 + h_2)}$

9 A book of weight W is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

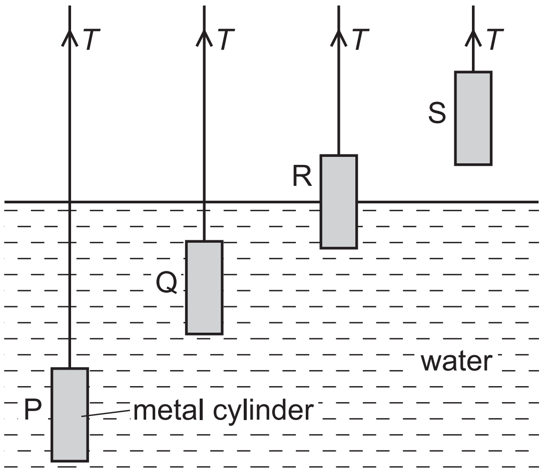
A the force W acting downwards on the Earth from the table

B the force W acting upwards on the book from the table

C the force W acting upwards on the Earth from the book

D the force W acting upwards on the table from the floor

10 A metal cylinder is suspended vertically in equilibrium by a cord. The diagram shows the cylinder in four different positions P, Q, R and S.



Which statement explains the variation of the tension *T* in the cord?

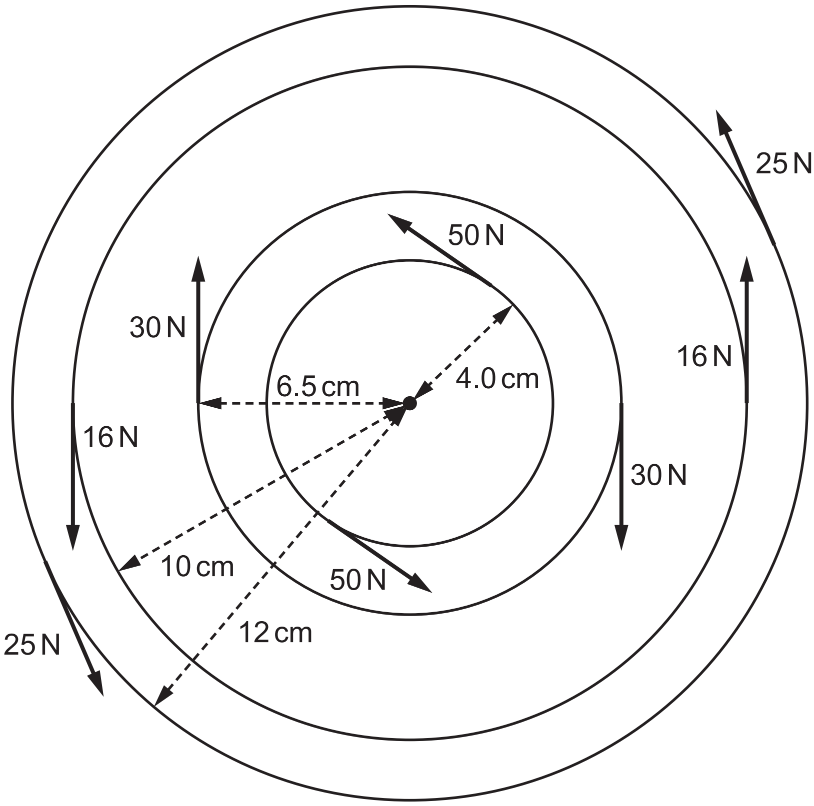
A At P and at Q, the tension *T* in the cord is the same because the difference in pressure between the top and bottom of the cylinder is the same.

B At Q, the tension *T* in the cord is less than at P because, at smaller depth, liquid pressure is smaller.

C At R, the tension *T* in the cord is less than at P because atmospheric pressure is less than water pressure.

D At S, the tension *T* in the cord is greater than at P because atmospheric pressure at S exerts no force on the top or bottom of the cylinder.

11 In a machine, many couples act on a rotating object as shown.



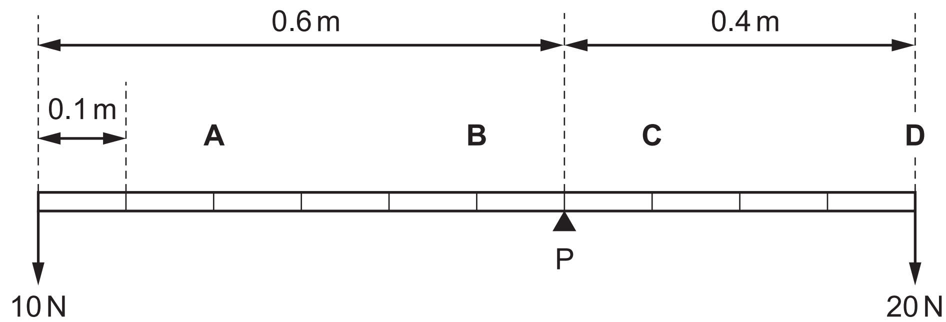
What is the resultant torque acting on the rotating object?

A 4.7 N m **B** 8.6 N m **C** 9.3 N m **D** 17.1 N m

12 A uniform beam is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends.

The length of the beam is marked at 0.1 m intervals. The weight of the beam is 100 N.

At which point should a further weight of 20 N be attached to achieve equilibrium?



13 What are the SI base units of the quantity $\dfrac{\text{pressure}}{\text{density}}$?

A s^{-2} **B** $kg^2\,s^{-2}$ **C** $kg^2\,m^2\,s^{-2}$ **D** $m^2\,s^{-2}$

14 Which quantities are conserved in an inelastic collision?

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

15 A cyclist is travelling at a constant speed up a hill. The frictional force resisting the cyclist's motion is 8.0 N.

The cyclist uses 450 J of energy to travel a distance of 20 m.

What is the increase in the gravitational potential energy of the cyclist?

A 160 J **B** 290 J **C** 440 J **D** 610 J

16 A stone of mass m falls from rest at the top of a cliff of height h into the sea below. Just before hitting the sea the stone has speed v.

What is the average force of air resistance acting on the stone during its fall?

A mg **B** $\dfrac{m(v^2 - 2gh)}{h}$ **C** $m\left(g - \dfrac{v^2}{2h}\right)$ **D** $m\left(gh - \dfrac{v^2}{2}\right)$

17 A railway engine accelerates a train of total mass 1200 tonnes (1 tonne = 1000 kg) from rest to a speed of $75\,\text{m}\,\text{s}^{-1}$.

How much useful work must be done on the train to reach this speed?

A 3.4×10^6 J **B** 6.8×10^6 J **C** 3.4×10^9 J **D** 6.8×10^9 J

18 What is a correct derivation of the equation relating power, force and velocity?

A power = $\dfrac{\text{work done}}{\text{time taken}}$ and work done = force × displacement

so power = $\dfrac{\text{force} \times \text{displacement}}{\text{time taken}}$

so power = force × velocity

B power = $\dfrac{\text{work done}}{\text{time taken}}$ and work done = force × distance

so power = $\dfrac{\text{force} \times \text{distance}}{\text{time taken}}$

so power = force × velocity

C power = $\dfrac{\text{work done}}{\text{time taken}}$ and work done = $\dfrac{\text{force}}{\text{displacement}}$

so power = $\dfrac{\text{force}}{\text{displacement}}$ × time taken

so power = $\dfrac{\text{force}}{\text{velocity}}$

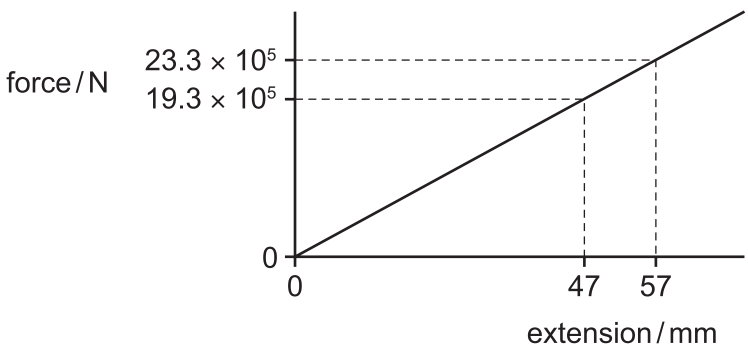
D power = $\dfrac{\text{work done}}{\text{time taken}}$ and work done = $\dfrac{\text{force}}{\text{distance}}$

so power = $\dfrac{\text{force}}{\text{distance}}$ × time taken

so power = $\dfrac{\text{force}}{\text{velocity}}$

19 A cable on a suspension bridge supports a weight of 19.3×10^5 N. This weight causes the cable to stretch by 47 mm.

A lorry crossing the bridge then increases the force on the cable to 23.3×10^5 N. The force-extension graph for the cable is shown.



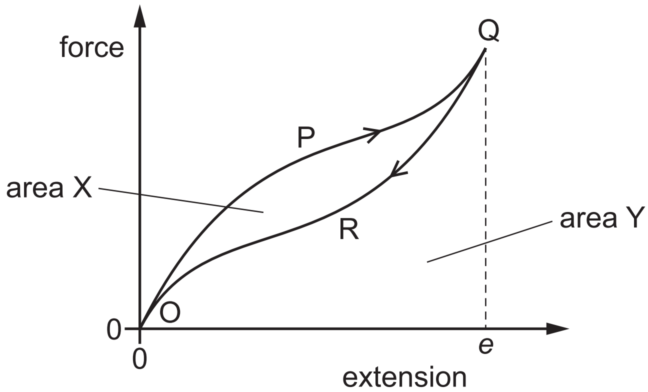
What is the **increase** in strain energy in the cable when the lorry is crossing the bridge?

A 21 kJ **B** 23 kJ **C** 45 kJ **D** 66 kJ

20 What are the units of stress, strain and the Young modulus?

	stress	strain	Young modulus
A	newton	metre	pascal
B	newton	no unit	newton
C	pascal	metre	newton
D	pascal	no unit	pascal

21 A rubber band is stretched and then relaxed to its original length. The diagram shows the force-extension graph for this process.



As the force is increased, the curve follows the path OPQ to extension *e*. As the force is reduced, the curve follows the path QRO to return to zero extension.

The area labelled X is between the curves OPQ and QRO. The area labelled Y is bounded by the curve QRO and the horizontal axis.

Which statement about the process is correct?

A Area X is the energy which heats the band as it is stretched to extension *e*.

B (Area X + area Y) is the minimum energy required to stretch the band to extension *e*.

C Area X is the elastic potential energy stored in the band when it is stretched to extension *e*.

D (Area Y – area X) is the net work done on the band during the process.

22 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}

23 Which statement about progressive longitudinal waves is **not** correct?

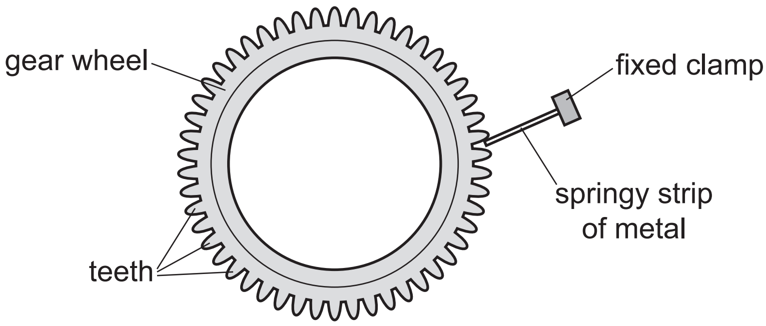
A The oscillations of the particles are parallel to the direction of travel of the wave energy.

B They have a series of nodes and antinodes.

C They need a medium through which to travel.

D They transfer energy.

24 A bicycle gear wheel is a disc with 50 ‘teeth’ equally spaced around its edge, as shown. The gear wheel is rotated 10 times each second. A springy strip of metal is vibrated by the rotating ‘teeth’. The metal strip produces a sound of frequency that is equal to the frequency of vibration of the strip.



The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

What is the wavelength of the emitted sound?

A 0.66 m **B** 1.5 m **C** 6.6 m **D** 500 m

25 An ambulance travels along a straight road at a speed of $30.0\,m\,s^{-1}$. Its siren emits sound of frequency 2000 Hz. The speed of sound in the air is $340\,m\,s^{-1}$. The ambulance passes a man standing at the side of the road.

What is the frequency of the sound heard by the man as the ambulance moves towards him and as the ambulance moves away from him?

	frequency heard as ambulance moves towards man / Hz	frequency heard as ambulance moves away from man / Hz
A	1820	2180
B	1840	2190
C	2180	1820
D	2190	1840

26 Three different electromagnetic waves P, Q and R have the frequencies shown.

	frequency / Hz
P	3×10^{10}
Q	3×10^{13}
R	6×10^{14}

Which row identifies P, Q and R?

	P	Q	R
A	infra-red	visible	ultraviolet
B	microwave	infra-red	visible
C	ultraviolet	X-ray	gamma ray
D	visible	ultraviolet	X-ray

27 Which row describes the oscillations of two moving particles in a stationary wave that are separated by a distance of half a wavelength?

	phase difference	amplitude
A	90°	different
B	90°	same
C	180°	different
D	180°	same

28 A parallel beam of red light of wavelength 700 nm is incident normally on a diffraction grating that has 400 lines per millimetre.

What is the total number of intensity maxima from the grating?

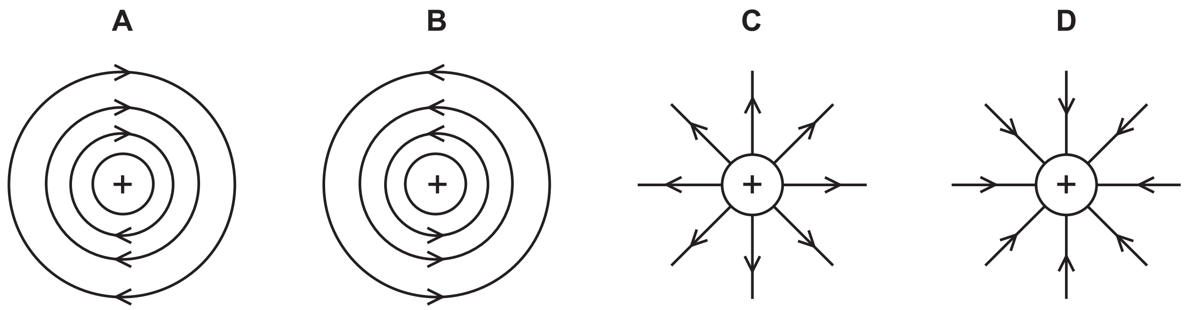
A 6 **B** 7 **C** 8 **D** 9

29 Two wave sources are oscillating in phase. Each source produces a wave of wavelength λ. The two waves from the sources meet at point X with a phase difference of 90°.

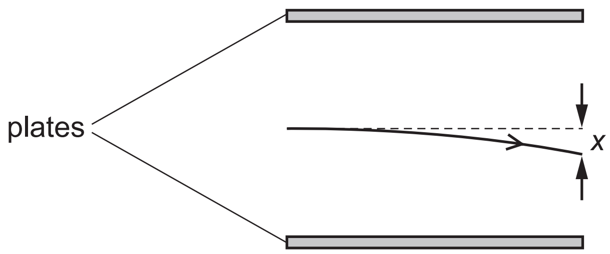
What is a possible difference in the distances from the two wave sources to point X?

A $\dfrac{\lambda}{8}$ **B** $\dfrac{\lambda}{4}$ **C** $\dfrac{\lambda}{2}$ **D** λ

30 Which diagram best illustrates the electric field around a positive point charge?



31 The path of an electron with initial speed v in the uniform electric field between two parallel plates is shown.



The vertical deflection x is measured at the right-hand edge of the plates.

The distance between the plates is halved. The potential difference between the plates remains the same.

What will be the new deflection of the electron with the same initial speed v?

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

32 The current in a circuit component is 2.00 μA.

How many electrons pass through the component each second?

A 1.25×10^{13} **B** 1.25×10^{16} **C** 1.25×10^{19} **D** 1.25×10^{25}

33 The filament of a 240 V, 100 W electric lamp heats up from room temperature to its operating temperature. As it heats up, its resistance increases by a factor of 16.

What is the resistance of the filament at room temperature?

A 36 Ω **B** 580 Ω **C** 1.5 kΩ **D** 9.2 kΩ

34 Two wires have the same length and the same resistance. Wire X is made of a metal of resistivity $1.7 \times 10^{-8}\,\Omega\,m$ and wire Y is made of a metal of resistivity $5.6 \times 10^{-8}\,\Omega\,m$.

The diameter of wire X is 0.315 mm.

What is the diameter of wire Y?

A 0.17 mm **B** 0.33 mm **C** 0.57 mm **D** 1.0 mm

35 A cell has a constant electromotive force.

A variable resistor is connected between the terminals of the cell.

The resistance of the variable resistor is decreased.

Which statement about the change of the cell's terminal potential difference (p.d.) is correct?

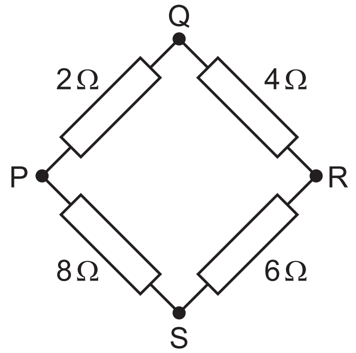
A The terminal p.d. is decreased because more work is done moving unit charge through the internal resistance of the cell.

B The terminal p.d. is decreased because the current in the variable resistor is decreased.

C The terminal p.d. is increased because more work is done moving unit charge through the variable resistor.

D The terminal p.d. is increased because the current in the variable resistor is increased.

36 Four resistors are connected in a square as shown.

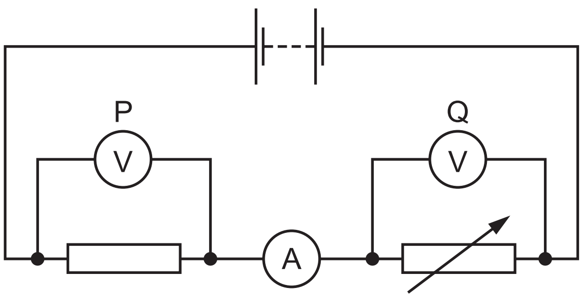


The resistance may be measured between any two junctions.

Between which two junctions is the measured resistance greatest?

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

37 A circuit is set up as shown.



The variable resistor is adjusted so that the ammeter reading decreases.

How do the readings of the voltmeters change?

	reading on voltmeter P	reading on voltmeter Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

38 In a television programme to illustrate scientific models, a presenter fires a gun many times at a bale of hay. Two small cannon balls are embedded within the hay some distance apart from each other.

The hay bale measures approximately $2\,m \times 2\,m \times 2\,m$ and the cannon balls are made of iron, approximately spherical, and about 5 cm in diameter.

What might the presenter be illustrating?

A α-particle scattering

B β^- decay

C conservation of momentum

D double-slit interference

39 A certain nuclide, uranium-235, has nucleon number 235, proton number 92 and neutron number 143. Data on four other nuclides are given below.

Which nuclide is an isotope of uranium-235?

	nucleon number	proton number	neutron number
A	235	91	144
B	236	92	144
C	237	94	143
D	238	95	143

40 During β^- decay, which change takes place to the quark composition of the nucleus that emits the β^- particle, and which other particle is emitted?

	quark change	other particle emitted
A	down to up	antineutrino
B	down to up	neutrino
C	up to down	antineutrino
D	up to down	neutrino

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* 2 8 3 6 5 9 1 2 7 2 *

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2017**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

IB17 06_9702_13/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_{\mathrm{e}} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_{\mathrm{p}} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_{\mathrm{A}} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

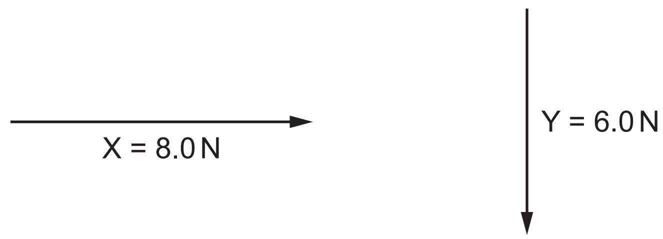
Formulae

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is the best estimate of the kinetic energy of a family car travelling at $50\,km\,h^{-1}$?

A $1.5 \times 10^3\,J$ **B** $1.5 \times 10^5\,J$ **C** $1.5 \times 10^7\,J$ **D** $1.5 \times 10^9\,J$

2 The diagram shows two vectors X and Y. The vectors are perpendicular to one another.



What is the magnitude and direction of vector (X – Y)?

A 10.0 N at an angle of 37° downwards from the direction of X

B 10.0 N at an angle of 37° upwards from the direction of X

C 14.0 N at an angle of 53° downwards from the direction of X

D 14.0 N at an angle of 53° upwards from the direction of X

3 Which expression using SI base units is equivalent to the volt?

A $kg\,m^2\,s^{-1}\,A^{-1}$

B $kg\,m\,s^{-2}\,A$

C $kg\,m^2\,s^{-1}\,A$

D $kg\,m^2\,s^{-3}\,A^{-1}$

4 A voltage is carefully measured with a high-quality instrument and found to be 2.321 V.

Two students, using two different methods, conclude that the voltage is 2.33 V and 2.344 V respectively.

Which statement is correct?

A 2.33 V is less accurate and less precise than 2.344 V.

B 2.33 V is less accurate and more precise than 2.344 V.

C 2.33 V is more accurate and less precise than 2.344 V.

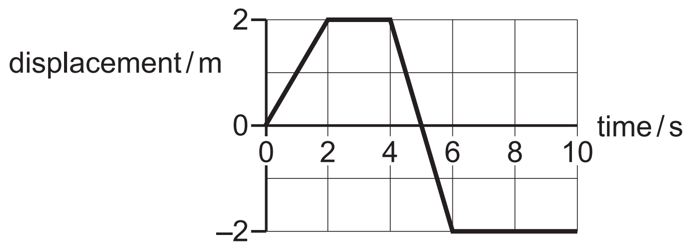
D 2.33 V is more accurate and more precise than 2.344 V.

5 On a planet, a vertically-launched projectile takes 12.5 s to return to its starting position. The projectile gains a maximum height of 170 m. The planet does not have an atmosphere.

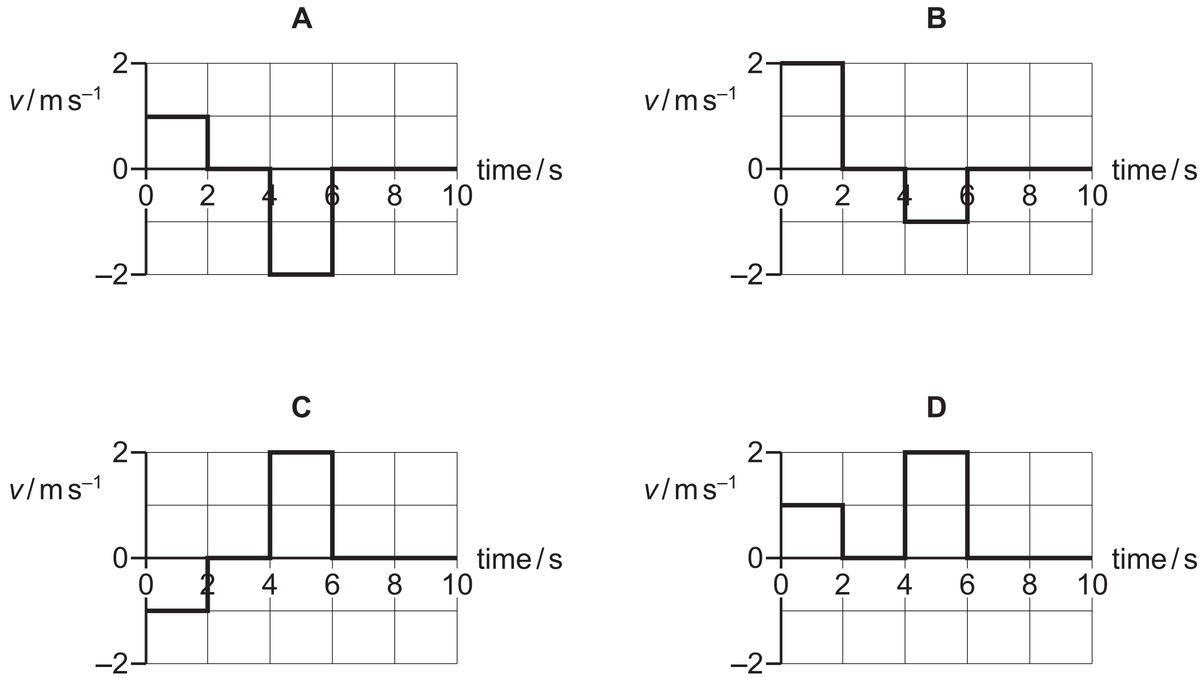
What is the acceleration of free fall on this planet?

A 2.2 m s^{-2} **B** 8.7 m s^{-2} **C** 27 m s^{-2} **D** 54 m s^{-2}

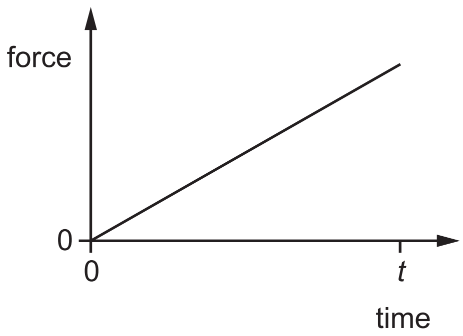
6 A displacement-time graph for a toy car is shown.



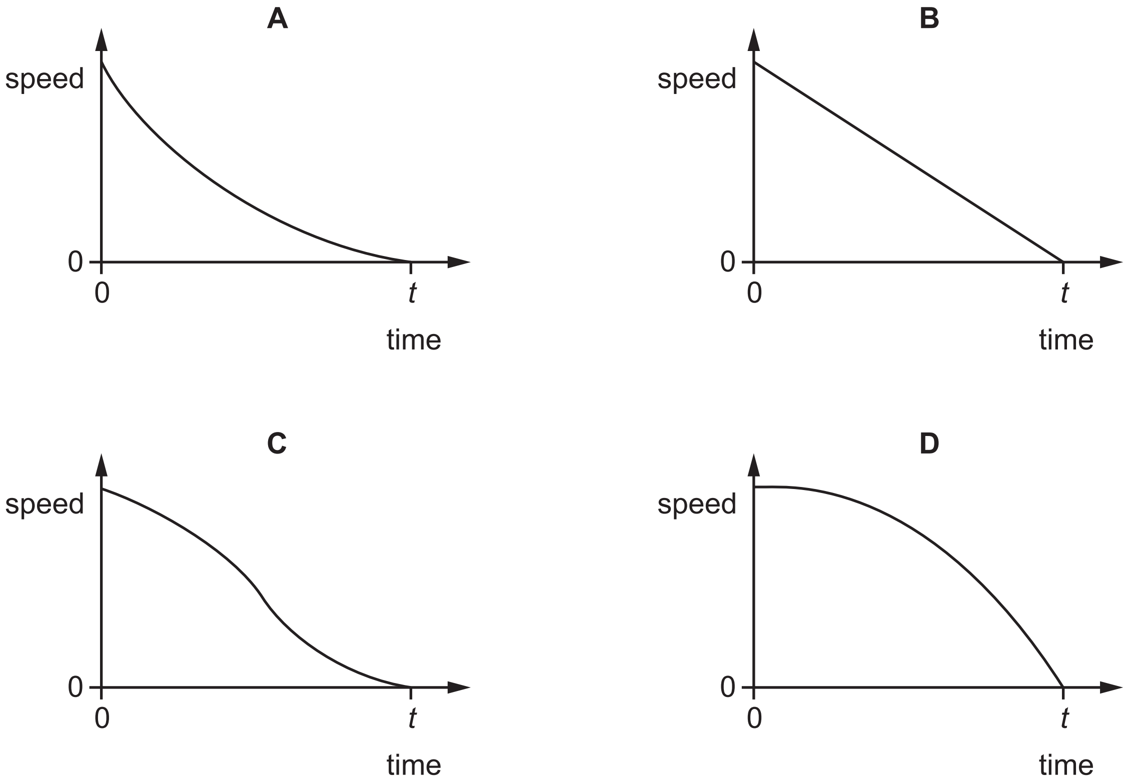
Which graph shows the variation with time of the velocity v of the car?



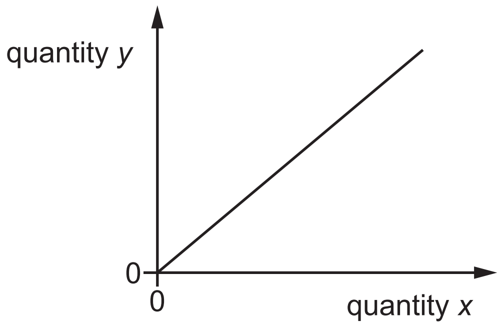
7 A driver stops his car in time t by gradually increasing the total braking force on the car. The graph shows the resultant force on the car.



Which graph shows how the speed of the car will vary during this time?



8 The graph shows the variation of a quantity y with a quantity x for a body that is falling in air at constant (terminal) velocity in a uniform gravitational field.



Which quantities could x and y represent?

	x	y
A	air resistance	acceleration
B	loss of height	gain in kinetic energy
C	loss of potential energy	work done against air resistance
D	time	velocity

9 A ball of mass 2.0 kg travels horizontally with a speed of $4.0\,\mathrm{m\,s^{-1}}$. The ball collides with a wall and rebounds in the opposite direction with a speed of $2.8\,\mathrm{m\,s^{-1}}$. The time of the collision is 150 ms.

What is the average force exerted on the wall?

A 16 N **B** 37 N **C** 53 N **D** 91 N

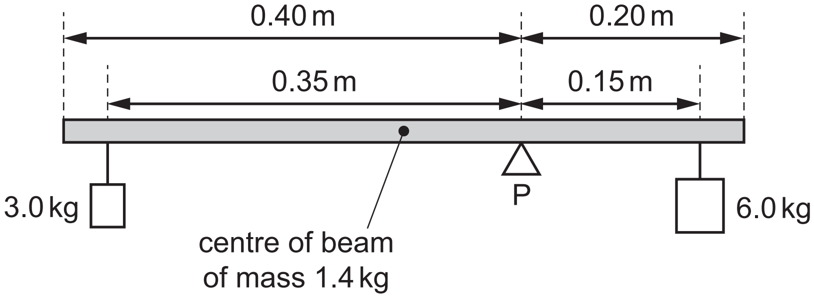
10 An ice-hockey puck of mass 150 g moves with an initial speed of $2.0\,\mathrm{m\,s^{-1}}$ along the surface of an ice rink.

The puck slides a distance of 30 m in a straight line before stopping.

What is the average frictional force acting on the puck?

A 0.010 N **B** 0.020 N **C** 0.067 N **D** 0.44 N

11 A uniform beam of mass 1.4 kg is pivoted at P as shown. The beam has a length of 0.60 m and P is 0.20 m from one end. Loads of 3.0 kg and 6.0 kg are suspended 0.35 m and 0.15 m from the pivot as shown.

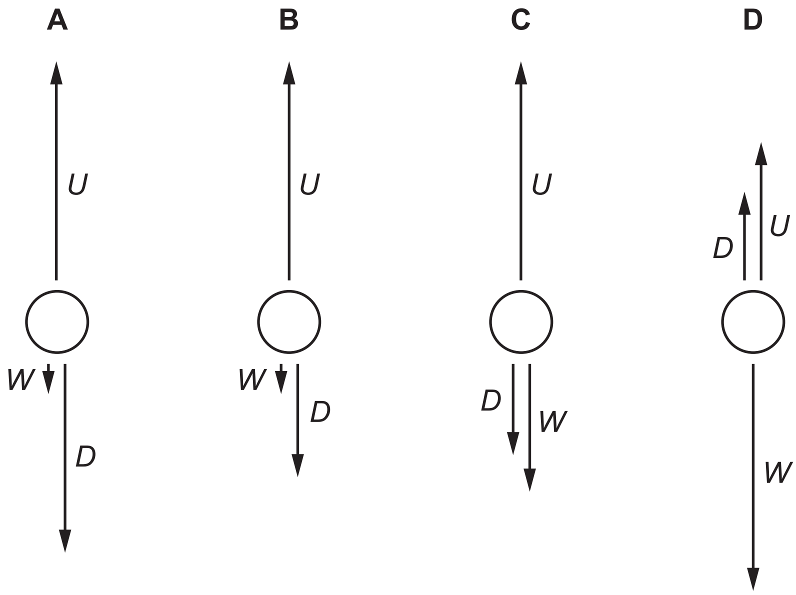


What is the torque that must be applied to the beam in order to maintain it in equilibrium?

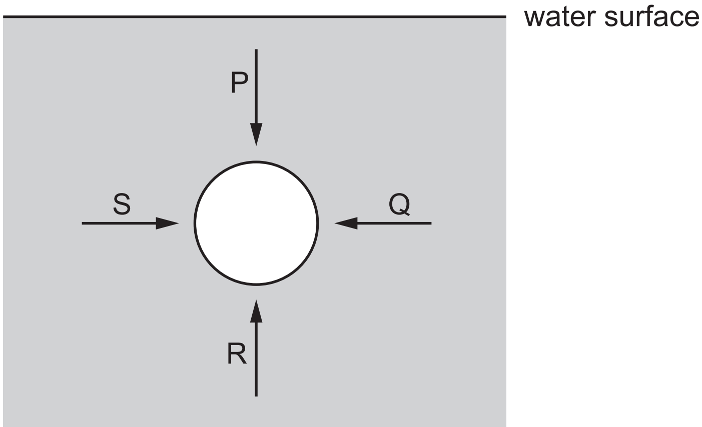
A 0.010 N m **B** 0.10 N m **C** 0.29 N m **D** 2.8 N m

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

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



13 The diagram represents a sphere under water. P, Q, R and S are forces acting on the sphere due to the pressure of the water.



Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.

Which information about the magnitudes of the forces is correct?

A $P < R$ and $S = Q$

B $P > R$ and $S = Q$

C $P = R$ and $S = Q$ and $P < S$

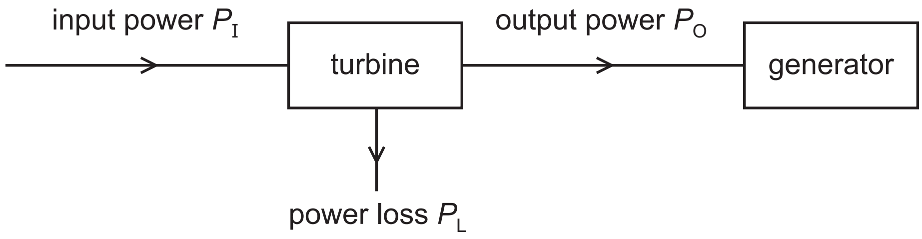
D $P = R$ and $S = Q$ and $P = S$

14 The first column in the table gives four examples of work being done. The second column gives more detail of the action.

Which row is **not** correct?

	example	detail
A	a girl dives from a diving board into a swimming pool	work is done by the girl against the gravitational field as she falls
B	a man pushes a car along a level road	work is done by the man against friction
C	an electron is accelerated towards a positively charged plate	work is done on the electron by the electric field of the plate
D	a piston is pushed outwards as a gas expands	work is done on the atmosphere by the gas

15 A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power is P_O. The power loss in the turbine is P_L, as shown below.



What is the efficiency of the turbine?

A $\frac{P_L}{P_O}$ **B** $\frac{P_I}{P_O}$ **C** $\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

16 A constant force pushes a block along a horizontal frictionless surface. The block moves from rest through a fixed distance.

What is the relationship between the final speed v of the block and its mass m?

A $\sqrt{v} \propto \frac{1}{m}$ **B** $v \propto \sqrt{m}$ **C** $v \propto \frac{1}{\sqrt{m}}$ **D** $\sqrt{v} \propto m$

17 A man has a mass of 80 kg. He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of $50\,\mathrm{cm\,s^{-1}}$.

What is the average useful power at which he is working?

A 40 W **B** 0.39 kW **C** 4.0 kW **D** 39 kW

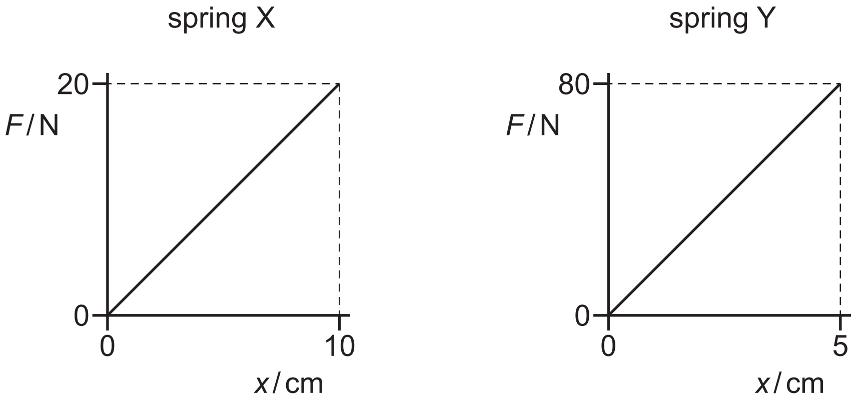
18 Two wires with the same Young modulus E and cross-sectional area A, but different lengths L, are subject to different tensile forces F. The extension e of each wire is the same.

The column headings in the table show four different quantities.

Which quantities have the same value and which quantities have different values for the two wires?

	$\frac{FL}{e}$	$\frac{Ae}{L}$	$\frac{E}{FL}$
A	different	different	same
B	different	same	same
C	same	different	different
D	same	different	same

19 Two springs X and Y stretch elastically. The graphs show the variation with extension x of the force F applied to each spring.



Which statement is correct?

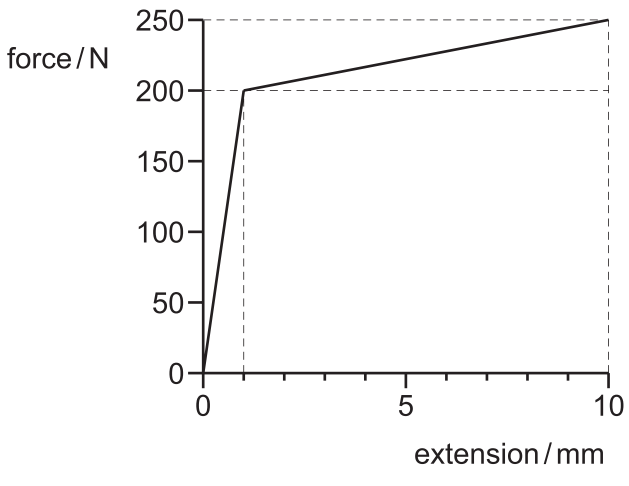
A When each spring is given the same extension, the energy stored in Y is 4 times the energy stored in X.

B When each spring is given the same extension, the energy stored in Y is 8 times the energy stored in X.

C When the same force is applied to each spring, the energy stored in Y is 4 times the energy stored in X.

D When the same force is applied to each spring, the energy stored in Y is 8 times the energy stored in X.

20 The diagram shows the force-extension graph for a steel wire, up to its breaking point.



What is the best estimate of the work done to break the wire?

A 2.1 J **B** 2.3 J **C** 2.4 J **D** 2.5 J

21 Which statement about electromagnetic waves in a vacuum is correct?

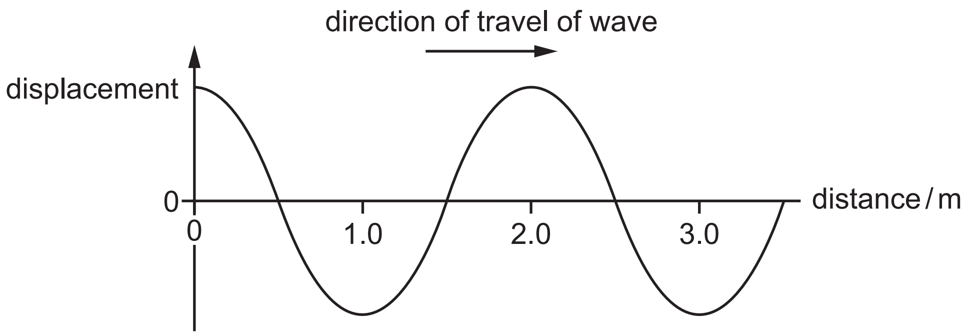
A Amplitude is inversely proportional to velocity.

B Frequency is inversely proportional to wavelength.

C Intensity is proportional to amplitude.

D Velocity is proportional to wavelength.

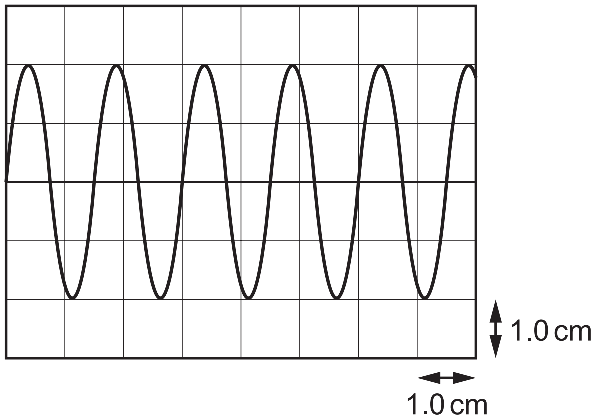
22 A transverse wave travels along a rope. The graph shows the variation of the displacement of the particles in the rope with distance along it at a particular instant.



At which distance along the rope do the particles have maximum upwards velocity?

A 0.5 m **B** 1.0 m **C** 1.5 m **D** 2.0 m

23 A trace is shown on the screen of a cathode-ray oscilloscope (c.r.o.).



The time-base setting is 2.5 ms cm^{-1} and the Y-gain is 2.0 V cm^{-1}.

What is the frequency and the amplitude of the waveform displayed by the c.r.o.?

	frequency / Hz	amplitude / V
A	0.00375	4.0
B	0.00375	8.0
C	267	4.0
D	267	8.0

24 A high-speed train approaches a stationary observer at a speed of 80 m s^{-1}. The train's horn emits a sound of frequency 250 Hz.

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

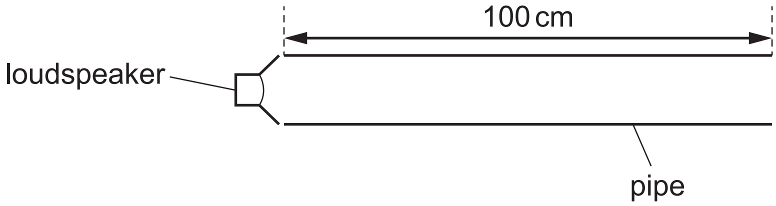
What is the observed frequency of the sound from the horn?

A 190 Hz **B** 200 Hz **C** 310 Hz **D** 330 Hz

25 Which row shows a correct frequency in Hz for each of the four principal radiations?

	X-rays	ultraviolet	microwaves	infra-red
A	10^{10}	10^{14}	10^{18}	10^{15}
B	10^{14}	10^{18}	10^{15}	10^{10}
C	10^{15}	10^{10}	10^{14}	10^{18}
D	10^{18}	10^{15}	10^{10}	10^{14}

26 A pipe of length 100 cm is open at both ends. A loudspeaker situated at one end of the pipe can emit sound of different wavelengths.



At which wavelength can a stationary wave be produced in the pipe?

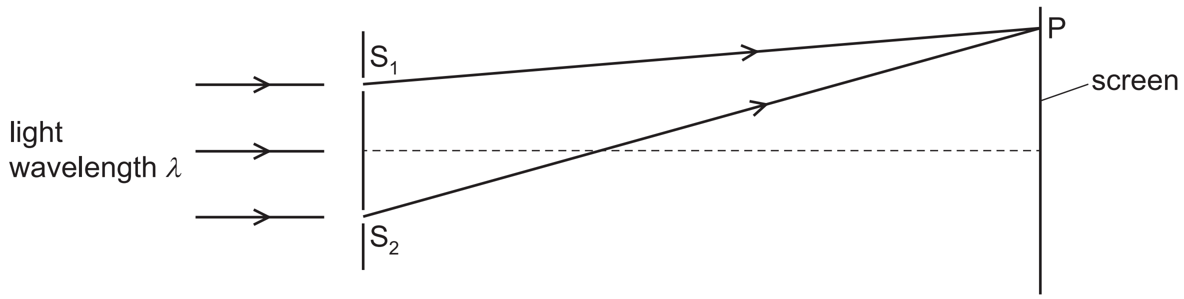
A 50 cm **B** 75 cm **C** 150 cm **D** 300 cm

27 Monochromatic light is incident on a diffraction grating and a diffraction pattern is observed.

Which row shows possible effects of replacing the grating with one that has twice as many lines per millimetre?

	number of orders of diffraction visible	angle between first and second orders of diffraction
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

28 Monochromatic light of wavelength λ is incident on two narrow slits S_1 and S_2, a small distance apart. A series of bright and dark fringes are observed on a screen a long distance away from the slits.



The nth **dark** fringe from the central bright fringe is observed at point P on the screen.

Which equation is correct for all positive values of n?

A $S_2P - S_1P = \frac{n\lambda}{2}$

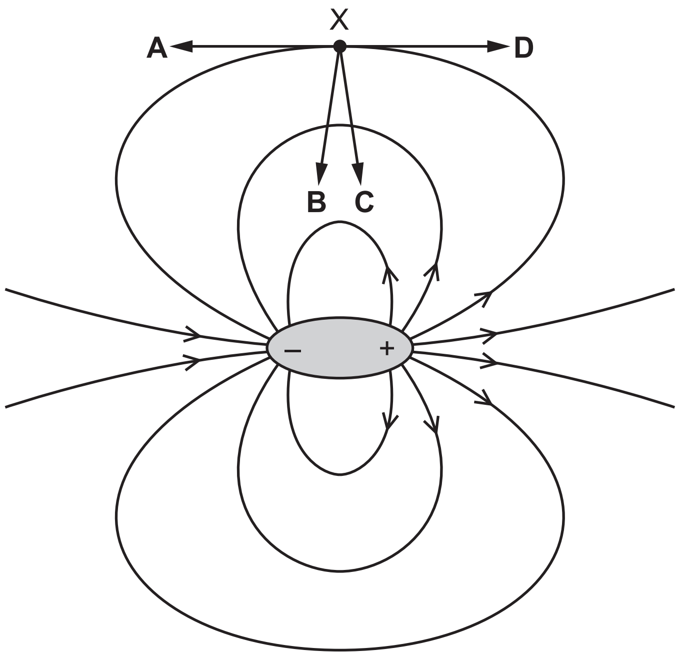
B $S_2P - S_1P = n\lambda$

C $S_2P - S_1P = (n - \frac{1}{2})\lambda$

D $S_2P - S_1P = (n + \frac{1}{2})\lambda$

29 A dipole is a pair of charges of equal magnitude, one negative and one positive. The electric field of a dipole is shown below.

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



30 In a uniform electric field, which statement is correct?

A All charged particles experience the same force.

B All charged particles move with the same velocity.

C All electric field lines are directed towards positive charges.

D All electric field lines are parallel.

31 Two metal plates are a distance of 30 cm apart in a vacuum.

A current exists between the two plates consisting of electrons moving at a constant speed of $1.5 \times 10^{6}\,\mathrm{m\,s^{-1}}$.

At any instant, there is always just one electron travelling between the plates.

What is the current between the plates?

A 3.2×10^{-26} A

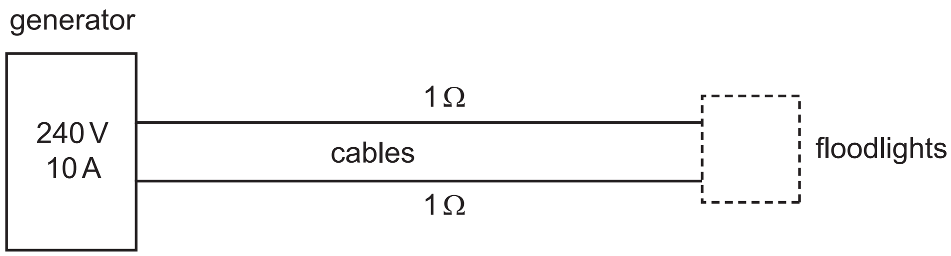
B 8.0×10^{-13} A

C 1.6×10^{-12} A

D 2.0×10^{-7} A

32 The diagram shows a portable generator connected by cables to floodlights. The generator produces a current of 10 A at a constant potential difference (p.d.) of 240 V.

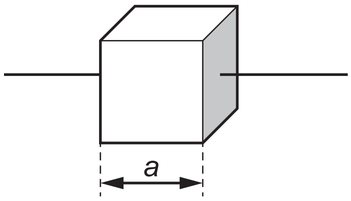
The total resistance of the cables is 2 Ω.



What is the p.d. *V* across, and the power *P* delivered to, the floodlights?

	V / V	*P* / W
A	220	2000
B	220	2200
C	230	2000
D	230	2300

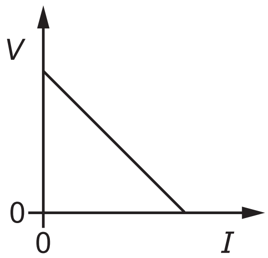
33 A metal cube with sides of length *a* has electrical resistance *R* between opposite faces.



What is the resistance between the opposite faces of a cube of the same metal with sides of length 3*a*?

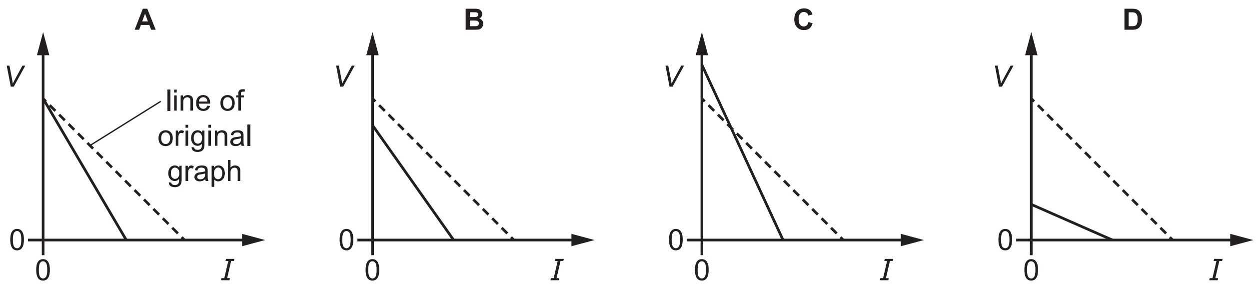
A $9R$ **B** $3R$ **C** $\frac{R}{3}$ **D** $\frac{R}{9}$

34 A graph of potential difference (p.d.) *V* across a cell against current *I* in the cell is shown.

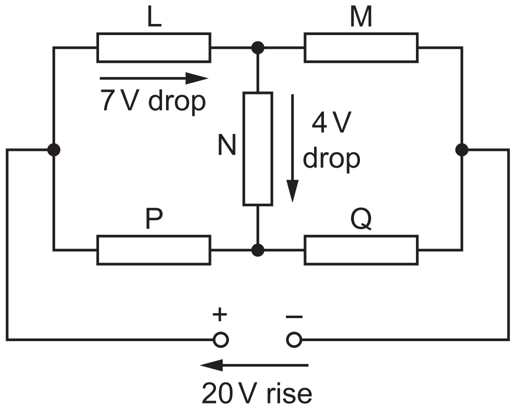


As the cell reaches the end of its useful life, its internal resistance increases and its electromotive force (e.m.f.) decreases.

Which diagram shows a graph of *V* against *I* for the cell nearing the end of its useful life?



35 A 20 V d.c. supply is connected to a circuit consisting of five resistors L, M, N, P and Q.

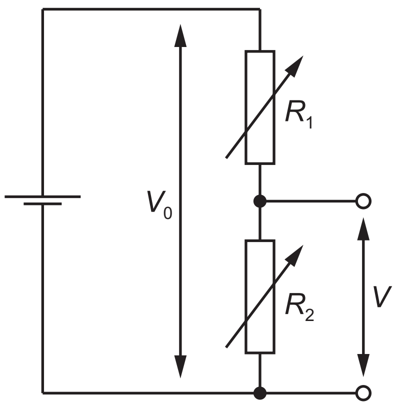


There is a potential drop of 7 V across L and a further 4 V potential drop across N.

What are the potential drops across M, P and Q?

	potential drop across M / V	potential drop across P / V	potential drop across Q / V
A	9	7	13
B	13	7	13
C	13	11	9
D	17	3	17

36 A potential divider circuit consists of a cell of negligible internal resistance in series with two variable resistors of resistances R_1 and R_2. The potential difference (p.d.) across the cell is V_0. The p.d. at the output is V.



Which statement is correct?

A When R_1 increases, it takes a greater proportion of V_0, so V decreases.

B When R_1 increases, the current through R_1 and R_2 decreases, so V increases.

C When R_2 decreases, it takes a smaller proportion of V_0, so V increases.

D When R_2 increases, the current through R_1 and R_2 decreases, so V decreases.

37 A nucleus of uranium-238, ${}^{238}_{92}\text{U}$, decays in a series of steps to form a nucleus of lead-206, ${}^{206}_{82}\text{Pb}$, as shown.

$${}^{238}_{92}\text{U} \rightarrow \text{...........} \rightarrow {}^{206}_{82}\text{Pb}$$

An α-particle or a β^- particle is emitted during each step.

What is the total number of β^- particles that are emitted?

A 6 **B** 8 **C** 10 **D** 16

38 Which statement about α-particles is correct?

A α-particles emitted from a single radioactive isotope have a continuous distribution of energies.

B α-particles have less ionising power than β-particles.

C The charge of an α-particle is $+1.60 \times 10^{-19}$ C.

D The speeds of α-particles can be as high as $1.5 \times 10^{7}\,\text{m}\,\text{s}^{-1}$.

39 The nuclear equation shown has a term missing.

$${}^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}\beta + \text{............}$$

What is represented by the missing term?

A an antineutrino

B an electron

C a neutrino

D a positron

40 Which particle is a fundamental particle?

A electron

B hadron

C neutron

D proton

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Cambridge International AS & A Level

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PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2018**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **20** printed pages.

CAMBRIDGE
International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho g h$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is a unit for stress?

A $kg\,m^{-1}\,s^{-2}$ **B** $kg\,m^{-2}\,s^{-2}$ **C** $N\,m^{-1}$ **D** $N\,m$

2 Physical quantities can be classed as vectors or as scalars.

Which pair of quantities consists of two vectors?

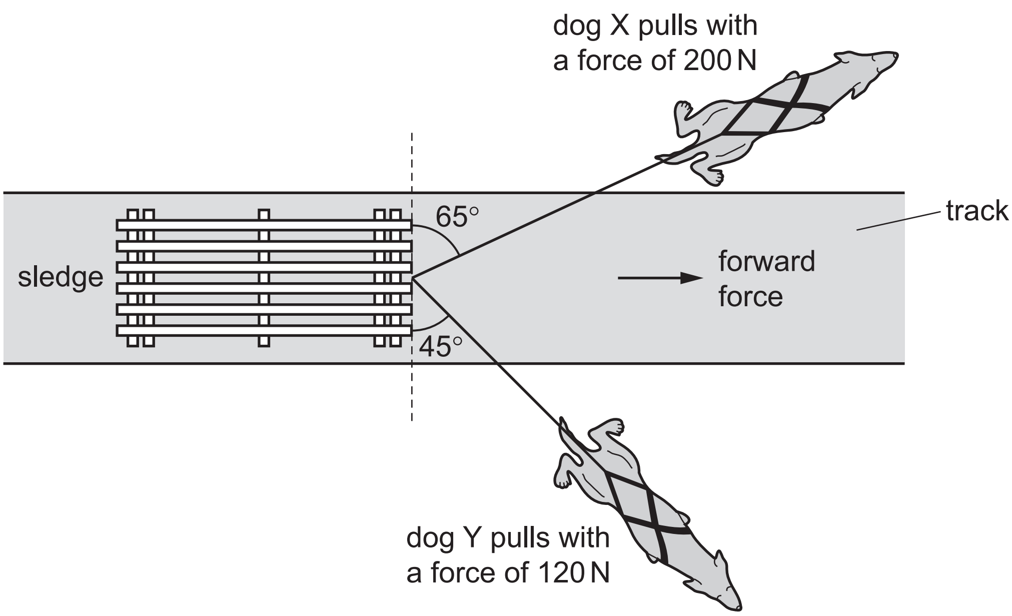
A kinetic energy and force

B momentum and time

C velocity and electric field strength

D weight and temperature

3 Two dogs pull a sledge along an icy track, as shown.

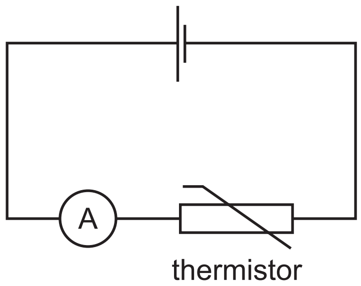


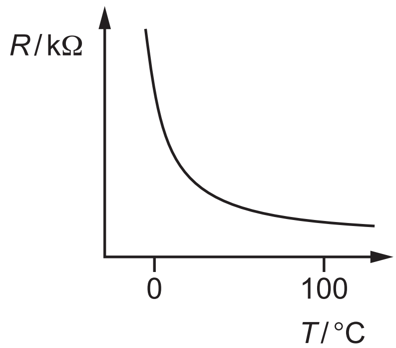
Dog X pulls with a force of 200 N at an angle of 65° to the front edge of the sledge. Dog Y pulls with a force of 120 N at an angle of 45° to the front edge of the sledge.

What is the resultant forward force on the sledge exerted by the two dogs?

A 80 N **B** 170 N **C** 270 N **D** 320 N

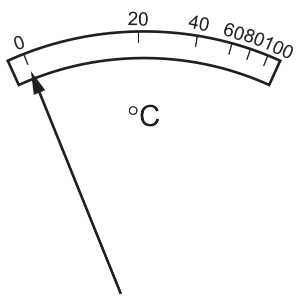
4 In the circuit shown, an analogue ammeter is to be recalibrated as a thermometer. The ammeter is connected in series with a thermistor. The thermistor is a component with a resistance that varies with temperature. The graph shows how the resistance R of the thermistor changes with temperature T.



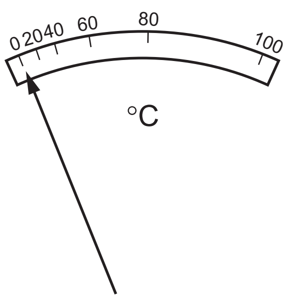


Which diagram could represent the temperature scale on the ammeter?

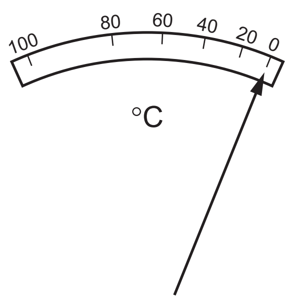
A



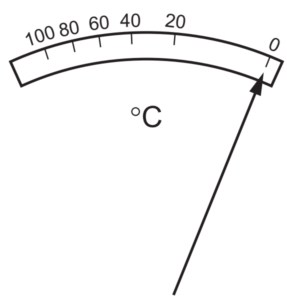
B



C



D



5 The sides of a cube are measured with calipers.

The measured length of each side is (30.0 ± 0.1) mm.

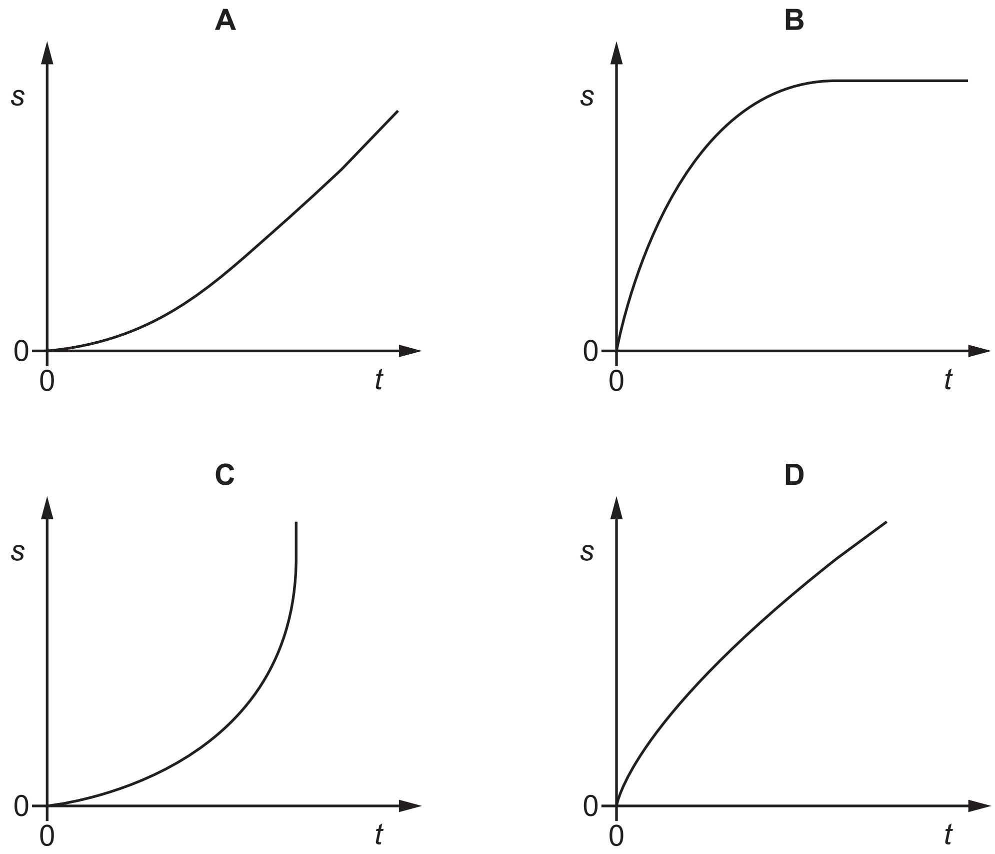
The measurements are used to calculate the volume of the cube.

What is the percentage uncertainty in the calculated value of the volume?

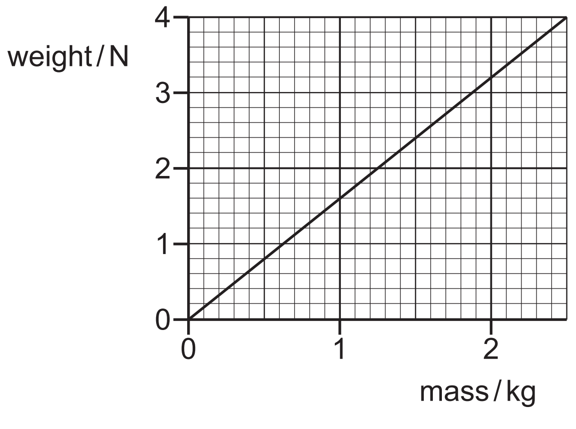
A 0.01% **B** 0.3% **C** 1% **D** 3%

6 A tennis ball falls freely, in air, from the top of a tall building.

Which graph best represents the variation with time t of the distance s fallen?



7 The graph shows the variation with mass of the weight of objects on a particular planet.



What is the value of the acceleration of free fall on the planet?

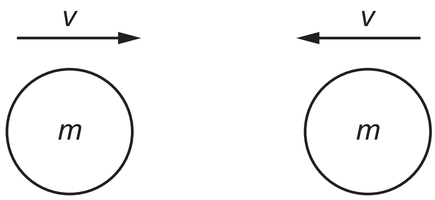
A 0.63 $m\,s^{-2}$ **B** 1.6 $m\,s^{-2}$ **C** 3.2 $m\,s^{-2}$ **D** 9.8 $m\,s^{-2}$

8 The momentum of a car of mass m increases from p_1 to p_2.

What is the increase in the kinetic energy of the car?

A $\dfrac{(p_2{}^2 - p_1{}^2)}{2m}$ **B** $\dfrac{(p_2 - p_1)^2}{2m}$ **C** $\dfrac{p_2 - p_1}{2m}$ **D** $\dfrac{p_1 - p_2}{2m}$

9 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?

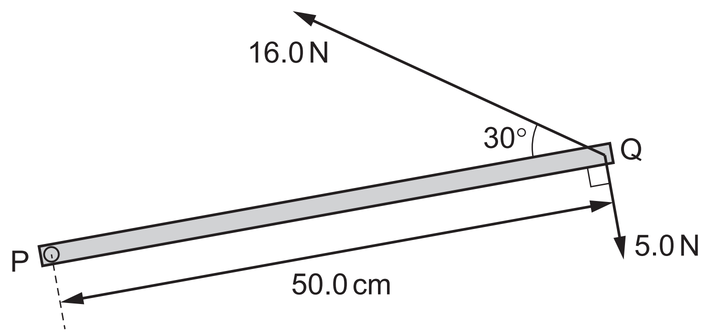
A The spheres stick together on impact.

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 $2mv$.

10 A horizontal metal bar PQ of length 50.0 cm is hinged at end P. The diagram shows the metal bar viewed from above.



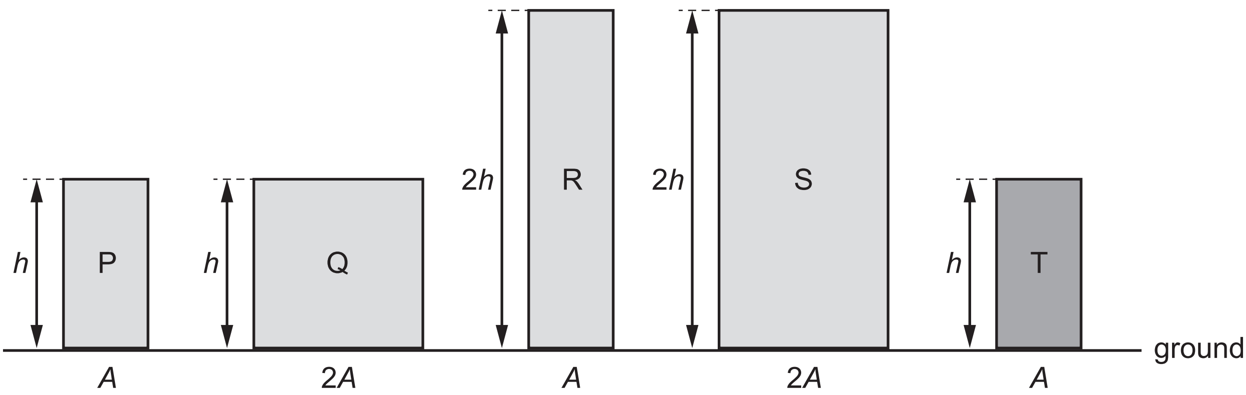
Two forces of 16.0 N and 5.0 N are in the horizontal plane and act on end Q as shown in the diagram.

What is the total moment about P due to the two forces?

A 1.5 N m **B** 4.4 N m **C** 6.5 N m **D** 9.4 N m

11 Blocks P, Q, R and S are made from material of the same density. Block T is made from a material of twice the density of the material of the other blocks.

The cross-sectional area and height of each of the blocks are shown.

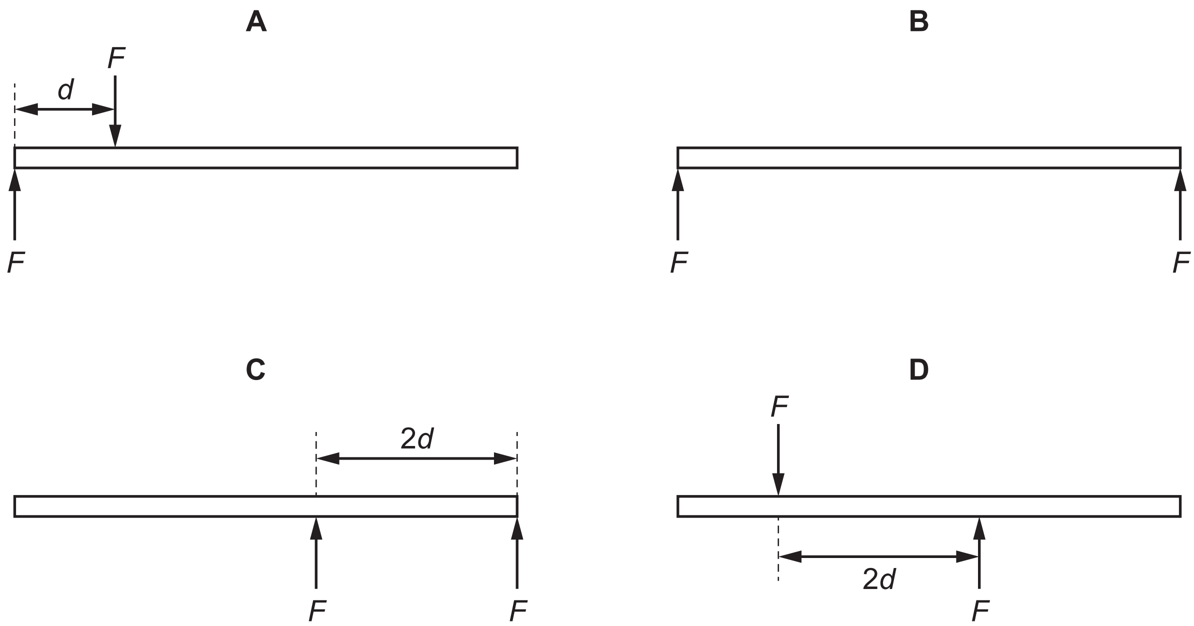


Which two blocks exert the same pressure on the ground?

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

12 Two parallel forces, each of magnitude F, act on a rod of length $5d$.

Which diagram shows the positions of the two forces that will produce the largest torque on the rod?



13 Liquids X and Y are stored in large open tanks. Liquid X has a density of $800\,kg\,m^{-3}$ and liquid Y has a density of $1200\,kg\,m^{-3}$.

At which depths are the pressures equal?

	depth in liquid X / m	depth in liquid Y / m
A	8	20
B	10	15
C	15	10
D	20	8

14 A train of mass $3.3 \times 10^6\,kg$ is moving at a constant speed up a slope inclined at an angle of 0.64° to the horizontal. The engine of the train is producing a useful output power of 14 MW.

Assume that there are no frictional forces opposing the motion of the train.

What is the speed of the train?

A $0.43\,m\,s^{-1}$ **B** $4.2\,m\,s^{-1}$ **C** $39\,m\,s^{-1}$ **D** $380\,m\,s^{-1}$

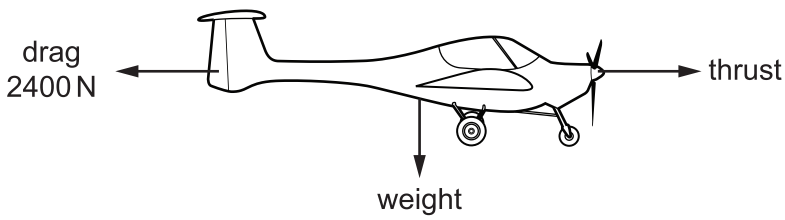
15 A cannon-ball of mass 3.50 kg is fired at a speed of $22.0\,m\,s^{-1}$ from a gun on a ship at a height of 6.00 m above sea level.

The total energy of the cannon-ball is the sum of the gravitational potential energy relative to the surface of the sea and the kinetic energy.

What is the total energy of the cannon-ball as it leaves the gun?

A 206 J **B** 641 J **C** 847 J **D** 1050 J

16 An aircraft travels at a constant velocity of $90\,m\,s^{-1}$ in horizontal flight. The diagram shows some of the forces acting on the aircraft.

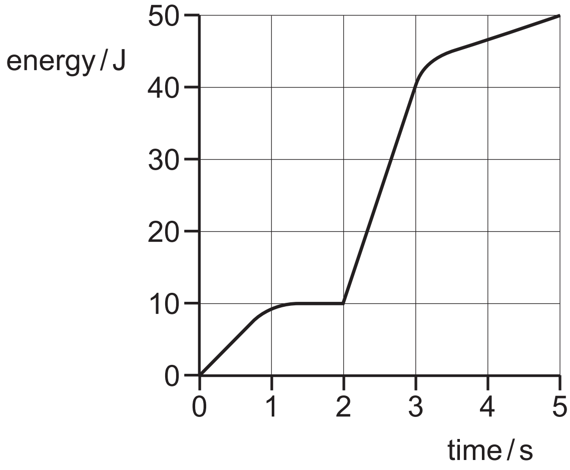


The mass of the aircraft is 2000 kg.

What is the power produced by the thrust force?

A $1.8 \times 10^5\,W$ **B** $2.2 \times 10^5\,W$ **C** $1.8 \times 10^6\,W$ **D** $2.0 \times 10^6\,W$

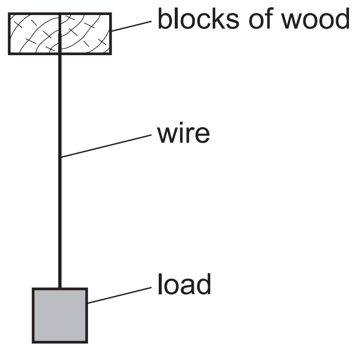
17 An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph.



What is the maximum electrical power generated at any instant during these first 5 seconds?

A 10 W **B** 13 W **C** 30 W **D** 50 W

18 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 extends its length by *x*.



A second wire is made of the same material, but of diameter 2*D* and length 3*L*. Both wires obey Hooke's law.

What is the extension of the second wire when the same load is applied?

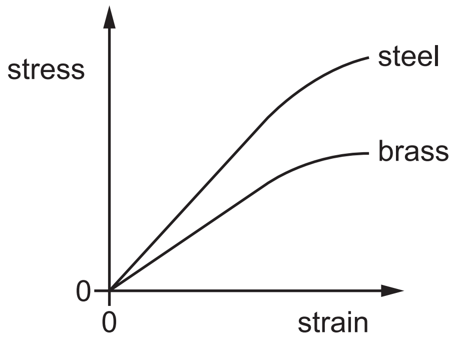
A $\frac{2}{3}x$ **B** $\frac{3}{4}x$ **C** $\frac{4}{3}x$ **D** $\frac{3}{2}x$

19 Two wires, one made of brass and the other of steel, are stretched in an experiment. Both wires obey Hooke's law during this experiment.

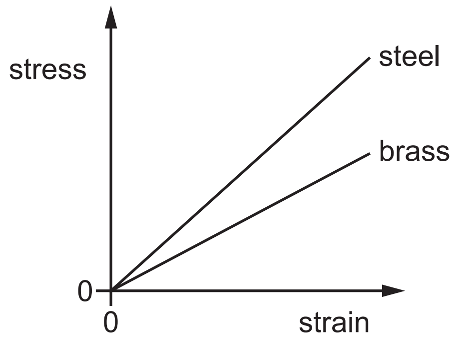
The Young modulus for brass is less than the Young modulus for steel.

Which graph shows how the stress varies with strain for both wires in this experiment?

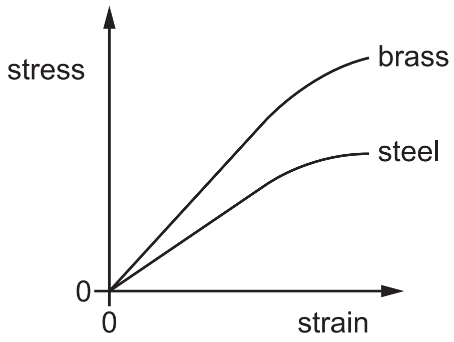
A



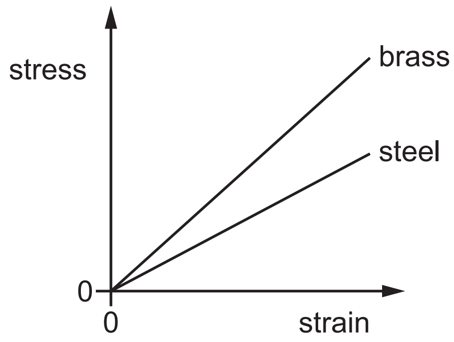
B



C

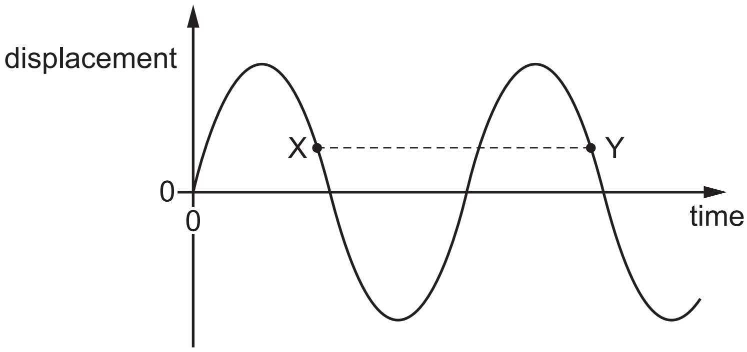


D



20 A transverse progressive wave is set up on a string.

The graph shows the variation with time of displacement for a point on this string.



The separation XY on the graph represents the ……1…… of the wave.

X and Y have equal ……2…… .

Which words correctly complete gaps 1 and 2?

	1	2
A	time period	amplitudes
B	time period	displacements
C	wavelength	amplitudes
D	wavelength	displacements

21 Which region of the electromagnetic spectrum includes waves with a frequency of 10^7 MHz?

A infra-red waves

B radio waves

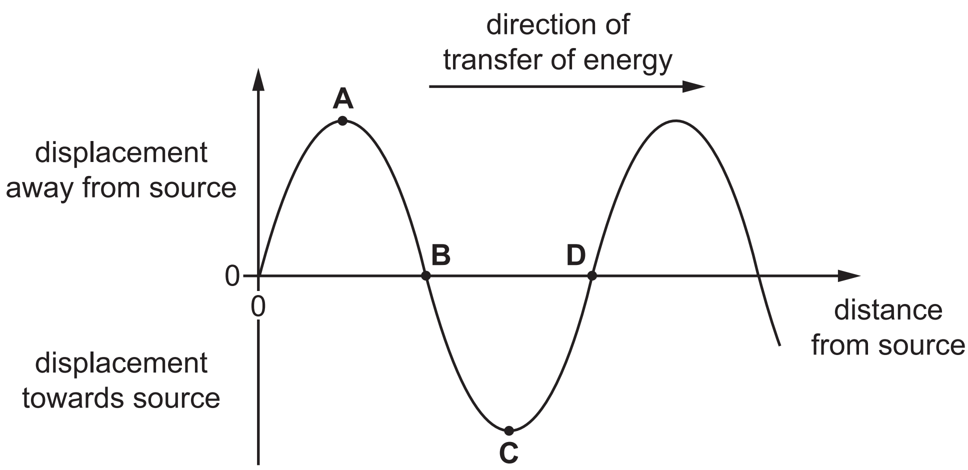
C ultraviolet waves

D X-rays

22 A longitudinal wave has vibrations parallel to the direction of transfer of energy by the wave.

The wave can be represented on a graph showing the variation of the displacement of the particles with distance from the source.

Which point on the graph is the centre of a compression?



23 What can be deduced from a table of wavelengths of the waves in the electromagnetic spectrum?

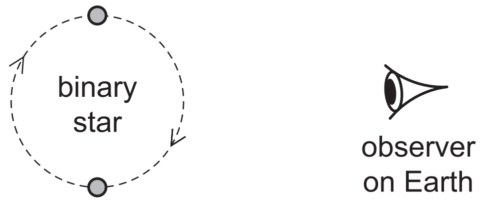
A Green light has a shorter wavelength than X-rays.

B Red light has a shorter wavelength than green light.

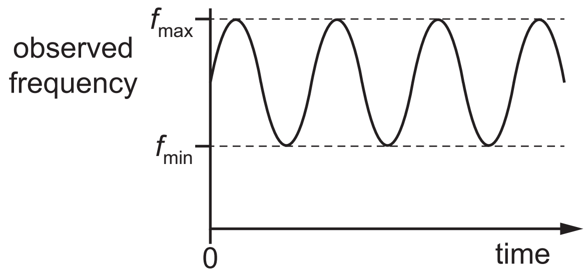
C The wavelength range for radio waves is less than that for infra-red waves.

D The wavelength range for X-rays is less than that for radio waves.

24 A binary star consists of two stars rotating around a common centre. Light from one of the stars is observed on the Earth.



The observed frequency of the light varies between a minimum frequency f_{min} and a maximum frequency f_{max}, as shown.

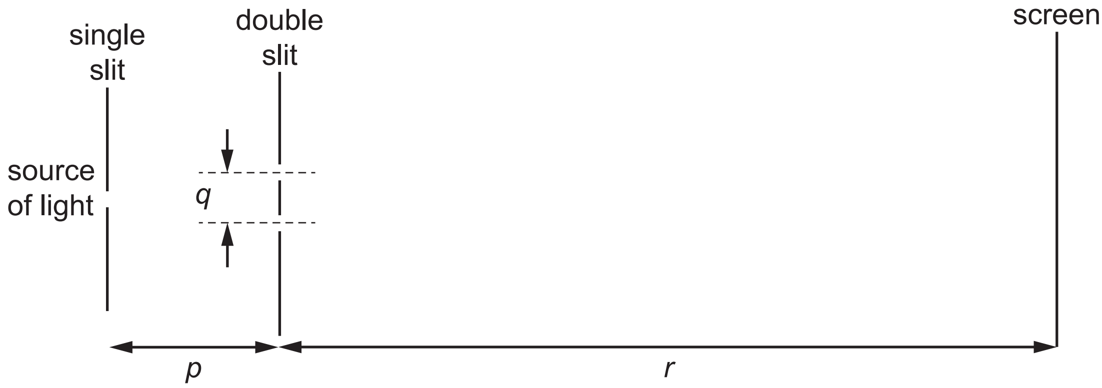


The rate of rotation of the binary star increases.

What is the change to f_{max} and the change to f_{min}?

	f_{max}	f_{min}
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

25 A teacher sets up the apparatus shown to demonstrate a double-slit interference pattern on the screen.



Which change to the apparatus will increase the fringe spacing?

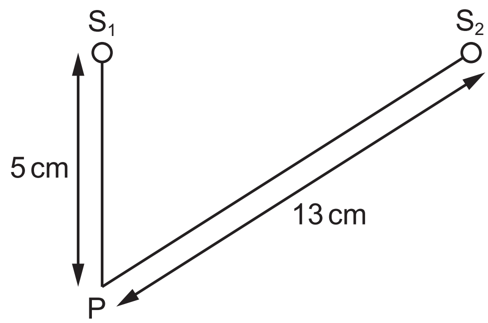
A decreasing the distance *p*

B decreasing the distance *q*

C decreasing the distance *r*

D decreasing the wavelength of the light

26 The diagram shows two sources of waves S_1 and S_2. The sources oscillate with a phase difference of 180°.

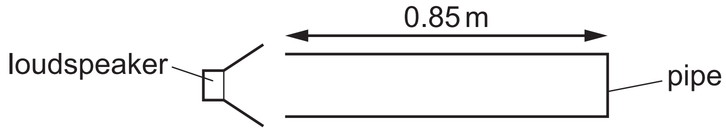


The sources each generate a wave of wavelength 2.0 cm. Each source produces a wave that has amplitude x_0 when it reaches point P.

What is the amplitude of the oscillation at P?

A 0 **B** $\dfrac{x_0}{2}$ **C** x_0 **D** $2x_0$

27 A pipe, closed at one end, has a loudspeaker at the open end. A stationary sound wave is formed in the air within the pipe with an antinode at the open end of the pipe.



The length of the pipe is 0.85 m.

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

Which frequency of sound from the loudspeaker would **not** produce a stationary wave?

A 100 Hz **B** 200 Hz **C** 300 Hz **D** 500 Hz

28 A particle has a charge of +2.0 mC and is in a vertical uniform electric field. An electric force of 1.0×10^{-2} N acts upwards on the particle.

What is the electric field strength?

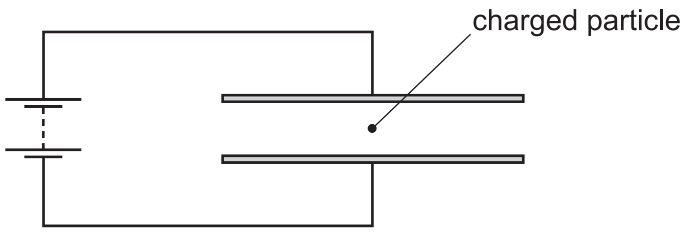
A 0.20 V m^{-1} downwards

B 0.20 V m^{-1} upwards

C 5.0 V m^{-1} downwards

D 5.0 V m^{-1} upwards

29 A charged particle is in the electric field between two horizontal metal plates connected to a battery, as shown. There is a force F on the particle due to the electric field.



The separation of the plates is doubled.

What is the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

30 The current I in a metal wire is given by the expression shown.

$$I = Anvq$$

What does the symbol n represent?

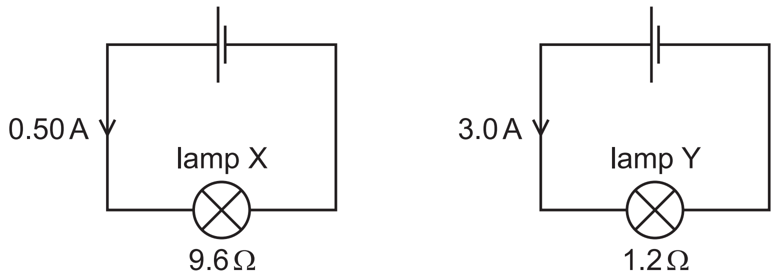
A the number of atoms per unit volume of the metal

B the number of free electrons per atom in the metal

C the number of free electrons per unit volume of the metal

D the total number of electrons per unit volume of the metal

31 The circuit diagrams show two lamps X and Y each connected to a cell. The current in lamp X is 0.50 A and its resistance is 9.6 Ω. The current in lamp Y is 3.0 A and its resistance is 1.2 Ω.



What is the ratio $\dfrac{\text{power in lamp X}}{\text{power in lamp Y}}$?

A 0.22 **B** 0.75 **C** 1.3 **D** 4.5

32 A cylindrical piece of a soft, electrically-conducting material has resistance R. It is rolled out so that its length is doubled but its volume stays constant.

What is its new resistance?

A $\dfrac{R}{2}$ **B** R **C** $2R$ **D** $4R$

33 The sum of the electrical currents into a point in a circuit is equal to the sum of the currents out of the point.

Which statement is correct?

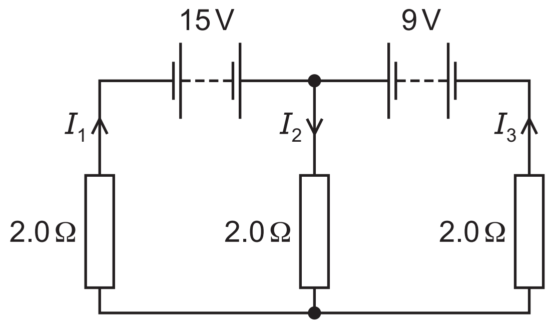
A This is Kirchhoff's first law, which results from the conservation of charge.

B This is Kirchhoff's first law, which results from the conservation of energy.

C This is Kirchhoff's second law, which results from the conservation of charge.

D This is Kirchhoff's second law, which results from the conservation of energy.

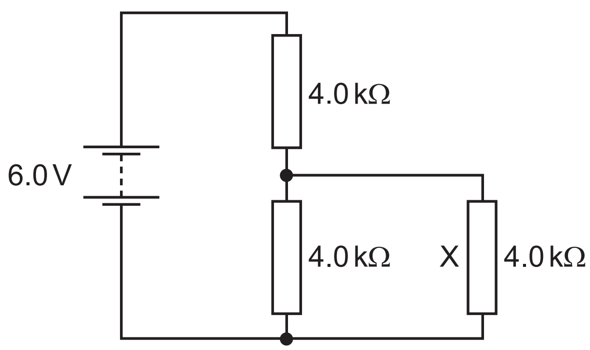
34 In the circuit shown, the batteries have negligible internal resistance.



What are the values of the currents I_1, I_2 and I_3?

	I_1 / A	I_2 / A	I_3 / A
A	–5.5	1.0	6.5
B	0.5	4.0	3.5
C	3.5	4.0	0.5
D	6.5	1.0	–5.5

35 A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors as shown.

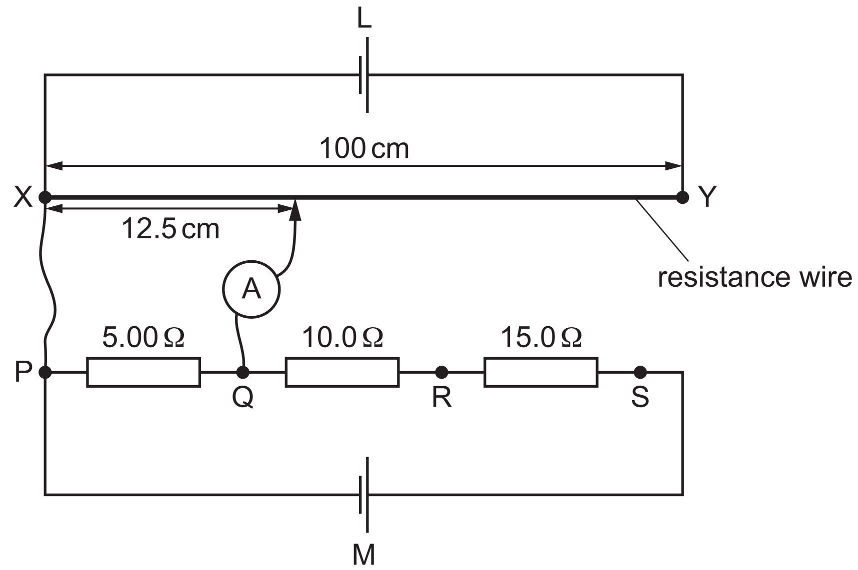


Each resistor has a resistance of 4.0 kΩ.

What is the current in resistor X?

A 0.25 mA **B** 0.50 mA **C** 0.75 mA **D** 1.0 mA

36 A uniform resistance wire XY of length 100 cm is connected in series with a cell L. Another cell M is connected in series with resistors of resistances 5.00 Ω, 10.0 Ω and 15.0 Ω.



The potential difference (p.d.) between P and Q is balanced against 12.5 cm of the resistance wire, so that the ammeter reads zero.

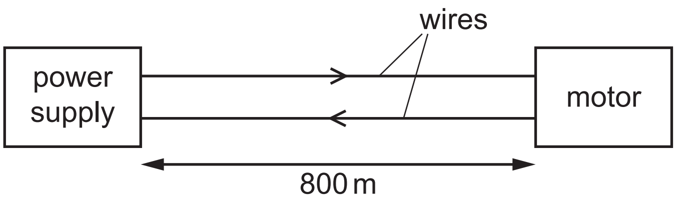
The p.d. across the other resistors is then balanced against other lengths of the resistance wire.

Which balanced lengths of resistance wire correspond to the connection points given in the table?

connection points	balanced length / cm			
	A	**B**	**C**	**D**
Q and R	12.5	25.0	25.0	25.0
Q and S	62.5	62.5	75.0	62.5
P and R	37.5	37.5	37.5	12.5

37 A motor is required to operate at a distance of 800 m from its power supply. The motor requires a potential difference (p.d.) of 16.0 V and a current of 0.60 A to operate.

Two wires are used to supply power to the motor as shown.



The resistance of each of these wires is 0.0050 Ω per metre.

What is the minimum output p.d. of the power supply?

A 11.2 V **B** 16.0 V **C** 18.4 V **D** 20.8 V

38 Which elementary particle is a lepton?

A proton

B neutron

C electron

D quark

39 How many down quarks are in a nucleus of hydrogen-3, ${}^{3}_{1}H$?

A 2 **B** 3 **C** 4 **D** 5

40 What is the correct equation for β^+ decay?

A neutron $\rightarrow$ proton + electron + electron antineutrino

B neutron $\rightarrow$ proton + electron + electron neutrino

C proton $\rightarrow$ neutron + positron + electron antineutrino

D proton $\rightarrow$ neutron + positron + electron neutrino

Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2018**

1 hour 15 minutes

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

* 4 4 6 2 8 9 6 4 9 6 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

IB18 06_9702_12/3RP

CAMBRIDGE International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 A sheet of gold leaf has a thickness of 0.125 μm. A gold atom has a radius of 174 pm.

Approximately how many layers of atoms are there in the sheet?

A 4 **B** 7 **C** 400 **D** 700

2 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. C_d is given by the equation

$$C_d = \frac{2F}{v^n \rho A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n?

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

3 A student measures the current through a resistor and the potential difference (p.d.) across it. There is a 4% uncertainty in the current reading and a 1% uncertainty in the p.d. reading. The student calculates the resistance of the resistor.

What is the percentage uncertainty in the calculated resistance?

A 0.25% **B** 3% **C** 4% **D** 5%

4 A student applies a potential difference V of (4.0 ± 0.1) V across a resistor of resistance R of $(10.0 \pm 0.3)\,\Omega$ for a time t of (50 ± 1) s.

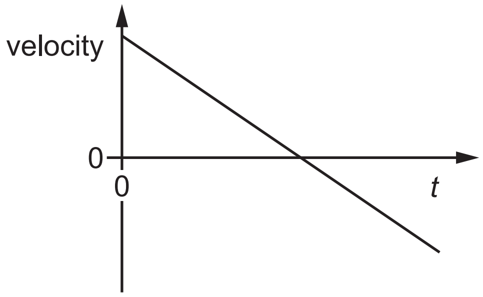
The student calculates the energy E dissipated using the equation below.

$$E = \frac{V^2 t}{R} = \frac{4.0^2 \times 50}{10.0} = 80\,\text{J}$$

What is the absolute uncertainty in the calculated energy value?

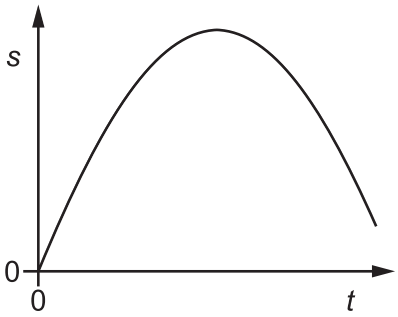
A 1.5 J **B** 3 J **C** 6 J **D** 8 J

5 The velocity of an object changes with time t as shown.

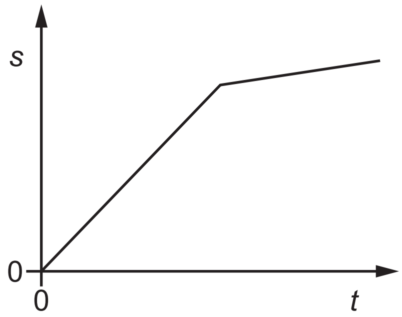


Which graph best shows the variation with time t of the displacement s of the object?

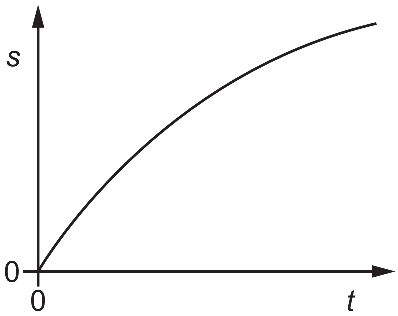
A



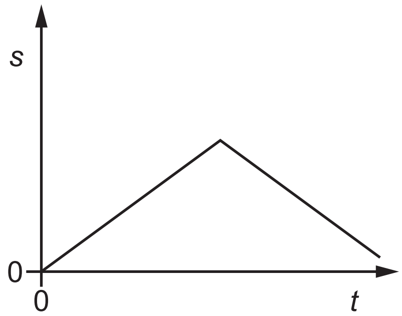
B



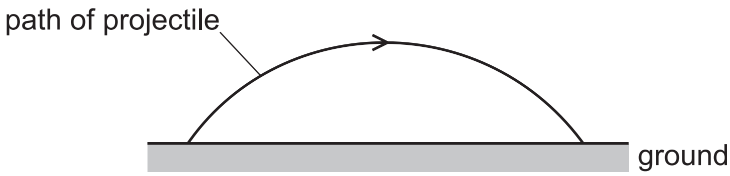
C



D

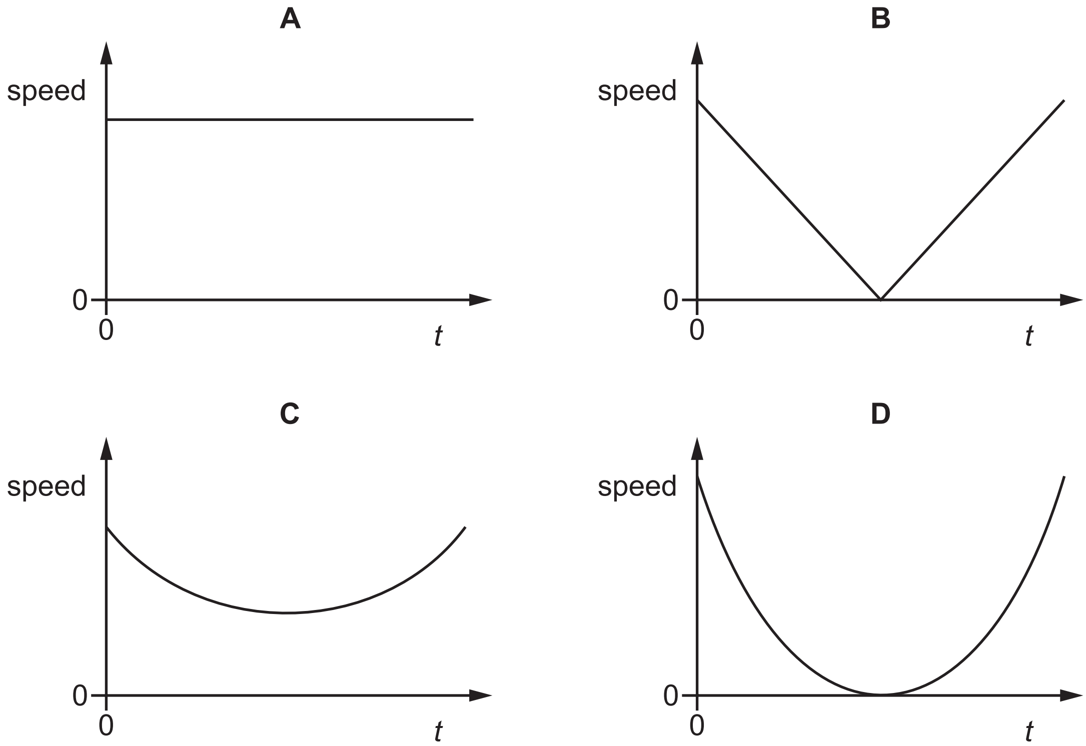


6 A projectile is launched at an angle to the horizontal at time $t = 0$. It travels over horizontal ground, as shown.

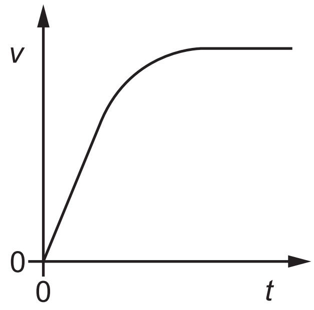


Assume that air resistance is negligible.

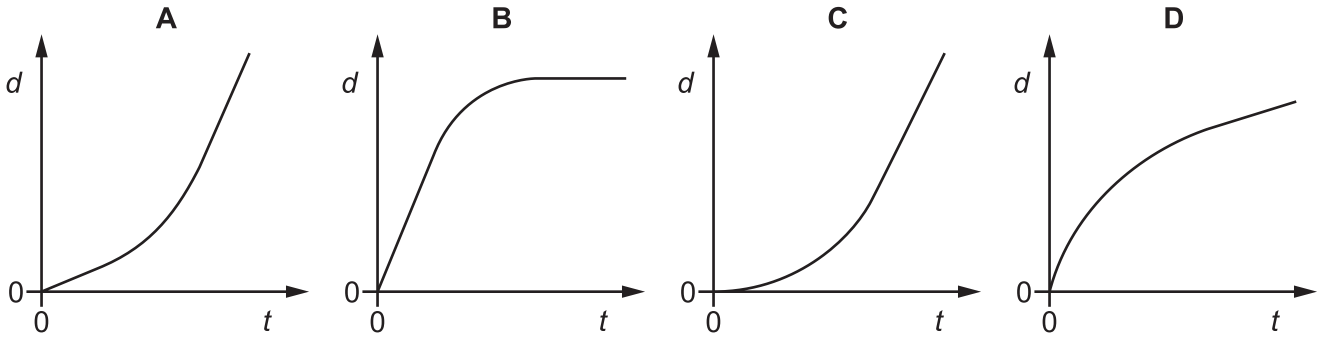
Which graph best shows the variation with t of the speed of the projectile from when it is launched to when it lands on the ground?



7 A sky-diver falls vertically from a helicopter and reaches constant (terminal) velocity. The graph shows the variation with time t of the speed v of the sky-diver.



Which graph shows the variation with time t of the distance d fallen by the sky-diver?



8 A tennis ball of mass 55 g is travelling horizontally with a speed of $30\,\text{m}\,\text{s}^{-1}$. The ball makes contact with a wall before rebounding in the horizontal direction with a speed of $20\,\text{m}\,\text{s}^{-1}$. The ball is in contact with the wall for a time of 5.0×10^{-3} s.

What is the average force exerted on the wall by the ball?

A 110 N **B** 220 N **C** 330 N **D** 550 N

9 An elastic collision occurs between two bodies X and Y. The mass of body X is m and the mass of body Y is $4m$. Body X travels at speed v before the collision and speed $\frac{3v}{5}$ in the opposite direction after the collision. Body Y is stationary before the collision.

What is the kinetic energy of body Y after the collision?

A $\frac{8}{10}mv^2$ **B** $\frac{34}{50}mv^2$ **C** $\frac{16}{50}mv^2$ **D** $\frac{1}{5}mv^2$

10 The density of water is $1.0\,g\,cm^{-3}$ and the density of glycerine is $1.3\,g\,cm^{-3}$.

Water is added to a measuring cylinder containing $40\,cm^3$ of glycerine so that the density of the mixture is $1.1\,g\,cm^{-3}$. Assume that the mixing process does not change the total volume of the liquid.

What is the volume of water added?

A $40\,cm^3$ **B** $44\,cm^3$ **C** $52\,cm^3$ **D** $80\,cm^3$

11 An astronaut throws a stone horizontally near to the surface of the Moon, where there is no atmosphere.

Which row describes the horizontal and vertical forces acting on the stone after release?

	horizontal force	vertical force
A	non-zero and constant	constant
B	non-zero and constant	decreasing
C	zero	constant
D	zero	decreasing

12 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?

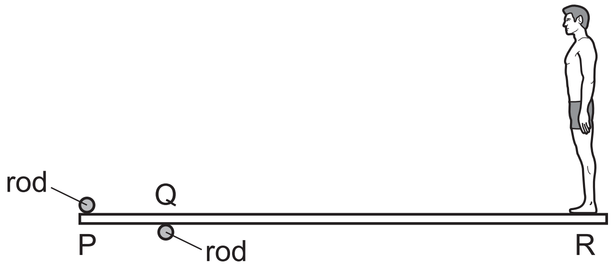
A $(p_b - p_t)$

B $(p_b - p_t)A$

C $(p_b - p_t)A - W$

D $(p_b - p_t)A + W$

13 A uniform diving-board is held by two fixed rods at points P and Q. A person stands at end R of the diving-board, as shown.

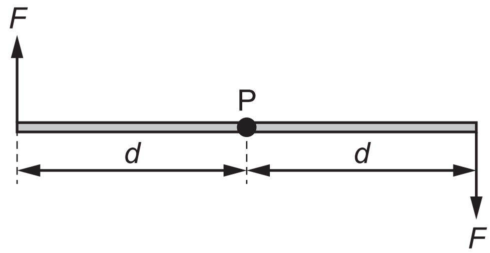


The forces exerted by the rods on the board are vertical. The board remains in equilibrium as the person slowly moves towards point Q from end R.

Which row describes the changes to the forces exerted by the rods on the board?

	force at P	force at Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

14 Two forces, each of magnitude F, act in opposite directions on a rod.

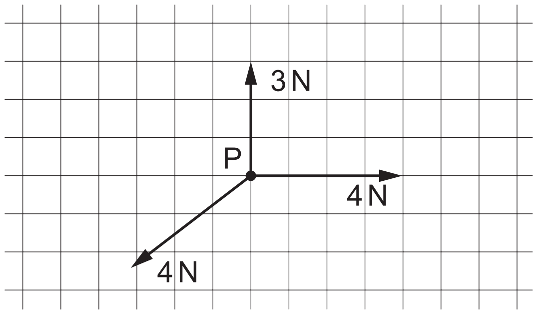


Each force acts on the rod at a distance d from the pivot P.

What is the torque of this couple about P?

A 0 **B** $F \times d$ **C** $2F \times d$ **D** $2F \times 2d$

15 The vector diagram shows three coplanar forces acting on an object at P.



The magnitude of the resultant of these three forces is 1 N.

What is the direction of this resultant force?

A ↙ **B** ↘ **C** ↖ **D** ↗

16 In ‘normal driving conditions’, an electric car has a range of 150 km. This uses all of the 200 MJ of energy stored in its batteries.

With the batteries initially fully charged, the car is driven 100 km in ‘normal driving conditions’. The batteries are then recharged from a household electrical supply delivering a constant current of 13.0 A at a potential difference of 230 V.

What is the minimum time required to recharge the batteries?

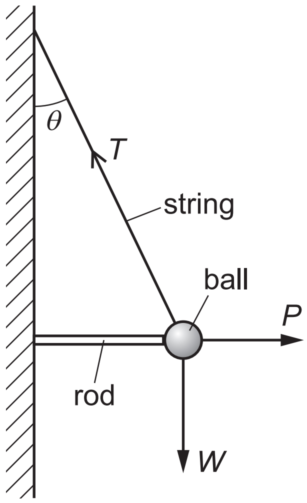
A 0.95 hours

B 12.4 hours

C 18.6 hours

D 27.9 hours

17 The diagram shows a ball of weight W hanging in equilibrium from a string.



The string is at an angle θ to the vertical. The tension in the string is T. The ball is held away from the wall by a horizontal force P from a metal rod.

What is the relationship between the magnitudes of T, P and W?

A $P = T\cos\theta$ and $W = T\sin\theta$

B $T = P + W$

C $T^2 = P^2 + W^2$

D $W = P\tan\theta$ and $W = T\cos\theta$

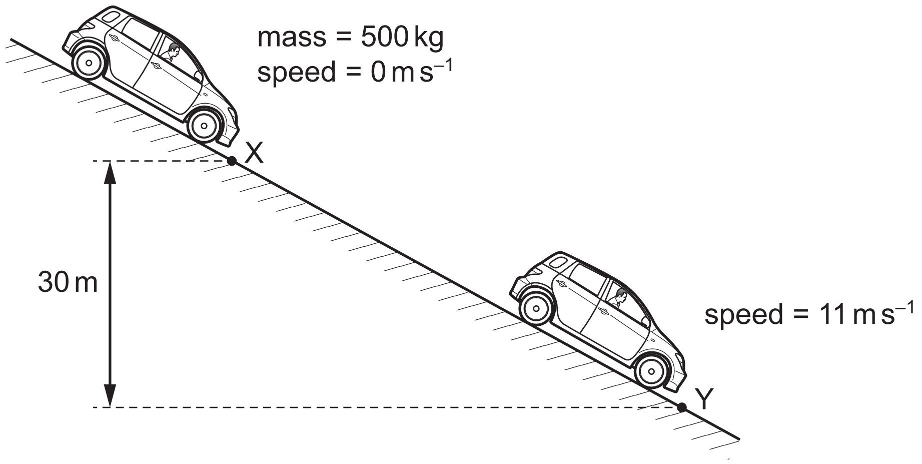
18 A steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with speed u, leaves it at speed v, and rebounds vertically to half of its original height. Ignore air resistance.

Which expression gives the value of $\frac{v}{u}$?

A $\frac{1}{2^2}$ **B** $\frac{1}{2}$ **C** $\frac{1}{\sqrt{2}}$ **D** $1 - \frac{1}{\sqrt{2}}$

19 A car of mass 500 kg is at rest at point X on a slope, as shown.

The car's brakes are released and the car rolls down the slope with its engine switched off. At point Y the car has moved through a vertical height of 30 m and has a speed of 11 m s^{-1}.



What is the energy dissipated by frictional forces when the car moves from X to Y?

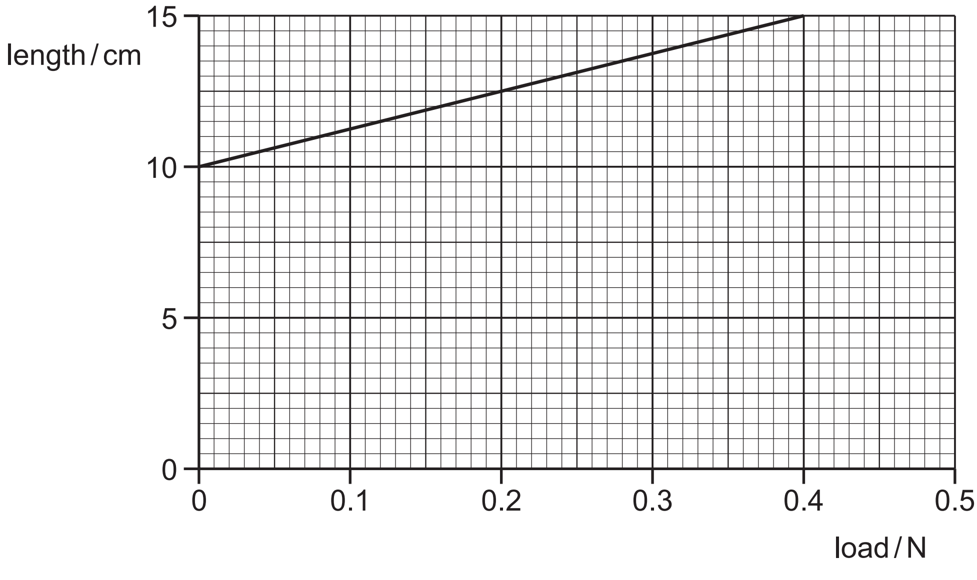
A 3.0×10^4 J **B** 1.2×10^5 J **C** 1.5×10^5 J **D** 1.8×10^5 J

20 An elastic material with Young modulus E is subjected to a tensile stress S. Hooke's law is obeyed.

What is the expression for the elastic energy stored per unit volume of the material?

A $\dfrac{E}{2S^2}$ **B** $\dfrac{2E}{S^2}$ **C** $\dfrac{S^2}{E}$ **D** $\dfrac{S^2}{2E}$

21 The graph shows the length of a spring as it is stretched by an increasing load.



What is the spring constant of the spring?

A 0.080 N m^{-1} **B** 0.13 N m^{-1} **C** 2.7 N m^{-1} **D** 8.0 N m^{-1}

22 Two lasers emit light in a vacuum. One laser emits red light and the other emits green light.

Which property of the two laser beams **must** be different?

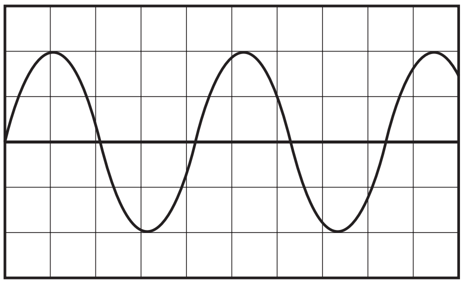
A amplitude

B frequency

C intensity

D speed

23 The diagram shows the screen of a cathode-ray oscilloscope (c.r.o.) displaying a wave.

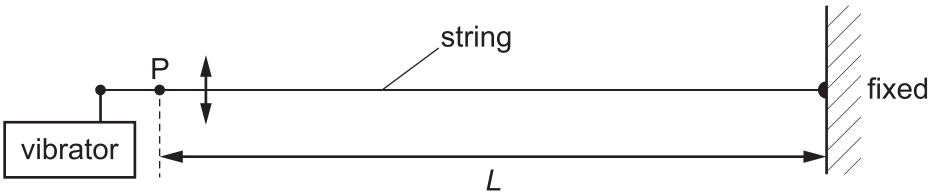


The time-base of the c.r.o. is set at 10 ms / division.

What is the frequency of the wave?

A 0.24 Hz **B** 4.2 Hz **C** 12 Hz **D** 24 Hz

24 A string is fixed at one end and the other end is attached to a vibrator. The frequency of the vibrator is slowly increased from zero. A series of stationary waves is formed. Assume that for a stationary wave there is a node at point P.



What are the first five wavelengths of the stationary waves that could be formed?

A $2\frac{L}{1}, 2\frac{L}{2}, 2\frac{L}{3}, 2\frac{L}{4}, 2\frac{L}{5}$

B $2\frac{L}{2}, 2\frac{L}{3}, 2\frac{L}{4}, 2\frac{L}{5}, 2\frac{L}{6}$

C $4\frac{L}{1}, 4\frac{L}{2}, 4\frac{L}{3}, 4\frac{L}{4}, 4\frac{L}{5}$

D $4\frac{L}{1}, 4\frac{L}{3}, 4\frac{L}{5}, 4\frac{L}{7}, 4\frac{L}{9}$

25 Which region of the electromagnetic spectrum has waves of wavelength 1000 times smaller than the wavelength of visible light?

A infra-red

B microwaves

C ultraviolet

D X-rays

26 The diagram shows apparatus for the measurement of the frequency of a sound wave.

Sound of the unknown frequency is reflected back from a metal plate. A microphone placed at a distance D from the metal plate detects the sound intensity. A minimum intensity is detected with D = 12.0 cm. The plate is moved further away from the microphone until the next minimum is detected with D = 15.0 cm.

The speed of sound in air is $336\,\mathrm{m\,s^{-1}}$.

What is the frequency of the sound?

A 56 Hz **B** 112 Hz **C** 5600 Hz **D** 11 200 Hz

27 An astronomer observes the light from a star that is moving away from the Earth.

For the observed light, what has been increased due to the star's motion?

A amplitude

B frequency

C speed

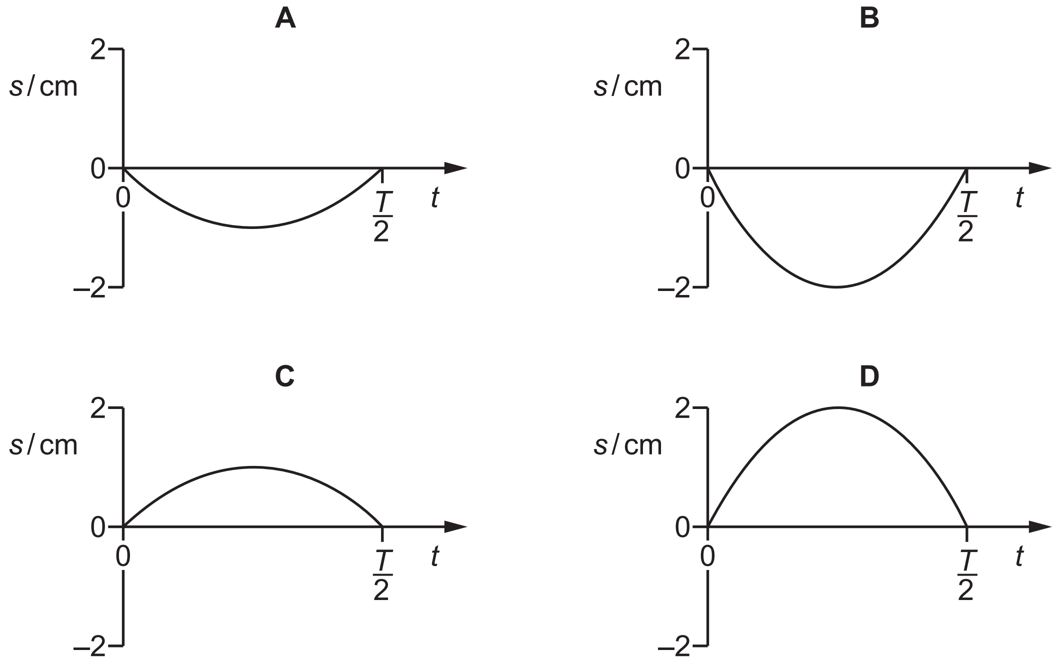
D wavelength

28 The diagram shows a stationary wave, at time t = 0, that has been set up on a string fixed between points P and S.

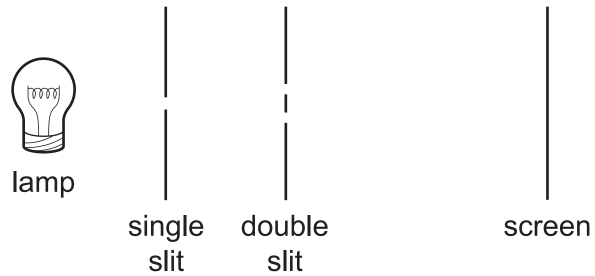
The nodes of the stationary wave occur on the string at P, Q, R and S. Point X is moving down at time t = 0. The points on the string vibrate with time period T and maximum amplitude 2 cm.

The displacement s is positive in the upward direction.

Which graph best shows the variation with t of the displacement s of point Y on the string?



29 A two-source interference experiment uses the apparatus shown.



What is the main purpose of the single slit?

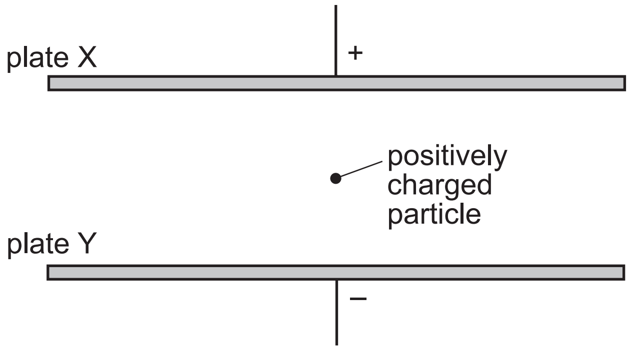
A to make a narrow beam of light

B to make the same amplitude of light incident on each slit

C to provide coherent light

D to provide monochromatic light

30 Two large parallel metal plates X and Y are situated in a vacuum as shown.



Plates X and Y carry equal and opposite charges.

What happens to the force on a positively charged particle as it moves from plate X to plate Y?

A It decreases because the positively charged particle is moving away from the positively charged plate.

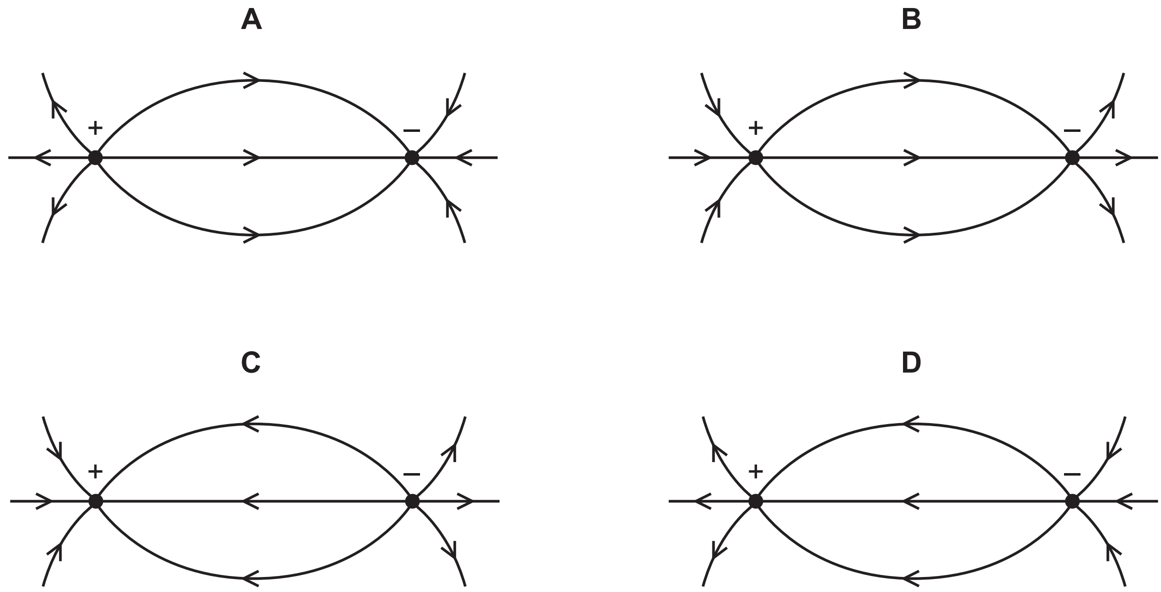
B It decreases because the positively charged particle is moving in the direction of the electric field between the plates.

C It increases because the positively charged particle is moving closer to a negatively charged plate.

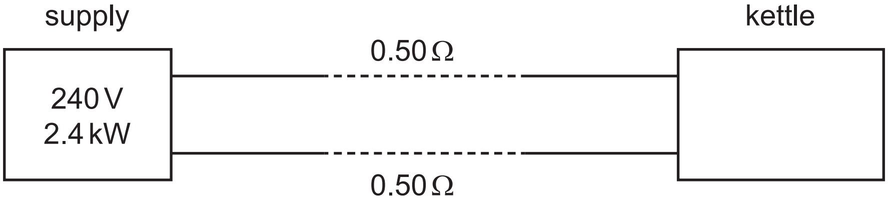
D It remains constant because the positively charged particle is in the uniform electric field between the plates.

31 Four diagrams representing the electric field between two oppositely-charged point charges are shown.

Which diagram correctly shows the electric field lines?



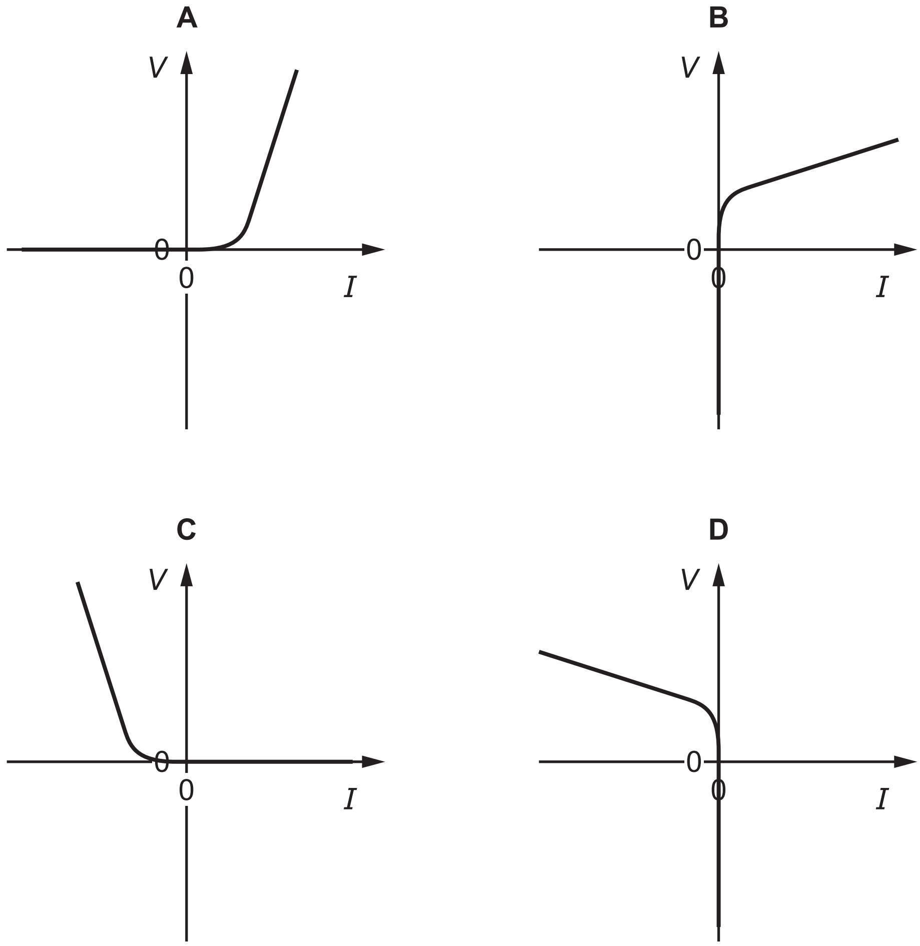
32 The power output of an electrical supply is 2.4 kW at a potential difference (p.d.) of 240 V. The two wires between the supply and a kettle each have a resistance of 0.50 Ω, as shown.



What is the power supplied to the kettle and what is the p.d. across the kettle?

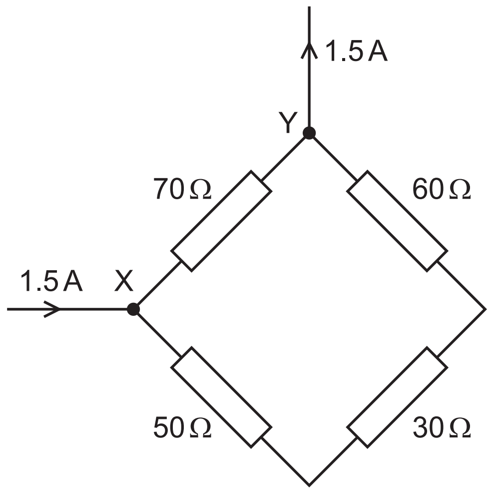
	power / kW	p.d. / V
A	2.3	230
B	2.3	235
C	2.4	230
D	2.4	235

33 Which graph shows the variation of voltage V with current I for a semiconductor diode?



34 Four different resistors are arranged as shown.

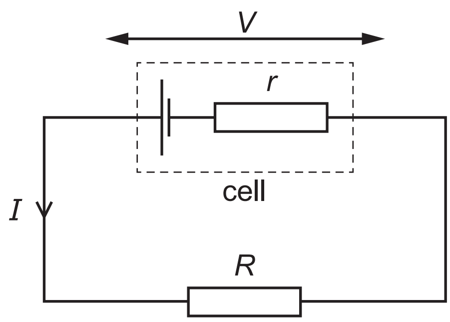
A current of 1.5 A enters the network at junction X and leaves through junction Y.



What is the current in the resistor of resistance 30 Ω?

A 0.21 A **B** 0.50 A **C** 0.75 A **D** 1.0 A

35 A cell of constant electromotive force drives a current I through an external resistor of resistance R. The terminal potential difference (p.d.) across the cell is V.

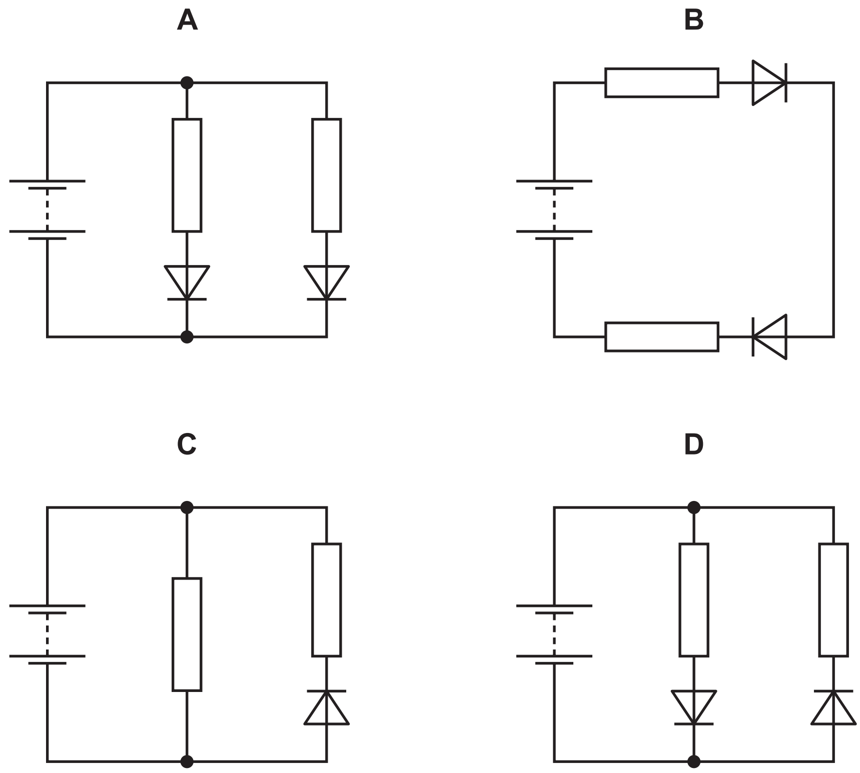


When the internal resistance r of the cell increases, what is the effect on V and on I?

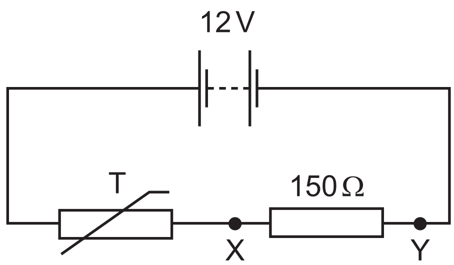
	V	I
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

36 In the circuits shown, the batteries are identical and all have negligible internal resistance. All of the resistors have the same resistance. The diodes have zero resistance when conducting and infinite resistance when not conducting.

In which circuit is the current in the battery greatest?



37 A thermistor is an electrical component with a resistance that varies with temperature. A thermistor T is used in a fire alarm system. The alarm is triggered when the potential difference between X and Y is 4.5 V.



What is the resistance of T when the alarm is triggered?

A 90 Ω **B** 150 Ω **C** 250 Ω **D** 400 Ω

38 In the α-particle scattering experiment, a beam of α-particles is aimed at a thin gold foil. Most of the α-particles go straight through or are deflected by a small angle. A very small proportion are deflected through more than 90°, effectively rebounding towards the source of the α-particles.

Which conclusion about the structure of atoms **cannot** be drawn from this experiment alone?

A Most of the atom is empty space.

B Most of the mass of an atom is concentrated in the nucleus.

C The nucleus contains both protons and neutrons.

D The nucleus is charged.

39 Radon-211, ${}^{211}_{86}\text{Rn}$, francium-210, ${}^{210}_{87}\text{Fr}$, and radium-212, ${}^{212}_{88}\text{Ra}$, are three nuclides.

How many neutrons does each nuclide have in its nucleus?

	radon-211	francium-210	radium-212
A	86	87	88
B	125	123	124
C	211	210	212
D	297	297	300

40 A neutron is composed of one up (u) quark and two down (d) quarks. When the neutron decays to a proton, there is β-emission.

What is the change in the quark structure of the neutron due to the β-emission?

(The symbol for a neutrino is ν_e and for an antineutrino is $\overline{\nu_e}$.)

A $d \rightarrow u + \beta^- + \nu_e$

B $d \rightarrow u + \beta^- + \overline{\nu_e}$

C $u \rightarrow d + \beta^+ + \nu_e$

D $u \rightarrow d + \beta^+ + \overline{\nu_e}$

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* 4 7 4 1 1 3 1 4 8 2 *

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2018**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **20** printed pages.

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Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is the best way of describing a physical quantity?

A a quantity with a magnitude and a direction but no unit

B a quantity with a magnitude and a unit

C a quantity with a magnitude but no direction

D a quantity with a unit but no magnitude

2 Which pair includes a vector quantity and a scalar quantity?

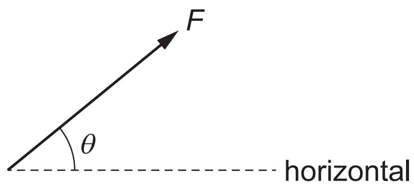
A displacement and acceleration

B force and kinetic energy

C power and speed

D work and potential energy

3 A force F acts at an angle θ to the horizontal.



What are the horizontal and the vertical components of the force?

	horizontal component	vertical component
A	$F\cos\theta$	$F\cos(90° - \theta)$
B	$F\cos\theta$	$F\sin(90° - \theta)$
C	$F\sin\theta$	$F\cos\theta$
D	$F\sin\theta$	$F\cos(90° - \theta)$

4 What will reduce the systematic errors when taking a measurement?

A adjusting the needle on a voltmeter so that it reads zero when there is no potential difference across it

B measuring the diameter of a wire at different points and taking the average

C reducing the parallax effects by using a marker and a mirror when measuring the amplitude of oscillation of a pendulum

D timing 20 oscillations, rather than a single oscillation, when finding the period of a pendulum

5 In an experiment to determine the Young modulus E of the material of a wire, the measurements taken are shown.

mass hung on end of wire	$m = 2.300 \pm 0.002\,\text{kg}$
original length of wire	$l = 2.864 \pm 0.005\,\text{m}$
diameter of wire	$d = 0.82 \pm 0.01\,\text{mm}$
extension of wire	$e = 7.6 \pm 0.2\,\text{mm}$

The Young modulus is calculated using

$$E = \frac{4mgl}{\pi d^2 e}$$

where g is the acceleration of free fall.

The calculated value of E is $1.61 \times 10^{10}\,\text{N m}^{-2}$.

How should the calculated value of E and its uncertainty be expressed?

A $(1.61 \pm 0.04) \times 10^{10}\,\text{N m}^{-2}$

B $(1.61 \pm 0.05) \times 10^{10}\,\text{N m}^{-2}$

C $(1.61 \pm 0.07) \times 10^{10}\,\text{N m}^{-2}$

D $(1.61 \pm 0.09) \times 10^{10}\,\text{N m}^{-2}$

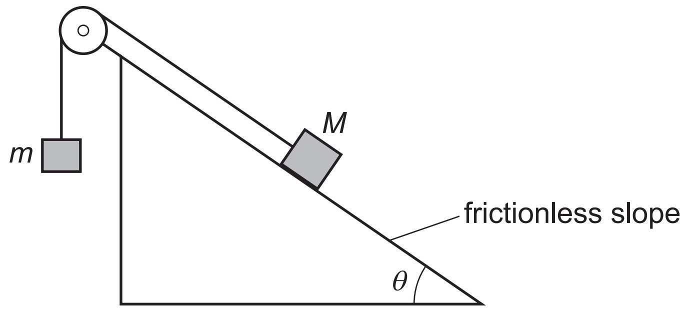
6 A rock on the surface of Mars is projected vertically upwards with an initial speed of $9.4\,\text{m s}^{-1}$. The rock rises to a height of 12 m above the surface.

Assume there is no atmosphere on Mars.

What is the acceleration of free fall near the surface of Mars?

A $0.39\,\text{m s}^{-2}$ **B** $3.7\,\text{m s}^{-2}$ **C** $7.4\,\text{m s}^{-2}$ **D** $9.8\,\text{m s}^{-2}$

7 Two masses, M and m, are connected by an inextensible string which passes over a frictionless pulley. Mass M rests on a frictionless slope, as shown.



The slope is at an angle θ to the horizontal.

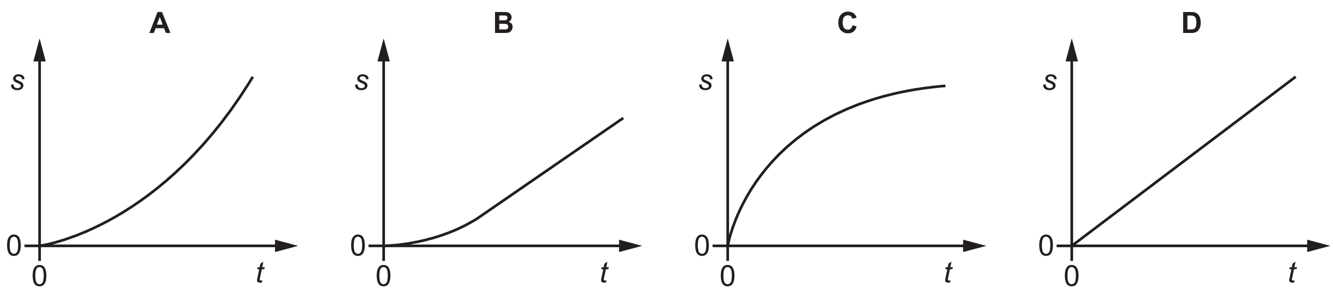
The two masses are initially held stationary and then released. Mass M moves down the slope.

Which expression **must** be correct?

A $\sin\theta < \frac{m}{M}$ **B** $\cos\theta < \frac{m}{M}$ **C** $\sin\theta > \frac{m}{M}$ **D** $\cos\theta > \frac{m}{M}$

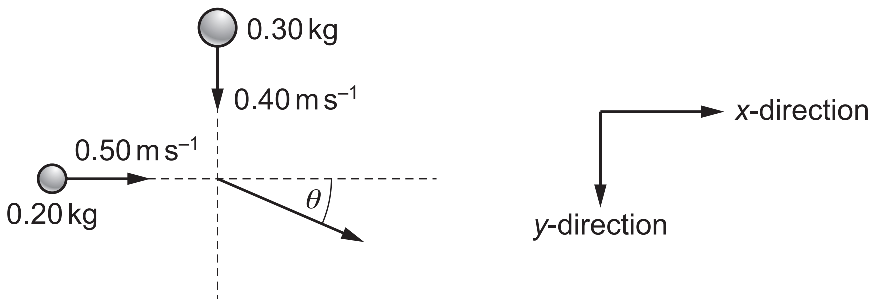
8 A sky-diver falls from a stationary balloon at time t = 0. As the sky-diver falls, her speed and the air resistance increase until the force of the air resistance is equal to her weight.

Which graph best shows the variation with time t of the displacement s for the motion of the sky-diver?



9 A ball of mass 0.20 kg, travelling in the x-direction at a speed of $0.50\,\mathrm{m\,s^{-1}}$, collides with a ball of mass 0.30 kg travelling in the y-direction at a speed of $0.40\,\mathrm{m\,s^{-1}}$.

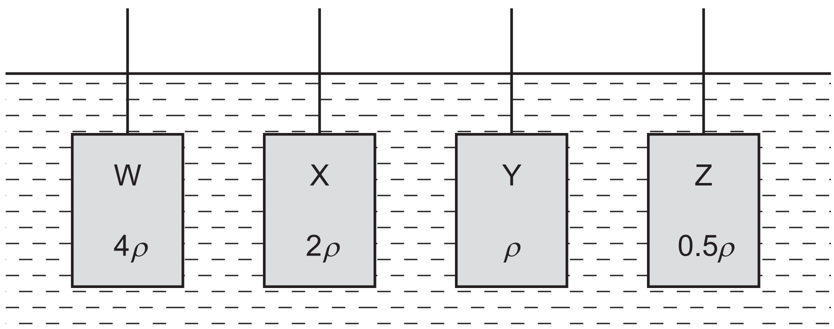
The two balls stick together after the collision, travelling at an angle θ to the x-direction.



What is the value of θ?

A 39° **B** 40° **C** 50° **D** 51°

10 Four cuboids with identical lengths, breadths and heights are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.



Water has density ρ.
Cuboid W is made of material of density 4ρ.
Cuboid X is made of material of density 2ρ.
Cuboid Y is made of material of density ρ.
Cuboid Z is made of material of density 0.5ρ.

Which statement is correct?

A The upthrust of the water on each of the cuboids is the same.

B The upthrust of the water on W is twice the upthrust of the water on X.

C The upthrust of the water on X is twice the upthrust of the water on W.

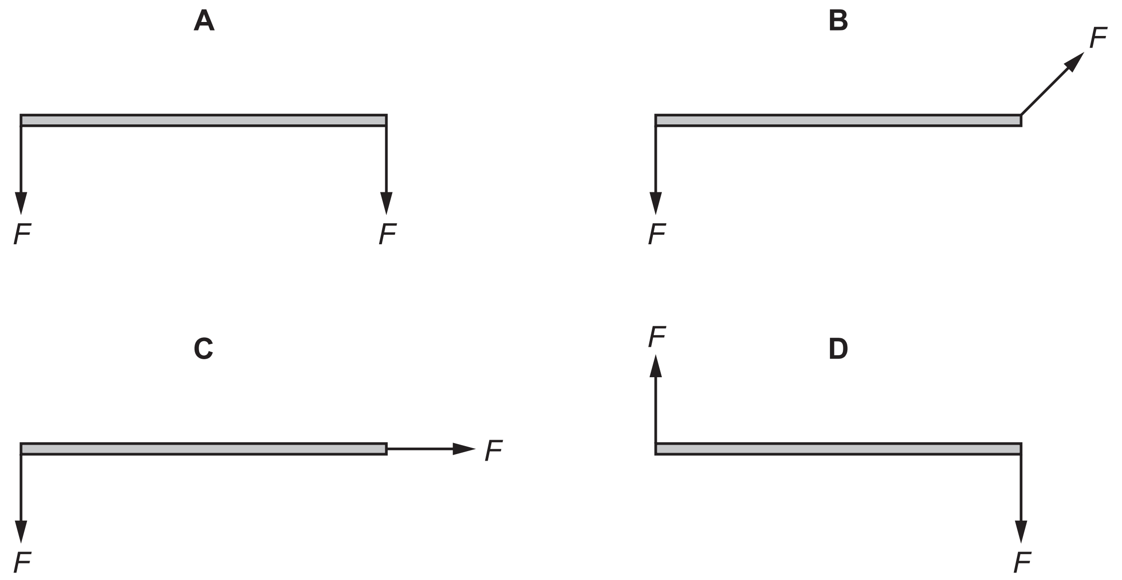
D The upthrust of the water on Y is zero.

11 A rectangular block of lead of density $1.13 \times 10^4\,\text{kg}\,\text{m}^{-3}$ has sides of length 12.0 cm, 15.0 cm and 10.0 cm.

What is the maximum pressure the block can exert when resting on a table?

A 1.13 kPa **B** 1.70 kPa **C** 11.1 kPa **D** 16.6 kPa

12 Which diagram shows a couple formed by two forces, each of magnitude F, acting on a rod?



13 Full-fat milk is made up of fat-free milk mixed with fat.

A volume of $1.000 \times 10^{-3}\,\text{m}^3$ of full-fat milk has a mass of 1.035 kg. It contains 4.00% fat by volume.

The density of fat-free milk is $1.040 \times 10^3\,\text{kg}\,\text{m}^{-3}$.

What is the density of fat?

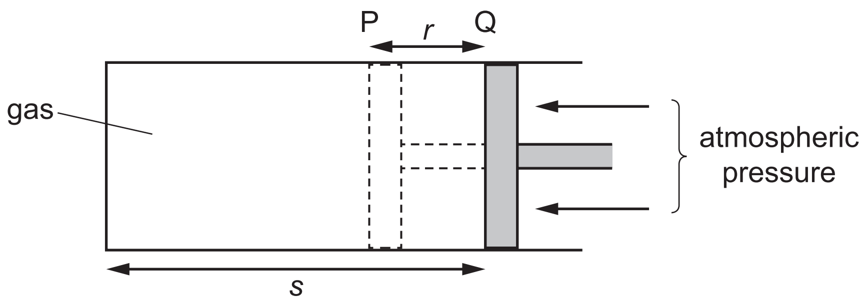
A $1.25 \times 10^2\,\text{kg}\,\text{m}^{-3}$

B $9.15 \times 10^2\,\text{kg}\,\text{m}^{-3}$

C $9.28 \times 10^2\,\text{kg}\,\text{m}^{-3}$

D $1.16 \times 10^3\,\text{kg}\,\text{m}^{-3}$

14 Gas is trapped inside a cylinder by a piston of cross-sectional area A. The piston is **not** frictionless.



The gas is heated and this causes it to expand, pushing back the piston through distance r from position P to position Q. The length of the gas column is then s.

Which expression represents the amount of work done by the gas against the atmosphere during this expansion?

A (atmospheric pressure) $\times Ar$

B (atmospheric pressure) $\times As$

C (pressure inside the gas) $\times Ar$

D (pressure inside the gas) $\times As$

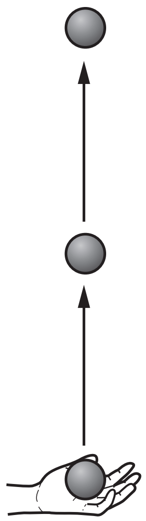
15 Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of $510\,\mathrm{kg\,s^{-1}}$. The reservoir is 280 m above the level of the turbine.

The electrical output from the generator driven by the turbine is a current of 205 A at a potential difference of 5800 V.

What is the efficiency of the system?

A 8.3% **B** 12% **C** 83% **D** 85%

16 A ball is thrown vertically up into the air. It rises to the top of its path before beginning to fall vertically downwards.



Assume that the gravitational potential energy of the ball is zero at its starting position.

Which statement about the ball is **not** correct?

A As it rises, its kinetic energy is transferred to gravitational potential energy.

B At the midpoint of its path, its gravitational potential energy is equal to its initial kinetic energy.

C At the top of its path, its kinetic energy is zero.

D At the top of its path, its total energy is less than its initial total energy.

17 A force of 1000 N is needed to lift the hook of a crane at a constant velocity. The crane is then used to lift a load of mass 1000 kg at a constant velocity of 0.50 $m\,s^{-1}$.

What is the power needed to lift the hook and the load?

A 4.9 kW **B** 5.4 kW **C** 20 kW **D** 22 kW

18 Data for a steel wire on an electric guitar are listed.

diameter = 5.0×10^{-4} m

Young modulus = 2.0×10^{11} Pa

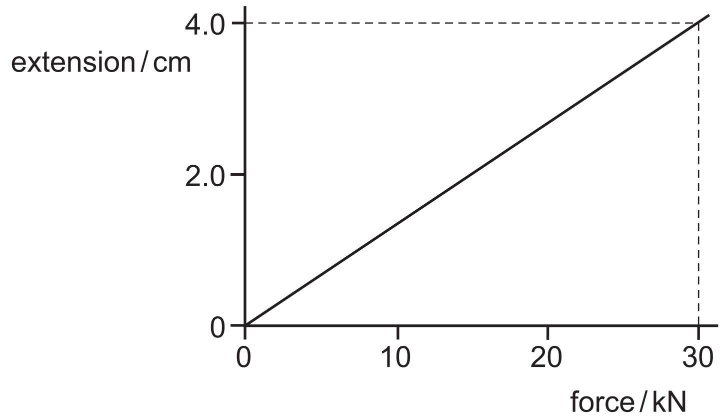
tension = 20 N

The wire snaps and contracts elastically. Assume the wire obeys Hooke's law.

By what percentage does the length l of a piece of the wire contract?

A 1.3×10^{-4} % **B** 5.1×10^{-4} % **C** 1.3×10^{-2} % **D** 5.1×10^{-2} %

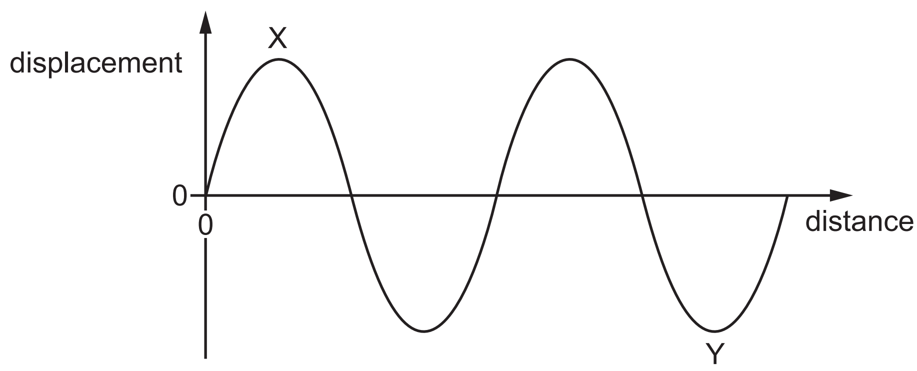
19 The graph shows how the extension of a spring varies with the force used to stretch it.



What is the strain energy in the spring when the extension is 4.0 cm?

A 60 J **B** 120 J **C** 600 J **D** 1200 J

20 The displacement-distance graph for a transverse progressive wave is shown.



The phase difference between points X and Y can be expressed as $(180\,n)°$.

What is the value of n?

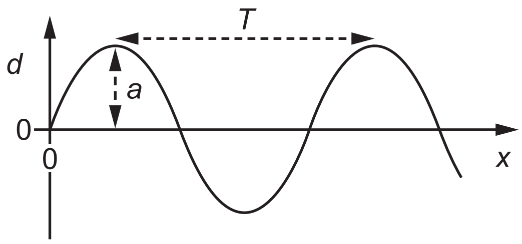
A 1.5 **B** 2.5 **C** 3.0 **D** 6.0

21 The four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x.

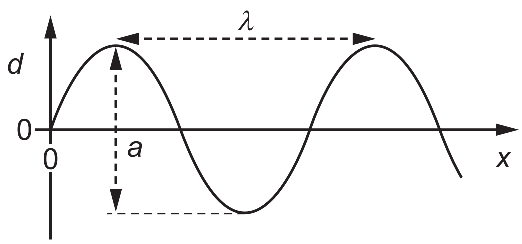
The labels on the graphs are intended to show the wavelength λ, the period T and the amplitude a of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?

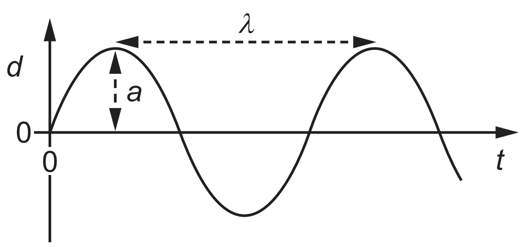
A



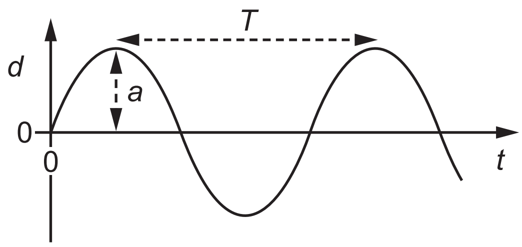
B



C

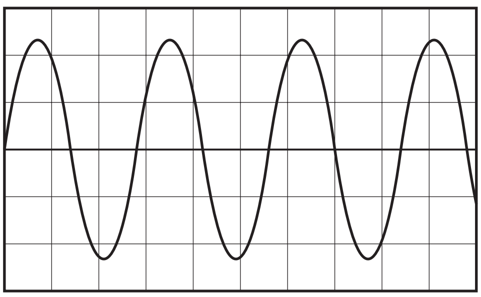


D



22 A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of a sound wave.

The diagram shows the waveform on the screen.



The time-base setting is 5.0 ms / div.

What is the frequency of the sound wave?

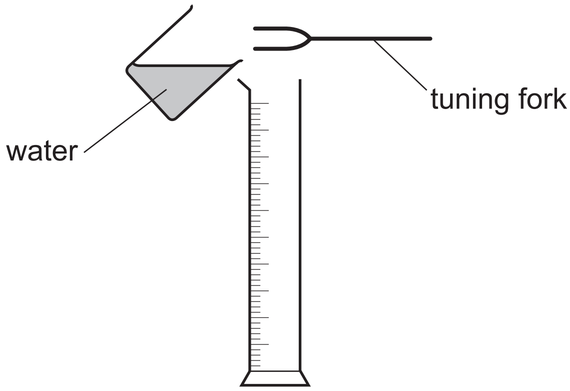
A 57 Hz **B** 71 Hz **C** 114 Hz **D** 143 Hz

23 A police car travels at a velocity of $30.0\,m\,s^{-1}$ directly towards a stationary observer. The horn of the car emits sound of frequency 2000 Hz. The speed of sound is $340\,m\,s^{-1}$.

What is the frequency of the sound heard by the observer?

A 1840 Hz **B** 2000 Hz **C** 2180 Hz **D** 2190 Hz

24 A vibrating tuning fork is held over a measuring cylinder, as shown.



Water is then gradually poured into the measuring cylinder. A much louder sound is first heard when the water level is 2.9 cm above the base of the measuring cylinder. A second much louder sound is heard when the water level reaches a height of 67.3 cm above the base.

The speed of sound in air is $330\,m\,s^{-1}$.

What is the frequency of the tuning fork?

A 128 Hz **B** 256 Hz **C** 512 Hz **D** 1024 Hz

25 A water wave in a ripple tank is diffracted as it passes through a gap in a barrier.

Which two factors affect the angle of diffraction of the wave?

A the amplitude and frequency of the incident wave

B the amplitude of the incident wave and the width of the gap

C the wavelength and amplitude of the incident wave

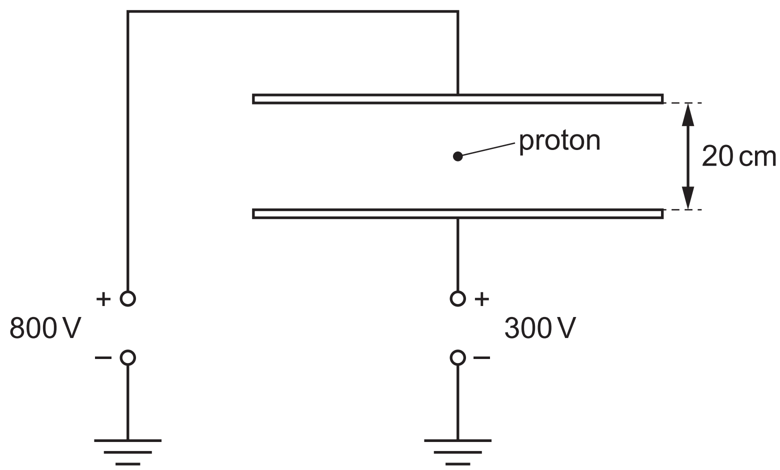
D the wavelength of the incident wave and the width of the gap

26 A double-slit interference pattern using red light of wavelength 7.0×10^{-7} m has a fringe spacing of 3.5 mm.

Which fringe spacing would be observed for the same arrangement of apparatus but using blue light of wavelength 4.5×10^{-7} m?

A 2.3 mm **B** 3.5 mm **C** 5.4 mm **D** 9.0 mm

27 Two parallel metal plates are situated 20 cm apart in a vacuum. They are connected to two sources of potential difference as shown.



A proton is released in the space between the plates.

What is the magnitude and direction of the acceleration of the proton?

A $2.4 \times 10^{11}\,\mathrm{m\,s^{-2}}$ downwards

B $2.4 \times 10^{11}\,\mathrm{m\,s^{-2}}$ upwards

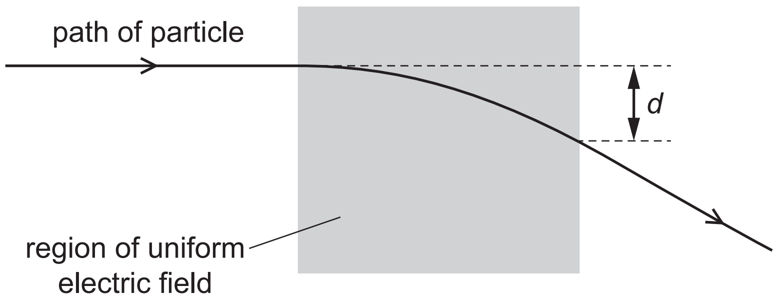
C $5.3 \times 10^{11}\,\mathrm{m\,s^{-2}}$ downwards

D $5.3 \times 10^{11}\,\mathrm{m\,s^{-2}}$ upwards

28 A particle having mass m and charge $+q$ enters a uniform electric field with speed v.

Initially, the particle is travelling at right-angles to the electric field.

During its movement through the field, the particle is deflected through distance d, as shown.



A second particle of mass $2m$, charge $+q$ and speed v enters the electric field along the same path.

What is the distance through which this particle is deflected in the electric field?

A $\dfrac{d}{4}$ **B** $\dfrac{d}{2}$ **C** $2d$ **D** $4d$

29 What is a possible charge on a particle?

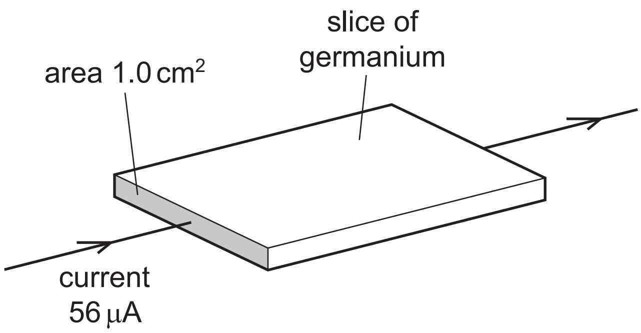
A 6.40×10^{-20} C

B 4.00×10^{-19} C

C 1.12×10^{-18} C

D 9.11×10^{-18} C

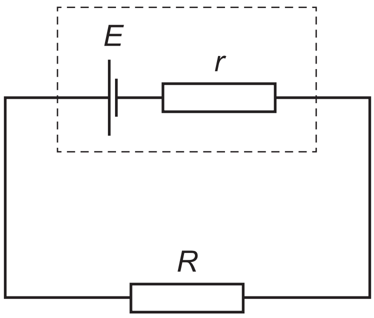
30 A slice of germanium of cross-sectional area $1.0\,\text{cm}^2$ carries a current of $56\,\mu\text{A}$. The number density of charge carriers in the germanium is $2.0 \times 10^{13}\,\text{cm}^{-3}$. Each charge carrier has a charge equal to the charge on an electron.



What is the average drift velocity of the charge carriers in the germanium?

A $0.18\,\text{m}\,\text{s}^{-1}$ **B** $18\,\text{m}\,\text{s}^{-1}$ **C** $180\,\text{m}\,\text{s}^{-1}$ **D** $1800\,\text{m}\,\text{s}^{-1}$

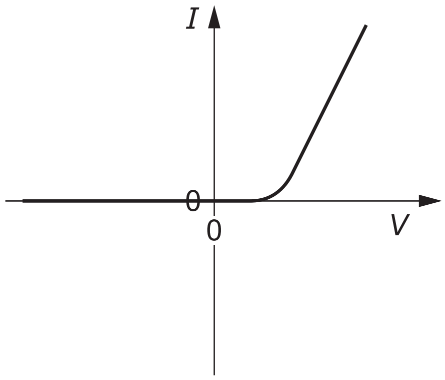
31 A cell of electromotive force (e.m.f.) E and internal resistance r is connected to an external resistor of resistance R, as shown.



What is the power dissipated in the external resistor?

A $\dfrac{E^2(R+r)}{R^2}$ **B** $\dfrac{E^2R}{(R+r)^2}$ **C** $\dfrac{E^2(R+r)}{r^2}$ **D** $\dfrac{E^2r}{(R+r)^2}$

32 The graph shows the I-V characteristic of an electrical component.



What is the component?

A a filament lamp

B a metallic conductor at constant temperature

C a resistor

D a semiconductor diode

33 A metal wire of length 1.4 m has a uniform cross-sectional area of $7.8 \times 10^{-7}\,\text{m}^2$.

The resistivity of the metal is $1.7 \times 10^{-8}\,\Omega\,\text{m}$.

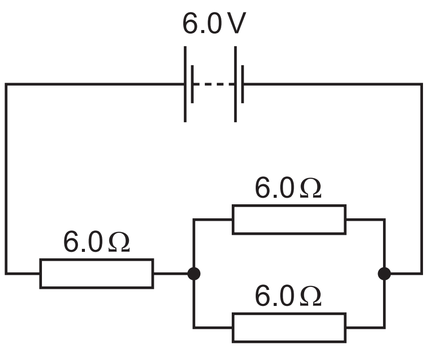
What is the resistance of the wire?

A $0.016\,\Omega$ **B** $0.031\,\Omega$ **C** $33\,\Omega$ **D** $64\,\Omega$

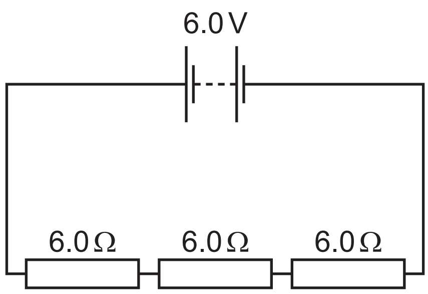
34 A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors each of resistance 6.0 Ω.

Which circuit will produce a current through the battery of 0.67 A?

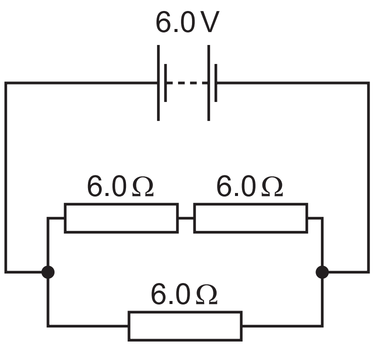
A



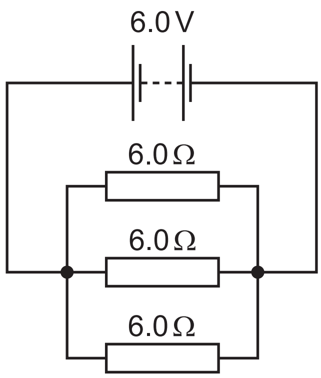
B



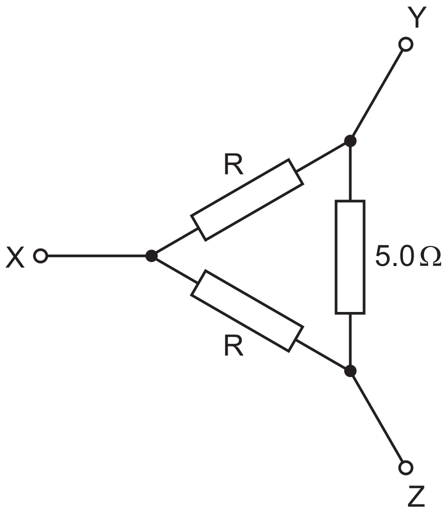
C



D



35 The diagram shows a network of three resistors. Two of these, marked R, are identical. The other resistor has a resistance of 5.0 Ω.



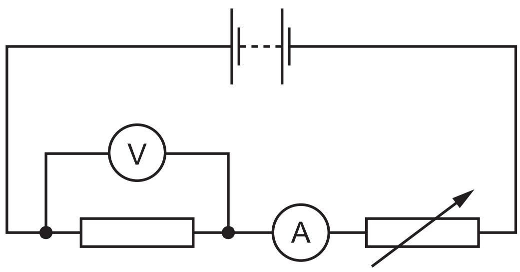
The resistance between Y and Z is found to be 2.5 Ω.

What is the resistance between X and Y?

A 0.30 Ω **B** 0.53 Ω **C** 1.9 Ω **D** 3.3 Ω

36 The diagram shows a battery, a fixed resistor, an ammeter and a variable resistor connected in series.

A voltmeter is connected across the fixed resistor.

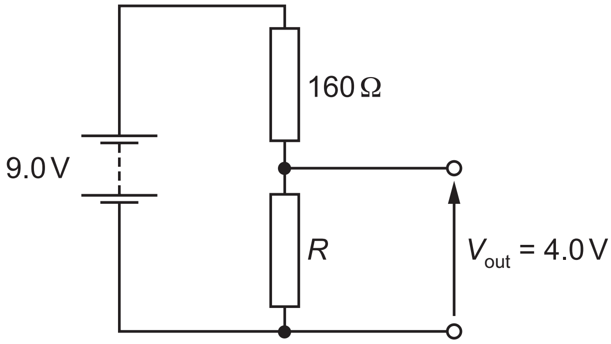


The resistance of the variable resistor is reduced.

Which row describes the changes in the readings of the ammeter and of the voltmeter?

	ammeter	voltmeter
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

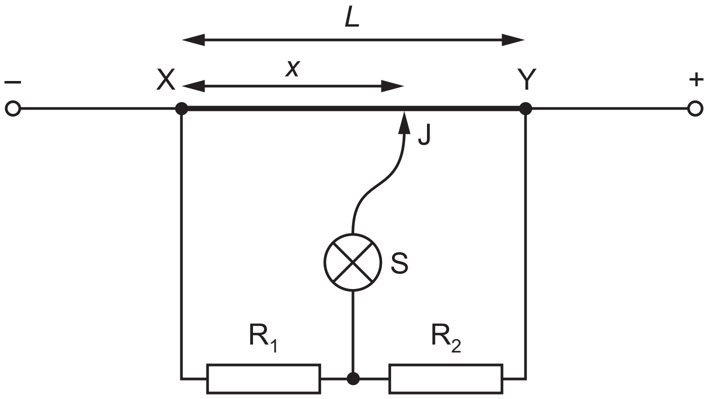
37 The circuit diagram shows a battery of electromotive force (e.m.f.) 9.0 V and negligible internal resistance. It is connected to two resistors of resistances 160 Ω and R. The output potential difference V_{out} is 4.0 V.



What is the resistance R?

A 32 Ω **B** 49 Ω **C** 71 Ω **D** 128 Ω

38 In the circuit shown, XY is a length L of uniform resistance wire. A potential difference is applied across XY. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a lamp S.



J is moved along XY to a point at which the lamp is off. This point is at a distance x from X.

The potential difference across R_1 is V_1 and the potential difference across R_2 is V_2.

What is the value of the ratio $\frac{V_1}{V_2}$?

A $\frac{L}{x}$ **B** $\frac{x}{L}$ **C** $\frac{L-x}{x}$ **D** $\frac{x}{L-x}$

39 A nucleus of magnesium-23 undergoes β^+ decay, as represented by the nuclear equation shown.

$$^{23}_{12}\mathrm{Mg} \rightarrow \mathrm{X} + \beta^+ + \nu_e$$

What is nucleus X?

A $^{22}_{11}\mathrm{Na}$ **B** $^{22}_{13}\mathrm{A}l$ **C** $^{23}_{11}\mathrm{Na}$ **D** $^{23}_{13}\mathrm{A}l$

40 Which list contains only leptons?

A electron, neutrino, positron

B electron, neutrino, proton

C electron, proton, neutron

D neutrino, neutron, positron

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2019**

1 hour 15 minutes

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

7108167400

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

IB19 06_9702_11/4RP

Cambridge Assessment International Education

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 Which unit can be expressed in base units as $kg\,m^2\,s^{-2}$?

A joule

B newton

C pascal

D watt

2 The luminosity L of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

r is the radius of the star,

T is the temperature of the star and

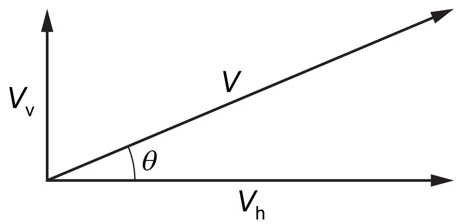
σ is a constant with units $W\,m^{-2}\,K^{-4}$.

What are the SI base units of L?

A $kg\,m^2\,s^{-1}$ **B** $kg\,m^2\,s^{-2}$ **C** $kg\,m^2\,s^{-3}$ **D** $kg\,m^2\,s^{-4}$

3 A particle has velocity V at an angle θ to the horizontal.

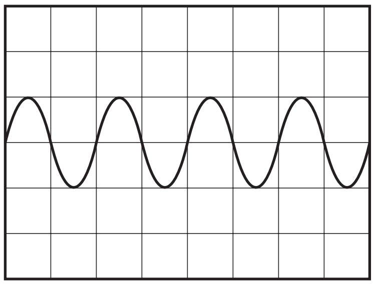
The components of the particle's velocity are V_v upwards in the vertical direction and V_h to the right in the horizontal direction, as shown.



What are expressions for the magnitude of V and for the angle θ?

	magnitude of V	θ
A	$\sqrt{(V_v^2 + V_h^2)}$	$\tan^{-1}\left(\frac{V_h}{V_v}\right)$
B	$\sqrt{(V_v^2 + V_h^2)}$	$\tan^{-1}\left(\frac{V_v}{V_h}\right)$
C	$\sqrt{(V_v^2 - V_h^2)}$	$\tan^{-1}\left(\frac{V_h}{V_v}\right)$
D	$\sqrt{(V_v^2 - V_h^2)}$	$\tan^{-1}\left(\frac{V_v}{V_h}\right)$

4 A whale produces sound waves of frequency 5 Hz. The waves are detected by a microphone and displayed on an oscilloscope.



What is the time-base setting on the oscilloscope?

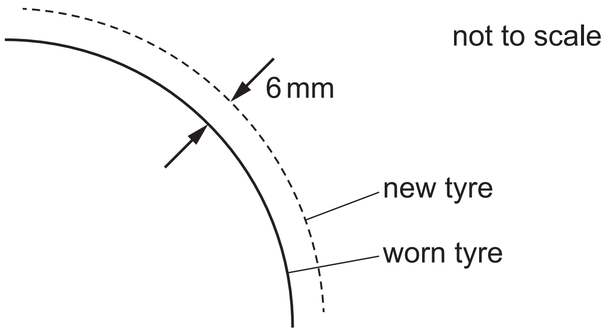
A $0.1\,\text{ms div}^{-1}$ **B** $1\,\text{ms div}^{-1}$ **C** $10\,\text{ms div}^{-1}$ **D** $100\,\text{ms div}^{-1}$

5 The speed shown on a car's speedometer is proportional to the rate of rotation of the tyres.

The variation of the diameter of a tyre as it wears introduces an error in the speed shown on the speedometer.

A car has new tyres of diameter 600 mm. The speedometer is accurately calibrated for this diameter.

The tyres wear as shown, with 6 mm of material being removed from the outer surface.



What is the error in the speed shown on the speedometer after this wear has taken place?

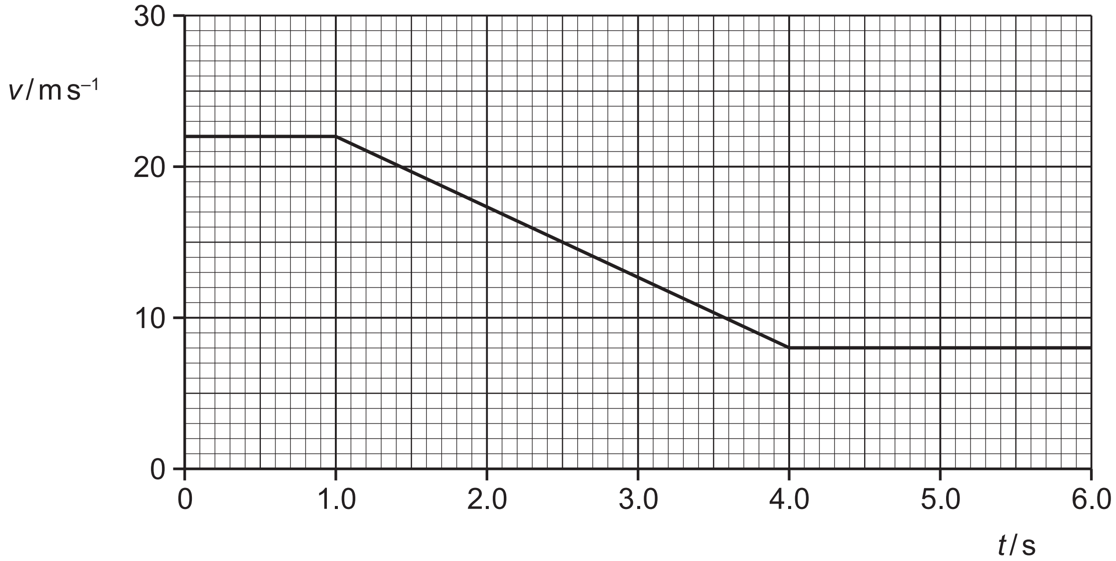
A The speed shown is too high by 1%.

B The speed shown is too high by 2%.

C The speed shown is too low by 1%.

D The speed shown is too low by 2%.

6 A car travels along a straight horizontal road. The graph shows the variation of the velocity v of the car with time t for 6.0 s of its journey.



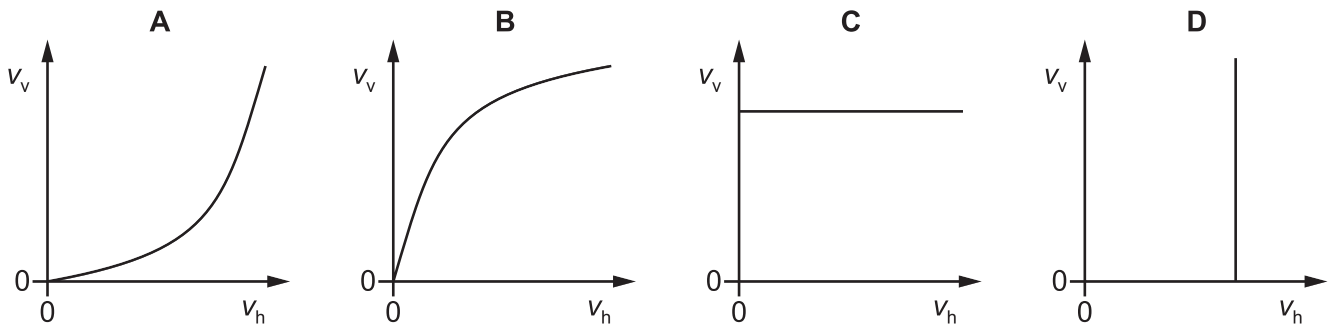
The brakes of the car are applied from t = 1.0 s to t = 4.0 s.

How far does the car travel while the brakes are applied?

A 21 m **B** 45 m **C** 67 m **D** 83 m

7 A stone is thrown horizontally from the top of a cliff and falls into the sea some time later. Air resistance is negligible.

Which graph shows how the vertical component v_v of velocity of this stone varies with its horizontal component v_h of velocity as it moves through the air?



8 A positive charge of 2.6×10^{-8} C is in a uniform electric field of field strength 300 000 V m^{-1}.

How much work must be done on the charge in order to move it a distance of 4.0 mm in the opposite direction to the direction of the field?

A 3.1×10^{-5} J

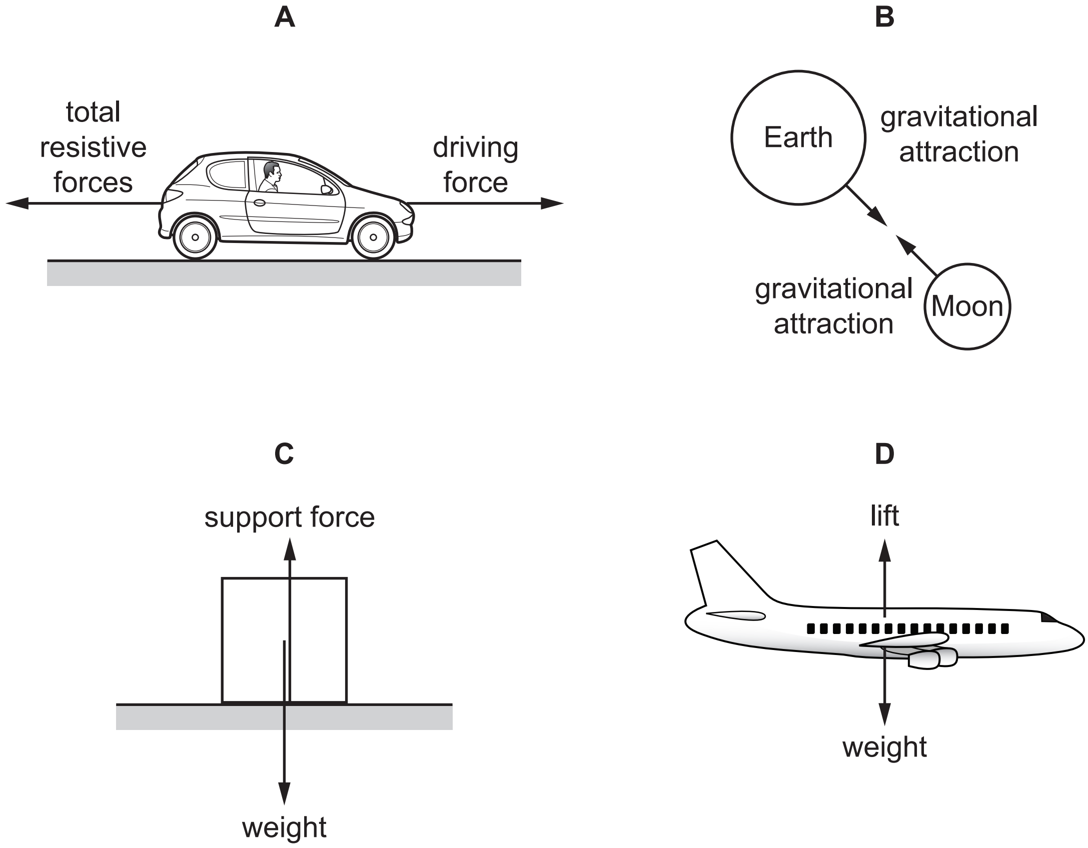
B 2.0×10^{-3} J

C 3.1×10^{-2} J

D 2.0 J

9 Each diagram illustrates a pair of forces of equal magnitude.

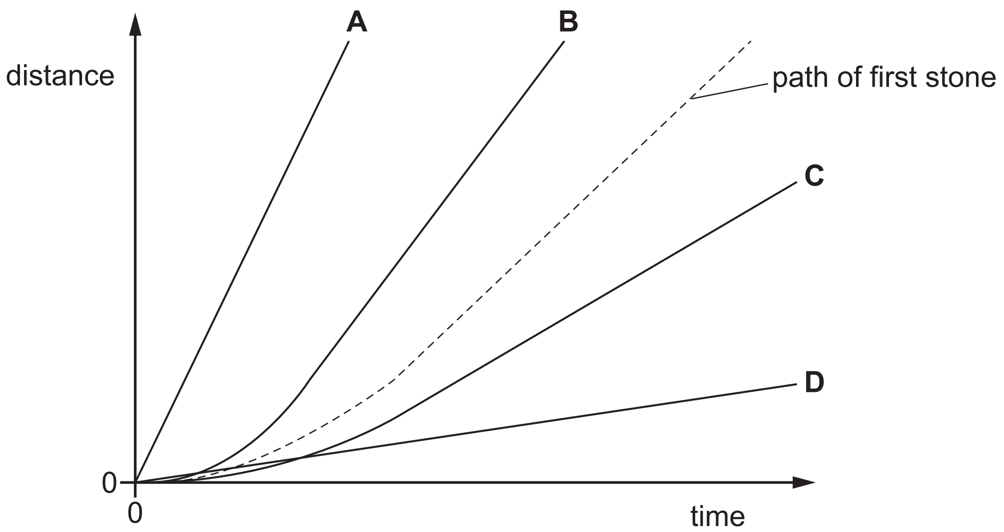
Which diagram gives an example of a pair of forces that is described by Newton's third law of motion?



10 A stone is dropped from a tall building. Air resistance is significant. The variation of distance fallen with time is shown by the dashed line.

A second stone with the same dimensions but a smaller mass is dropped from the same building.

Which line represents the motion of the second stone?

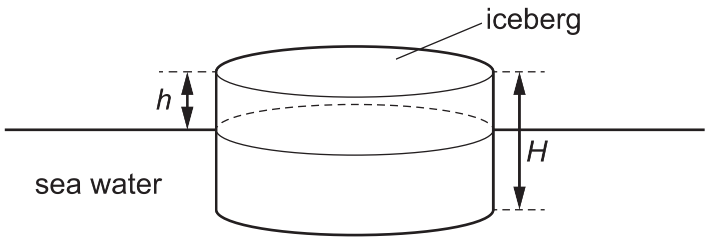


11 A helium atom of mass m collides normally with a wall. The atom arrives at the wall with speed v and then rebounds along its original path. Assume that the collision is perfectly elastic.

What is the change in the momentum of the atom during its collision?

A zero **B** $0.5\,mv$ **C** mv **D** $2mv$

12 A cylindrical iceberg of height H floats in sea water. The top of the iceberg is at height h above the surface of the water.

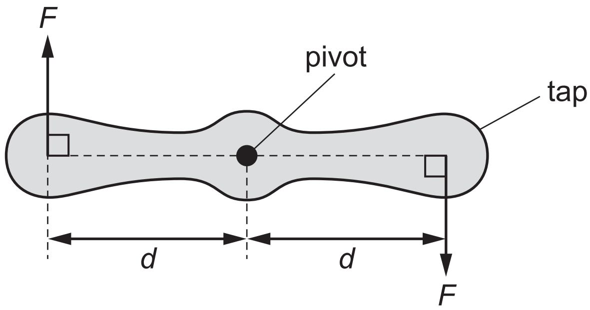


The density of ice is ρ_i and the density of sea water is ρ_w.

What is the height h of the iceberg above the sea water?

A $\left(1-\dfrac{\rho_i}{\rho_w}\right)H$ **B** $\left(\dfrac{\rho_i}{\rho_w}-1\right)H$ **C** $\dfrac{\rho_w}{\rho_i}H$ **D** $\dfrac{\rho_i}{\rho_w}H$

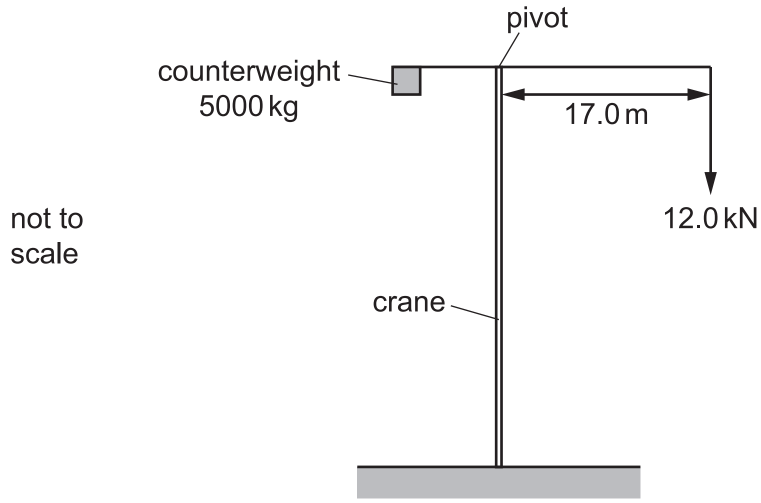
13 A couple is applied to a tap as shown.



What is the torque of the couple?

A $\dfrac{Fd}{2}$ **B** Fd **C** $2Fd$ **D** $4Fd$

14 A crane uses a counterweight to stop it from toppling over when lifting a load, as shown.



The counterweight has a mass of 5000 kg. The crane is required to lift a load of 12.0 kN and the horizontal distance from the pivot to the load is 17.0 m.

How far from the pivot should the centre of gravity of the counterweight be positioned in order to keep the crane in equilibrium?

A 0.0408 m **B** 0.240 m **C** 4.16 m **D** 40.8 m

15 Three parallel forces act on an object. As a result of these forces, the object is in equilibrium.

What **must** be correct for these forces?

A They all act along the same line.

B They all have the same magnitude.

C They do **not** all act along the same line.

D They do **not** all have the same magnitude.

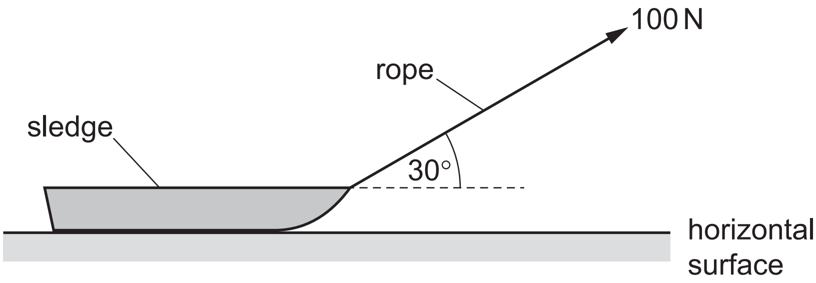
16 An empty glass beaker has a mass of 103 g. When filled with water, it has a total mass of 361 g. When filled with cooking oil, it has a total mass of 351 g.

The density of water is 1.00 g cm^{-3}.

What is the density of the cooking oil?

A 0.961 g cm^{-3} **B** 0.972 g cm^{-3} **C** 1.03 g cm^{-3} **D** 1.04 g cm^{-3}

17 A rope is attached to a sledge and a boy uses the rope to pull the sledge along a horizontal surface with a constant velocity. The tension in the rope is 100 N and the rope is held at 30° to the horizontal.



How much work does the boy do on the sledge when he pulls it a distance of 5.0 m along the surface?

A 250 J **B** 290 J **C** 430 J **D** 500 J

18 The kinetic energy E_k of an object of mass m moving at speed v is given by the equation shown.

$$E_k = \frac{1}{2}mv^2$$

Which equation is **not** used in the derivation of this equation?

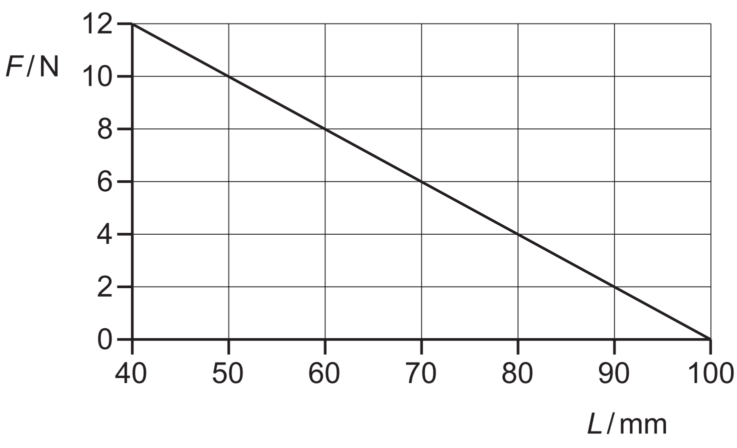
A $F = ma$ **B** $s = vt$ **C** $v^2 = u^2 + 2as$ **D** $W = Fs$

19 A grasshopper of mass 0.12 g jumps vertically. It uses its back legs over a time of 0.020 s to jump, leaving the ground with a velocity of 3.0 m s^{-1}.

What is the average power developed by the legs of the grasshopper?

A 9.0×10^{-3} W **B** 1.8×10^{-2} W **C** 2.7×10^{-2} W **D** 37 W

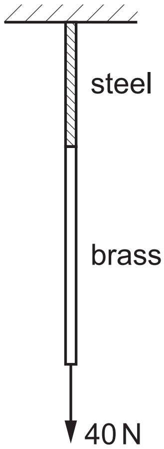
20 A spring of original length 100 mm is compressed by a force. The graph shows the variation of the compressing force F with the length L of the spring.



What is the energy stored in the spring when the length is 70 mm?

A 0.090 J **B** 0.21 J **C** 0.27 J **D** 0.63 J

21 A 0.80 m length of steel wire and a 1.4 m length of brass wire are joined together. The combined wires are suspended from a fixed support and a force of 40 N is applied, as shown.



The Young modulus of steel is 2.0×10^{11} Pa.

The Young modulus of brass is 1.0×10^{11} Pa.

Each wire has a cross-sectional area of $2.4 \times 10^{-6}\,m^2$.

The wires obey Hooke's law.

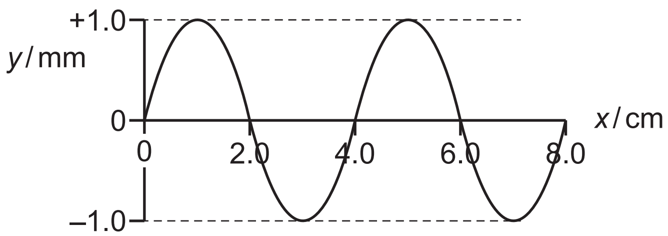
What is the total extension? Ignore the weights of the wires.

A 1.7×10^{-4} m **B** 3.0×10^{-4} m **C** 3.9×10^{-4} m **D** 9.0×10^{-4} m

22 A transverse wave in a medium has the waveform shown, where

y = vertical displacement and x = horizontal distance.

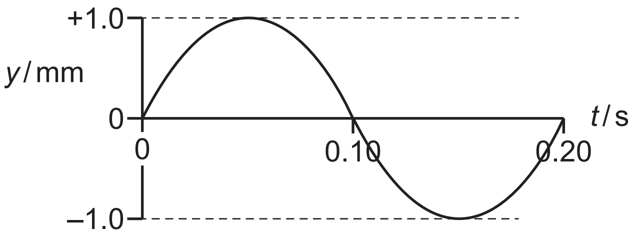
The speed of the wave is $20.0\,\mathrm{cm\,s^{-1}}$.



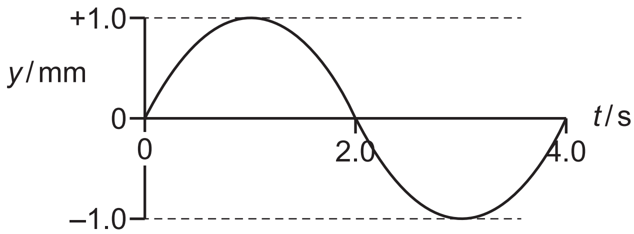
A particle of the medium oscillates vertically.

Which graph of vertical displacement y against time t best represents the motion of this particle?

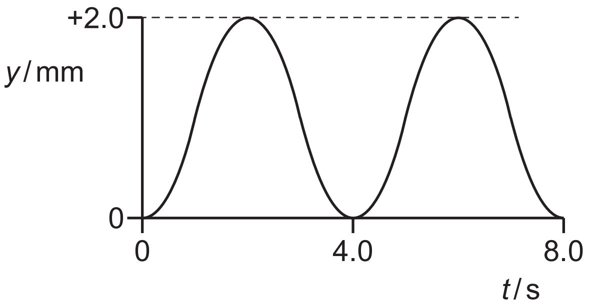
A



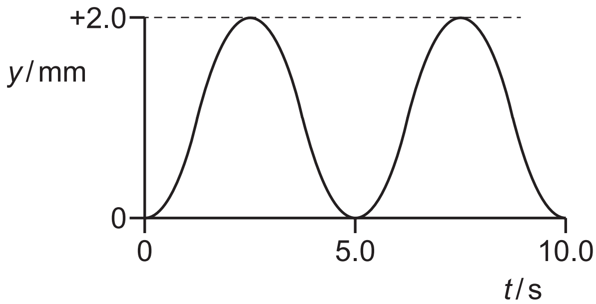
B



C

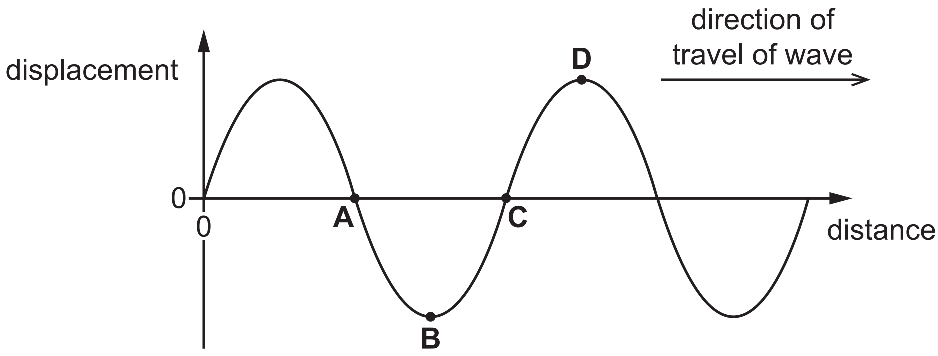


D



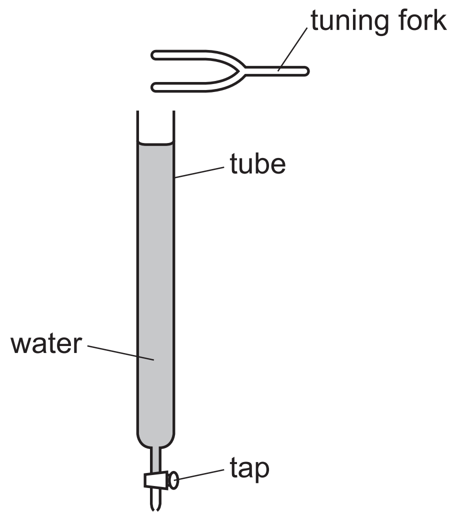
23 The graph shows the variation of the displacement of particles with distance along a transverse wave at an instant in time. The wave is moving to the right.

Which position along the wave corresponds to a point where particles in the wave are travelling the fastest upwards?



24 A long tube, filled with water, has a tap fitted at its base, as shown.

A tuning fork is sounded above the tube and the water is allowed to run gradually out of the tube.

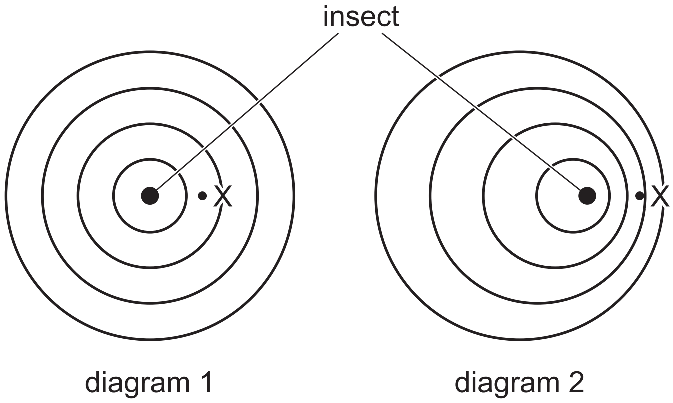


A louder sound is heard at intervals as the water runs out of the tube. The change in water level between louder sounds is 32 cm.

What is the wavelength of the sound in the tube?

A 16 cm **B** 32 cm **C** 64 cm **D** 128 cm

25 A stationary insect on the surface of water creates circular waves with its legs, as shown in diagram 1. The insect begins to travel to the right as shown in diagram 2.



Which row describes the change to the waves at X caused by the movement of the insect?

	frequency	wave speed
A	decreases	increases
B	decreases	stays the same
C	increases	increases
D	increases	stays the same

26 A toy motorboat moving with constant velocity v vibrates up and down on the surface of a pond. This causes the boat to act as a source of circular water waves of frequency 2.0 Hz. The speed of the waves is $1.5\,m\,s^{-1}$.

A man, standing at the edge of the pond, observes that the waves from the boat approach him with a frequency of 3.0 Hz.

The formula for Doppler effect calculations with sound waves may also be used for water waves.

What is a possible value of v?

	speed / $m\,s^{-1}$	direction
A	0.50	directly away from the man
B	0.50	directly towards the man
C	0.75	directly away from the man
D	0.75	directly towards the man

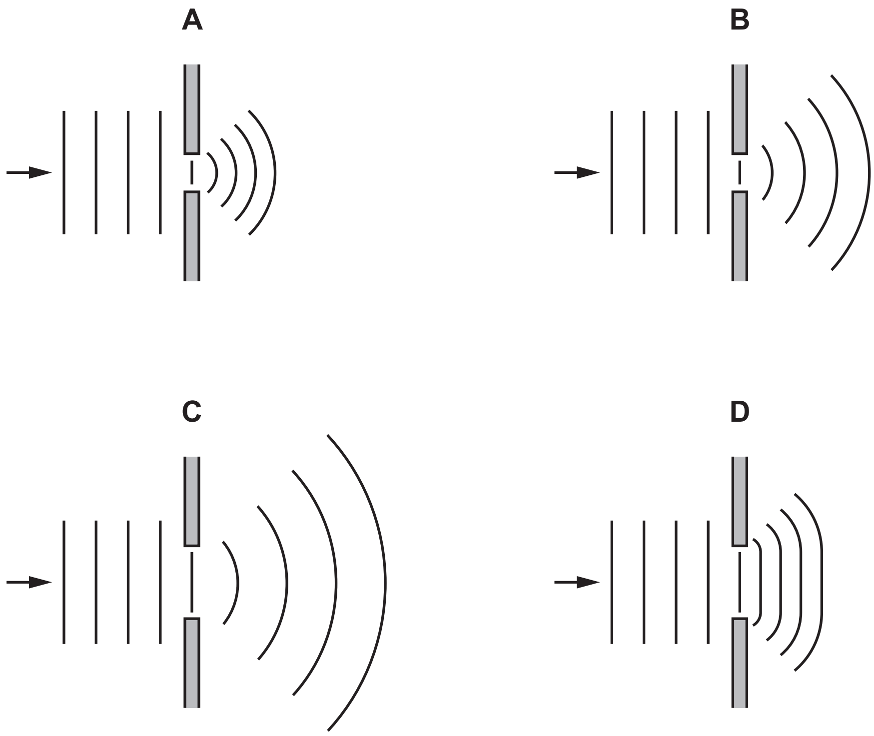
27 Two progressive waves of frequency 300 Hz superpose to produce a stationary wave in which adjacent nodes are 1.5 m apart.

What is the speed of the progressive waves?

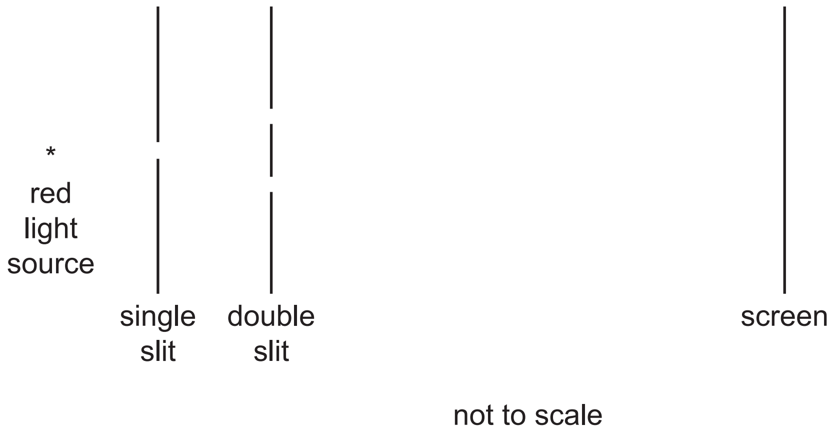
A $100\,m\,s^{-1}$ **B** $200\,m\,s^{-1}$ **C** $450\,m\,s^{-1}$ **D** $900\,m\,s^{-1}$

28 The diagrams show the diffraction of water waves in a ripple tank as they pass through a gap between two barriers.

Which diagram is correct?



29 A double-slit interference experiment is set up as shown.



Fringes are formed on the screen. The distance between successive bright fringes is found to be 4 mm.

Two changes are then made to the experimental arrangement. The double slit is replaced by another double slit which has half the spacing. The screen is moved so that its distance from the double slit is twice as great.

What is now the distance between successive bright fringes?

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

30 The interference patterns from a diffraction grating and a double slit are compared.

Using the diffraction grating, yellow light of the first order is seen at 30° to the normal to the grating.

The same light produces interference fringes on a screen 1.0 m from the double slit. The slit separation is 500 times greater than the line spacing of the grating.

What is the fringe separation on the screen?

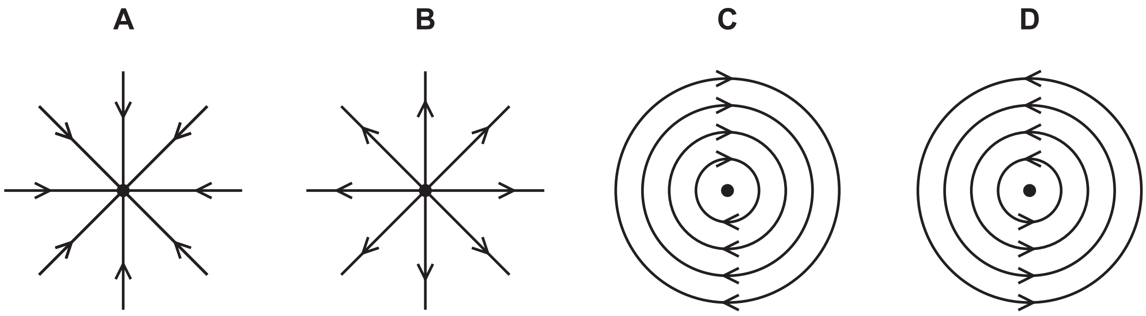
A 2.5×10^{-7} m

B 1.0×10^{-5} m

C 1.0×10^{-3} m

D 1.0×10^{-1} m

31 Which diagram shows the pattern of the electric field lines due to a negative point charge?



32 In an electrolyte, the electric current is carried by charged particles (ions) in solution.

What is **not** a possible value for the charge on an ion in solution?

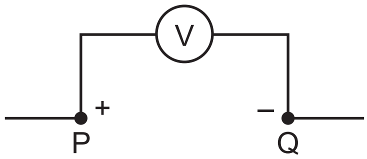
A -4.8×10^{-19} C

B $+1.6 \times 10^{-19}$ C

C $+3.2 \times 10^{-19}$ C

D $+4.0 \times 10^{-19}$ C

33 A voltmeter connected between two points P and Q in an electrical circuit shows a reading of 1 V.



Which statement is correct?

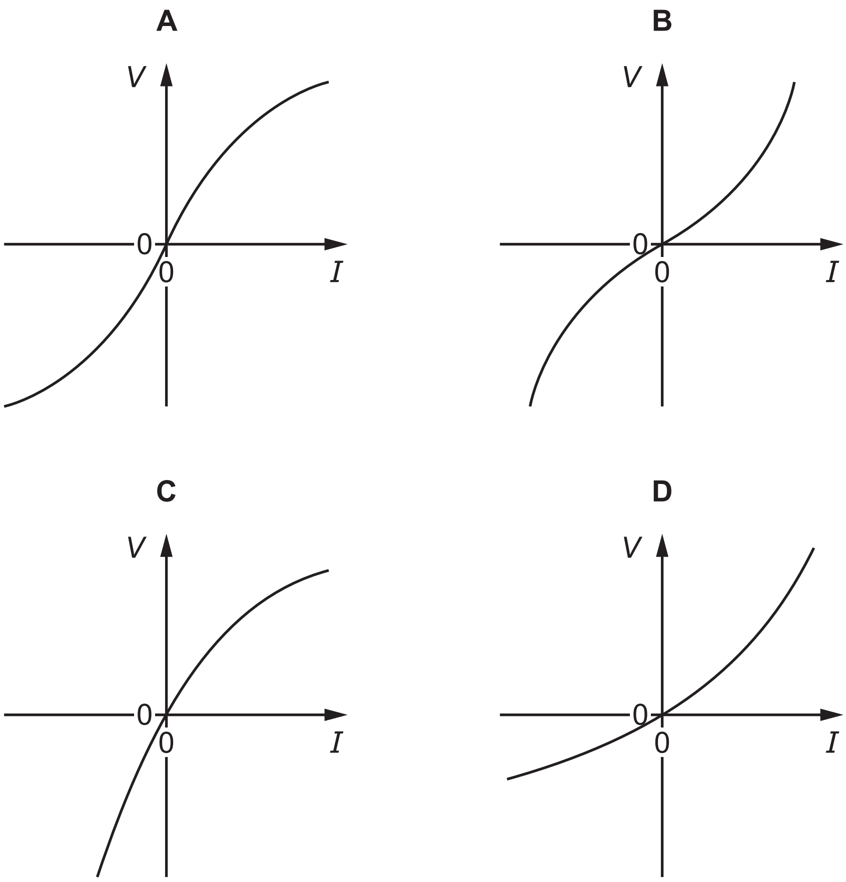
A The energy needed to move +1 C of charge from P to Q is 1 J.

B The energy needed to move +1 C of charge from Q to P is 1 J.

C The energy needed to move one electron from P to Q is 1 J.

D The energy needed to move one electron from Q to P is 1 J.

34 Which graph best represents the variation with current I of potential difference V for a filament lamp?



35 When a battery is connected to a resistor, the battery gradually becomes warm. This causes the internal resistance of the battery to increase whilst its electromotive force (e.m.f.) stays unchanged.

As the internal resistance of the battery increases, how do the terminal potential difference and the output power change, if at all?

	terminal potential difference	output power
A	decreases	decreases
B	decreases	unchanged
C	unchanged	decreases
D	unchanged	unchanged

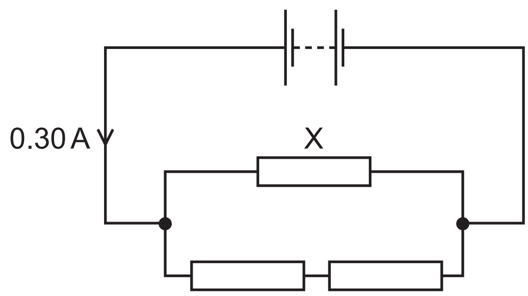
36 A cell is connected to a resistor of resistance 3.00 Ω. The current in the resistor is 1.00 A.

A second identical resistor is added in parallel. The current becomes 1.93 A.

What are the e.m.f. *E* and internal resistance *r* of the cell?

	E / V	r / Ω
A	0.113	3.11
B	3.04	0.0358
C	3.11	0.113
D	9.34	6.34

37 A battery with negligible internal resistance is connected to three resistors, as shown.



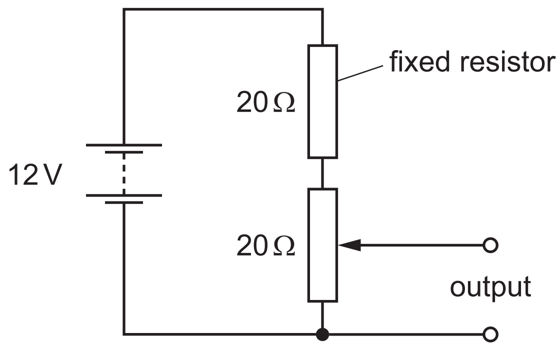
All three resistors have the same resistance.

The current in the battery is 0.30 A.

What is the current in resistor X?

A 0.10 A **B** 0.15 A **C** 0.20 A **D** 0.30 A

38 The diagram shows a potentiometer and a fixed resistor connected across a 12 V battery of negligible internal resistance.



The fixed resistor and the potentiometer each have resistance 20 Ω. The circuit is designed to provide a variable output voltage.

What is the range of output voltages?

A 0 – 6 V **B** 0 – 12 V **C** 6 – 12 V **D** 12 – 20 V

39 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?

A A tiny proportion of the alpha-particles are deflected through large angles.

B Slower alpha-particles are deflected through larger angles.

C The kinetic energies of the deflected alpha-particles are unchanged.

D The number of alpha-particles deflected depends on the thickness of the foil.

40 Some particles are a combination of three quarks.

Which combination of quarks would **not** result in a particle with a charge of either $+1.6 \times 10^{-19}$ C or zero?

A up, down, down

B up, strange, strange

C up, up, down

D up, up, up

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2019**

1 hour 15 minutes

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

2852605020

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **20** printed pages and **4** blank pages.

IB19 06_9702_12/3RP

Cambridge Assessment International Education

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is equivalent to 2000 microvolts?

A $2\,\mu J\,C^{-1}$ **B** $2\,mV$ **C** $2\,pV$ **D** $2000\,mV$

2 What is the number of SI base units required to express electric field strength and power?

	electric field strength	power
A	3	3
B	3	2
C	4	2
D	4	3

3 The Planck constant h has SI units J s.

Which equation could be used to calculate the Planck constant?

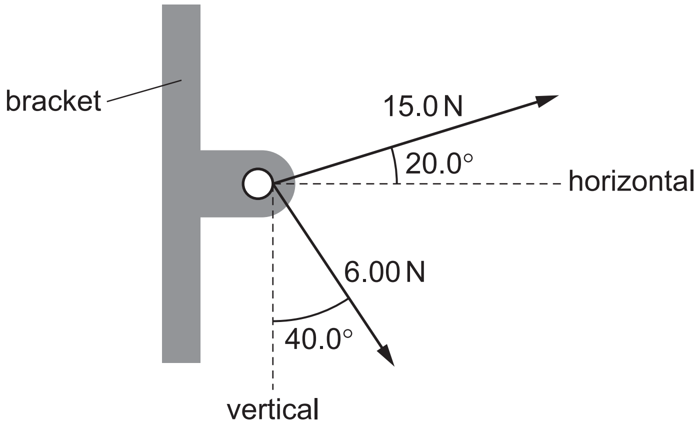
A $h = \dfrac{DE}{v}$ where D is distance, E is energy and v is velocity

B $h = \dfrac{v}{D}$ where v is velocity and D is distance

C $h = \dfrac{1}{4\pi E}$ where E is electric field strength

D $h = \dfrac{Fr^2}{m}$ where F is force, r is radius and m is mass

4 Two cables are attached to a bracket and exert forces as shown.



What are the magnitudes of the horizontal and vertical components of the resultant of the two forces?

	horizontal component / N	vertical component / N
A	9.73	0.534
B	9.73	10.2
C	18.0	0.534
D	18.0	10.2

5 A student wishes to determine the density ρ of lead. She measures the mass and diameter of a small sphere of lead:

$$\text{mass} = (0.506 \pm 0.005)\,\text{g}$$

$$\text{diameter} = (2.20 \pm 0.02)\,\text{mm.}$$

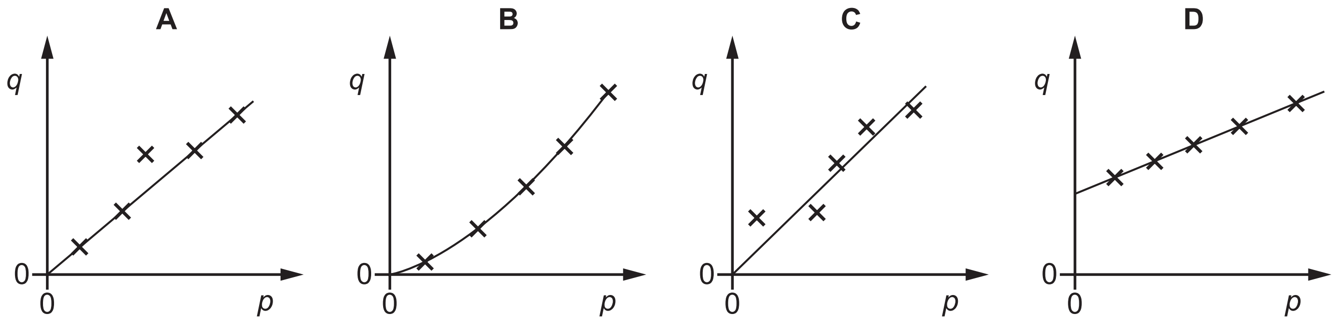
What is the best estimate of the percentage uncertainty in her calculated value of ρ?

A 1.7% **B** 1.9% **C** 2.8% **D** 3.7%

6 Two quantities p and q are directly proportional to each other.

Experimental results are taken and plotted in a graph of q against p.

Which graph shows there were random errors in the measurements of p and q?



7 A man of mass 75.2 kg uses a set of weighing scales to measure his mass three times. He obtains the following readings.

	mass / kg
reading 1	80.2
reading 2	80.1
reading 3	80.2

Which statement best describes the precision and accuracy of the weighing scales?

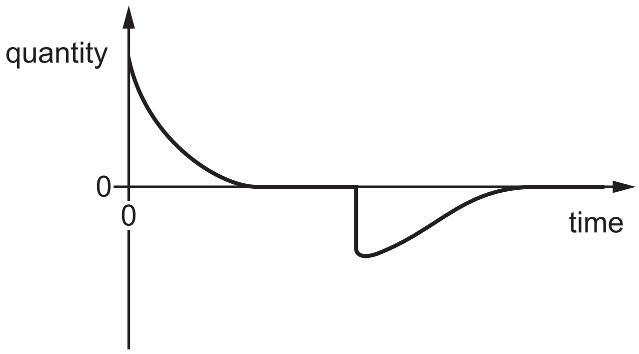
A not precise to ± 0.1 kg and accurate to ± 0.1 kg

B not precise to ± 0.1 kg and not accurate to ± 0.1 kg

C precise to ± 0.1 kg and accurate to ± 0.1 kg

D precise to ± 0.1 kg and not accurate to ± 0.1 kg

8 The graph shows how a physical quantity varies with time.



Which event could best be represented by the graph?

A the acceleration of a firework rising to a maximum height and falling to the ground

B the acceleration of a skydiver leaving an aircraft, falling, opening a parachute and falling to the ground

C the speed of a javelin as it leaves an athlete's hand, falls and sinks into the ground

D the speed of a high jump athlete leaving the ground, jumping over a bar and descending to the ground

9 What describes the mass of an object?

A the force the object experiences due to gravity

B the momentum of the object before a collision

C the resistance of the object to changes in motion

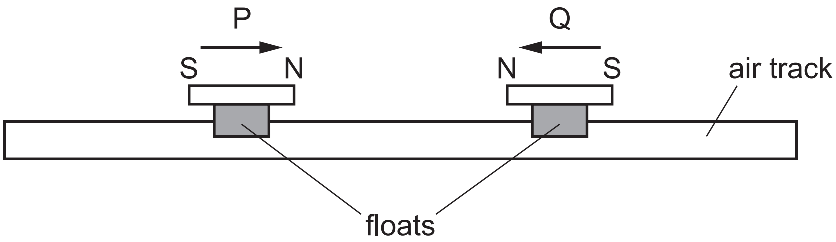
D the weight of the object as measured by a balance

10 A car has mass m. A person needs to push the car with force F in order to give the car acceleration a. The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

Which expression gives the constant resistive force opposing the motion of the car?

A ma **B** $2ma$ **C** $3ma$ **D** $4ma$

11 Two bar magnets P and Q are mounted on floats which can slide without friction along an air track.



The two magnets slide towards each other along the air track and interact, without making contact.

The relative speed of approach of the magnets is equal to their relative speed of separation.

Which statement about P and Q must be correct?

A During the interaction between P and Q some of the total kinetic energy is lost.

B During the interaction between P and Q some of the total momentum is lost.

C The momentum of Q after the interaction is equal to the momentum of P before the interaction.

D The values of (kinetic energy of P + kinetic energy of Q) before and after the interaction are equal.

12 A submarine descends vertically at constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight.

Which relationship between their magnitudes is correct?

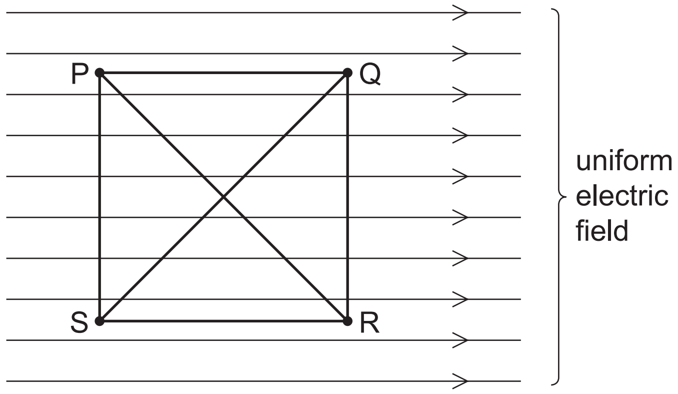
A weight < drag

B weight = drag

C weight < upthrust

D weight > upthrust

13 A small positive charge can move inside a uniform electric field.

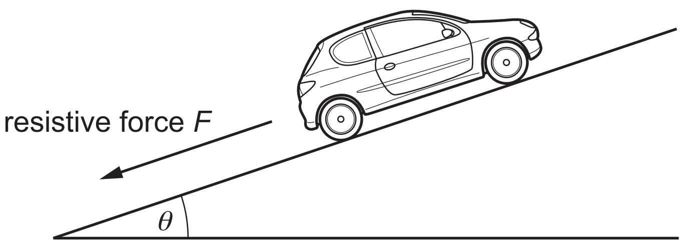


The charge moves along different straight paths between points P, Q, R and S.

Which row gives two paths that result in the same total work done on the charge?

	path 1	path 2
A	P to R	Q to S
B	P to R	P to S
C	S to Q	S to R
D	S to Q	R to P

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. The acceleration of free fall is g.



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

A $mg \cos \theta$

B $mg \sin \theta$

C $mg \cos \theta + F$

D $mg \sin \theta + F$

15 A volume of $1.5\,m^3$ of water is mixed with $0.50\,m^3$ of alcohol. The density of water is $1000\,kg\,m^{-3}$ and the density of alcohol is $800\,kg\,m^{-3}$.

The volume of the mixture is $2.0\,m^3$.

What is the density of the mixture?

A $850\,kg\,m^{-3}$ **B** $900\,kg\,m^{-3}$ **C** $940\,kg\,m^{-3}$ **D** $950\,kg\,m^{-3}$

16 A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

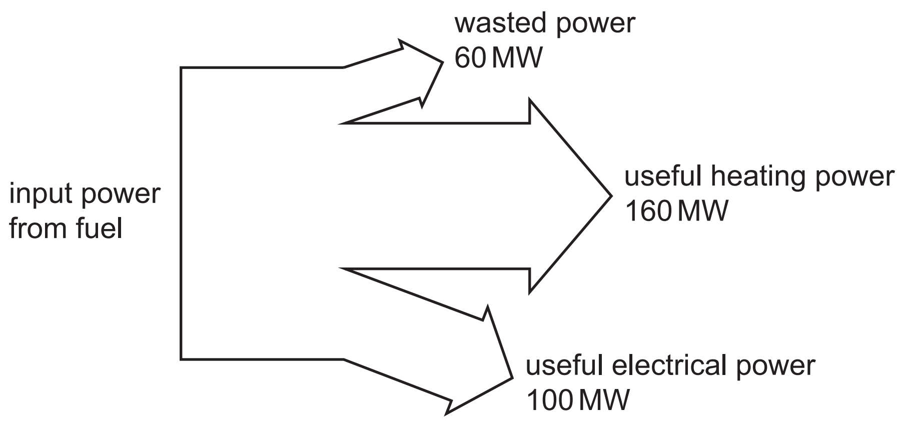
A Gravitational potential energy is converted into kinetic energy of the air.

B Gravitational potential energy is converted into kinetic energy of the parachutist.

C Gravitational potential energy is converted into thermal energy of the air.

D Gravitational potential energy is converted into thermal energy of the parachutist.

17 A combined heat and power (CHP) station generates electrical power and useful heat. The diagram shows the input and output powers for a CHP station.



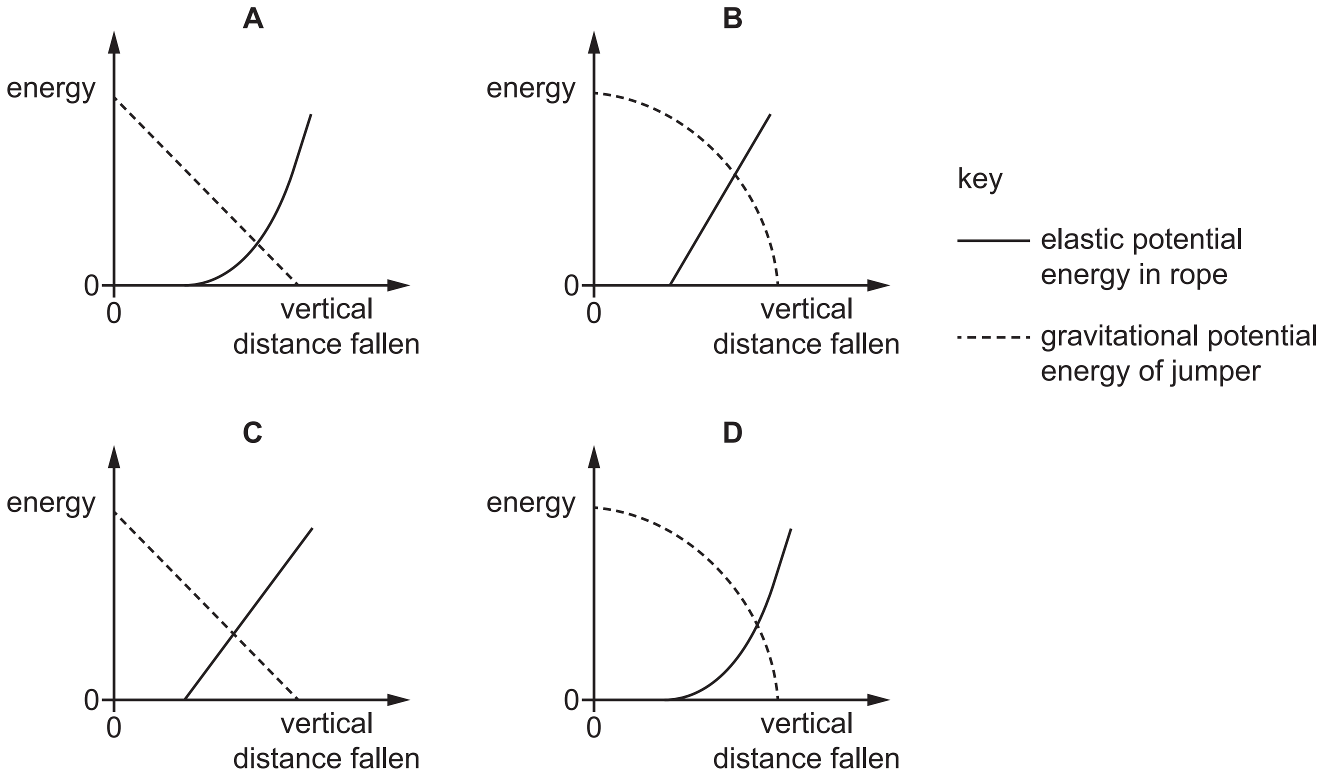
What is the efficiency of the CHP station for producing useful power?

A 31% **B** 38% **C** 50% **D** 81%

18 A bungee jumper jumps off a high bridge, when attached to it by a long elastic rope which obeys Hooke's law.

The gravitational potential energy of the jumper is measured relative to the lowest point reached by the jumper.

Which graph shows the variation of the gravitational potential energy of the jumper, and the elastic potential energy in the rope, with the vertical distance fallen from the top of the bridge?



19 A train on a mountain railway is carrying 200 people of average mass 70 kg up a slope at an angle of 30° to the horizontal and at a speed of $6.0\,\mathrm{m\,s^{-1}}$. The train itself has a mass of 80 000 kg. The percentage of the power from the engine which is used to raise the passengers and the train is 40%.

What is the power of the engine?

A 1.1 MW **B** 2.8 MW **C** 6.9 MW **D** 14 MW

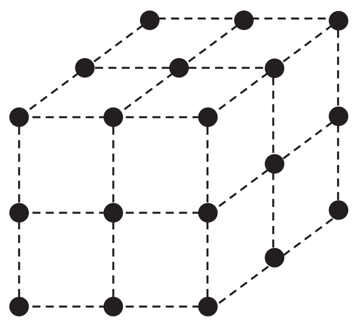
20 A wire X is stretched by a force and gains elastic potential energy E.

The same force is applied to wire Y of the same material, with the same initial length but twice the diameter of wire X. Both wires obey Hooke's law.

What is the gain in elastic potential energy of wire Y?

A $0.25E$ **B** $0.5E$ **C** $2E$ **D** $4E$

21 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 $9.2 \times 10^{3}\,\text{kg}\,\text{m}^{-3}$.

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

A 3.8×10^{-29} m

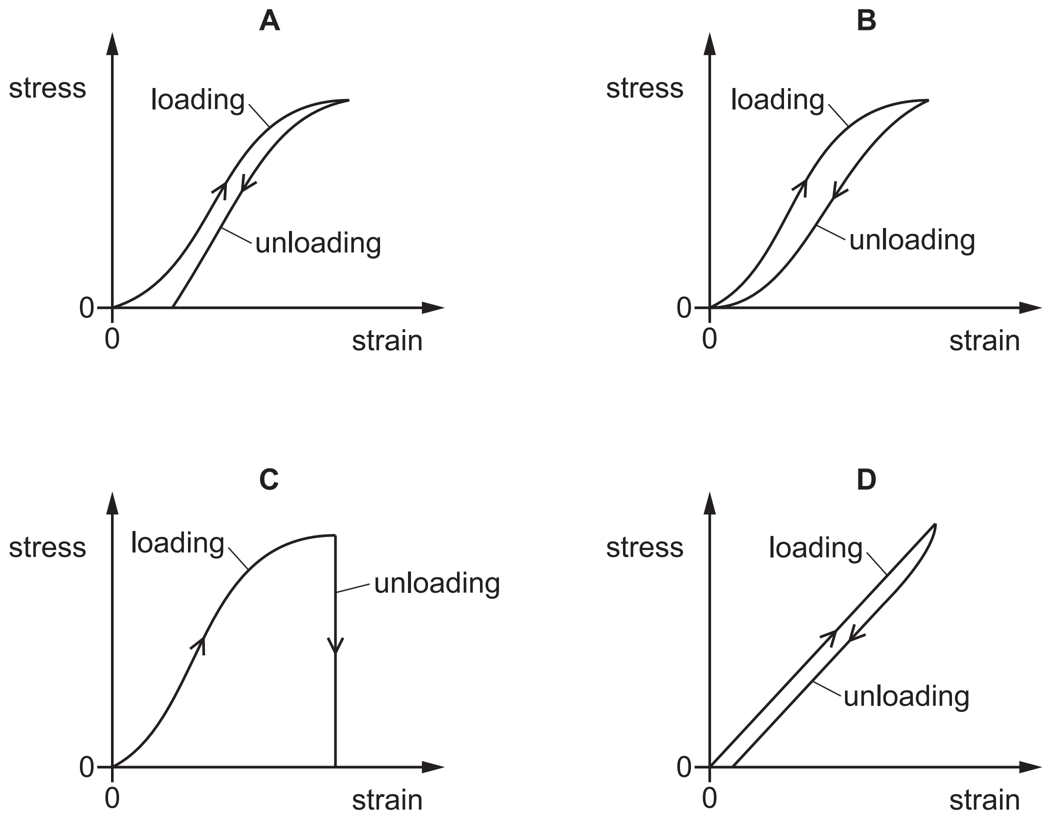
B 6.2×10^{-15} m

C 3.4×10^{-10} m

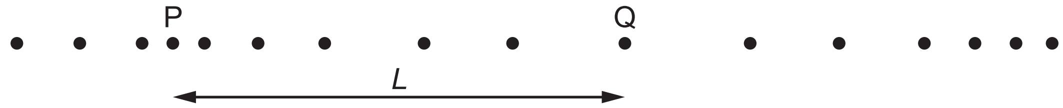
D 3.0×10^{-9} m

22 The stress-strain graphs for loading and unloading four different materials are shown.

Which material exhibits purely elastic behaviour?



23 The diagram illustrates the position of particles in a progressive sound wave at one instant in time.



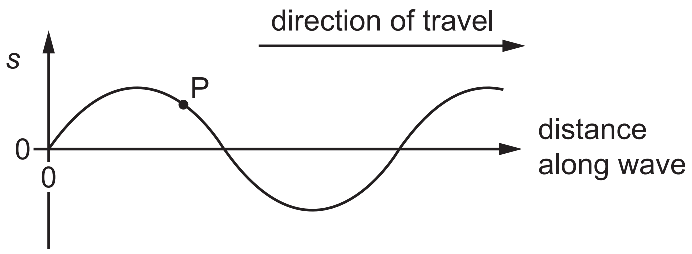
The speed of the wave is v. P and Q are two points in the wave a distance L apart.

What is an expression for the frequency of the wave?

A $\dfrac{v}{2L}$ **B** $\dfrac{v}{L}$ **C** $\dfrac{2v}{L}$ **D** $\dfrac{L}{v}$

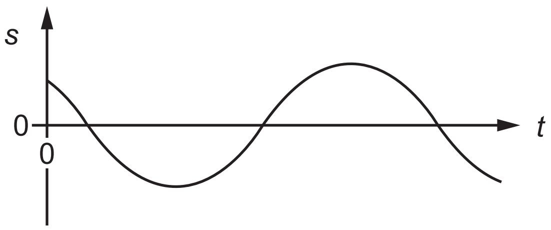
24 A wave moves along the surface of water.

The diagram shows the variation of displacement s with distance along the wave at time t = 0.

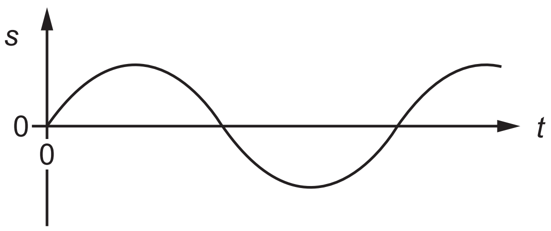


Which graph best shows the variation with time t of the displacement s of the point P on the wave?

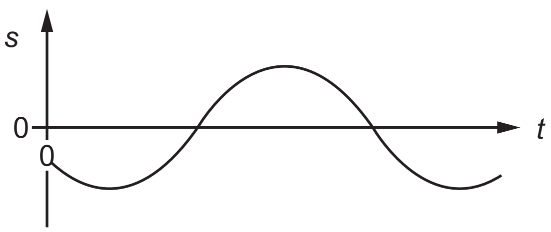
A



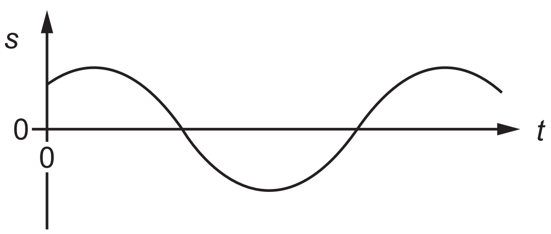
B



C



D



25 In an experiment to determine the wavelength of sound in air, a stationary wave is set up in an air column.

The distance between a node and an adjacent antinode is L.

What is the wavelength of the sound?

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

26 In one of the first experiments to demonstrate the Doppler effect, a train was filled with trumpeters all playing a note of frequency 440 Hz. The difference in observed frequency of the note as the train directly approached a stationary observer was 22 Hz. The speed of sound was $340\,\mathrm{m\,s^{-1}}$.

At which speed was the train moving?

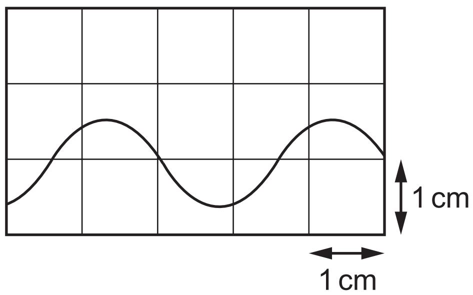
A $15.4\,\mathrm{m\,s^{-1}}$ **B** $16.2\,\mathrm{m\,s^{-1}}$ **C** $17.0\,\mathrm{m\,s^{-1}}$ **D** $17.9\,\mathrm{m\,s^{-1}}$

27 The electromagnetic spectrum consists of waves with different wavelengths.

Which row correctly identifies regions of the electromagnetic spectrum?

	10^{-10} m	10^{-8} m	10^{-5} m	10^{-2} m
A	microwaves	X-rays	ultraviolet	infrared
B	infrared	microwaves	X-rays	ultraviolet
C	microwaves	infrared	ultraviolet	X-rays
D	X-rays	ultraviolet	infrared	microwaves

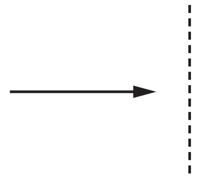
28 A cathode-ray oscilloscope (CRO) is used to display the trace from a sound wave. The time-base is set at $5\,\mu\mathrm{s\,mm^{-1}}$.



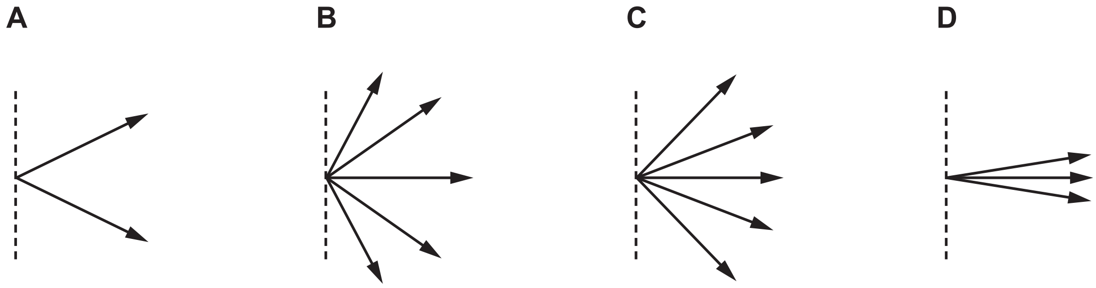
What is the frequency of the sound wave?

A 6.7 Hz **B** 67 Hz **C** 6.7 kHz **D** 67 kHz

29 Monochromatic light is directed at a diffraction grating, as shown.



Which diagram could show **all** the possible directions of the light, after passing through the grating, that give maximum intensity?



30 Why can an observable interference pattern **never** be obtained between two monochromatic beams of light from different lamps?

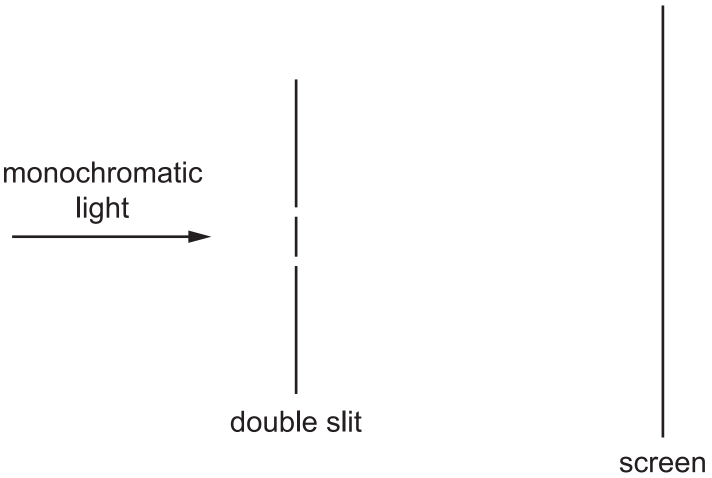
A The frequency of the light from the two lamps can never be the same.

B The light from the two lamps can never be coherent.

C The temperature of the filaments of the two lamps used can never be the same.

D The wavelength of the light from the two lamps must always be different.

31 A student sets up apparatus to observe the double-slit interference of monochromatic light, as shown.



Interference fringes are formed on the screen.

Which change would increase the distance between adjacent fringes?

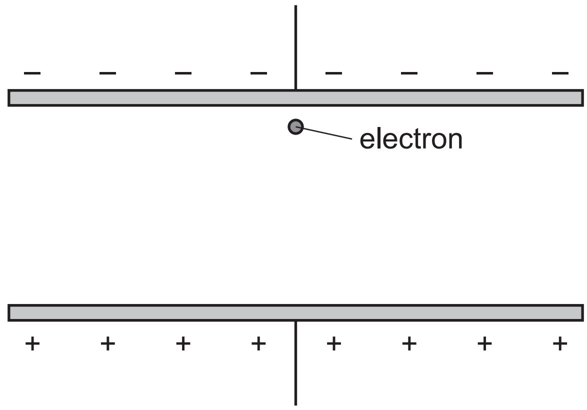
A Decrease the distance between the two slits.

B Decrease the width of each slit.

C Move the screen closer to the double slit.

D Use light of a higher frequency.

32 An electron is situated in a vacuum between two charged plates, as shown.



Which statement describes the motion of the electron due to the uniform electric field?

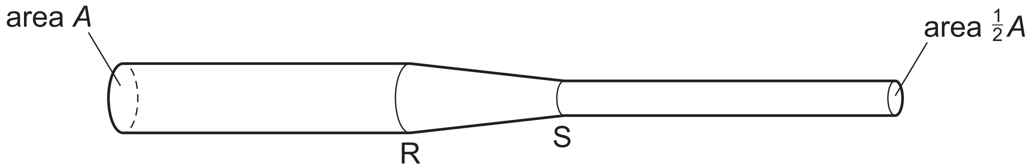
A It moves downwards with a constant acceleration.

B It moves downwards with zero acceleration.

C It moves upwards with a constant acceleration.

D It moves upwards with a decreasing acceleration.

33 A length of wire is connected into a circuit.



The area of the cross-section of the wire changes from A at R to $\frac{1}{2}A$ at S.

There is a constant current in the wire. Charge Q passes R in time t.

What is the charge passing point S in the same time t?

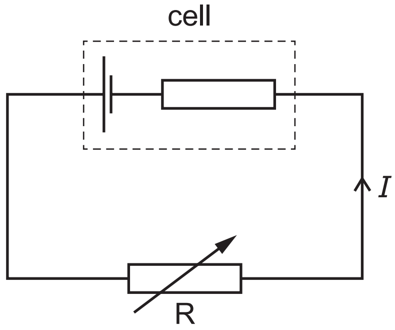
A $\frac{1}{2}Q$ **B** Q **C** $Q\sqrt{2}$ **D** $2Q$

34 Four wires are made of the same metal. The cross-sectional areas, lengths and thermodynamic temperatures of the wires are shown.

Which wire has the largest resistance?

	cross-sectional area	length	temperature
A	A	$2L$	$2T$
B	A	L	T
C	$2A$	$2L$	$2T$
D	$2A$	L	T

35 A cell with internal resistance is connected to a variable resistor R as shown.



The resistance of R is gradually decreased.

How do the current I and the terminal potential difference across the cell change?

	current I	terminal potential difference across cell
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

36 Kirchhoff's first law states that the sum of the currents entering a junction in a circuit is equal to the sum of the currents leaving it.

The law is based on the conservation of a physical quantity.

What is this physical quantity?

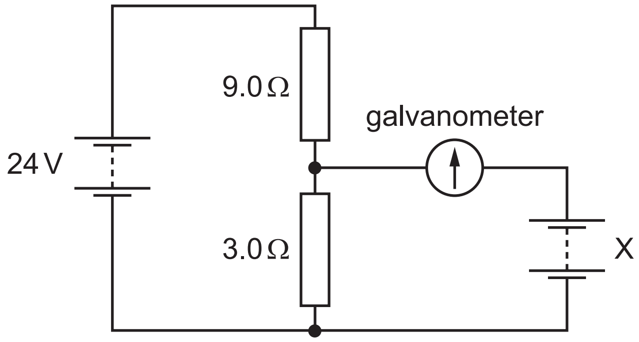
A charge

B energy

C mass

D momentum

37 A circuit contains two batteries, each of negligible internal resistance, and two resistors as shown.



The galvanometer has a current reading of zero.

What is the electromotive force (e.m.f.) of battery X?

A 6.0 V **B** 8.0 V **C** 16.0 V **D** 18.0 V

38 A nucleus of francium-221 ($^{221}_{87}Fr$) decays into a nucleus of bismuth-209 ($^{209}_{83}Bi$) in several steps.

Which particles could be emitted?

A 2 α-particles and 4 β^- particles

B 2 α-particles and 4 β^+ particles

C 3 α-particles and 2 β^- particles

D 3 α-particles and 2 β^+ particles

39 Which equation describes the changes to the quark composition of a nucleus and the lepton emission during the process of β^+ decay?

A down $\rightarrow$ up + positron + electron neutrino

B down $\rightarrow$ up + positron + electron antineutrino

C up $\rightarrow$ down + positron + electron neutrino

D up $\rightarrow$ down + positron + electron antineutrino

40 There are protons, neutrons and electrons in the simple model of an atom.

To which class (group), hadron or lepton, do these particles belong?

	hadron	lepton
A	electron	proton and neutron
B	neutron	proton and electron
C	proton and electron	neutron
D	proton and neutron	electron

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Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2019**

1 hour 15 minutes

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

3457171416

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **17** printed pages and **3** blank pages.

IB19 06_9702_13/4RP

Cambridge Assessment International Education

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which is an SI base unit?

A current

B gram

C kelvin

D volt

2 Osmium, a naturally occurring element, has a density of $23\,000\,\text{kg}\,\text{m}^{-3}$.

What is also a value of the density of osmium?

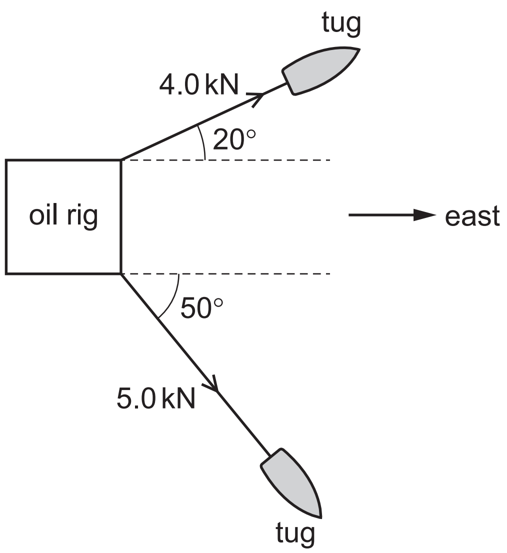
A $2.3 \times 10^{4}\,\mu\text{g}\,\text{cm}^{-3}$

B $2.3 \times 10^{4}\,\text{g}\,\text{cm}^{-3}$

C $2.3\,\text{kg}\,\text{cm}^{-3}$

D $2.3 \times 10^{-2}\,\text{kg}\,\text{cm}^{-3}$

3 Two tugs are towing an oil rig as shown.



The tensions in the towing cables are 4.0 kN and 5.0 kN.

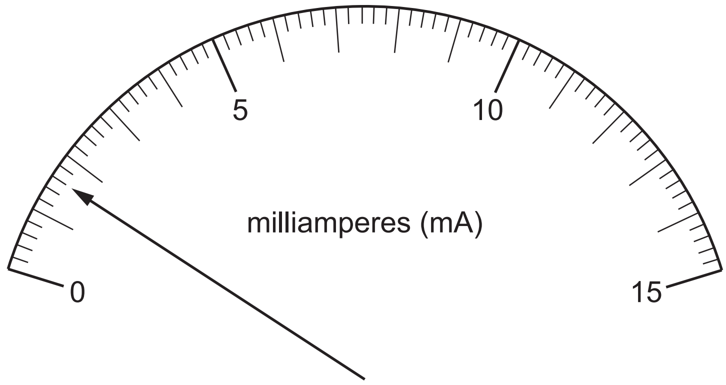
What is the total force acting on the rig due to the cables, in the direction to the east?

A 3.1 kN **B** 5.2 kN **C** 7.0 kN **D** 7.3 kN

4 What is the approximate kinetic energy of an Olympic athlete when running at maximum speed during a 100 m race?

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

5 The diagram shows the reading on an analogue ammeter.



Which digital ammeter reading is the same as the reading on the analogue ammeter?

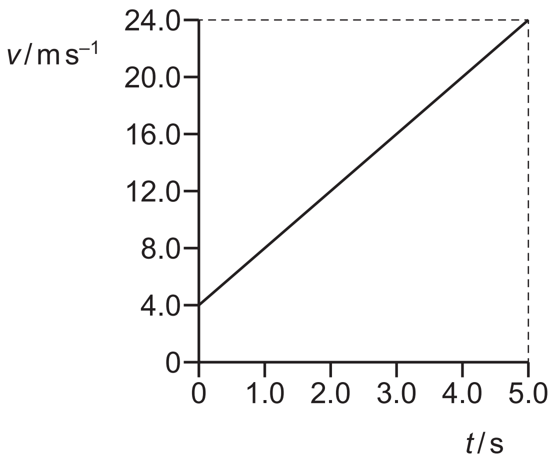
	display units	display reading
A	μA	1600
B	μA	160
C	mA	16.0
D	A	1.60

6 A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The micrometer reading is 5.00 mm ± 0.01 mm.

What will be the percentage uncertainty in a calculation of the volume of the sphere, using these values?

A 0.2% **B** 0.4% **C** 0.6% **D** 1.2%

7 The graph shows the variation of velocity v with time t for an object.



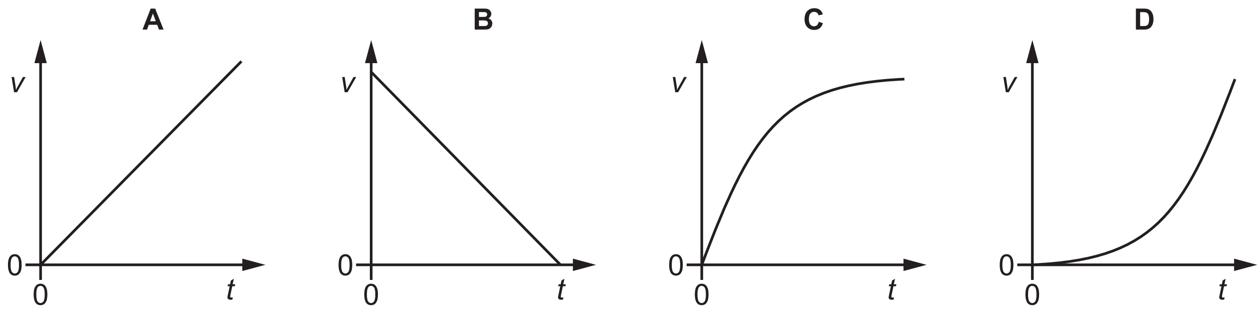
The object passes a fixed point at time $t = 0$.

What is the displacement of the object from the fixed point at time $t = 5.0\,\text{s}$ and what is the acceleration of the object?

	displacement / m	acceleration / m s^{-2}
A	60	4.0
B	70	4.0
C	60	4.8
D	70	4.8

8 A skydiver jumps from an aeroplane and falls vertically through the air.

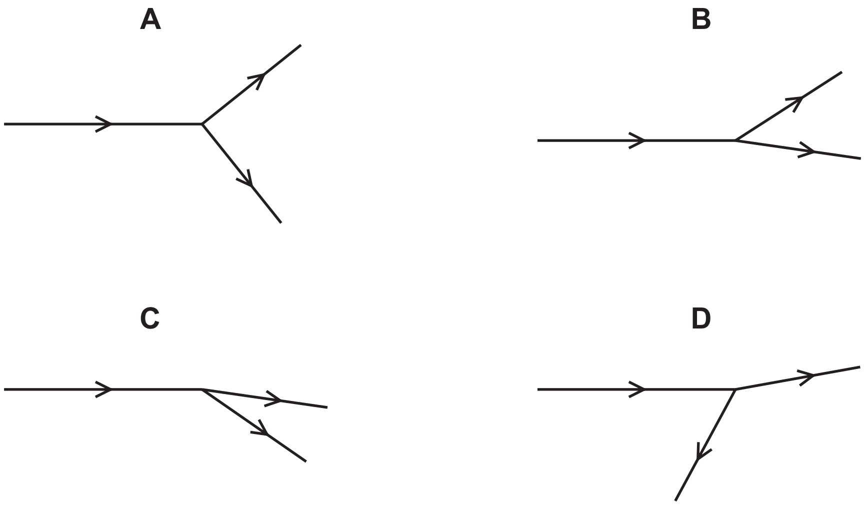
Which graph shows the variation with time t of the skydiver's vertical velocity v?



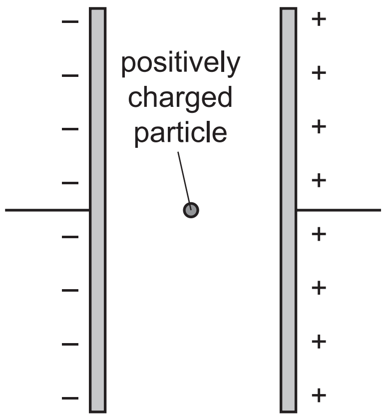
9 A nucleus collides with a stationary nucleus in a vacuum. The diagrams show the paths of the nuclei before and after the collision.

No other particles are involved in the collision.

Which diagram is **not** possible?



10 A uniform electric field is created by two parallel vertical plates. A positively charged particle is in the vacuum between the plates, as shown.



Which statement is correct?

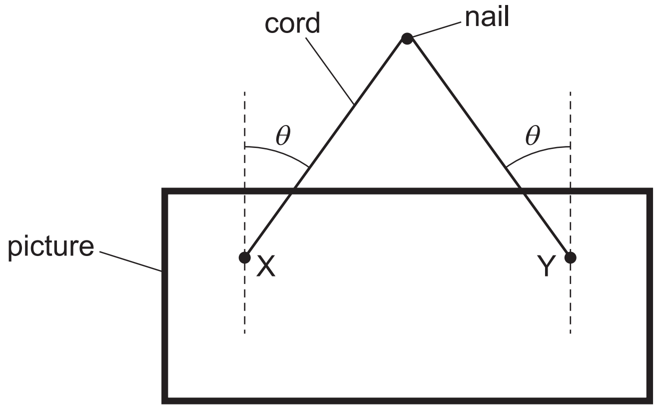
A The electric field makes the particle move towards the negative plate with a constant speed.

B The electric field makes the particle move towards the negative plate with a constant acceleration.

C The electric field produces a uniform rate of decrease in the particle's acceleration.

D The electric field produces a uniform rate of increase in the particle's acceleration.

11 A picture is suspended from a nail by a single cord connected to two points X and Y on the picture. There is negligible friction between the cord and the nail so that the tension in both sides of the cord is the same. The picture hangs symmetrically, as shown.



The tension in the cord is T. The angle between the cord and the vertical is θ on both sides.

Which statement is correct?

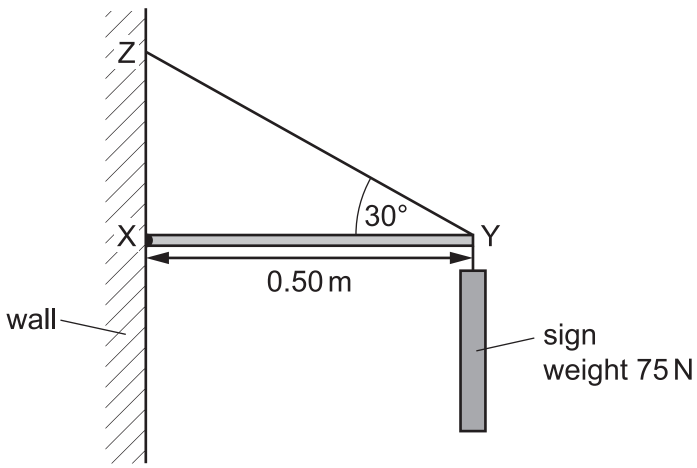
A Increasing the length of the cord, with points X and Y in the same place on the picture, would reduce the tension in the cord.

B Moving points X and Y further apart on the picture while keeping the length of the cord constant would reduce the tension in the cord.

C Moving points X and Y to the top edge of the picture while keeping their distance apart constant and the length of the cord constant would reduce the tension in the cord.

D The weight of the picture is equal to $T\cos\theta$.

12 A shop sign weighing 75 N hangs from a frame attached to a vertical wall.

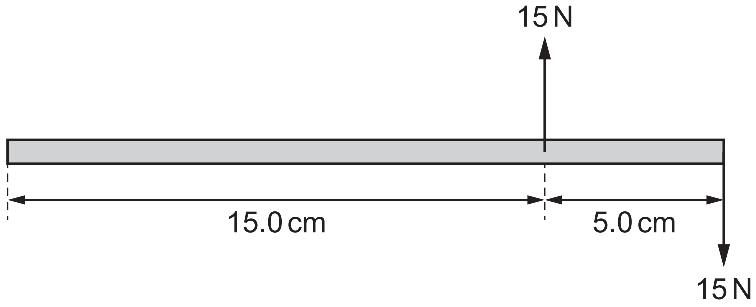


The frame consists of a horizontal rod XY and a rod YZ that is at an angle of 30° to the horizontal. Rod XY is attached to the wall by a hinge at X and has length 0.50 m. Assume that the weights of the rods are negligible.

What is the horizontal force exerted by the wall on rod XY?

A 0 N **B** 43 N **C** 130 N **D** 150 N

13 What is the torque of the couple shown?



A 0.75 N m **B** 1.50 N m **C** 3.00 N m **D** 5.25 N m

14 Water has a density of 1.0 g cm^{-3}.

Glycerine has a density of 1.3 g cm^{-3}.

A student measures out a volume of 40 cm^3 of glycerine into a container.

The student adds water to the container to make a mixture of water and glycerine. Assume that the total volume of water and glycerine does not change when the two liquids are mixed.

Which volume of water needs to be added to make a mixture of density 1.1 g cm^{-3}?

A 4.0 cm^3 **B** 8.0 cm^3 **C** 34 cm^3 **D** 80 cm^3

15 Which statement about the principle of conservation of energy is correct?

A Energy conversion helps to conserve energy sources.

B Energy is conserved only in systems with an efficiency of 100%.

C The supply of energy is limited so energy should be conserved.

D The total amount of energy in a closed system is constant.

16 A student can run or walk up the stairs to her classroom.

Which statement describes the power required and the gravitational potential energy gained while running up the stairs compared to walking up them?

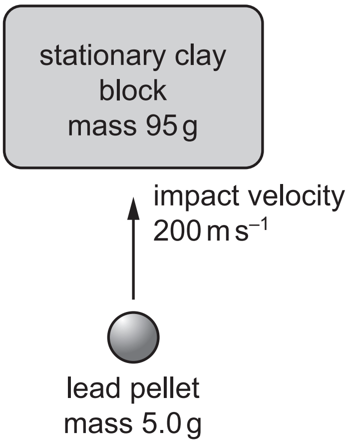
A Running provides more gravitational potential energy and uses more power.

B Running provides more gravitational potential energy and uses the same power.

C Running provides the same gravitational potential energy and uses more power.

D Running provides the same gravitational potential energy and uses the same power.

17 A lead pellet is shot vertically upwards into a clay block that is stationary at the moment of impact but is able to rise freely after impact.



The mass of the pellet is 5.0 g and the mass of the clay block is 95 g.

The pellet hits the block with an initial vertical velocity of $200\,\text{m}\,\text{s}^{-1}$. It embeds itself in the block and does not emerge.

How high above its initial position will the block rise?

A 5.1 m **B** 5.6 m **C** 10 m **D** 100 m

18 On the surface of a planet, 30 J of work is done against gravity to raise a mass of 1.0 kg through a height of 10 m.

How much work must be done to raise a mass of 4.0 kg through a height of 5.0 m on this planet?

A 15 J **B** 60 J **C** 120 J **D** 200 J

19 Four solid steel rods, each of length 2.0 m and cross-sectional area $250\,\text{mm}^2$, equally support an object weighing 10 kN. The weight of the object causes the rods to contract by 0.10 mm. The rods obey Hooke's law.

What is the Young modulus of steel?

A $2.0 \times 10^{8}\,\text{N}\,\text{m}^{-2}$

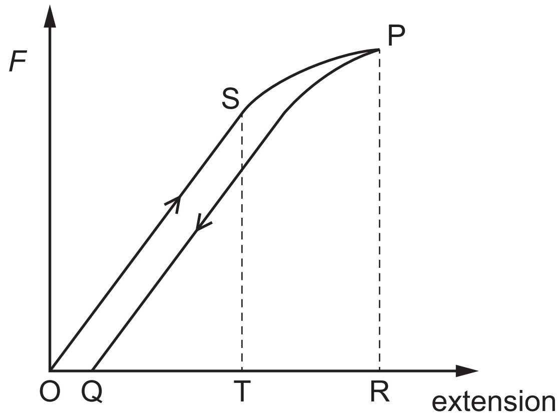
B $2.0 \times 10^{11}\,\text{N}\,\text{m}^{-2}$

C $8.0 \times 10^{8}\,\text{N}\,\text{m}^{-2}$

D $8.0 \times 10^{11}\,\text{N}\,\text{m}^{-2}$

20 A wire is attached at one end to a fixed point. A tensile force F is applied to the other end of the wire, causing it to extend. This is shown on the graph by the line OSP.

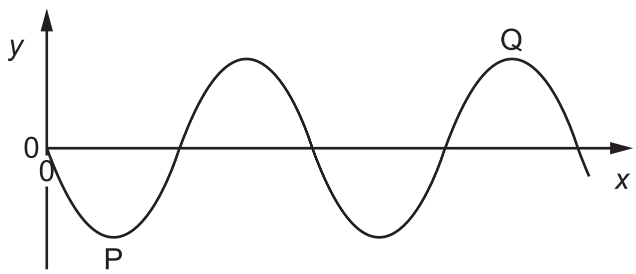
The force F is then gradually reduced to zero and the wire contracts. This is shown on the graph by the line PQ.



Which area on the graph represents the work done by the wire as it contracts?

A OSTO **B** OSPRO **C** QPRQ **D** OSPQO

21 The graph shows the variation of displacement y with distance x along a progressive wave at one instant in time.



What is the phase difference between points P and Q on the wave?

A 90° **B** 270° **C** 540° **D** 630°

22 Wave-power generators take advantage of the energy that is transferred by the motion of waves across the surface of the oceans. The energy of a wave depends on its amplitude.

What is the correct definition of amplitude?

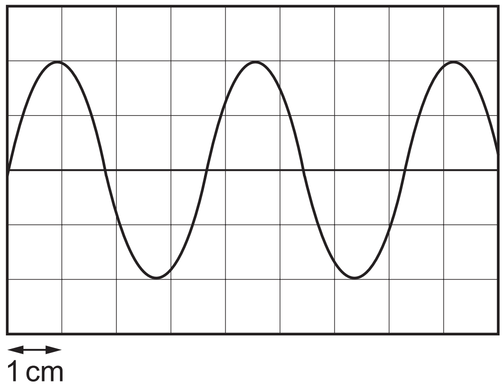
A the average amount of energy possessed by a wave

B the difference in displacement between a peak and a trough

C the maximum displacement of a point on the wave from equilibrium

D the number of oscillations of a wave that occur per second

23 A sound wave of frequency 270 Hz is recorded by a cathode-ray oscilloscope (CRO). The waveform on the CRO is shown.



What is the time-base setting on the CRO?

A 0.1 ms cm^{-1} **B** 1 ms cm^{-1} **C** 10 ms cm^{-1} **D** 100 ms cm^{-1}

24 A motor boat vibrates in the water so that it produces water waves of frequency 0.20 Hz. The speed of these waves in the water is 20 m s^{-1}. The motor boat moves with a speed of 5.0 m s^{-1} directly towards a stationary sailing boat.

The Doppler effect equation for sound waves also applies to water waves.

What is the frequency with which the waves hit the stationary sailing boat?

A 0.15 Hz **B** 0.16 Hz **C** 0.25 Hz **D** 0.27 Hz

25 Infrared laser light is used for the transmission of data along optic fibres.

What is a typical wavelength of infrared radiation?

A 5×10^{-5} m **B** 5×10^{-7} m **C** 2×10^{-9} m **D** 2×10^{-11} m

26 An elastic string is attached to an oscillator at one end and clamped at the other end so that the string is horizontal and in tension.

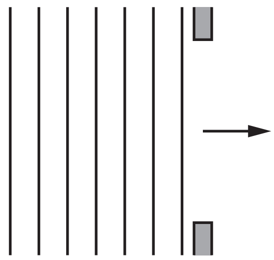
The oscillator is made to oscillate vertically. The frequency of oscillation is gradually increased from zero until a stationary wave is set up in the string. The frequency is then increased further to frequency *f*, when a second stationary wave is set up in the string.

The frequency is then increased further.

At which frequency does a third stationary wave occur?

A 1.2*f* **B** 1.5*f* **C** 2.0*f* **D** 3.0*f*

27 In an experiment, water waves in a ripple tank are incident on a gap, as shown.



Some diffraction of the water waves is observed.

Which change to the experiment would provide a better demonstration of diffraction?

A Increase the amplitude of the waves.

B Increase the frequency of the waves.

C Increase the wavelength of the waves.

D Increase the width of the gap.

28 Light of wavelength λ is emitted from two point sources R and S and falls onto a distant screen.

(not to scale)

At point P on the screen, the light intensity is zero.

What could explain the zero intensity at P?

A Light from the two sources is emitted 180° out of phase and the path difference to P is $\frac{1}{2}\lambda$.

B Light from the two sources is emitted in phase and the path difference to P is λ.

C Light from the two sources is emitted 90° out of phase and the path difference to P is λ.

D Light from the two sources is emitted in phase and the path difference to P is $\frac{1}{2}\lambda$.

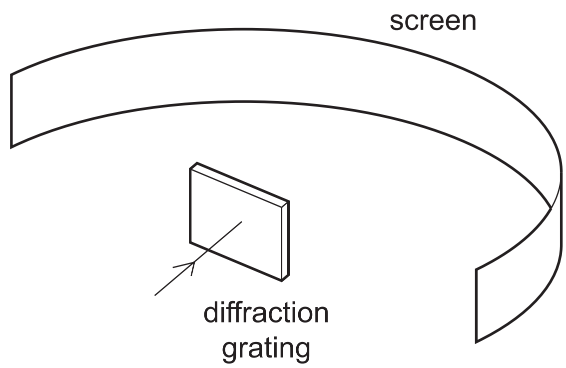
29 Apparatus is arranged to show double-slit interference using monochromatic light. The slit separation is 0.10 mm. The distance from the double slit to the screen where the interference pattern is observed is 2.4 m and the fringe width is 12 mm.

The distance to the screen is now changed to 1.8 m and the slit separation is doubled.

What is the new fringe width?

A 1.5 mm **B** 4.5 mm **C** 6.0 mm **D** 9.0 mm

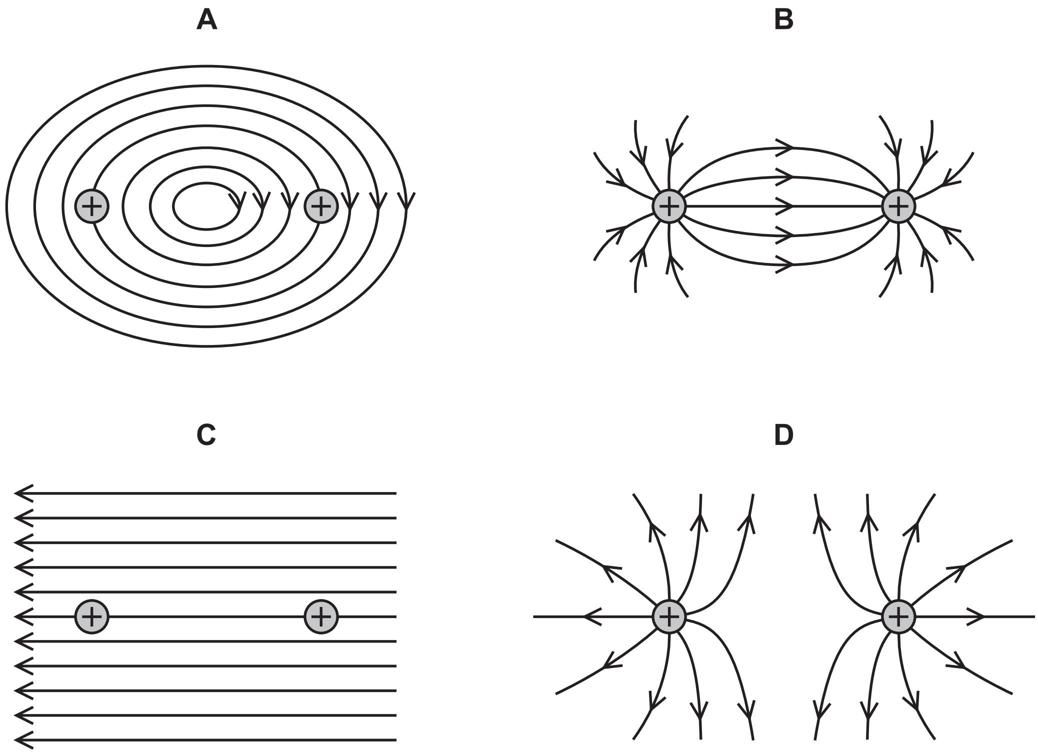
30 Monochromatic light of wavelength 690 nm passes through a diffraction grating with 300 lines per mm, producing a series of maxima (bright spots) on a screen.



What is the greatest number of maxima that can be observed?

A 4 **B** 5 **C** 8 **D** 9

31 Which diagram represents the electric field line pattern due to a combination of two positive charges?



32 Which two units are used to define the volt?

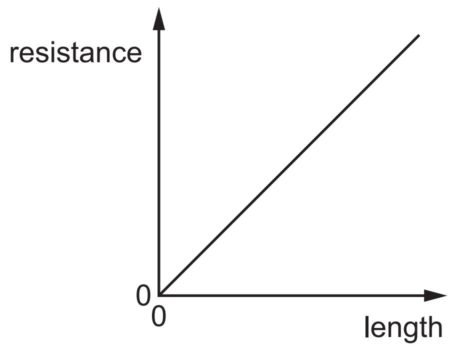
A ampere and ohm

B coulomb and joule

C coulomb and ohm

D coulomb and second

33 The graph shows the variation with length of the resistance of a uniform metal wire.



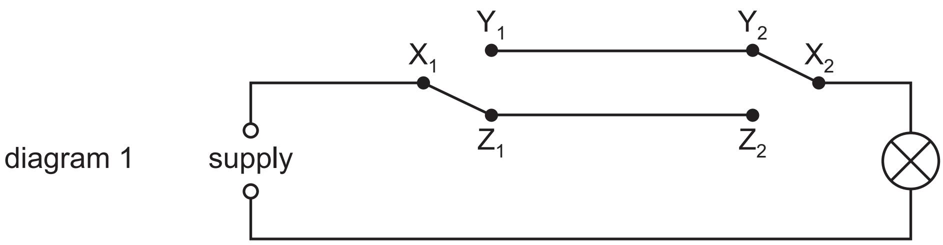
The gradient of the graph is G.
The wire has cross-sectional area A.

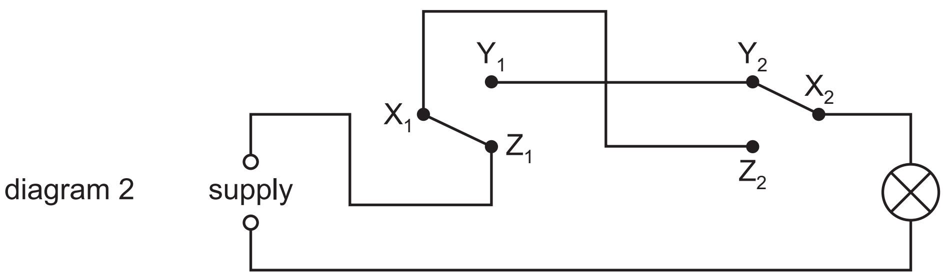
Which expression could be used to calculate the resistivity of the metal of the wire?

A $G \times A$ **B** $\frac{G}{A}$ **C** $\frac{A}{G}$ **D** $G \times A^2$

34 Diagram 1 shows a lamp connected to a supply through two switches.

During repairs, an electrician mistakenly reverses the connections X_1 and Z_1, so that Z_1 is connected to the supply and X_1 to the other switch at Z_2, as shown in diagram 2.





Which switch positions will now light the lamp?

A	X_1 to Y_1	X_2 to Y_2
B	X_1 to Y_1	X_2 to Z_2
C	X_1 to Z_1	X_2 to Y_2
D	X_1 to Z_1	X_2 to Z_2

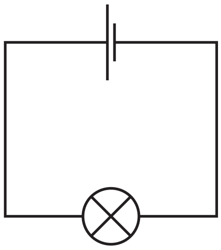
35 A wire supplying a shower heater with a current of 35 A has a resistance of 25 mΩ.

What is the power dissipated in the wire?

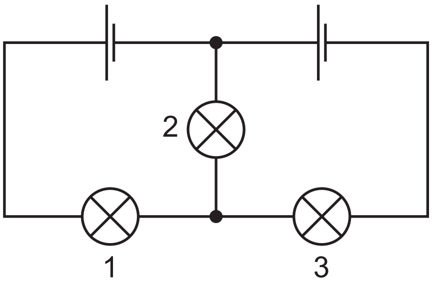
A 31 W **B** 49 W **C** 31 kW **D** 49 kW

36 A student has a set of identical cells and identical lamps. The cells have negligible internal resistance.

A lamp connected to a cell lights with normal brightness.



What happens when the student connects the lamps and the cells as shown?



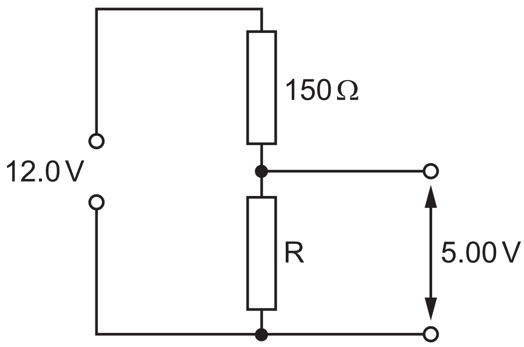
A All three lamps light with normal brightness.

B Only lamp 2 lights with normal brightness.

C Only lamps 1 and 3 light with normal brightness.

D None of the lamps light with normal brightness.

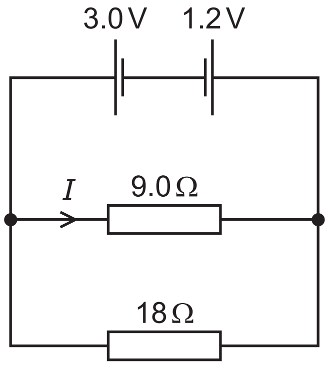
37 A potential divider circuit is shown.



What is the resistance of resistor R in the potential divider circuit?

A 62.5 Ω **B** 107 Ω **C** 210 Ω **D** 360 Ω

38 Two cells of electromotive force (e.m.f.) 3.0 V and 1.2 V and negligible internal resistance are connected to resistors of resistance 9.0 Ω and 18 Ω as shown.



What is the current I in the 9.0 Ω resistor?

A 0.10 A **B** 0.20 A **C** 0.30 A **D** 0.47 A

39 What is a correct estimate of the order of magnitude of the diameter of a typical atomic nucleus?

A 10^{-14} m **B** 10^{-18} m **C** 10^{-22} m **D** 10^{-26} m

40 Which statement describes β^- decay in terms of a simple quark model?

A A down quark changes to an up quark, and an electron and an electron antineutrino are emitted.

B A down quark changes to an up quark, and a positron and an electron neutrino are emitted.

C An up quark changes to a down quark, and an electron and an electron antineutrino are emitted.

D An up quark changes to a down quark, and a positron and an electron neutrino are emitted.

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 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.

IB20 06_9702_11/2RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate of the kinetic energy of a car travelling at a speed of $30\,\text{m}\,\text{s}^{-1}$?

A 10^2 J **B** 10^4 J **C** 10^6 J **D** 10^8 J

2 The frequency *f* of vibration of a mass *m* supported by a spring with spring constant *k* is given by the equation

$$f = Cm^p k^q$$

where *C* is a constant with no units.

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	$\frac{1}{2}$	$\frac{1}{2}$

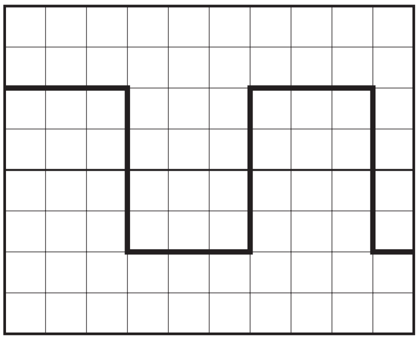
3 The power produced by a force moving an object is given by the equation shown.

$$\text{power} = \frac{\text{work}}{\text{time}} = \frac{\text{force} \times \text{displacement}}{\text{time}}$$

Which quantities are scalars and which are vectors?

	scalars	vectors
A	displacement, time	force, power
B	power, work	displacement, force
C	power, force	displacement, work
D	work, time	power, displacement

4 A cathode-ray oscilloscope displays a square wave, as shown.



The time-base setting is 0.20 ms per division.

What is the frequency of the square wave?

A 0.83 Hz **B** 830 Hz **C** 1300 Hz **D** 1700 Hz

5 A measurement is taken correctly but with a ruler at a significantly higher temperature than that at which the ruler was calibrated. The higher temperature causes the ruler to expand.

What describes the effect on the measurement caused by the higher temperature and how the measurement may be improved?

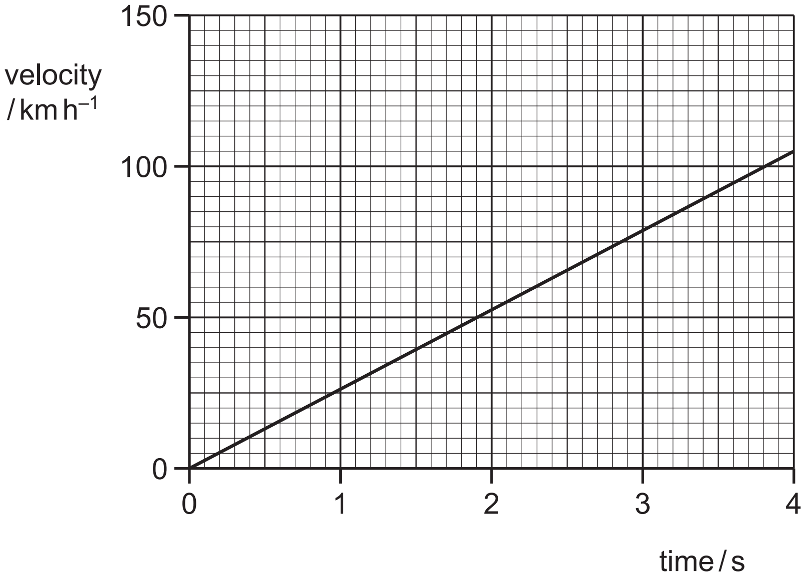
A The measurement will be subject to a random error. The measurement can be made more accurate by taking the average of several repeated measurements.

B The measurement will be subject to a random error. The measurement can be made more precise by taking the average of several repeated measurements.

C The measurement will be subject to a systematic error. The measurement can be made more accurate by taking the average of several repeated measurements.

D The measurement will be subject to a systematic error. The measurement can be made more precise by taking the average of several repeated measurements.

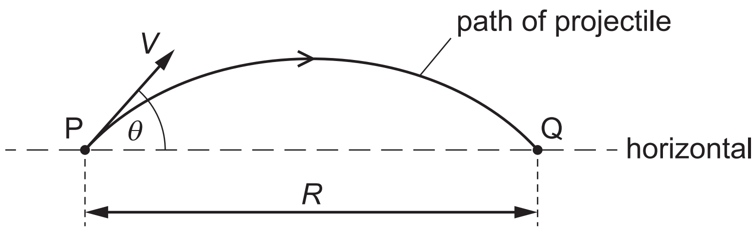
6 The velocity of an electric car changes as shown.



What is the acceleration of the car?

A $210\,\text{m s}^{-2}$ **B** $58\,\text{m s}^{-2}$ **C** $26\,\text{m s}^{-2}$ **D** $7.3\,\text{m s}^{-2}$

7 A projectile is fired from point P with velocity V at an angle θ to the horizontal. It lands at point Q, a horizontal distance R from P, after time T.



The acceleration of free fall is g. Air resistance is negligible.

Which equation is correct?

A $R = VT\cos\theta$

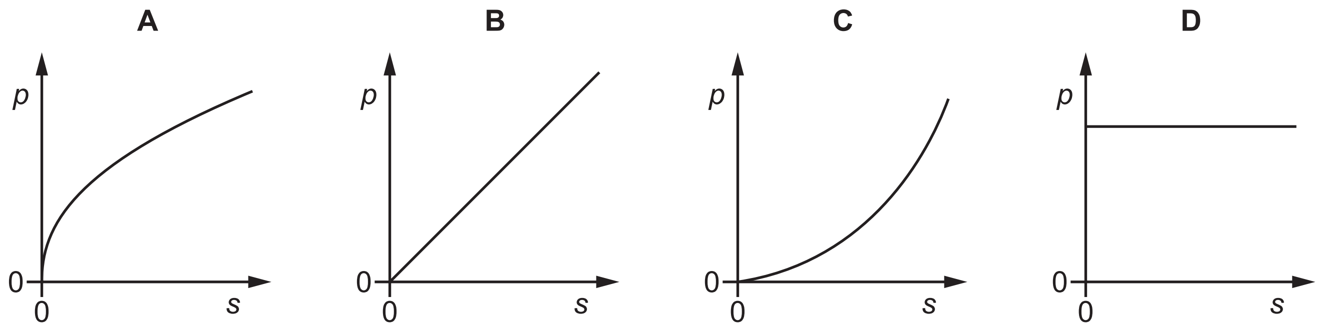
B $R = VT\sin\theta$

C $R = VT\cos\theta - \frac{1}{2}gT^2$

D $R = VT\sin\theta - \frac{1}{2}gT^2$

8 A car accelerates from rest in a straight line with constant acceleration.

Which graph best represents the variation of the momentum p of the car with the distance s travelled by the car?



9 The resultant force F on a raindrop of mass m falling with velocity v is given by the equation

$$F = mg - kv^2$$

where k is a constant and g is the acceleration of free fall.

What is the velocity of the raindrop when it reaches a constant (terminal) velocity?

A $\sqrt{\dfrac{k}{mg}}$ **B** $\dfrac{k}{mg}$ **C** $\sqrt{\dfrac{mg}{k}}$ **D** $\dfrac{mg}{k}$

10 A stationary toy gun fires a bullet.

Which statement about the bullet and the gun, immediately after firing, is **not** correct?

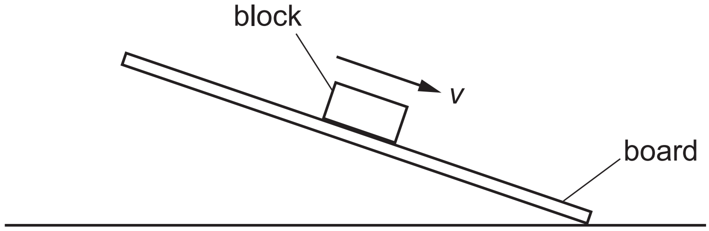
A The force exerted on the bullet by the gun has the same magnitude as the force exerted on the gun by the bullet.

B The force exerted on the bullet by the gun is in the opposite direction to the force exerted on the gun by the bullet.

C The gun and the bullet have the same magnitude of momentum.

D The kinetic energy of the gun must equal the kinetic energy of the bullet.

11 A wooden block rests on the rough surface of a board. One end of the board is then raised until the block slides down the board at constant velocity *v*.



What describes the forces acting on the block when it is sliding with constant velocity?

	frictional force on block	resultant force on block
A	down the board	down the board
B	down the board	zero
C	up the board	down the board
D	up the board	zero

12 Which statement best describes a couple?

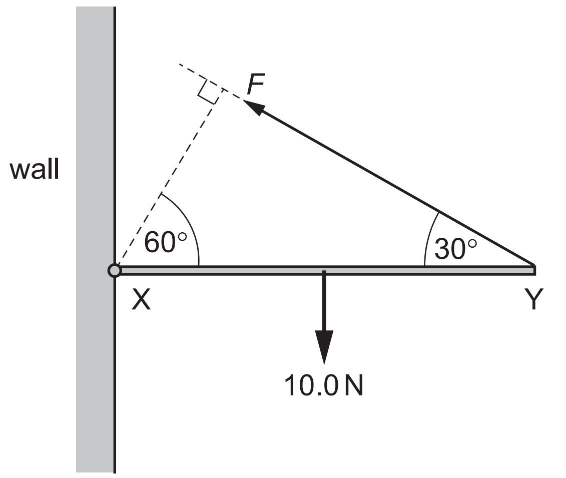
A a pair of forces of equal magnitude acting in opposite directions which produce rotational motion but not translational motion

B a pair of forces of equal magnitude acting in opposite directions which produce translational motion but not rotational motion

C a pair of forces of equal magnitude acting in the same direction which produce rotational motion but not translational motion

D a pair of forces of equal magnitude acting in the same direction which produce translational motion but not rotational motion

13 A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force F acting from Y at an angle of 30° to the horizontal, as shown.



What is the value of F?

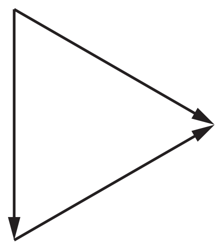
A 5.0 N **B** 8.7 N **C** 10.0 N **D** 20.0 N

14 Four combinations of vectors are shown, each representing all the forces acting on an object. The forces all act in the same plane.

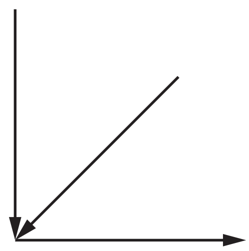
The object is in equilibrium.

Which combination of vectors could represent the forces acting on the object?

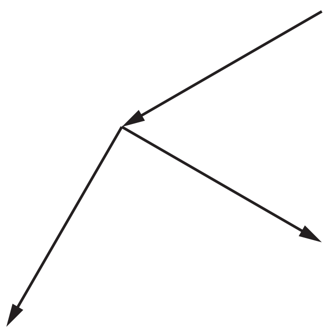
A



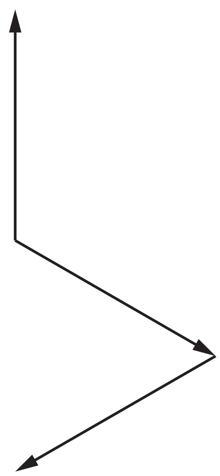
B



C



D



15 A rectangular metal bar exerts a pressure of 15 200 Pa on the horizontal surface on which it rests.

The height of the metal bar is 80 cm.

What is the density of the metal?

A $190\,\text{kg}\,\text{m}^{-3}$

B $1900\,\text{kg}\,\text{m}^{-3}$

C $19\,000\,\text{kg}\,\text{m}^{-3}$

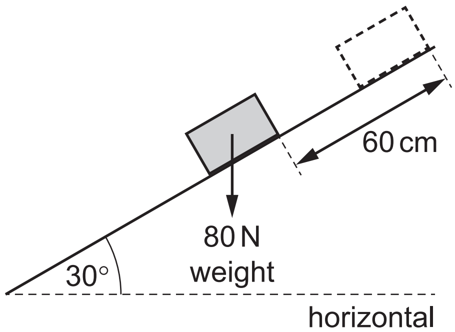
D $190\,000\,\text{kg}\,\text{m}^{-3}$

16 A mass attached to the lower end of a spring bounces up and down.

At which points in the path of the mass do the gravitational potential energy of the mass (GPE), the elastic potential energy in the spring (EPE) and the kinetic energy of the mass (KE) have their highest values?

	GPE	EPE	KE
A	bottom	middle	top
B	bottom	top	middle
C	top	bottom	middle
D	top	bottom	top

17 A block of weight 80 N is pushed a distance of 60 cm up a slope inclined at 30° to the horizontal. There is a frictional force of 25 N between the block and the surface of the slope.

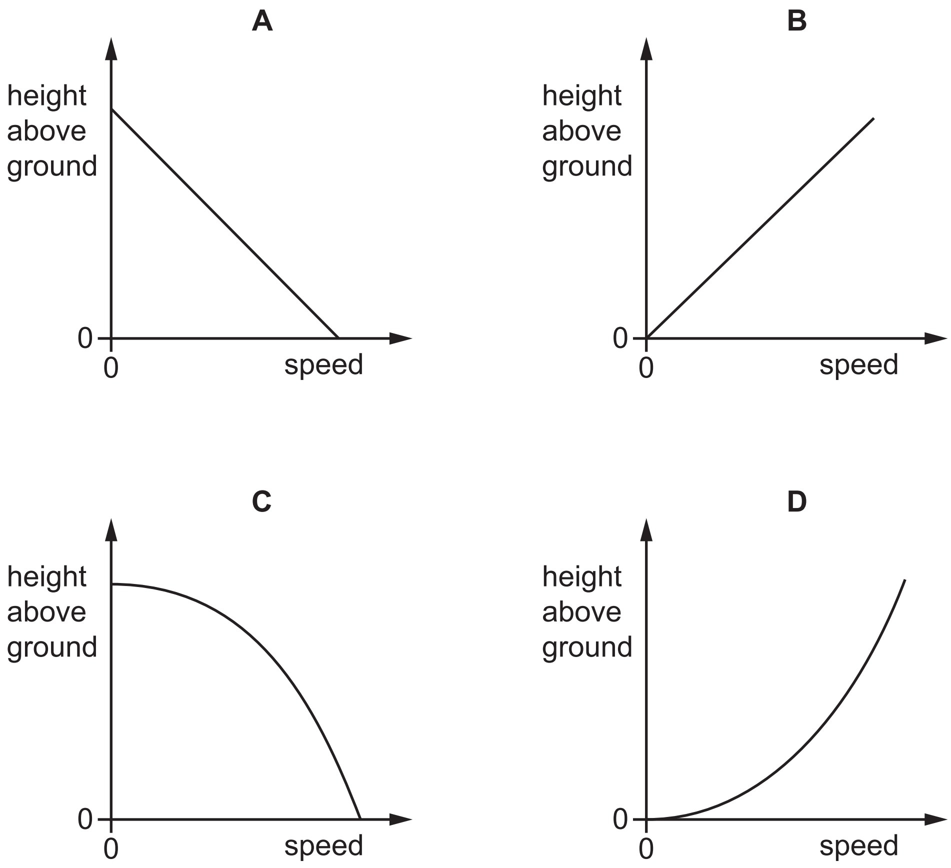


What is the work W_g done against the gravitational force and the work W_f done against the frictional force?

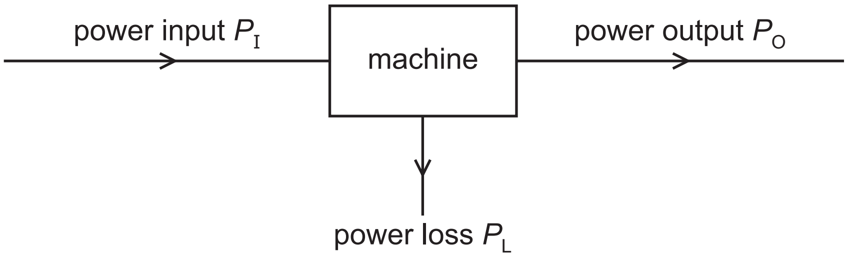
	W_g / J	W_f / J
A	24	7.5
B	24	15
C	48	7.5
D	48	15

18 A ball is dropped from rest and falls towards the ground. Air resistance is negligible.

Which graph shows the variation with speed of the height of the ball above the ground?



19 Power is transferred through a machine as shown.



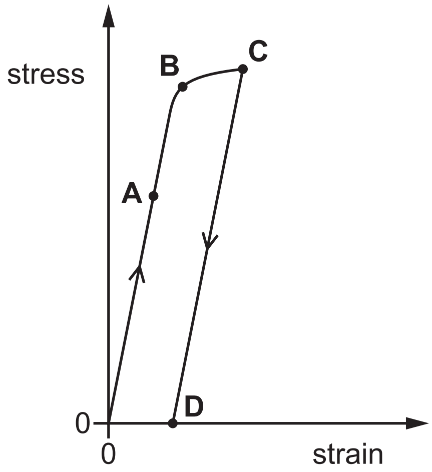
What is the efficiency of the machine?

A $\dfrac{P_I}{P_O + P_L}$ **B** $\dfrac{P_L}{P_I}$ **C** $\dfrac{P_L}{P_O}$ **D** $\dfrac{P_O}{P_I}$

20 A tensile force is used to extend a sample of a material. The force is then removed.

The variation with strain of the applied stress is shown on the graph.

Which point on the graph could represent the elastic limit for the material?



21 A tensile force is applied to an unstretched rubber band, causing it to stretch. The tensile force is then removed.

Which statement about the rubber band **must** be correct?

A If the rubber band stretches elastically and plastically, all the work done by the force is converted to thermal energy in the rubber.

B If the rubber band stretches elastically, it obeys Hooke's law.

C If the rubber band stretches elastically, the gradient of the force–extension graph represents the work done by the force.

D If the rubber band stretches plastically, the rubber band will be longer after the force is removed than it was before the force is applied.

22 A sound wave reduces in intensity but maintains a constant frequency as it travels through air.

Which statement is correct?

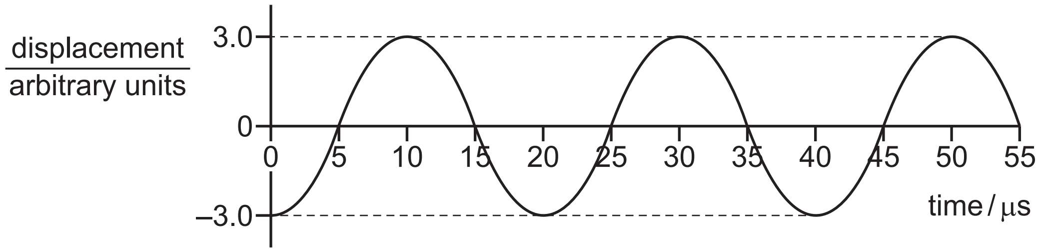
A The maximum displacement of the particles changes between one particle and the next particle.

B The phase difference between adjacent particles is zero.

C The wavelength is the distance between two particles that have a phase difference of 180°.

D Two particles that have a phase difference of 360° have the same maximum displacement.

23 The graph shows the variation with time of the displacement of an electromagnetic wave at a point.



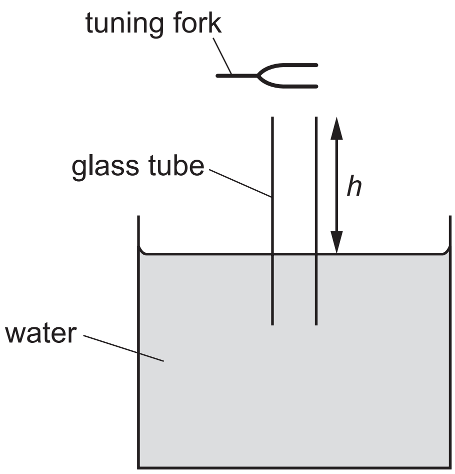
The wave is travelling in a vacuum.

What is the amplitude and what is the wavelength of the wave?

	amplitude / arbitrary units	wavelength / m
A	3.0	6000
B	6.0	6000
C	3.0	7500
D	6.0	7500

24 A long glass tube is almost completely immersed in a large tank of water. A tuning fork is struck and held just above the open end of the tube as it is slowly raised.

A louder sound is first heard when the height *h* of the end of the tube above the water is 18.8 cm. A louder sound is next heard when *h* is 56.4 cm. The speed of sound in air is $330\,m\,s^{-1}$.



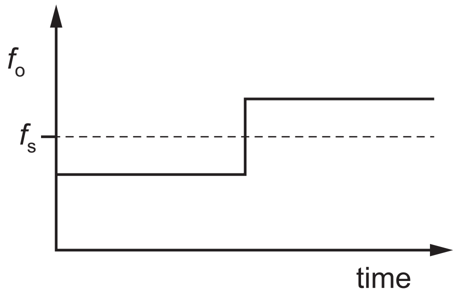
What is the frequency of the sound produced by the tuning fork?

A 220 Hz **B** 440 Hz **C** 660 Hz **D** 880 Hz

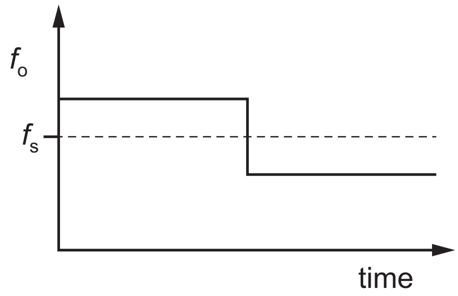
25 A source emitting sound of a single frequency f_s travels at constant speed directly towards an observer. The source then passes the observer and continues to move directly away from the observer. The velocity of the source remains constant.

Which graph represents the variation with time of the frequency f_o of the sound heard by the observer?

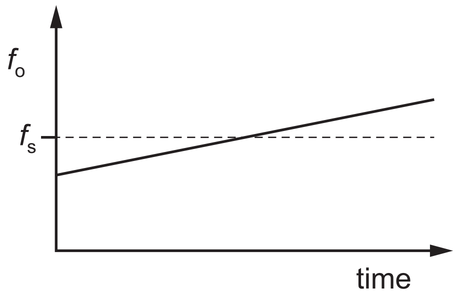
A



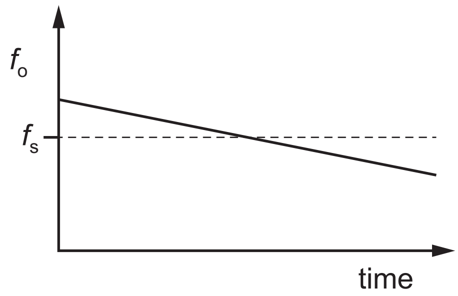
B



C



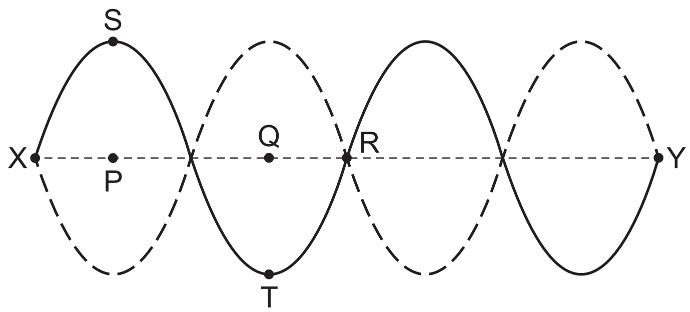
D



26 What are the names of the electromagnetic waves that have wavelengths in a vacuum of 100 pm and of 100 μm?

	wavelength 100 pm	wavelength 100 μm
A	γ-rays	infrared
B	γ-rays	red light
C	X-rays	infrared
D	X-rays	red light

27 The diagram shows a string stretched between fixed points X and Y. There is a stationary wave on the string.



The solid curve shows the string at a position of maximum displacement. The dashed curve shows the other position of maximum displacement. The straight central dashed line shows the mean position of the string. Point S on the string is directly above point P. Point T on the string is directly below Q.

Which statement is correct?

A A short time later, point R on the string will be displaced.

B Points S and T on the string move in opposite directions.

C The distance between P and Q is one wavelength.

D Two points on the string that are equal distances from point R vibrate in phase.

28 Which statement **must** be true for diffraction to occur when a wave passes through a gap?

A The wave is able to travel in a vacuum.

B The wave is progressive.

C The wave has a large amplitude.

D The wave has a long wavelength.

29 Light of a single wavelength is incident normally on two slits that are 0.20 mm apart. Interference fringes are observed on a screen that is 5.4 m away from the slits. The distance between successive bright fringes is 12 mm.

What is the wavelength of the light?

A 440 nm **B** 540 nm **C** 650 nm **D** 900 nm

30 A diffraction grating and a screen are used to determine the single wavelength λ of the light from a source.

What is an essential feature of this experiment?

A A curved screen must be used.

B The diffraction angle θ must be measured for at least two interference maxima.

C The light waves incident on the grating must be coherent.

D The third order intensity maximum must be produced.

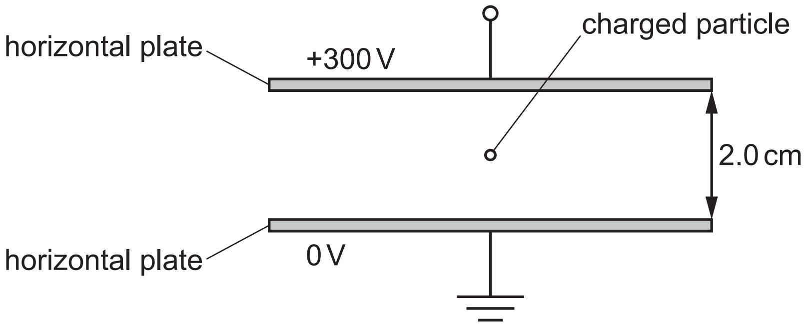
31 A small charge q is placed in the electric field of a large charge Q.

Both charges experience a force F.

What is the electric field strength of the charge Q at the position of the charge q?

A $\dfrac{F}{Qq}$ **B** $\dfrac{F}{Q}$ **C** FqQ **D** $\dfrac{F}{q}$

32 A charged particle is in a vacuum between two horizontal metal plates as shown.



The acceleration of the particle is $7.15 \times 10^{11}\,\mathrm{m\,s^{-2}}$ downwards. The particle has a mass of $3.34 \times 10^{-27}\,\mathrm{kg}$.

What is the charge on the particle?

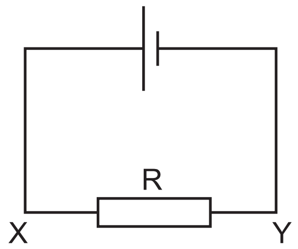
A $+1.6 \times 10^{-19}\,\mathrm{C}$

B $-1.6 \times 10^{-19}\,\mathrm{C}$

C $+1.6 \times 10^{-17}\,\mathrm{C}$

D $-1.6 \times 10^{-17}\,\mathrm{C}$

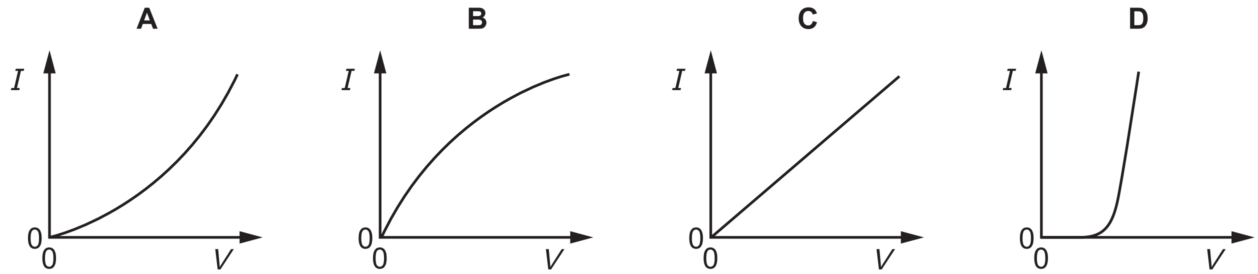
33 The current in the circuit shown is 3.2 mA.



What are the direction of flow and the rate of flow of electrons through the resistor R?

	direction of flow	rate of flow / s^{-1}
A	X to Y	2.0×10^{16}
B	X to Y	5.1×10^{-22}
C	Y to X	2.0×10^{16}
D	Y to X	5.1×10^{-22}

34 Which graph best represents the way the current I through a filament lamp varies with the potential difference V across it?



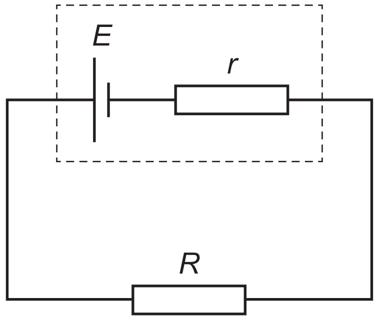
35 A cylindrical metal wire X has resistance R. The same volume of the same metal is made into a cylindrical wire Y of double the length.

What is the resistance of wire Y?

A R **B** $2R$ **C** $4R$ **D** $8R$

36 A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a resistor of resistance R.

A maximum power P can be dissipated by the resistor without overheating.



What is the maximum value of E if the resistor does not overheat?

A $R\sqrt{\dfrac{P}{(R-r)}}$ **B** $R\sqrt{\dfrac{P}{(R+r)}}$ **C** $(R-r)\sqrt{\dfrac{P}{R}}$ **D** $(R+r)\sqrt{\dfrac{P}{R}}$

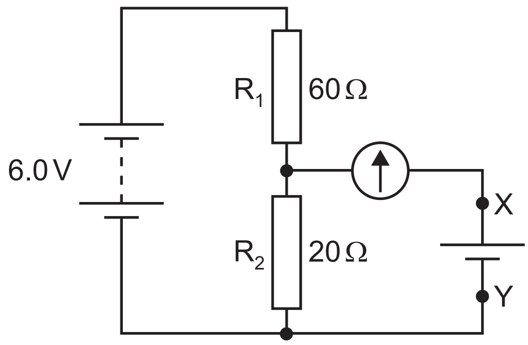
37 Three identical resistors can be connected together in four different ways.

The resistances of two of these combinations are 4.0 Ω and 9.0 Ω.

What is the resistance of each individual resistor?

A 3.0 Ω **B** 6.0 Ω **C** 12 Ω **D** 18 Ω

38 In the circuit shown, a battery of negligible internal resistance is connected in series with a pair of fixed resistors R_1 and R_2.



The circuit is to be used to test whether the electromotive force (e.m.f.) of a particular cell is 1.5 V. The cell is connected between terminals X and Y in parallel with R_2 and in series with a galvanometer.

Which statement about the test is correct?

A Any non-zero reading on the galvanometer means the cell has an e.m.f. of 1.5 V.

B The battery does not need to have an e.m.f. of 6.0 V.

C The cell may be connected either way round between X and Y.

D The galvanometer does not need a scale calibrated in amperes.

39 An element has two isotopic forms.

What are the nuclear arrangements of these two isotopes?

A They have different nucleon numbers and different proton numbers.

B They have different nucleon numbers but the same proton number.

C They have the same nucleon number and the same proton number.

D They have the same nucleon number but different proton numbers.

40 A hadron has a charge +*e*, where *e* is the elementary charge.

Which combination of up (u) and down (d) quarks could form this hadron?

A ddd **B** udd **C** uud **D** uuu

Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2020**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 2 4 5 8 9 5 6 3 8 3 *

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 **24** pages. Blank pages are indicated.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate of the mass of a raindrop?

A 10^{1} kg **B** 10^{-1} kg **C** 10^{-3} kg **D** 10^{-5} kg

2 Which quantity is a scalar?

A acceleration

B force

C kinetic energy

D momentum

3 A galvanometer of resistance 5 Ω is to be used in a null method.

In order to protect the galvanometer from damage due to an excessive initial current, resistors of resistance 0.5 Ω and 1 kΩ are available.

Which arrangement would provide this protection?

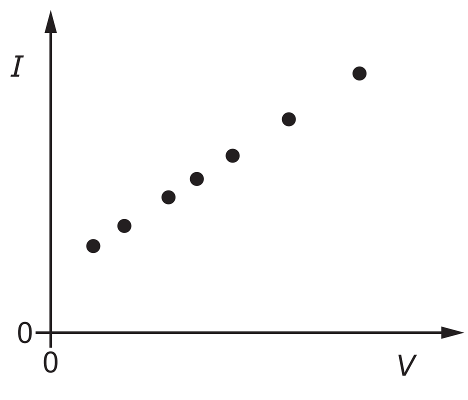
A the 0.5 Ω resistor in series with the galvanometer

B the 0.5 Ω resistor in parallel with the galvanometer and this combination placed in series with the 1 kΩ resistor

C the 1 kΩ resistor in parallel with the galvanometer

D the 1 kΩ resistor in parallel with the galvanometer and this combination placed in series with the 0.5 Ω resistor

4 Readings are made of the current I for different voltages V across a fixed resistor. The results are plotted on a graph to show the variation of I with V.



What is the best description of the errors in the readings?

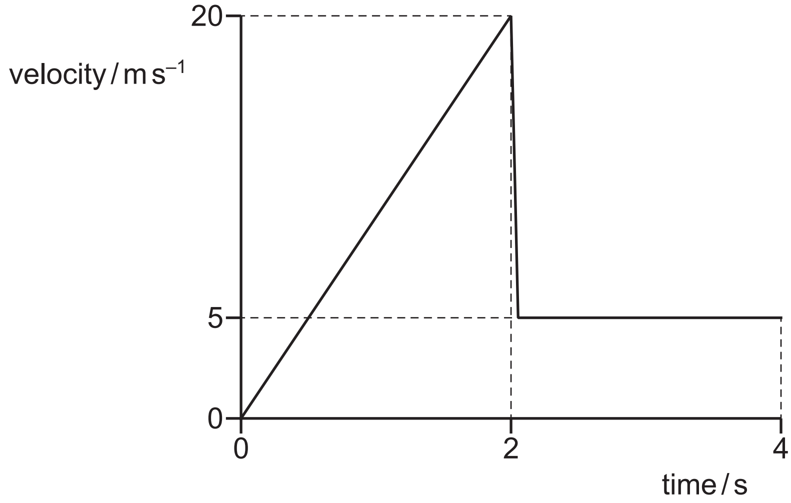
A both systematic and random

B neither systematic nor random

C random only

D systematic only

5 A stone is dropped from a height of 20 m above water. The graph shows the variation with time of the velocity of the stone.



Which statement describes the approximate position of the stone four seconds after it is dropped?

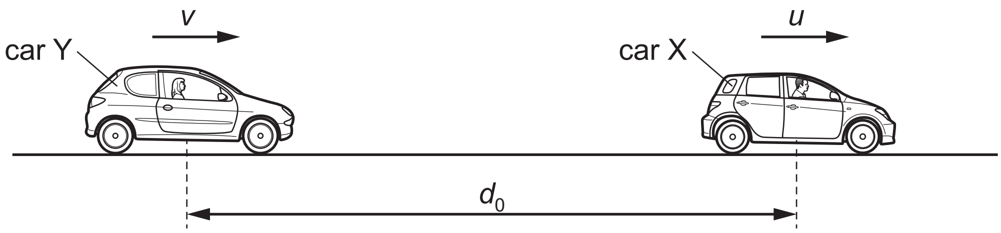
A It is at a distance of 10 m above the surface of the water.

B It is at a distance of 10 m below the surface of the water.

C It is at a distance of 20 m below the surface of the water.

D It is at a distance of 30 m below the surface of the water.

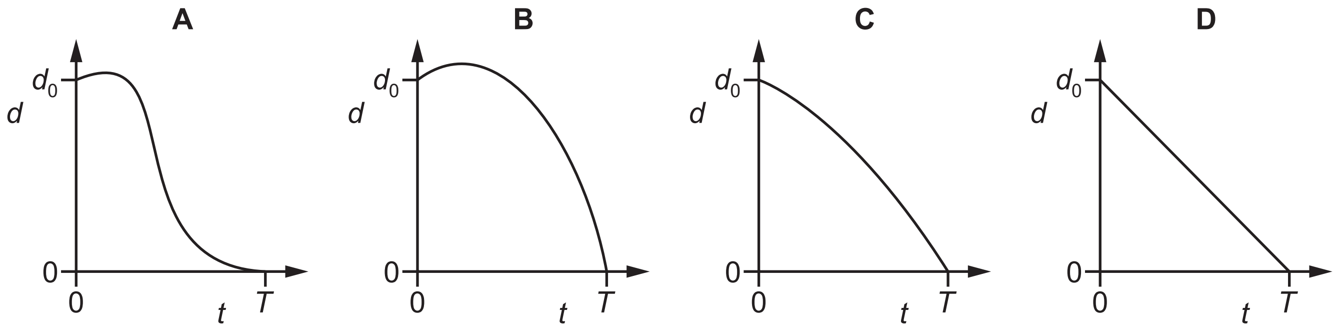
6 A car X is travelling at a constant speed u along a straight road. At time $t = 0$ a second car Y is a distance d_0 behind car X and travelling at a speed v in the same direction. Speed v is less than speed u.



At time $t = 0$ car Y begins to accelerate with a constant acceleration.

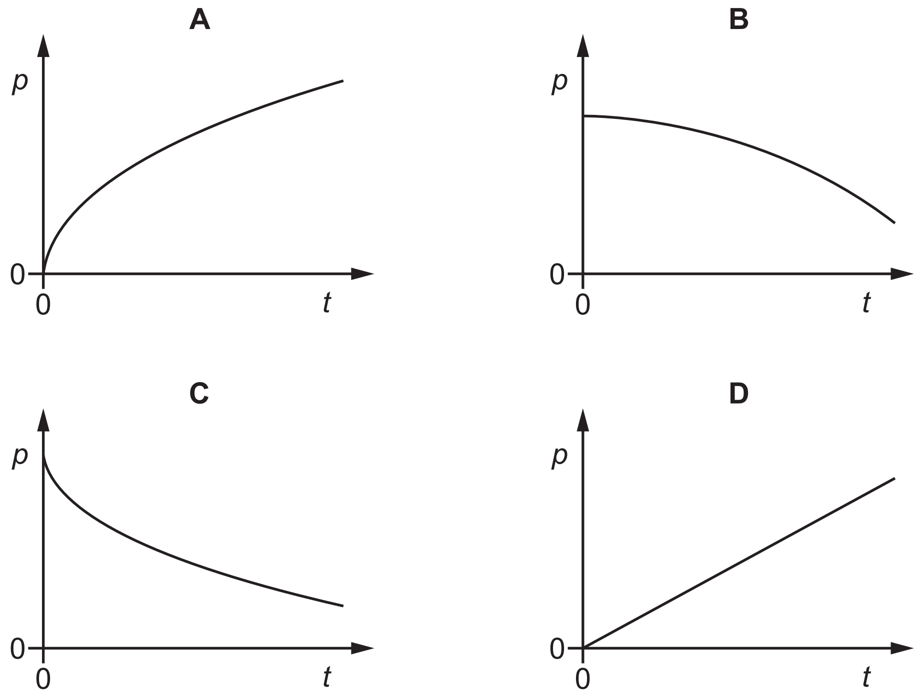
Car Y overtakes car X at time $t = T$.

Which graph could best show the variation with time t of the distance d between the cars?



7 The resultant force acting on an object is slowly increased.

Which graph could show the variation with time t of the momentum p of the object?



8 An astronaut has a weight of 660 N when she is standing on the Earth's surface.

The acceleration of free fall on the surface of Mars is $3.71\,\mathrm{m\,s^{-2}}$.

What would be the weight of the astronaut if she stood on the surface of Mars?

A 67.3 N **B** 178 N **C** 250 N **D** 660 N

9 A mass m_1 travelling with speed u_1 collides with a mass m_2 travelling with speed u_2 in the same direction. After the collision, mass m_1 has speed v_1 and mass m_2 has speed v_2 in the same direction. The collision is perfectly elastic.

Which equation is **not** correct?

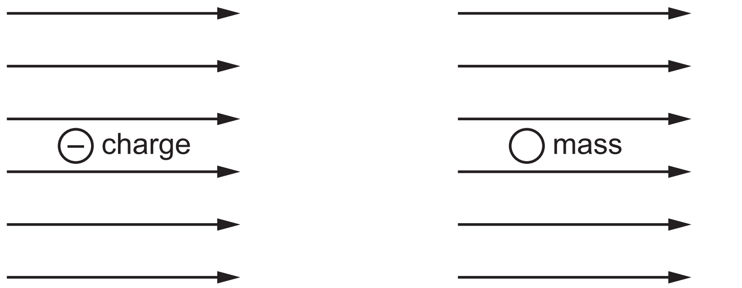
A $m_1u_1^2 - m_1v_1^2 = m_2v_2^2 - m_2u_2^2$

B $v_2 + u_2 = v_1 + u_1$

C $m_1(u_1 - v_1) = m_2(v_2 - u_2)$

D $m_1(u_1 - v_1)^2 = m_2(u_2 - v_2)^2$

10 The diagrams show a negative electric charge situated in a uniform electric field and a mass situated in a uniform gravitational field.

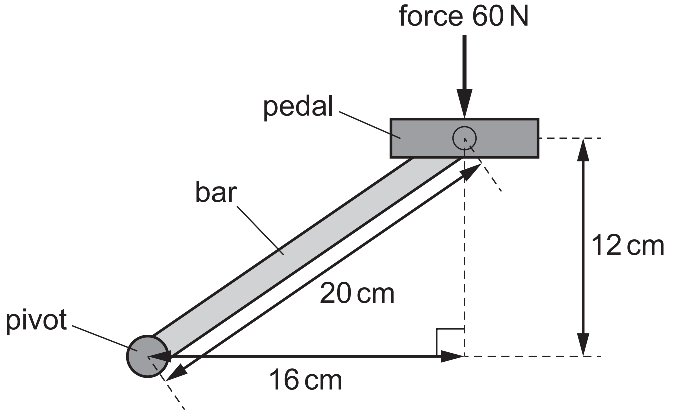


uniform electric field　　　　uniform gravitational field

Which row shows the directions of the forces acting on the charge and on the mass?

	charge	mass
A	⊖ →	○ →
B	← ⊖	○ →
C	⊖ →	○ ↓
D	← ⊖	○ ↓

11 A bicycle pedal is connected to a pivot by a metal bar, as shown.

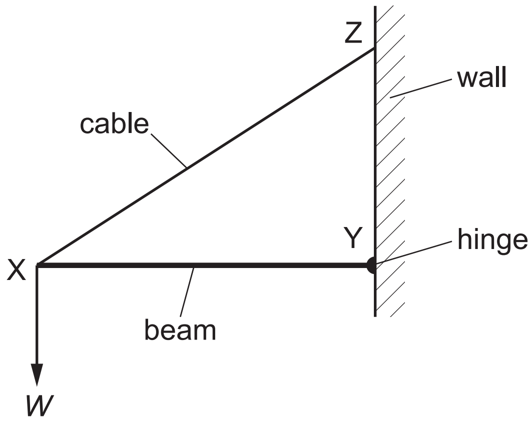


The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

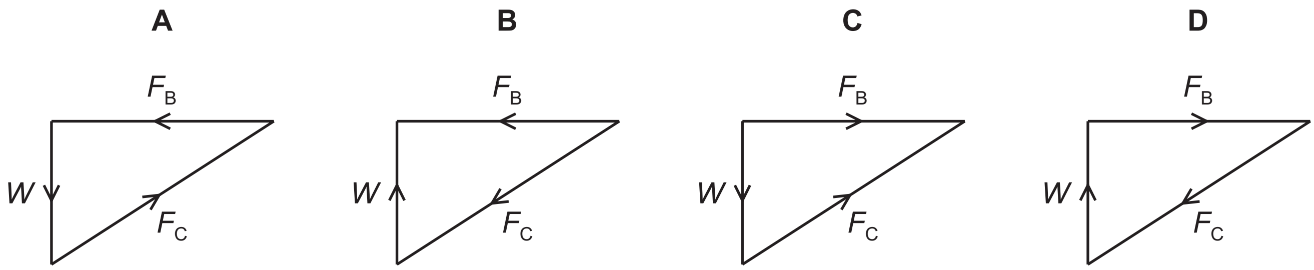
A 7.2 N m　　**B** 9.6 N m　　**C** 12 N m　　**D** 1200 N m

12 A thin horizontal beam XY is freely hinged at point Y to a vertical wall. The beam is held stationary by a cable XZ which is attached to the wall at point Z.

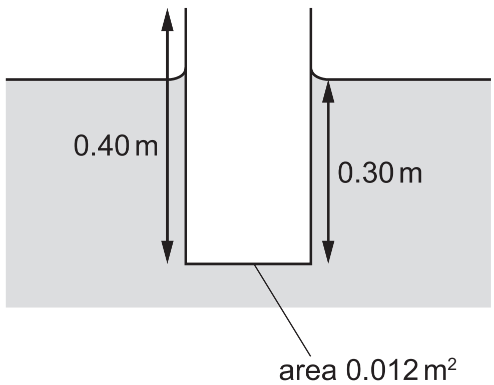


The beam supports a weight W at point X. The forces in the cable and the beam are F_C and F_B respectively.

Which vector triangle represents the forces acting on point X?



13 A pipe, open at one end, floats in a liquid as shown.



The cross-sectional area of the pipe is $0.012\,m^2$. The weight of the pipe is 32 N.

What is the density of the liquid?

A $680\,kg\,m^{-3}$ **B** $910\,kg\,m^{-3}$ **C** $6700\,kg\,m^{-3}$ **D** $8900\,kg\,m^{-3}$

14 During an interval of time, fuel supplies energy X to a car.

Some of this energy is converted into kinetic energy as the car accelerates.

The rest of the energy Y is lost as thermal energy.

What is the efficiency of the car?

A $\dfrac{X}{X-Y}$ **B** $\dfrac{Y}{X-Y}$ **C** $\dfrac{X-Y}{X}$ **D** $\dfrac{X-Y}{Y}$

15 In which situation is work done on an object?

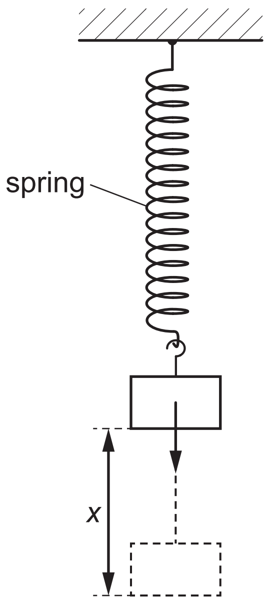
A The object slides with a constant velocity along a horizontal frictionless surface in a vacuum.

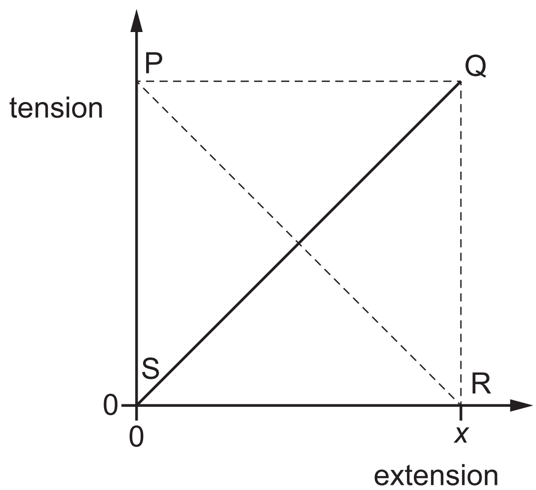
B A person holds the object at arm's length and at a fixed height above the ground.

C A person pushes the object up a frictionless ramp.

D The stationary object floats partially submerged in water.

16 A spring is attached at one end to a fixed point. A mass is then hung from the other end of the spring. The spring has extension x when the system is in equilibrium.





The variation of the tension in the spring with its extension is shown on the graph.

Which statement is correct?

A Area SPR represents the energy stored in the spring which cannot be recovered.

B Area SPQR represents the energy stored in the spring which can be recovered.

C Area SPQ represents the loss of gravitational potential energy of the mass due to the extension of the spring.

D Area SQR represents the elastic potential energy stored in the spring.

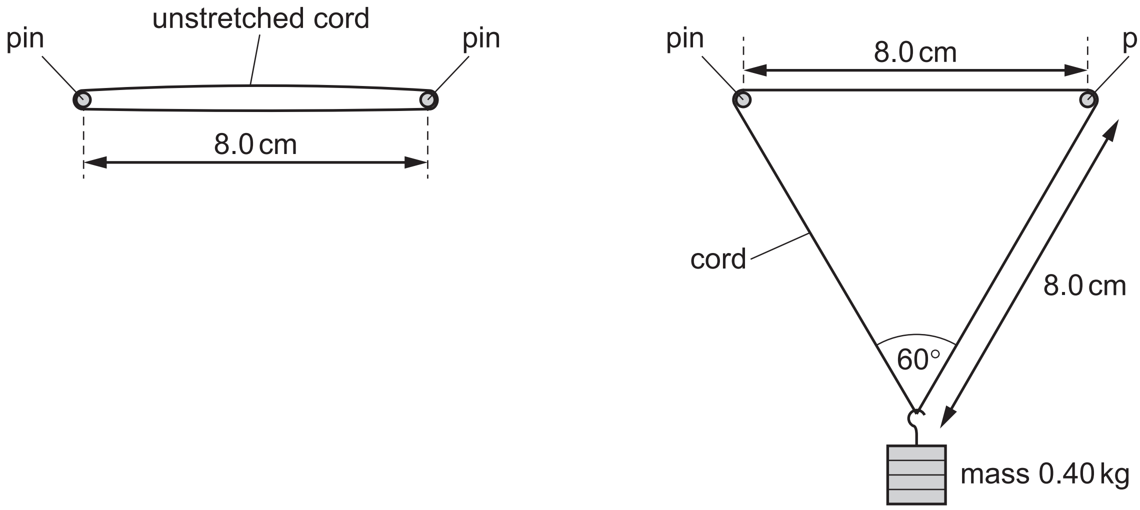
17 An escalator in an underground station has 25 people standing on it and is moving with a speed of $4.3\,\mathrm{m\,s^{-1}}$. The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40°.

What is the minimum power required to lift these people?

A 5.4 kW **B** 6.4 kW **C** 53 kW **D** 63 kW

18 An elastic cord of unstretched total length 16.0 cm and cross-sectional area $2.0 \times 10^{-6}\,\mathrm{m}^2$ is held horizontally by two smooth pins a distance 8.0 cm apart.

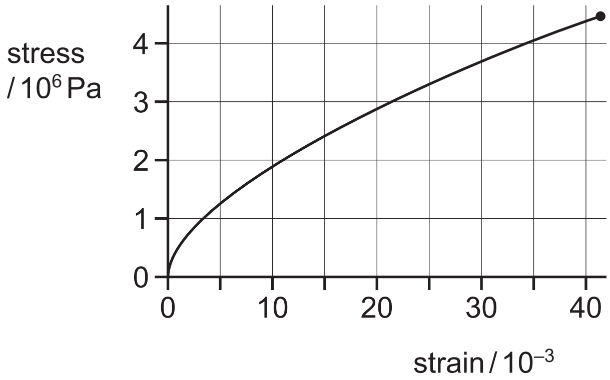
The cord obeys Hooke's law. A load of mass 0.40 kg is suspended centrally on the cord. The angle between the two sides of the cord supporting the load is 60°.



What is the Young modulus of the cord material?

A 5.7×10^5 Pa **B** 1.1×10^6 Pa **C** 2.3×10^6 Pa **D** 3.9×10^6 Pa

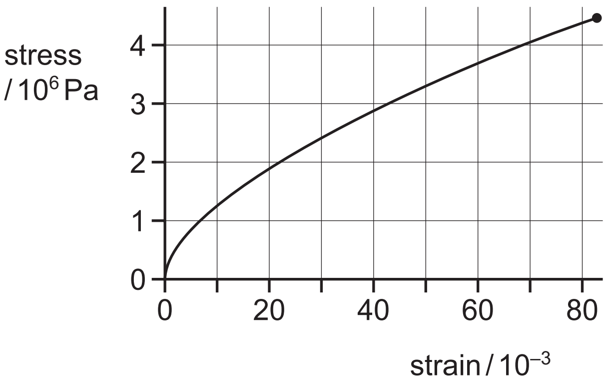
19 A student is investigating the mechanical properties of a metal. He applies different loads to a long thin wire up to its breaking point, and measures the extension of the wire for each load. He then plots a graph of stress against strain.



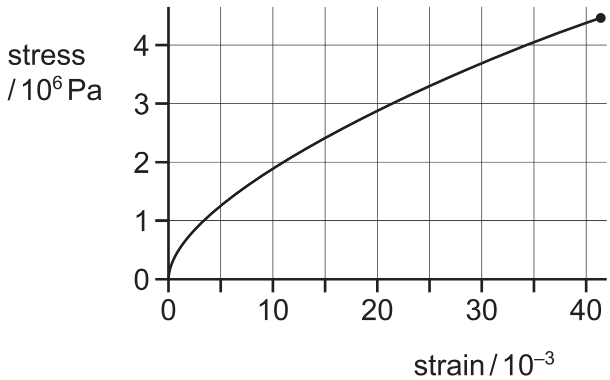
The student repeats the experiment with a wire made from the same metal, with twice the original length and half the diameter.

Which graph is obtained?

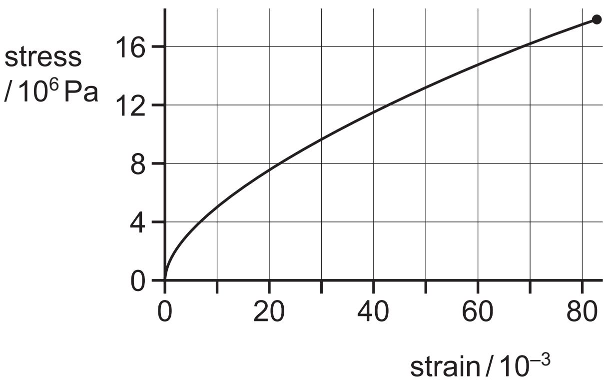
A



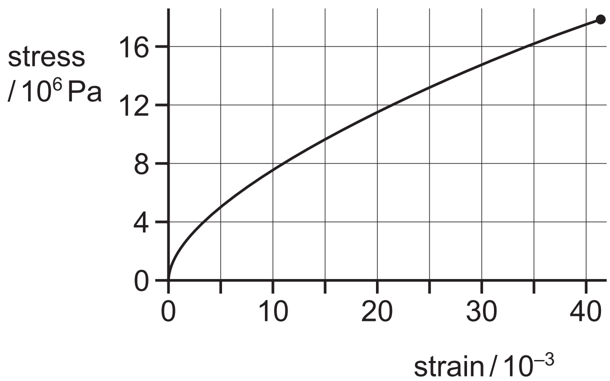
B



C



D



20 Which statement describes what is meant by the plastic deformation of a material?

A It always obeys Hooke's law.

B It does not return to its original length when the extending force is removed.

C It never obeys Hooke's law.

D It returns to its original length when the extending force is removed.

21 A transverse wave is moving along a rope. Two points X and Y on the rope are a quarter of a wavelength apart from each other.

Which statement is **not** possible for the two points X and Y at any instant?

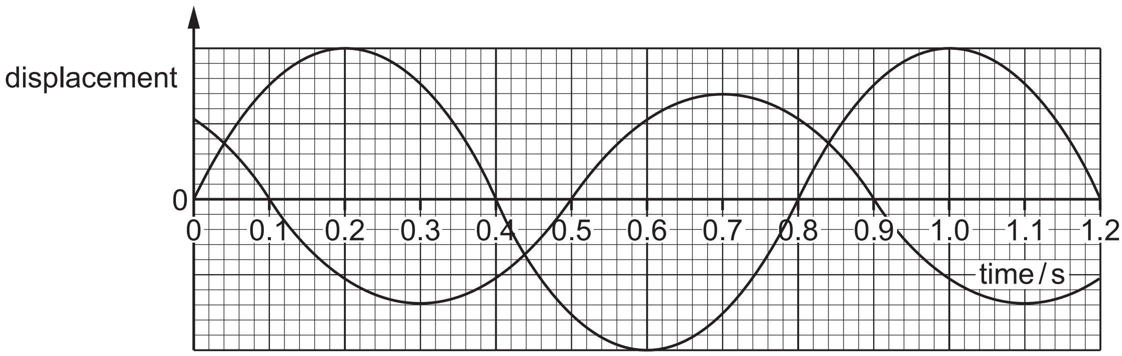
A They are both stationary.

B They are displaced in opposite directions from their equilibrium position.

C They are moving in opposite directions.

D They both have displacements of the same magnitude from their equilibrium positions.

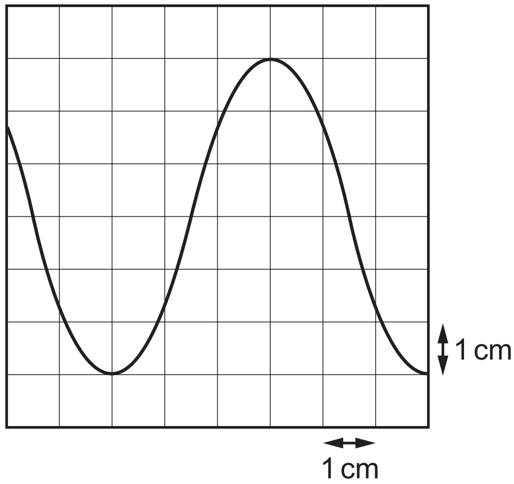
22 Two progressive waves meet at a fixed point P. The variation with time of the displacement of each wave at point P is shown in the graph.



What is the phase difference between the two waves at point P?

A 45° **B** 90° **C** 135° **D** 180°

23 A microphone connected to the Y-plates of a cathode-ray oscilloscope (CRO) is placed in front of a loudspeaker. The trace on the screen of the CRO is shown.

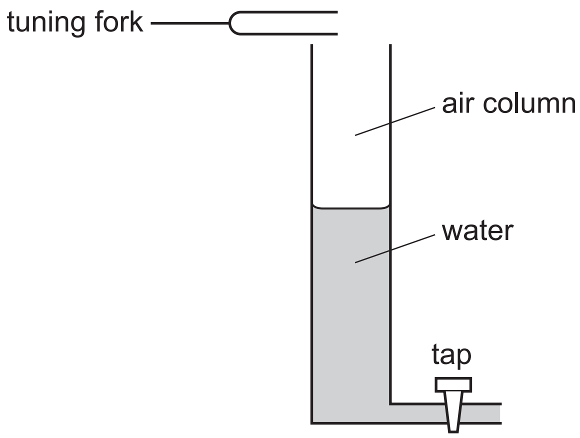


The time-base setting is $0.5\,\text{ms}\,\text{cm}^{-1}$ and the Y-plate sensitivity is $0.2\,\text{mV}\,\text{cm}^{-1}$.

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the CRO?

	frequency / Hz	amplitude / mV
A	330	0.6
B	330	1.2
C	670	0.6
D	670	1.2

24 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.



The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

What is the wavelength of the sound wave?

A 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

25 A stationary person measures the speed and wavelength of the sound from a horn on a stationary vehicle. The person then repeats the measurements when the vehicle is approaching at a constant speed.

Which row describes the measured wavelength and the measured speed of the sound wave from the moving vehicle when compared with the sound wave from the stationary vehicle?

	wavelength of the sound wave	speed of the sound wave
A	longer	greater
B	shorter	greater
C	longer	same
D	shorter	same

26 The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^{2} m
A	gamma-ray	X-ray	infrared	microwave	radio wave
B	radio wave	microwave	infrared	X-ray	gamma-ray
C	radio wave	microwave	ultraviolet	infrared	X-ray
D	X-ray	infrared	ultraviolet	microwave	radio wave

27 Two progressive waves meet at a point.

Which condition must be met for superposition of the waves to occur?

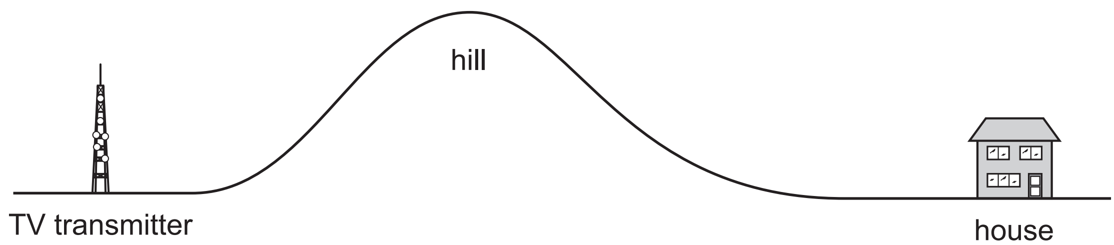
A The waves must be coherent.

B The waves must be of the same type.

C The waves must be travelling in opposite directions.

D The waves must meet in phase.

28 A hill separates a television (TV) transmitter from a house. The transmitter cannot be seen from the house. However, the house has good TV reception.



By which wave effect at the hill could the TV signal reach the house?

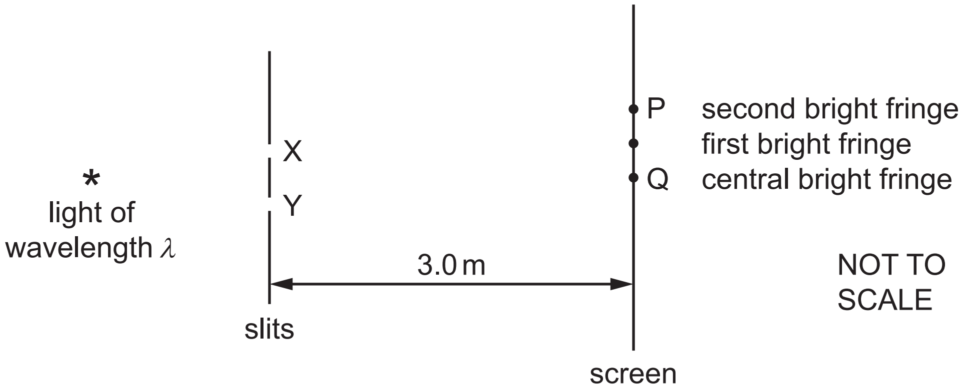
A coherence

B diffraction

C interference

D reflection

29 The diagram shows an arrangement for demonstrating two-source interference using coherent light of a single wavelength λ.



An interference pattern is observed on a screen 3.0 m away from the slits X and Y, which have a separation of 1.0 mm.

The central bright fringe is at Q, and the **second** bright fringe from the centre is at P.

What is the distance between Q and P?

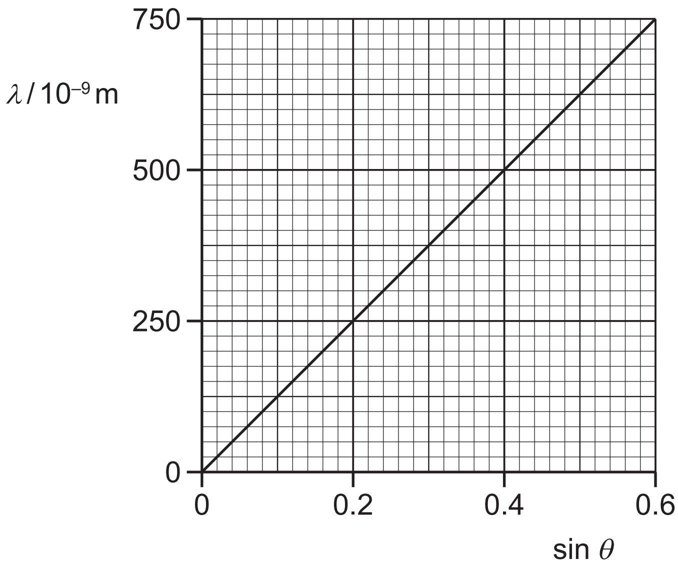
A $6.0 \times 10^{3}\,\lambda$

B $3.0 \times 10^{3}\,\lambda$

C $6.7 \times 10^{-4}\,\lambda$

D $3.3 \times 10^{-4}\,\lambda$

30 Light of wavelength λ is incident normally on a diffraction grating. The angle between the **second**-order maximum and the normal to the grating is θ. The variation with sin θ of λ is shown on the graph.

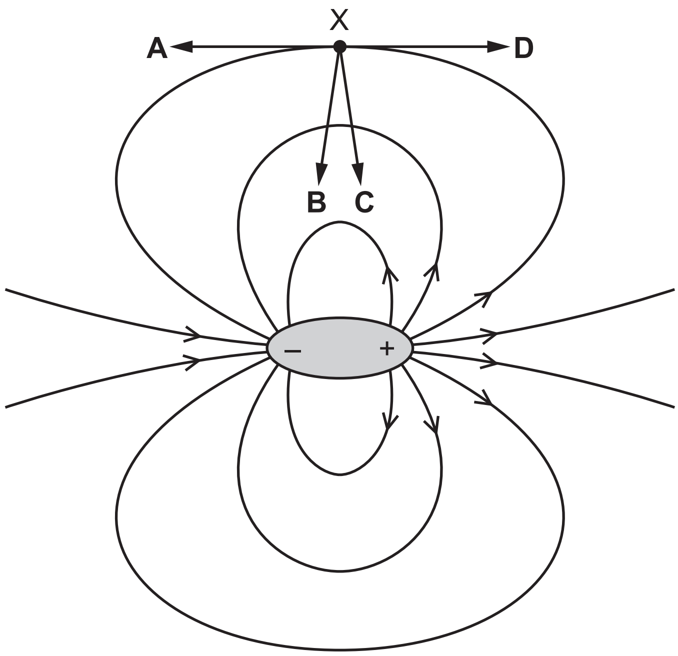


How many lines per millimetre are on the diffraction grating?

A $400\,mm^{-1}$ **B** $625\,mm^{-1}$ **C** $800\,mm^{-1}$ **D** $1250\,mm^{-1}$

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

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



32 A charged oil droplet of mass *m* is falling, initially freely, in a vacuum between two horizontal metal plates that are separated by a distance *x*.

A potential difference (p.d.) *V* is then applied across the plates. This results in the oil droplet continuing to accelerate downwards but with a reduced acceleration *a*.

The polarity of the applied p.d. is then reversed so that the direction of the electric force on the droplet is reversed. This results in the downwards acceleration of the oil droplet increasing to 3*a*.

What is the magnitude of the charge on the oil droplet?

A $\dfrac{max}{V}$ **B** $2\dfrac{max}{V}$ **C** $3\dfrac{max}{V}$ **D** $4\dfrac{max}{V}$

33 The number density of free electrons in copper is $8.0 \times 10^{28}\,\mathrm{m^{-3}}$.

A copper wire has diameter 0.42 mm.

What is the average drift speed of the free electrons in the wire when the current in the wire is 0.57 A?

A $8.0 \times 10^{-11}\,\mathrm{m\,s^{-1}}$

B $3.2 \times 10^{-10}\,\mathrm{m\,s^{-1}}$

C $8.0 \times 10^{-5}\,\mathrm{m\,s^{-1}}$

D $3.2 \times 10^{-4}\,\mathrm{m\,s^{-1}}$

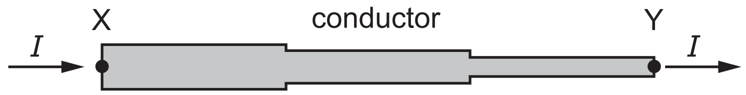
34 An electric kettle is rated at 2.0 kW, which describes the power supplied to the heating coil in the kettle.

The coil has a resistance of 5.0 kΩ.

What is the current in the coil?

A 0.40 A **B** 0.63 A **C** 1.6 A **D** 2.5 A

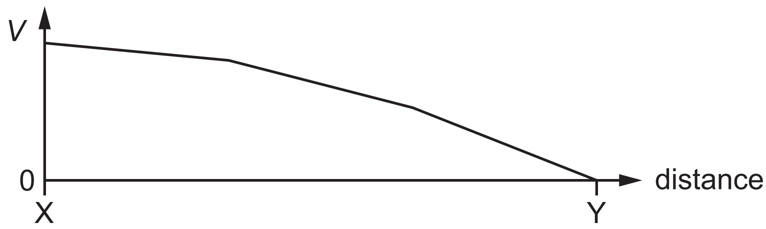
35 A conductor consists of three wires connected in series. The wires are all made of the same metal but have different cross-sectional areas. There is a current I in the conductor.



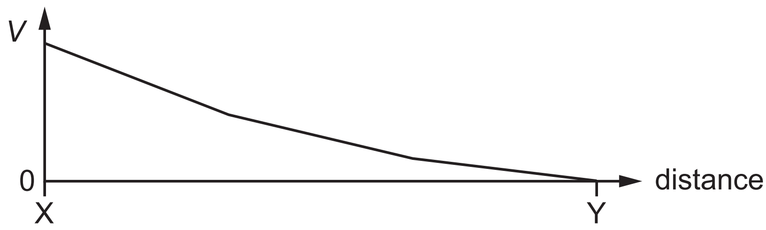
Point Y on the conductor is at zero potential.

Which graph best shows the variation of potential V with distance along the conductor?

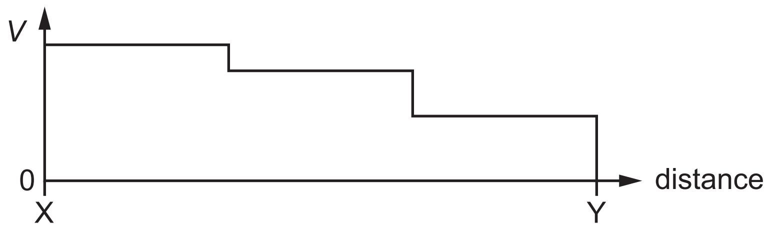
A



B



C



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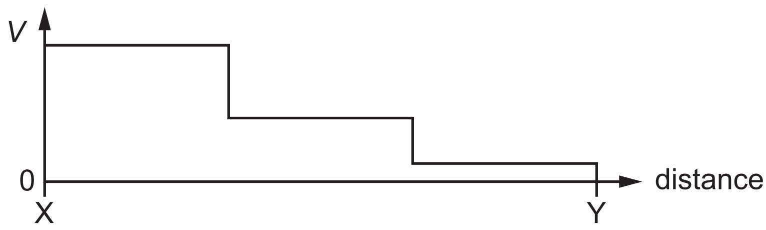
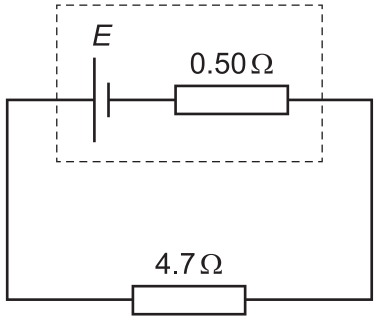


36 A cell of electromotive force (e.m.f.) E and internal resistance $0.50\,\Omega$ is connected to a resistor of resistance $4.7\,\Omega$.



The maximum power that can be dissipated by the resistor without overheating is 0.50 W.

What is the maximum value of E for the resistor **not** to overheat?

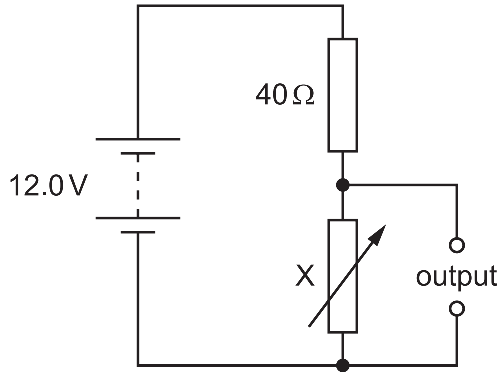
A 1.4 V **B** 1.5 V **C** 1.7 V **D** 2.9 V

37 Kirchhoff's first and second laws link to the conservation of physical quantities.

Which quantities do they link to?

	first law	second law
A	charge	energy
B	charge	momentum
C	energy	charge
D	energy	momentum

38 In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0 Ω to 500 Ω. The electromotive force (e.m.f.) of the battery is 12.0 V. It has negligible internal resistance.



What is the maximum range of values of potential difference across the output?

A 1.3 V to 11.1 V

B 1.3 V to 12.0 V

C 1.5 V to 11.1 V

D 1.5 V to 12.0 V

39 An unstable nucleus goes through successive decays to become a final, stable nucleus.

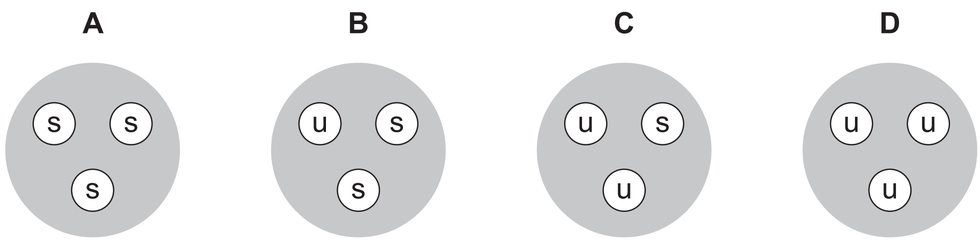
The initial nucleus and the final nucleus are isotopes of each other.

How many α and β^- particles could have been emitted during the decay sequence?

	particle	
	α	β^-
A	1	0
B	1	2
C	2	0
D	2	1

40 A hadron has a charge of –*e* and is composed of three quarks.

What could be the quark composition of the hadron?



key

u = up quark
s = strange quark

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2020**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

9562105662

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 **24** pages. Blank pages are indicated.

IB20 06_9702_13/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$p = \rho g h$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 A man is running a race in a straight line.

What is an approximate value of his kinetic energy?

A 10 J **B** 100 J **C** 1000 J **D** 10 000 J

2 A sample of gas has a mass of 4.8 μg and occupies a volume of 1.2 dm^3.

What is the density of the sample of gas?

A 4.0×10^{-3} kg m^{-3}

B 4.0×10^{-5} kg m^{-3}

C 4.0×10^{-6} kg m^{-3}

D 4.0×10^{-8} kg m^{-3}

3 Which characteristics are possessed by a vector quantity but **not** by a scalar quantity?

A direction only

B magnitude and direction

C magnitude and unit

D unit only

4 A circuit is set up in order to determine the resistance of a 12 V, 1.2 W lamp when operating normally. An analogue ammeter and an analogue voltmeter are used.

Which ranges for the meters would be most suitable?

	ammeter range / A	voltmeter range / V
A	0–0.5	0–20
B	0–0.5	0–100
C	0–10	0–20
D	0–10	0–100

5 Two liquid-in-glass thermometers in a well-mixed liquid are individually observed by 10 different students. All agree that one thermometer reads 21 °C and the other thermometer reads 23 °C.

What is a possible explanation for the difference?

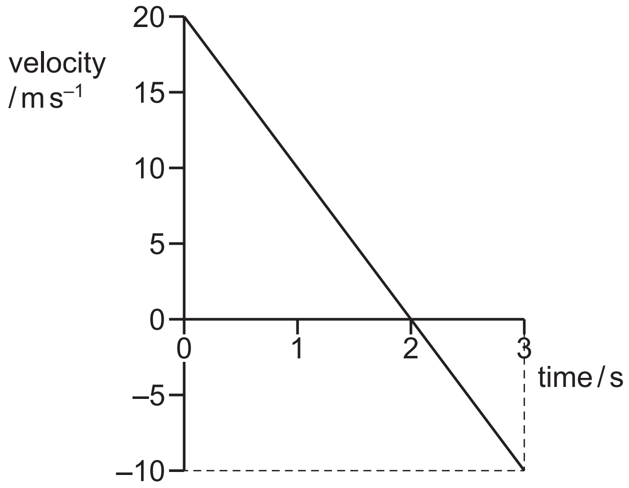
A The liquid is not all at the same temperature.

B The readings are not precise.

C There is a random error affecting the readings.

D There is a systematic error affecting the readings.

6 The graph shows how the velocity of a ball varies with time from the moment it is hit vertically upwards from the ground.



What is the displacement of the ball from the ground after a time of 3.0 s?

A 15 m **B** 25 m **C** 30 m **D** 45 m

7 Two students each throw a ball horizontally from the top of a tower. The two balls are released at the same time.

The first student throws her ball with a speed of 20 m s^{-1} and the second student throws his ball with a speed of 10 m s^{-1}.

Assume air resistance is negligible and that the balls land on horizontal ground.

Which row describes the horizontal distances travelled and the landing times of the two balls on the ground?

	horizontal distances	landing times
A	same	same
B	same	different
C	different	same
D	different	different

8 A ball of mass m travels vertically downwards and then hits a horizontal floor at speed u.

It rebounds vertically upwards with speed v.

The collision lasts a time Δt.

What is the average resultant force exerted on the ball during the collision?

A $\dfrac{mv - mu}{\Delta t}$ downwards

B $\dfrac{mv - mu}{\Delta t}$ upwards

C $\dfrac{mv + mu}{\Delta t}$ downwards

D $\dfrac{mv + mu}{\Delta t}$ upwards

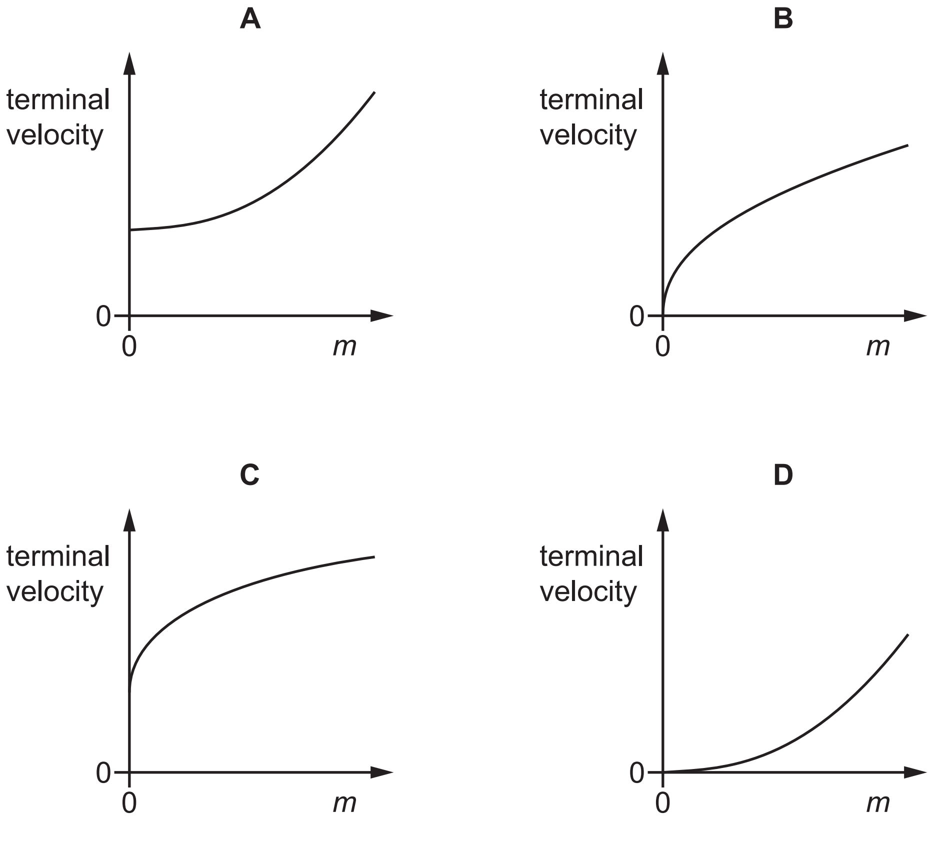
9 The resultant force F on a raindrop of mass m falling vertically with velocity v is given by the equation

$$F = mg - kv^2$$

where k is a constant and g is the acceleration of free fall.

The falling raindrop eventually reaches a constant (terminal) velocity.

Which graph shows the variation of the terminal velocity of the raindrop with mass m?



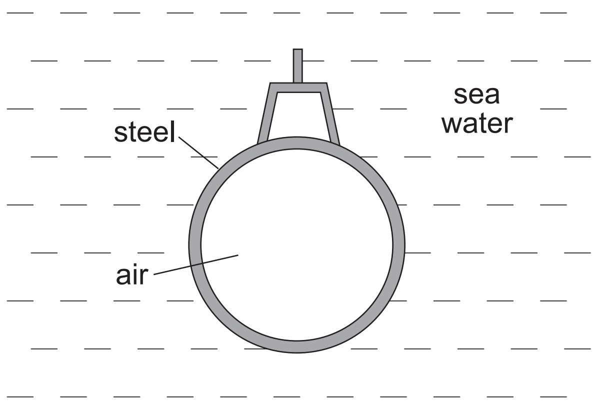
10 A ball of mass m, moving at a velocity v, collides with a stationary ball of mass $2m$.

The two balls stick together.

Which fraction of the initial kinetic energy is lost on impact?

A $\frac{1}{9}$ **B** $\frac{1}{3}$ **C** $\frac{2}{3}$ **D** $\frac{8}{9}$

11 A submarine is in equilibrium in a fully submerged position.



What causes the upthrust on the submarine?

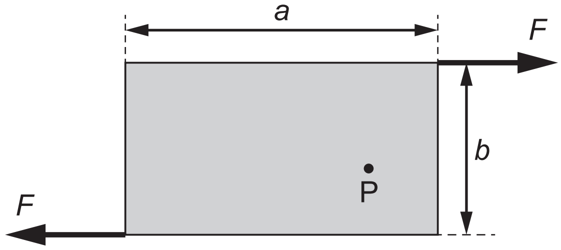
A The air in the submarine is less dense than sea water.

B There is a difference in water pressure acting on the top and on the bottom of the submarine.

C The sea water exerts a greater upward force on the submarine than the weight of the steel.

D The submarine displaces its own volume of sea water.

12 Two forces, each of magnitude F, act along the edges of a rectangular metal plate, as shown.

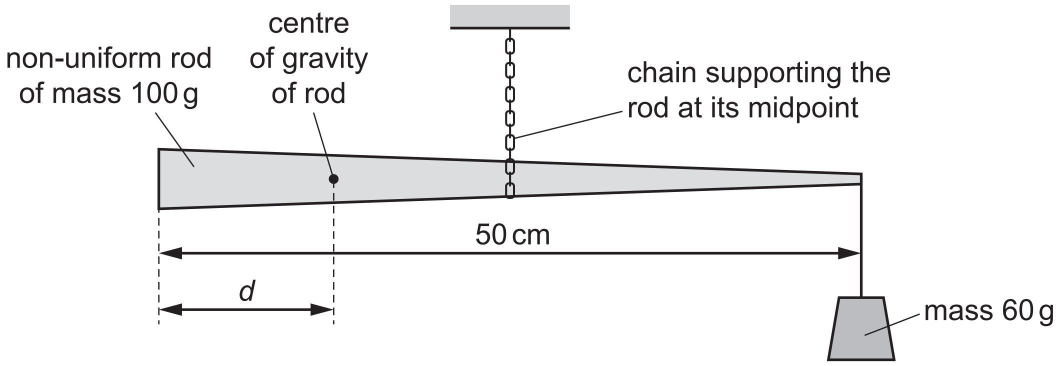


The plate has length a and width b.

What is the torque about point P?

A Fa **B** Fb **C** $2Fa$ **D** $2Fb$

13 A non-uniform rod has a mass of 100 g and a length of 50 cm. It is supported by a chain at its midpoint. The rod is held in equilibrium by having a mass of 60 g suspended from its right-hand end, as shown.

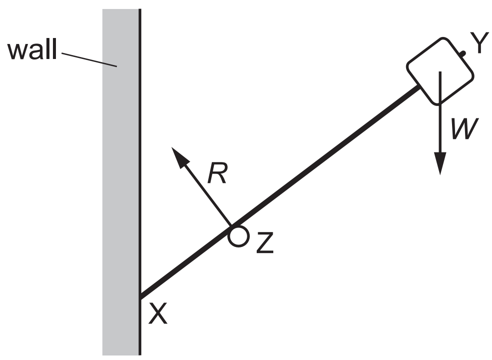


The centre of gravity of the rod is a distance d from its left-hand end.

What is the value of d?

A 10 cm **B** 15 cm **C** 25 cm **D** 40 cm

14 A light rigid rod XY has an object of weight W fixed at one end. The rod is in equilibrium, resting on a support at Z and a vertical wall at X. The support exerts a force R on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces R and W.



What is the direction of the force on the rod at X?

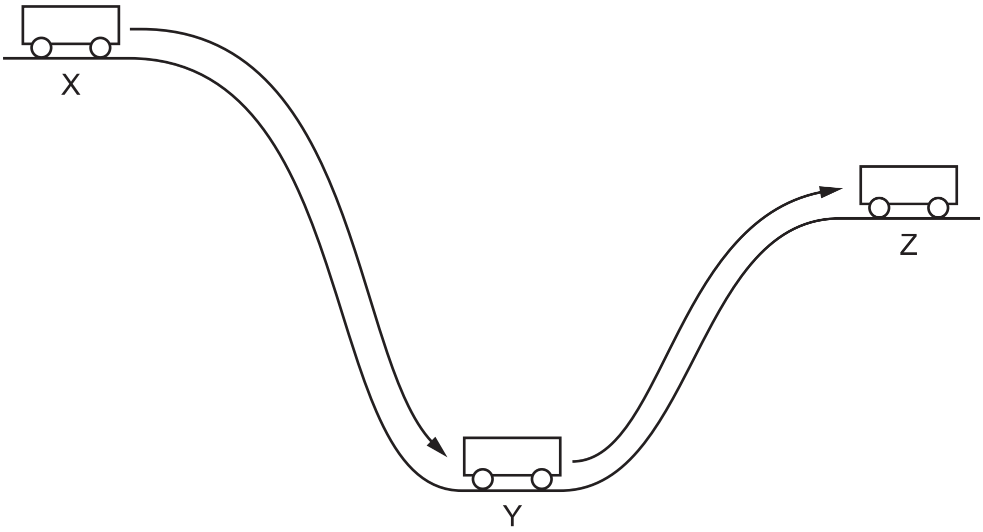
15 Liquid Q has twice the density of liquid R.

At depth x in liquid R, the pressure due to the liquid is 4 kPa.

At which depth in liquid Q is the pressure due to the liquid 7 kPa?

A $\frac{2x}{7}$ **B** $\frac{7x}{8}$ **C** $\frac{8x}{7}$ **D** $\frac{7x}{2}$

16 A trolley starts from rest at X. It rolls down to Y and eventually comes to rest at Z.

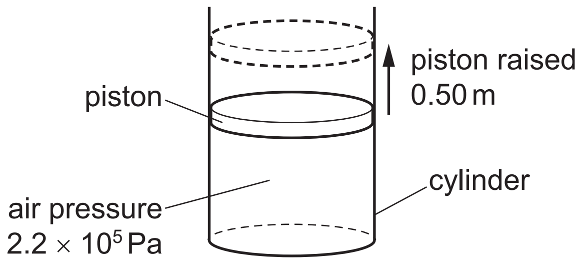


Which row is a possible summary of the energy changes during this process?

	X to Y	Y to Z
A	PE $\rightarrow$ KE	KE $\rightarrow$ PE
B	PE $\rightarrow$ KE	KE $\rightarrow$ PE + heat
C	PE $\rightarrow$ KE + heat	KE $\rightarrow$ PE
D	PE $\rightarrow$ KE + heat	KE $\rightarrow$ PE + heat

key
PE = potential energy
KE = kinetic energy

17 A cylinder is heated, causing the air inside to expand at a constant pressure of 2.2×10^5 Pa.



The expansion of the air causes the piston to rise through a vertical distance of 0.50 m, doing 11 kJ of work. Frictional forces are negligible.

What is the cross-sectional area of the piston?

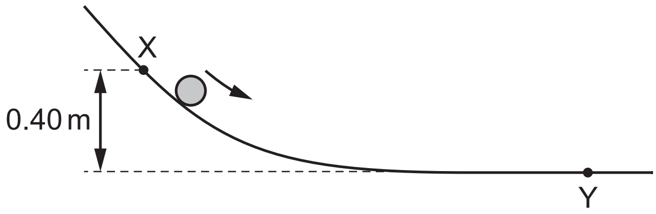
A $1.0 \times 10^{-4}\,m^2$

B $2.5 \times 10^{-2}\,m^2$

C $5.0 \times 10^{-2}\,m^2$

D $1.0 \times 10^{-1}\,m^2$

18 A ball slides down a curved track, as shown.



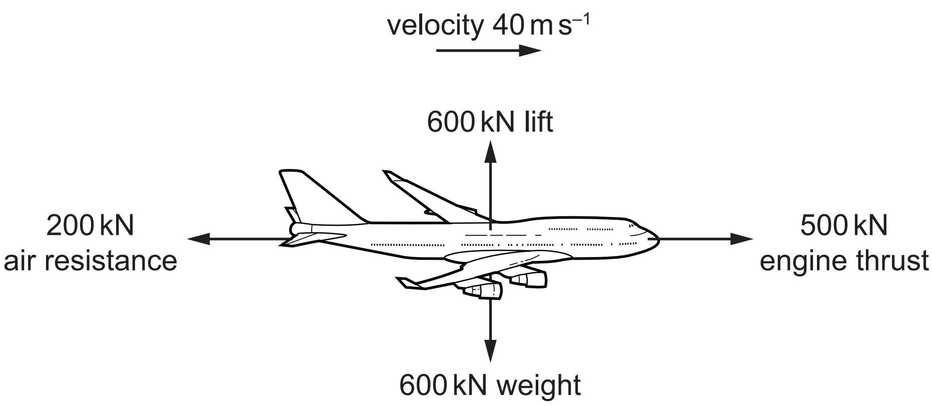
Point X is at a height of 0.40 m above point Y. The speed of the ball at point X is $2.5\,\mathrm{m\,s^{-1}}$.

Frictional forces are negligible.

What is the speed of the ball at point Y?

A $2.8\,\mathrm{m\,s^{-1}}$ **B** $3.2\,\mathrm{m\,s^{-1}}$ **C** $3.8\,\mathrm{m\,s^{-1}}$ **D** $14\,\mathrm{m\,s^{-1}}$

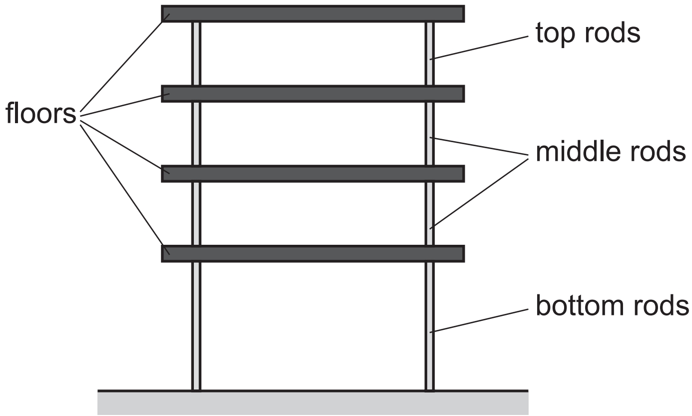
19 The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is $40\,\mathrm{m\,s^{-1}}$.



At which rate is its kinetic energy increasing?

A 2.4 MW **B** 8.0 MW **C** 12 MW **D** 20 MW

20 The diagram shows a simplified model of a building with four identical heavy floors.



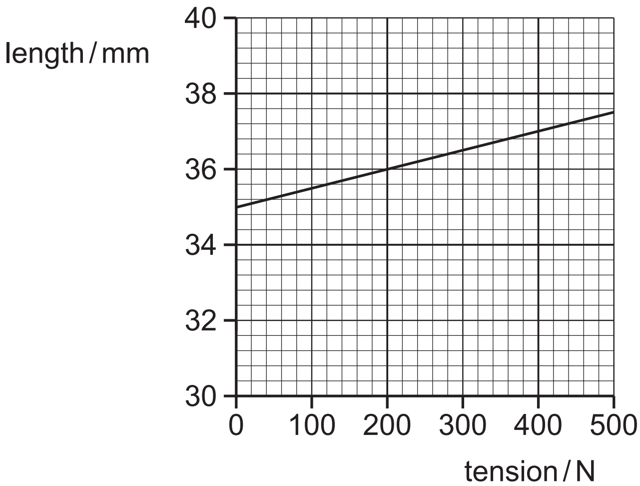
The spacing of the bottom floor from the ground is twice that of the spacing between the floors. Between each floor are equal numbers of vertical steel supporting rods of negligible mass compared with the floors. The rods are of different diameters so that the stress in each rod is the same.

What is the ratio $\dfrac{\text{diameter of bottom rods}}{\text{diameter of top rods}}$?

A 2 **B** 4 **C** 8 **D** 16

21 The Achilles tendon in a rabbit's leg is stretched when the rabbit jumps.

The graph shows the variation with tension of the length of the tendon.



What is the strain energy in the tendon when the tension is 400 N?

A 0.40 J **B** 0.80 J **C** 2.4 J **D** 7.4 J

22 A wave of amplitude A has an intensity I.

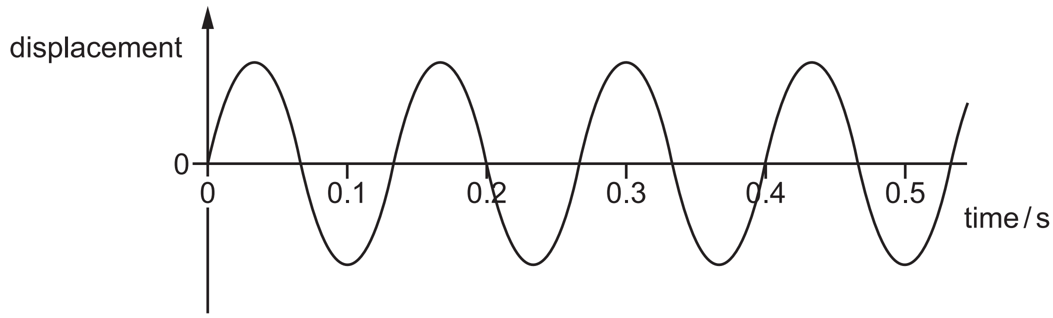
After passing through a certain medium, the wave has a new intensity of $\frac{I}{4}$.

What is the new amplitude of the wave?

A $2A$ **B** $\frac{A}{2}$ **C** $\frac{A}{4}$ **D** $\frac{A}{16}$

23 A wave travels along a coiled spring.

The graph shows the variation with time of the displacement of a point on the spring.

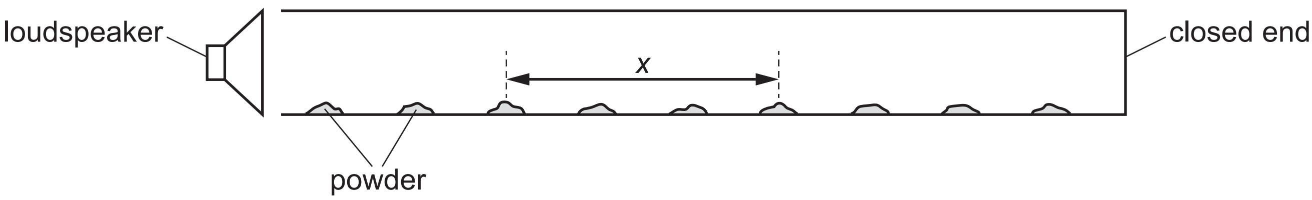


What is the frequency of the wave?

A 0.13 Hz **B** 0.20 Hz **C** 5.0 Hz **D** 7.5 Hz

24 A loudspeaker is set up at the open end of a closed tube containing powder.

When the loudspeaker produces sound of frequency 1200 Hz, a stationary wave is produced in the tube. The powder gathers at the nodes of the stationary wave as shown.



The speed of sound in the air is $336\,\mathrm{m\,s^{-1}}$.

What is the value of distance x?

A 28 cm **B** 42 cm **C** 84 cm **D** 112 cm

25 A stationary source S emits a sound wave of frequency *f*.

The source now moves away from a stationary observer.

Which statement is correct?

A The frequency of the source S and the observed frequency are now both higher than *f*.

B The frequency of the source S and the observed frequency are now both lower than *f*.

C The frequency of the source S is now lower than *f*.

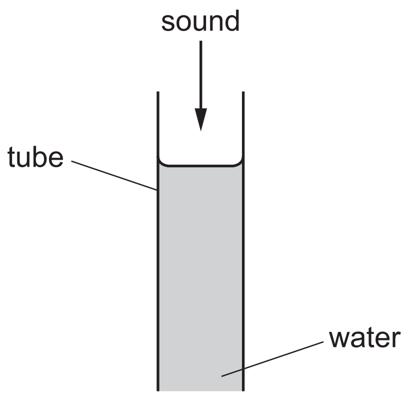
D The observed frequency is now lower than *f*.

26 The table lists possible wavelengths of four different electromagnetic waves.

Which row is correct?

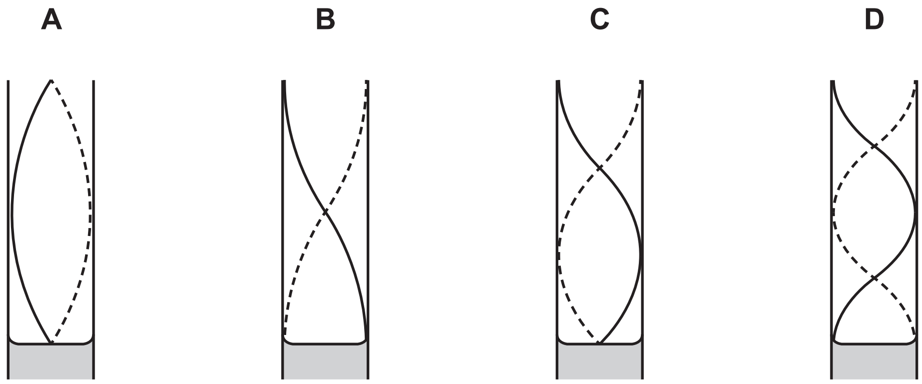
	type of wave	approximate wavelength / m
A	infrared	10^{-5}
B	radio	10^{-3}
C	ultraviolet	10^{-12}
D	X-rays	10^{-7}

27 A vertical tube is partially filled with water. A sound wave moves down the tube and is reflected by the surface of the water. The frequency of the sound wave is gradually increased from zero until a much louder sound is heard.



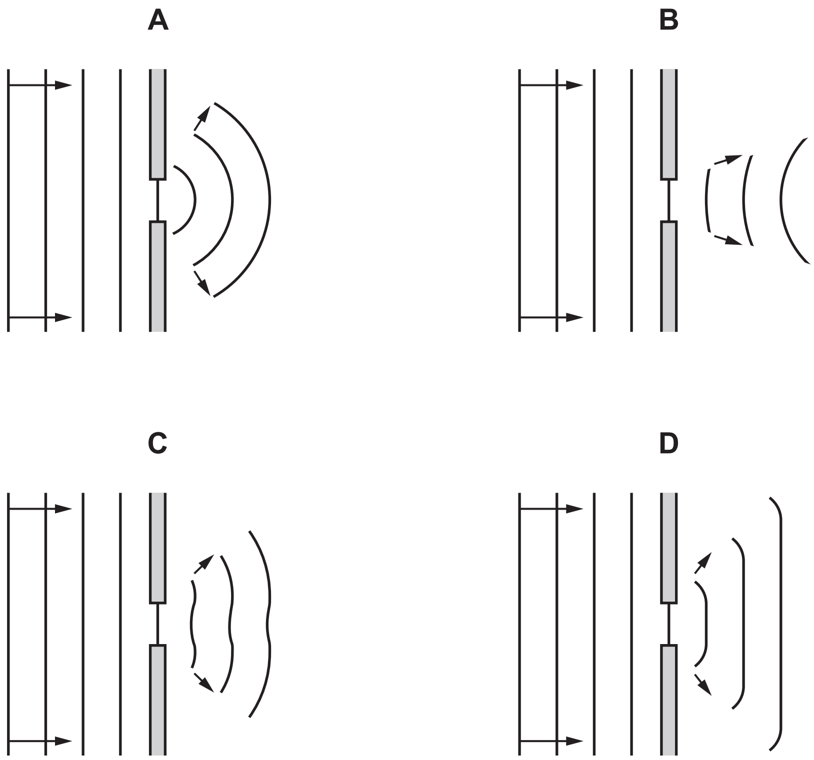
Water is then removed from the tube until a second louder sound is heard.

Which diagram shows the new pattern of the stationary wave that is formed?



28 Water waves in a ripple tank are made to pass through a small gap as shown.

Which diagram shows the waves after they have passed through the gap?



29 A double-slit interference experiment is set up using green light.

A pattern of interference fringes is formed on a screen.

Which single change will increase the separation of the fringes?

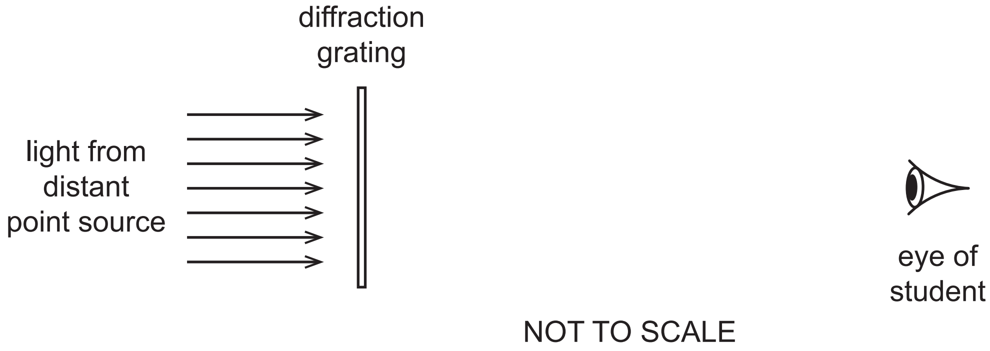
A increase the width of each slit

B move the screen nearer to the double slit

C use slits that are further apart

D use red light instead of green light

30 Light of a single wavelength from a distant point source falls normally onto a diffraction grating positioned with its lines vertical.



The plane of the diffraction grating is at right angles to the incident light. A student looks at the grating from a position near to the grating.

What could the student see?

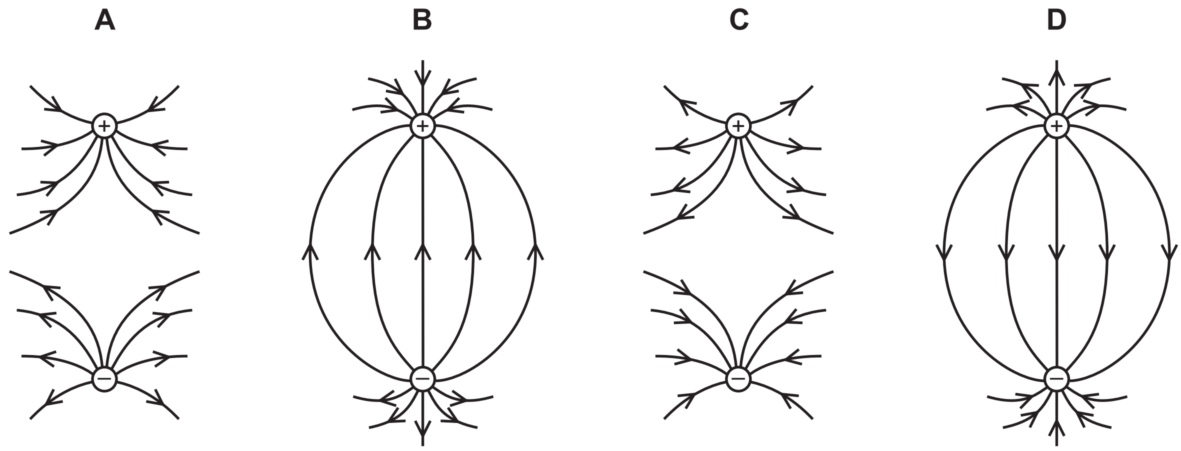
A a central point source with a series of point source images on either side

B a central vertical line with a series of spectra on either side

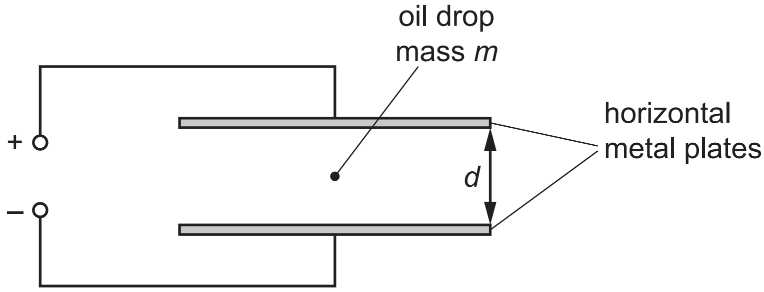
C a series of fine vertical lines

D a single point source

31 Which diagram best represents the electric field between two point charges of equal magnitude and opposite sign?



32 A negatively charged oil drop of mass m is between two horizontal parallel metal plates a distance d apart.



When the potential difference (p.d.) between the plates is V_1 the oil drop rises at a constant speed. When the p.d. is decreased to a value V_2 the oil drop falls at the same constant speed.

Air resistance acts on the drop when it is moving. The upthrust on the drop is negligible.

The acceleration of free fall is g.

What is the charge on the oil drop?

A $\dfrac{mdg}{V_1 - V_2}$ **B** $\dfrac{mdg}{V_1 + V_2}$ **C** $\dfrac{2mdg}{V_1 - V_2}$ **D** $\dfrac{2mdg}{V_1 + V_2}$

33 The unit of electric charge is the coulomb.

What is meant by 1 coulomb?

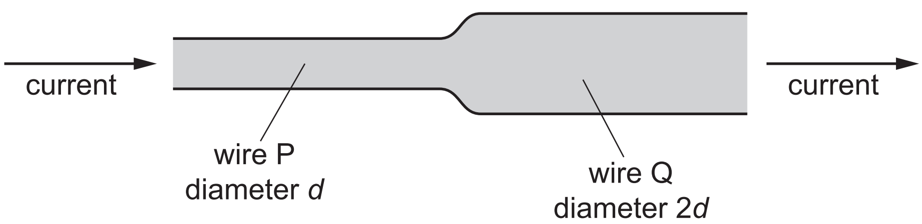
A the charge passing a point in 1 second when a current produces 1 joule of work

B the charge passing a point in 1 second when a current produces 1 watt of power

C the charge passing a point in 1 second when there is a current of 1 ampere

D the charge passing a point in 1 second when there is 1 ohm of resistance

34 Two copper wires are joined together and carry a current, as shown.

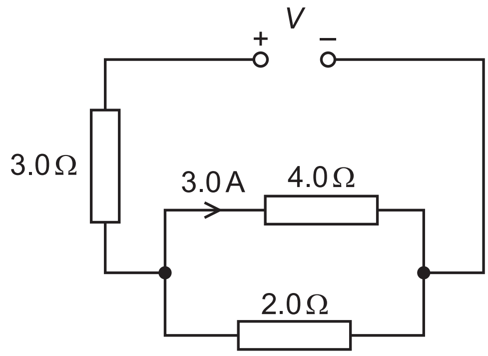


Wire P has diameter d and wire Q has diameter $2d$.

What is the ratio $\dfrac{\text{average drift speed of the free electrons in wire P}}{\text{average drift speed of the free electrons in wire Q}}$?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** 2 **D** 4

35 A power supply of electromotive force (e.m.f.) V and negligible internal resistance is connected in the circuit shown. There is a current of 3.0 A in the 4.0 Ω resistor.



What is the value of V?

A 15 V **B** 29 V **C** 39 V **D** 51 V

36 The wire of a heating element has resistance R. The wire breaks and is replaced by a different wire.

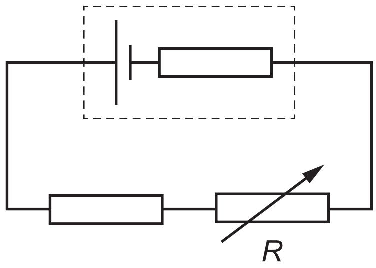
Data for the original wire and for the replacement wire are shown in the table.

	length	diameter	resistivity of metal
original wire	l	d	ρ
replacement wire	l	$2d$	2ρ

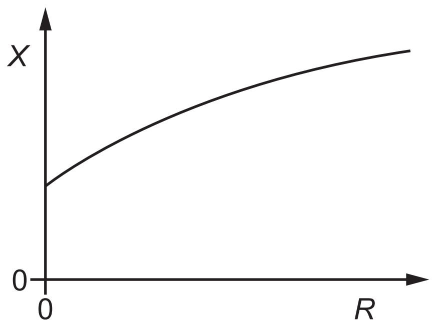
What is the resistance of the replacement wire?

A $\frac{R}{4}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

37 A fixed resistor and a variable resistor are connected in series with a cell that has an internal resistance, as shown.



The graph shows the variation of a quantity *X* with the resistance *R* of the variable resistor as *R* is increased from zero to its maximum value.



What could *X* represent?

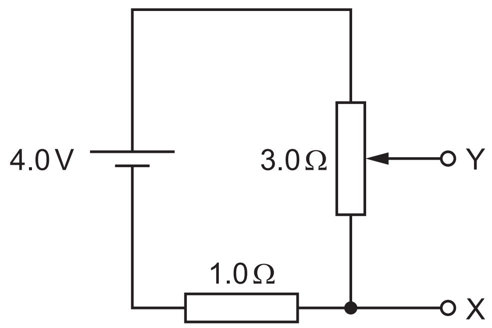
A the current in the circuit

B the electromotive force of the cell

C the potential difference across the internal resistance

D the terminal potential difference across the cell

38 A cell of electromotive force (e.m.f.) 4.0 V and negligible internal resistance is connected to a fixed resistor of resistance 1.0 Ω and a potentiometer of maximum resistance 3.0 Ω, as shown.



Which range of potential differences can be obtained between the terminals X and Y?

A 0 V to 3.0 V

B 0 V to 4.0 V

C 1.0 V to 3.0 V

D 1.0 V to 4.0 V

39 Radiation from a radioactive source has a range of a few millimetres in air and can be deflected by an electric field.

Which type of radiation is being emitted?

A α-radiation

B β^- radiation

C β^+ radiation

D γ-rays

40 Which equation describes the process of β^+ decay?

key:

u = up quark

d = down quark

ν = (electron) neutrino

$\bar{\nu}$ = (electron) antineutrino

A ddu $\rightarrow$ uud + β^+ + ν

B ddu $\rightarrow$ uud + β^+ + $\bar{\nu}$

C uud $\rightarrow$ ddu + β^+ + ν

D uud $\rightarrow$ ddu + β^+ + $\bar{\nu}$

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2021**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 9 5 9 0 1 5 4 9 5 8 *

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.
- Any rough working should be done on this question paper.

This document has **20** pages.

IB21 06_9702_11/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate of the volume of an adult person?

A $0.10\,m^3$ **B** $0.50\,m^3$ **C** $1.0\,m^3$ **D** $2.0\,m^3$

2 Which combination of units could be used for expressing the power dissipated in a resistor?

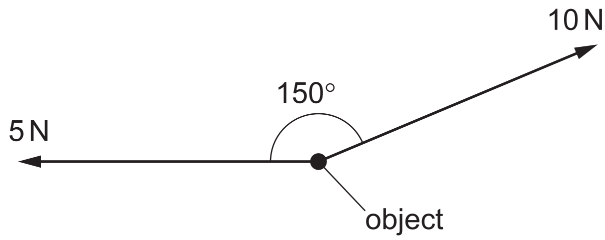
A newton per second ($N\,s^{-1}$)

B newton second (N s)

C newton metre (N m)

D newton metre per second ($N\,m\,s^{-1}$)

3 A force of 10 N and a force of 5 N act on an object.



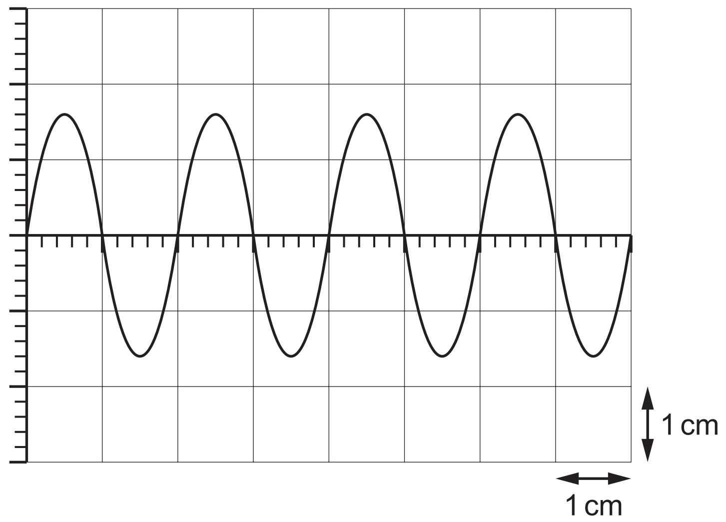
The angle between the forces is 150°.

The resultant force on the object can be resolved into a pair of perpendicular components.

Which row shows numerical expressions for a possible pair of perpendicular components?

	force component / N	force component / N
A	10 cos 30° – 5	10 cos 30°
B	10 sin 30° – 5	10 cos 30°
C	10 – 5 cos 30°	5 sin 30°
D	10 – 5 sin 30°	5 cos 30°

4 A signal of frequency 25 Hz is displayed on the screen of a cathode-ray oscilloscope.



What is the time-base setting?

A $10\,\text{ms}\,\text{cm}^{-1}$ **B** $20\,\text{ms}\,\text{cm}^{-1}$ **C** $25\,\text{ms}\,\text{cm}^{-1}$ **D** $40\,\text{ms}\,\text{cm}^{-1}$

5 A micrometer screw gauge is used to measure the diameter of a wire.

The reading on the micrometer with the jaws closed is (-0.05 ± 0.02) mm.

The reading with the wire in position between the two jaws is $(+1.03 \pm 0.02)$ mm.

What is the diameter of the wire?

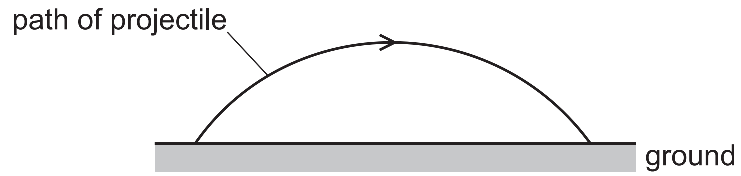
A (0.98 ± 0.02) mm

B (1.08 ± 0.02) mm

C (0.98 ± 0.04) mm

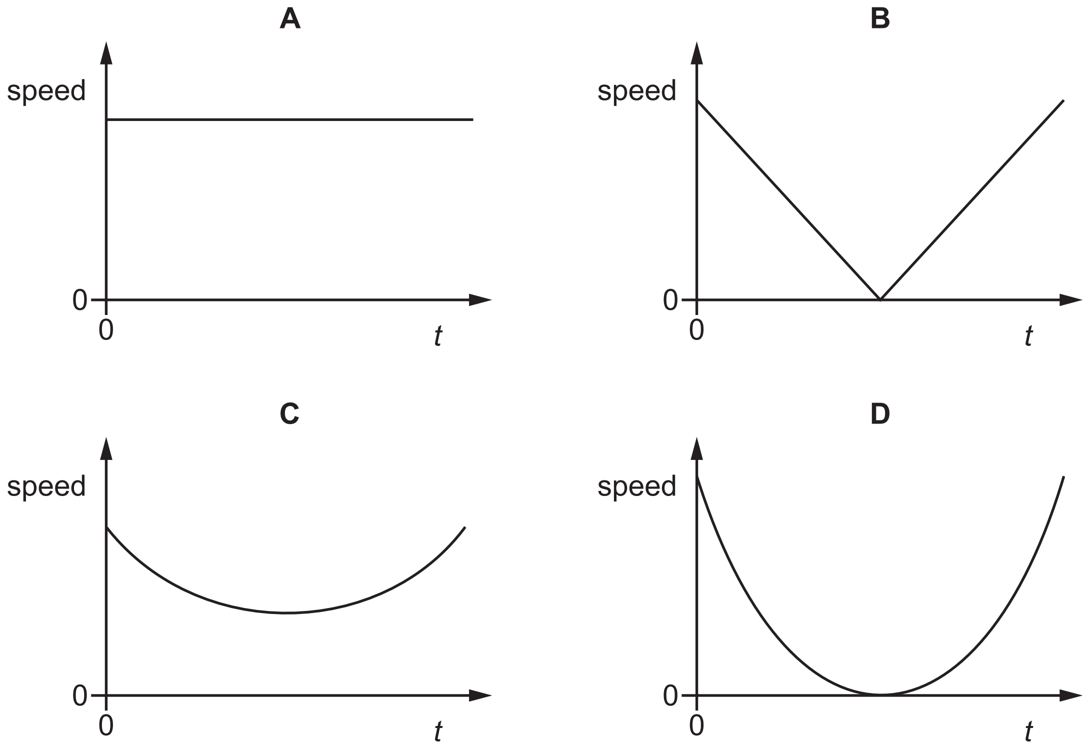
D (1.08 ± 0.04) mm

6 A projectile is launched at an angle to the horizontal at time $t = 0$. It travels over horizontal ground, as shown.



Air resistance is negligible.

Which graph best shows the variation with t of the speed of the projectile from when it is launched to when it lands on the ground?



7 A train, initially at rest at a station, has a uniform acceleration of $0.20\,\mathrm{m\,s^{-2}}$ until it reaches a speed of $20\,\mathrm{m\,s^{-1}}$. It travels for a time at this constant speed and then has a uniform deceleration of $0.40\,\mathrm{m\,s^{-2}}$ until it comes to rest at the next station. The distance between the two stations is 3000 m.

What is the time taken by the train to travel between the two stations?

A 75 s **B** 150 s **C** 230 s **D** 300 s

8 A rocket is fired from the Earth into space.

Newton's third law of motion describes how forces act in pairs. One of the forces of a pair is the weight of the rocket.

What is the other force of this pair?

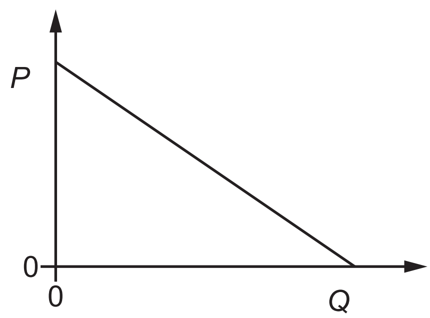
A air resistance

B force of the exhaust gases on the rocket

C force of the rocket on the exhaust gases

D gravitational force of the rocket on the Earth

9 The graph shows how quantity *P* varies with quantity *Q* for a body falling vertically downwards in a uniform gravitational field with air resistance.



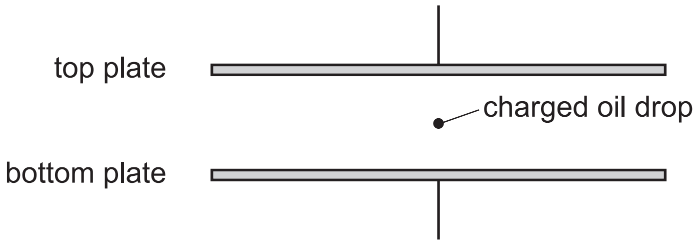
Which pair of quantities could be represented by *P* and *Q*?

	P	*Q*
A	acceleration	force of air resistance
B	acceleration	time
C	velocity	force of air resistance
D	velocity	time

10 Which quantities are conserved in an inelastic collision?

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

11 A charged oil drop is held stationary between two charged parallel plates.



Which forces act on the oil drop?

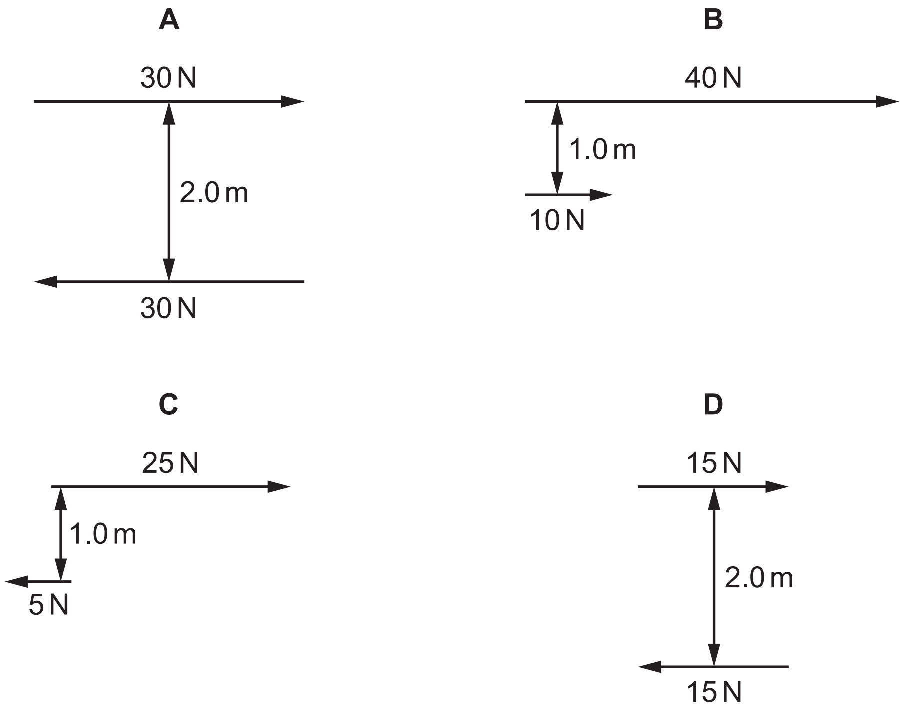
A both electric and gravitational

B electric only

C gravitational only

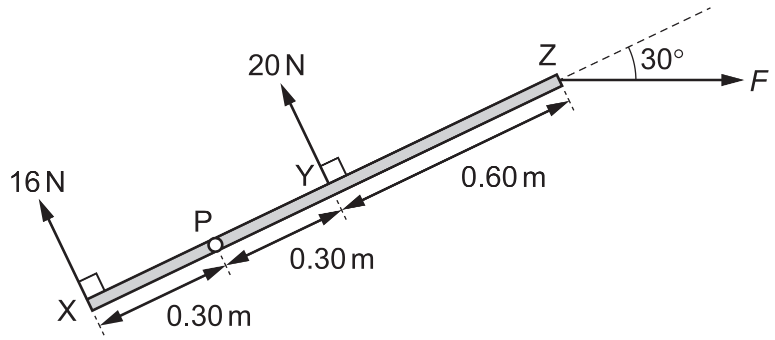
D neither electric nor gravitational

12 Which pair of forces forms a couple with a torque of 30 N m?



13 A uniform rigid bar XZ with negligible mass is 1.20 m long. The bar is pivoted at point P. Three coplanar forces act on the bar as shown. Forces of 16 N and 20 N act perpendicularly to the bar at points X and Y respectively. Force *F* acts at point Z at an angle of 30° to the axis of the bar.

The distances along the bar of the pivot and of the forces are shown.



The bar experiences a resultant moment about P of 6.0 N m in a clockwise direction.

What is the magnitude of *F*?

A 9.2 N **B** 11 N **C** 16 N **D** 24 N

14 Water of depth 9.0 cm is covered by oil of depth 5.0 cm in a measuring cylinder.

The density of the water is 1000 kg m^{-3} and the density of the oil is 800 kg m^{-3}.

What is the total pressure exerted on the base of the measuring cylinder due to the oil and water?

A 390 Pa **B** 880 Pa **C** 1200 Pa **D** 1300 Pa

15 A rocket is fired upwards.

As it accelerates upwards after leaving the launch pad, which forms of energy are changing?

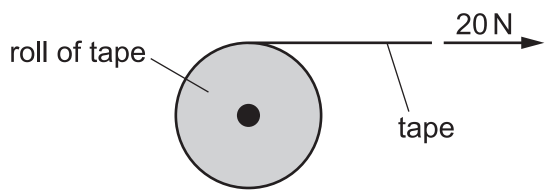
A chemical energy, gravitational potential energy and kinetic energy

B chemical energy and gravitational potential energy only

C chemical energy and kinetic energy only

D gravitational potential energy and kinetic energy only

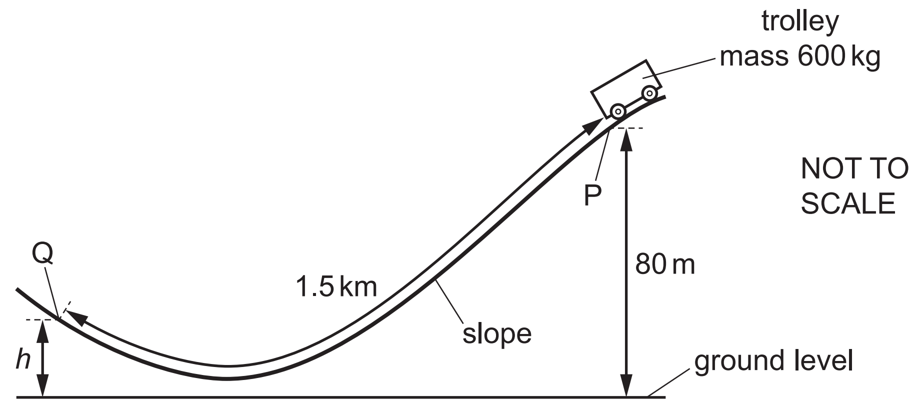
16 A roll of tape of length 50 m requires a constant force of 20 N to unwrap it.



What is the work done in unwrapping the whole roll?

A 0.4 J **B** 2.5 J **C** 500 J **D** 1000 J

17 A trolley of mass 600 kg is initially at point P on a slope, at a height of 80 m above ground level, as shown. The trolley is released from rest and moves along the slope, first coming to rest at point Q, at height *h* above ground level.



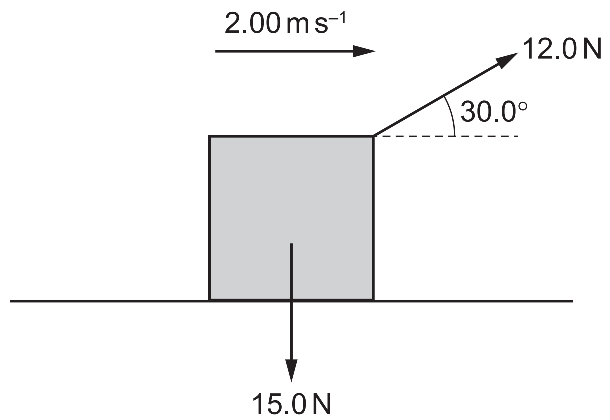
The total distance PQ moved by the trolley along the slope is 1.5 km. A constant resistive force of 300 N opposes the motion of the trolley on the slope.

What is *h*?

A 3.5 m **B** 76 m **C** 79 m **D** 80 m

18 An object of weight 15.0 N is pulled along a horizontal surface at a constant velocity of 2.00 $m s^{-1}$.

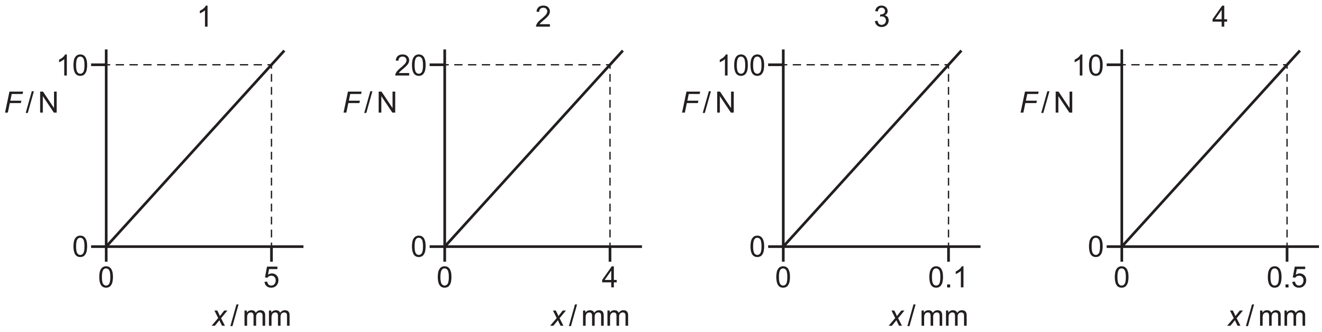
The force pulling the object is 12.0 N at 30.0° to the horizontal, as shown.



What is the power used to move the object?

A 12.0 W **B** 20.8 W **C** 24.0 W **D** 30.0 W

19 The spring constants of four springs are determined by plotting the following graphs of force F against extension x.



Which order of the graphs shows **decreasing** spring constants?

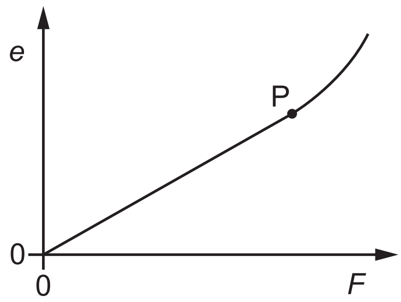
A $2 \rightarrow 1 \rightarrow 3 \rightarrow 4$

B $3 \rightarrow 4 \rightarrow 2 \rightarrow 1$

C $4 \rightarrow 2 \rightarrow 1 \rightarrow 3$

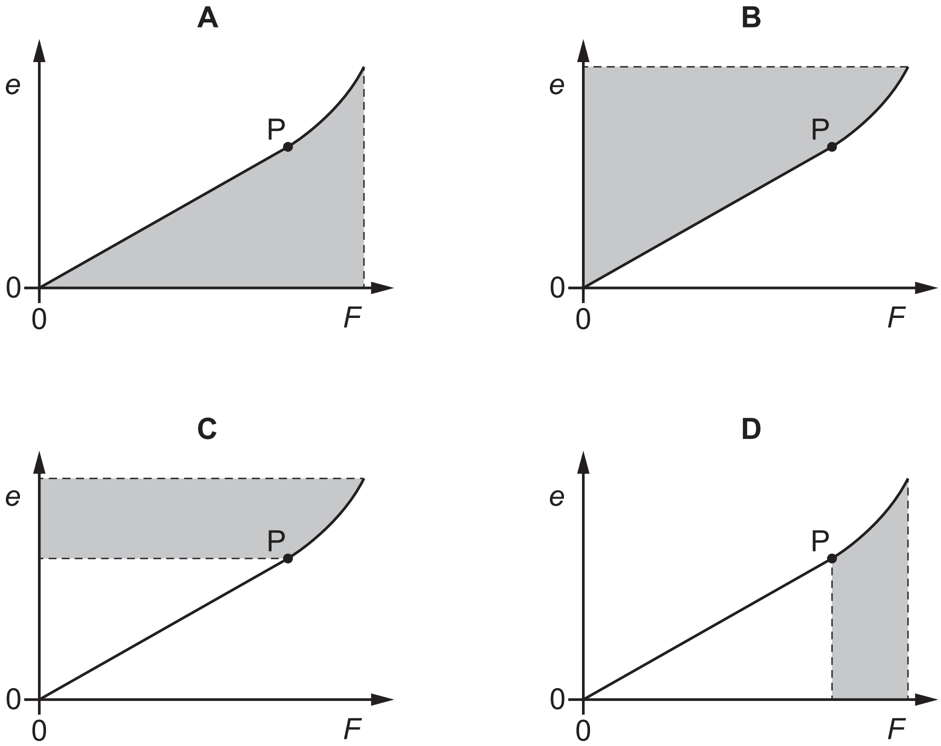
D $4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

20 Forces are applied to the ends of a rod so that its length increases. The variation with force F of the extension e of the rod is shown.

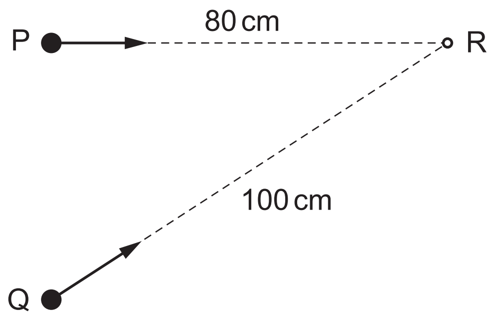


The point P is the elastic limit.

Which shaded area represents the work done during the plastic deformation of the rod?



21 Two identical waves are produced by sources at points P and Q. The waves travel along different paths to reach point R, as shown.



Both waves have a wavelength of 6.0 cm. The waves are in phase at point R.

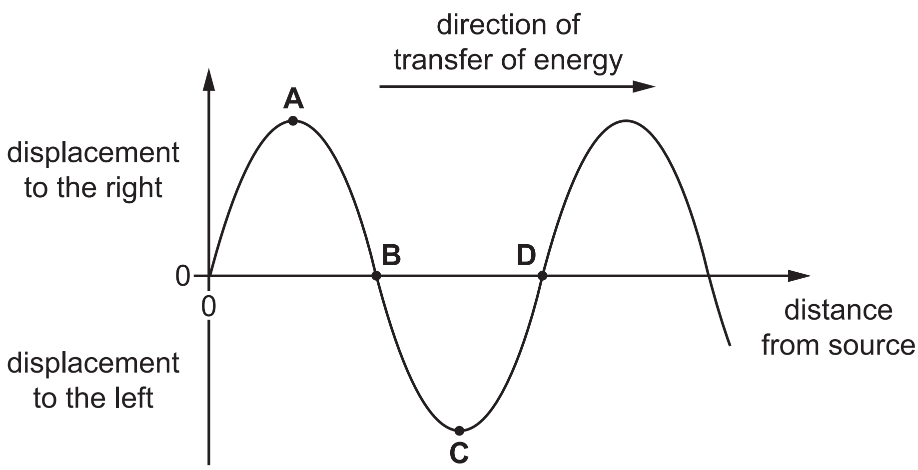
What is the phase difference between the waves as they leave points P and Q?

A 0° **B** 60° **C** 90° **D** 120°

22 A longitudinal wave travelling from left to right has vibrations parallel to the direction of transfer of energy by the wave.

The wave can be represented on a graph showing the variation with distance of the displacement of the particles from their equilibrium positions at one instant.

Which point on the graph is the centre of a compression?



23 A stationary wave is formed from two identical sound waves.

A microphone is placed at a position of maximum loudness. It is then moved along the stationary wave from this first position of maximum loudness to the fourth position of maximum loudness. The microphone moves a distance of 12 cm.

The speed of sound is 330 m s^{-1}.

What is the frequency of the sound waves?

A 4100 Hz **B** 5500 Hz **C** 8300 Hz **D** 11 000 Hz

24 An ambulance has a siren that emits sound of a constant frequency. The ambulance is moving directly towards a stationary observer.

The ambulance decelerates as it is approaching the observer and then accelerates after it has passed the observer.

How does the frequency of the sound heard by the observer change as the ambulance is approaching and as it is moving away from the observer?

	approaching observer	moving away from observer
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

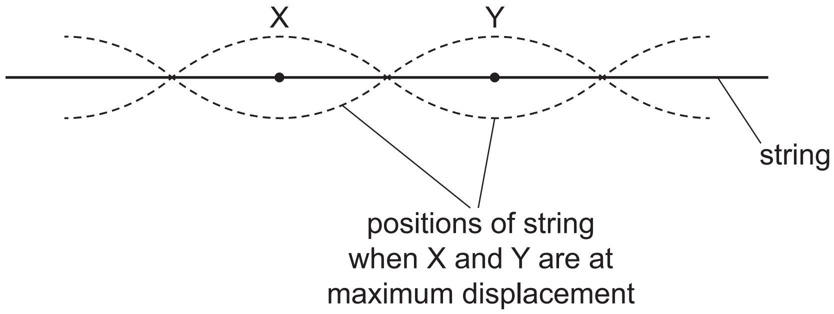
25 Microwaves in a vacuum travel at speed X and have wavelength of order of magnitude Y.

What are the speed and a possible order of magnitude of wavelength of X-rays in a vacuum?

	speed	wavelength
A	X	$10^{-8}\,Y$
B	X	$10^{-4}\,Y$
C	$10^{4}\,X$	Y
D	$10^{8}\,X$	Y

26 The diagram shows part of a stationary wave on a string.

X and Y are points on the string. The vibrations at X and Y are 180° out of phase.



What is the distance between X and Y?

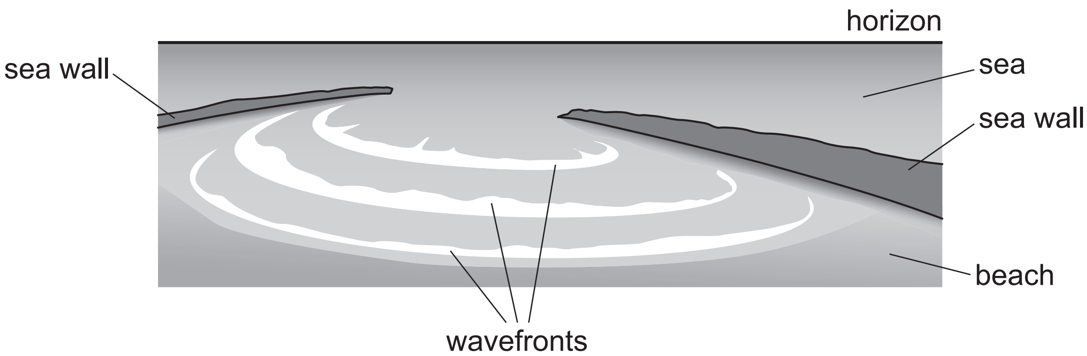
A one-quarter of a wavelength

B half a wavelength

C one wavelength

D two wavelengths

27 Which wave behaviour is shown in the diagram?



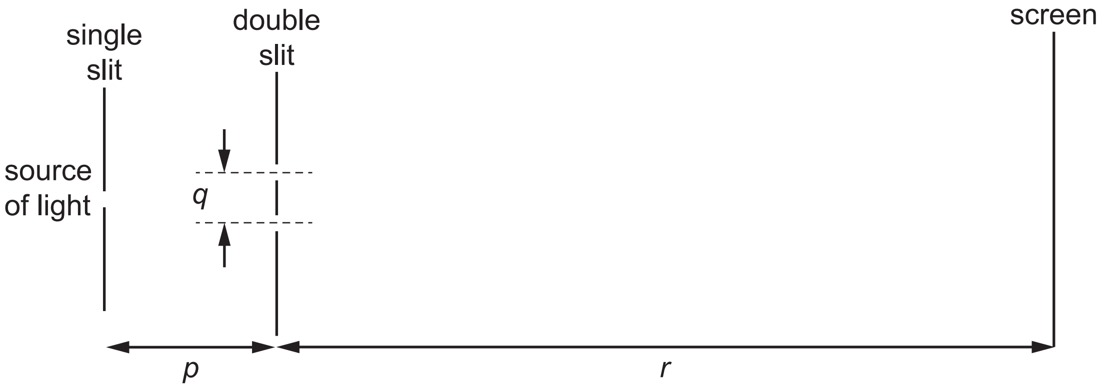
A diffraction

B Doppler shift

C interference

D superposition

28 A teacher sets up the apparatus shown to demonstrate a double-slit interference pattern on a screen.



Which change to the apparatus will increase the fringe spacing?

A decrease the distance *p*

B decrease the distance *q*

C decrease the distance *r*

D decrease the wavelength of the light

29 Light of a single unknown wavelength and blue light of a single wavelength are both incident normally on a diffraction grating. Two diffraction patterns are produced, one for each wavelength of light.

The third-order maximum for the blue light occurs at the same angle as the second-order maximum for the light of unknown wavelength. The wavelength of the blue light is 480 nm.

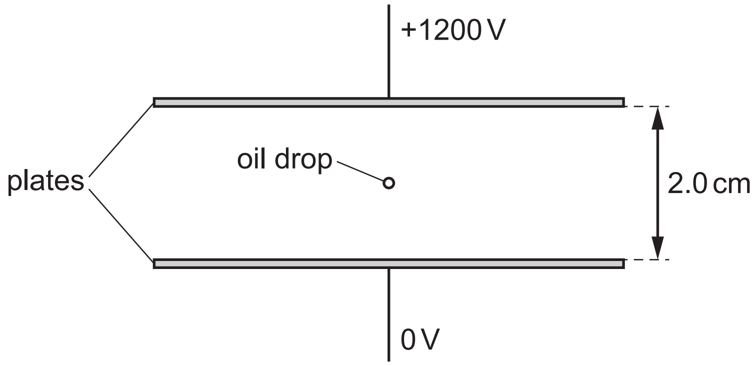
What is the unknown wavelength?

A 320 nm **B** 720 nm **C** 960 nm **D** 1440 nm

30 What is the electric field strength in a region where a proton accelerates at $2.00\,\text{m}\,\text{s}^{-2}$ due to the field?

A $11.4\,\text{pV}\,\text{m}^{-1}$ **B** $5.22\,\text{nV}\,\text{m}^{-1}$ **C** $10.4\,\text{nV}\,\text{m}^{-1}$ **D** $20.9\,\text{nV}\,\text{m}^{-1}$

31 An oil drop of mass 2.6×10^{-15} kg and with a charge of -4.8×10^{-19} C is in a vacuum between two horizontal plates. The plates have a separation of 2.0 cm and a potential difference (p.d.) between them of 1200 V, as shown.



Which statement describes the motion of the oil drop?

A It is stationary.

B It has a downward acceleration of $9.7\,\text{m}\,\text{s}^{-2}$.

C It has an upward acceleration of $1.3\,\text{m}\,\text{s}^{-2}$.

D It has an upward acceleration of $11\,\text{m}\,\text{s}^{-2}$.

32 Which two units are used to define the coulomb?

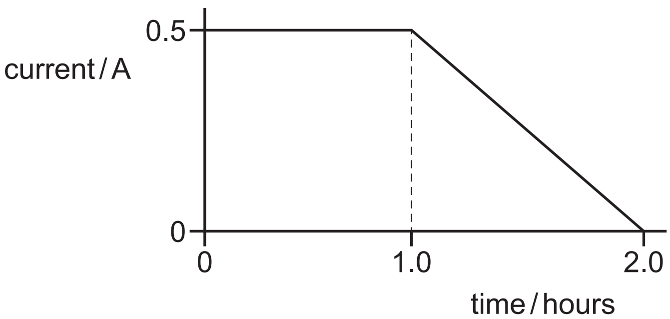
A ampere and second

B ampere and volt

C volt and ohm

D volt and second

33 A mobile phone battery is charged by connecting it to a constant potential difference of 5.0 V. After a time of 1.0 hour, the initial current of 0.50 A slowly decreases to zero, as shown.



What is the best estimate of the energy transferred to the battery during the time of 2.0 hours shown in the graph?

A 2700 J **B** 9000 J **C** 14 000 J **D** 18 000 J

34 A length of wire is connected into an electric circuit. The current in the wire is measured.

Which change on its own could increase the current in the wire?

A an increase in the length of the wire

B an increase in the radius of the wire

C an increase in the resistance of the wire

D an increase in the resistivity of the wire

35 A cell is described as having an electromotive force (e.m.f.) of 6 V.

What does this mean?

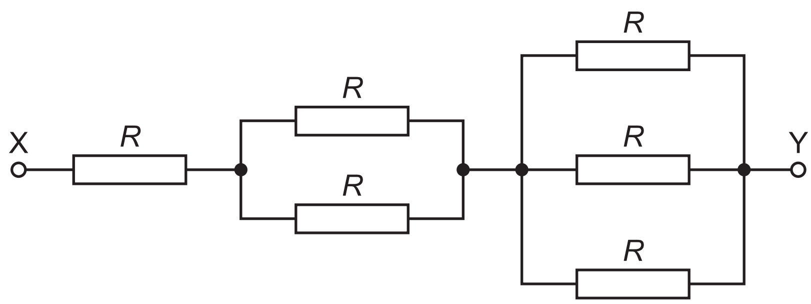
A 1 coulomb of charge always dissipates 6 J of energy in the internal resistance of the cell.

B 1 electron gains 6 J of energy when passing through the cell.

C There is a potential difference of 6 V applied across any external circuit connected to the cell.

D When 1 coulomb of charge passes through the cell, 6 J of chemical energy is transformed.

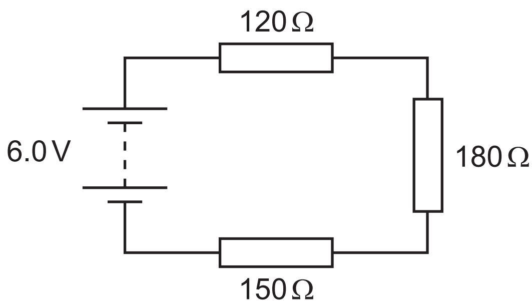
36 The diagram shows a network of resistors. Each resistor has resistance R.



What is the total resistance of the network between points X and Y?

A $\frac{R}{6}$ **B** $\frac{6R}{11}$ **C** $\frac{11R}{6}$ **D** $6R$

37 Three resistors are connected in series with a battery, as shown. The battery has negligible internal resistance.

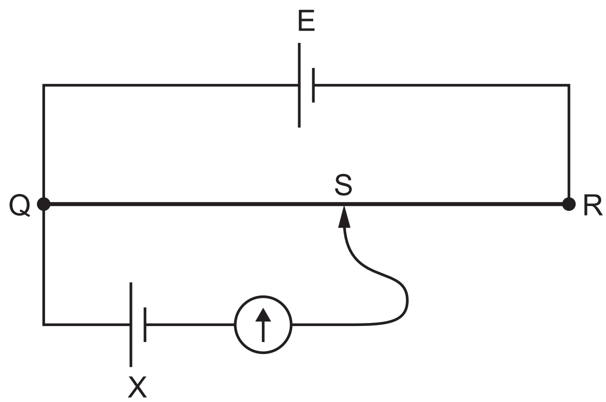


What is the potential difference across the 180 Ω resistor?

A 1.6 V **B** 2.4 V **C** 3.6 V **D** 4.0 V

38 A potentiometer circuit is used to determine the unknown electromotive force (e.m.f.) of a cell X.

In the circuit shown, E is a cell with an e.m.f. that is known accurately. QR is the potentiometer wire, which has a movable contact S. Contact S is connected to a galvanometer and to cell X.



What is **not** a necessary requirement to determine the e.m.f. of X from the circuit?

A The e.m.f. of cell X must be lower than the e.m.f. of cell E.

B The internal resistance of cell X must be known.

C The lengths QS and QR must be determined accurately.

D The resistance of the wire QR must be proportional to its length.

39 A nucleus of uranium, ${}^{235}_{92}\mathrm{U}$, undergoes a series of decays. During the series of decays, two α-particles and one β^- particle are emitted.

As a result, a nucleus of actinium, Ac, is formed.

What is the correct notation for the nuclide of actinium that is formed?

A ${}^{227}_{87}\mathrm{Ac}$ **B** ${}^{227}_{89}\mathrm{Ac}$ **C** ${}^{231}_{87}\mathrm{Ac}$ **D** ${}^{231}_{89}\mathrm{Ac}$

40 Which particle is a fundamental particle?

A electron

B hadron

C neutron

D proton

Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2021**

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

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- 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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

IB21 06_9702_12/2RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is **not** a reasonable estimate of the physical property indicated?

A 2×10^3 W for the power dissipated by the heating element of an electric kettle

B 4×10^2 m^3 for the volume of water in a swimming pool

C 5×10^5 N s for the momentum of a lorry moving along a road

D 6×10^2 N for the weight of a fully grown racehorse

2 Which quantity could have units of N m V^{-1}?

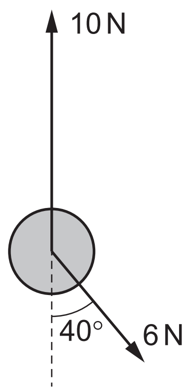
A acceleration

B charge

C current

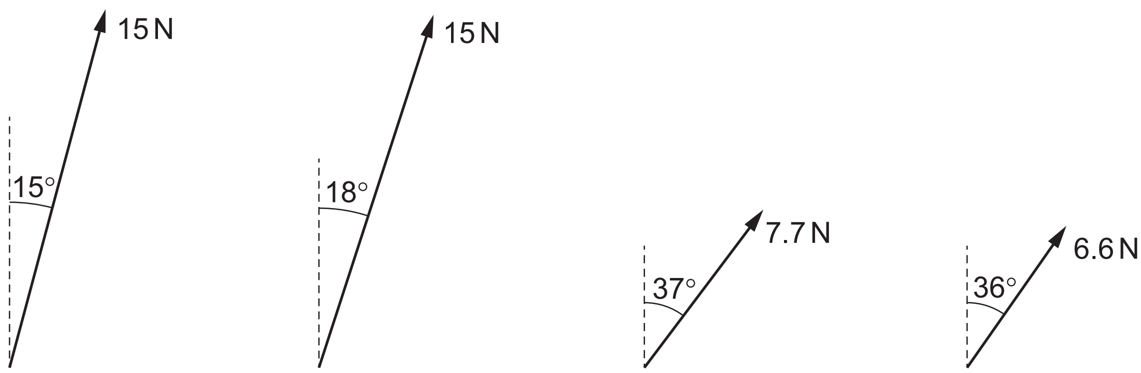
D resistance

3 An object is acted upon by two forces, 10 N in the vertical direction and 6 N at 40° to the vertical, as shown.

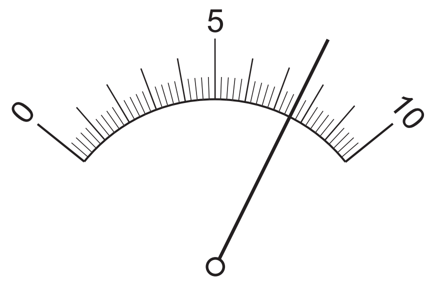


What is the resultant force acting on the object?

A **B** **C** **D**



4 An analogue ammeter with a range of 0–250 mA is connected into an electrical circuit. The diagram shows the ammeter's display.



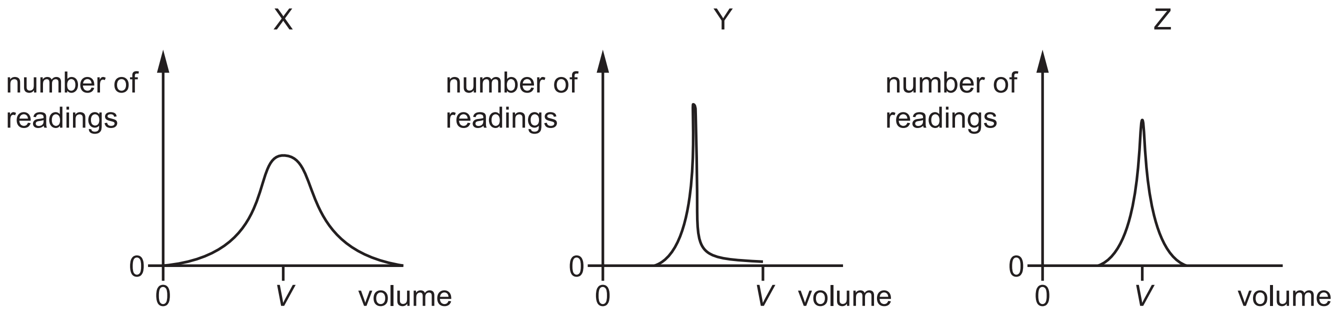
What is the reading on the ammeter?

A 76 mA **B** 165 mA **C** 183 mA **D** 190 mA

5 Students take readings of the volume of a liquid using three different pieces of measuring equipment X, Y and Z.

The true value of the volume of the liquid is V.

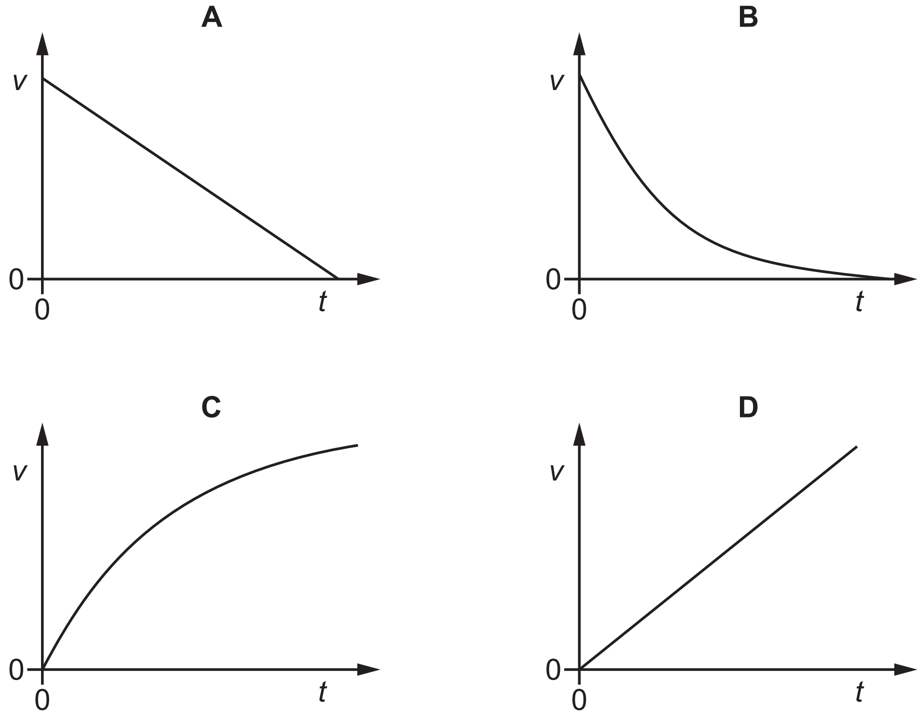
The students' results are shown.



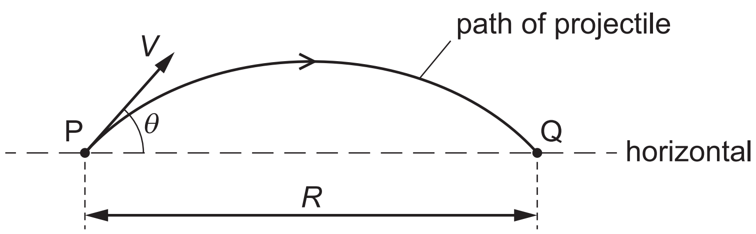
How many pieces of equipment are precise and how many are accurate?

	number of precise pieces of equipment	number of accurate pieces of equipment
A	1	1
B	1	2
C	2	1
D	2	2

6 Which graph shows the variation with time t of the velocity v of an object falling vertically downwards in a vacuum?



7 A projectile is fired from point P with velocity V at an angle θ to the horizontal. It lands at point Q, a horizontal distance R from P. Air resistance is negligible.



The acceleration of free fall is g.

Which equation for R is correct?

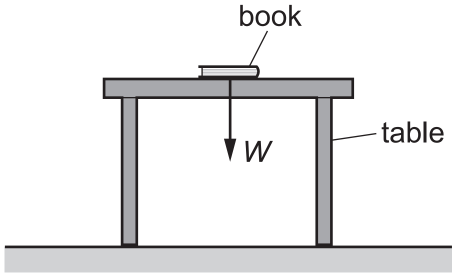
A $R = \dfrac{V^2 \sin\theta \cos\theta}{g}$

B $R = \dfrac{2V^2 \sin\theta \cos\theta}{g}$

C $R = \dfrac{V^2 \sin\theta \cos\theta}{2g}$

D $R = \dfrac{V^2 g \sin\theta \cos\theta}{2}$

8 A book of weight W is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

A the force W acting downwards on the Earth from the table

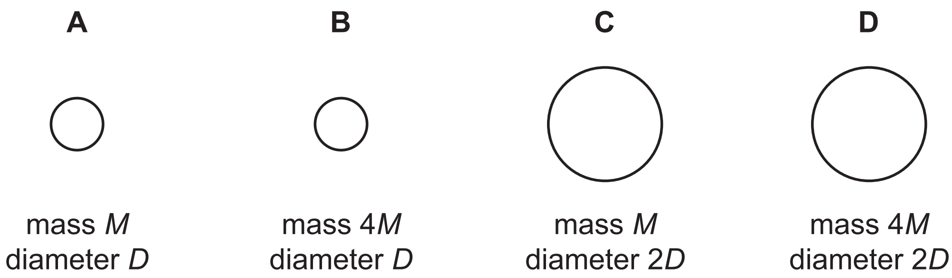
B the force W acting upwards on the book from the table

C the force W acting upwards on the Earth from the book

D the force W acting upwards on the table from the floor

9 Four balls are dropped at the same time from the top of a very tall tower. There is no wind blowing.

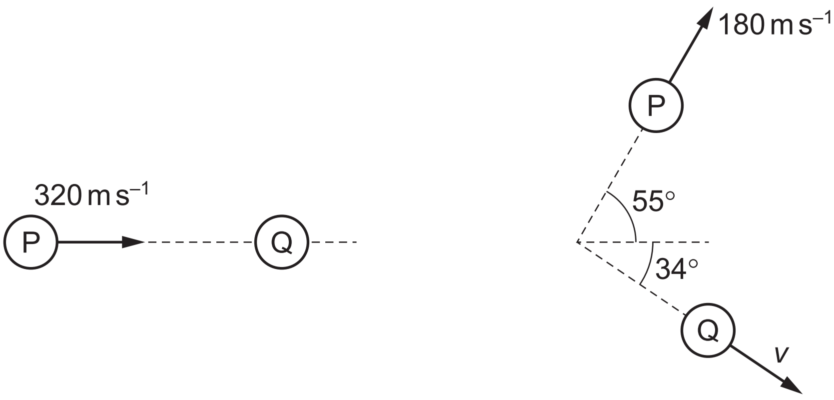
Which ball hits the ground first?



10 A nitrogen molecule P travelling at a speed of $320\,\text{m}\,\text{s}^{-1}$ in a vacuum collides with a stationary nitrogen molecule Q.

After the collision, P travels at a velocity of $180\,\text{m}\,\text{s}^{-1}$ at an angle of 55° to its original path.

Q travels in a direction at an angle of 34° to the initial path of P.



before collision after collision

Assume that there are no external forces acting on the molecules.

What is the magnitude v of the velocity of Q after the collision?

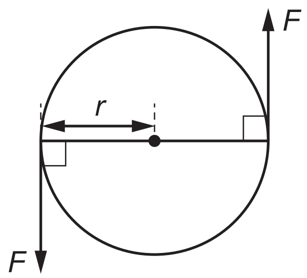
A $120\,\text{m}\,\text{s}^{-1}$ **B** $140\,\text{m}\,\text{s}^{-1}$ **C** $180\,\text{m}\,\text{s}^{-1}$ **D** $260\,\text{m}\,\text{s}^{-1}$

11 A charged particle is placed in a uniform field of force. The direction of the force on the particle is opposite to the direction of the field.

What is the field and what is the charge on the particle?

	field	charge on particle
A	electric	negative
B	electric	positive
C	gravitational	negative
D	gravitational	positive

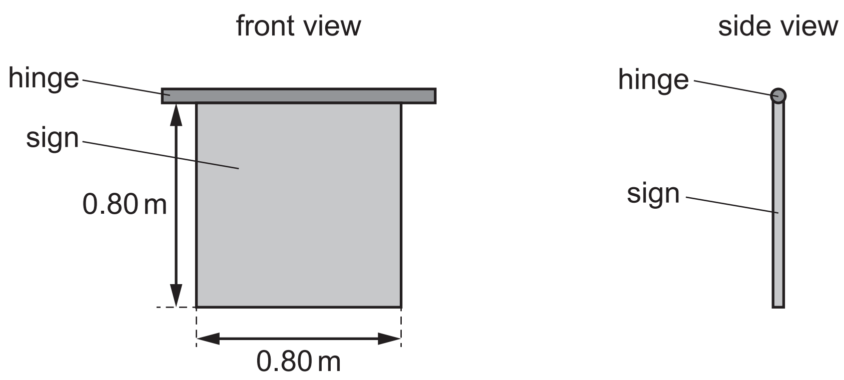
12 A disc of radius r is acted upon by two opposite forces, each of magnitude F. The forces form a couple, as shown.



What is the torque of this couple?

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

13 A uniform square sign of weight 40 N is suspended vertically from its top edge by a horizontal hinge, as shown.



The hinge is not frictionless. When the sign is displaced from the vertical by an external force and then released, it does not return to the vertical position.

The maximum torque exerted by the hinge on the sign is 6.0 N m. The sign is displaced by 90° so that it is horizontal and then gradually released.

At which angle to the vertical does the sign hang after release?

A 11° **B** 22° **C** 68° **D** 79°

14 Each foot of an elephant has a circular cross-section with a circumference of 1.4 m. The elephant has a mass of 5400 kg.

The elephant is standing still with all four feet on the ground. Assume the pressure under each foot is the same.

What is the approximate pressure exerted on the ground by each of the elephant's feet?

A 8.7 kPa **B** 35 kPa **C** 85 kPa **D** 340 kPa

15 A stone is falling vertically through the air at a constant (terminal) velocity.

Which energy change is occurring?

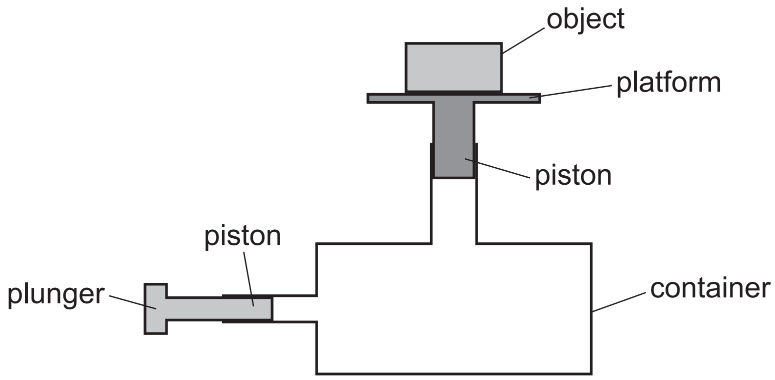
A gravitational potential energy to thermal energy

B gravitational potential energy to kinetic energy of the stone

C kinetic energy to gravitational potential energy of the stone

D kinetic energy of the stone to thermal energy

16 An object of weight 12 N rests on a platform on top of a container with two pistons, as shown. The container contains a fixed mass of gas, and the pistons are free to move.

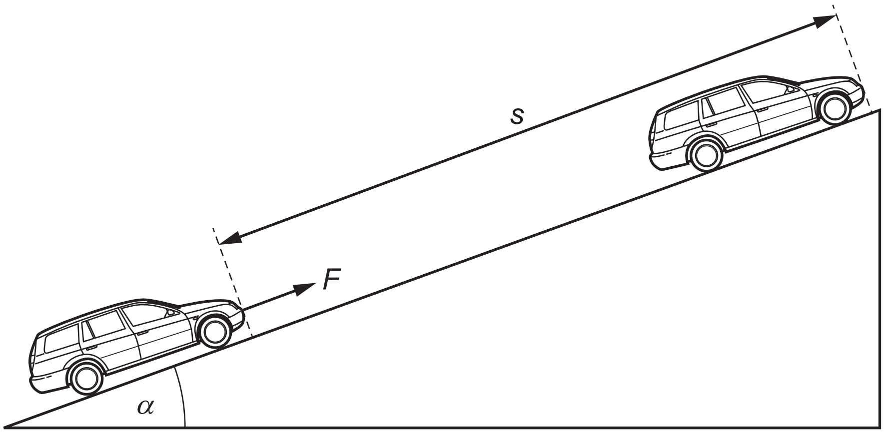


The plunger is slowly pushed 4.0 cm to the right. As a result, the object slowly moves upwards a distance 0.50 cm.

How much work is done on the object?

A 0.060 J **B** 0.48 J **C** 6.0 J **D** 48 J

17 A constant force *F*, acting on a car of mass *m*, moves the car up a slope through a distance *s* at constant velocity *v*. The angle of the slope to the horizontal is α.



The acceleration of free fall is *g*.

What is the ratio $\dfrac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

A $\dfrac{mgs\sin\alpha}{Fv}$ **B** $\dfrac{mv}{Fs}$ **C** $\dfrac{mv^2}{2Fs}$ **D** $\dfrac{mg\sin\alpha}{F}$

18 What is the definition of power?

A Power is the product of force and velocity.

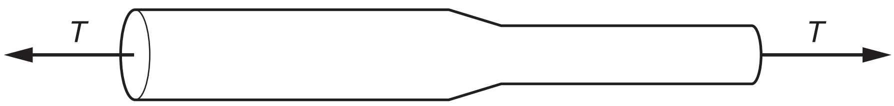
B Power is the product of force and work done per unit time.

C Power is the product of force per unit time and velocity.

D Power is the rate at which work is done.

19 A steel bar of circular cross-section is under tension *T*, as shown.

The diameter of the wide portion is double the diameter of the narrow portion.



What is the value of $\dfrac{\text{stress in the wide portion}}{\text{stress in the narrow portion}}$?

A 0.25 **B** 0.50 **C** 2.0 **D** 4.0

20 Two guitar strings are stretched by tensile forces.

String X is stretched by a tensile force F that causes an extension x.

String Y is stretched by a tensile force $2F$ that causes an extension $2x$.

The strings obey Hooke's law.

What is the ratio $\dfrac{\text{strain energy in stretched string X}}{\text{strain energy in stretched string Y}}$?

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

21 Two lasers emit light in a vacuum. One laser emits red light and the other emits green light.

Which property of the light from the two lasers **must** be different?

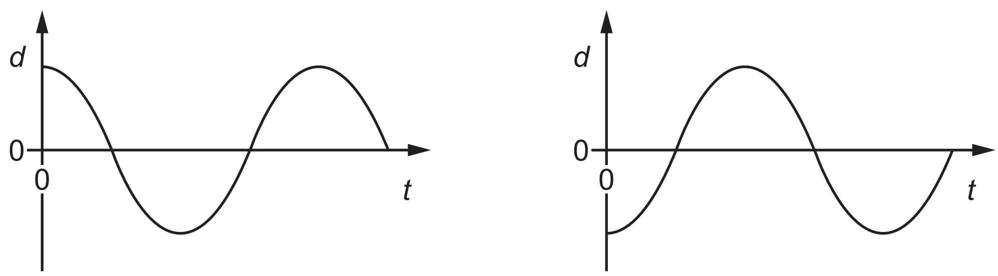
A amplitude

B frequency

C intensity

D speed

22 Two particles in a progressive wave are a distance 10 cm apart. The two graphs show the variation with time t of the displacement d of the two particles.



What could be represented by the two graphs?

A particles in a longitudinal wave with a compression and the nearest rarefaction separated by 10 cm

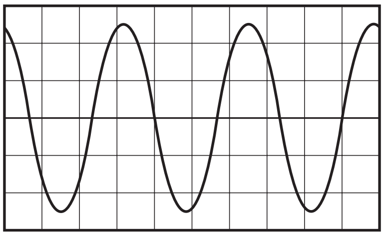
B particles in a longitudinal wave with a compression and the nearest rarefaction separated by 20 cm

C particles in a transverse wave with a peak and the nearest trough separated by 20 cm

D particles in a transverse wave with two adjacent peaks separated by 10 cm

23 A sound wave is detected by a microphone that is connected to a cathode-ray oscilloscope (CRO).

The screen of the CRO displays a waveform, as shown.



The time-base is set to $20\,\mu s\,div^{-1}$.

What is the frequency of the sound wave?

A 15 Hz **B** 15 000 Hz **C** 20 000 Hz **D** 30 000 Hz

24 A person stands at the side of a straight railway track. A train moves towards the person and emits sound from its whistle. The person hears a sound of frequency 1690 Hz as the train approaches him.

The person then hears sound of frequency 1500 Hz as the train moves away from him. The speed of sound in air is $340\,m\,s^{-1}$.

What is the speed of the train?

A $20\,m\,s^{-1}$ **B** $38\,m\,s^{-1}$ **C** $41\,m\,s^{-1}$ **D** $43\,m\,s^{-1}$

25 Which list shows electromagnetic waves in order of decreasing frequency?

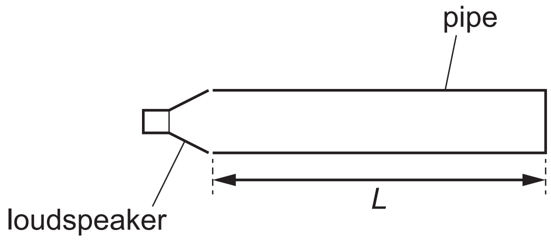
A gamma-rays → infrared → ultraviolet → radio waves

B gamma-rays → ultraviolet → infrared → radio waves

C radio waves → infrared → ultraviolet → gamma-rays

D radio waves → ultraviolet → infrared → gamma-rays

26 A pipe of length L is open at one end and closed at the other end. A loudspeaker is at the open end and emits a sound wave into the pipe.

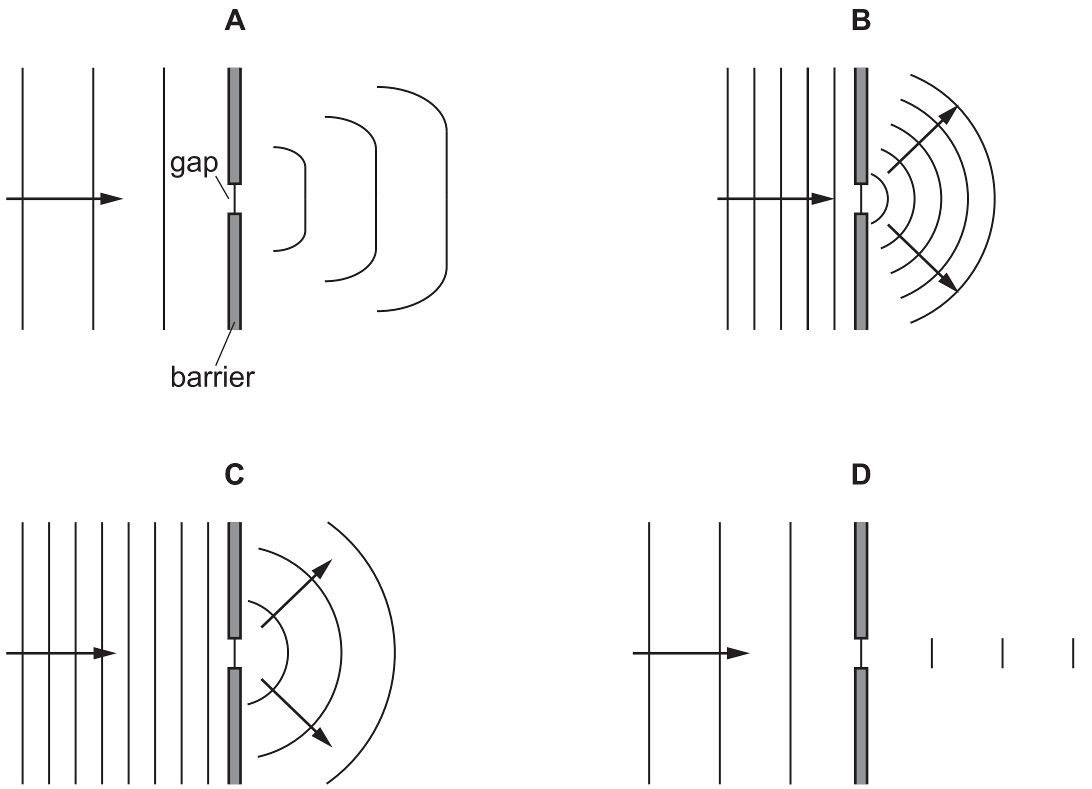


When a stationary wave is formed, there is an antinode at the open end of the pipe.

Which wavelength of sound could be used to produce a stationary wave?

A $\frac{2L}{3}$ **B** L **C** $\frac{4L}{3}$ **D** $2L$

27 Which diagram best shows how water waves diffract when they pass through a gap in a barrier?



28 In a two-source interference experiment, light of a single frequency is incident on a double slit.

The light waves emerging from the slits are coherent.

What is meant by *coherent*?

A The waves are in phase.

B The waves have a constant phase difference.

C The waves have the same amplitude.

D The waves interfere constructively wherever they overlap.

29 A parallel beam of light consists of light of wavelength 420 nm and light of wavelength 630 nm.

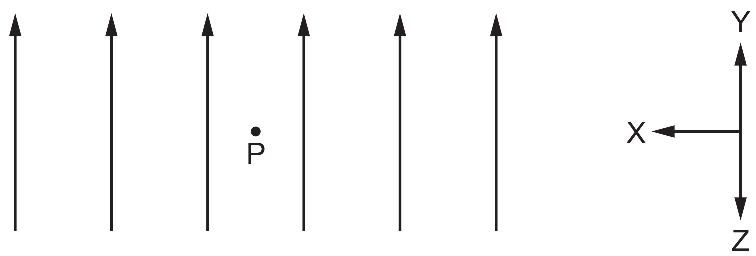
The light is incident normally on a diffraction grating.

The diffraction maxima for the two wavelengths overlap only at an angle of 31° from the direction of the incident light beam.

What could be the line spacing of the diffraction grating?

A 1.2 μm **B** 1.6 μm **C** 2.4 μm **D** 3.7 μm

30 A positively charged particle P is in an electric field, as shown.



The field lines (lines of force) are evenly spaced and parallel.

Which statement is correct?

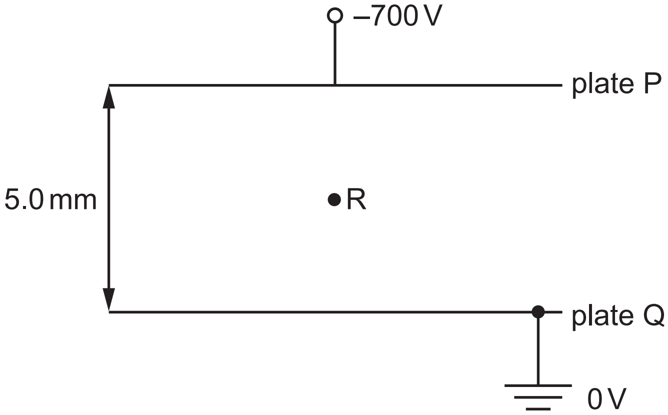
A Moving P a small distance in any direction will not change the electric force on P.

B Moving P a small distance in direction Y will increase the electric force on P.

C Moving P a small distance in direction Z will increase the electric force on P.

D Moving P a small distance in direction X will increase the electric force on P.

31 The diagram shows two parallel metal plates P and Q, separated by a distance of 5.0 mm. There is a potential difference of 700 V between the plates. Plate Q is earthed.



What is the magnitude and direction of the electric field at point R?

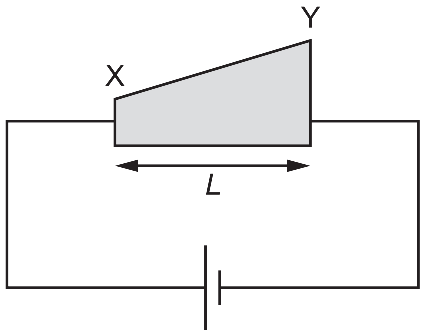
A $1.4 \times 10^{2}\,\mathrm{N\,C^{-1}}$ from P towards Q

B $1.4 \times 10^{2}\,\mathrm{N\,C^{-1}}$ from Q towards P

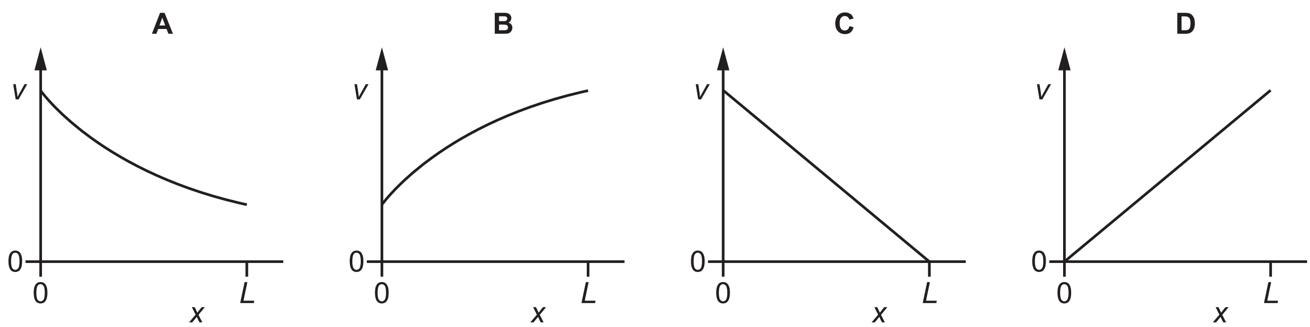
C $1.4 \times 10^{5}\,\mathrm{N\,C^{-1}}$ from P towards Q

D $1.4 \times 10^{5}\,\mathrm{N\,C^{-1}}$ from Q towards P

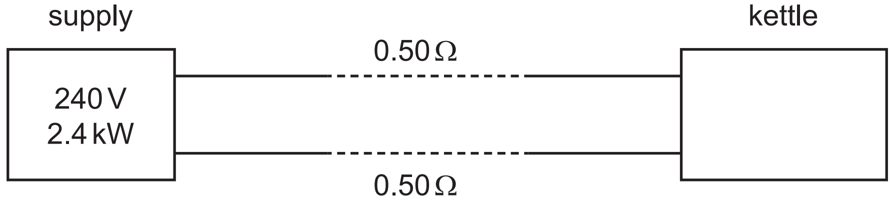
32 A wedge-shaped metal conductor of length L, varying width and uniform thickness is connected to a cell, as shown.



Which graph best shows how the average drift velocity v of electrons in the conductor varies with distance x from end X?



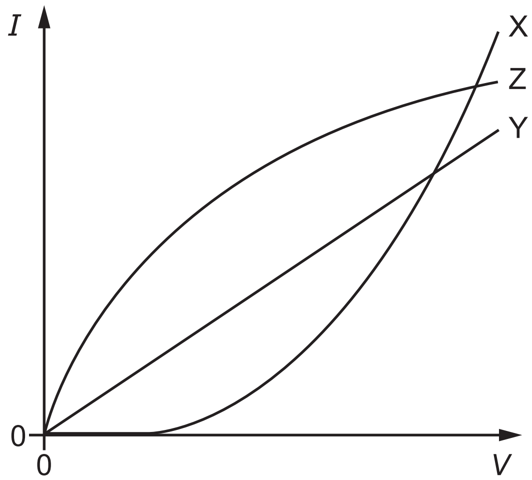
33 The power output of an electrical supply is 2.4 kW at a potential difference (p.d.) of 240 V. The two wires between the supply and a kettle each have a resistance of 0.50 Ω, as shown.



What is the power supplied to the kettle and what is the p.d. across the kettle?

	power / kW	p.d. / V
A	2.3	230
B	2.3	235
C	2.4	230
D	2.4	235

34 The graph shows the variation with potential difference V of the current I in components X, Y and Z.



Which row correctly identifies the components?

	metallic conductor at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	Y	X

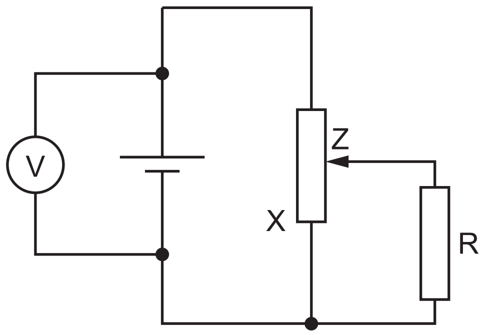
35 A wire of resistance 9.55 Ω has a diameter of 0.280 mm.

It is made of metal of resistivity 4.90×10^{-7} Ω m.

What is the length of the wire?

A 1.20 m **B** 4.80 m **C** 19.0 m **D** 76.0 m

36 A cell of constant electromotive force (e.m.f.) but with internal resistance is connected to a fixed resistor R using a potentiometer. A voltmeter measures the potential difference (p.d.) between the terminals of the cell.



Which statement explains the change to the reading of the voltmeter as contact Z is moved towards end X of the potentiometer?

A The voltmeter reading decreases because the current through the cell decreases.

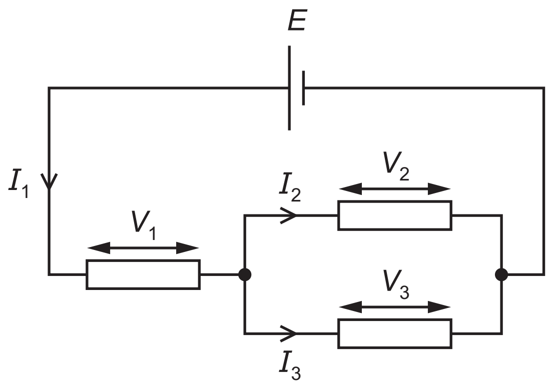
B The voltmeter reading decreases because the current through the cell increases.

C The voltmeter reading increases because the current through the cell decreases.

D The voltmeter reading increases because the current through the cell increases.

37 A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected to a circuit.

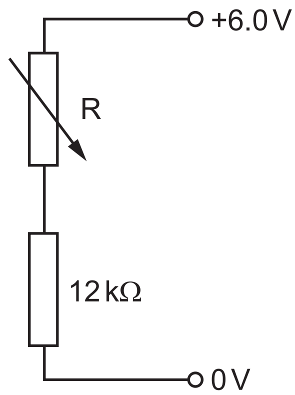
The circuit has currents I_1, I_2 and I_3, and potential differences V_1, V_2 and V_3, as shown.



Which equation represents a statement of Kirchhoff's first law?

A $I_1 = I_2 + I_3$ **B** $I_1 = I_2 = I_3$ **C** $E = V_1 + V_2$ **D** $V_1 = V_2 = V_3$

38 Two resistors are connected in series with a 6.0 V power supply, as shown.



What is the resistance of the variable resistor R to give a potential difference of 1.0 V across the 12 kΩ resistor?

A 2.0 kΩ **B** 10 kΩ **C** 60 kΩ **D** 72 kΩ

39 A nucleus of magnesium decays into a nucleus X by emitting a β^+ particle. The decay is represented by the equation shown.

$$^{23}_{12}\mathrm{Mg} \rightarrow \,^{P}_{Q}\mathrm{X} + \,^{0}_{1}\beta^{+}$$

What are the values of P and Q?

	P	Q
A	22	11
B	22	13
C	23	11
D	23	13

40 In β^- decay, a neutron inside a nucleus changes to a proton.

Which statement describes the quark composition of the nucleus during the decay?

A The number of down quarks decreases by one.

B The number of down quarks increases by one.

C The number of down quarks stays the same.

D The number of up quarks stays the same.

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2021**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 9 1 2 0 2 9 7 8 2 5 *

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

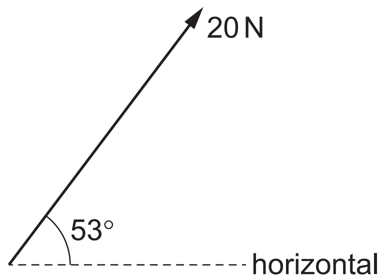
1 What is a reasonable estimate of the kinetic energy of an Olympic athlete sprinting in a 100 m race?

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

2 What is a unit of momentum?

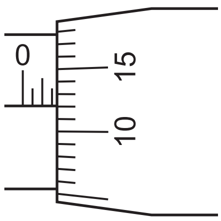
A $\mathrm{kg\,m\,s^{-2}}$ **B** $\mathrm{N\,s^{-1}}$ **C** $\mathrm{N\,s}$ **D** $\mathrm{kg\,s\,m^{-1}}$

3 What is the horizontal component of the force shown?

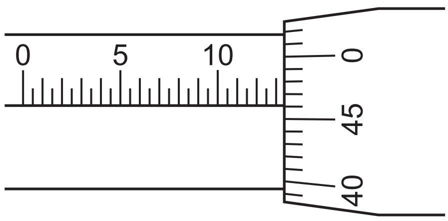


A 12 N **B** 16 N **C** 25 N **D** 27 N

4 The diagram shows two readings on a micrometer.



reading 1



reading 2

What is the difference between the two readings?

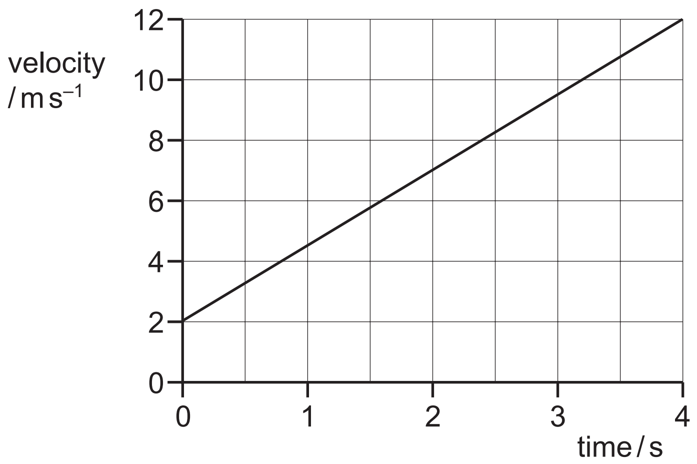
A 10.34 mm **B** 11.84 mm **C** 12.34 mm **D** 12.84 mm

5 The diameter of a circular disc is measured as (7.0 ± 0.1) mm.

What is the area of the disc and the absolute uncertainty in the area?

	area of disc / $\mathrm{mm^2}$	absolute uncertainty / $\mathrm{mm^2}$
A	38.5	±0.5
B	38	±1
C	154	±2
D	154	±4

6 The diagram shows a velocity–time graph for a car.



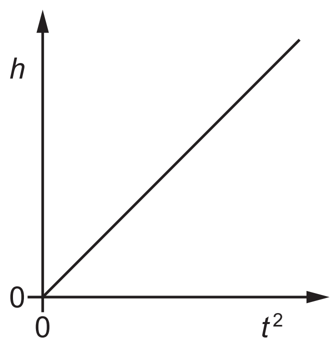
What is the distance travelled during the first 4.0 s?

A 2.5 m **B** 3.0 m **C** 20 m **D** 28 m

7 A steel ball is dropped from rest from a height h above the ground. The ball hits the ground after a time t.

This is repeated for a number of different heights.

The graph shows the variation of h with t^2 for the ball.

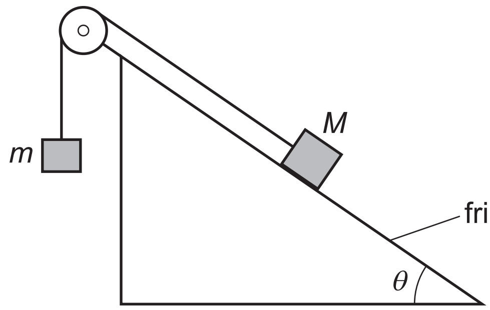


The gradient of the graph is G.

Which expression gives the acceleration of the ball?

A $\frac{G}{2}$ **B** G **C** $2G$ **D** G^2

8 Two masses, M and m, are connected by an inextensible string which passes over a frictionless pulley. Mass M rests on a frictionless slope, as shown.



The slope is at an angle θ to the horizontal.

The two masses are initially held stationary and then released. Mass M accelerates down the slope.

Which expression **must** be correct?

A $\sin\theta < \dfrac{m}{M}$ **B** $\cos\theta < \dfrac{m}{M}$ **C** $\sin\theta > \dfrac{m}{M}$ **D** $\cos\theta > \dfrac{m}{M}$

9 The weights and masses of four different objects on the surfaces of four different planets are shown.

Which planet has the lowest value of acceleration of free fall at its surface?

	weight	mass
A	40 mN	6.0 g
B	3.0 N	500 g
C	10 N	1 kg
D	2.6 kN	750 kg

10 A rock in deep space is travelling towards a distant star and collides with a stationary spacecraft.

What is **not** a possible outcome of the collision?

A The rock becomes stationary and the spacecraft moves towards the star.

B The rock moves away from the star and so does the spacecraft.

C The rock moves away from the star and the spacecraft moves towards the star.

D The rock moves towards the star and so does the spacecraft.

11 A steel ball is falling at a constant (terminal) speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

What is the order of increasing magnitude of these three forces?

A upthrust → viscous drag → weight

B viscous drag → upthrust → weight

C viscous drag → weight → upthrust

D weight → upthrust → viscous drag

12 What is a couple?

A a pair of equal forces acting in the same direction but along different lines

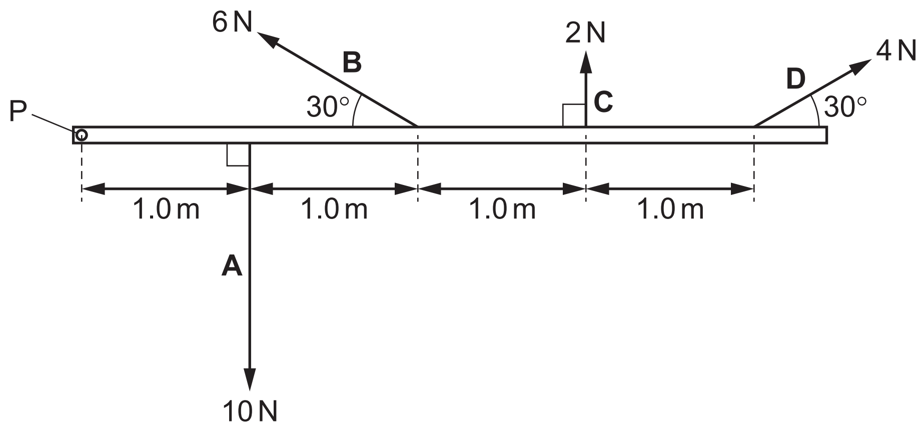
B a pair of forces that are equal and opposite but acting along different lines

C a pair of forces that produce no resultant force and no resultant moment

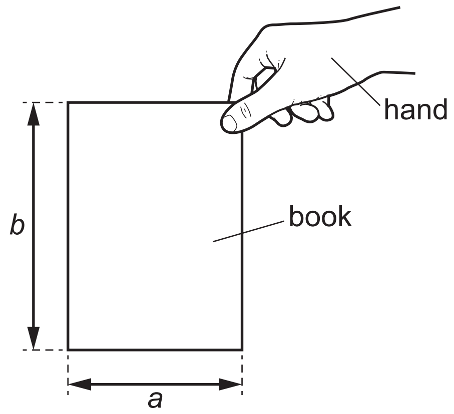
D a pair of unequal forces acting in opposite directions but along the same line

13 Four coplanar forces act on a rigid rod, as shown. The rod is hinged at P.

Which force produces the greatest moment about point P?



14 A book of weight W has a rectangular shape and is of uniform thickness. The book is held in a vertical plane so that the longer sides of the book are vertical, as shown.



Which expression gives the approximate torque exerted by the hand on the book?

A $\dfrac{Wa}{2}$ clockwise

B $\dfrac{Wb}{2}$ anticlockwise

C Wa clockwise

D Wb anticlockwise

15 The derivation of the pressure equation $\Delta p = \rho g \Delta h$ uses a number of relationships between quantities.

Which relationship is **not** used in the derivation of this equation?

A density = $\dfrac{\text{mass}}{\text{volume}}$

B potential energy = mass × acceleration of free fall × height

C pressure = $\dfrac{\text{force}}{\text{area}}$

D weight = mass × acceleration of free fall

16 A spring is initially neither compressed nor extended.

A force can be applied to this spring so that it is either compressed to a shorter length or extended to a longer length.

What is the change in the elastic potential energy in the spring when it is extended and when it is compressed?

	change in the elastic potential energy	
	spring is extended	spring is compressed
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

17 A sample of gas is sealed in a cylinder by a piston. The frictionless piston is free to move, so that the pressure of the gas remains constant at 1.80×10^5 Pa.

The gas initially occupies a volume of $2.40 \times 10^{-4}\,m^3$.

The gas now does 14.4 J of work.

What is the volume of the gas after doing this work?

A $0.80 \times 10^{-4}\,m^3$

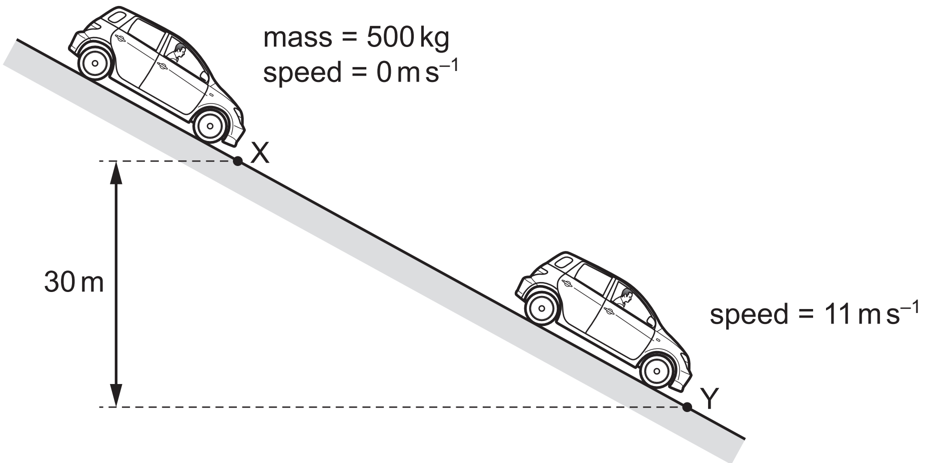
B $1.60 \times 10^{-4}\,m^3$

C $3.20 \times 10^{-4}\,m^3$

D $4.00 \times 10^{-4}\,m^3$

18 A car of mass 500 kg is at rest at point X on a slope, as shown.

The car's brakes are released and the car rolls down the slope with its engine switched off. At point Y the car has moved through a vertical height of 30 m and has a speed of 11 m s^{-1}.



What is the energy dissipated by frictional forces when the car moves from X to Y?

A 3.0×10^4 J **B** 1.2×10^5 J **C** 1.5×10^5 J **D** 1.8×10^5 J

19 Which expression **cannot** be used to calculate power?

A $\dfrac{(\text{force} \times \text{displacement})}{\text{time}}$

B force $\times$ velocity

C $\dfrac{\text{work done}}{\text{time}}$

D work done $\times$ velocity

20 The stress σ in a material is given by the equation shown.

$$\sigma = \frac{F}{A}$$

The strain ε in the same material is given by the equation shown.

$$\varepsilon = \frac{x}{L}$$

Which expression gives the Young modulus of the material?

A $\dfrac{\varepsilon}{\sigma}$ **B** $\dfrac{Fx}{AL}$ **C** $\dfrac{\sigma x}{L}$ **D** $\dfrac{F}{A\varepsilon}$

21 What is an example of plastic deformation?

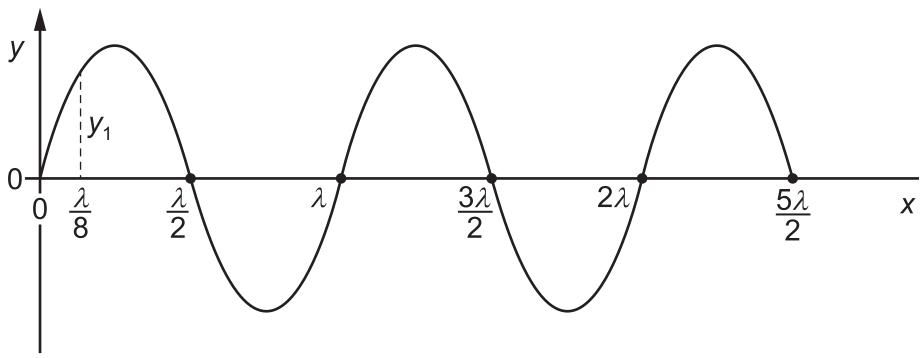
A A rubber ball is momentarily compressed every time it hits the ground.

B A spoon stirring some coffee in a ceramic mug hits its surface and makes a clinking sound.

C A toolbox is left on a horizontal plank. When the toolbox is removed, the plank is no longer straight.

D The spring in some bathroom weighing scales is compressed by a person standing on the scales.

22 A transverse progressive wave of wavelength λ is set up on a stretched string. The graph shows the variation of displacement y with distance x at a particular instant of time. The wave has displacement $+y_1$ at distance $x = \frac{\lambda}{8}$.



What are the next two values of x where the displacement y is again equal to $+y_1$?

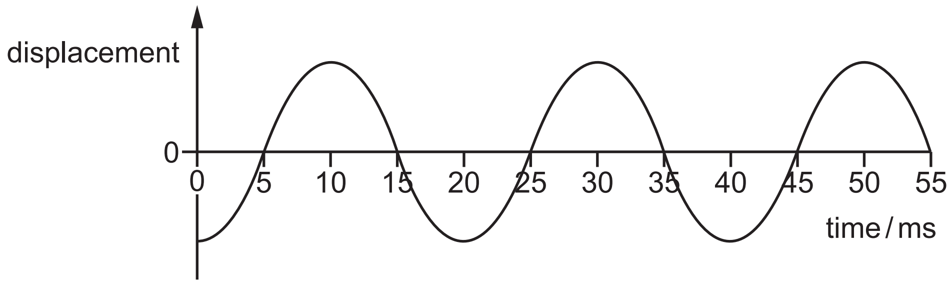
A $\frac{3\lambda}{8}$ and $\frac{5\lambda}{8}$

B $\frac{3\lambda}{8}$ and $\frac{9\lambda}{8}$

C $\frac{5\lambda}{8}$ and $\frac{9\lambda}{8}$

D $\frac{9\lambda}{8}$ and $\frac{17\lambda}{8}$

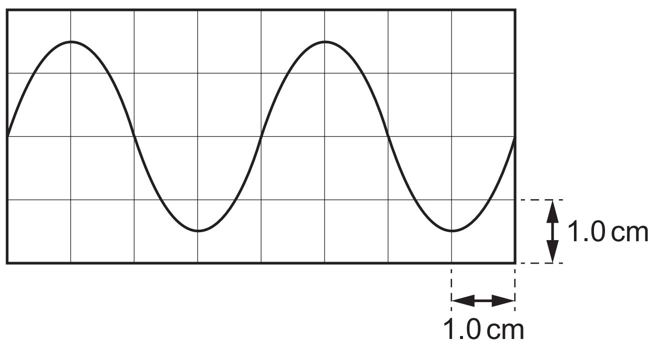
23 The graph shows the variation with time of the displacement of an air particle as a progressive sound wave passes through the air. The speed of sound in air is 330 $m s^{-1}$.



What is the wavelength of the wave?

A 6.6 m **B** 8.3 m **C** 20 m **D** 25 m

24 A microphone is connected to a cathode-ray oscilloscope (CRO). A sound wave of constant frequency is detected by the microphone. The screen of the CRO is shown.



The time-base is set at 1.0 $ms\,cm^{-1}$.

What is the frequency of the sound wave?

A 250 Hz **B** 500 Hz **C** 670 Hz **D** 4000 Hz

25 A train's whistle is emitting sound of frequency 500 Hz as the train moves with a speed of 20 $m s^{-1}$ along a straight track. The train moves directly towards a stationary observer standing next to the track and then passes the observer.

The speed of sound in air is 330 $m s^{-1}$.

What is the difference between the frequencies of the sound heard by the observer before and after the train has passed the observer?

A 29 Hz **B** 32 Hz **C** 40 Hz **D** 61 Hz

26 Gamma-rays, microwaves, visible light and X-rays are four regions of the electromagnetic spectrum.

Which list shows these four regions in order of increasing wavelength?

A microwaves → visible light → X-rays → gamma-rays

B gamma-rays → X-rays → visible light → microwaves

C X-rays → gamma-rays → microwaves → visible light

D microwaves → visible light → gamma-rays → X-rays

27 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 correct?

A The waves must have equal frequencies, but different speeds and wavelengths.

B The waves must have equal speeds, but different wavelengths and frequencies.

C The waves must have equal speeds, frequencies and wavelengths.

D The waves must have equal wavelengths, but different speeds and frequencies.

28 The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

Which size of architectural features in a large concert hall would best diffract sound waves of frequency 0.44 kHz?

A 1.3 mm **B** 750 mm **C** 7.5 m **D** 17 m

29 A double-slit interference pattern using red light of wavelength $7.0 \times 10^{-7}\,\mathrm{m}$ has a fringe spacing of 3.5 mm.

Which fringe spacing would be observed for the same arrangement of apparatus but using blue light of wavelength $4.5 \times 10^{-7}\,\mathrm{m}$?

A 2.3 mm **B** 3.5 mm **C** 5.4 mm **D** 9.0 mm

30 A beam of light of a single wavelength is incident normally on a diffraction grating.

The angle of diffraction θ is measured for each order of diffraction n. The distance between adjacent slits in the diffraction grating is d.

A graph is plotted to determine the wavelength of the light.

Which graph should be plotted and how is the wavelength determined from the graph?

	y-axis	x-axis	wavelength
A	n	$d\sin\theta$	gradient
B	n	$d\sin\theta$	1 / gradient
C	$\sin\theta$	d/n	gradient
D	$\sin\theta$	$d \times n$	1 / gradient

31 A particle has a charge of +2.0 mC and is in a vertical uniform electric field. An electric force of 1.0×10^{-2} N acts upwards on the particle.

What is the electric field strength?

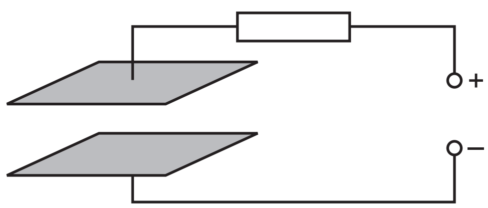
A $0.20\,\mathrm{V\,m^{-1}}$ downwards

B $0.20\,\mathrm{V\,m^{-1}}$ upwards

C $5.0\,\mathrm{V\,m^{-1}}$ downwards

D $5.0\,\mathrm{V\,m^{-1}}$ upwards

32 The diagram shows two parallel metal plates connected to a d.c. power supply through a resistor.



There is a uniform electric field in the region between the plates.

Which change would cause a **decrease** in the strength of the electric field?

A a small increase in the distance between the plates

B a small increase in the potential difference between the plates

C a small increase in the resistance of the resistor

D a small increase to the area of both plates

33 A wire has a length of 12 cm and contains a total of 5.1×10^{22} free electrons.

When a potential difference is applied across the ends of the wire, the free electrons move with an average drift speed of $4.0 \times 10^{-6}\,\mathrm{m\,s^{-1}}$.

What is the current in the wire?

A 0.0027 A **B** 0.0039 A **C** 0.27 A **D** 0.39 A

34 A battery is marked 9.0 V.

What does this mean?

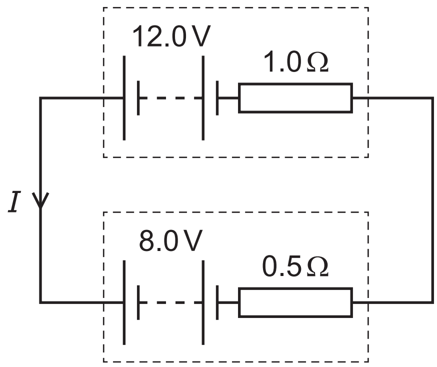
A Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

B The battery supplies 9.0 J of electrical energy to an external circuit for each coulomb of charge.

C The potential difference across any component connected to the battery will be 9.0 V.

D There will always be a potential difference of 9.0 V across the battery terminals.

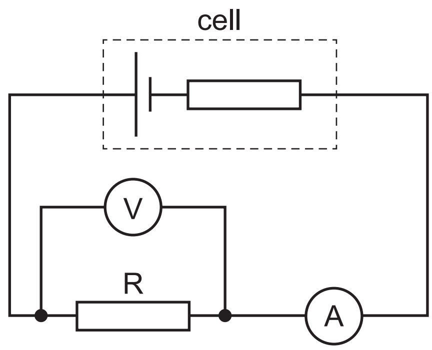
35 The diagram shows a circuit containing two batteries connected together.



What is the current I?

A 2.7 A **B** 4.0 A **C** 8.0 A **D** 13 A

36 The circuit shown includes a cell of constant internal resistance and an external resistor R.

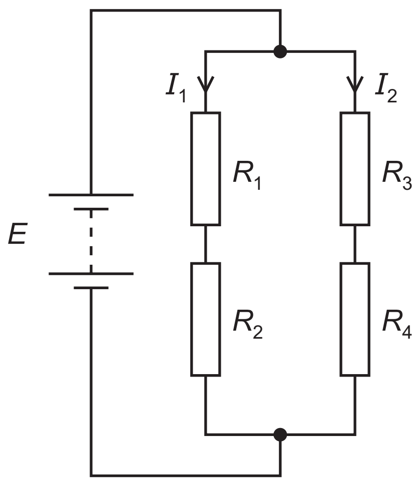


A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	increases	decreases
D	increases	stays the same

37 A battery of electromotive force (e.m.f.) E and negligible internal resistance is connected to four resistors of resistances R_1, R_2, R_3 and R_4.



The currents I_1 and I_2 in the resistors are as shown.

Which equation is correct?

A $0 = I_1(R_1 + R_2) + I_2(R_3 + R_4)$

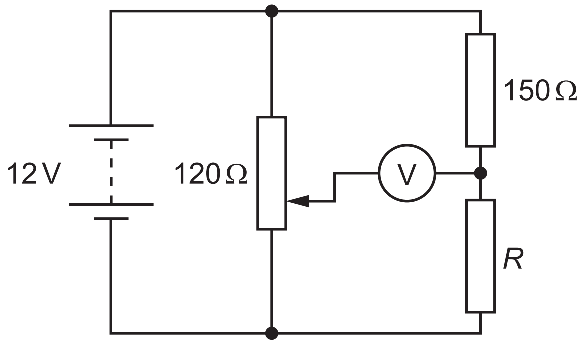
B $0 = I_1(R_1 + R_2) - I_2(R_3 + R_4)$

C $E = I_1(R_1 + R_2) + I_2(R_3 + R_4)$

D $E = I_1(R_1 + R_2) - I_2(R_3 + R_4)$

38 In the circuit shown, a potentiometer of total resistance 120 Ω is connected in parallel with a resistor of resistance 150 Ω and a resistor of resistance R.

The battery has electromotive force (e.m.f.) 12 V and negligible internal resistance.



The voltmeter reads 0 V when the slider of the potentiometer is $\frac{1}{4}$ of the way from its lower end, as shown.

What is resistance R?

A 30 Ω **B** 38 Ω **C** 50 Ω **D** 450 Ω

39 A beam of α-particles is incident on a thin gold foil. One α-particle collides head-on with a gold nucleus and is deflected back along its original path.

Which statement could explain why the recoil speed of the gold nucleus is small compared with the recoil speed of the α-particle?

A Most α-particles are only slightly deflected as they pass through the gold foil.

B The α-particle and the gold nucleus repel each other.

C The mass of the gold nucleus is much greater than the mass of the α-particle.

D The momentum of the α-particle decreases as it approaches the gold nucleus.

40 A hadron is composed of three quarks. The hadron has a charge.

What is a possible quark composition of the hadron?

A down, down, up

B down, up, strange

C up, strange, strange

D up, up, strange

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

6540158902

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

Data

acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$
speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_\mathrm{o} = \dfrac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 Which term represents a physical quantity?

A metre

B percentage uncertainty

C quark flavour

D spring constant

2 Which two units are identical when expressed in terms of SI base units?

A $\mathrm{J\,C^{-1}}$ and $\mathrm{kg\,m^{2}\,A^{-1}\,s^{-2}}$

B $\mathrm{J\,s}$ and $\mathrm{kg\,m^{2}\,s^{-1}}$

C $\mathrm{N\,m}$ and $\mathrm{kg\,m^{3}\,s^{-2}}$

D $\mathrm{N\,s}$ and $\mathrm{kg\,m\,s^{-3}}$

3 A value for the acceleration of free fall on Earth is given as $(10 \pm 2)\,\mathrm{m\,s^{-2}}$.

Which statement is correct?

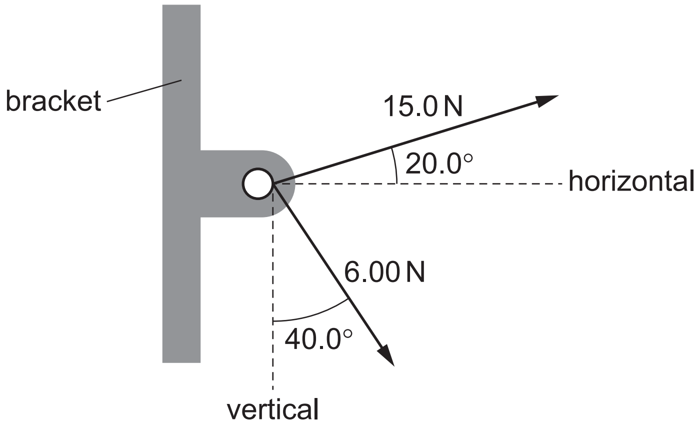
A The value is accurate but not precise.

B The value is both precise and accurate.

C The value is neither precise nor accurate.

D The value is precise but not accurate.

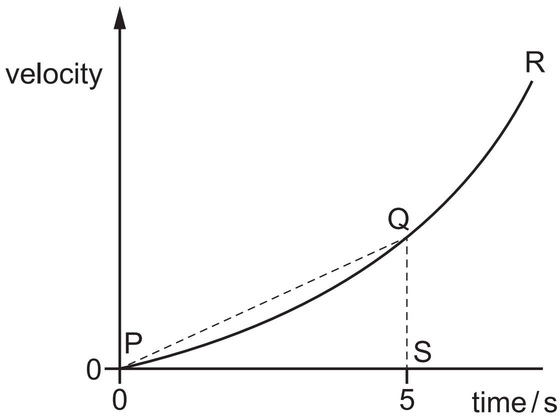
4 Two cables are attached to a bracket and exert forces as shown.



What are the magnitudes of the horizontal and vertical components of the resultant of the two forces?

	horizontal component / N	vertical component / N
A	9.73	0.534
B	9.73	10.2
C	18.0	0.534
D	18.0	10.2

5 The curved line PQR is the velocity–time graph for a car starting from rest.



What is the average acceleration of the car over the first 5 s?

A the area below the curve PQ

B the area of the triangle PQS

C the gradient of the straight line PQ

D the gradient of the tangent at Q

6 A ball is thrown horizontally with a speed of $10.0\,\mathrm{m\,s^{-1}}$ above horizontal ground. The ball hits the ground after a time of 3.0 s.

Air resistance is negligible.

What is the speed of the ball just before it hits the ground?

A $10\,\mathrm{m\,s^{-1}}$ **B** $29\,\mathrm{m\,s^{-1}}$ **C** $31\,\mathrm{m\,s^{-1}}$ **D** $39\,\mathrm{m\,s^{-1}}$

7 An object is moving along the ground in a straight line at a constant speed.

Which statement about the resultant force acting on the object is correct?

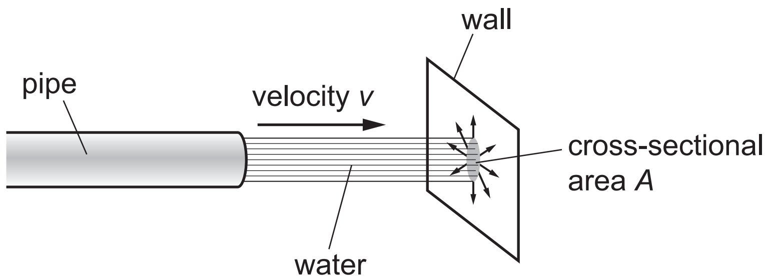
A The resultant force acting on the object is equal to its weight.

B The resultant force acting on the object is equal to the product of its mass and its velocity.

C The resultant force acting on the object is equal to the resistive force.

D The resultant force acting on the object is equal to zero.

8 Water flows out of a pipe and hits a wall.



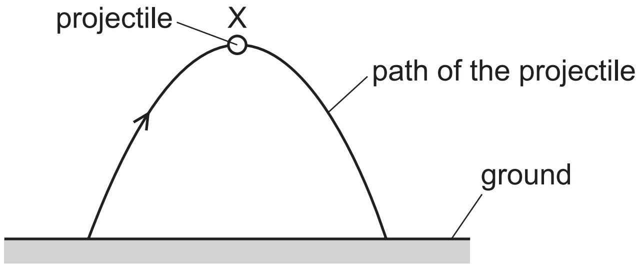
When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.

The density of the water is ρ. The water does not rebound from the wall.

What is the force exerted on the wall by the water?

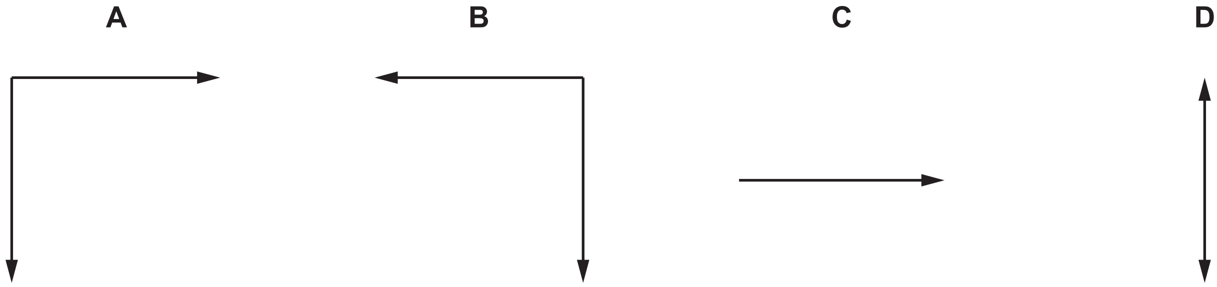
A $\dfrac{\rho v}{A}$ **B** $\dfrac{\rho v^2}{A}$ **C** $\rho A v$ **D** $\rho A v^2$

9 A projectile is launched at an angle above horizontal ground and travels through the air.



The projectile reaches its maximum height at position X. Assume that no upthrust acts on the projectile.

Which diagram shows the **directions** of the force or forces acting on the projectile at position X?



10 What is a statement of the principle of conservation of momentum?

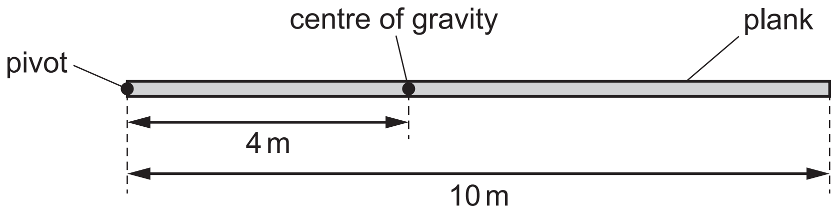
A A force is equal to the rate of change of momentum of the object upon which it acts.

B In a perfectly elastic collision, the relative momentum of the objects before impact is equal to their relative momentum after impact.

C The momentum of an object is the product of the mass of the object and its velocity.

D The total momentum of a system of interacting objects remains constant, providing no resultant external force acts on the system.

11 A horizontal wooden plank is pivoted at one end, as shown.



The plank has a mass of 100 kg and a length of 10 m. The centre of gravity of the plank is a distance of 4 m from the pivot.

What is the moment of the weight of the plank about the pivot?

A 4×10^2 N m **B** 5×10^2 N m **C** 4×10^3 N m **D** 5×10^3 N m

12 When **must** an object be in equilibrium?

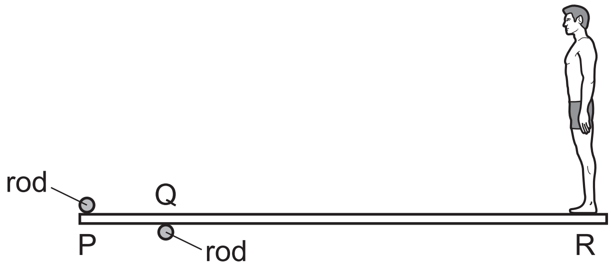
A when no resultant force acts on the object

B when no resultant force and no resultant torque act on the object

C when no resultant torque acts on the object

D when the upward force on the object is equal and opposite to its weight

13 A uniform diving board is held by two fixed rods at points P and Q. A person stands at end R of the diving board, as shown.

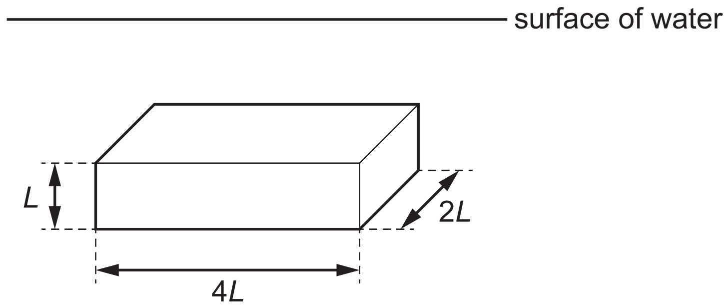


The forces exerted by the rods on the board are vertical. The board remains in equilibrium as the person slowly moves towards point Q from end R.

Which row describes the changes to the magnitudes of the forces exerted by the rods on the board?

	force at P	force at Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

14 A solid block has sides of length L, $2L$ and $4L$. The block is submerged in water of uniform density so that the faces with the largest area are horizontal, as shown.



The upthrust acting on the block is U.

The block is now rotated to a new position so that the faces with the smallest area are horizontal. The block remains fully submerged in the water.

What is the upthrust acting on the block in its new position?

A $\frac{U}{4}$ **B** U **C** $2U$ **D** $4U$

15 In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of:

1200 kg of oil of density 1100 $kg\,m^{-3}$

1500 kg of oil of density 860 $kg\,m^{-3}$

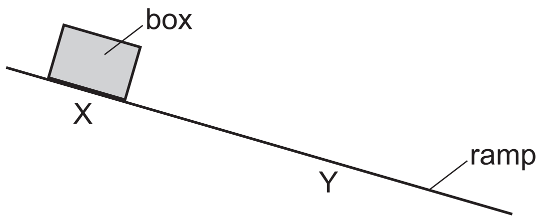
4000 kg of oil of density 910 $kg\,m^{-3}$.

What is the density of the mixture?

A 927 $kg\,m^{-3}$ **B** 933 $kg\,m^{-3}$ **C** 957 $kg\,m^{-3}$ **D** 1045 $kg\,m^{-3}$

16 A box slides down a rough ramp.

The change in the gravitational potential energy of the box is 16 J as it moves between positions X and Y. The box has 24 J of kinetic energy at X and 35 J of kinetic energy at Y.



How much work is done against the frictional force?

A 5 J **B** 19 J **C** 27 J **D** 43 J

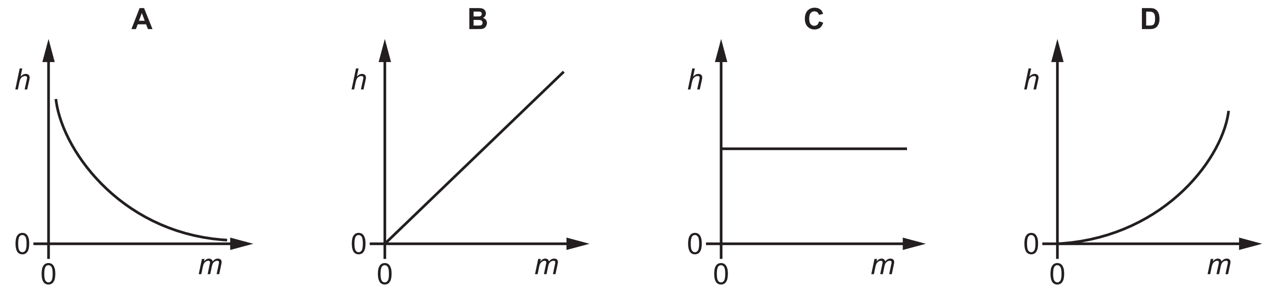
17 The total energy supplied to an electric motor is E. Energy Q is wasted and the remaining energy does useful work.

What is the efficiency of the motor?

A $\dfrac{Q}{E}$ **B** $\left(\dfrac{Q}{E}\right) - 1$ **C** $1 - \left(\dfrac{Q}{E}\right)$ **D** $\dfrac{(1 - Q)}{E}$

18 Objects with different masses are placed on the horizontal surface of a table. The objects are then raised to different heights above the table. The gain in gravitational potential energy of each object is the same.

Which graph best shows the variation of the height h of the objects above the table with their mass m?



19 Two wires, P and Q, are made from the same metal and hang vertically from a steel girder.

Wire Q has half the length and twice the diameter of wire P.

Identical masses are attached to the bottom of each wire. Both wires obey Hooke's law as they are stretched by the weight of the masses.

What is the ratio $\frac{\text{extension of wire P}}{\text{extension of wire Q}}$?

A $\frac{8}{1}$ **B** $\frac{4}{1}$ **C** $\frac{1}{1}$ **D** $\frac{1}{2}$

20 Which statement about elastic and plastic deformation **must** be correct?

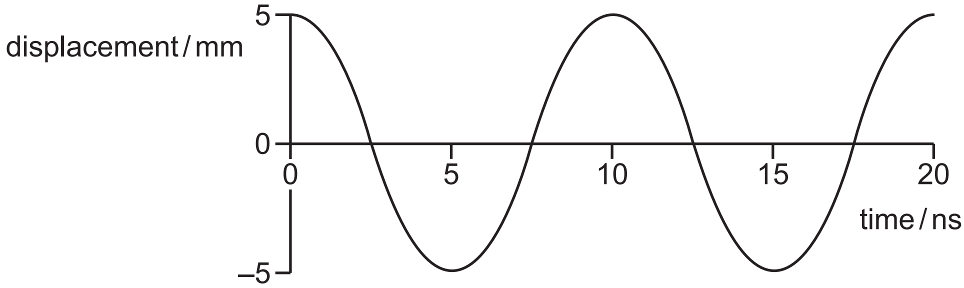
A Elastic deformation and plastic deformation are proportional to the applied force.

B Elastic deformation and plastic deformation cause no change in volume.

C Elastic deformation causes heating of the material but plastic deformation does not.

D Elastic deformation is reversible but plastic deformation is not.

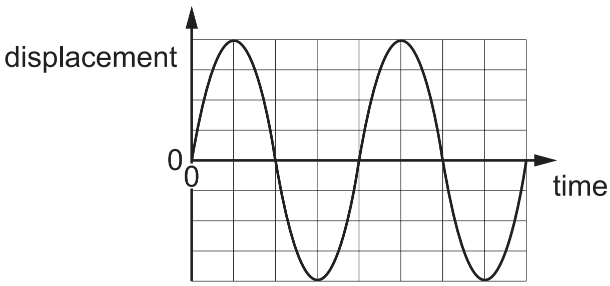
21 The graph shows the variation with time of the displacement of a particle as a progressive wave passes.



What are the frequency and the amplitude of the wave?

	frequency / MHz	amplitude / mm
A	100	5
B	200	5
C	100	10
D	200	10

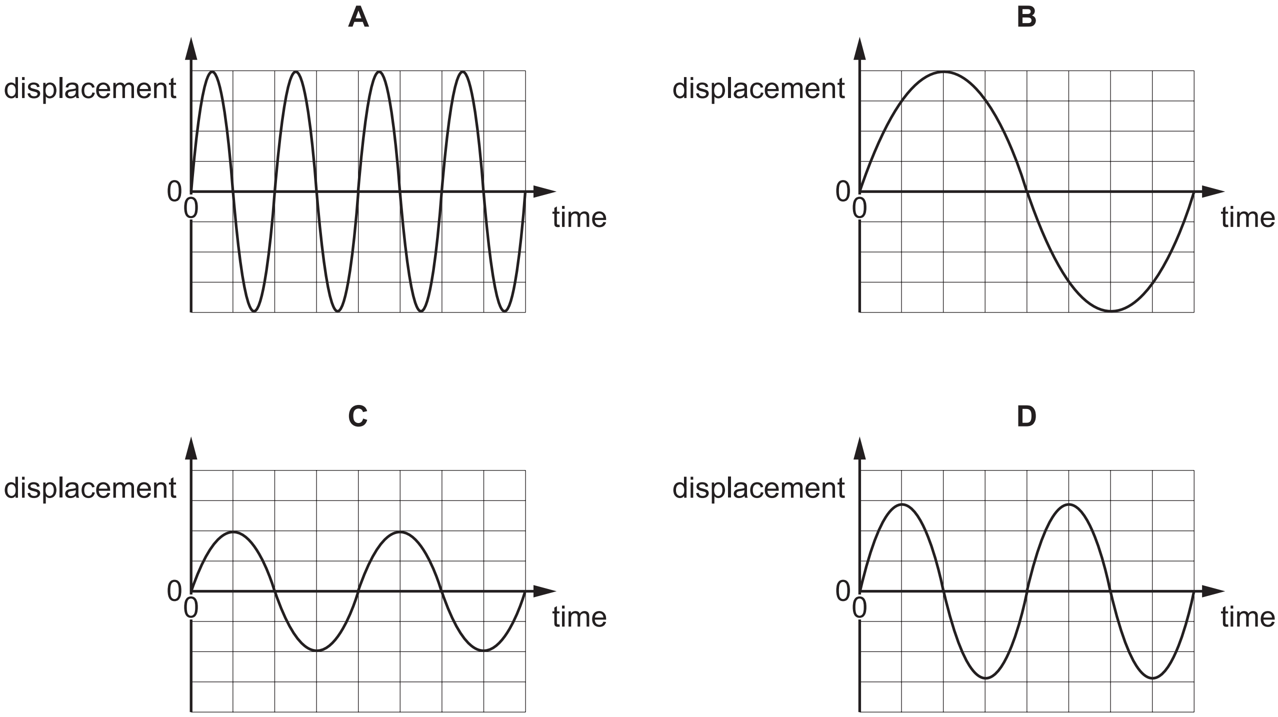
22 The graph shows the variation of the displacement of an air particle with time as a sound wave passes through air.



The intensity of the sound is halved while the frequency remains constant.

The four graphs below are drawn to the same scale as the graph above.

Which graph shows the displacement of the air particle?



23 Which statement is correct?

A Gases cannot transmit longitudinal waves.

B Longitudinal sound waves cannot form stationary waves.

C Solids can transmit both transverse and longitudinal waves.

D Transverse waves cannot pass through a vacuum.

24 A car is travelling at a constant velocity directly towards a man standing in the middle of the road.

The driver sounds the car's horn as a warning. The horn emits a sound wave of constant frequency.

The frequency of the sound heard by the man is different from the frequency of the sound emitted by the horn.

Which statement is correct?

A The frequency of the sound emitted by the horn is greater than the frequency of the sound heard by the man.

B The frequency of the sound heard by the man depends on the distance between the car and the man.

C The sound waves continually accelerate as they move from the horn to the man.

D The wavelength of the sound heard by the man is less than the wavelength of the sound emitted by the horn.

25 Which statement about electromagnetic waves is correct?

A A wave of wavelength 5.0×10^{-6} m is invisible to the human eye.

B They can all travel at different speeds in free space.

C They cannot be polarised.

D They consist of vibrating atoms.

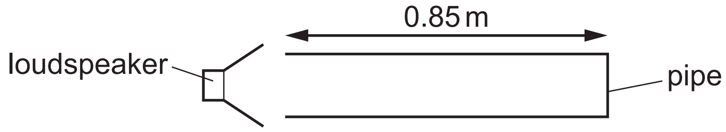
26 A stationary wave is set up on a string that is stretched between two fixed points that are 48 cm apart.

At one instant, the appearance of the string is as shown.

What is the wavelength of the stationary wave?

A 16 cm **B** 32 cm **C** 48 cm **D** 72 cm

27 A pipe, closed at one end, has a loudspeaker at the open end. For some frequencies of sound from the loudspeaker, a stationary sound wave is formed in the air within the pipe with an antinode at the open end of the pipe.



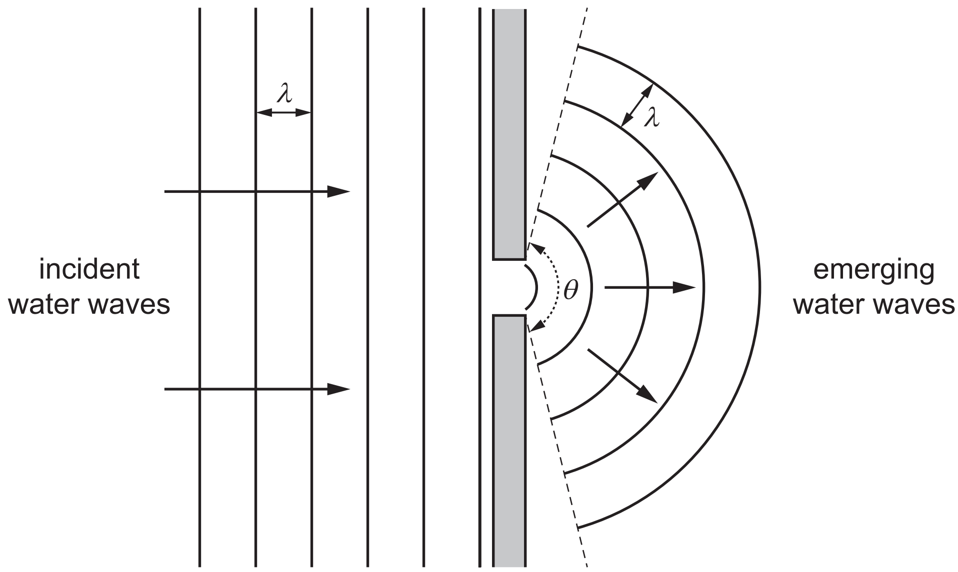
The length of the pipe is 0.85 m.

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

Which frequency of sound from the loudspeaker would **not** produce a stationary wave?

A 100 Hz **B** 200 Hz **C** 300 Hz **D** 500 Hz

28 Water waves of wavelength λ are incident normally on an obstacle with a narrow gap. The width of the gap is equal to λ. The waves from the gap emerge over an angle θ, as shown.



The gap is slowly widened.

Which changes, if any, occur to θ and to the wavelength of the emerging waves?

	θ	wavelength
A	decreases	remains the same
B	increases	remains the same
C	remains the same	decreases
D	remains the same	increases

29 Light of a single frequency passes through two narrow slits and produces an interference pattern on a screen some distance away. The interference fringes are very close together.

Which change would **increase** the distance between the fringes?

A Increase the brightness of the light source.

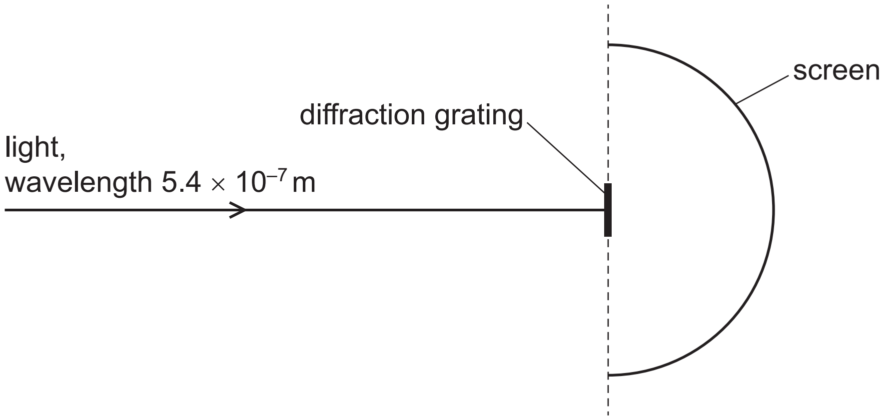
B Increase the distance between the slits and the screen.

C Increase the distance between the two slits.

D Increase the frequency of the light used.

30 Light of wavelength 5.4×10^{-7} m is incident normally on a diffraction grating.

The separation between adjacent lines in the grating is 2.0×10^{-6} m. The light that emerges from the grating falls on a semicircular screen, as shown in the view from above.



VIEW FROM ABOVE

The grating is at the centre of the semicircle, and the lines of the grating are vertical.

How many bright dots are formed on the screen?

A 3 **B** 4 **C** 6 **D** 7

31 A straight copper wire of diameter 0.42×10^{-3} m has a number density of free electrons of 8.5×10^{28} m^{-3}. In a given time interval, a charge of 0.15 C moves through the wire.

What is the average displacement of the free electrons along the wire in this time interval?

A 3.3×10^{-8} m **B** 2.0×10^{-5} m **C** 8.0×10^{-5} m **D** 2.5×10^{-4} m

32 What is the definition of the potential difference (p.d.) across a component?

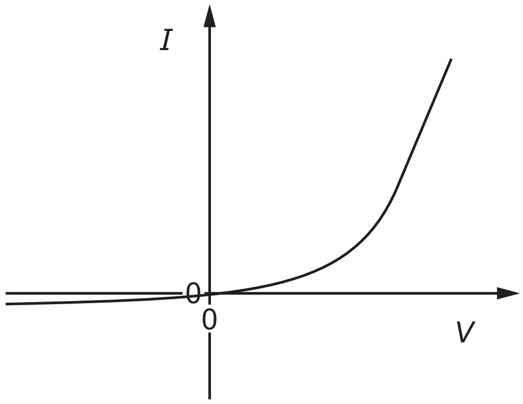
A the electrical power supplied to the component

B the energy transferred to the component per unit charge

C the product of the current in the component and its resistance

D the voltage across the component

33 The graph shows the I–V characteristic for a semiconductor diode.



Which statement can be deduced from the graph?

A Above a certain positive potential difference the diode obeys Ohm's law.

B Current is directly proportional to potential difference when the current in the diode is in one direction.

C The diode has zero resistance when the current in the diode is in one direction.

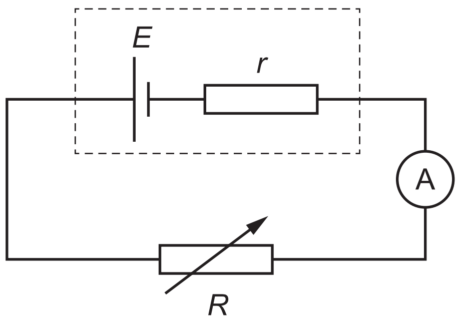
D The resistance of the diode depends upon the potential difference across it.

34 A wire has a resistance of $30\,\Omega$. A second wire is made from the same material, has the same mass and is three times as long as the first wire.

What is the resistance of the second wire?

A $10\,\Omega$ **B** $30\,\Omega$ **C** $90\,\Omega$ **D** $270\,\Omega$

35 A cell has internal resistance r and electromotive force (e.m.f.) E. The cell is connected in series with an ammeter and a variable resistor of resistance R.



When R is $10\,\Omega$ the ammeter reads 0.3 A.

When R is $5\,\Omega$ the ammeter reads 0.4 A.

What is the value of E?

A 0.5 V **B** 2 V **C** 3 V **D** 6 V

36 The sum of the currents entering a junction in an electrical circuit is always equal to the sum of the currents leaving the junction.

Why is this?

A It is a consequence of the conservation of charge.

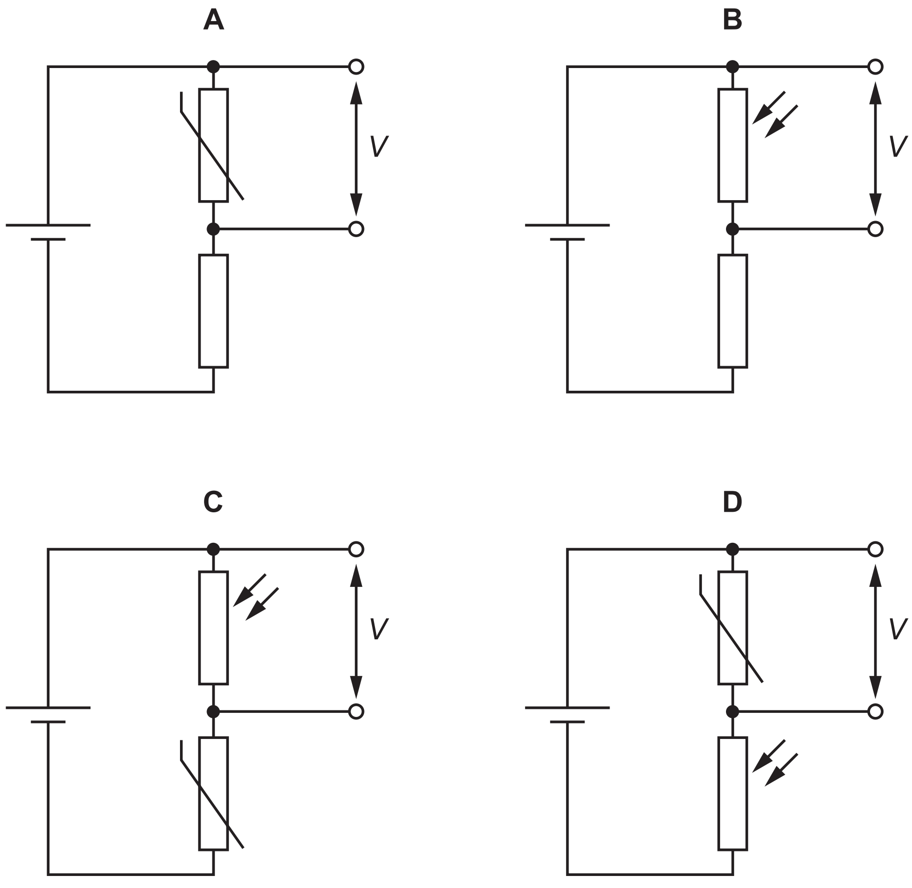
B It is a consequence of the conservation of electromotive force.

C It is a consequence of the conservation of energy.

D It is a consequence of the conservation of potential difference.

37 In the circuits shown, the temperature remains constant.

In which circuit does the potential difference (p.d.) V increase with increasing light intensity?



38 Carbon-14 decays into nitrogen-14 by emitting a β^- particle.

Which statement explains why the β^- particles are emitted with a range of different kinetic energies?

A The carbon-14 nuclei have slightly different masses.

B The emitted β^- particles have a range of different masses.

C The energy released in the decay process is different for each carbon-14 nucleus that decays.

D The energy released in the decay process is shared between the nitrogen-14 nucleus, a β^- particle and an antineutrino.

39 A nucleus of a radioactive element emits an α-particle, then a β^- particle and then another β^- particle.

Which statement describes the final element that is produced?

A It is a different element of higher proton number than the original element.

B It is a different element of lower nucleon number than the original element.

C It is an isotope of the original element.

D It is the same element as the original element but with a different proton number.

40 How many hadrons, baryons and mesons are there in a nucleus of $^{9}_{4}Be$?

	hadrons	baryons	mesons
A	9	4	5
B	9	5	4
C	9	9	0
D	13	9	0

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 3 1 5 4 3 7 5 3 9 2 *

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

IB22 06_9702_12/2RP

Data

acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$
speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_\mathrm{o} = \dfrac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 Which estimate is reasonable?

A 1×10^{-3} kg for the mass of a grain of sand

B 1×10^{-2} m^3 for the volume of a tennis ball

C 1×10^{0} J for the work done lifting an apple from waist height to head height

D 1×10^{4} W for the power of a light bulb in a house

2 What is the symbol for the SI base unit of temperature?

A C **B** K **C** °C **D** °K

3 Which statement about systematic errors is **not** correct?

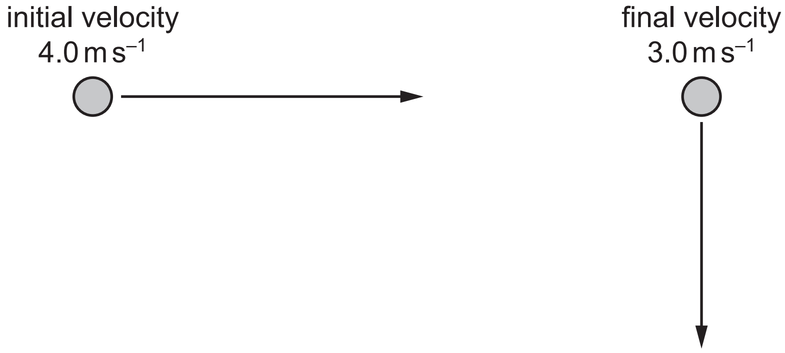
A A systematic error can be caused by using an incorrectly calibrated instrument.

B One particular type of systematic error can affect all the measurements by the same amount.

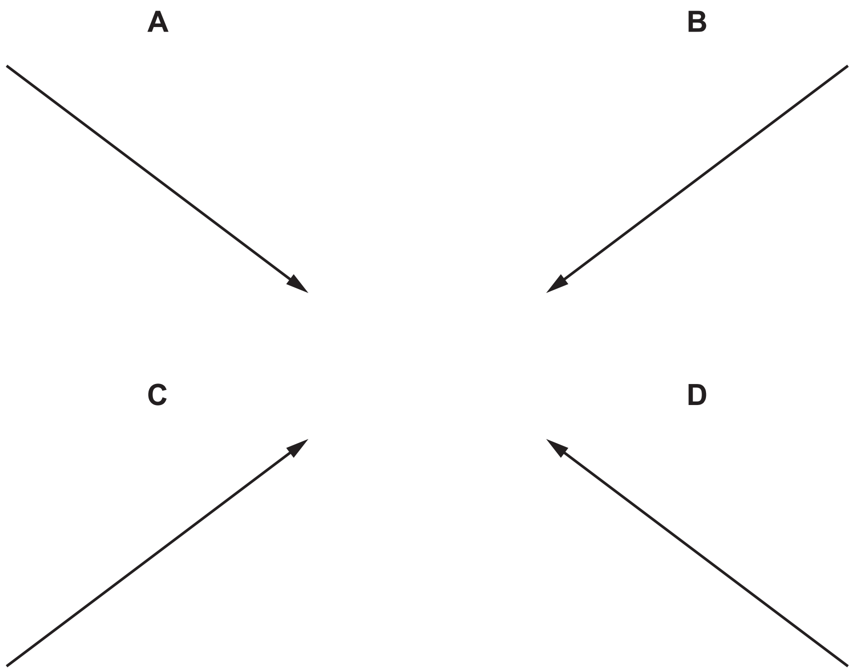
C The effect of a systematic error can be reduced by repeating and averaging the measurements.

D Zero error is a type of systematic error.

4 An object is moving with an initial velocity of $4.0\,\mathrm{m\,s^{-1}}$ to the right. The velocity of the object changes so that its final velocity is $3.0\,\mathrm{m\,s^{-1}}$ downwards, as shown.

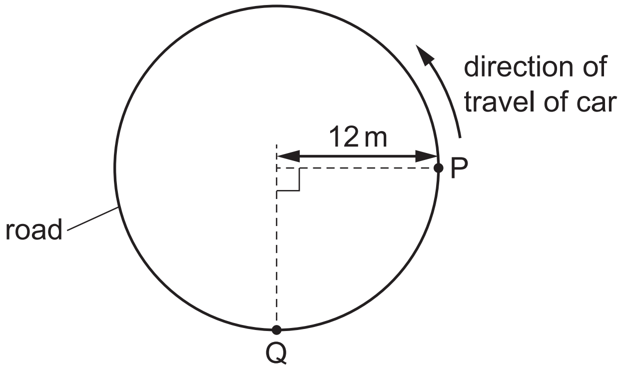


Which arrow represents the change in velocity of the object?



5 A car travels anticlockwise along a horizontal circular road of radius 12 m, as shown.

The car takes a time of 4.0 s to move from position P to position Q.



What is the magnitude of the average velocity of the car for the journey from P to Q?

A $4.2\,\text{m}\,\text{s}^{-1}$ **B** $4.7\,\text{m}\,\text{s}^{-1}$ **C** $6.0\,\text{m}\,\text{s}^{-1}$ **D** $14\,\text{m}\,\text{s}^{-1}$

6 The water surface in a deep well is 78.0 m below the top of the well. A person at the top of the well drops a heavy stone down the well.

Air resistance is negligible. The speed of sound in the air is $330\,\text{m}\,\text{s}^{-1}$.

What is the time interval between the person dropping the stone and hearing it hitting the water?

A 3.75 s **B** 3.99 s **C** 4.19 s **D** 4.22 s

7 Which statement is **not** a requirement of a pair of forces that obey Newton's third law of motion?

A The forces act in opposite directions.

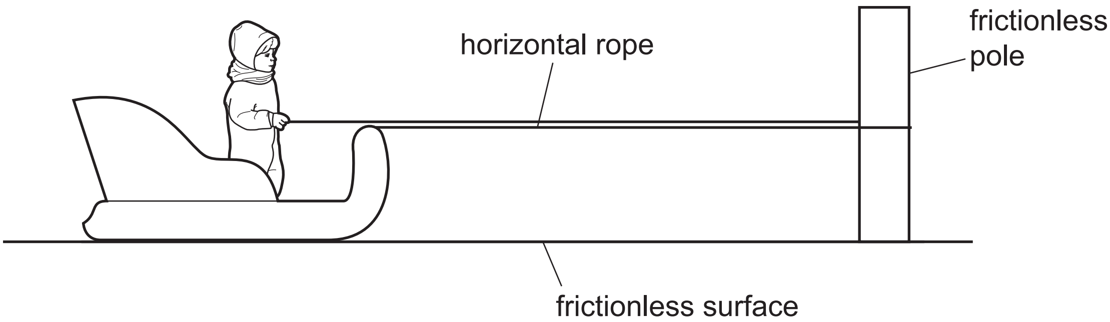
B The forces act on different objects.

C The forces act on objects in contact.

D The forces are of equal magnitude.

8 A child of mass 20 kg stands on the rough surface of a sledge of mass 40 kg. The sledge can slide on a horizontal frictionless surface.

One end of a rope is attached to the sledge. The rope passes around a fixed frictionless pole, and the other end of the rope is held by the child, as shown.



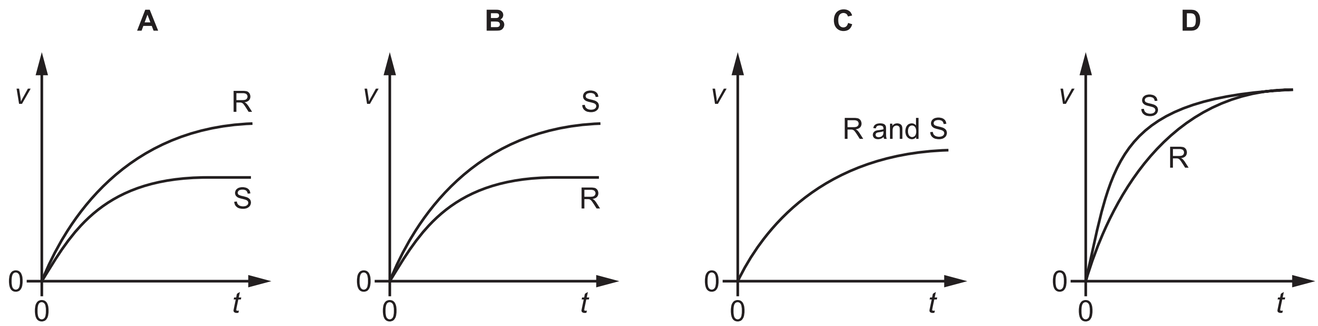
The rope is horizontal. The child pulls on the rope with a horizontal force of 12 N. This causes the child and the sledge to move with equal acceleration towards the pole.

What is the frictional force between the child and the sledge?

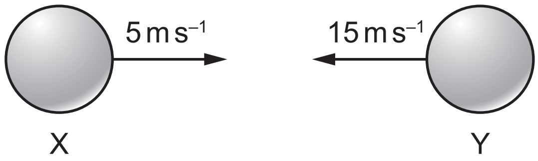
A 4.0 N **B** 6.0 N **C** 8.0 N **D** 12 N

9 A stone S and a foam rubber ball R are identical spheres of equal volume. They are released from rest at time t = 0 and fall vertically through the air. Both reach terminal velocity.

Which graph best shows the variation with time t of the speed v of the stone and of the rubber ball?



10 Two balls X and Y are moving towards each other with speeds of $5\,\mathrm{m\,s^{-1}}$ and $15\,\mathrm{m\,s^{-1}}$ respectively.



They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of $7\,\mathrm{m\,s^{-1}}$.

What is the speed and direction of ball X after the collision?

A $3\,\mathrm{m\,s^{-1}}$ to the left

B $13\,\mathrm{m\,s^{-1}}$ to the left

C $3\,\mathrm{m\,s^{-1}}$ to the right

D $13\,\mathrm{m\,s^{-1}}$ to the right

11 Two forces form a couple.

Which statement describes the two forces?

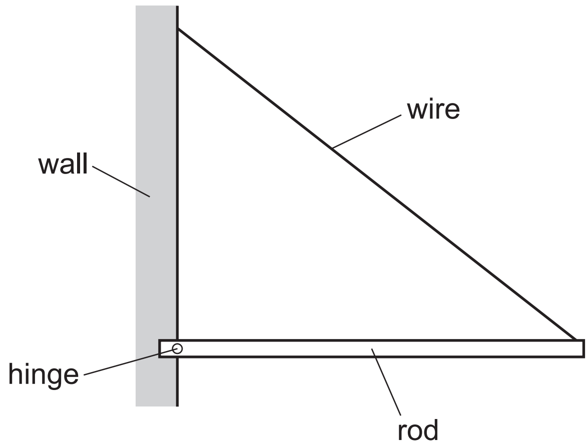
A They are in the same direction.

B They are perpendicular to each other.

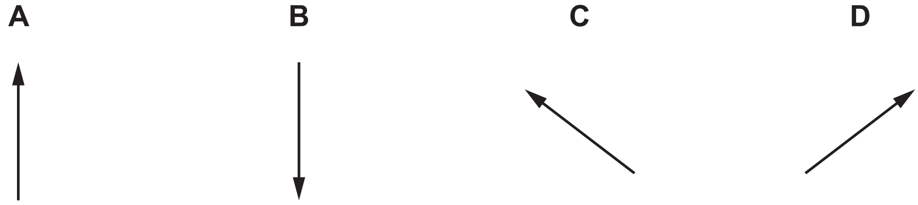
C They have the same magnitude.

D They pass through the same point.

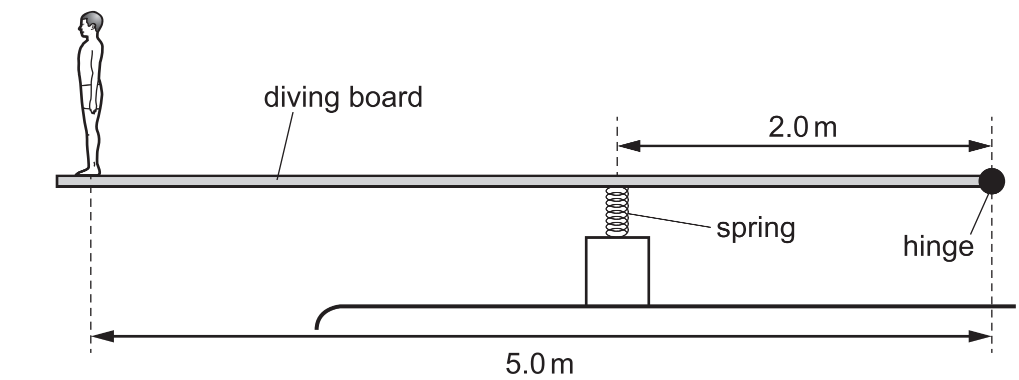
12 A uniform rod is attached by a hinge at one end to a wall. The other end of the rod is supported by a wire so that the rod is horizontal and in equilibrium.



Which arrow shows the direction of the force on the rod from the hinge?



13 A diving board of length 5.0 m is hinged at one end and supported 2.0 m from this end by a spring of spring constant $10\,kN\,m^{-1}$. A child of mass 40 kg stands at the far end of the board.



What is the extra compression of the spring caused by the child standing on the end of the board?

A 1.0 cm **B** 1.6 cm **C** 9.8 cm **D** 16 cm

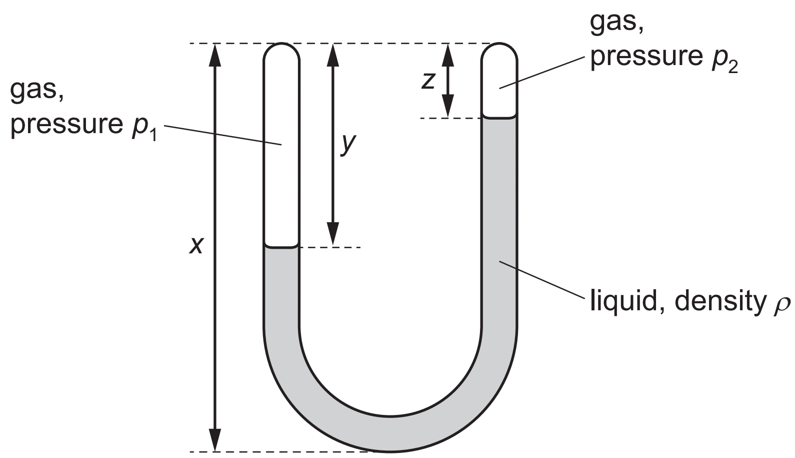
14 A granite rock at the surface of the Earth has density ρ. The rock is transported to the surface of another planet.

The acceleration of free fall on the surface of the other planet is twice that on the surface of the Earth.

What is the density of the rock on the other planet?

A 0.5ρ **B** ρ **C** 2ρ **D** 4ρ

15 A closed U-shaped tube contains a stationary liquid of density ρ. One side of the tube contains a gas at pressure p_1 and the other side contains a gas at pressure p_2, as shown.



The acceleration of free fall is g.

Which equation is correct?

A $p_1 = \rho gy$

B $p_2 = \rho g(x - z)$

C $p_1 - p_2 = \rho g(y - z)$

D $p_1 + p_2 = \rho gx$

16 Which product of two quantities is equal to power?

A force × distance

B force × velocity

C work done × time

D work done × velocity

17 Researchers have developed a new type of filament lamp with an efficiency of 40%. Old-type filament lamps have an efficiency of 5.0%. The two types of lamp produce the same useful output power.

What is the ratio $\dfrac{\text{input power to new type of lamp}}{\text{input power to old type of lamp}}$?

A 0.13 **B** 0.63 **C** 1.6 **D** 8.0

18 A student attempts to derive the formula for kinetic energy E_K. She begins by considering an object of mass m which is initially at rest. A constant force F applied to the object causes it to accelerate to final velocity v in displacement s. The kinetic energy gained by the object is equal to the work done on the object by the force F.

Which equation would the student **not** need in order to derive the formula for E_K?

A $F = ma$ **B** $W = Fs$ **C** $E = \frac{1}{2}Fs$ **D** $v^2 = u^2 + 2as$

19 A metal wire obeys Hooke's law and has a Young modulus of 2.0×10^{11} Pa. The wire has an original length of 1.6 m and a diameter of 0.48×10^{-3} m.

What is the spring constant of the wire?

A $7.2 \times 10^{3}\,\mathrm{N\,m^{-1}}$

B $2.3 \times 10^{4}\,\mathrm{N\,m^{-1}}$

C $2.9 \times 10^{4}\,\mathrm{N\,m^{-1}}$

D $9.0 \times 10^{4}\,\mathrm{N\,m^{-1}}$

20 A wire is being stretched by a tensile force.

Which statement about the elastic limit **must** be correct?

A The deformation is plastic after the elastic limit has been reached.

B The deformation is plastic until the elastic limit is reached.

C The extension is proportional to the tensile force after the elastic limit has been reached.

D The extension is proportional to the tensile force until the elastic limit is reached.

21 Which statement is correct for **all** types of progressive wave?

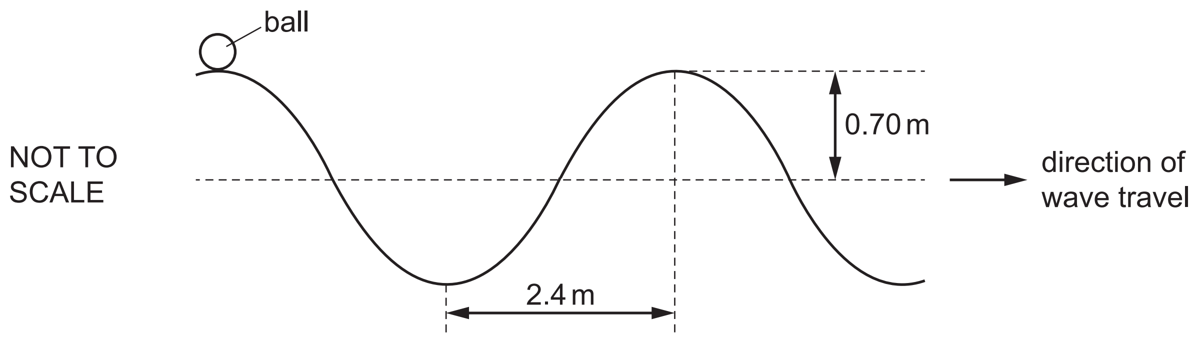
A The distance from a peak to the next trough is equal to a wavelength.

B They can be demonstrated in ripple tanks.

C They consist of vibrating atoms.

D They transfer energy from one position to another.

22 A transverse water wave is moving along the surface of some water. This causes a ball to move vertically without moving horizontally as it floats upon the surface. At one instant, the ball is at the position shown.



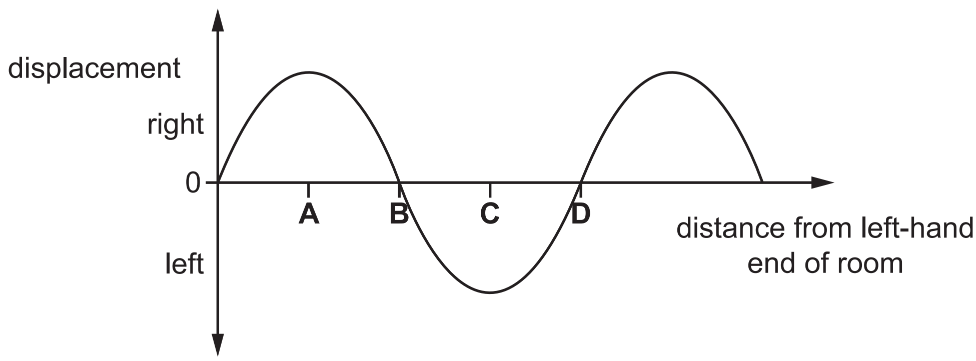
The wave has a frequency of 0.20 Hz and an amplitude of 0.70 m. The distance between a trough and an adjacent peak is 2.4 m.

What is the distance travelled by the ball in a time of 20 s?

A 5.6 m **B** 9.6 m **C** 11.2 m **D** 19.2 m

23 A sound wave travels from left to right across a room. The variation with distance across the room of the displacement of the air molecules at one instant is shown.

At which distance will the air pressure be lowest?



24 A source emits a sound wave of a single frequency. The Doppler effect causes a different frequency of sound to be heard by a stationary observer.

What is a requirement for the Doppler effect to occur?

A a source that is moving as it produces the sound wave

B a source that produces a polarised sound wave

C a source that produces a sound wave of changing amplitude

D a source that produces a sound wave of changing frequency

25 An electromagnetic wave in free space has a frequency of 2.5×10^{14} Hz.

Which region of the electromagnetic spectrum includes this frequency?

A infrared

B microwave

C ultraviolet

D X-ray

26 Two polarising filters are placed next to each other so that their planes are parallel.

The first polarising filter has its transmission axis at an angle of 50° to the vertical.

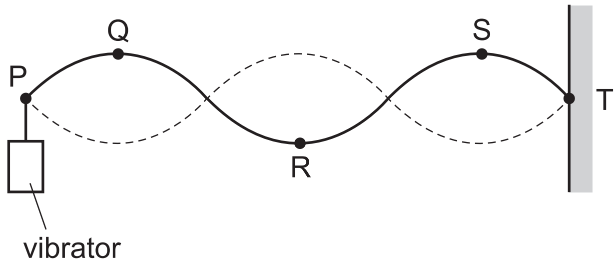
The second polarising filter has its transmission axis at an angle of 20° to the vertical. The angle between the transmission axes of the two polarising filters is 30°.

A beam of vertically polarised light of intensity $8.0\,\mathrm{W\,m^{-2}}$ is incident normally on the first polarising filter.

What is the intensity of the light that is transmitted from the second polarising filter?

A zero **B** $2.5\,\mathrm{W\,m^{-2}}$ **C** $2.9\,\mathrm{W\,m^{-2}}$ **D** $6.0\,\mathrm{W\,m^{-2}}$

27 A stationary wave on a stretched string is set up between two points P and T.



Which statement about the stationary wave is correct?

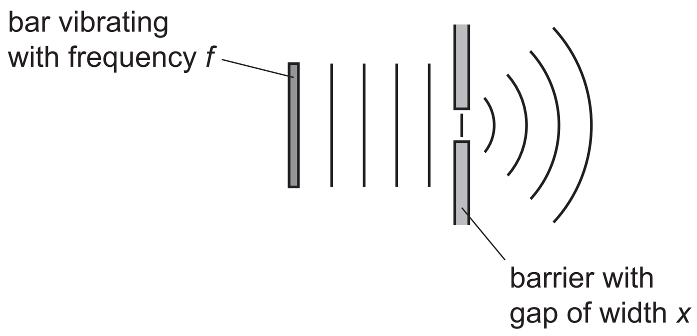
A Point R is at a node.

B Points Q and S vibrate in phase.

C The distance between P and T is three wavelengths.

D The wave transfers energy from P to T.

28 A bar vibrates with frequency *f* to produce water waves in a ripple tank.



The waves pass through a gap of width *x* in a barrier so that diffraction occurs.

Which combination of vibration frequency and gap width will produce the smallest angle of diffraction?

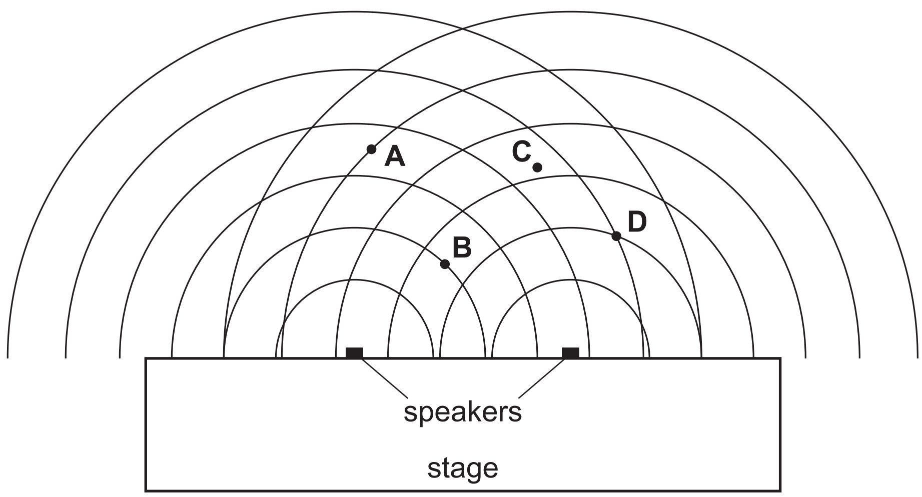
	vibration frequency	gap width
A	$\frac{f}{2}$	$\frac{x}{2}$
B	$\frac{f}{2}$	$2x$
C	$2f$	$\frac{x}{2}$
D	$2f$	$2x$

29 An outdoor concert has two large speakers beside the stage for broadcasting music.

In order to test the speakers, they are made to emit sound of the same wavelength and the same amplitude.

The curved lines in the diagram represent wavefronts.

Where is the loudest sound heard?



30 The equation

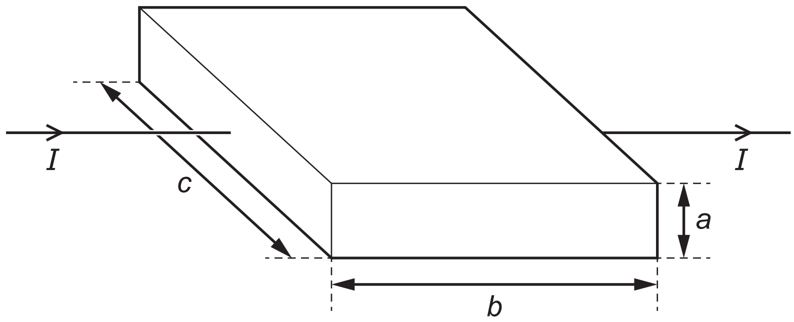
$$\lambda = \frac{d \sin\theta}{n}$$

is used to calculate the wavelength λ of light in an experiment that uses a diffraction grating. The light from the diffraction grating is displayed on a screen.

What do the symbols n and d represent?

	n	d
A	number of slits in the grating	distance between adjacent slits in the grating
B	number of slits in the grating	distance from grating to screen
C	order of intensity maximum	distance between adjacent slits in the grating
D	order of intensity maximum	distance from grating to screen

31 The diagram shows a metal block.

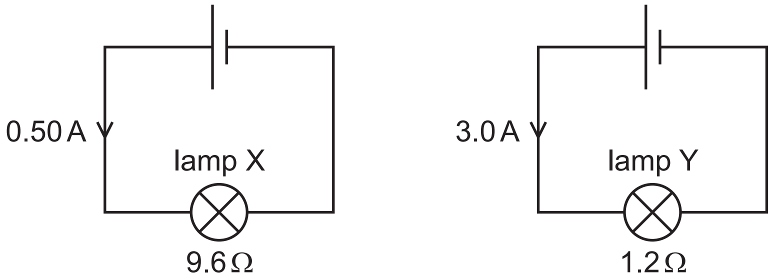


The block has sides of length a, b and c as shown, and its volume is V. Each charge carrier has a charge $-q$ and the number density of the charge carriers in the metal is n. It takes each charge carrier an average time of t to pass through the block.

What is an expression for the current I?

A $I = nqabc$ **B** $I = \frac{nqV}{t}$ **C** $I = \frac{nqbc}{t}$ **D** $I = nqaV$

32 The circuit diagrams show two lamps X and Y each connected to a cell. The current in lamp X is 0.50 A and its resistance is 9.6 Ω. The current in lamp Y is 3.0 A and its resistance is 1.2 Ω.



What is the ratio $\dfrac{\text{power in lamp X}}{\text{power in lamp Y}}$?

A 0.22 **B** 0.75 **C** 1.3 **D** 4.5

33 The intensity of light incident on a light-dependent resistor (LDR) is increased. The temperature of a thermistor is increased. In each case, the current in the component is maintained at a constant value.

What happens to the potential difference across each component?

	LDR	thermistor
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

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 $\dfrac{R}{16}$ **B** $\dfrac{R}{8}$ **C** $\dfrac{R}{2}$ **D** R

35 A cell with constant electromotive force (e.m.f.) is connected across a fixed resistor. Over time, the internal resistance of the cell increases.

Which change occurs as the internal resistance of the cell increases?

A a decrease in the charge of each charge carrier

B a decrease in the potential difference measured across the cell

C an increase in the energy dissipated per unit time in the fixed resistor

D an increase in the number of charge carriers leaving the cell per unit time

36 Kirchhoff's first and second laws are consequences of the conservation of different quantities.

What are those quantities?

	Kirchhoff's first law	Kirchhoff's second law
A	charge	energy
B	energy	current
C	current	charge
D	energy	charge

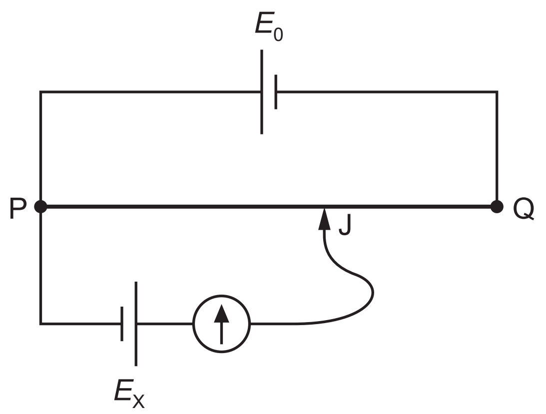
37 A potentiometer circuit is used to determine the electromotive force (e.m.f.) E_X of a cell. The circuit includes a second cell of known e.m.f. E_0 and negligible internal resistance, and a uniform resistance wire PQ of known length.

E_X is less than E_0.

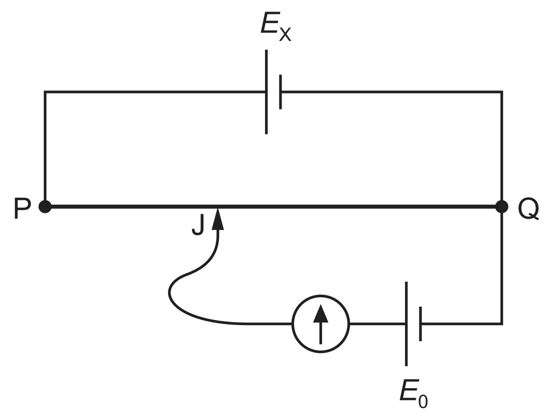
The movable connection J can be positioned anywhere along the length of the resistance wire.

Which circuit is suitable for determining E_X?

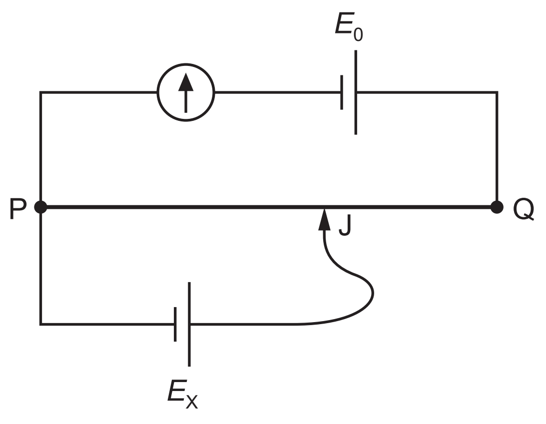
A



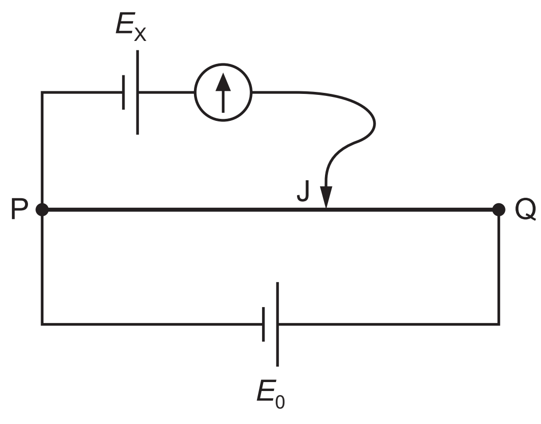
B



C



D



38 In an experiment on α-particle scattering, α-particles are directed at a thin gold foil. Most of the α-particles pass straight through the foil or are deflected by a small angle. A small number of α-particles are deflected by a large angle.

Which statement **cannot** be deduced from this experiment?

A Atoms are mostly empty space.

B Most of the mass of an atom is concentrated in the nucleus.

C The nucleus of an atom contains protons.

D The nucleus of an atom is small compared to the size of an atom.

39 Four nuclei are represented below.

$$^{28}_{14}\text{E} \quad ^{25}_{15}\text{G} \quad ^{25}_{12}\text{M} \quad ^{24}_{13}\text{Q}$$

Which statement about these nuclei is correct?

A An uncharged atom of element Q has 24 orbital electrons.

B Nuclei G and M are isotopes of the same element.

C When E absorbs a neutron and then emits an α-particle, E transforms into M.

D When M emits a β^- particle, M transforms into Q.

40 A neutron is composed of one up (u) quark and two down (d) quarks. When a neutron decays to a proton, a beta-particle is emitted.

What is the change in the quark structure of the neutron due to the emission of the beta-particle?

(The symbol for a neutrino is ν_e and for an antineutrino is $\overline{\nu_e}$.)

A $d \rightarrow u + \beta^- + \nu_e$

B $d \rightarrow u + \beta^- + \overline{\nu_e}$

C $u \rightarrow d + \beta^+ + \nu_e$

D $u \rightarrow d + \beta^+ + \overline{\nu_e}$

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

8903615403

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.
- Any rough working should be done on this question paper.

This document has **20** pages.

Data

acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$
speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of proton	$m_{\mathrm{p}} = 1.67 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_{\mathrm{e}} = 9.11 \times 10^{-31}\,\mathrm{kg}$
Avogadro constant	$N_{\mathrm{A}} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_{\mathrm{o}} = \dfrac{f_{\mathrm{s}} v}{v \pm v_{\mathrm{s}}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 Which pair of quantities are physical quantities?

A charge and ampere

B efficiency and kilogram

C pascal and strain

D period and potential difference

2 Which list of unit prefixes decreases in magnitude from left to right?

A centi, deci, milli

B deci, milli, centi

C pico, kilo, milli

D kilo, milli, pico

3 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. C_d is given by the equation

$$C_d = \frac{2F}{v^n \rho A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n?

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

4 A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The measurement of the diameter is 5.00 mm ± 0.01 mm.

What is the percentage uncertainty in the calculated volume of the sphere, using these values?

A 0.2% **B** 0.4% **C** 0.6% **D** 1.2%

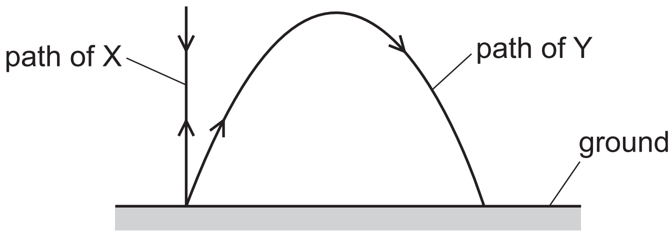
5 Forces of magnitudes 2 N, 4 N and 7 N combine to produce a resultant force.

The magnitudes of the three forces are fixed, but the forces may act in any direction in the same plane.

What is **not** a possible magnitude of the resultant force?

A 0 N **B** 5 N **C** 8 N **D** 13 N

6 Two projectiles, X and Y, are fired into the air from the same place on level ground and reach the same maximum height, as shown.



Projectile X is fired vertically upwards and projectile Y is fired at an angle to the horizontal.

Air resistance is negligible.

Which statement is correct?

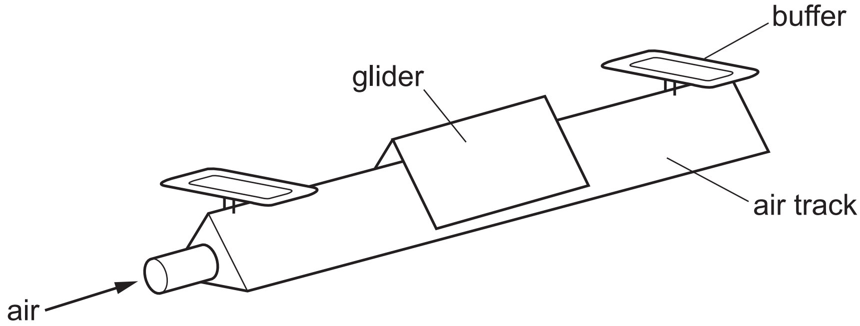
A X and Y are at rest at their maximum heights.

B X and Y are fired with the same speed.

C X and Y take the same time to return to the ground.

D X and Y travel the same distance.

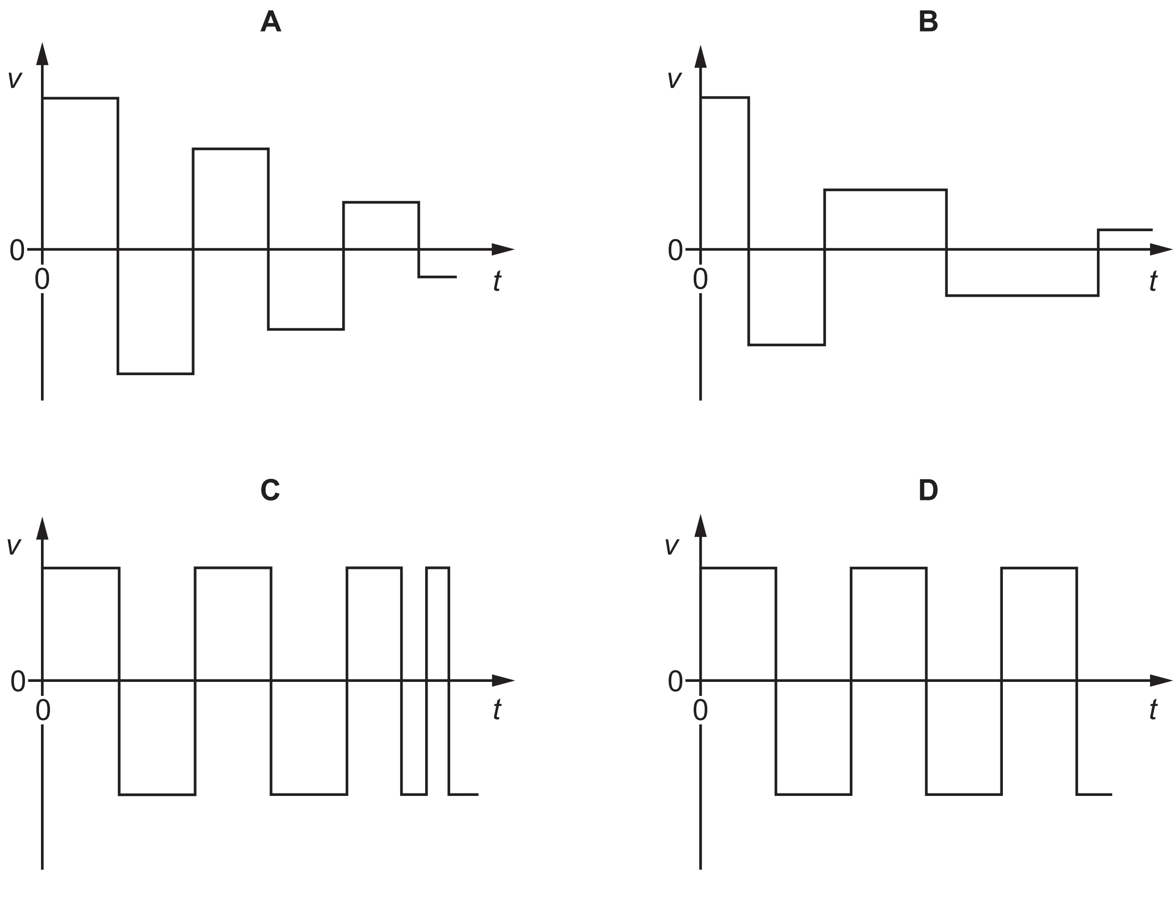
7 A small glider moves along a horizontal air track as shown.



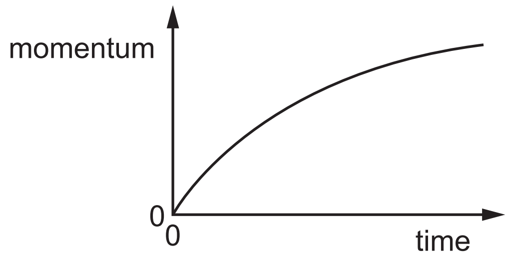
At each end of the air track, the glider has a perfectly elastic collision with a fixed buffer.

The glider moves at a constant speed between collisions.

Which graph represents the variation with time *t* of the velocity *v* of the glider as it moves between the two buffers?



8 A car accelerates from rest. The graph shows the variation of the momentum of the car with time.



What is the meaning of the gradient of the graph at a particular time?

A the kinetic energy of the car

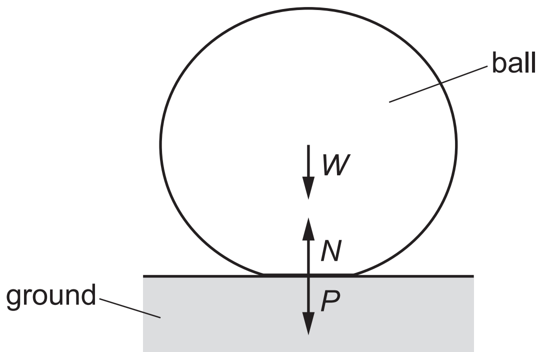
B the rate of change of kinetic energy of the car

C the resultant force on the car

D the velocity of the car

9 A ball is dropped onto horizontal ground and bounces vertically upwards. When the ball is in contact with the ground, the following forces act:

- the weight W of the ball
- the contact force P exerted on the ground by the ball
- the contact force N exerted on the ball by the ground.



When the ball is in contact with the ground, the ball is momentarily stationary.

At this instant, which relationship is correct?

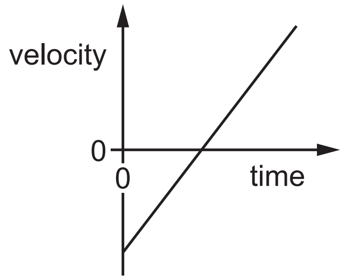
A $N = P + W$ **B** $N > P + W$ **C** $N = W$ **D** $N > W$

10 A person stands on the edge of a high cliff that is next to the sea. The person throws a stone vertically upwards. Air resistance acts on the stone.

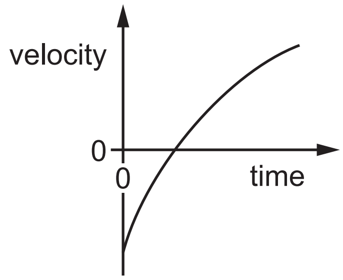
The stone eventually hits the sea.

Which velocity–time graph best shows the motion of the stone from when it is released until it hits the sea?

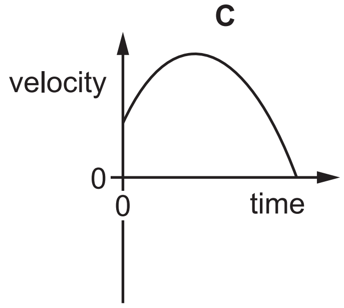
A



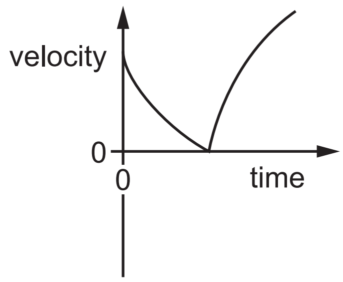
B



C



D



11 Skaters of masses 80 kg and 40 kg move directly towards each other and collide.

Before the collision, the heavier skater is moving to the right at a speed of $2.0\,\mathrm{m\,s^{-1}}$ and the lighter skater is moving to the left at a speed of $1.0\,\mathrm{m\,s^{-1}}$.

After the collision, the heavier skater moves to the right at a speed of $0.80\,\mathrm{m\,s^{-1}}$.

What is the relative speed of separation of the two skaters?

A $0.6\,\mathrm{m\,s^{-1}}$ **B** $1.4\,\mathrm{m\,s^{-1}}$ **C** $2.2\,\mathrm{m\,s^{-1}}$ **D** $2.6\,\mathrm{m\,s^{-1}}$

12 Which statement describes the two forces in a couple?

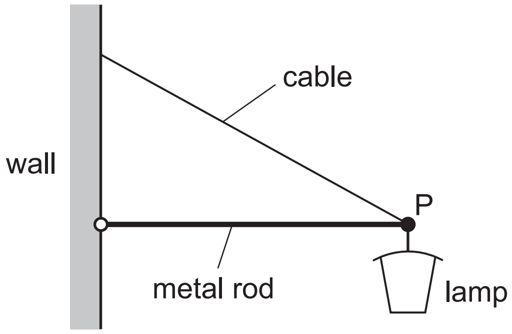
A They act in the same direction.

B They act through the same point.

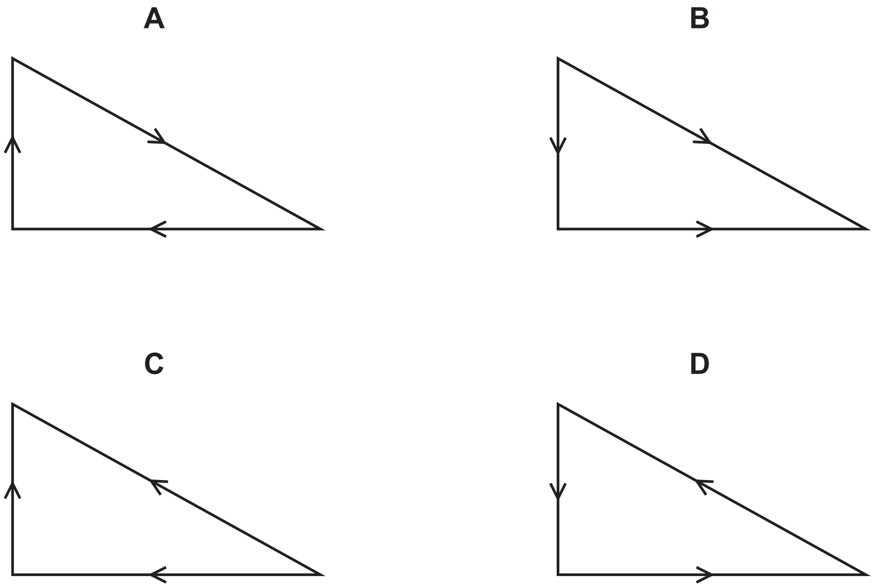
C They produce zero resultant force.

D They produce zero resultant moment.

13 A street lamp is fixed to a wall by a metal rod and a cable.

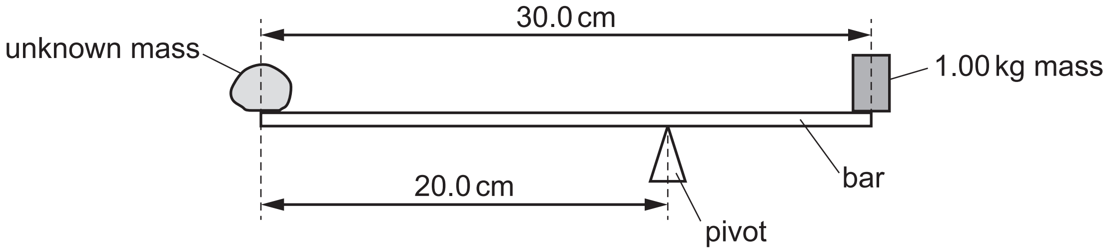


Which vector triangle could represent the forces acting on the end of the rod at point P?



14 An unknown mass and a 1.00 kg mass are fixed at opposite ends of a bar. The bar has negligible mass and a length of 30.0 cm.

The bar balances when supported by a pivot placed 20.0 cm from the unknown mass, as shown.

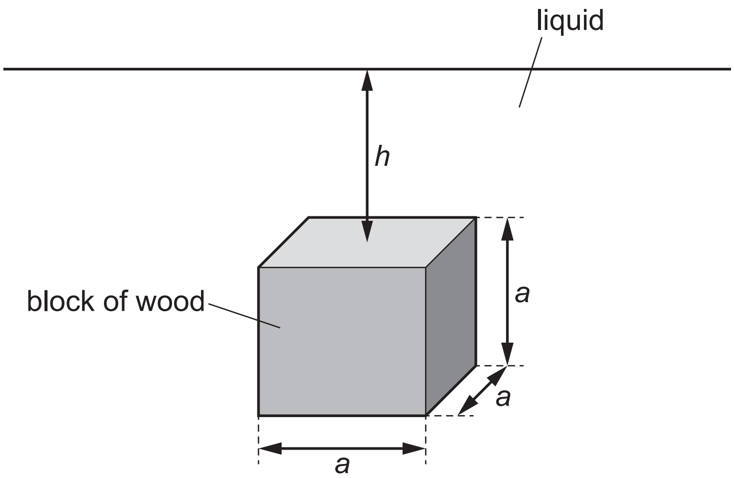


What is the unknown mass?

A 333 g **B** 500 g **C** 667 g **D** 1000 g

15 A block of wood of density ρ_w has sides of length a.

The block is immersed in a liquid of density ρ_L. The top surface of the block is at a depth h below the surface of the liquid.



The acceleration of free fall is g.

What is the upthrust acting on the block from the liquid?

A $\rho_L a^3 g$ **B** $\rho_w a^3 g$ **C** $\rho_L hg$ **D** $\rho_L ag$

16 A technical article about diesel engines expresses the energy available from diesel fuel both as $41.8\,\text{MJ}\,\text{kg}^{-1}$ and as $34.9\,\text{GJ}\,\text{m}^{-3}$.

What is the density of diesel fuel?

A $8.35 \times 10^2\,\text{kg}\,\text{m}^{-3}$

B $1.20 \times 10^3\,\text{kg}\,\text{m}^{-3}$

C $8.35 \times 10^5\,\text{kg}\,\text{m}^{-3}$

D $1.20 \times 10^6\,\text{kg}\,\text{m}^{-3}$

17 What is meant by the efficiency of a system?

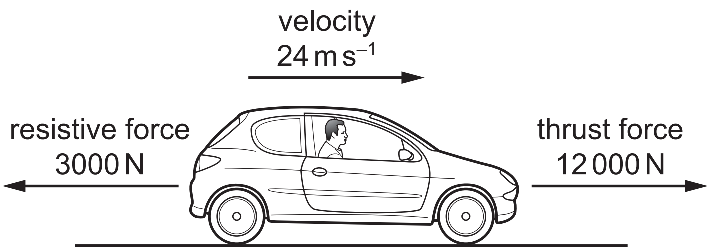
A the difference between the useful energy output from the system and the total energy input

B the difference between the useful energy output from the system and the wasted energy output

C the ratio of the useful energy output from the system to the total energy input

D the ratio of the useful energy output from the system to the wasted energy output

18 A car of weight 15 000 N is travelling along a horizontal road.

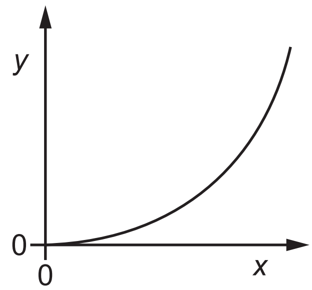


At one instant, the thrust force acting on the car from the engine is 12 000 N and the resistive force acting on the car is 3000 N. The velocity of the car at this instant is $24\,m\,s^{-1}$.

What is the power output from the engine?

A 72 kW **B** 220 kW **C** 290 kW **D** 360 kW

19 The diagram shows the variation of a quantity *y* with a quantity *x* for objects in a uniform gravitational field.



What could *x* and *y* represent?

	x	*y*
A	mass for different objects moving at the same speed	kinetic energy
B	speed for an object of constant mass	kinetic energy
C	vertical distance fallen for an object of constant mass	change of gravitational potential energy
D	mass for different objects falling the same vertical distance	change of gravitational potential energy

20 A steel wire has a length of 300 cm and a cross-sectional area of $0.50\,mm^2$. The Young modulus of steel is 2.0×10^{11} Pa.

One end of the wire is attached to a fixed point. A load of 10 N is hung from the other end. The wire obeys Hooke's law.

What is the extension of the wire?

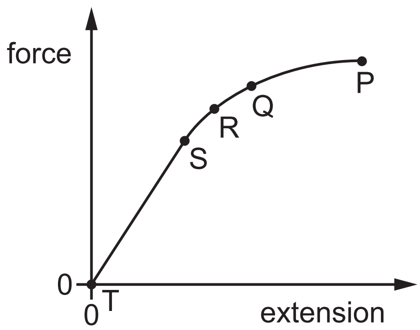
A 3.0×10^{-7} m

B 3.0×10^{-5} m

C 3.0×10^{-4} m

D 3.0×10^{-2} m

21 The extension of a copper wire is measured for different forces applied to the wire. A graph is plotted to show the variation of the force on the wire against extension. The maximum force is applied at point P.



Which statement **must** be correct?

A Point R is the limit of proportionality.

B The elastic potential energy of the wire at point S is given by the area under the graph between points T and S.

C There is no plastic deformation between points Q and P.

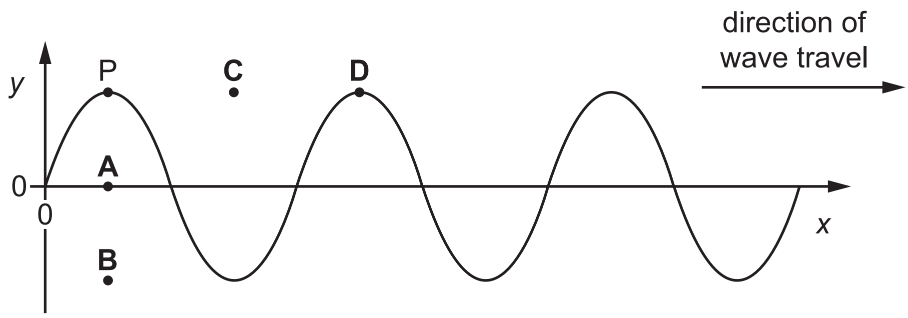
D The wire obeys Hooke's law up to a point between R and Q.

22 The variation with distance x of the displacement y of a transverse wave on a rope is shown at time $t = 0$.

The wave has a frequency of 0.5 Hz.

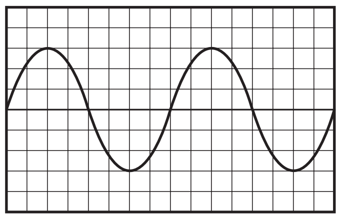
A point P on the rope is marked. The diagram shows the original position of P and four new positions.

What is the position of P at time $t = 1$ s?



23 A cathode-ray oscilloscope (CRO) is connected to a microphone which detects sound of constant frequency.

The trace on the screen of the CRO is shown.



Which property of the sound wave is measured using **only** information from the CRO?

A amplitude

B period

C speed

D wavelength

24 A transverse wave and a longitudinal wave both travel in the same direction down a long stretched spring.

Which statement is **not** correct for these two forms of wave?

A The displacement measurements for the particles of the two waves are made at right angles to each other.

B The energy transferred by the two waves is in the same direction.

C The velocities of the two waves are in the same direction.

D The wavelength measurements for the two waves are made at right angles to each other.

25 A man standing next to a stationary train hears sound of frequency 400 Hz emitted from the train's horn. The train then moves directly away from the man and sounds its horn when it has a speed of $50\,\mathrm{m\,s^{-1}}$. The speed of sound in the air is $340\,\mathrm{m\,s^{-1}}$.

What is the difference in frequency of the sound heard by the man on the two occasions?

A 51 Hz **B** 69 Hz **C** 350 Hz **D** 470 Hz

26 Which list of regions of the electromagnetic spectrum is in order of increasing wavelength from left to right?

A gamma-ray → ultraviolet → infrared

B infrared → microwave → ultraviolet

C microwave → X-ray → infrared

D X-ray → ultraviolet → gamma-ray

27 The principle of superposition states that a certain quantity is added when two or more waves meet at a point.

What is this quantity?

A amplitude

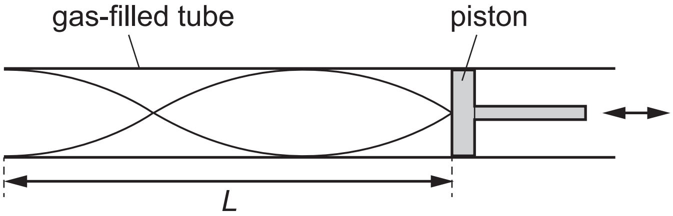
B displacement

C intensity

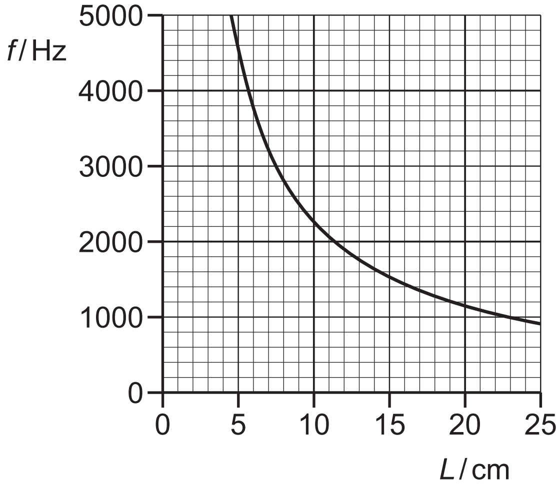
D wavelength

28 A stationary sound wave is formed in a gas-filled tube of length L, which is closed at one end by a piston. The length of the tube can be altered by moving the piston.

The length of the tube and the frequency of the sound are varied so that the stationary wave always has two antinodes and two nodes, as shown.



The graph shows the variation of the frequency f of the stationary sound wave with the length L of the tube.

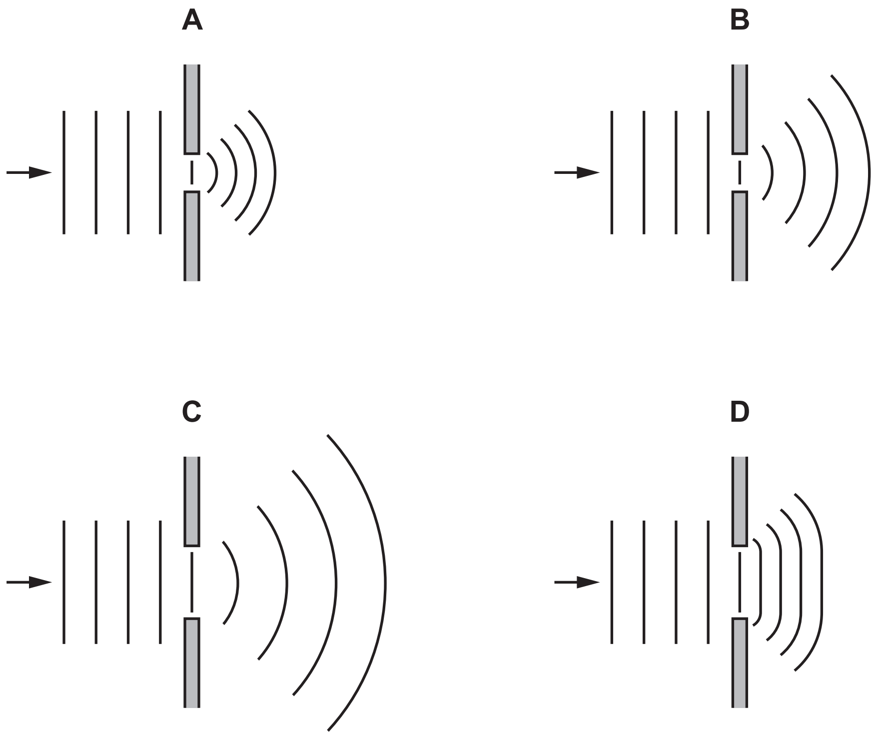


What is the speed of sound in the gas in the tube?

A $150\,\mathrm{m\,s^{-1}}$ **B** $230\,\mathrm{m\,s^{-1}}$ **C** $300\,\mathrm{m\,s^{-1}}$ **D** $340\,\mathrm{m\,s^{-1}}$

29 The diagrams show the diffraction of water waves in a ripple tank as they pass through a gap between two barriers.

Which diagram is correct?



30 A beam of light from a laser is incident normally on a double slit. Interference fringes are seen on a screen placed parallel to the double slit.

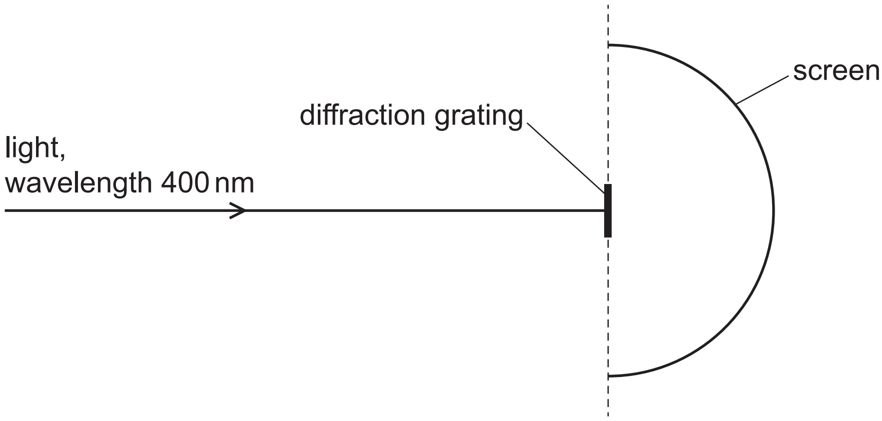
The separation of the two slits is a. The distance between the slits and the screen is D. The distance between the centres of two adjacent bright fringes is x.

D and a are both halved.

What is the distance between the centres of two adjacent bright fringes after these changes?

A $\frac{x}{2}$ **B** x **C** $2x$ **D** $4x$

31 A beam of light of wavelength 400 nm is incident normally on a diffraction grating that has 300 lines per millimetre. The light passes through the grating and produces a series of maxima which are observed on a semicircular screen, as shown.



VIEW FROM ABOVE

What is the total number of maxima observed on the screen?

A 8 **B** 9 **C** 16 **D** 17

32 Two wires, X and Y, are made from the same metal.

The diameter of wire Y is twice that of wire X.

Wire X, wire Y and a battery are connected in series.

What is the ratio $\dfrac{\text{average drift speed of free electrons in wire X}}{\text{average drift speed of free electrons in wire Y}}$?

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

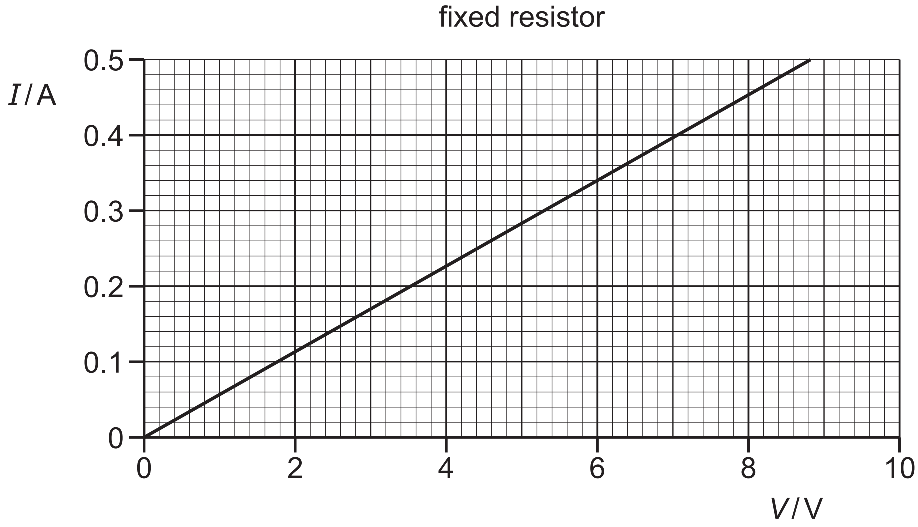
33 A resistor has resistance R. When the potential difference (p.d.) across the resistor is V, the current in the resistor is I. The power dissipated in the resistor is P. Work W is done when charge Q flows through the resistor.

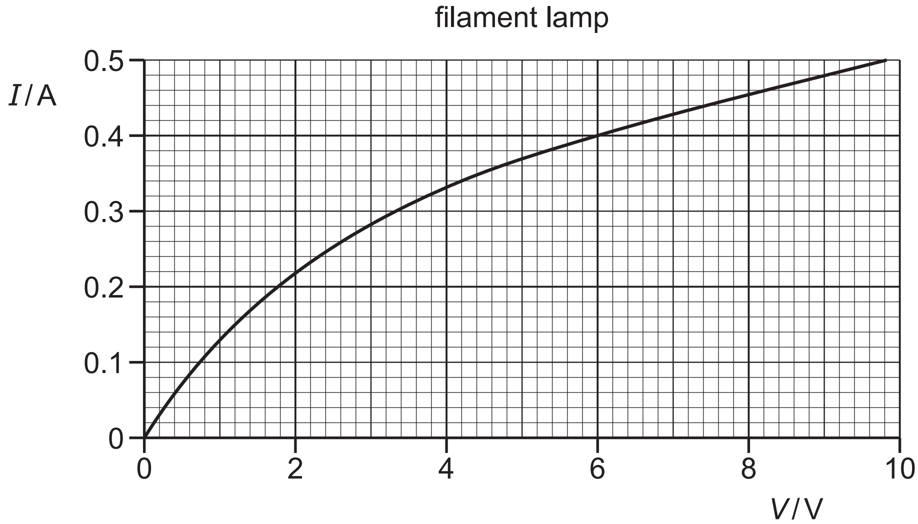
What is **not** a valid relationship between these variables?

A $I = \frac{P}{V}$ **B** $Q = \frac{W}{V}$ **C** $R = \frac{P}{I^2}$ **D** $R = \frac{V}{P}$

34 A fixed resistor and a filament lamp are connected in series to a power supply.

The I–V characteristics for the two components are shown.





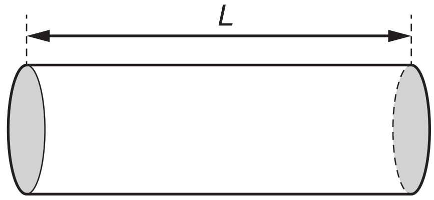
The current in the fixed resistor is 0.34 A.

What is the resistance of the filament lamp?

A 0.081 Ω **B** 12 Ω **C** 15 Ω **D** 18 Ω

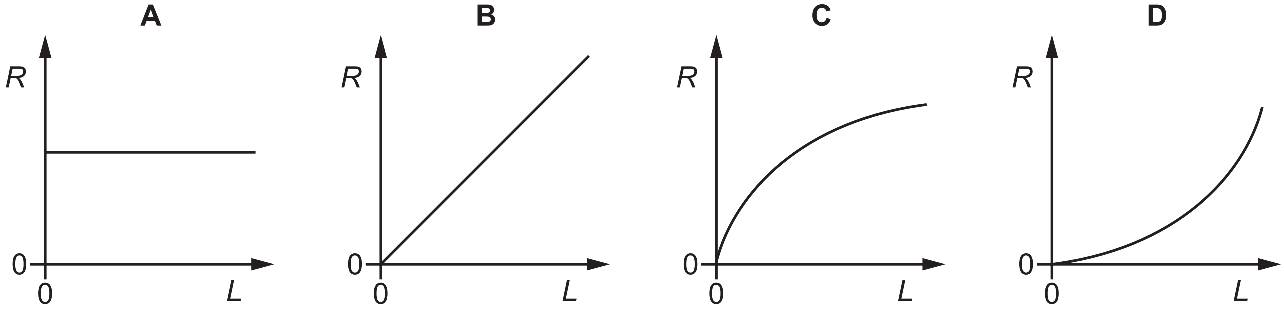
35 A piece of conducting putty (modelling clay) of constant resistivity is formed into a cylindrical shape.

The resistance R between its flat ends (shaded) is measured.

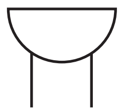


The same volume of putty is re-formed into cylinders of different lengths L, and the resistance R between the flat ends is measured for each value of L.

Which graph best shows the variation of R with L?



36 The diagram shows the symbol for a component that may be used in an electrical circuit.



Which component is represented by this circuit symbol?

A buzzer

B electric bell

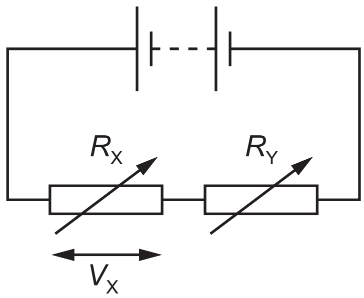
C loudspeaker

D microphone

37 Which row correctly describes Kirchhoff's laws?

	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy
B	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge
C	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge
D	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy

38 A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



The variable resistors have resistances R_X and R_Y.

V_X is the potential difference (p.d.) across the variable resistor with resistance R_X.

R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

39 An actinium nucleus has a nucleon number of 227 and a proton number of 89. It decays to form a radium nucleus, emitting a β^- particle and an α-particle in the process.

What are the nucleon number and the proton number of this radium nucleus?

	nucleon number	proton number
A	223	87
B	223	88
C	224	87
D	225	86

40 Which statement is **not** correct?

A A meson consists of three quarks.

B A proton is a baryon.

C A quark is a fundamental particle.

D There are six flavours (types) of quark.

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2016**

1 hour 15 minutes

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

5340221462

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **20** printed pages.

IB16 11_9702_11/4RP

CAMBRIDGE
International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is the order of magnitude of the Young modulus for a metal such as copper?

A 10^{-11} Pa **B** 10^{-4} Pa **C** 10^{4} Pa **D** 10^{11} Pa

2 The force F between two point charges q_1 and q_2, a distance r apart, is given by the equation

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

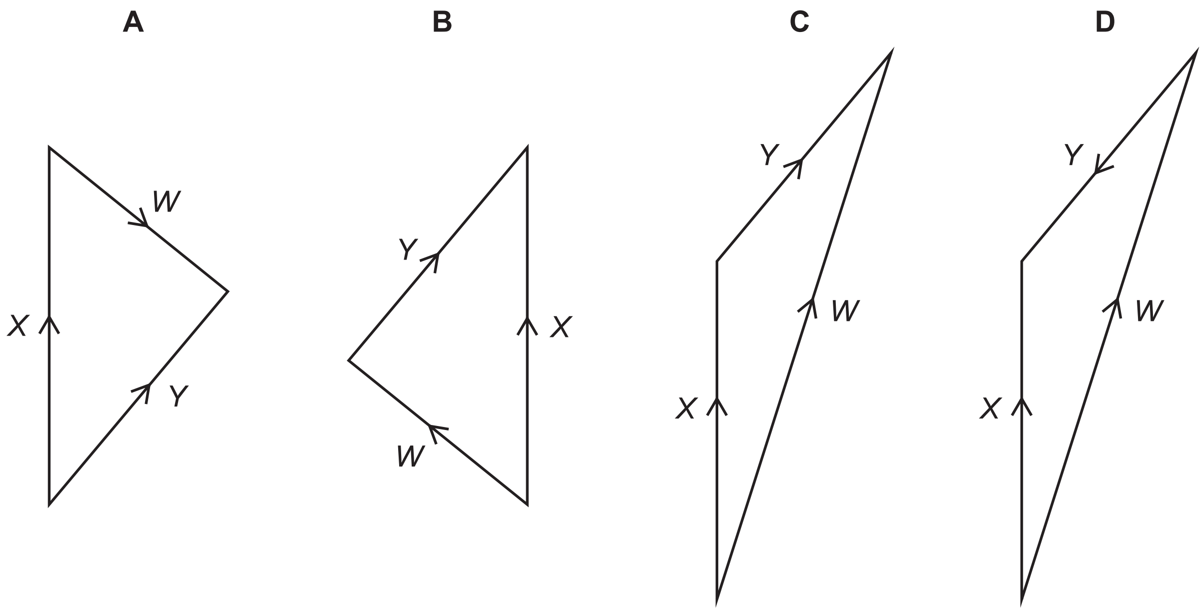
where k is a constant.

What are the SI base units of k?

A $\mathrm{kg\,m^3\,s^{-4}\,A^2}$ **B** $\mathrm{kg\,m^3\,s^{-4}\,A^{-2}}$ **C** $\mathrm{kg\,m^3\,A^2}$ **D** $\mathrm{kg\,m^3\,A^{-2}}$

3 An aeroplane can fly at a velocity X when moving through still air. When flying in wind the aeroplane's velocity relative to the ground is Y.

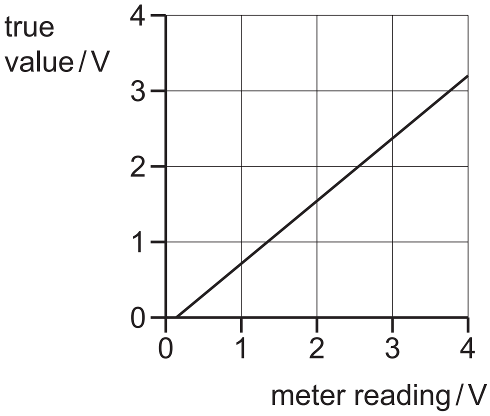
Which vector diagram shows the magnitude and direction of the wind velocity W?



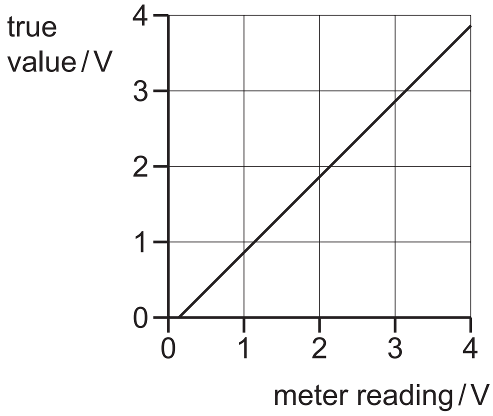
4 A voltmeter gives readings that are larger than the true values and has a systematic error that varies with voltage.

Which graph shows the calibration curve for the voltmeter?

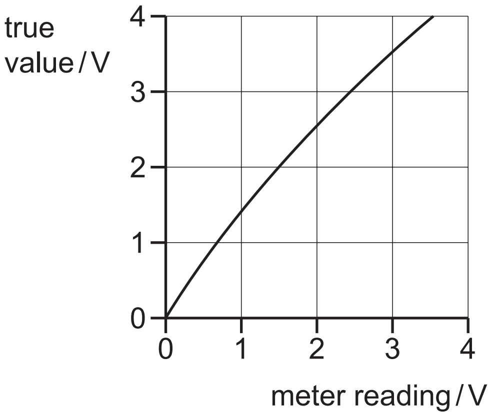
A



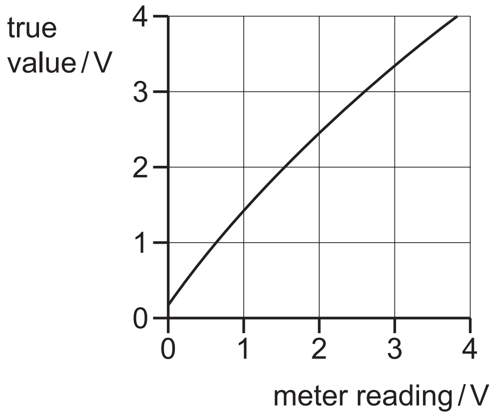
B



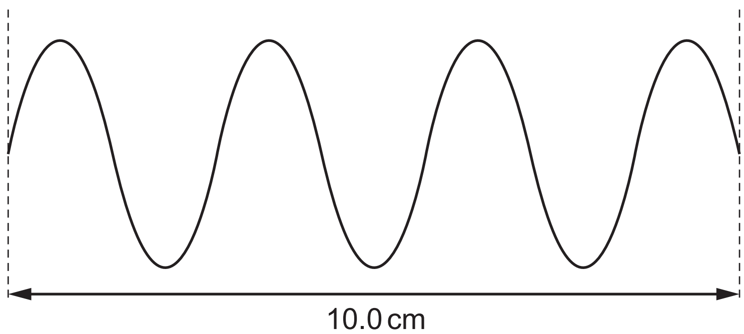
C



D



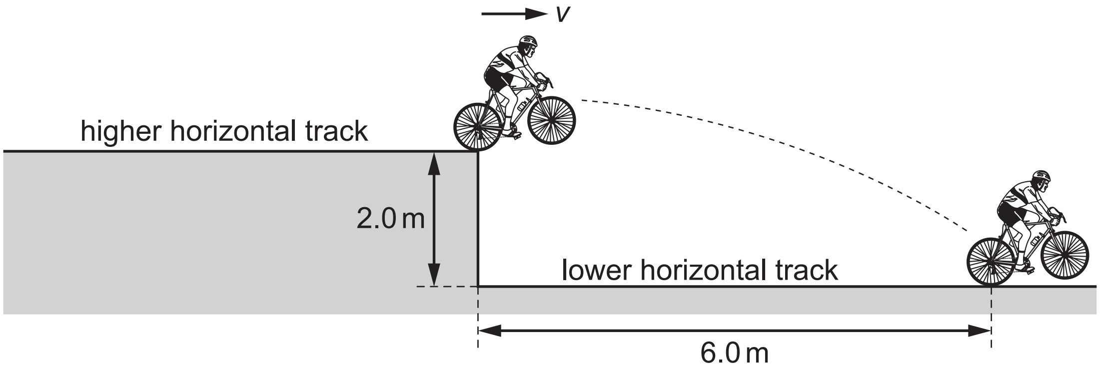
5 A student uses a cathode-ray oscilloscope (c.r.o.) to measure the period of a signal. She sets the time-base of the c.r.o. to $5\,\text{ms}\,\text{cm}^{-1}$ and observes the trace illustrated below. The trace has a length of 10.0 cm.



What is the period of the signal?

A 7.1×10^{-6} s **B** 1.4×10^{-5} s **C** 7.1×10^{-3} s **D** 1.4×10^{-2} s

6 A cyclist pedals along a raised horizontal track. At the end of the track, he travels horizontally into the air and onto a track that is vertically 2.0 m lower.

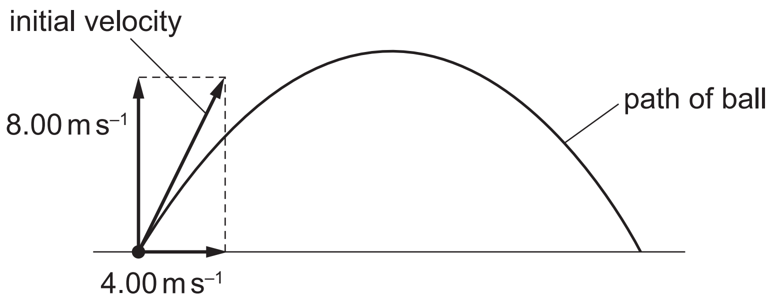


The cyclist travels a horizontal distance of 6.0 m in the air. Air resistance is negligible.

What is the horizontal velocity *v* of the cyclist at the end of the higher track?

A $6.3\,\mathrm{m\,s^{-1}}$ **B** $9.4\,\mathrm{m\,s^{-1}}$ **C** $9.9\,\mathrm{m\,s^{-1}}$ **D** $15\,\mathrm{m\,s^{-1}}$

7 An astronaut on the Moon, where there is no air resistance, throws a ball. The ball's initial velocity has a vertical component of $8.00\,\mathrm{m\,s^{-1}}$ and a horizontal component of $4.00\,\mathrm{m\,s^{-1}}$, as shown.

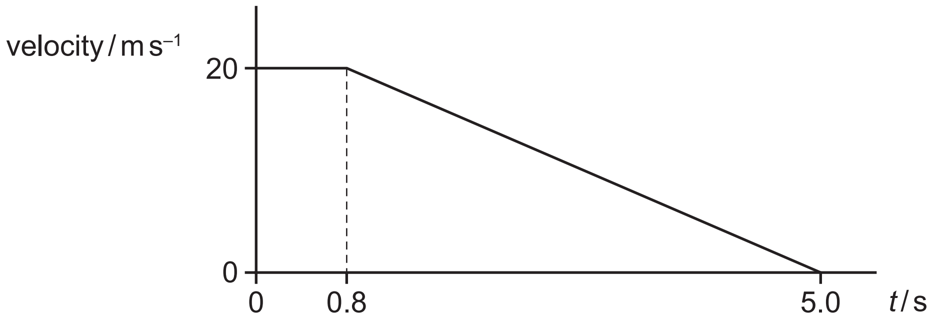


The acceleration of free fall on the Moon is $1.62\,\mathrm{m\,s^{-2}}$.

What will be the speed of the ball 9.00 s after being thrown?

A $6.6\,\mathrm{m\,s^{-1}}$ **B** $7.7\,\mathrm{m\,s^{-1}}$ **C** $10.6\,\mathrm{m\,s^{-1}}$ **D** $14.6\,\mathrm{m\,s^{-1}}$

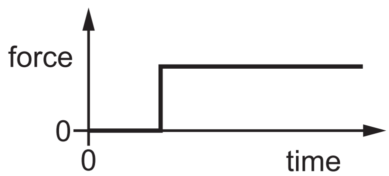
8 A car is travelling at constant velocity. At time t = 0, the driver of the car sees an obstacle in the road and then brakes to a halt. The graph shows the variation with t of the velocity of the car.



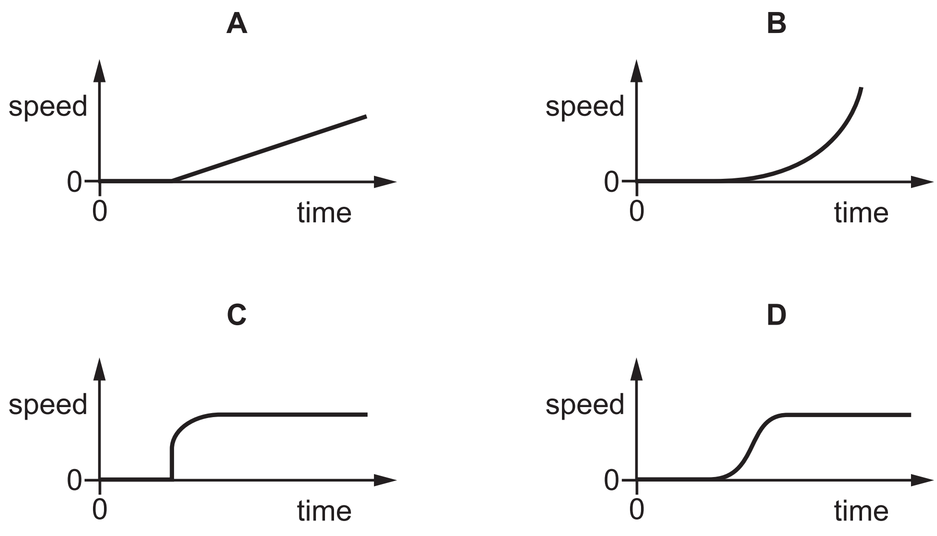
How far does the car travel in the 5.0 s after the driver sees the obstacle?

A 16 m **B** 42 m **C** 58 m **D** 84 m

9 A car is stationary at traffic lights. When the traffic lights change to green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.



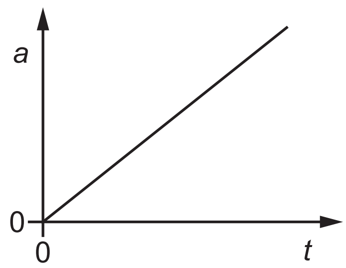
Which graph shows the variation with time of the speed of the car?



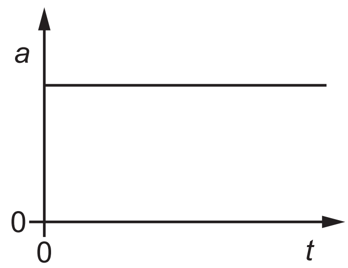
10 A beach-ball falls vertically from a high hotel window. Air resistance is **not** negligible.

Which graph shows the variation with time t of the acceleration a of the ball?

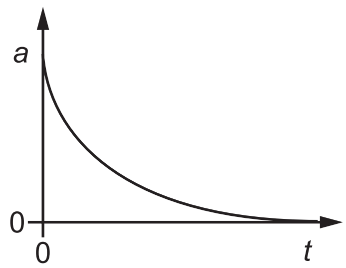
A



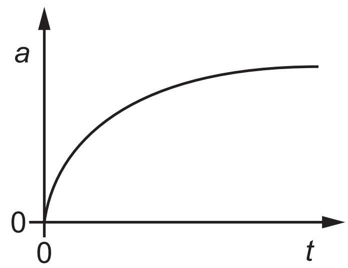
B



C



D



11 A car has mass m. A person needs to push the car with force F in order to give the car acceleration a. The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

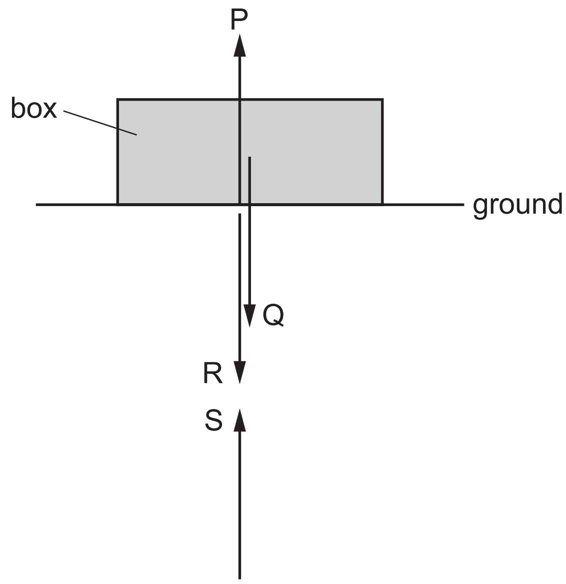
Which expression gives the constant resistive force opposing the motion of the car?

A ma **B** $2ma$ **C** $3ma$ **D** $4ma$

12 A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.

Forces P and Q act on the box. Forces R and S act on the Earth.

For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

A P is the equal and opposite force to Q and both are forces of contact.

B Q is the equal and opposite force to P and both are gravitational forces.

C R is the equal and opposite force to S and both are forces of contact.

D S is the equal and opposite force to Q and both are gravitational forces.

13 Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2.

Which collision is **not** elastic?

	u_1 / m s^{-1}	u_2 / m s^{-1}	v_1 / m s^{-1}	v_2 / m s^{-1}
A	2	–5	–5	–2
B	3	–3	0	6
C	3	–2	1	6
D	5	2	3	6

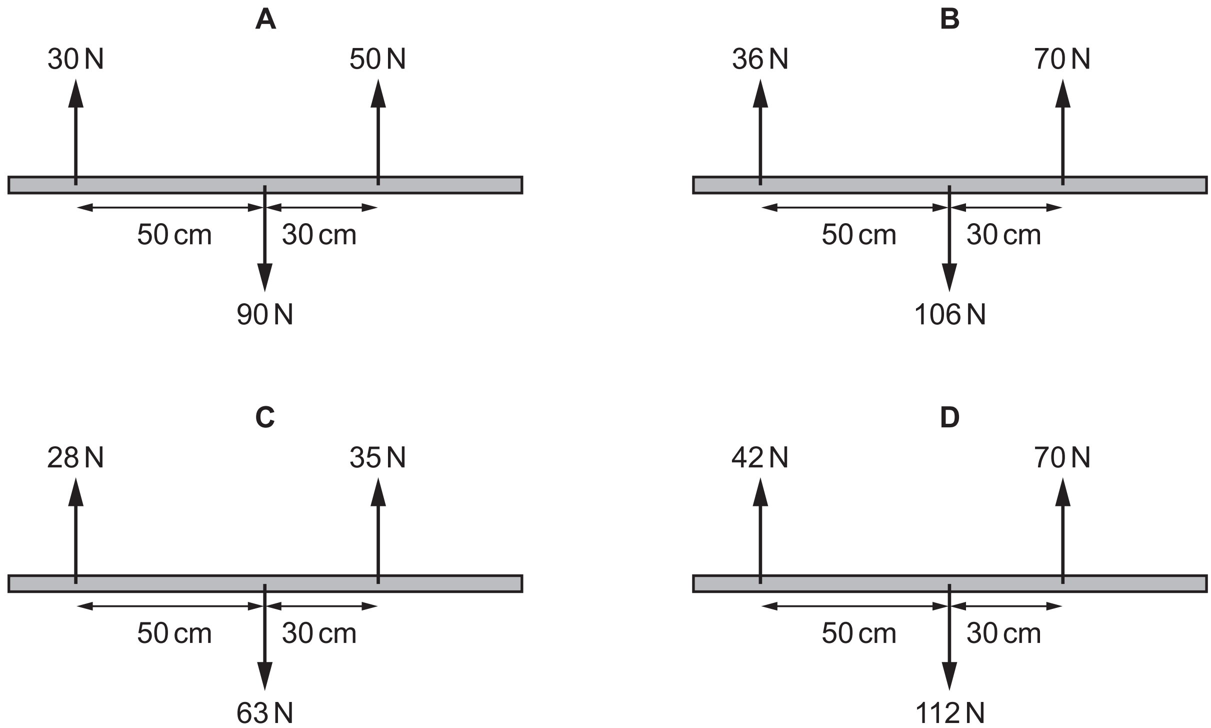
14 A submarine has circular windows of diameter 0.30 m. The windows can experience a maximum external pressure of 660 kPa before they crack.

What is the minimum external force needed to crack the windows?

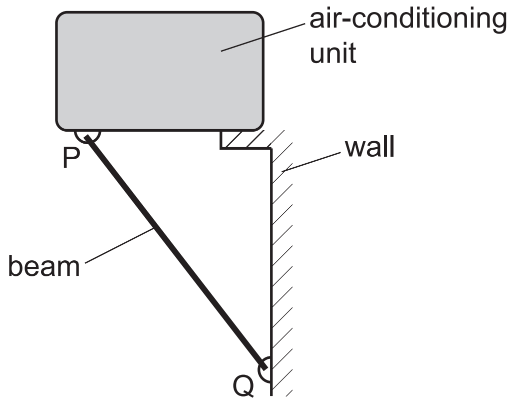
A 47 000 N **B** 190 000 N **C** 310 000 N **D** 620 000 N

15 Four beams of the same length each have three forces acting on them.

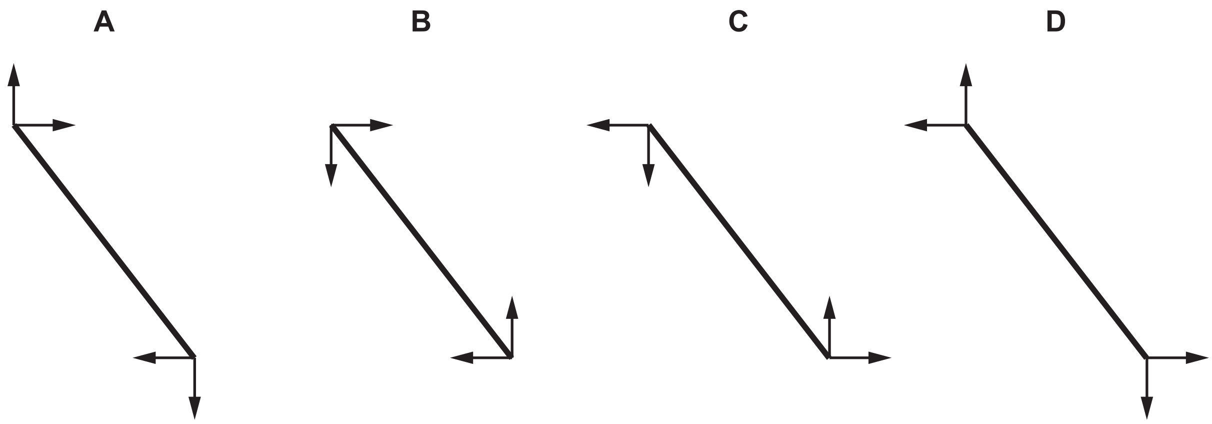
Which beam has both zero resultant force and zero resultant torque acting?



16 An air-conditioning unit is supported by a rigid beam PQ, as shown.



Which diagram shows the directions of the horizontal and vertical forces acting on the ends of the beam?



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

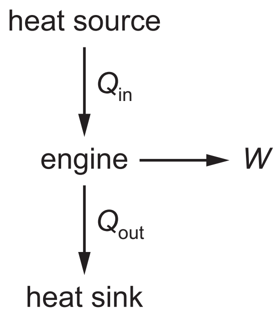
In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^5\,\mathrm{kg\,s^{-1}}$. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

A 5.6% **B** 43% **C** 57% **D** 68%

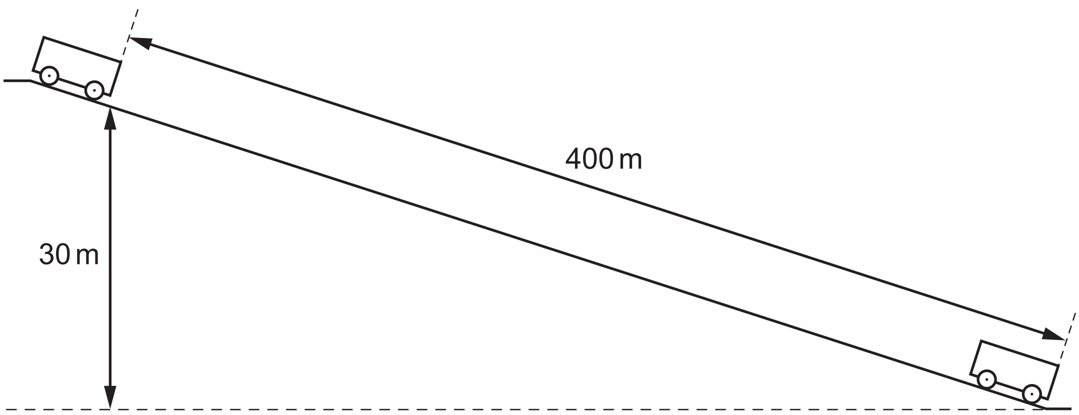
18 An engine transforms thermal energy into mechanical work. The engine takes in thermal energy Q_{in} from a heat source and gives out thermal energy Q_{out} to a heat sink, producing useful work W.



What is the efficiency of this engine?

A $\dfrac{W}{Q_{in}+Q_{out}}$ **B** $\dfrac{W}{Q_{in}-Q_{out}}$ **C** $\dfrac{W}{Q_{in}}$ **D** $\dfrac{W}{Q_{out}}$

19 A truck of mass 500 kg moves from rest at the top of a section of track 400 m long and 30 m high, as shown. The frictional force acting on the truck is 250 N throughout its journey.



What is the final speed of the truck?

A $14\,m\,s^{-1}$ **B** $24\,m\,s^{-1}$ **C** $31\,m\,s^{-1}$ **D** $190\,m\,s^{-1}$

20 Which condition must apply for the work done by an expanding gas to be $p\Delta V$, where p is the pressure of the gas and ΔV is its change in volume?

A No thermal energy must be supplied to the gas.

B The expansion must be at a constant rate.

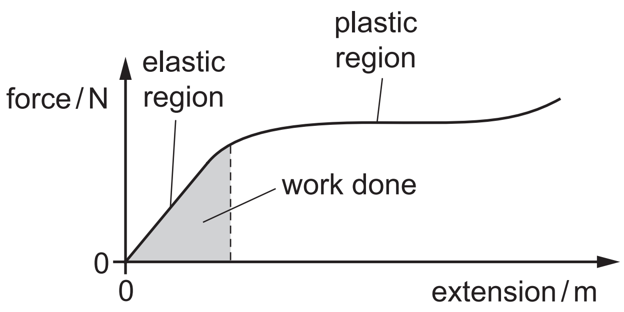
C The pressure must be constant.

D The temperature of the gas must be constant.

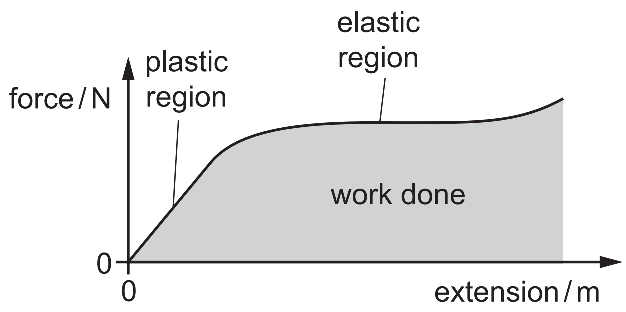
21 A metal wire is stretched to breaking point and the force-extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?

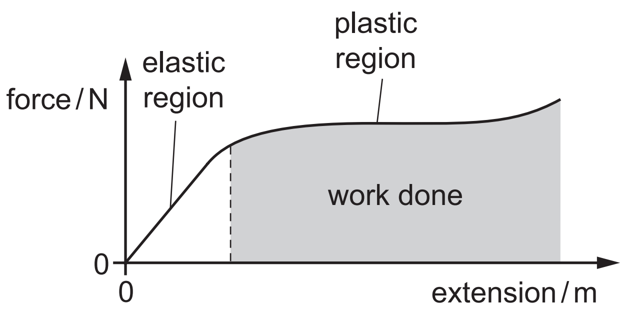
A



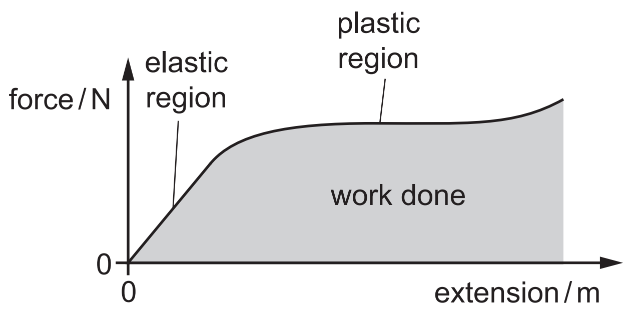
B



C



D



22 A copper wire hangs vertically from a fixed point. A load is attached to the lower end of the wire producing an extension x. The wire obeys Hooke's law.

Which single change gives an extension $2x$?

A Halve the cross-sectional area of the wire.

B Halve the diameter of the wire.

C Halve the length of the wire.

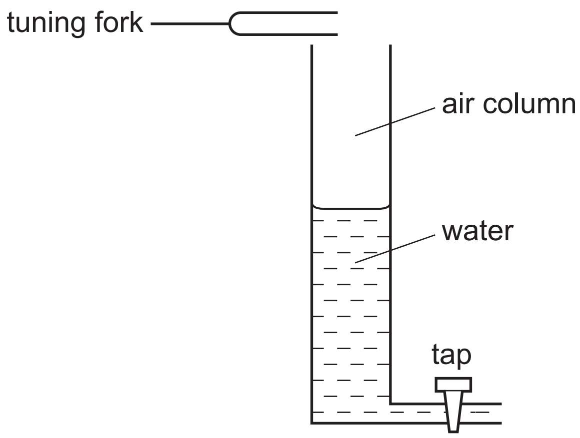
D Halve the load on the wire.

23 The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^{2} m
A	gamma ray	X-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	X-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	X-ray
D	X-ray	infra-red	ultraviolet	microwave	radio wave

24 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.

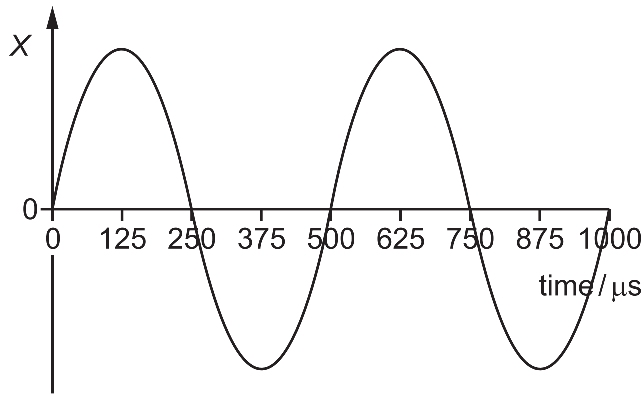


The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

What is the wavelength of the sound wave?

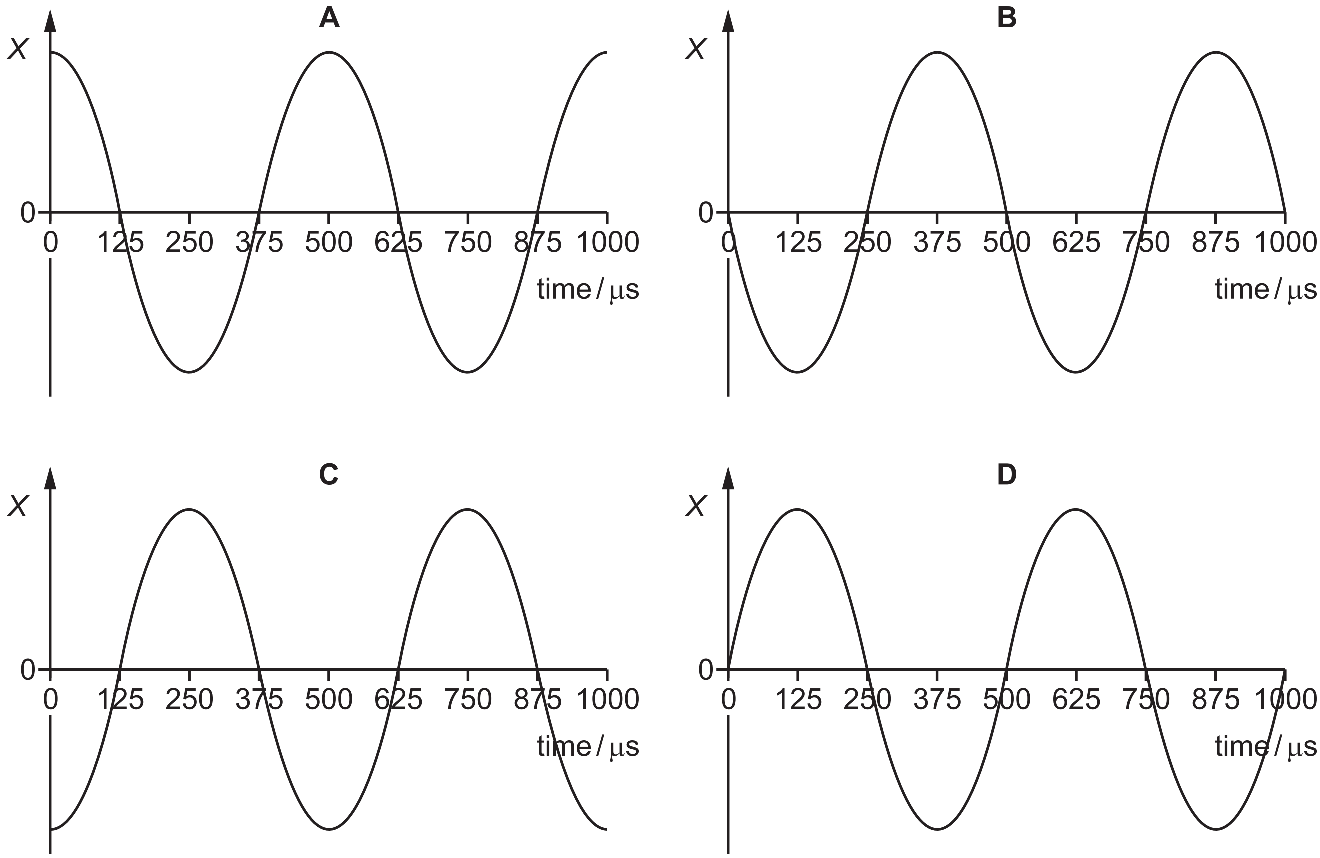
A 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

25 The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.

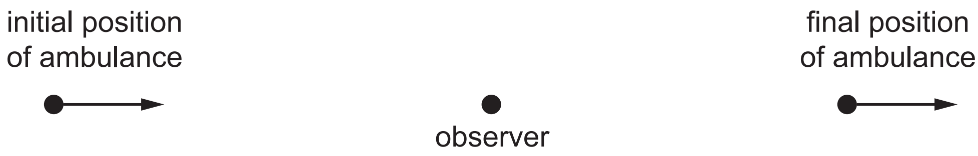


The velocity of sound in the gas is $330\,m\,s^{-1}$. All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.165 m further away from the source of the sound?



26 The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m s^{-1}. The ambulance is travelling with a constant velocity of 25 m s^{-1} towards an observer.

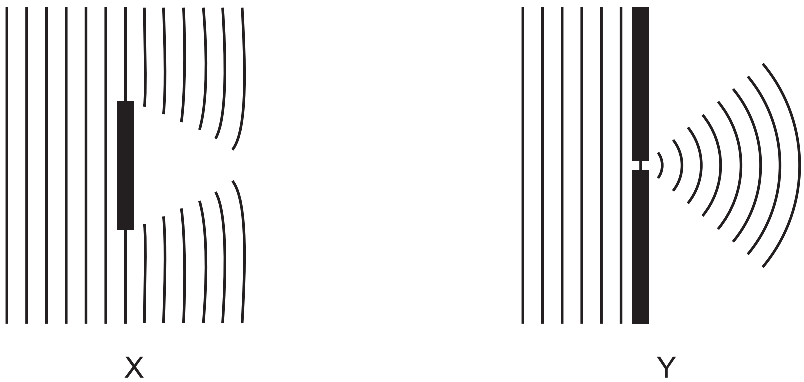


Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

A 49 Hz **B** 84 Hz **C** 91 Hz **D** 98 Hz

27 Diagrams X and Y show the passage of water waves around an obstacle and through a gap.

The thick lines are barriers to the waves and each thin line represents a wavefront.



Which statement is correct?

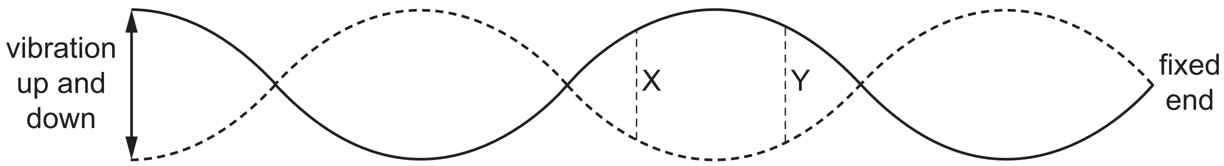
A Diagrams X and Y both illustrate diffraction.

B Diagrams X and Y both illustrate interference.

C Only diagram X illustrates interference.

D Only diagram Y illustrates diffraction.

28 The diagram shows a long rope fixed at one end. The other end is moved up and down, setting up a stationary wave.

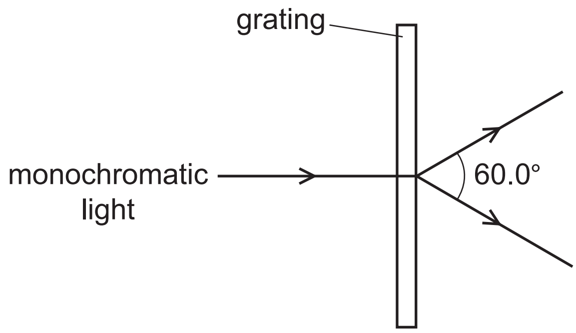


What is the phase difference between the oscillations at X and at Y?

A 0 **B** 45° **C** 90° **D** 135°

29 A diffraction grating is used to measure the wavelength of monochromatic light.

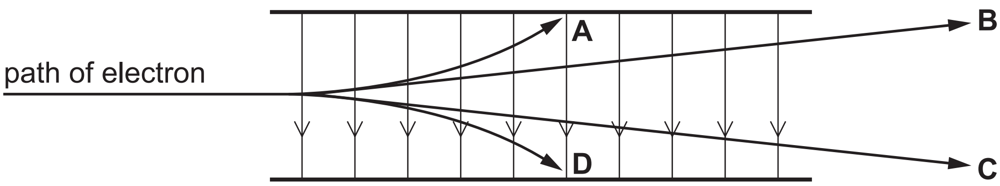
The spacing of the slits in the grating is 1.15×10^{-6} m. The angle between the first order diffraction maxima is 60.0°, as shown in the diagram.



What is the wavelength of the light?

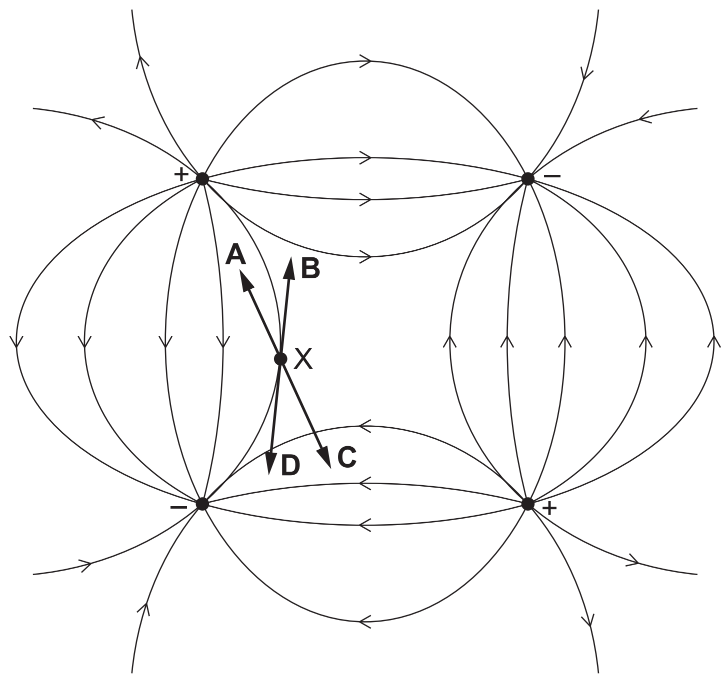
A 288 nm **B** 498 nm **C** 575 nm **D** 996 nm

30 Which path shows a possible movement of an electron in the electric field shown?

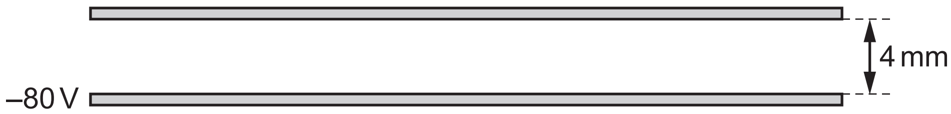


31 The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

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



32 Two large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of –80 V.



Which potential should be applied to the upper plate to create an electric field of strength 60 000 V m^{-1} upwards in the space between the plates?

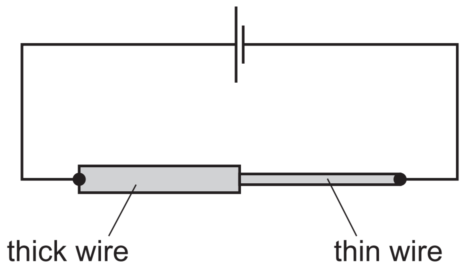
A –320 V **B** –160 V **C** +160 V **D** +320 V

33 An electric kettle is marked 3.10 kW. It is used with an electrical supply of 240 V.

What is the electric current in the kettle and what is the kettle's electrical resistance when working?

	current / A	resistance / Ω
A	0.0129	18 600
B	0.0770	3100
C	12.9	18.6
D	12.9	3100

34 A thick copper wire is connected to a thin copper wire in series with a cell, as shown.



What is significantly **less** in the thick wire than in the thin wire?

A the charge passing a point per unit time

B the drift speed of the electrons

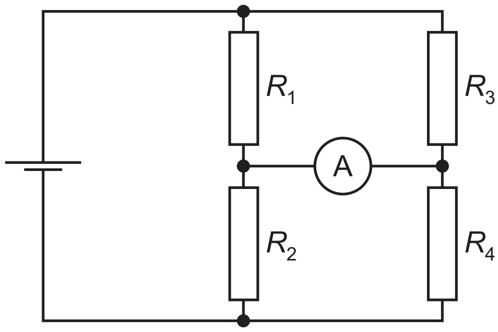
C the number density of the free electrons

D the number of free electrons passing a point per unit time

35 What is a typical value for the order of magnitude of the resistivity of copper?

A 10^{-13} Ω m **B** 10^{-8} Ω m **C** 10^{-3} Ω m **D** 10^{2} Ω m

36 In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1, R_2, R_3 and R_4.

Which equation is correct?

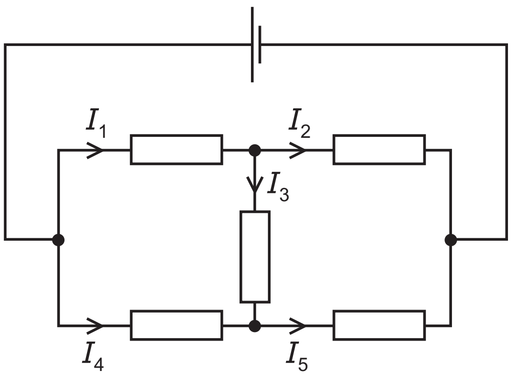
A $R_1 - R_3 = R_2 - R_4$

B $R_1 \times R_3 = R_2 \times R_4$

C $R_1 - R_4 = R_2 - R_3$

D $R_1 \times R_4 = R_2 \times R_3$

37 The diagram shows currents I_1, I_2, I_3, I_4 and I_5 in different branches of a circuit.



Which equation is correct?

A $I_1 = I_2 + I_3$

B $I_2 = I_1 + I_3$

C $I_3 = I_4 + I_5$

D $I_4 = I_5 + I_3$

38 What is a proton?

A a hadron

B a particle consisting of two down quarks and one up quark

C a positive fundamental particle

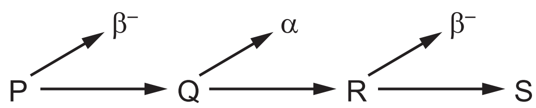
D a positive lepton

39 What are the correct descriptions of a γ-ray and a β^- particle?

	γ-ray	β^- particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	helium-4 nucleus

40 In a radioactive decay series, three successive decays each result in a particle being emitted.

The first decay results in the emission of a β^- particle. The second decay results in the emission of an α particle. The third decay results in the emission of another β^- particle.



Nuclides P and S are compared.

Which statement is correct?

A P and S are identical in all respects.

B P and S are isotopes of the same element.

C S is a different element of lower atomic number.

D S is a different element of reduced mass.

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2016**

1 hour 15 minutes

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

1047509797

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

CAMBRIDGE International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Concrete has a density of $2400\,\text{kg}\,\text{m}^{-3}$.

Which mass of concrete fills a rectangular space of dimensions $8.0\,\text{cm} \times 90\,\text{cm} \times 110\,\text{cm}$?

A 79 kg **B** 190 kg **C** 790 kg **D** 1900 kg

2 The speed v of sound in a gas is given by the equation

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

where P is the pressure of the gas, ρ is its density and γ is a constant.

What are the SI base units of γ?

A $\text{m}^{-1}\,\text{s}$ **B** $\text{m}^{3}\,\text{s}^{-3}$ **C** $\text{m}^{-4}\,\text{s}^{-4}$ **D** no units

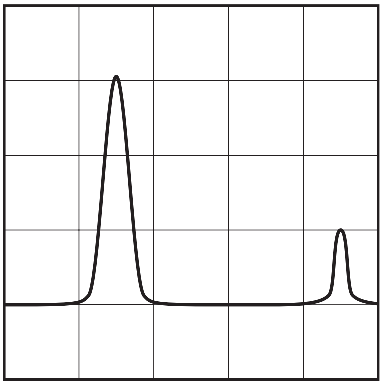
3 The motion of an object moving from rest with a constant acceleration a may be represented by the equation shown.

$$v^2 = 2as$$

Which row describes the quantities represented by the symbols v and s?

	v	s
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

4 A cathode-ray oscilloscope (c.r.o.) displays a waveform as shown.



The time interval between two adjacent peaks of the waveform is 0.006 s.

What is the time-base setting of the c.r.o.?

A 2 μs / division

B 20 μs / division

C 2 ms / division

D 3 ms / division

5 A value for the acceleration of free fall on Earth is given as $(10 \pm 2)\,\mathrm{m\,s^{-2}}$.

Which statement is correct?

A The value is accurate but not precise.

B The value is both precise and accurate.

C The value is neither precise nor accurate.

D The value is precise but not accurate.

6 An experiment to determine atmospheric pressure P uses the equation $P = \rho g h$ where

$\rho = (13\,600 \pm 100)\,\mathrm{kg\,m^{-3}}$,

$g = (9.81 \pm 0.02)\,\mathrm{m\,s^{-2}}$,

$h = (0.762 \pm 0.005)\,\mathrm{m}$.

What is the value of P, with its uncertainty, when stated to an appropriate number of significant figures?

A $(1.0166 \pm 0.0162) \times 10^5\,\mathrm{Pa}$

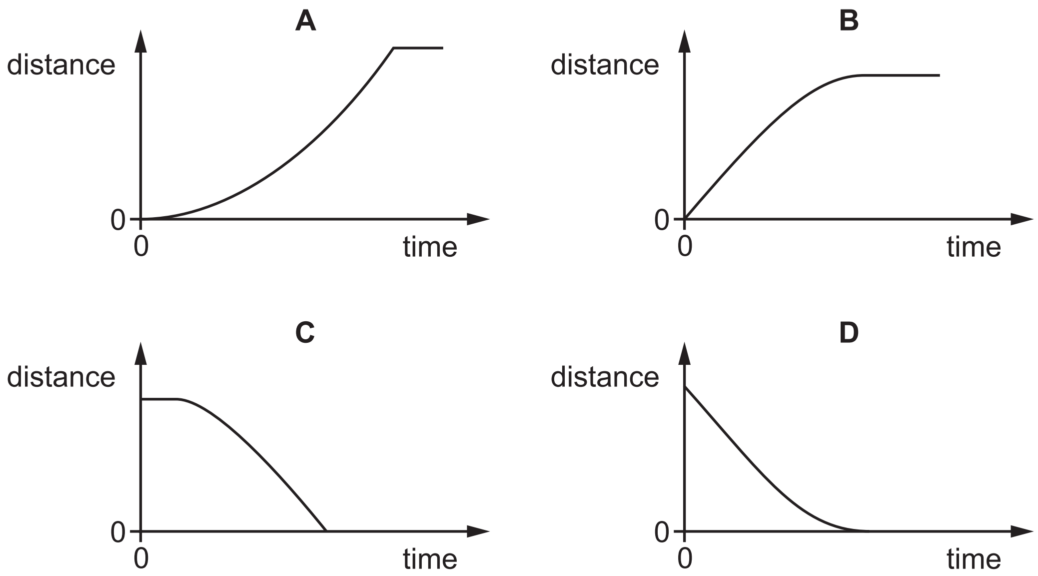
B $(1.017 \pm 0.016) \times 10^5\,\mathrm{Pa}$

C $(1.017 \pm 1.6\%) \times 10^5\,\mathrm{Pa}$

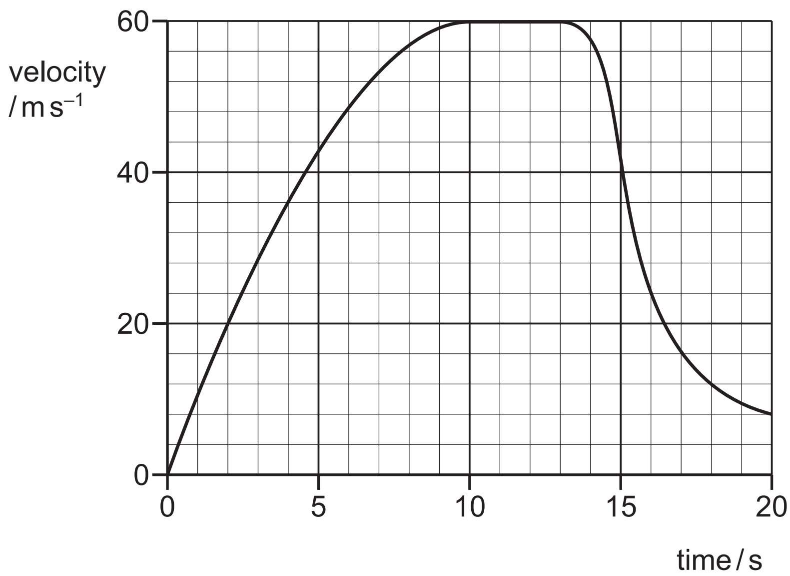
D $(1.02 \pm 0.02) \times 10^5\,\mathrm{Pa}$

7 A lorry travels at a constant speed and then decelerates until it stops.

Which graph shows the variation with time of the distance travelled by the lorry?



8 The graph shows the vertical velocity of a parachutist during the first 20 s of her jump.

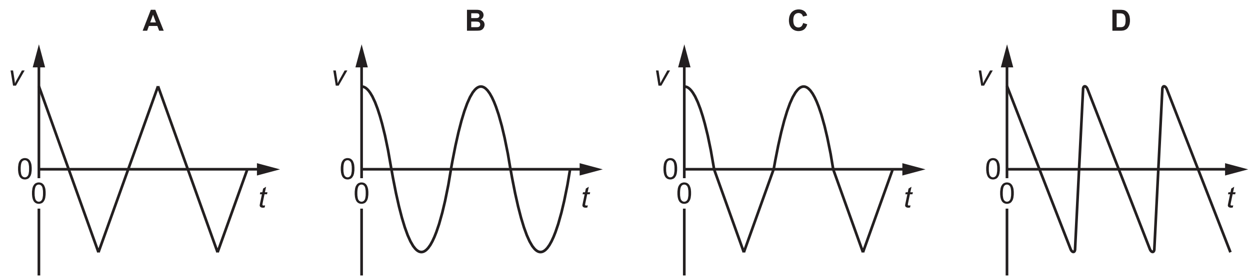


Approximately how far does she fall **before** opening the parachute?

A 390 m **B** 570 m **C** 710 m **D** 770 m

9 A girl is jumping on a trampoline.

Which graph shows the variation of the girl's velocity v with time t?



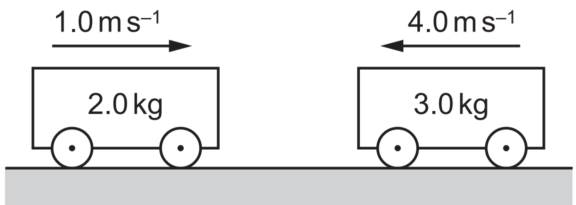
10 In order that a train can stop safely, it will always pass a signal showing a yellow light before it reaches a signal showing a red light. Drivers apply the brake at the yellow light and this results in a uniform deceleration to stop exactly at the red light.

The distance between the red and yellow lights is x.

If the speed of the train is increased by 20%, without changing the deceleration of the train, what must be the minimum distance between the lights?

A $1.20x$ **B** $1.25x$ **C** $1.44x$ **D** $1.56x$

11 Two frictionless trolleys are moving towards each other along the same horizontal straight line. Their masses and velocities are shown.



The trolleys collide and stick together.

What is the velocity of the trolleys after the collision?

A $2.0\,\text{m}\,\text{s}^{-1}$ to the left

B $2.0\,\text{m}\,\text{s}^{-1}$ to the right

C $2.8\,\text{m}\,\text{s}^{-1}$ to the left

D $2.8\,\text{m}\,\text{s}^{-1}$ to the right

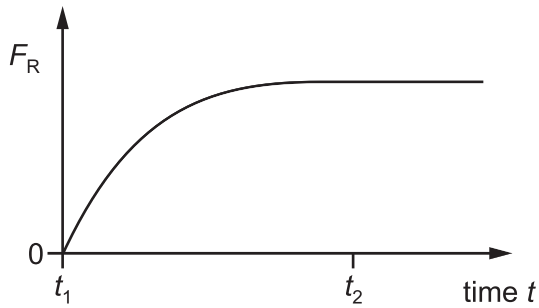
12 A bullet of mass 8.0 g travels at a speed of $300\,\text{m}\,\text{s}^{-1}$. The bullet hits a target and stops after a time of $100\,\mu\text{s}$.

What is the average force exerted by the target on the bullet?

A 24 N **B** 240 N **C** 2400 N **D** 24 000 N

13 A light ball is falling vertically through air.

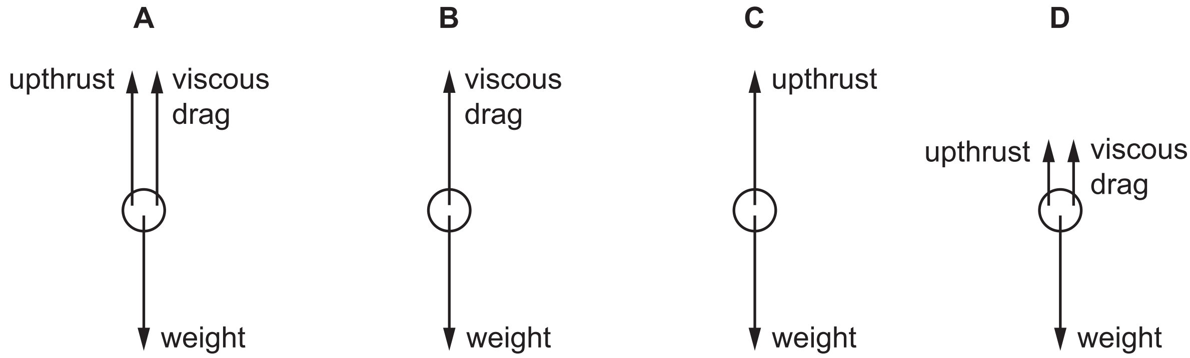
The variation with time t of the resistive force F_R acting on the ball is shown.



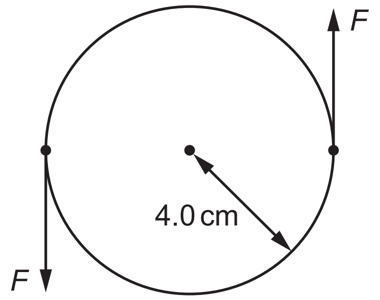
At which times are the speed of the ball zero, the speed at a maximum and the acceleration zero?

	zero speed	maximum speed	zero acceleration
A	t_1	t_2	t_1
B	t_1	t_2	t_2
C	t_2	t_1	t_1
D	t_2	t_1	t_2

14 Which diagram best shows the forces acting on a ball falling at a constant velocity through a liquid?



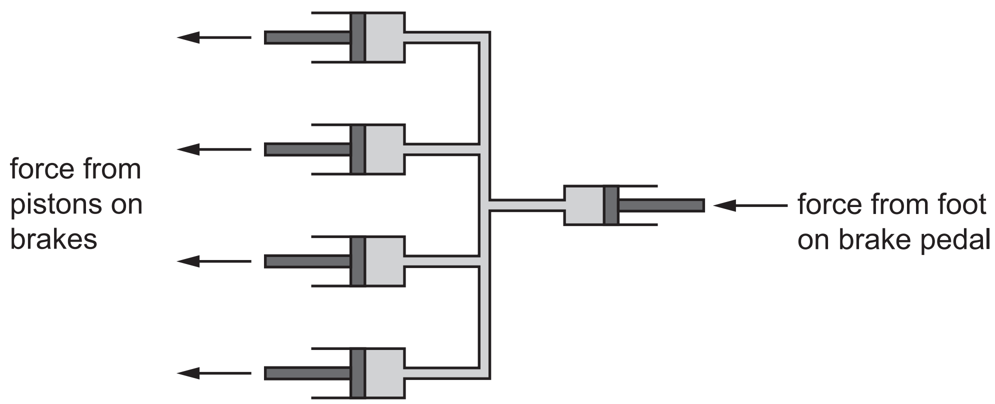
15 A minimum torque of 20 N m must be applied to the lid of a jar for it to open. The radius of the lid is 4.0 cm.



What is the minimum force *F* that must act on each side of the lid in order to open it?

A 2.5 N **B** 5.0 N **C** 250 N **D** 500 N

16 The diagram shows the brake system of a car.



The pipes are filled with incompressible liquid. When a force is applied to the brake pedal, the pressure in the liquid increases and applies a force to each of the four wheels.

The area of the piston connected to the brake pedal is 8 cm^2.

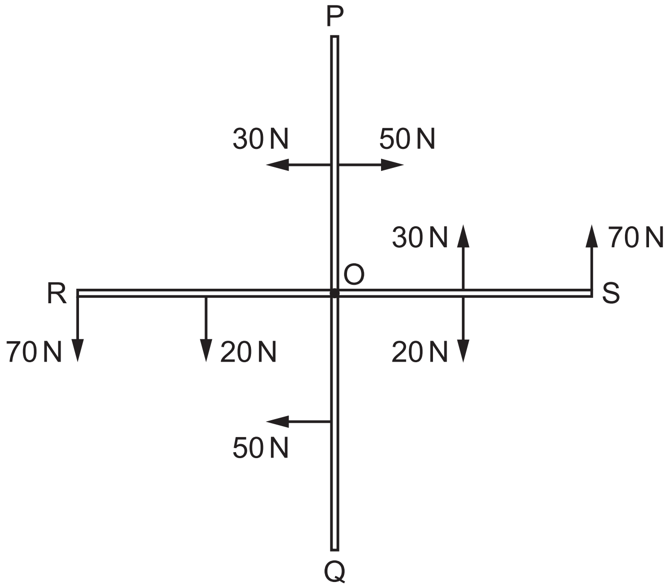
The area of each piston connected to the brakes is 12 cm^2.

A force of 800 N is applied by the foot to the brake pedal.

What is the force applied to each brake?

A 300 N **B** 530 N **C** 1200 N **D** 4800 N

17 A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.00 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the magnitude of the resultant moment on the structure about O?

A 45 N m **B** 90 N m **C** 120 N m **D** 190 N m

18 On the surface of a planet, 30 J of work is done against gravity to raise a mass of 1.0 kg through a height of 10 m.

How much work must be done to raise a mass of 4.0 kg through a height of 5.0 m on this planet?

A 15 J **B** 60 J **C** 120 J **D** 200 J

19 The speed of a car increases from 10 m s^{-1} to 15 m s^{-1} and its kinetic energy increases by E_1.

Later, the speed of the car increases from 15 m s^{-1} to 25 m s^{-1} and its kinetic energy increases by E_2.

What is the ratio $\frac{E_2}{E_1}$?

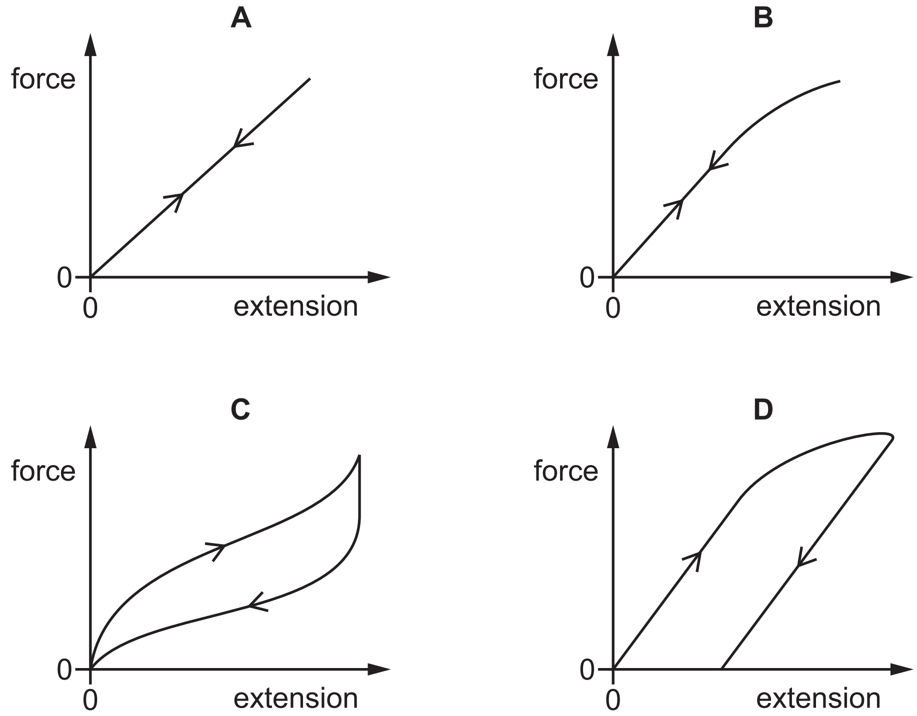
A 1.6 **B** 2.6 **C** 3.2 **D** 4.0

20 A car travels at a constant speed of 25 m s^{-1} up a slope. The wheels driven by the engine exert a forward force of 3000 N. There is a drag force due to air resistance and friction of 2100 N. The weight of the car has a component down the slope of 900 N.

What is the rate at which thermal energy is dissipated?

A zero **B** 2.3×10^4 W **C** 5.3×10^4 W **D** 7.5×10^4 W

21 Which force-extension graph shows plastic deformation of a sample of material?



22 Four solid steel rods, each of length 2.0 m and cross-sectional area 250 mm^2, equally support an object weighing 10 kN. The weight of the object causes the rods to contract by 0.10 mm.

What is the Young modulus of steel?

A 2.0×10^8 N m^{-2}

B 2.0×10^{11} N m^{-2}

C 8.0×10^8 N m^{-2}

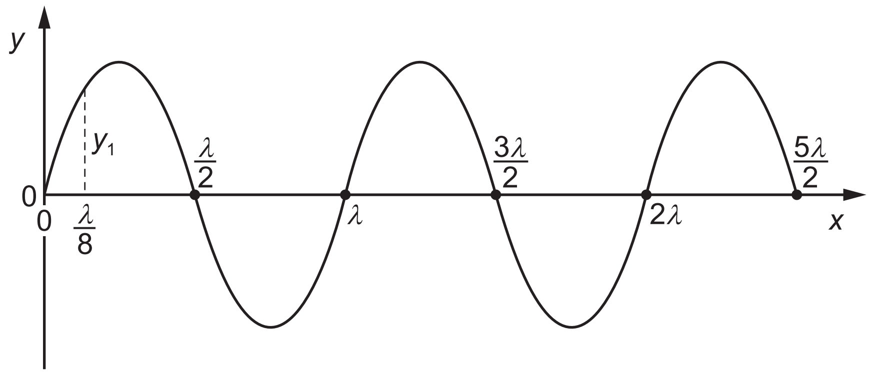
D 8.0×10^{11} N m^{-2}

23 High-frequency sound waves with frequency 2.0 MHz travel with a speed of 2.0 km s^{-1} through a liquid.

What is the shortest distance between a compression and a rarefaction (expansion) in the liquid?

A 0.5 mm **B** 1.0 mm **C** 5.0 mm **D** 10.0 mm

24 A transverse progressive wave of wavelength λ is set up on a stretched string. The graph shows the variation of displacement y with distance x at a particular instant of time. The displacement where distance $x = \dfrac{\lambda}{8}$ is y_1.



What are the next two values of x where the displacement y is again equal to y_1?

A $\dfrac{3\lambda}{8}$ and $\dfrac{5\lambda}{8}$

B $\dfrac{3\lambda}{8}$ and $\dfrac{9\lambda}{8}$

C $\dfrac{5\lambda}{8}$ and $\dfrac{9\lambda}{8}$

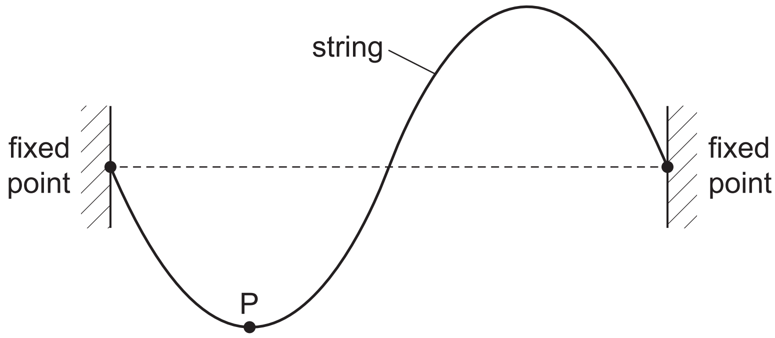
D $\dfrac{9\lambda}{8}$ and $\dfrac{17\lambda}{8}$

25 A man standing next to a stationary train hears sound of frequency 400 Hz emitted from the train's horn. The train then moves directly away from the man and sounds its horn when it has a speed of $50\,\text{m}\,\text{s}^{-1}$. The speed of sound is $340\,\text{m}\,\text{s}^{-1}$.

What is the difference in frequency of the sound heard by the man on the two occasions?

A 51 Hz **B** 69 Hz **C** 349 Hz **D** 469 Hz

26 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 ms?

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

27 Observable interference fringes are produced using light from a double slit. The intensity of the light emerging from each slit is initially the same.

The intensity of the light emerging from one of the slits is now reduced.

How does this affect the interference pattern?

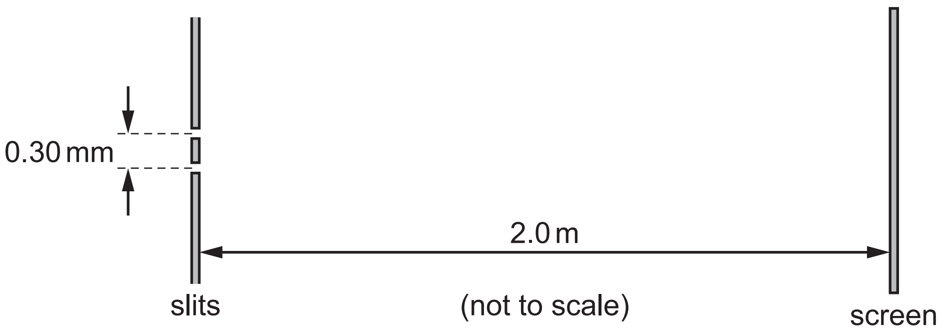
A The bright fringes and the dark fringes all become brighter.

B The bright fringes and the dark fringes all become darker.

C The bright fringes become brighter and the dark fringes become darker.

D The bright fringes become darker and the dark fringes become brighter.

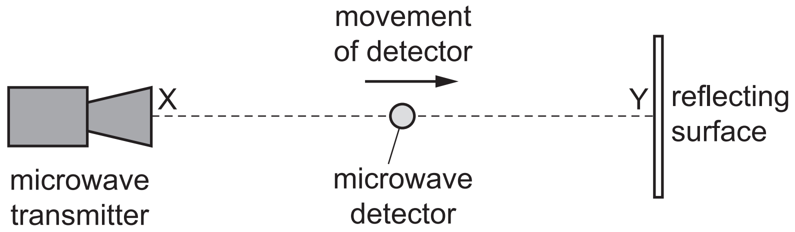
28 Monochromatic light of wavelength 450 nm passes through two parallel slits 0.30 mm apart. Bright fringes are observed on a screen 2.0 m away.



How far apart are the bright fringes on the screen?

A 1.3 mm **B** 1.5 mm **C** 3.0 mm **D** 6.0 mm

29 A microwave transmitter is placed at a fixed distance from a flat reflecting surface, as shown.



A microwave detector is moved steadily in a straight line from X to Y. A series of maxima and minima of intensity is obtained. The distance between adjacent maxima is 1.5 cm.

What is the frequency of the microwave radiation?

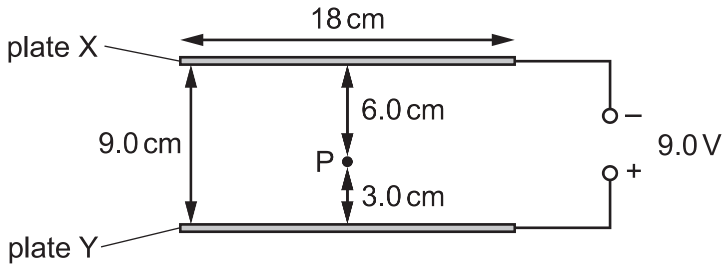
A 1.0×10^{8} Hz

B 2.0×10^{8} Hz

C 1.0×10^{10} Hz

D 2.0×10^{10} Hz

30 Two parallel circular metal plates X and Y, each of diameter 18 cm, have a separation of 9.0 cm. A potential difference of 9.0 V is applied between them.

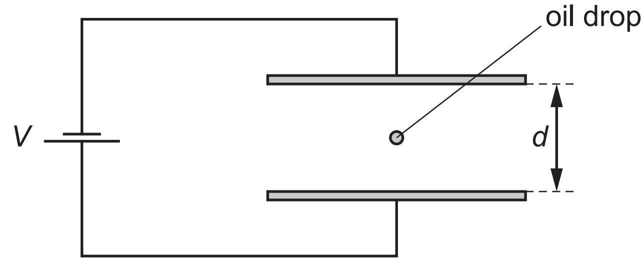


Point P is 6.0 cm from the surface of plate X and 3.0 cm from the surface of plate Y.

What is the electric field strength at P?

A $50\,\mathrm{N\,C^{-1}}$ **B** $100\,\mathrm{N\,C^{-1}}$ **C** $150\,\mathrm{N\,C^{-1}}$ **D** $300\,\mathrm{N\,C^{-1}}$

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

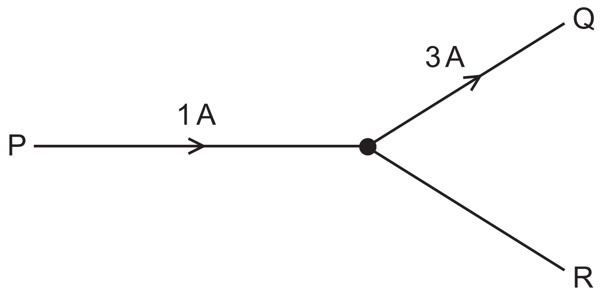


The potential difference between the plates is V and the acceleration of free fall is g.

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** $\frac{d}{Vg}$

32 The diagram shows a junction in a circuit where three wires P, Q and R meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.



How much charge passes a given point in wire R in a time of 5 s?

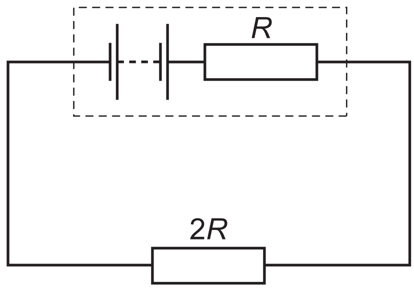
A 0.4 C **B** 2 C **C** 10 C **D** 20 C

33 A wire carries a current of 2.0 A for 1.0 hour.

How many electrons pass a point in the wire in this time?

A 1.2×10^{-15} **B** 7.2×10^{3} **C** 1.3×10^{19} **D** 4.5×10^{22}

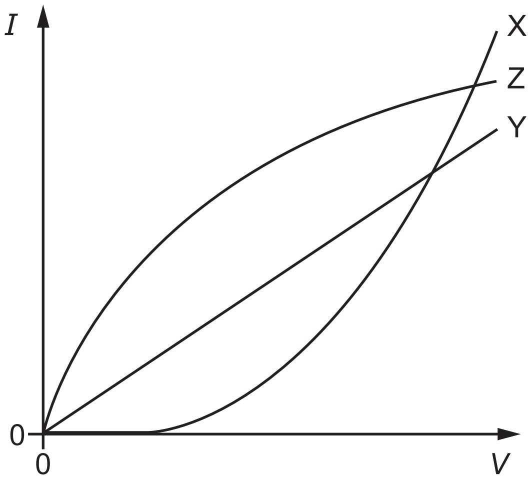
34 The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R.



What is the ratio $\dfrac{\text{power in internal resistance}}{\text{power in external resistor}}$?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** 2 **D** 4

35 The graph shows the variation with potential difference V of the current I in components X, Y and Z.



Which row correctly identifies the components?

	metallic conductor at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	Y	X

36 Four statements about either potential difference or electromotive force are listed.

1 It involves changing electrical energy into other forms.

2 It involves changing other energy forms into electrical energy.

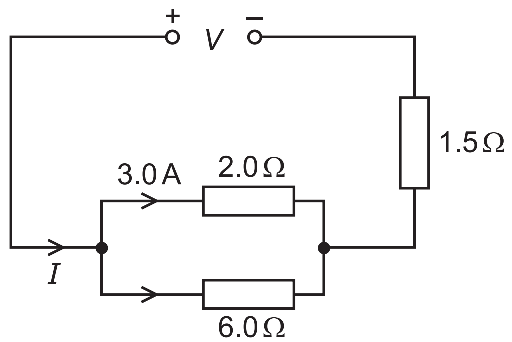
3 It is the energy per unit charge to move charge around a complete circuit.

4 It is the work done per unit charge by the charge moving from one point to another.

Which statements apply to potential difference and which apply to electromotive force?

	potential difference	electromotive force
A	1 and 3	2 and 4
B	1 and 4	2 and 3
C	2 and 3	1 and 4
D	2 and 4	1 and 3

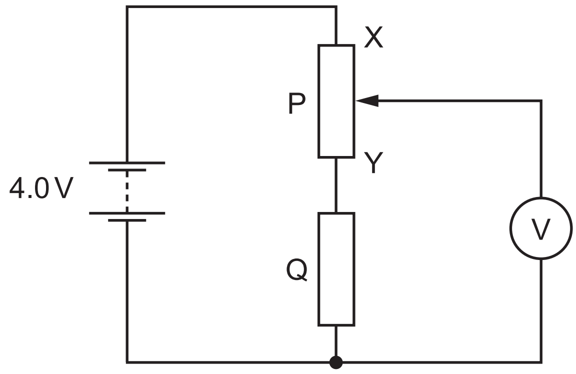
37 In the circuit shown, there is a current of 3.0 A in the 2.0 Ω resistor.



What are the values of the current I delivered by the power supply and the voltage V across it?

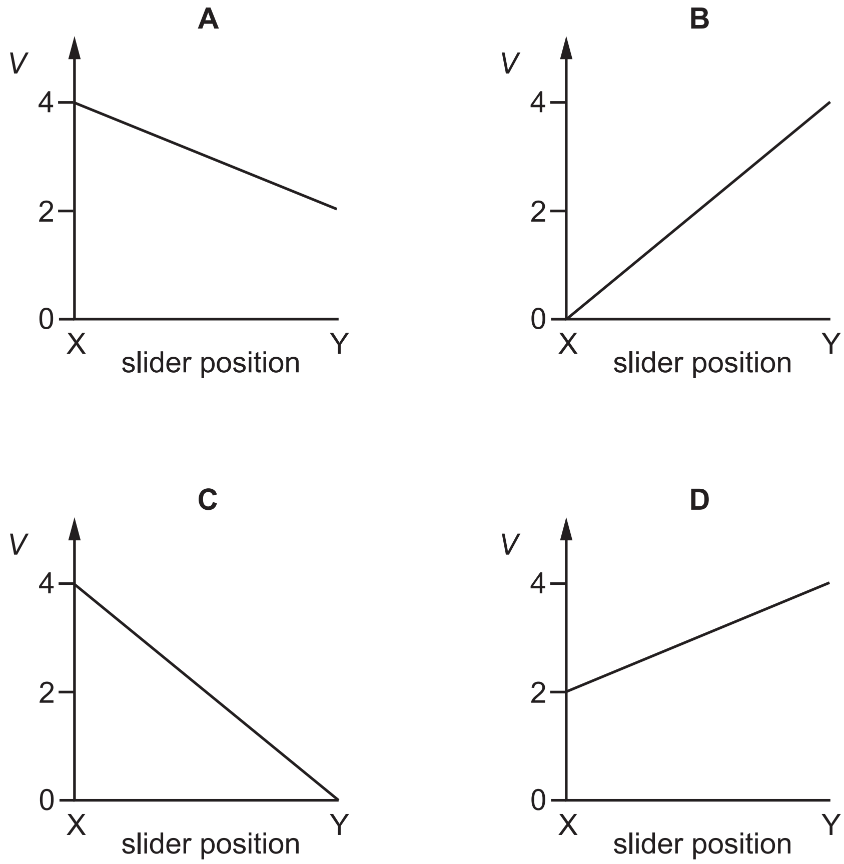
	I/A	V/V
A	3.0	10.5
B	4.0	9.0
C	4.0	12
D	12	18

38 In the circuit below, P is a potentiometer of total resistance 10 Ω and Q is a fixed resistor of resistance 10 Ω. The battery has an e.m.f. of 4.0 V and negligible internal resistance. The voltmeter has a very high resistance.



The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading *V* is plotted against slider position.

Which graph is obtained?



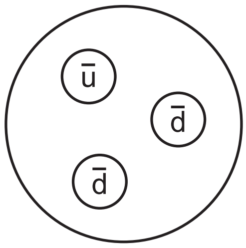
39 The calcium nuclide ${}^{42}_{20}\mathrm{Ca}$ is formed by β^- decay.

What are the nucleon (mass) number and proton (atomic) number of the unstable nuclide that underwent β^- decay to form the calcium nuclide?

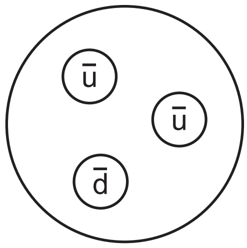
	nucleon number	proton number
A	41	19
B	41	21
C	42	19
D	42	21

40 Which diagram represents the structure of an antineutron?

A



B



key

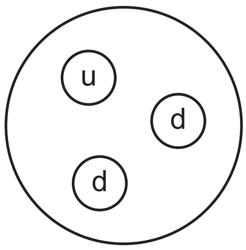
u up quark

d down quark

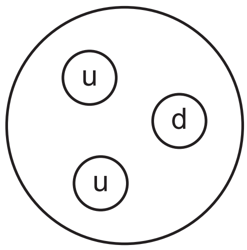
$\bar{u}$ up antiquark

$\bar{d}$ down antiquark

C



D



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Cambridge International AS & A Level

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PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2016**

1 hour 15 minutes

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, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

IB16 11_9702_13/FP

CAMBRIDGE
International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is the order of magnitude of the Young modulus for a metal such as copper?

A 10^{-11} Pa **B** 10^{-4} Pa **C** 10^{4} Pa **D** 10^{11} Pa

2 The force F between two point charges q_1 and q_2, a distance r apart, is given by the equation

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

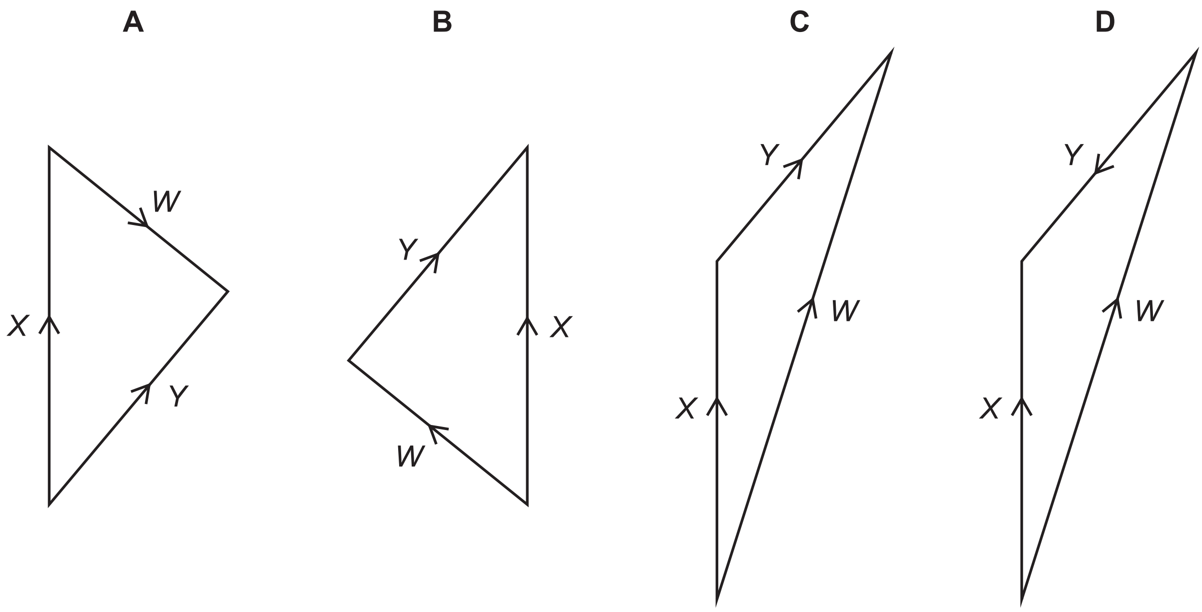
where k is a constant.

What are the SI base units of k?

A $\mathrm{kg\,m^3\,s^{-4}\,A^2}$ **B** $\mathrm{kg\,m^3\,s^{-4}\,A^{-2}}$ **C** $\mathrm{kg\,m^3\,A^2}$ **D** $\mathrm{kg\,m^3\,A^{-2}}$

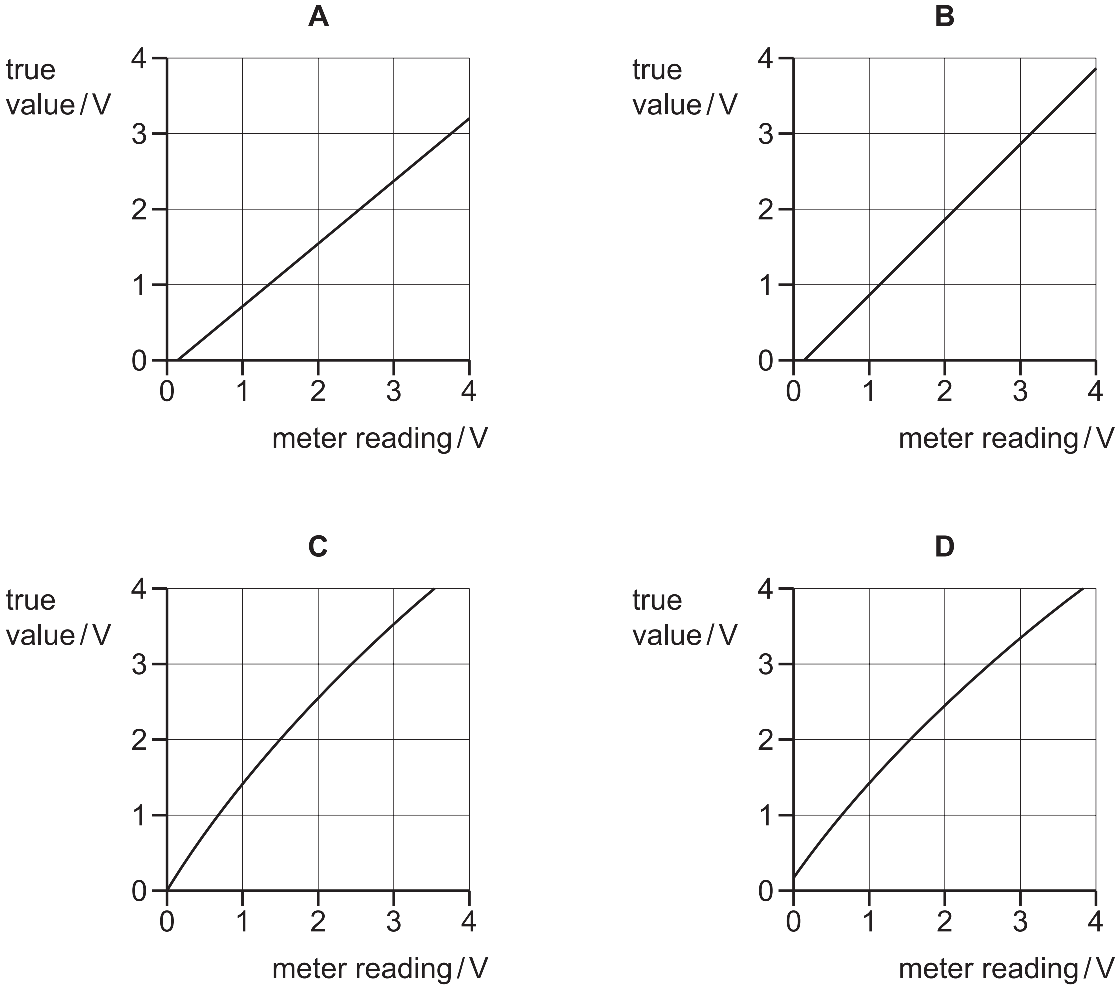
3 An aeroplane can fly at a velocity X when moving through still air. When flying in wind the aeroplane's velocity relative to the ground is Y.

Which vector diagram shows the magnitude and direction of the wind velocity W?

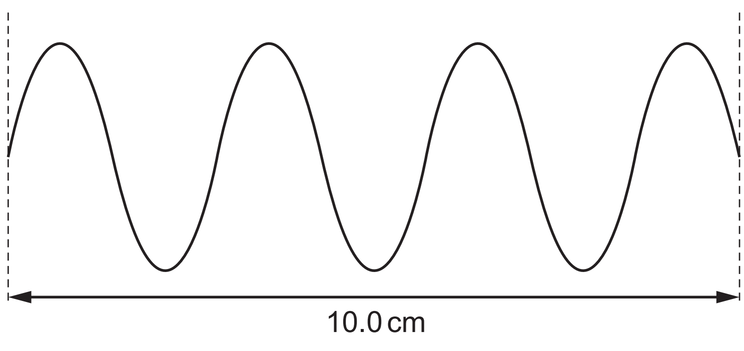


4 A voltmeter gives readings that are larger than the true values and has a systematic error that varies with voltage.

Which graph shows the calibration curve for the voltmeter?



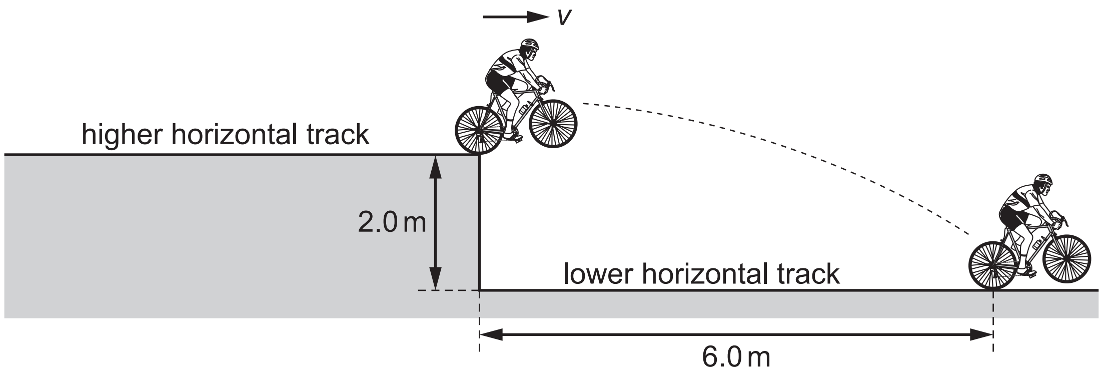
5 A student uses a cathode-ray oscilloscope (c.r.o.) to measure the period of a signal. She sets the time-base of the c.r.o. to $5\,\text{ms}\,\text{cm}^{-1}$ and observes the trace illustrated below. The trace has a length of 10.0 cm.



What is the period of the signal?

A 7.1×10^{-6} s **B** 1.4×10^{-5} s **C** 7.1×10^{-3} s **D** 1.4×10^{-2} s

6 A cyclist pedals along a raised horizontal track. At the end of the track, he travels horizontally into the air and onto a track that is vertically 2.0 m lower.

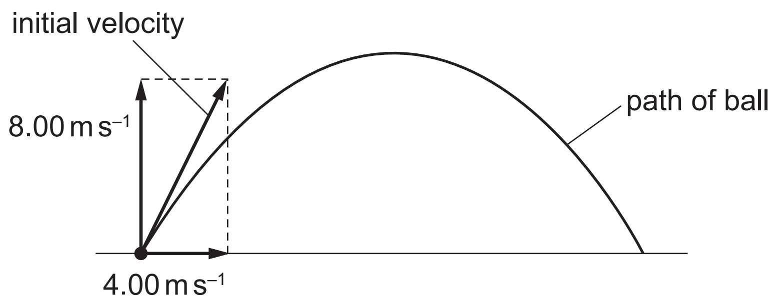


The cyclist travels a horizontal distance of 6.0 m in the air. Air resistance is negligible.

What is the horizontal velocity v of the cyclist at the end of the higher track?

A $6.3\,\text{m}\,\text{s}^{-1}$ **B** $9.4\,\text{m}\,\text{s}^{-1}$ **C** $9.9\,\text{m}\,\text{s}^{-1}$ **D** $15\,\text{m}\,\text{s}^{-1}$

7 An astronaut on the Moon, where there is no air resistance, throws a ball. The ball's initial velocity has a vertical component of $8.00\,\text{m}\,\text{s}^{-1}$ and a horizontal component of $4.00\,\text{m}\,\text{s}^{-1}$, as shown.

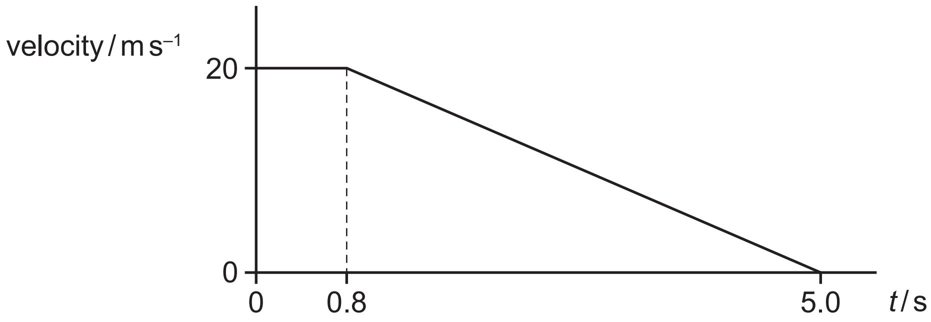


The acceleration of free fall on the Moon is $1.62\,\text{m}\,\text{s}^{-2}$.

What will be the speed of the ball 9.00 s after being thrown?

A $6.6\,\text{m}\,\text{s}^{-1}$ **B** $7.7\,\text{m}\,\text{s}^{-1}$ **C** $10.6\,\text{m}\,\text{s}^{-1}$ **D** $14.6\,\text{m}\,\text{s}^{-1}$

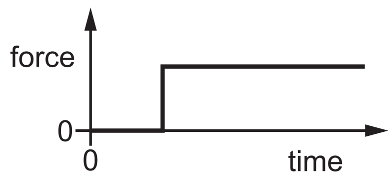
8 A car is travelling at constant velocity. At time $t = 0$, the driver of the car sees an obstacle in the road and then brakes to a halt. The graph shows the variation with t of the velocity of the car.



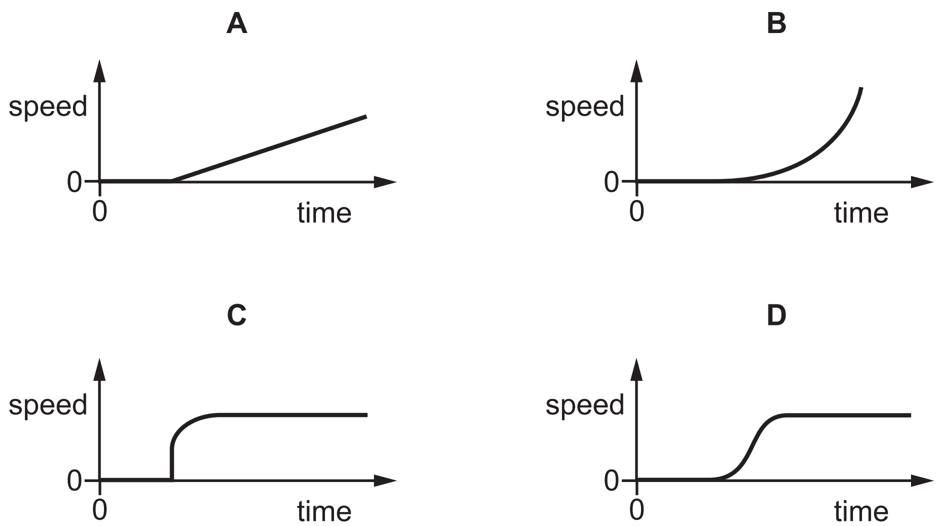
How far does the car travel in the 5.0 s after the driver sees the obstacle?

A 16 m **B** 42 m **C** 58 m **D** 84 m

9 A car is stationary at traffic lights. When the traffic lights change to green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.



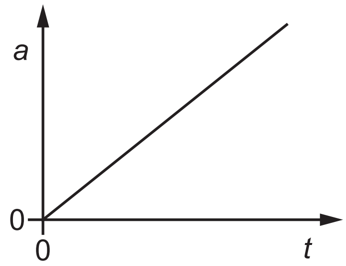
Which graph shows the variation with time of the speed of the car?



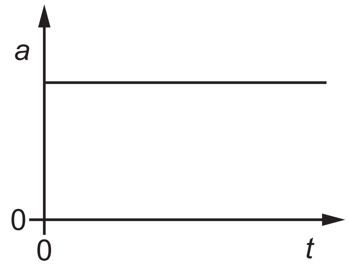
10 A beach-ball falls vertically from a high hotel window. Air resistance is **not** negligible.

Which graph shows the variation with time t of the acceleration a of the ball?

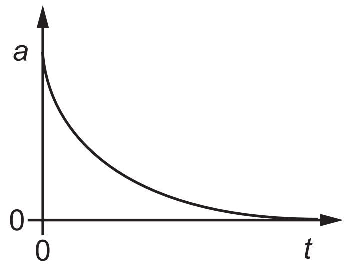
A



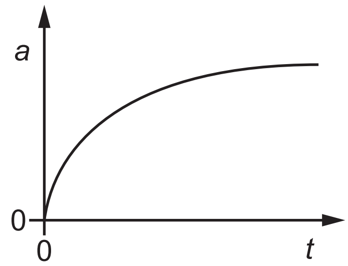
B



C



D



11 A car has mass m. A person needs to push the car with force F in order to give the car acceleration a. The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

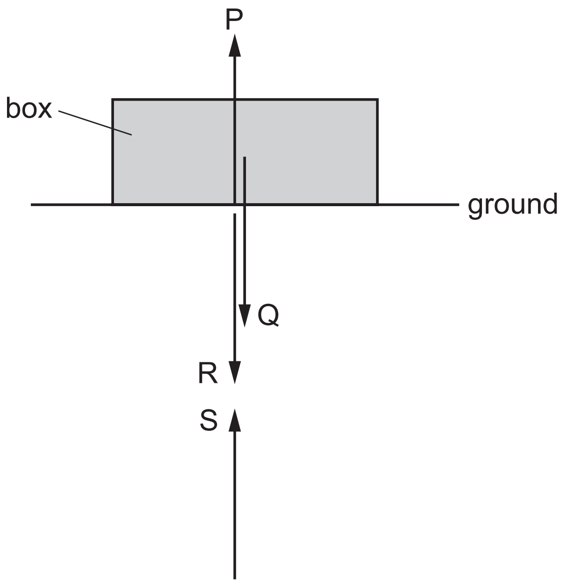
Which expression gives the constant resistive force opposing the motion of the car?

A ma **B** $2ma$ **C** $3ma$ **D** $4ma$

12 A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.

Forces P and Q act on the box. Forces R and S act on the Earth.

For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

A P is the equal and opposite force to Q and both are forces of contact.

B Q is the equal and opposite force to P and both are gravitational forces.

C R is the equal and opposite force to S and both are forces of contact.

D S is the equal and opposite force to Q and both are gravitational forces.

13 Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2.

Which collision is **not** elastic?

	u_1 / m s^{-1}	u_2 / m s^{-1}	v_1 / m s^{-1}	v_2 / m s^{-1}
A	2	–5	–5	–2
B	3	–3	0	6
C	3	–2	1	6
D	5	2	3	6

14 A submarine has circular windows of diameter 0.30 m. The windows can experience a maximum external pressure of 660 kPa before they crack.

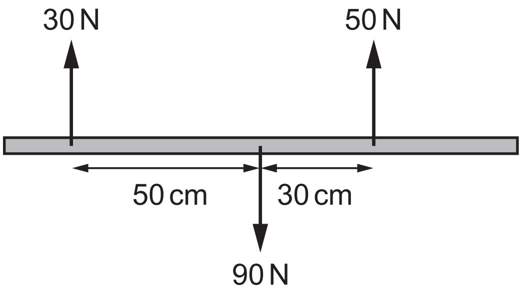
What is the minimum external force needed to crack the windows?

A 47 000 N **B** 190 000 N **C** 310 000 N **D** 620 000 N

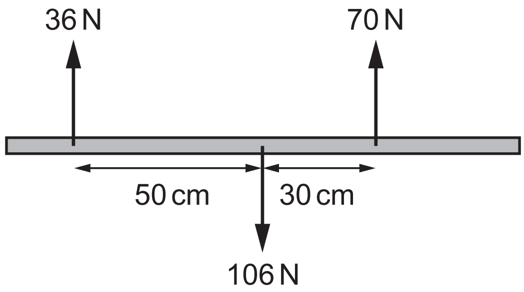
15 Four beams of the same length each have three forces acting on them.

Which beam has both zero resultant force and zero resultant torque acting?

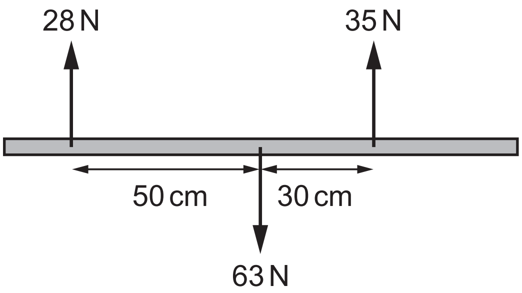
A



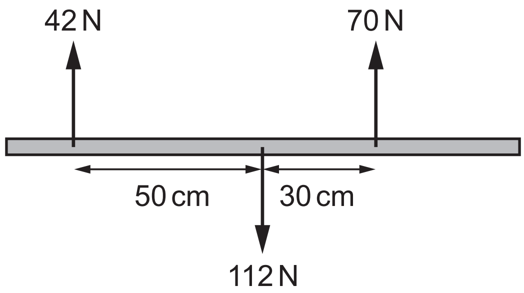
B



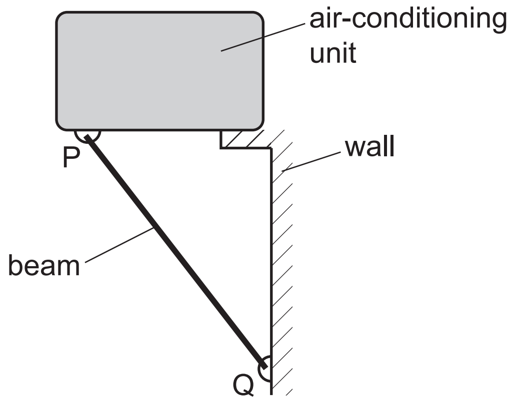
C



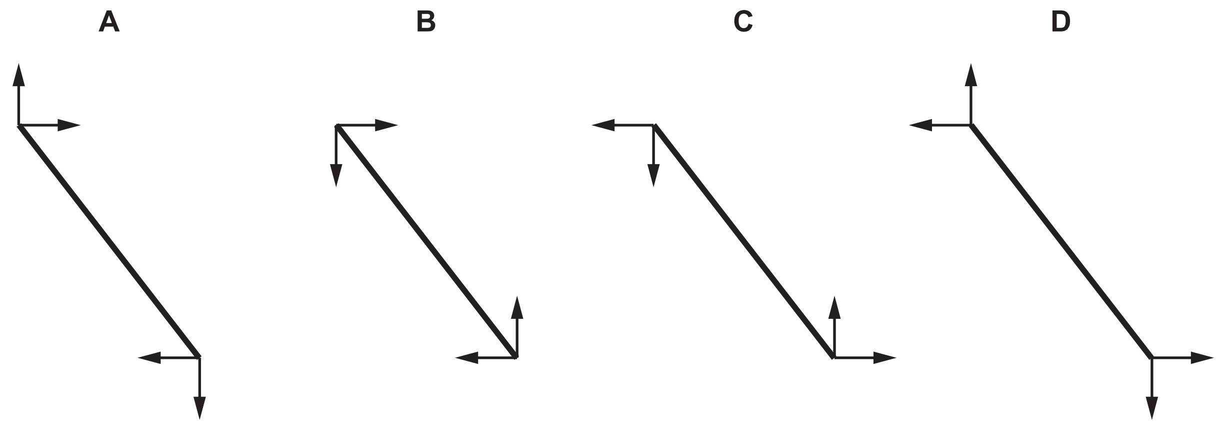
D



16 An air-conditioning unit is supported by a rigid beam PQ, as shown.



Which diagram shows the directions of the horizontal and vertical forces acting on the ends of the beam?



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

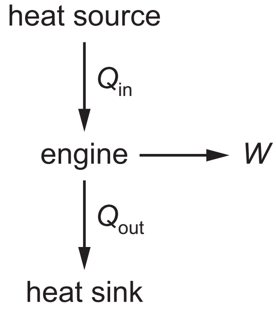
In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^{5}\,\mathrm{kg\,s^{-1}}$. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

A 5.6% **B** 43% **C** 57% **D** 68%

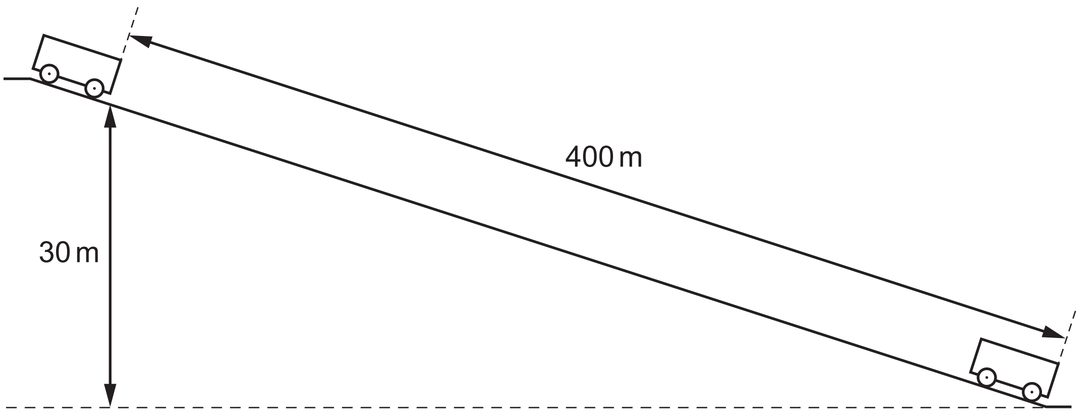
18 An engine transforms thermal energy into mechanical work. The engine takes in thermal energy Q_{in} from a heat source and gives out thermal energy Q_{out} to a heat sink, producing useful work W.



What is the efficiency of this engine?

A $\dfrac{W}{Q_{in}+Q_{out}}$ **B** $\dfrac{W}{Q_{in}-Q_{out}}$ **C** $\dfrac{W}{Q_{in}}$ **D** $\dfrac{W}{Q_{out}}$

19 A truck of mass 500 kg moves from rest at the top of a section of track 400 m long and 30 m high, as shown. The frictional force acting on the truck is 250 N throughout its journey.



What is the final speed of the truck?

A $14\,\mathrm{m\,s^{-1}}$ **B** $24\,\mathrm{m\,s^{-1}}$ **C** $31\,\mathrm{m\,s^{-1}}$ **D** $190\,\mathrm{m\,s^{-1}}$

20 Which condition must apply for the work done by an expanding gas to be $p\Delta V$, where p is the pressure of the gas and ΔV is its change in volume?

A No thermal energy must be supplied to the gas.

B The expansion must be at a constant rate.

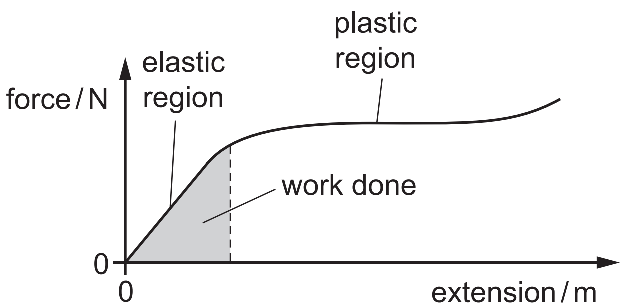
C The pressure must be constant.

D The temperature of the gas must be constant.

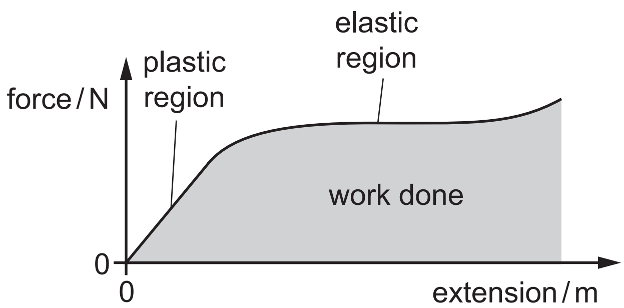
21 A metal wire is stretched to breaking point and the force-extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?

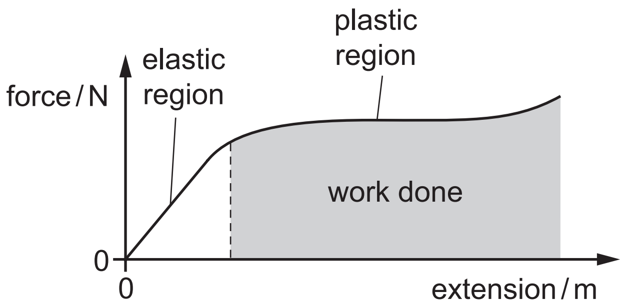
A



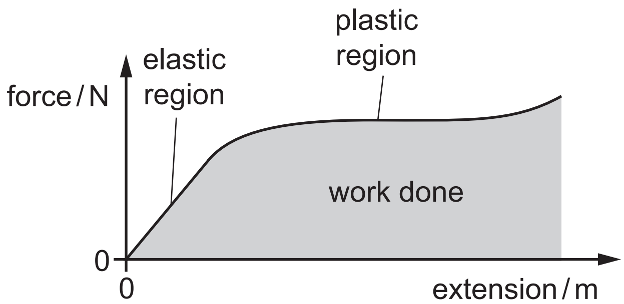
B



C



D



22 A copper wire hangs vertically from a fixed point. A load is attached to the lower end of the wire producing an extension x. The wire obeys Hooke's law.

Which single change gives an extension $2x$?

A Halve the cross-sectional area of the wire.

B Halve the diameter of the wire.

C Halve the length of the wire.

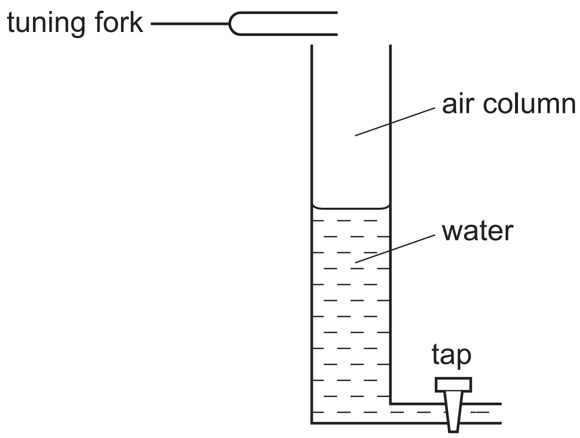
D Halve the load on the wire.

23 The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^{2} m
A	gamma ray	X-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	X-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	X-ray
D	X-ray	infra-red	ultraviolet	microwave	radio wave

24 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.

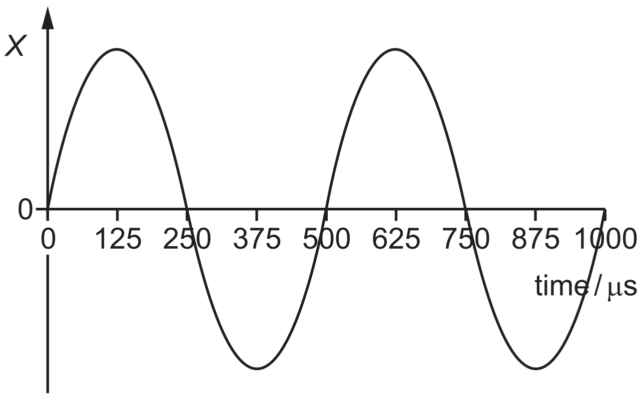


The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

What is the wavelength of the sound wave?

A 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

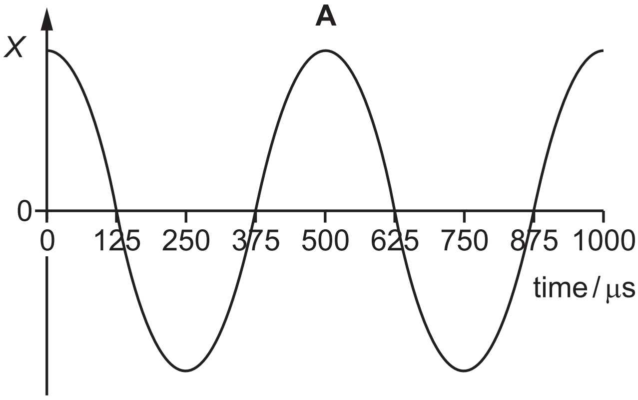
25 The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.



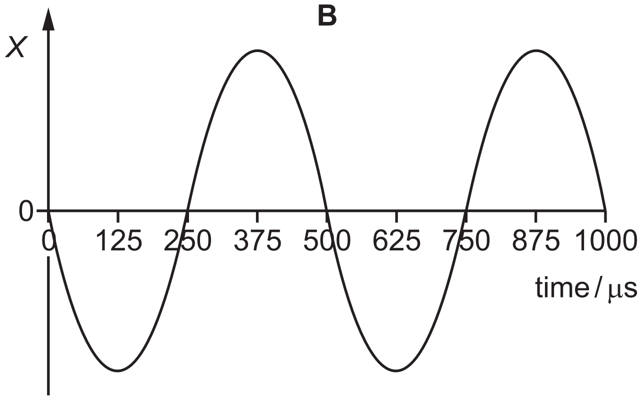
The velocity of sound in the gas is $330\,\mathrm{m\,s^{-1}}$. All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.165 m further away from the source of the sound?

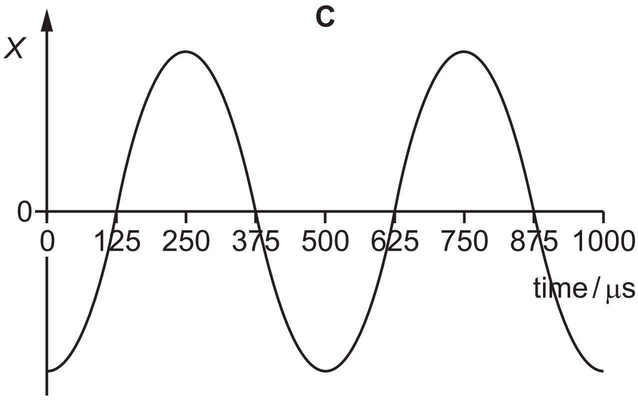
A



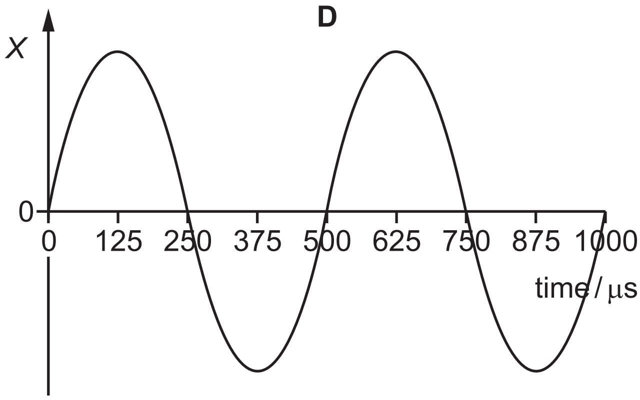
B



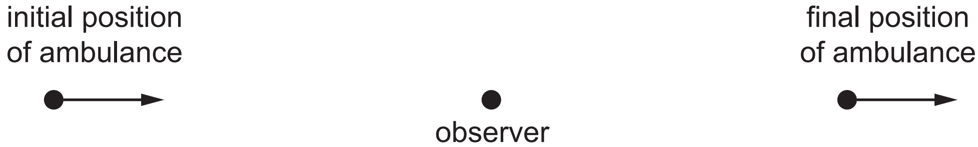
C



D



26 The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m s^{-1}. The ambulance is travelling with a constant velocity of 25 m s^{-1} towards an observer.

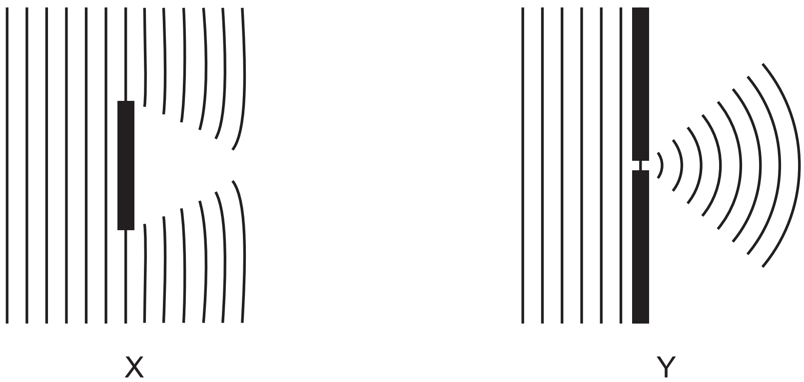


Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

A 49 Hz **B** 84 Hz **C** 91 Hz **D** 98 Hz

27 Diagrams X and Y show the passage of water waves around an obstacle and through a gap.

The thick lines are barriers to the waves and each thin line represents a wavefront.



Which statement is correct?

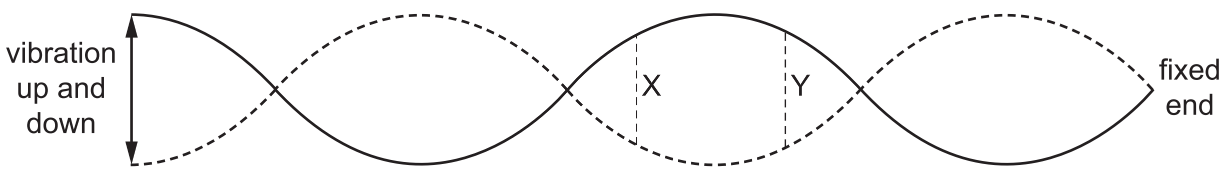
A Diagrams X and Y both illustrate diffraction.

B Diagrams X and Y both illustrate interference.

C Only diagram X illustrates interference.

D Only diagram Y illustrates diffraction.

28 The diagram shows a long rope fixed at one end. The other end is moved up and down, setting up a stationary wave.

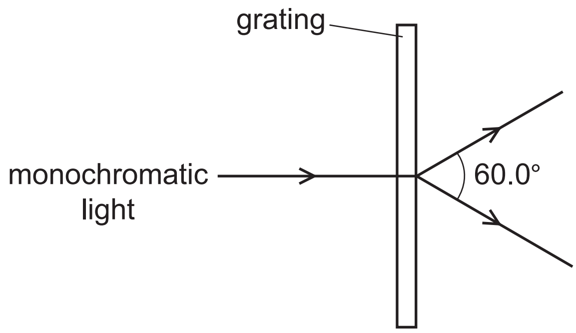


What is the phase difference between the oscillations at X and at Y?

A 0 **B** 45° **C** 90° **D** 135°

29 A diffraction grating is used to measure the wavelength of monochromatic light.

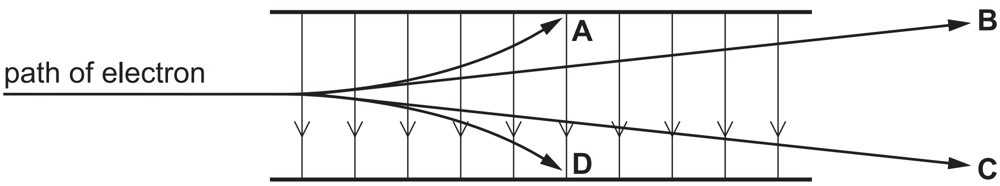
The spacing of the slits in the grating is 1.15×10^{-6} m. The angle between the first order diffraction maxima is 60.0°, as shown in the diagram.



What is the wavelength of the light?

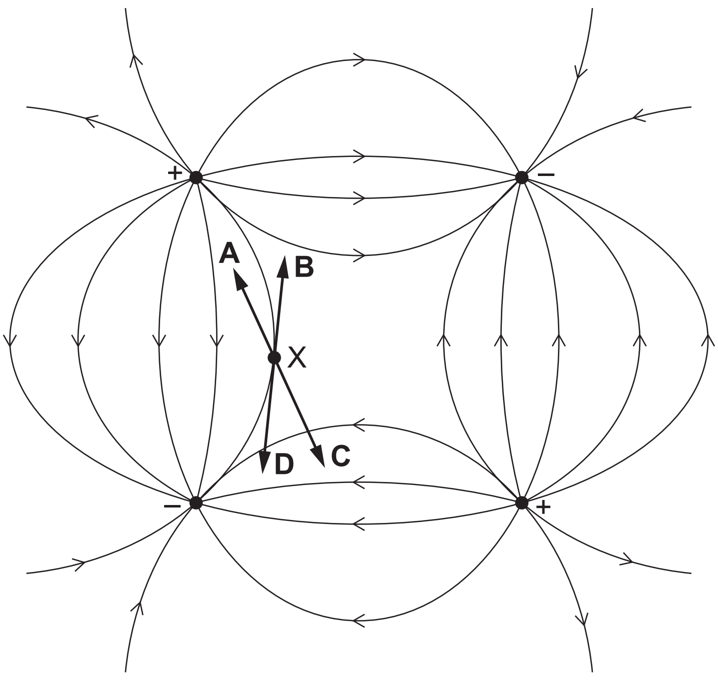
A 288 nm **B** 498 nm **C** 575 nm **D** 996 nm

30 Which path shows a possible movement of an electron in the electric field shown?

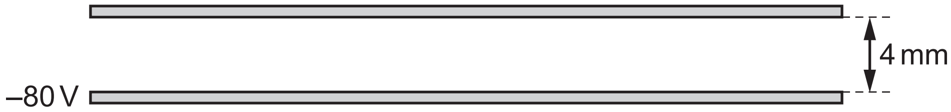


31 The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

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



32 Two large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of –80 V.



Which potential should be applied to the upper plate to create an electric field of strength 60 000 V m^{-1} upwards in the space between the plates?

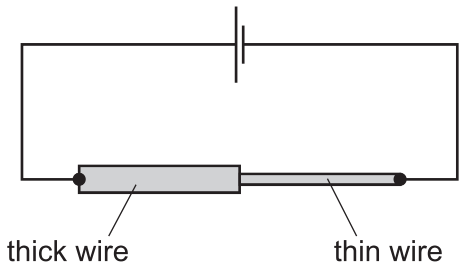
A –320 V **B** –160 V **C** +160 V **D** +320 V

33 An electric kettle is marked 3.10 kW. It is used with an electrical supply of 240 V.

What is the electric current in the kettle and what is the kettle's electrical resistance when working?

	current / A	resistance / Ω
A	0.0129	18 600
B	0.0770	3100
C	12.9	18.6
D	12.9	3100

34 A thick copper wire is connected to a thin copper wire in series with a cell, as shown.



What is significantly **less** in the thick wire than in the thin wire?

A the charge passing a point per unit time

B the drift speed of the electrons

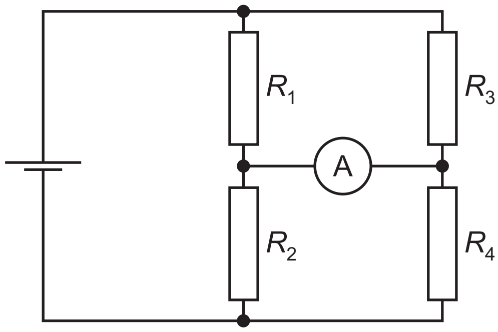
C the number density of the free electrons

D the number of free electrons passing a point per unit time

35 What is a typical value for the order of magnitude of the resistivity of copper?

A 10^{-13} Ω m **B** 10^{-8} Ω m **C** 10^{-3} Ω m **D** 10^{2} Ω m

36 In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1, R_2, R_3 and R_4.

Which equation is correct?

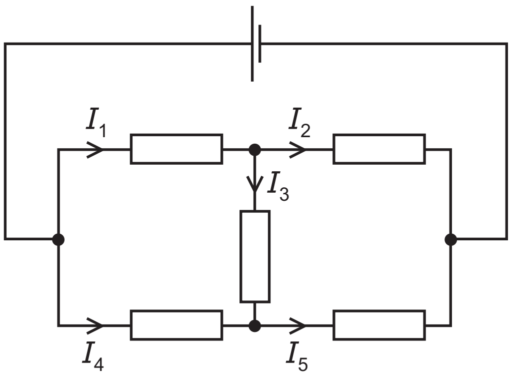
A $R_1 - R_3 = R_2 - R_4$

B $R_1 \times R_3 = R_2 \times R_4$

C $R_1 - R_4 = R_2 - R_3$

D $R_1 \times R_4 = R_2 \times R_3$

37 The diagram shows currents I_1, I_2, I_3, I_4 and I_5 in different branches of a circuit.



Which equation is correct?

A $I_1 = I_2 + I_3$

B $I_2 = I_1 + I_3$

C $I_3 = I_4 + I_5$

D $I_4 = I_5 + I_3$

38 What is a proton?

A a hadron

B a particle consisting of two down quarks and one up quark

C a positive fundamental particle

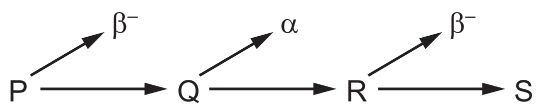
D a positive lepton

39 What are the correct descriptions of a γ-ray and a β^- particle?

	γ-ray	β^- particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	helium-4 nucleus

40 In a radioactive decay series, three successive decays each result in a particle being emitted.

The first decay results in the emission of a β^- particle. The second decay results in the emission of an α particle. The third decay results in the emission of another β^- particle.



Nuclides P and S are compared.

Which statement is correct?

A P and S are identical in all respects.

B P and S are isotopes of the same element.

C S is a different element of lower atomic number.

D S is a different element of reduced mass.

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2017**

1 hour 15 minutes

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

8916777828

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which SI unit, expressed in base units, is **not** correct?

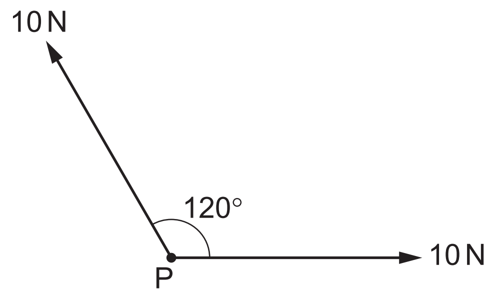
A unit of force, $kg\,m\,s^{-2}$

B unit of momentum, $kg\,m\,s^{-1}$

C unit of pressure, $kg\,m^{-2}\,s^{-2}$

D unit of work, $kg\,m^{2}\,s^{-2}$

2 Two forces, each of 10 N, act at a point P as shown. The angle between the directions of the forces is 120°.



What is the magnitude of the resultant force?

A 5 N **B** 10 N **C** 17 N **D** 20 N

3 An ion is accelerated in a vacuum by a series of electrodes. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

A the average force on the ion

B the change in kinetic energy of the ion

C the change in momentum of the ion

D the change in velocity of the ion

4 What is a typical value of the wavelength of a microwave travelling in a vacuum?

A 3 000 000 pm

B 30 nm

C 30 000 μm

D 3000 mm

5 A double-slit interference experiment is used to determine the wavelength of light from a monochromatic source.

The following measurements are used.

slit separation $a = 0.50 \pm 0.02\,\text{mm}$

fringe separation $x = 1.7 \pm 0.1\,\text{mm}$

distance between slits and screen $D = 2.000 \pm 0.002\,\text{m}$

What is the percentage uncertainty in the calculated wavelength?

A 0.1% **B** 1% **C** 6% **D** 10%

6 In still air, a bird can fly at a speed of $10\,\text{m}\,\text{s}^{-1}$. The wind is blowing from the east at $8.0\,\text{m}\,\text{s}^{-1}$.

In which direction must the bird fly in order to travel to a destination that is due north of the bird's current location?

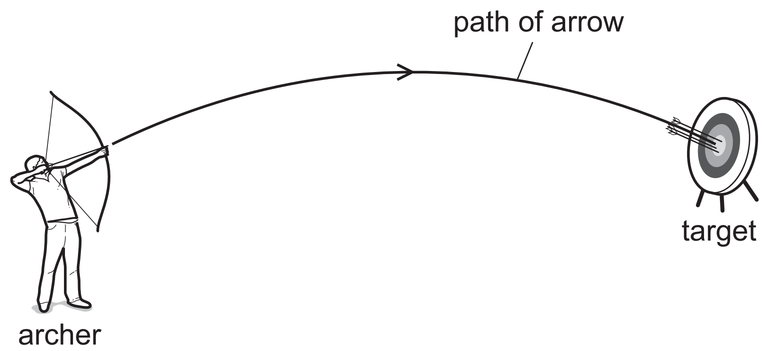
A 37° east of north

B 37° west of north

C 53° east of north

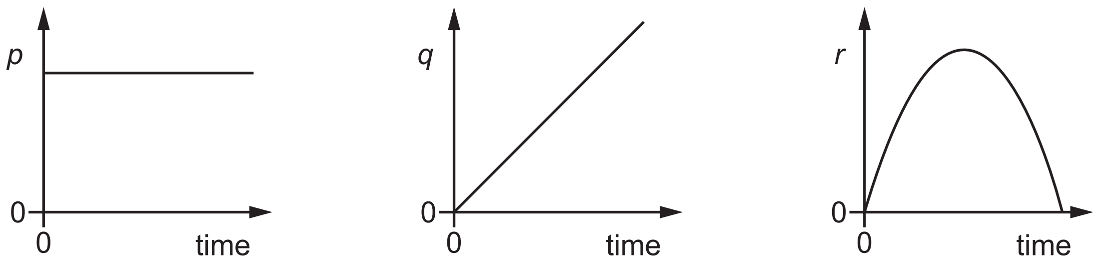
D 53° west of north

7 An archer shoots an arrow at a target. The diagram shows the path of the arrow.



Air resistance is assumed to be negligible.

The graphs show how three different quantities p, q and r, relating to the motion of the arrow, vary with time.



Which quantity is the horizontal component of displacement and which quantity is the vertical component of displacement of the arrow?

	horizontal component of displacement	vertical component of displacement
A	p	q
B	q	r
C	r	p
D	r	q

8 The three forces acting on a hot-air balloon that is moving vertically are its weight, the force due to air resistance and the upthrust force.

The hot-air balloon descends vertically at constant speed. The force of air resistance on the balloon is F.

Which weight of material must be released from the balloon so that it ascends vertically at the same constant speed?

A F **B** $2F$ **C** $3F$ **D** $4F$

9 A car is moving at constant speed in a straight line with the engine providing a driving force equal to the resistive force F.

When the engine is switched off, the car is brought to rest in a distance of 100 m by the resistive force.

It may be assumed that F is constant during the deceleration.

The process is then repeated for the same car with the same initial speed but with a constant resistive force of 0.800 F.

How far will the car travel while decelerating?

A 120 m **B** 125 m **C** 156 m **D** 250 m

10 What is a statement of the principle of conservation of momentum?

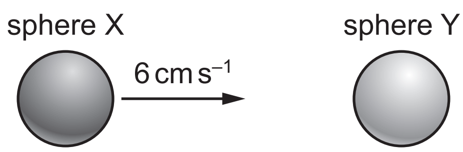
A In an elastic collision momentum is constant.

B Momentum is the product of mass and velocity.

C The force acting on a body is proportional to its rate of change of momentum.

D The momentum of an isolated system is constant.

11 Two solid spheres form an isolated system. Sphere X moves with speed 6 cm s^{-1} in a straight line directly towards a stationary sphere Y, as shown.



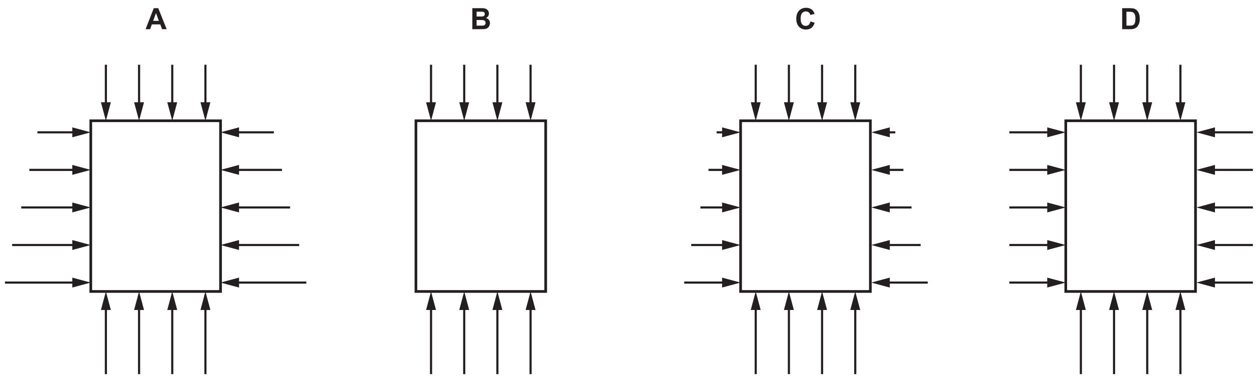
The spheres have a perfectly elastic collision. After the collision, sphere X moves with speed 2 cm s^{-1} in the same direction as before the collision.

What is the speed of sphere Y?

A 2 cm s^{-1} **B** 4 cm s^{-1} **C** 6 cm s^{-1} **D** 8 cm s^{-1}

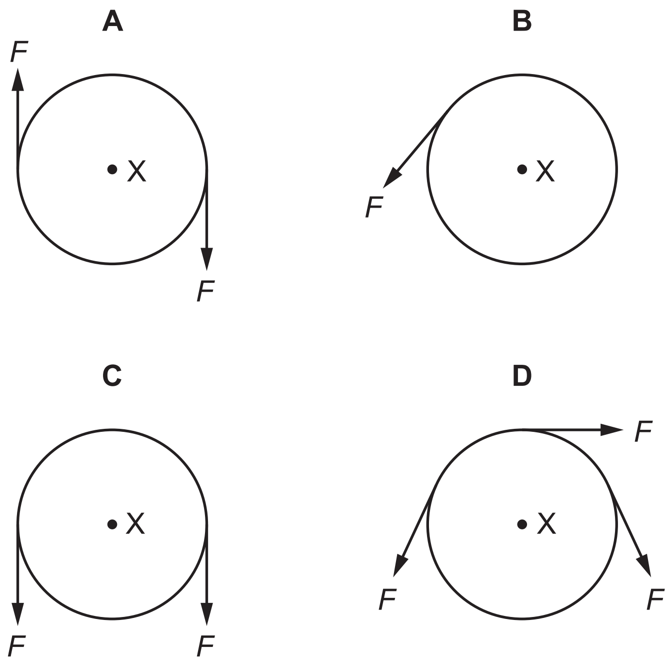
12 A block is submerged vertically in a liquid. The four diagrams show, to scale, the forces exerted by the liquid on the block.

Which diagram correctly shows a possible situation as viewed from the side?

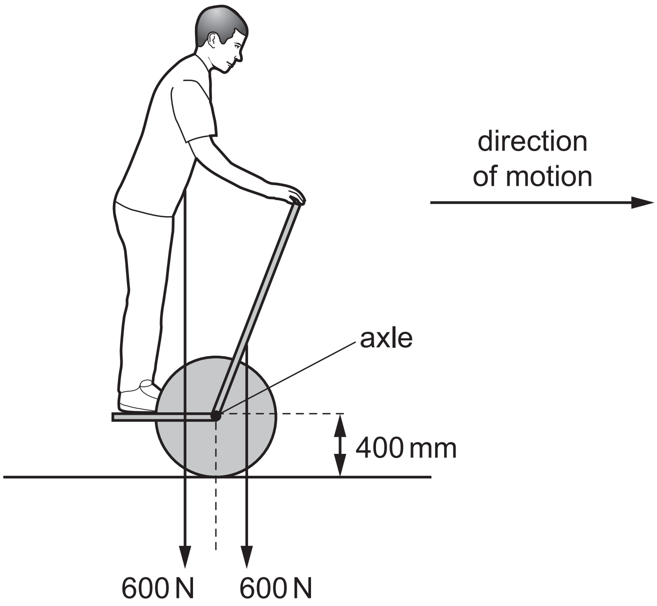


13 A rigid circular disc of radius r has its centre at X. A number of forces of equal magnitude F act at the edge of the disc. All the forces are in the plane of the disc.

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



14 The diagram shows a motorised vehicle for carrying one person.



The vehicle has two wheels on one axle. The passenger stands on a platform between the wheels.

The weight of the machine is 600 N. Its centre of mass is 200 mm in front of the axle. The wheel radius is 400 mm.

When stationary, a passenger of weight 600 N stands with his centre of mass 200 mm behind the axle to balance the machine.

The motor is now switched on to provide a horizontal force of 90 N at the ground to move the vehicle forwards.

How far and in which direction must the passenger move his centre of mass to maintain balance?

A 60 mm backwards

B 60 mm forwards

C 140 mm backwards

D 140 mm forwards

15 The derivation of the pressure equation $\Delta p = \rho g \Delta h$ uses a number of relationships between quantities.

Which relationship is **not** used in the derivation of this equation?

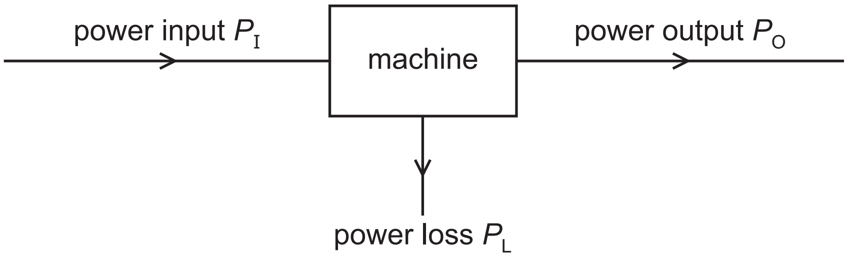
A density = $\dfrac{\text{mass}}{\text{volume}}$

B potential energy = mass × acceleration of free fall × height

C pressure = $\dfrac{\text{force}}{\text{area}}$

D weight = mass × acceleration of free fall

16 Power is transferred through a machine as shown.



What is the efficiency of the machine?

A $\dfrac{P_I}{P_O + P_L}$ **B** $\dfrac{P_L}{P_I}$ **C** $\dfrac{P_L}{P_O}$ **D** $\dfrac{P_O}{P_I}$

17 A piston in a gas supply pump has an area of $400\,cm^2$. The pump moves the gas against a fixed pressure of 3000 Pa.

During part of its stroke, the piston moves a distance of 25 cm in one direction. How much work is done by the piston during this movement?

A 30 J **B** 3.0×10^3 J **C** 3.0×10^5 J **D** 3.0×10^7 J

18 A stone is projected vertically upwards from the ground at an initial speed of $15\,m\,s^{-1}$. Air resistance is negligible.

What is the maximum height reached by the stone?

A 0.76 m **B** 11 m **C** 23 m **D** 110 m

19 A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of $340\,m^3$ per minute.

The overall efficiency of the turbine and generator system is 90%.

What is the output power of the power station? (The density of water is $1000\,kg\,m^{-3}$.)

A 0.15 MW **B** 1.5 MW **C** 1.7 MW **D** 90 MW

20 A spring is loaded with weights. When the weights are removed, the spring returns to its original length.

The spring is then loaded with heavier weights. When the weights are removed, the spring is longer than it was originally.

Which types of deformation are shown by this experiment?

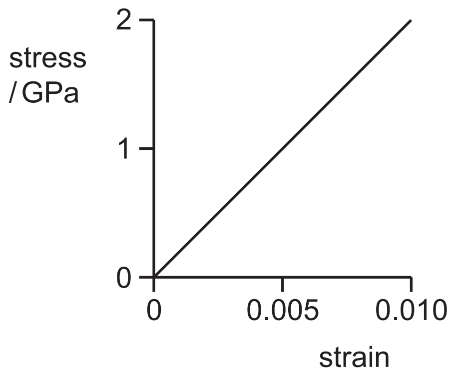
A both elastic and plastic deformation

B elastic deformation only

C neither elastic nor plastic deformation

D plastic deformation only

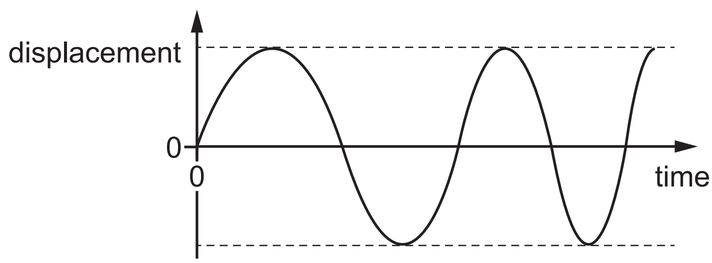
21 The stress-strain graph for a metal is shown.



What is the strain energy per unit volume of a rod made from this metal when the strain of the rod is 0.010?

A $10\,\text{kJ}\,\text{m}^{-3}$ **B** $100\,\text{kJ}\,\text{m}^{-3}$ **C** $1.0\,\text{MJ}\,\text{m}^{-3}$ **D** $10\,\text{MJ}\,\text{m}^{-3}$

22 The displacement-time graph for a layer of air in the path of a sound wave is shown.



Which wave quantity is increasing?

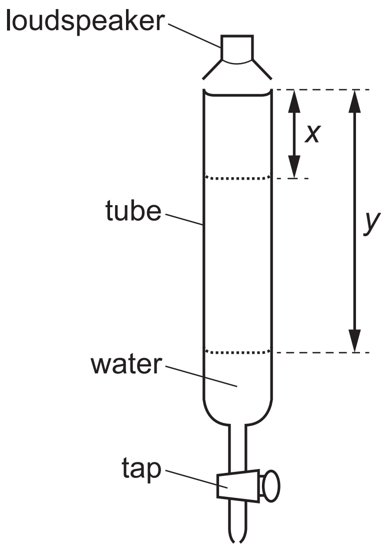
A amplitude

B frequency

C period

D wavelength

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** $4(y - x)$

24 Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size.

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

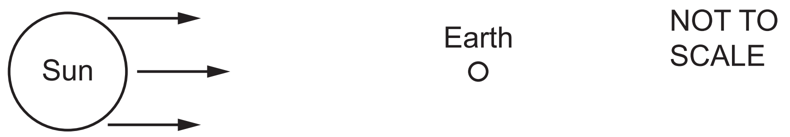
A microwaves passing a steel post

B radio waves passing a copper wire

C sound waves passing a human hair

D visible light waves passing a gate post

25 Light of a particular wavelength λ_s is emitted from the Sun. At any instant, a band of wavelengths ranging from less than λ_s to more than λ_s is observed on the Earth. This is caused by the Doppler effect.



What could be the explanation for this Doppler effect?

A The Sun is moving at right-angles to a line joining the Sun and the Earth.

B The Sun is moving away from the Earth.

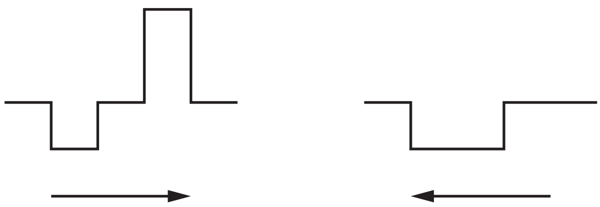
C The Sun is moving towards the Earth.

D The Sun is rotating.

26 What is the order of magnitude of the frequencies of electromagnetic waves in the visible spectrum?

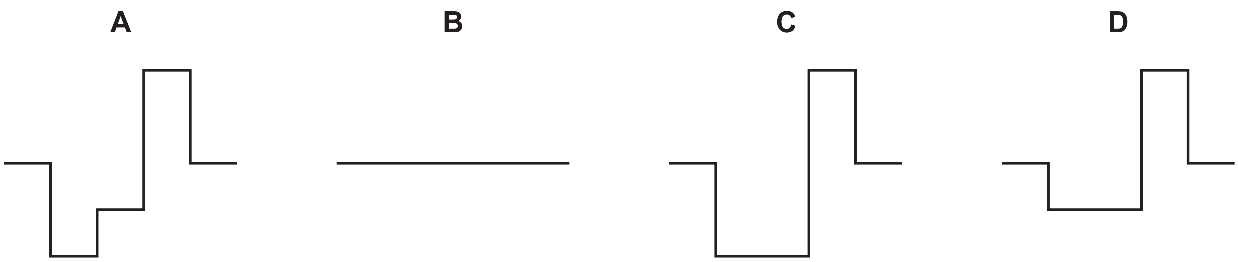
A 10^{10} Hz **B** 10^{12} Hz **C** 10^{14} Hz **D** 10^{16} Hz

27 Two signals approach each other, as shown.

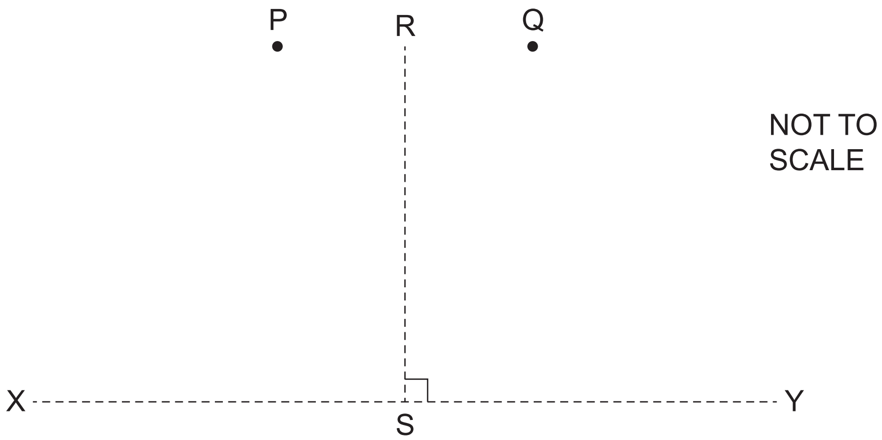


At one instant, the signals completely overlap.

According to the principle of superposition, what is the shape of the resulting signal at this instant?



28 Coherent waves are produced at P and at Q and travel outwards in all directions. The line RS is half-way between P and Q and perpendicular to the line joining P and Q. The distance RS is much greater than the distance PQ.



Along which of the lines shown is an interference pattern observed?

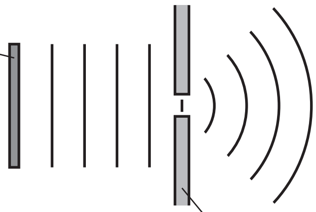
A both RS and XY

B RS only

C XY only

D neither RS nor XY

29 A bar vibrates with frequency f to produce water waves in a ripple tank.

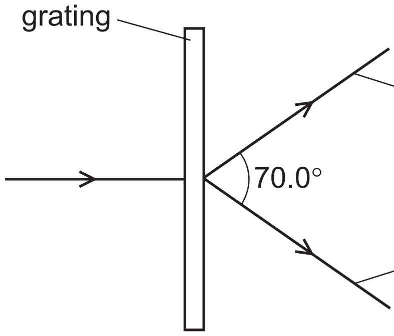


The waves pass through a gap of width x in a barrier so that diffraction occurs.

Which combination of vibration frequency and gap width will produce the smallest angle of diffraction?

	vibration frequency	gap width
A	$\frac{f}{2}$	$\frac{x}{2}$
B	$\frac{f}{2}$	$2x$
C	$2f$	$\frac{x}{2}$
D	$2f$	$2x$

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

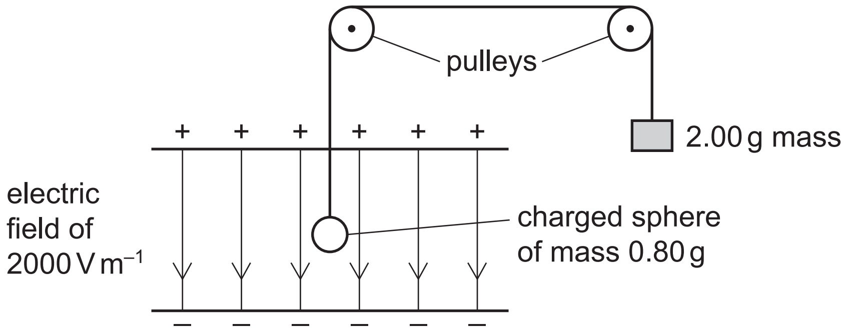


The spacing of the slits in the grating is 1.00×10^{-6} m. The angle between the first order diffraction maxima is 70.0°.

What is the wavelength of the light?

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

31 A small charged sphere of mass 0.80 g hangs from a light thread inside a vertical uniform electric field of strength 2000 V m^{-1}. The thread passes over two frictionless pulleys and a mass of 2.00 g hangs on the other end.

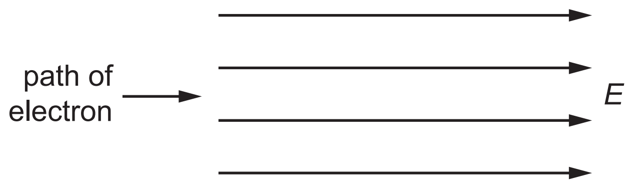


The sphere is in equilibrium.

What is the charge on the sphere?

A –5.9 μC **B** +0.60 μC **C** +5.9 μC **D** +9.8 μC

32 An electron enters a region of space where there is a uniform electric field *E* as shown.

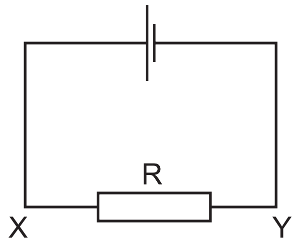


Initially, the electron is moving parallel to, and in the direction of, the electric field.

What is the subsequent path and change of speed of the electron caused by the electric field?

	path of electron	speed of electron
A	curved	decreases
B	curved	increases
C	linear	decreases
D	linear	increases

33 The current in the circuit shown is 3.2 mA.



What are the direction of flow and the rate of flow of electrons through the resistor R?

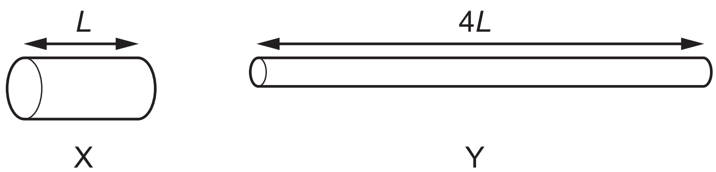
	direction of flow	rate of flow / s^{-1}
A	X to Y	2.0×10^{16}
B	X to Y	5.1×10^{-22}
C	Y to X	2.0×10^{16}
D	Y to X	5.1×10^{-22}

34 A filament lamp has a resistance of 180 Ω when the current in it is 500 mA.

What is the power dissipated in the lamp?

A 45 W **B** 90 W **C** 290 W **D** 360 W

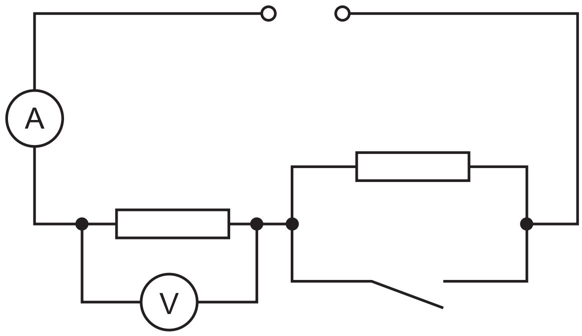
35 Two copper wires X and Y have the same volume. Wire Y is four times as long as wire X.



What is the ratio $\dfrac{\text{resistance of wire Y}}{\text{resistance of wire X}}$?

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

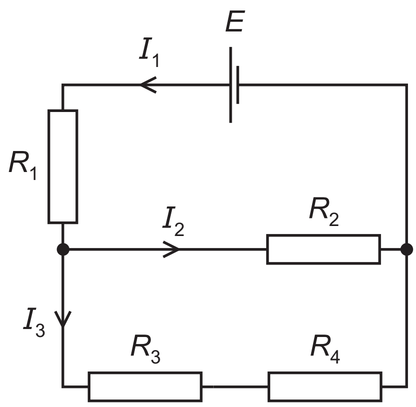
36 In the circuit shown, the ammeter reading is I and the voltmeter reading is V.



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

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

37 A cell of electromotive force E and negligible internal resistance is connected to a network of resistors of resistances R_1, R_2, R_3 and R_4 as shown.



The branches of the circuit have currents I_1, I_2 and I_3.

Which equation is correct?

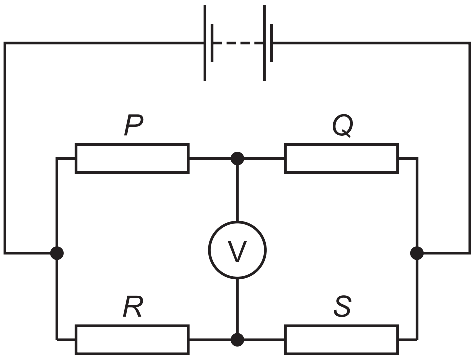
A $I_1R_1 + I_2R_2 = I_3R_3 + I_3R_4$

B $I_2R_2 - I_3R_4 - I_3R_3 = 0$

C $E = I_1R_1 + I_2R_2 + I_3R_3 + I_3R_4$

D $E = I_1R_1 + I_2R_2 - I_3R_3 - I_3R_4$

38 The circuit diagram shows four resistors of different resistances P, Q, R and S connected to a battery.



The voltmeter reading is zero.

Which equation is correct?

A $P - Q = R - S$

B $P - S = Q - R$

C $PQ = RS$

D $PS = QR$

39 An astatine nucleus has a nucleon number of 218 and a proton number of 85. It decays to form a polonium nucleus, emitting a β^- particle and an α-particle in the process.

What are the nucleon number and the proton number of this polonium nucleus?

	nucleon number	proton number
A	214	83
B	214	84
C	215	83
D	216	82

40 What is the quark composition of a hydrogen-3 nucleus, ${}^{3}_{1}H$?

	number of quarks	
	up	down
A	4	5
B	5	4
C	5	7
D	7	5

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

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PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2017**

1 hour 15 minutes

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

7470697625

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **20** printed pages.

IB17 11_9702_12/2RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which pair of units are **not** the same when expressed in SI base units?

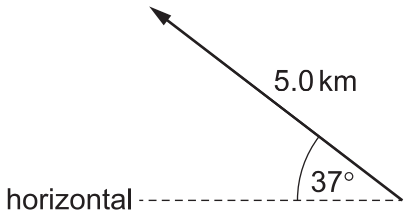
A $\mathrm{m\,s^{-2}}$ and $\mathrm{N\,kg^{-1}}$

B $\mathrm{N\,s}$ and $\mathrm{kg\,m\,s^{-1}}$

C Pa and $\mathrm{N\,m^{-2}}$

D $\mathrm{V\,m^{-2}}$ and $\mathrm{N\,C^{-1}}$

2 What is the vertical component of this displacement vector?



A 3.0 km **B** 3.8 km **C** 4.0 km **D** 5.0 km

3 The units of specific heat capacity are $\mathrm{J\,kg^{-1}\,K^{-1}}$.

What are the SI base units of specific heat capacity?

A $\mathrm{m\,s^{-2}\,K^{-1}}$ **B** $\mathrm{m\,s^{-1}\,K^{-1}}$ **C** $\mathrm{m^2\,s^{-2}\,K^{-1}}$ **D** $\mathrm{m^2\,s^{-1}\,K^{-1}}$

4 A quantity y is to be determined from the equation shown.

$$y = \frac{px}{q^2}$$

The percentage uncertainties in p, x and q are shown.

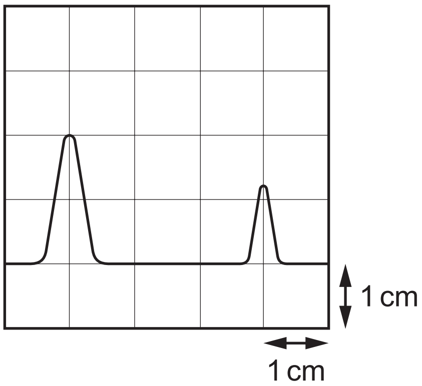
	percentage uncertainty
p	6%
x	2%
q	4%

What is the percentage uncertainty in y?

A 0.5% **B** 0.75% **C** 12% **D** 16%

5 A transmitter emits a pulse of electromagnetic waves towards a reflector. The pulse is reflected and returns to the transmitter.

A detector is located at the transmitter. The emitted pulse and the reflected pulse are displayed on a cathode-ray oscilloscope (c.r.o.) as shown.



The pulse takes 6.3 μs to travel from the transmitter to the reflector.

What is the time-base setting of the c.r.o.?

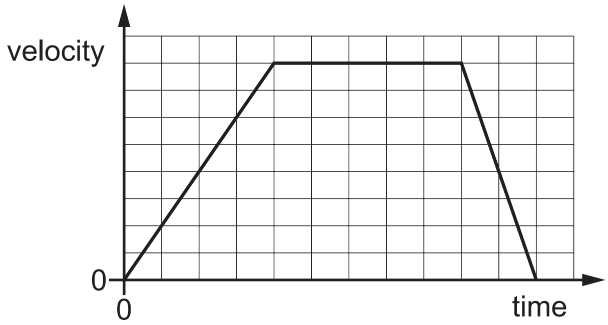
A 2.1 $\mu s\,cm^{-1}$ **B** 3.2 $\mu s\,cm^{-1}$ **C** 4.2 $\mu s\,cm^{-1}$ **D** 6.3 $\mu s\,cm^{-1}$

6 A hot-air balloon is moving vertically upwards with a constant speed of 3.00 $m\,s^{-1}$. A sandbag is dropped from the balloon. It takes 5.00 s for the sandbag to fall to the ground.

What was the height of the balloon when the sandbag was released?

A 29 m **B** 108 m **C** 123 m **D** 138 m

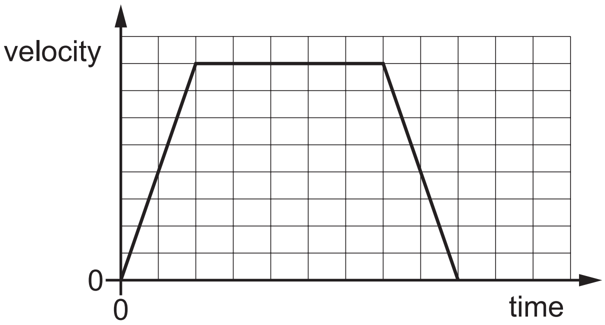
7 The velocity-time graph for a train starting at one station and stopping at the next is shown.



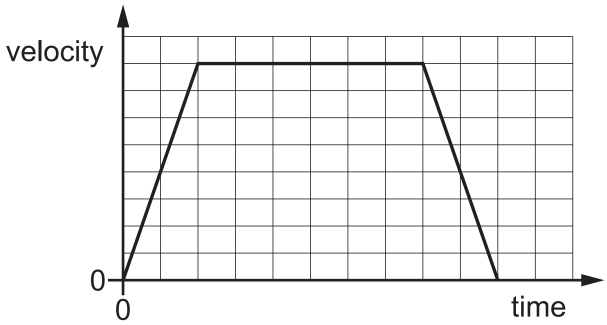
Another train has double the acceleration but the same maximum speed and the same deceleration.

Which velocity-time graph, on the same scale, shows the motion of this train between the same stations?

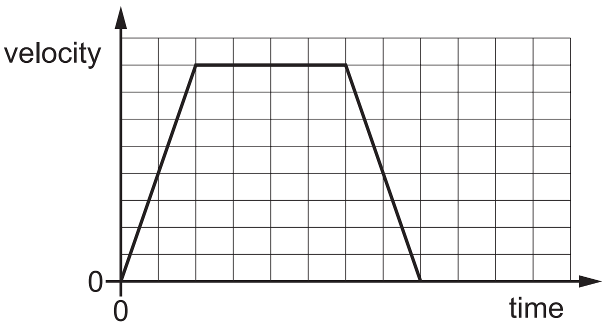
A



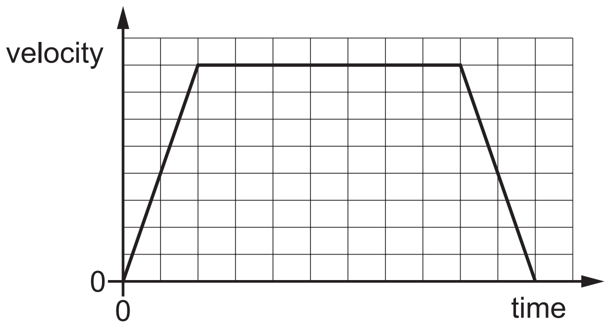
B



C

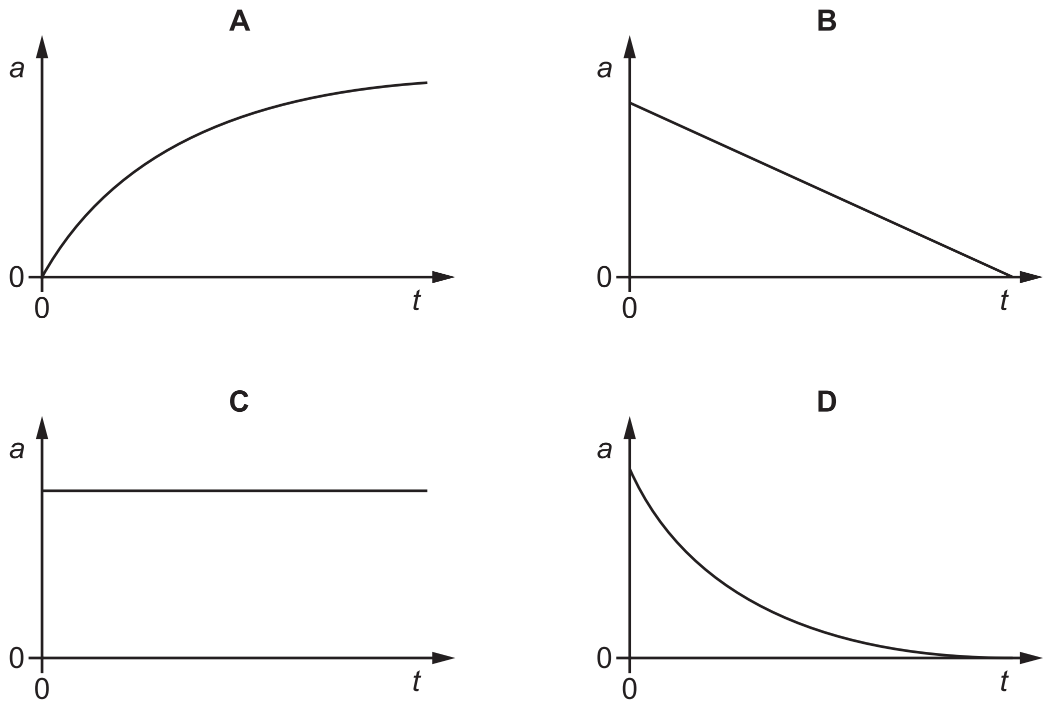


D



8 A stone is released from rest and falls a long distance in air.

Which graph could show the variation with time t of the acceleration a of the stone?



9 A slow vehicle and a fast vehicle travel towards each other in a straight line and then collide.

Which outcome is **never** possible, regardless of the masses of the vehicles?

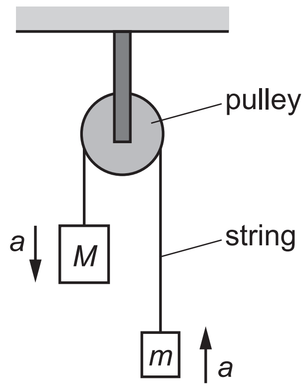
A Both vehicles stop.

B Only one vehicle stops.

C The fast vehicle's speed increases.

D The slow vehicle's speed increases.

10 Two blocks of masses M and m are joined by a thin string which passes over a frictionless pulley, as shown.

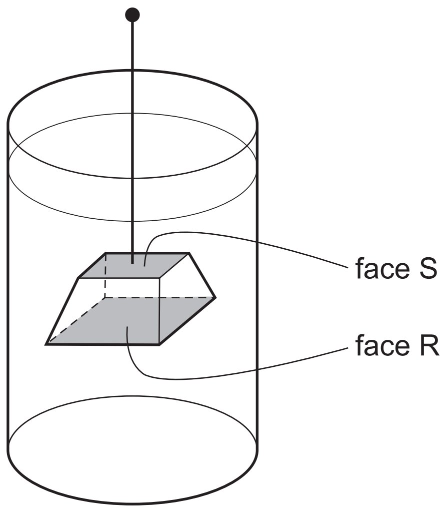


The acceleration of free fall is g.

What is the acceleration a of the two blocks?

A $\dfrac{(M+m)}{(M-m)}g$ **B** $\dfrac{(M-m)}{(M+m)}g$ **C** $\dfrac{M}{m}g$ **D** $\dfrac{m}{M}g$

11 The diagram shows a block of copper suspended in water.



The block experiences an upthrust from the water.

Which statement is the basis of an explanation for this upthrust?

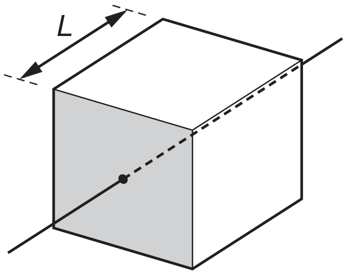
A Copper is more dense than water.

B The area of face R is greater than the area of face S.

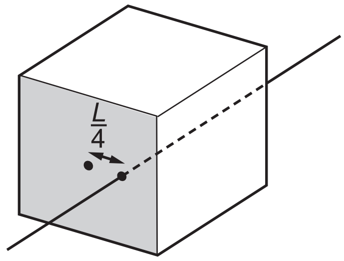
C The density of water increases with depth.

D The pressure of water increases with depth.

12 The diagram shows a solid cube with weight W and sides of length L. It is supported at rest 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 keep the cube at rest?

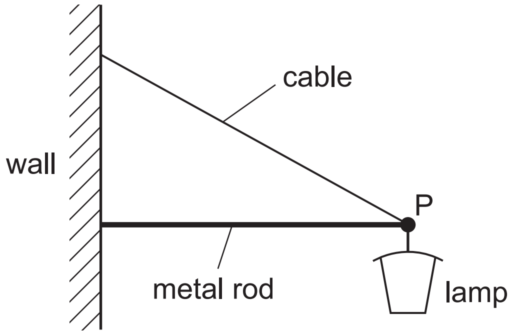
A $\frac{WL}{4}$ anticlockwise

B $\frac{WL}{4}$ clockwise

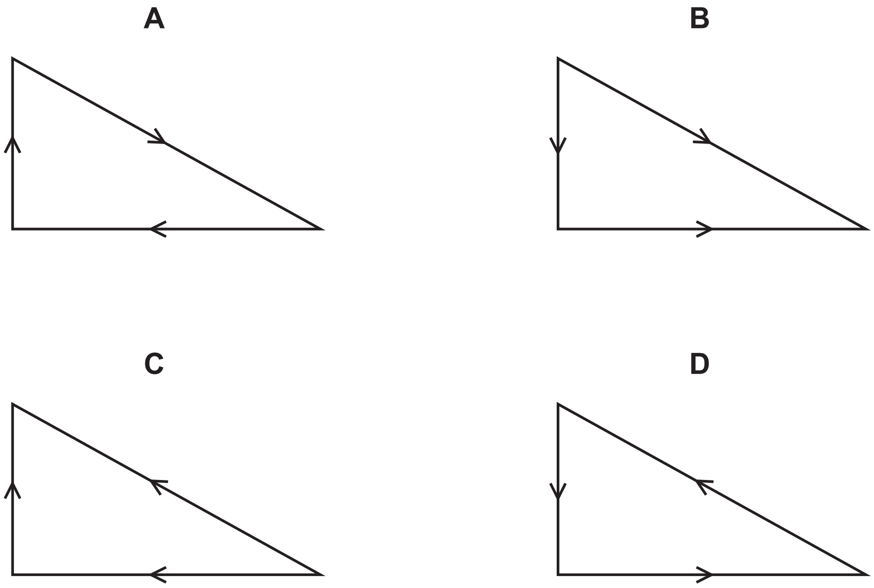
C $\frac{WL}{2}$ anticlockwise

D $\frac{WL}{2}$ clockwise

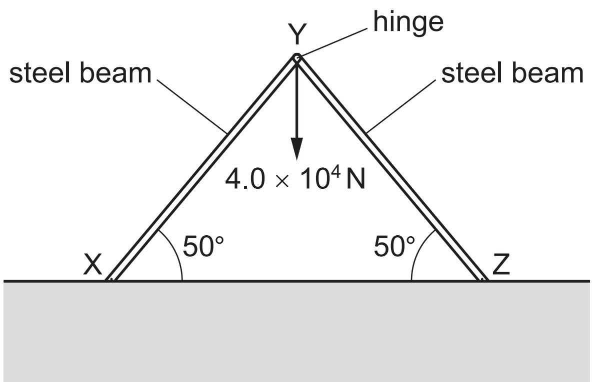
13 A street lamp is fixed to a wall by a metal rod and a cable.



Which vector triangle could represent the forces acting at point P?



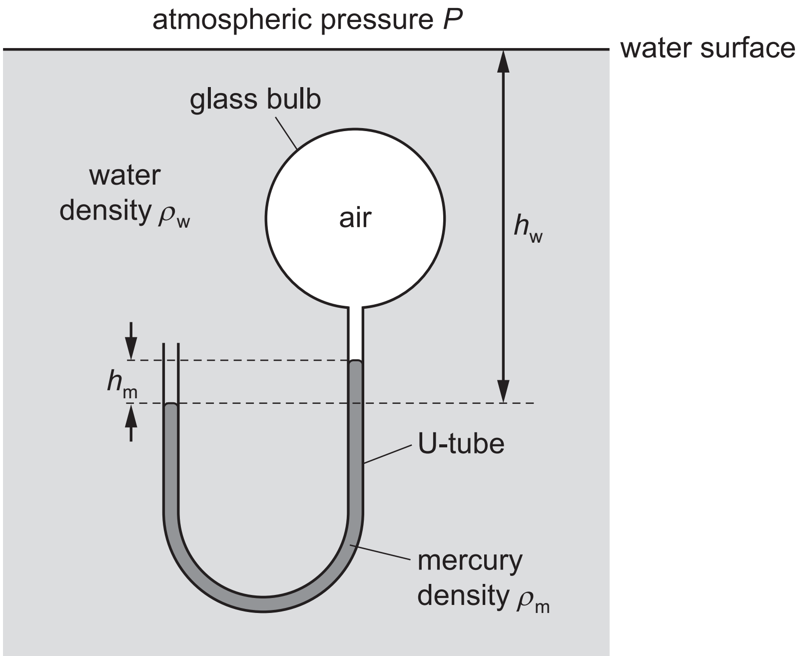
14 Two rigid steel beams XY and YZ are fixed at their lower ends and are hinged at Y. Each beam is inclined at 50° to the horizontal, as shown. A weight of 4.0×10^4 N hangs from Y. The structure is in equilibrium.



What is the force exerted by each beam on the hinge at Y?

A 2.6×10^4 N **B** 3.1×10^4 N **C** 5.2×10^4 N **D** 6.2×10^4 N

15 Air is trapped inside a glass bulb which is immersed in water and attached to a U-tube containing mercury. The densities of water and mercury are ρ_w and ρ_m respectively. The surface of the water is open to the atmosphere where atmospheric pressure is P.



The acceleration of free fall is g.

What is the pressure of the air in the glass bulb?

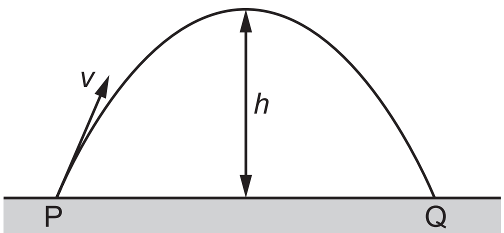
A $P + g\rho_w h_w + g\rho_m h_m$

B $P + g\rho_w h_w - g\rho_m h_m$

C $g\rho_w h_w + g\rho_m h_m$

D $g\rho_w h_w - g\rho_m h_m$

16 A ball of mass m is thrown up to height h in air with an initial velocity v, as shown.

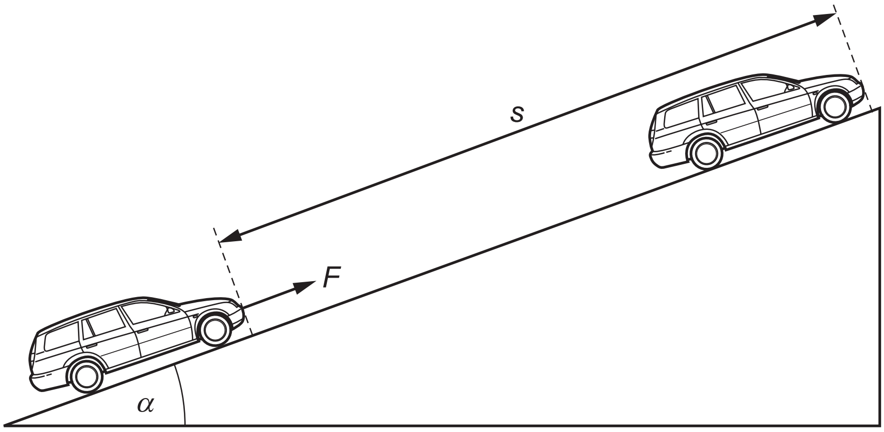


Air resistance is negligible. The acceleration of free fall is g.

What is the **total** work done by the gravitational force on the ball during its flight from P to Q?

A zero **B** $\frac{1}{2}mv^2$ **C** mgh **D** $2mgh$

17 A constant force F, acting on a car of mass m, moves the car up a slope through a distance s at constant velocity v. The angle of the slope to the horizontal is α.



What is the ratio $\dfrac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

A $\dfrac{mgs\sin\alpha}{Fv}$ **B** $\dfrac{mv}{Fs}$ **C** $\dfrac{mv^2}{2Fs}$ **D** $\dfrac{mg\sin\alpha}{F}$

18 Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.

Which statement is correct?

A Car X has half the kinetic energy of car Y.

B Car X has one quarter of the kinetic energy of car Y.

C Car X has twice the kinetic energy of car Y.

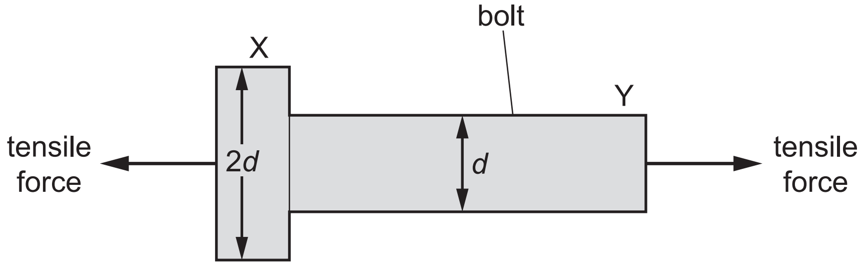
D The two cars have the same kinetic energy.

19 During refuelling, a petrol car receives 50 litres of fuel in 90 seconds. The petrol has 34 MJ of energy per litre.

For an electric car to receive the same amount of energy in the same time from a 230 V supply, what is the minimum current required?

A 2700 A **B** 8.2×10^4 A **C** 7.4×10^6 A **D** 6.6×10^8 A

20 A bolt is subjected to a tensile force, as shown.



The bolt has a circular cross-section. At end X the diameter is 2*d*. At end Y the diameter is *d*.

What is the ratio $\dfrac{\text{stress at Y}}{\text{stress at X}}$?

A 0.25 **B** 0.50 **C** 2.0 **D** 4.0

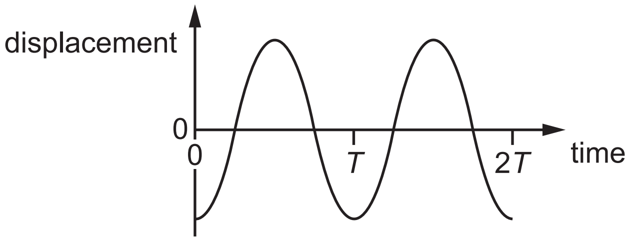
21 A rectangular block of steel supporting a very large component of a bridge has a height of 15 cm and a cross-section of 20 cm × 12 cm. It is designed to compress 1 mm when under maximum, evenly distributed, load.

The Young modulus of steel is $2.0 \times 10^{11}\,\mathrm{N\,m^{-2}}$.

What is the maximum load it can support?

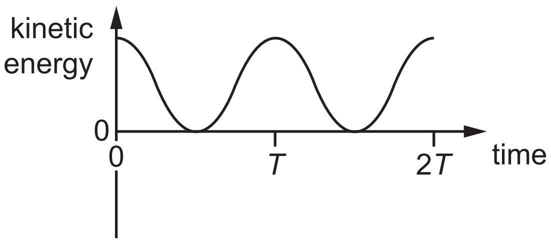
A 32 MN **B** 56 GN **C** 720 GN **D** 32 TN

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

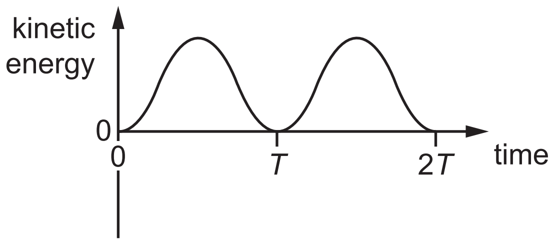


Which graph best shows how the kinetic energy of the air particle varies with time?

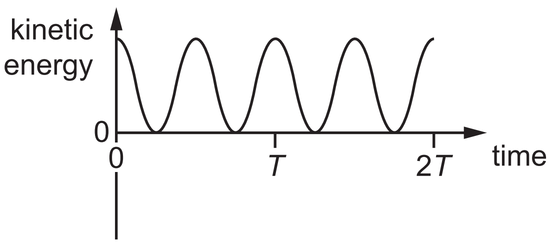
A



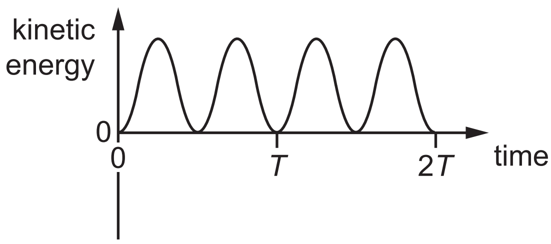
B



C



D



23 Which wave is a longitudinal wave?

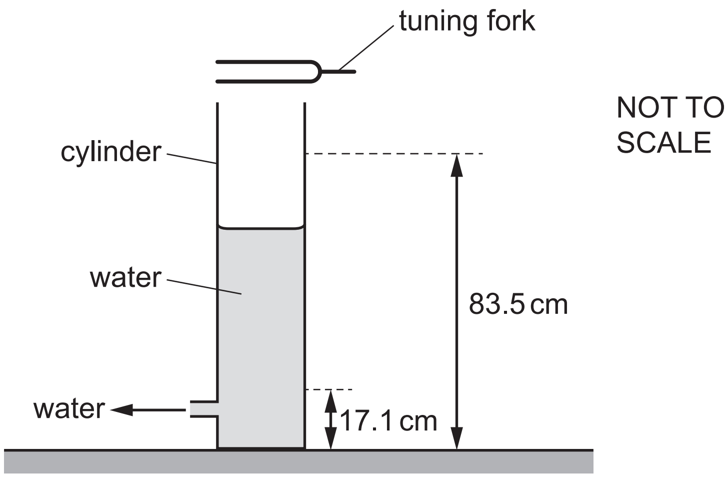
A a light wave travelling through air

B a radio wave from a broadcasting station

C a ripple on the surface of water

D a sound wave travelling through air

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 $340\,\mathrm{m\,s^{-1}}$.

What is the frequency of the tuning fork?

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

25 A train that is moving in a straight line along a railway track has a whistle that continuously emits sound of frequency *f*.

A woman standing by the side of the track hears sound of frequency 0.85*f*.

The speed of sound in the air is $340\,\mathrm{m\,s^{-1}}$.

What is the velocity of the train?

A $51\,\mathrm{m\,s^{-1}}$ away from the woman

B $51\,\mathrm{m\,s^{-1}}$ towards the woman

C $60\,\mathrm{m\,s^{-1}}$ away from the woman

D $60\,\mathrm{m\,s^{-1}}$ towards the woman

26 Orange light in a vacuum has a wavelength of 600 nm.

What is the frequency of this light?

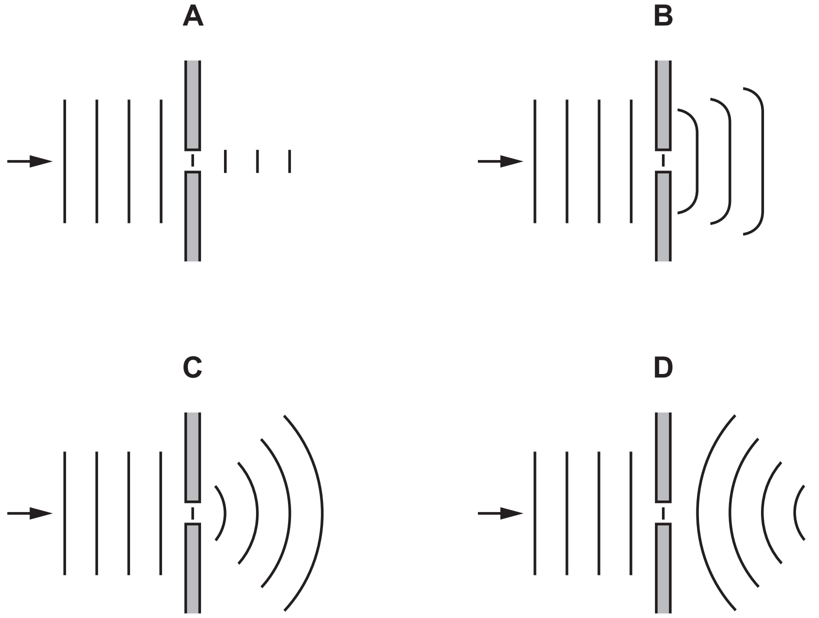
A 180 Hz **B** 5.0×10^{5} Hz **C** 1.8×10^{11} Hz **D** 5.0×10^{14} Hz

27 A stationary sound wave has a series of nodes. The distance between the first and the sixth node is 30.0 cm.

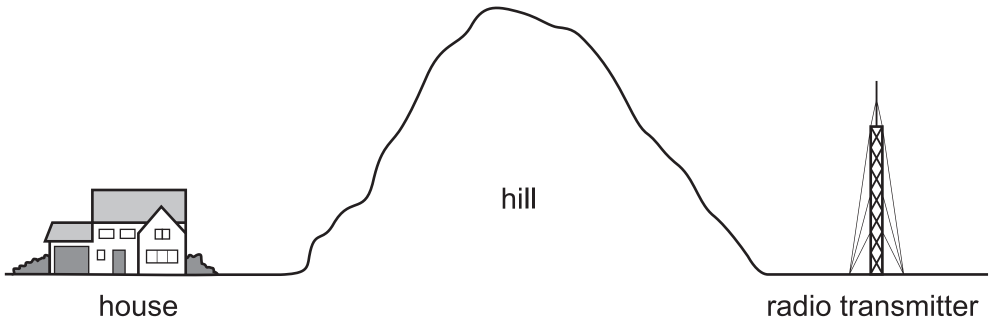
What is the wavelength of the sound wave?

A 5.0 cm **B** 6.0 cm **C** 10.0 cm **D** 12.0 cm

28 Which diagram shows the diffraction of water waves in a ripple tank?



29 A hill stands between a radio transmitter and a house, as shown.



The radio transmitter cannot be seen from the house, but radio waves from the transmitter are received at the house.

Why is this?

A The wavelength of light is longer than the wavelength of radio waves so there is more diffraction of light over the hill.

B The wavelength of light is shorter than the wavelength of radio waves so there is more diffraction of light over the hill.

C The wavelength of radio waves is longer than the wavelength of light so there is more diffraction of radio waves over the hill.

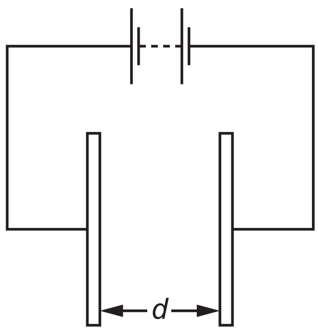
D The wavelength of radio waves is shorter than the wavelength of light so there is more diffraction of radio waves over the hill.

30 In an experiment to demonstrate double-slit interference using light, the distance from the slits to the screen is doubled and the slit separation is halved. The wavelength of the light is kept constant.

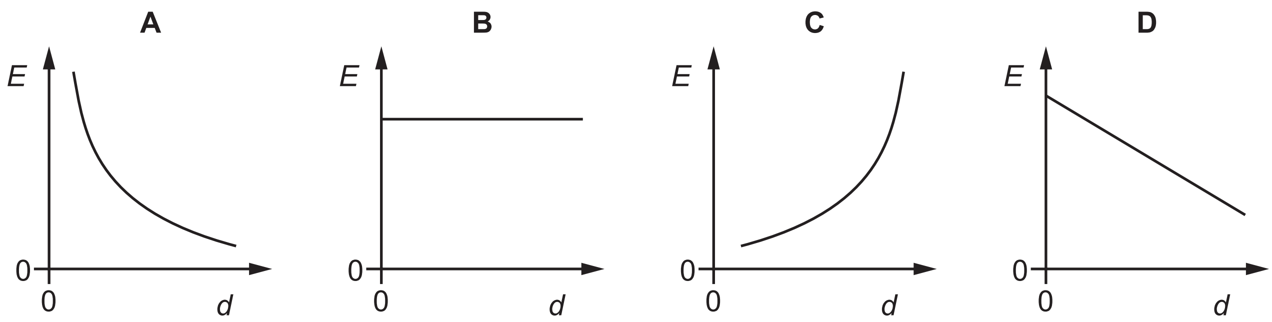
By which factor does the separation of adjacent bright fringes change?

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

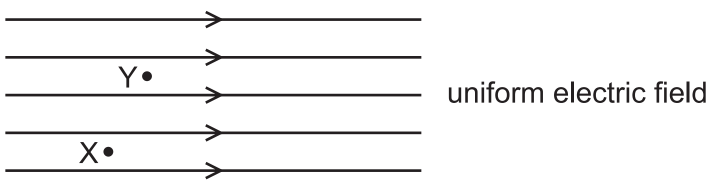
31 The diagram shows two metal plates connected to a constant high voltage.



Which graph shows the variation of the electric field strength E midway between the two plates as the distance d between the two plates is increased?



32 An electron moves between two points X and Y in a uniform electric field, as shown.



The distance between X and Y is 4.0 cm and the line XY is at an angle of 60° to the direction of the field.

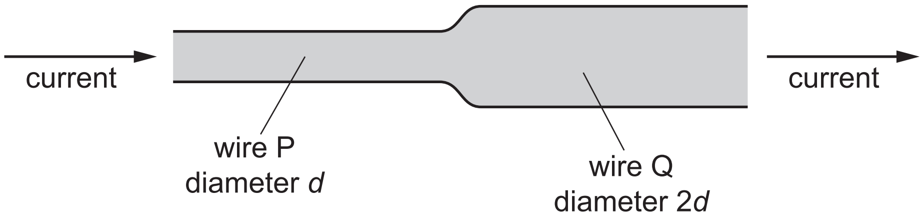
The field exerts the only force on the electron.

The field strength is $100\,\mathrm{N\,C^{-1}}$.

What is the change in the kinetic energy of the electron as it moves from X to Y?

A –4 eV **B** –2 eV **C** +2 eV **D** +4 eV

33 Two copper wires are joined together and carry a current, as shown.

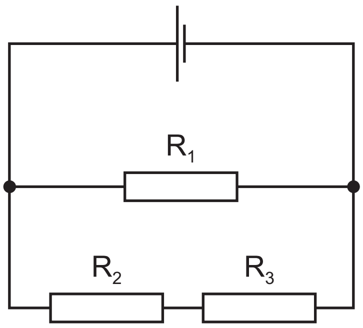


Wire P has diameter d and wire Q has diameter $2d$.

What is the ratio $\dfrac{\text{average drift speed of the free electrons in wire P}}{\text{average drift speed of the free electrons in wire Q}}$?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** 2 **D** 4

34 A cell of negligible internal resistance is connected to resistors R_1, R_2 and R_3, as shown. The cell provides power to the circuit and power is dissipated in the resistors.



Which word equation **must** be correct?

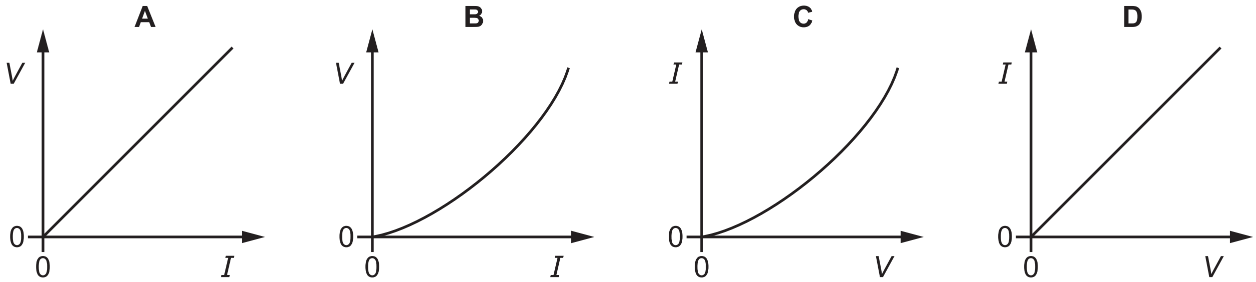
A power loss in R_1 = power loss in R_2 + power loss in R_3

B power loss in R_2 = power loss in R_3

C power output of cell = power loss in R_1 + power loss in R_2 + power loss in R_3

D power output of cell = power loss in R_1

35 Which graph represents a metallic conductor, where the resistance of the conductor is given by the gradient of the graph?

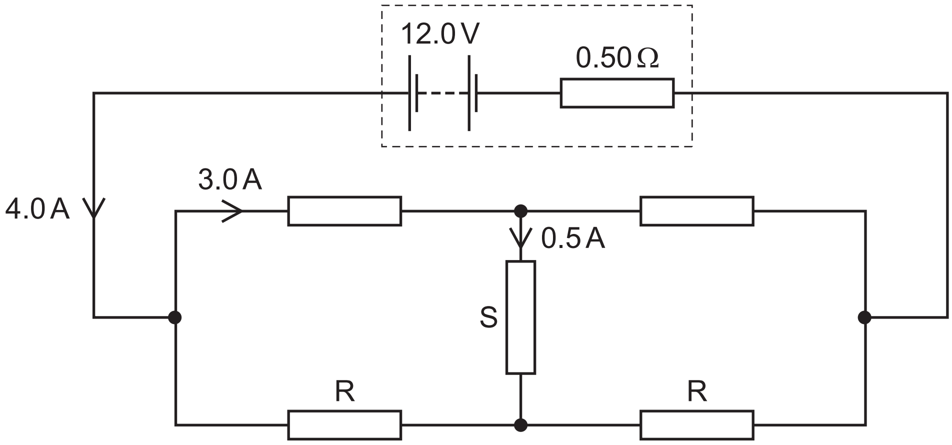


36 A typical mobile phone battery has an e.m.f. of 5.0 V and an internal resistance of 200 mΩ.

What is the terminal p.d. of the battery when it supplies a current of 500 mA?

A 4.8 V **B** 4.9 V **C** 5.0 V **D** 5.1 V

37 The circuit shown contains a resistor S that is neither in series nor in parallel with the other resistors.

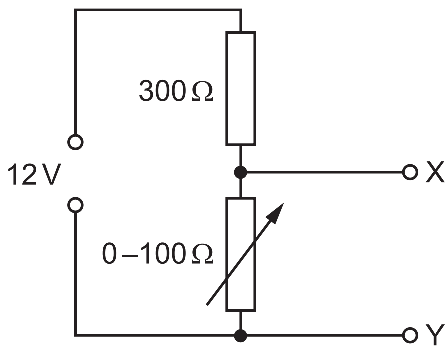


Kirchhoff's laws can be used with the data in the diagram to deduce the resistance of each of the two identical resistors labelled R.

What is the resistance of each resistor R?

A 3.0 Ω **B** 4.0 Ω **C** 4.8 Ω **D** 5.0 Ω

38 The diagram shows a potential divider connected to a 12 V supply of negligible internal resistance.



Which range of voltages can be obtained between X and Y?

A 0 to 3 V **B** 0 to 4 V **C** 0 to 8 V **D** 0 to 9 V

39 The diagram shows a sequence of radioactive decays involving three α-particles and a β^- particle.

$${}^{237}_{93}\text{Np} \xrightarrow{\alpha} \text{Q} \xrightarrow{\beta^-} \text{R} \xrightarrow{\alpha} \text{S} \xrightarrow{\alpha} \text{T}$$

What is nuclide T?

A ${}^{225}_{88}\text{Ra}$ **B** ${}^{231}_{88}\text{Ra}$ **C** ${}^{225}_{90}\text{Th}$ **D** ${}^{229}_{90}\text{Th}$

40 Which combination of up (u) and down (d) quarks forms a neutron?

A u u u **B** u u d **C** u d d **D** d d d

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2017**

1 hour 15 minutes

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

9755944367

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

CAMBRIDGE
International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho g h$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 How many cubic nanometres, nm^3, are in a cubic micrometre, μm^3?

A 10^3 **B** 10^6 **C** 10^9 **D** 10^{12}

2 The maximum theoretical power P of a wind turbine is given by the equation

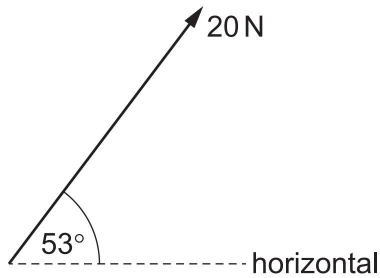
$$P = k\rho A v^n$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n?

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

3 What is the horizontal component of the force shown?



A 12 N **B** 16 N **C** 20 N **D** 27 N

4 A school has a piece of aluminium that it uses for radioactivity experiments. Its thickness is marked as 3.2 mm. A student decides to check this value. He has vernier calipers which give measurements to 0.1 mm and a micrometer which gives measurements to 0.01 mm.

Which statement **must** be correct?

A The micrometer gives a more accurate measurement.

B The micrometer gives a more precise measurement.

C The vernier calipers give a more accurate measurement.

D The vernier calipers give a more precise measurement.

5 Four possible sources of error in a series of measurements are listed.

1 an analogue meter whose scale is read from different angles

2 a meter which always measures 5% too high

3 a meter with a needle that is not frictionless, so the needle sometimes sticks slightly

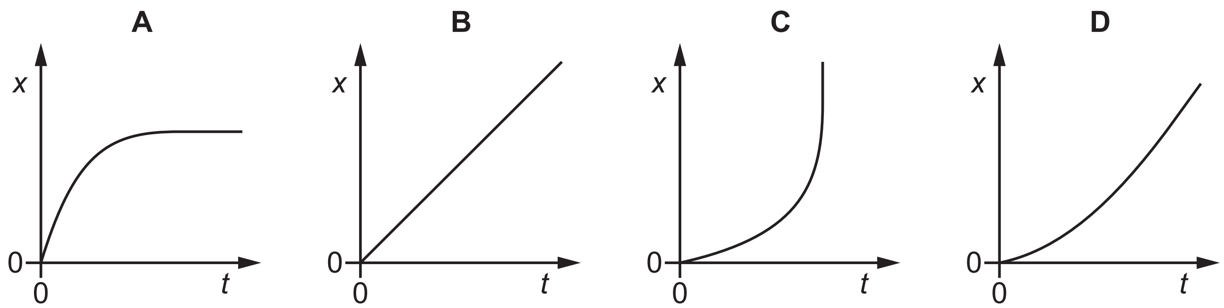
4 a meter with a zero error

Which errors are random and which are systematic?

	random error	systematic error
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

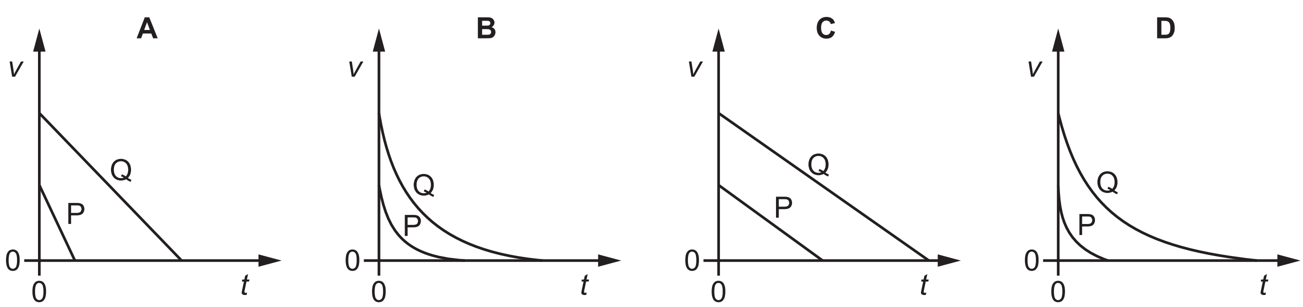
6 A football falls from the top of a tall building.

Which graph best represents the way in which the distance x fallen varies with time t?

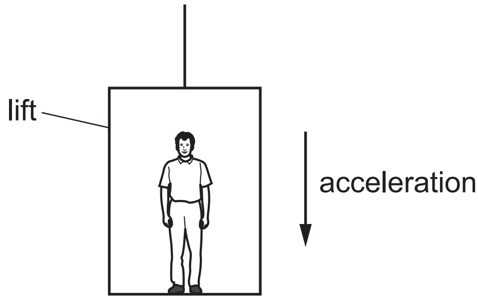


7 Two identical cars P and Q are travelling along a straight road. Car Q is travelling at twice the speed of car P. The brakes are applied to both cars, producing the same constant deceleration.

Which graph shows how the velocity v of each car varies with time t?



8 A man stands in a lift that is accelerating vertically downwards, as shown.



Which statement describes the force exerted by the man on the floor?

A It is equal to the weight of the man.

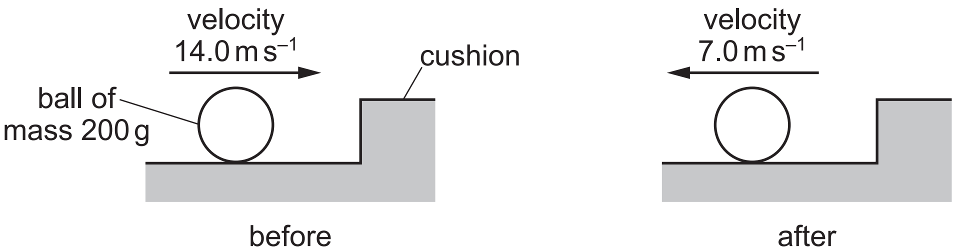
B It is greater than the force exerted by the floor on the man.

C It is less than the force exerted by the floor on the man.

D It is less than the weight of the man.

9 A snooker ball of mass 200 g hits the cushion of a snooker table at right-angles with a speed of $14.0\,\mathrm{m\,s^{-1}}$.

The ball rebounds with half of its initial speed. The ball is in contact with the cushion for 0.60 s.



What is the average force exerted on the ball by the cushion?

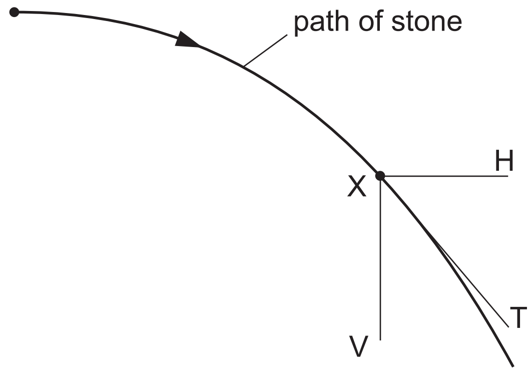
A 2.3 N **B** 7.0 N **C** 2300 N **D** 7000 N

10 Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together.

What is the speed of the trucks after the collision?

A $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

11 A stone is projected horizontally in a vacuum and moves along the path shown.

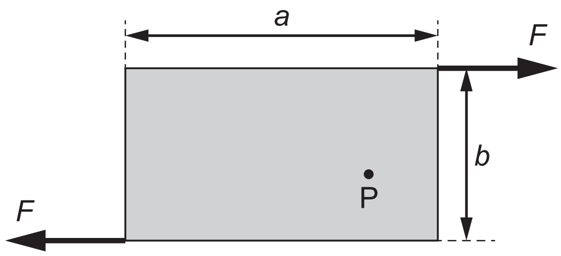


X is a point on this path. XV and XH are vertical and horizontal lines respectively through X. XT is the tangent to the path at X.

Along which directions do forces act on the stone at X?

A XV and XH **B** XV only **C** XH only **D** XT only

12 Two forces, each of magnitude F, act along the edges of a rectangular metal plate, as shown.

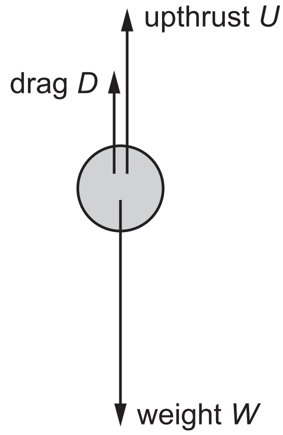


The plate has length a and width b.

What is the torque about point P?

A Fa **B** Fb **C** $2Fa$ **D** $2Fb$

13 A solid sphere falls at constant (terminal) velocity in a liquid. The three forces acting on the sphere are shown in the diagram.



How are the three forces related?

A $W + D = U$

B $W > U + D$

C $W - U = D$

D $W < D + U$

14 A thin horizontal plate of area $0.036\,m^2$ is beneath the surface of a liquid of density $930\,kg\,m^{-3}$. The force on one side of the plate due to the pressure of the liquid is 290 N.

What is the depth of the plate beneath the surface of the liquid?

A 0.88 m **B** 1.1 m **C** 1.8 m **D** 8.7 m

15 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.

16 A car of total mass 1560 kg is travelling with a constant speed of $32\,\text{m}\,\text{s}^{-1}$. The driving force provided by the car is 680 N. The kinetic energy of the car is 800 kJ and its momentum is 50 000 N s.

Which two items of data could be used to calculate the useful power output of the car?

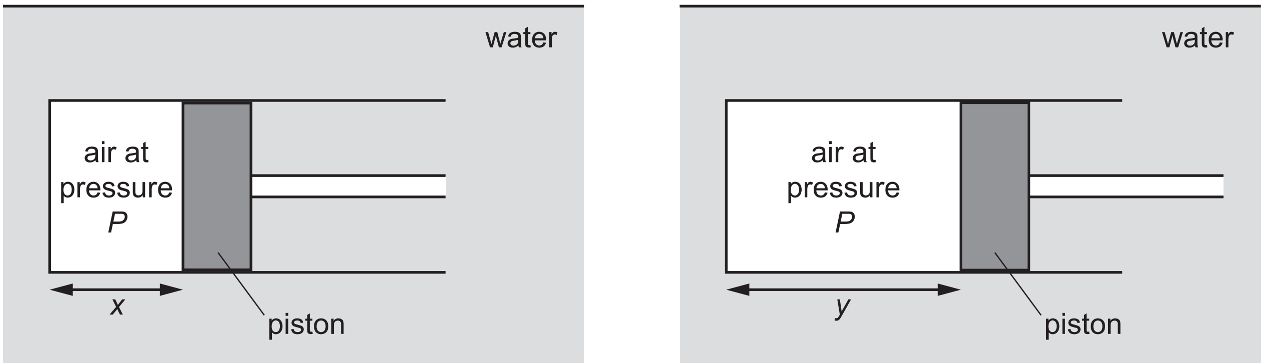
A driving force and momentum

B kinetic energy and mass

C mass and momentum

D speed and driving force

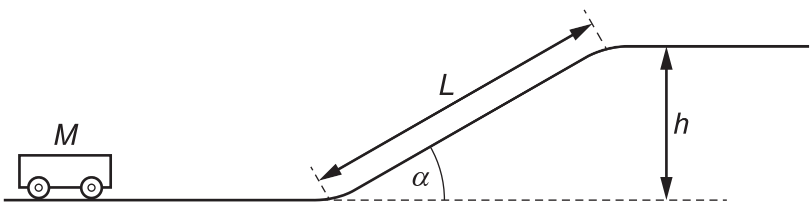
17 A horizontal cylinder of cross-sectional area A is fitted with a frictionless piston and contains air at pressure P. It is immersed in hot water and the length of the air column increases from x to y. The pressure P is constant.



Which equation represents the work done by the trapped air during this process?

A PAy **B** $-PAy$ **C** $PA(y-x)$ **D** $-PA(y-x)$

18 A trolley rolls along a horizontal surface and then travels up a slope before reaching a second horizontal surface. The slope is of length L. The trolley has mass M. The slope is at an angle α to the horizontal surface. The second horizontal surface is at height h above the first surface.



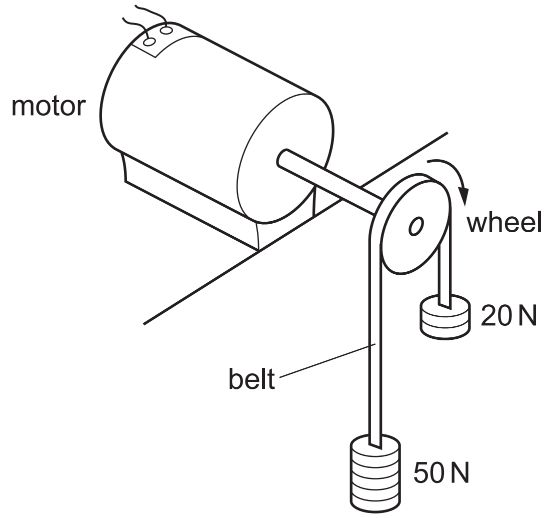
Assume negligible frictional forces. The acceleration of free fall is known.

In order to determine the minimum initial velocity of the trolley for it to reach the top of the slope, which additional values are needed?

A h and M **B** M, L and h **C** α, L, M **D** h only

19 The diagram shows an arrangement used to find the output power of an electric motor.

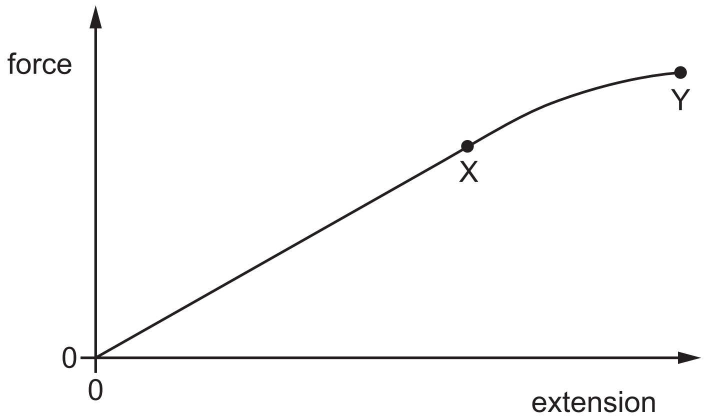
The wheel attached to the motor's axle has a circumference of 0.5 m and the belt which passes over it is stationary when the weights have the values shown.



When the wheel is making 20 revolutions per second, what is the output power of the motor?

A 300 W **B** 500 W **C** 600 W **D** 700 W

20 A sample of metal is subjected to a force which increases to a maximum value and then decreases back to zero. A force-extension graph for the sample is shown.



When the sample contracts, it follows the same force-extension curve as when it was being stretched.

What is the behaviour of the metal between X and Y?

A both elastic and plastic

B not elastic and not plastic

C plastic but not elastic

D elastic but not plastic

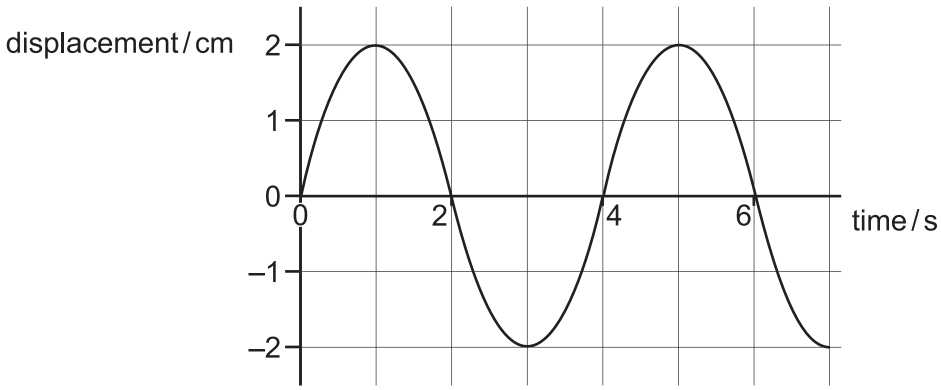
21 A load is hung from the end of a metal wire. The load is increased and the wire stretches elastically. The table shows the length of the wire for different loads.

load / kN	length / mm
0	500.0
1.0	502.0
2.0	504.0
3.0	506.0
4.0	508.0

When the load is 4.0 kN, what is the strain energy stored in the wire?

A 16 J **B** 32 J **C** 1.0 kJ **D** 2.0 kJ

22 The graph shows how the displacement of a particle in a wave varies with time.



Which statement is correct?

A The wave has a period of 2 s and could be either transverse or longitudinal.

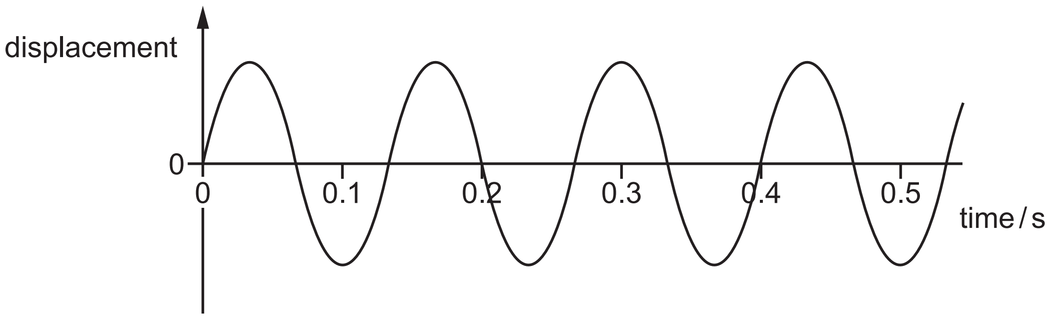
B The wave has a period of 2 s and must be transverse.

C The wave has a period of 4 s and could be either transverse or longitudinal.

D The wave has a period of 4 s and must be transverse.

23 A wave travels along a coiled spring.

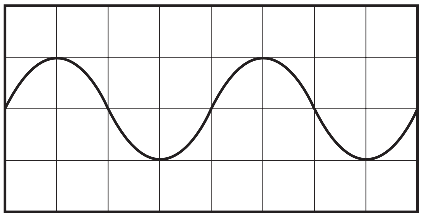
The graph shows the variation with time of the displacement of a point on the spring.



What is the frequency of the wave?

A 0.13 Hz **B** 0.20 Hz **C** 5.0 Hz **D** 7.5 Hz

24 An electrical signal is displayed on a cathode-ray oscilloscope (c.r.o.).



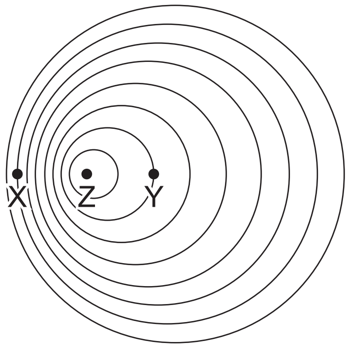
The time-base setting is $50\,\text{ms}\,\text{div}^{-1}$.

The Y-gain setting is $2\,\text{V}\,\text{div}^{-1}$.

What is the amplitude of the signal?

A 2 V **B** 4 V **C** 5 V **D** 10 V

25 A source of sound of frequency *F* at point Z is moving at a steady speed. The pattern of the emitted wavefronts is shown.



Which row describes the frequencies of the sound heard by stationary observers at X and Y?

	frequency heard at X	frequency heard at Y
A	$<F$	$<F$
B	$<F$	$>F$
C	$>F$	$<F$
D	$>F$	$>F$

26 A car travelling at a steady speed in a straight line passes close to a stationary observer. The observer measures the frequency of the sound from the engine.

As the car approaches, the observed frequency is 220 Hz. When the car moves away, the observed frequency is 180 Hz.

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

What is the speed of the car?

A $8.5\,\mathrm{m\,s^{-1}}$ **B** $31\,\mathrm{m\,s^{-1}}$ **C** $34\,\mathrm{m\,s^{-1}}$ **D** $38\,\mathrm{m\,s^{-1}}$

27 Which frequency of electromagnetic radiation could be ultraviolet?

A 1.0×10^{6} Hz

B 1.0×10^{9} Hz

C 1.0×10^{12} Hz

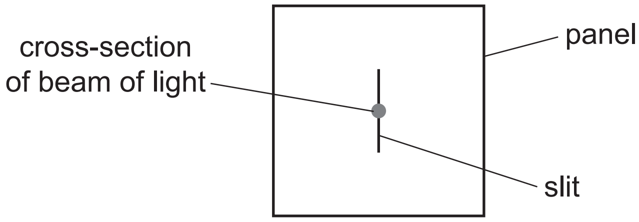
D 1.0×10^{15} Hz

28 An electromagnetic wave travels in a straight line through a vacuum. The wave has a frequency of 6.0 THz.

What is the number of wavelengths in a distance of 1.0 m along the wave?

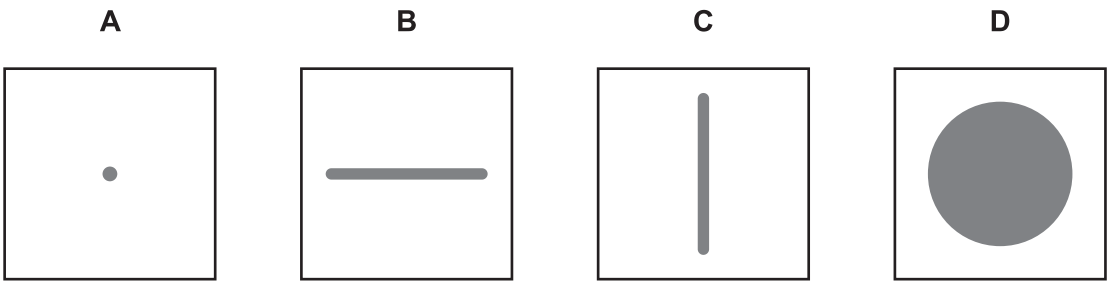
A 5.0×10^{-5} **B** 2.0×10^{1} **C** 2.0×10^{4} **D** 5.0×10^{7}

29 A beam of laser light is directed towards a narrow slit.



After emerging from the other side of the slit, the light then falls on a screen.

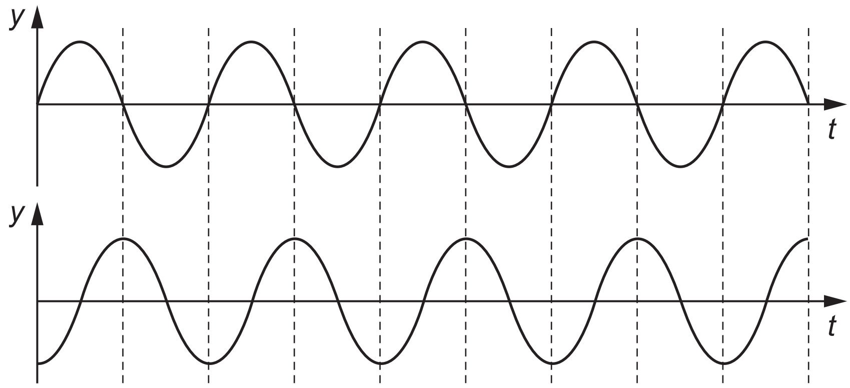
What is the pattern of light seen on the screen?



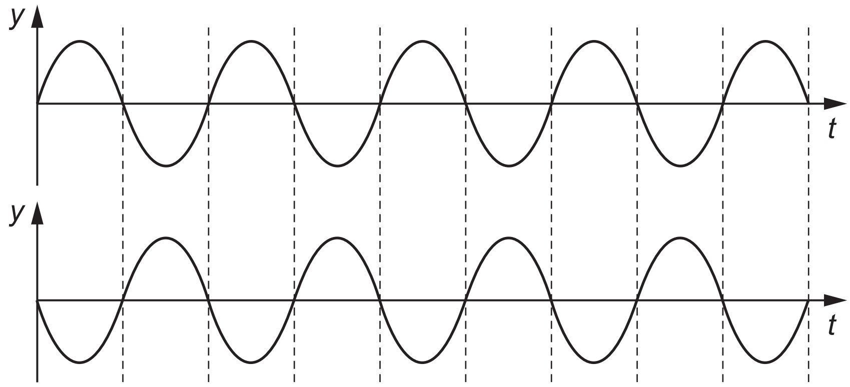
30 The diagrams show four pairs of waves. In each case the displacement y measured at a fixed point is plotted against time t.

Which pair of waves is **not** coherent?

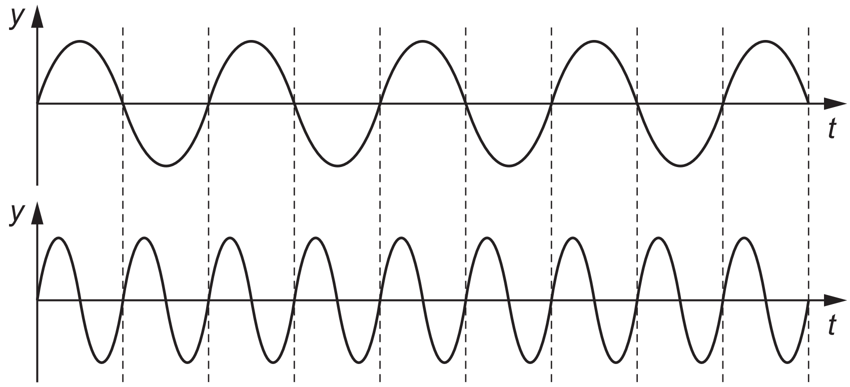
A



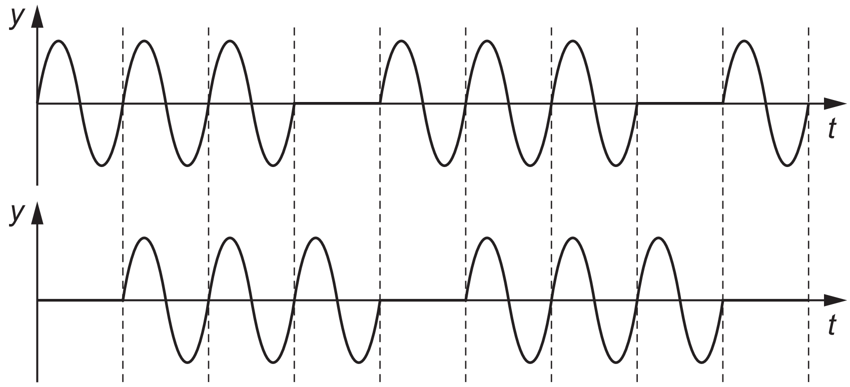
B



C



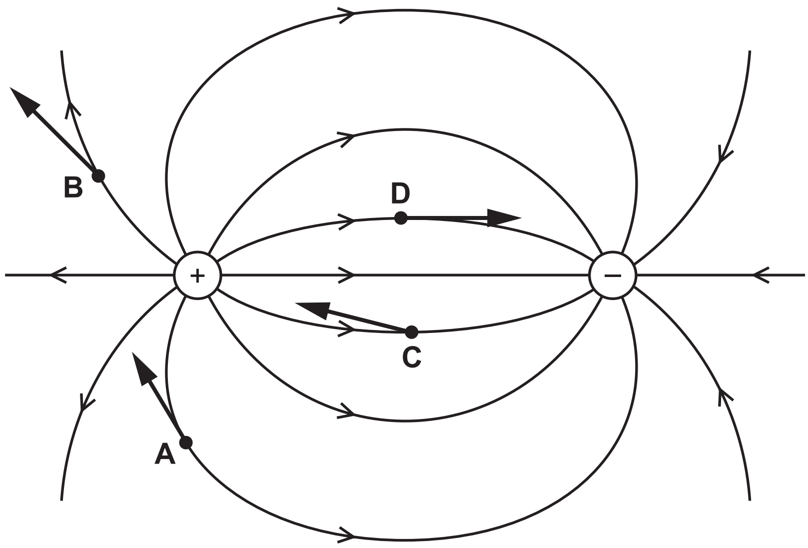
D



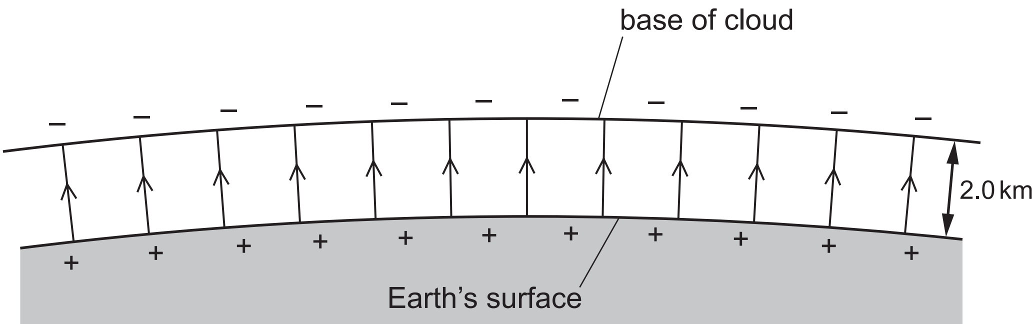
31 The diagram shows the electric field near a positively charged sphere and a negatively charged sphere.

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?



32 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches $25\,kN\,C^{-1}$. 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, 2.0 km high, for lightning to occur?

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

33 The number density of conduction electrons in copper is $8.0 \times 10^{28}\,m^{-3}$.

What is the average drift speed of electrons in a copper wire of diameter 0.42 mm when the current in the wire is 0.57 A?

A $8.0 \times 10^{-11}\,m\,s^{-1}$

B $3.2 \times 10^{-10}\,m\,s^{-1}$

C $8.0 \times 10^{-5}\,m\,s^{-1}$

D $3.2 \times 10^{-4}\,m\,s^{-1}$

34 A simple circuit comprises a source of electromotive force (e.m.f.) connected to a load.

How does the output power *P* of the source depend on the internal resistance *r* of the source and the resistance *R* of the load?

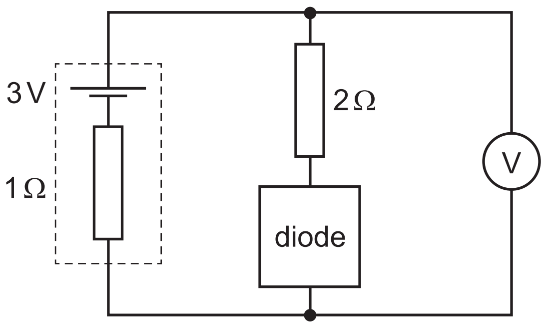
A *P* is independent of both *r* and *R*.

B *P* depends on *r* but not on *R*.

C *P* depends on *R* but not on *r*.

D *P* depends on both *r* and *R*.

35 An ideal diode has zero resistance when forward biased and infinite resistance when reverse biased. The diode is connected in series with a 2 Ω resistor across the terminals of a source having electromotive force (e.m.f.) 3 V and internal resistance 1 Ω, as shown.

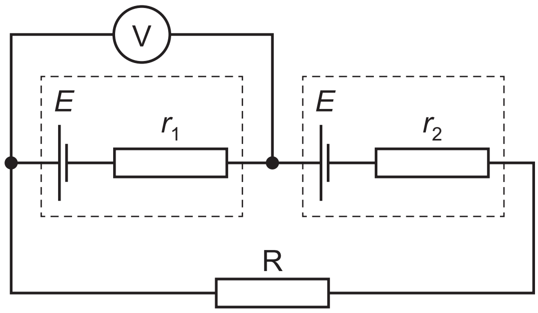


A high-resistance voltmeter is connected across the diode and resistor.

Which row gives the readings of the voltmeter for the two ways of connecting the diode?

	forward biased	reverse biased
A	1 V	3 V
B	2 V	0 V
C	2 V	3 V
D	3 V	0 V

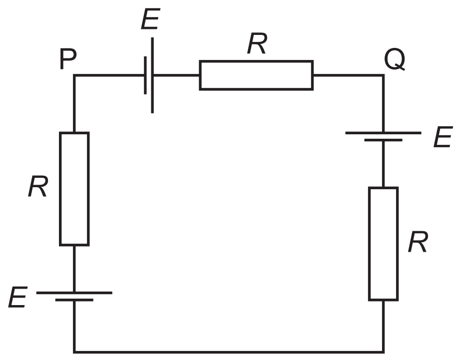
36 Two cells, each with electromotive force (e.m.f.) E, but different internal resistances r_1 and r_2, are connected in series to a resistor R. The reading on the voltmeter is 0 V.



What is the resistance of R?

A 0 **B** $r_1 - r_2$ **C** $r_1 + r_2$ **D** $\frac{r_1 r_2}{r_1 + r_2}$

37 Three identical cells each have electromotive force (e.m.f.) E and negligible internal resistance. The cells are connected to three identical resistors, each of resistance R, as shown.



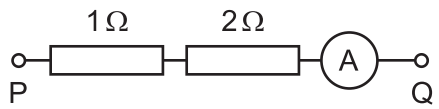
What is the potential difference between P and Q?

A 0 **B** $\frac{E}{3}$ **C** $\frac{2E}{3}$ **D** E

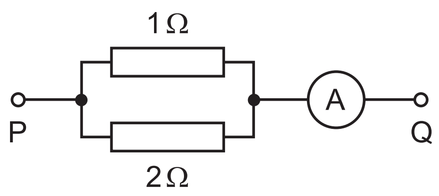
38 In each arrangement of resistors, the ammeter has a resistance of 2 Ω.

Which arrangement gives the largest reading on the ammeter when the same potential difference is applied between points P and Q?

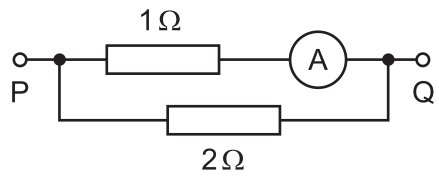
A



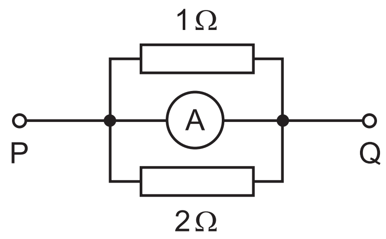
B



C



D



39 Each option shows the number of neutrons, protons and electrons in two atoms, some of which are ionised.

Which pair of atoms in the table are isotopes of the same element?

	neutron	proton	electron
A	20 20	17 19	20 20
B	28 28	23 24	23 24
C	34 36	29 29	29 28
D	40 42	32 31	32 32

40 Which combination of up (u) and down (d) quarks forms a proton?

A u u u **B** u u d **C** u d d **D** d d d

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2018**

1 hour 15 minutes

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

5690949700

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **21** printed pages and **3** blank pages.

CAMBRIDGE
International Examinations

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 The radius of the Earth is approximately 6.4×10^6 m, and the radius of the Moon is approximately 1.7×10^6 m. A student wishes to build a scale model of the Solar System in the classroom, using a football of radius 0.12 m to represent the Earth.

Which object would best represent the Moon?

A basketball

B cherry

C golf ball

D tennis ball

2 When a beam of light is incident on a surface, it delivers energy to the surface. The intensity of the beam is defined as the energy delivered per unit area per unit time.

What is the unit of intensity, expressed in SI base units?

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

3 A ship is travelling with a velocity of $8.0\,\text{km h}^{-1}$ in a direction 30° east of north.

What are the components of the ship's velocity in the east and north directions?

	component of velocity in east direction / km h^{-1}	component of velocity in north direction / km h^{-1}
A	4.0	4.0
B	4.0	6.9
C	4.6	6.9
D	6.9	4.0

4 A micrometer screw gauge is used to measure the diameter of a copper wire.

The reading with the wire in position is shown in diagram 1. The wire is removed and the jaws of the micrometer are closed. The new reading is shown in diagram 2.

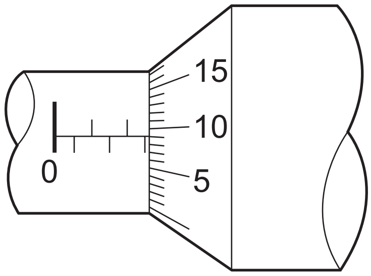


diagram 1

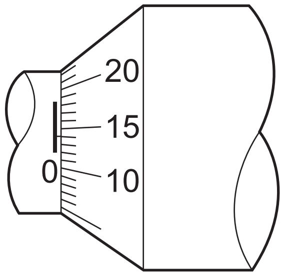


diagram 2

What is the diameter of the wire?

A 1.90 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

5 A digital meter has an accuracy of ±1%.

The meter is used to measure the current in an electrical circuit.

The reading on the meter varies between 3.04 A and 3.08 A.

What is the value of the current, with its uncertainty?

A (3.06 ± 0.02) A

B (3.06 ± 0.04) A

C (3.06 ± 0.05) A

D (3.06 ± 0.07) A

6 A tennis ball is thrown horizontally in air from the top of a tall building.

The effect of air resistance is **not** negligible.

What happens to the horizontal and to the vertical components of the ball's velocity?

	horizontal component of velocity	vertical component of velocity
A	constant	constant
B	constant	increases at a constant rate
C	decreases to zero	increases at a constant rate
D	decreases to zero	increases to a maximum value

7 Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of $20\,\text{m}\,\text{s}^{-1}$.

What is the minimum force required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 108 000 N

8 A ball of mass *m* is thrown vertically into the air. When the ball has speed *v*, the air resistance acting on the ball is *F*.

What is the magnitude of the acceleration of the ball when its speed is *v* as it rises and as it falls?

	acceleration when ball is rising	acceleration when ball is falling
A	$g - \frac{F}{m}$	$g - \frac{F}{m}$
B	$g - \frac{F}{m}$	$g + \frac{F}{m}$
C	$g + \frac{F}{m}$	$g - \frac{F}{m}$
D	$g + \frac{F}{m}$	$g + \frac{F}{m}$

9 What is a statement of the principle of conservation of momentum?

A A force is equal to the rate of change of momentum of the body upon which it acts.

B In a perfectly elastic collision, the relative momentum of the bodies before impact is equal to their relative momentum after impact.

C The momentum of a body is the product of the mass of the body and its velocity.

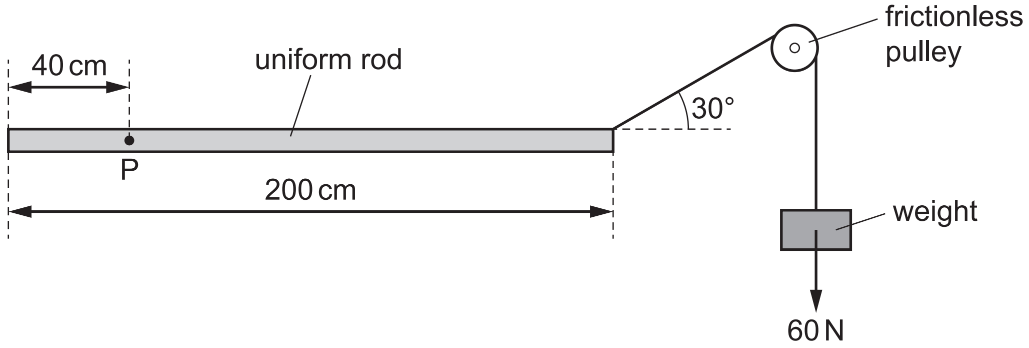
D The total momentum of a system of interacting bodies remains constant, providing no resultant external force acts on the system.

10 A charged particle is placed in a uniform field of force. The direction of the force on the particle is opposite to the direction of the field.

What is the field and what is the charge on the particle?

	field	charge on particle
A	electric	negative
B	electric	positive
C	gravitational	negative
D	gravitational	positive

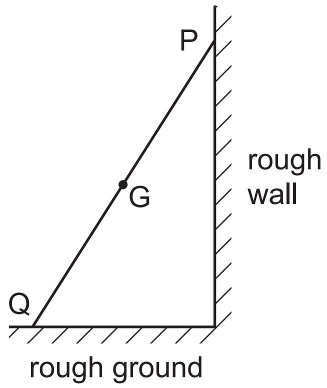
11 A uniform rod of length 200 cm is freely pivoted at point P. The rod is held horizontally in equilibrium by a 60 N weight that is attached to the rod by a string passing over a frictionless pulley.



What is the weight of the rod?

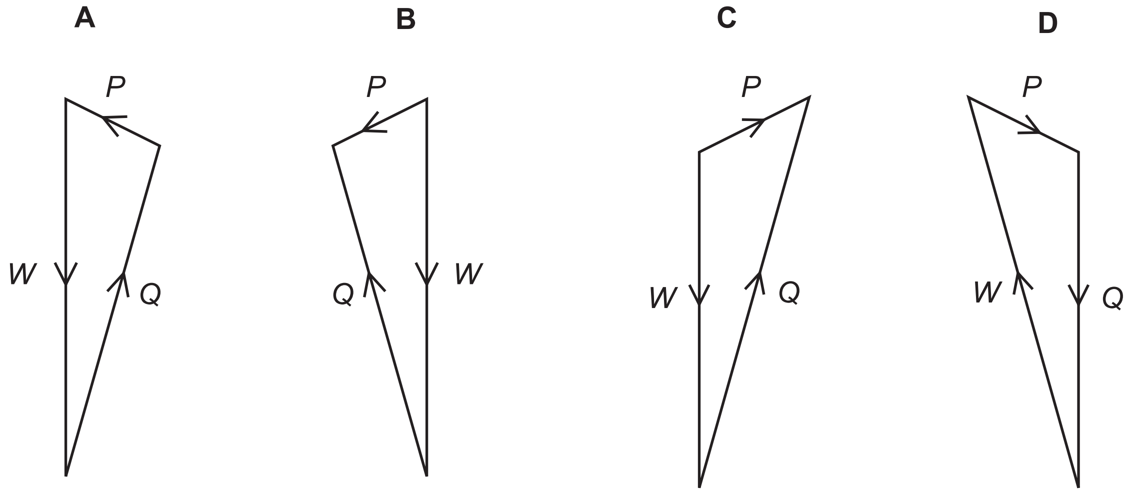
A 30 N **B** 60 N **C** 80 N **D** 140 N

12 A ladder rests in equilibrium on rough ground against a rough wall.

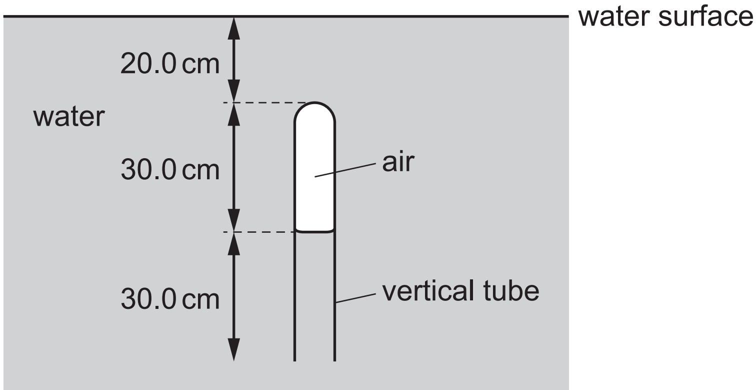


The weight W of the ladder acts through the centre of gravity G. Forces also act on the ladder at P and at Q. These forces are P and Q respectively.

Which vector triangle represents the forces on the ladder?



13 A vertical tube, closed at one end, is immersed in water. A column of air is trapped inside the tube.



The density of water is 1000 kg m^{-3}.

What is the difference between the pressure of the air in the tube and the atmospheric pressure?

A 1960 Pa **B** 2940 Pa **C** 4910 Pa **D** 7850 Pa

14 A rocket is fired upwards.

As it accelerates upwards after leaving the launch pad, which forms of energy are changing?

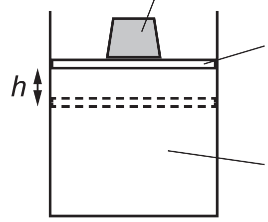
A chemical energy, gravitational potential energy and kinetic energy

B chemical energy and gravitational potential energy only

C chemical energy and kinetic energy only

D gravitational potential energy and kinetic energy only

15 A mass m is on top of a platform that is supported by gas in a cylinder of cross-sectional area A, as shown.



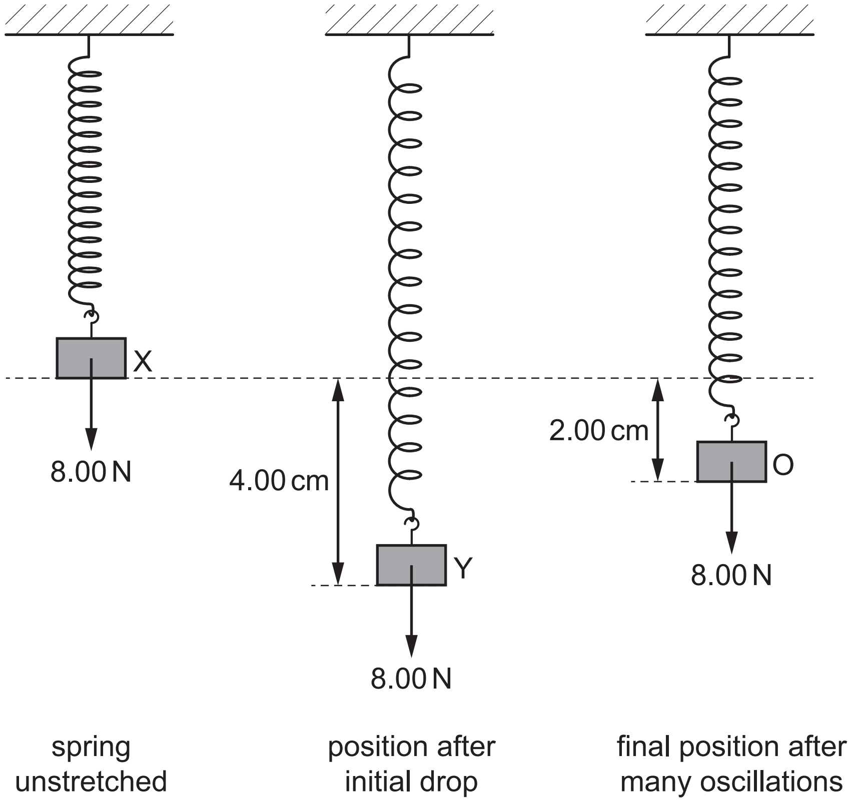
The platform has negligible mass and can move freely up and down.

The gas is heated and expands so that the mass is raised through a height h. Atmospheric pressure is p.

What is the ratio $\dfrac{\text{gain in gravitational potential energy of the mass}}{\text{work done by the gas}}$?

A $\dfrac{mg}{pA}$ **B** $\dfrac{mg}{mg + pA}$ **C** $\dfrac{pA}{mg}$ **D** $\dfrac{mg - pA}{mg}$

16 An 8.00 N weight is attached to the lower end of a spring which is fixed at its upper end. The weight is initially held at rest at position X and the spring is unstretched. The weight is then released and falls to position Y, which is 4.00 cm below X. The weight oscillates and then eventually comes to rest at O, which is 2.00 cm below X.



How much energy is lost from the system?

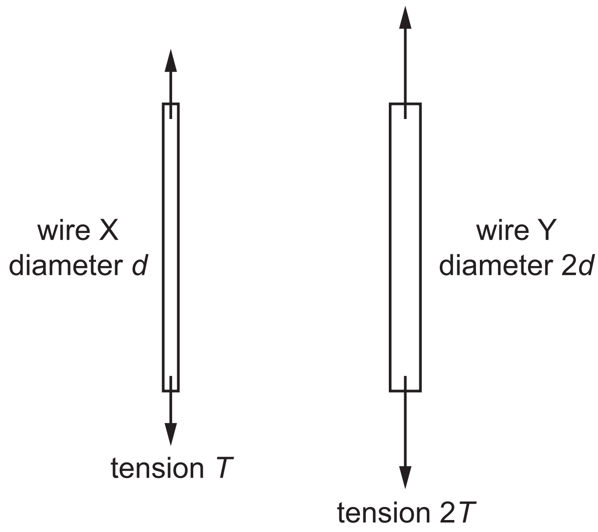
A 0.04 J **B** 0.08 J **C** 0.16 J **D** 0.32 J

17 The force resisting the motion of a car is proportional to the square of the car's speed. The magnitude of the force at a speed of $20.0\,m\,s^{-1}$ is 800 N.

What useful output power is required from the car's engine to maintain a steady speed of $40.0\,m\,s^{-1}$?

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

18 Two wires X and Y are made from the same material. Wire Y has twice the diameter and experiences twice the tension of wire X. The wires obey Hooke's law and have the same original length.



Wire X has extension *e*.

What is the extension of wire Y?

A $\frac{e}{4}$ **B** $\frac{e}{2}$ **C** e **D** $2e$

19 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis) for a wire obeying Hooke's law?

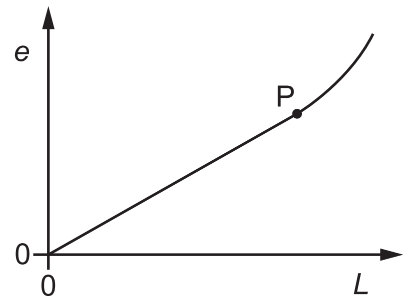
A elastic limit

B spring constant

C stress

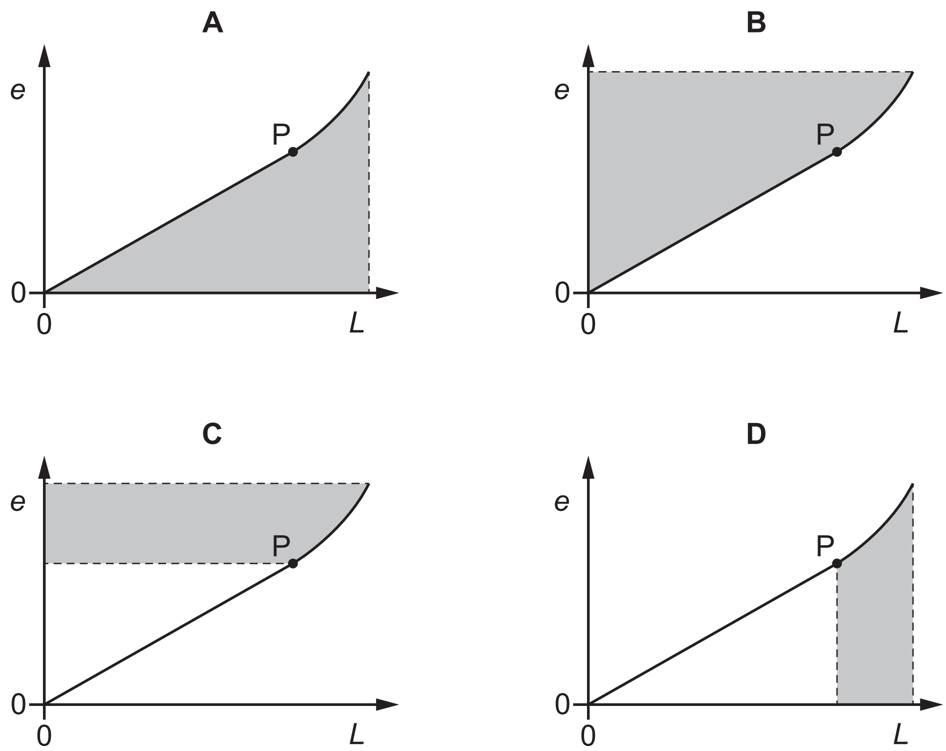
D Young modulus

20 Forces are applied to the ends of a rod so that its length increases. The variation with load *L* of the extension *e* of the rod is shown.

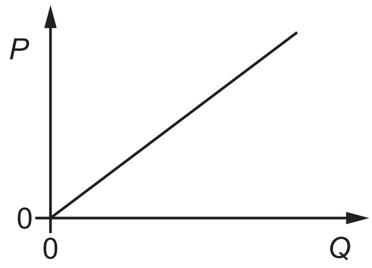


The point P is the elastic limit.

Which shaded area represents the work done during the plastic deformation of the rod?



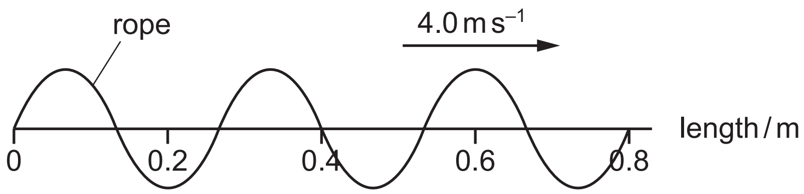
21 The graph shows the variation of a quantity *P* with a quantity *Q* for a sound wave travelling in air.



What could *P* and *Q* be?

	P	*Q*
A	amplitude	intensity
B	frequency	wavelength
C	speed	frequency
D	wavelength	period

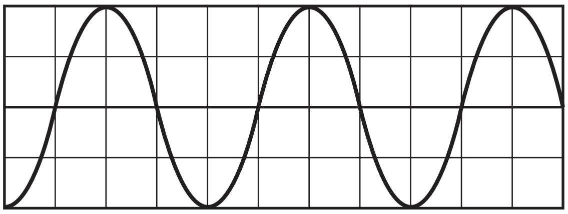
22 A vibration generator produces a progressive wave on a rope. The diagram shows the rope at one instant. The wave travels at a speed of $4.0\,m\,s^{-1}$.



What are the wavelength and the frequency of the wave?

	wavelength / m	frequency / Hz
A	0.13	15
B	0.13	30
C	0.27	15
D	0.27	30

23 The diagram shows the waveform of a signal displayed on a cathode-ray oscilloscope.



The time-base is set at 5.0 ms per division.

The Y-gain is set at 5.0 mV per division.

What are the amplitude and the frequency of the signal?

	amplitude / mV	frequency / Hz
A	10	50
B	10	100
C	20	50
D	20	100

24 A jet aircraft travels at a speed of $0.8v$ where v is the speed of sound. The aircraft approaches a stationary observer. The frequency of sound emitted by the aircraft is 100 Hz.

Which frequency does the observer hear?

A 56 Hz **B** 180 Hz **C** 400 Hz **D** 500 Hz

25 A telescope detects and analyses some electromagnetic radiation of wavelength 2 cm.

Which type of telescope is it?

A microwave telescope

B optical telescope

C radio telescope

D X-ray telescope

26 What may be used to produce stationary waves?

A blowing air over the top of an empty bottle

B making a loud sound near a mountain

C passing monochromatic light through a double slit

D passing water waves through a narrow slit

27 What is an example of the diffraction of a wave?

A laser light travelling along an optic fibre

B light waves forming images on a cinema screen

C microwaves passing the edge of a metal plate

D sound waves diverging as they pass through air

28 When the light from two lamps falls on a screen, no interference pattern can be obtained.

Why is this?

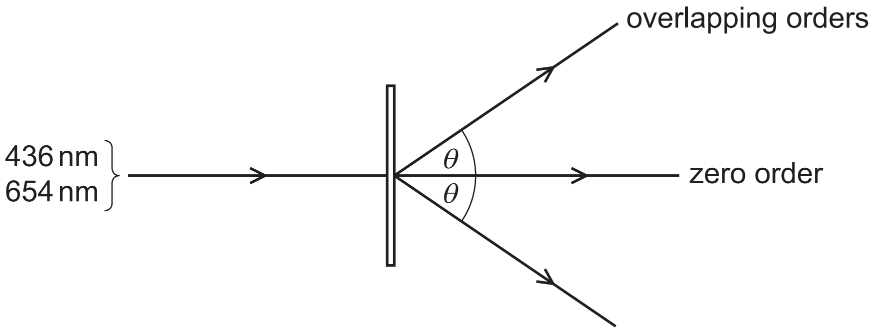
A The lamps are not point sources.

B The lamps emit light of different amplitudes.

C The light from the lamps is not coherent.

D The light from the lamps is white.

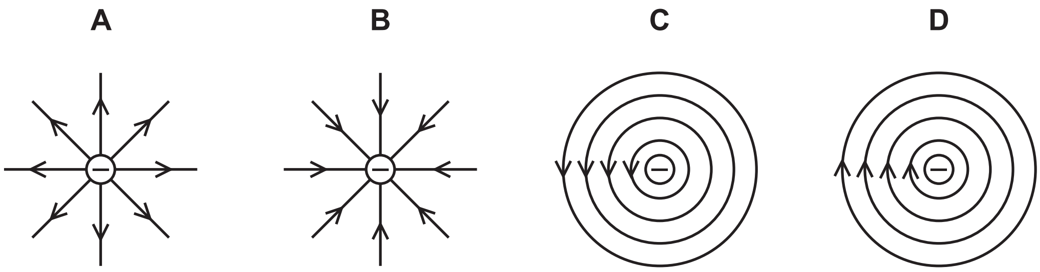
29 A beam of light consists of two wavelengths of 436 nm and 654 nm. A diffraction grating of 5.00×10^5 lines m^{-1} produces a diffraction pattern in which the second order of one of these wavelengths occurs at the same angle θ as the third order of the other wavelength.



What is the angle θ?

A 19.1° **B** 25.8° **C** 40.8° **D** 78.8°

30 Which diagram shows the electric field lines surrounding an isolated negative point charge?

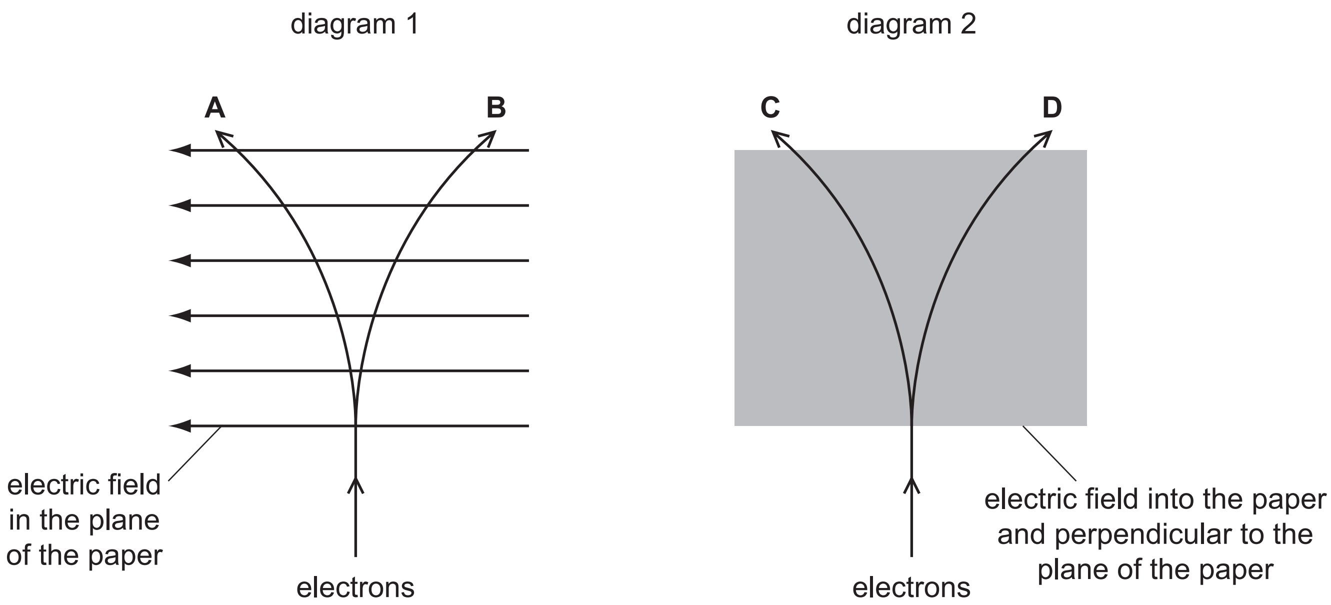


31 A beam of electrons is directed into an electric field and is deflected by it.

Diagram 1 represents an electric field in the plane of the paper.
Diagram 2 represents an electric field directed perpendicular to the plane of the paper.

The lines **A**, **B**, **C** and **D** represent possible paths of the electron beam. All paths are in the plane of the paper.

Which line best represents the path of the electrons inside the field?



32 A charged particle of charge q and mass m is initially at rest in a uniform electric field. The field is produced by parallel metal plates separated by a distance d and having a potential difference V between them.

What is an expression for the acceleration of the charged particle?

A $\frac{md}{qV}$ **B** $\frac{mV}{qd}$ **C** $\frac{qd}{mV}$ **D** $\frac{qV}{md}$

33 When there is a current of 5.0 A in a copper wire, the average drift velocity of the free electrons is $8.0 \times 10^{-4}\,\mathrm{m\,s^{-1}}$.

What is the average drift velocity in a different copper wire that has twice the diameter and a current of 10.0 A?

A $4.0 \times 10^{-4}\,\mathrm{m\,s^{-1}}$

B $8.0 \times 10^{-4}\,\mathrm{m\,s^{-1}}$

C $1.6 \times 10^{-3}\,\mathrm{m\,s^{-1}}$

D $3.2 \times 10^{-3}\,\mathrm{m\,s^{-1}}$

34 What is equivalent to one volt?

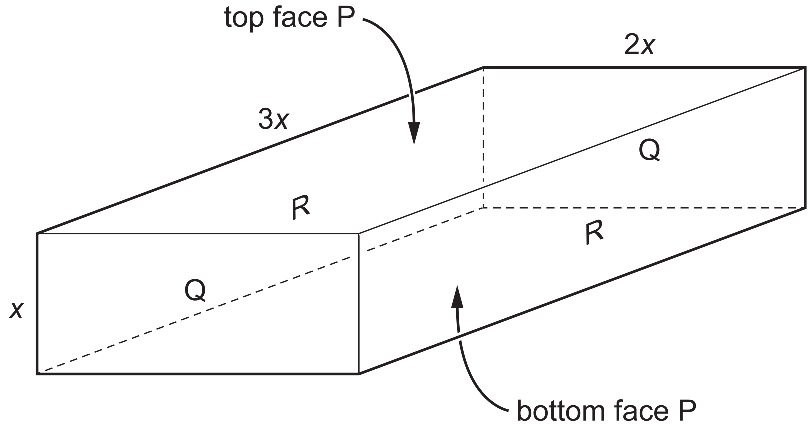
A one coulomb per second

B one joule per coulomb

C one joule per second

D one joule second per coulomb squared

35 The diagram shows a rectangular block with dimensions x, $2x$ and $3x$.



Electrical contact can be made to the block between opposite pairs of faces (for example, between the faces labelled R).

Which statement describing the electrical resistance of the block is correct?

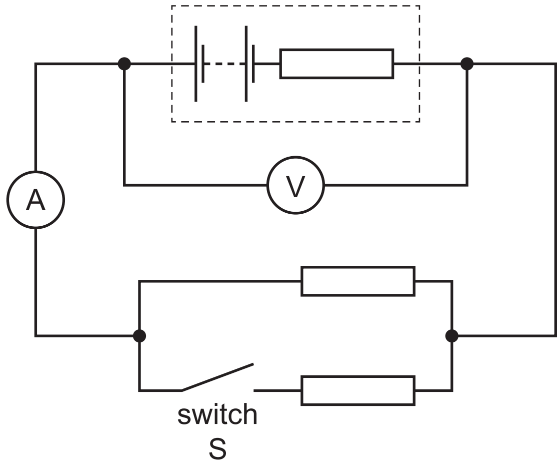
A It is maximum between the faces labelled P.

B It is maximum between the faces labelled Q.

C It is maximum between the faces labelled R.

D It is the same, whichever pair of faces is used.

36 A battery, with internal resistance, is connected to a parallel arrangement of two resistors and a switch S, as shown.

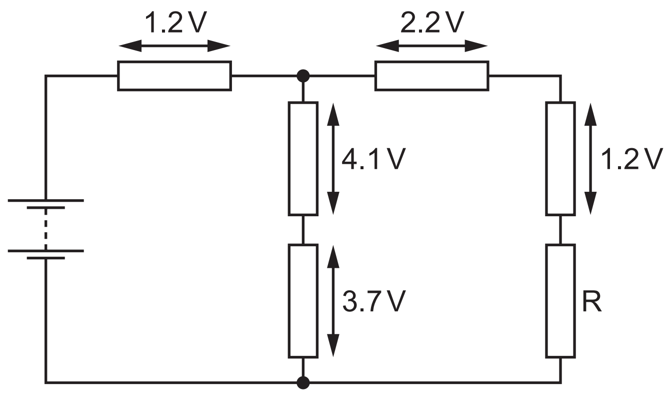


Initially switch S is open.

What happens to the voltmeter and ammeter readings when switch S is closed?

	voltmeter reading	ammeter reading
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

37 A battery is connected to a network of six resistors, as shown.



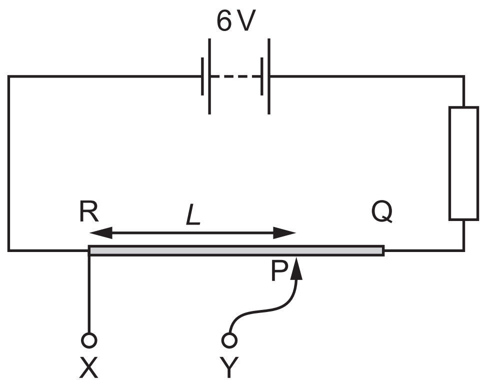
The potential differences across five of the resistors are labelled on the diagram.

What is the potential difference across resistor R?

A 4.4 V **B** 4.6 V **C** 6.6 V **D** 11.2 V

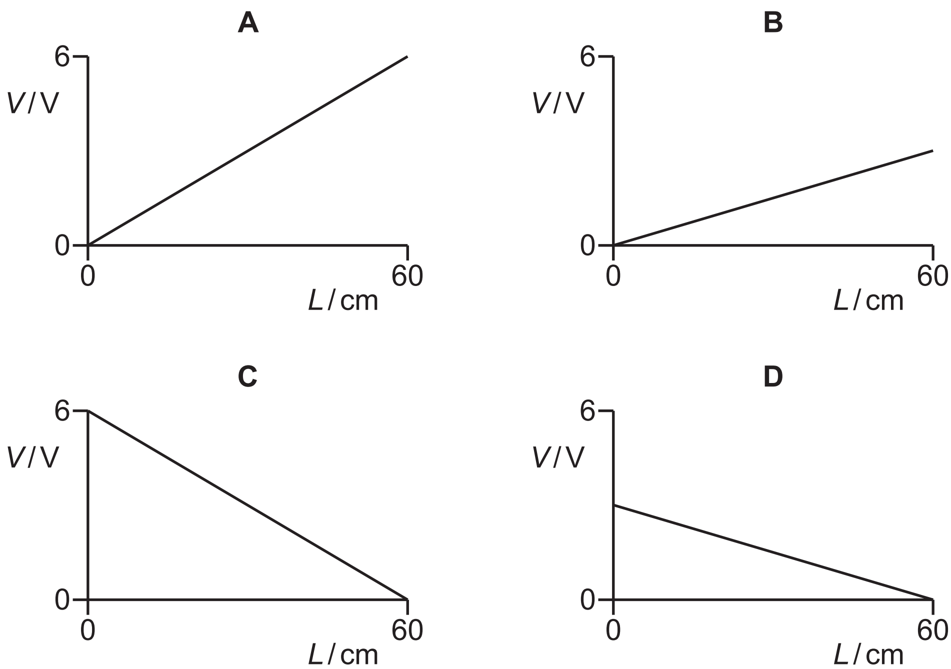
38 The diagram shows a battery of electromotive force (e.m.f.) 6 V, connected in series with a resistor and a uniform resistance wire RQ of length 60 cm.

The resistance of RQ is equal to the resistance of the resistor.



Terminal X is connected to fixed point R. Terminal Y is connected to point P, a connection that may be made at any position along the wire. *L* is the distance between R and P.

Which graph shows the variation with *L* of the potential difference (p.d.) *V* across XY?



39 A nucleus emits a β^- particle.

What is the change to the proton number and to the nucleon number of the nucleus?

	proton number	nucleon number
A	–1	+1
B	0	–1
C	+1	–1
D	+1	0

40 How many up quarks and how many down quarks are in a nucleus of the nuclide $^{37}_{17}\mathrm{C}l$?

	up quarks	down quarks
A	51	60
B	54	57
C	57	54
D	60	51

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2018**

1 hour 15 minutes

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

* 3 3 7 4 4 3 5 7 9 5 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

IB18 11_9702_12/RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 A car is travelling at a speed of $20\,m\,s^{-1}$. The table contains values for the kinetic energy and the momentum of the car.

Which values are reasonable estimates?

	kinetic energy / J	momentum / $kg\,m\,s^{-1}$
A	3×10^5	3×10^4
B	3×10^5	5×10^6
C	2×10^7	3×10^4
D	2×10^7	5×10^6

2 What is the unit of resistance when expressed in SI base units?

A $kg\,m^2\,s^{-2}\,A^{-1}$

B $kg\,m^2\,s^{-3}\,A^{-2}$

C $kg\,m\,s^{-2}\,A^{-1}$

D $kg\,m\,s^{-3}\,A^{-1}$

3 Which list contains both scalar and vector quantities?

A acceleration, momentum, velocity, weight

B area, current, force, work

C distance, kinetic energy, power, pressure

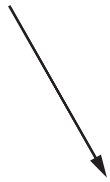
D mass, temperature, time, speed

4 Vectors P and Q are drawn to scale.

Which diagram represents the vector (P + Q)?

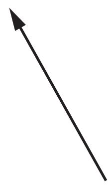
A

B



C

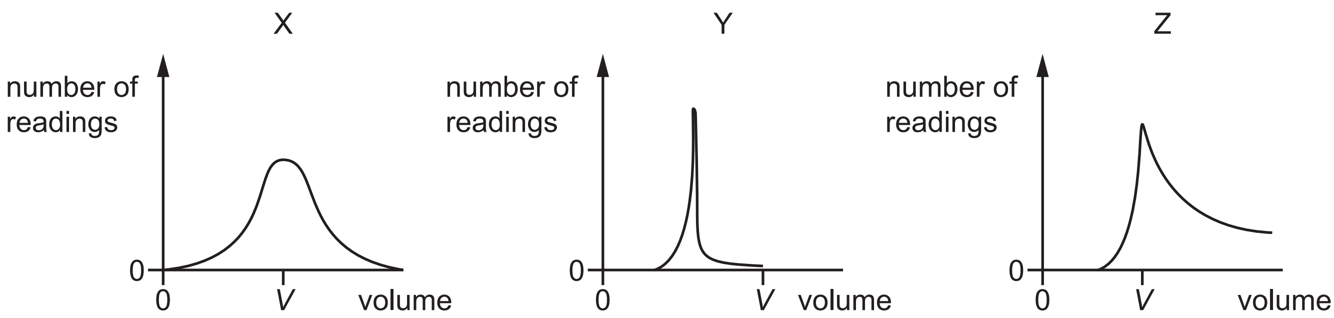
D



5 Students take readings of the volume of a liquid using three different pieces of measuring equipment X, Y and Z.

The true value of the volume of the liquid is V.

The students' results are shown.



How many pieces of equipment are precise and how many are accurate?

	number of precise pieces of equipment	number of accurate pieces of equipment
A	1	1
B	1	2
C	2	1
D	2	2

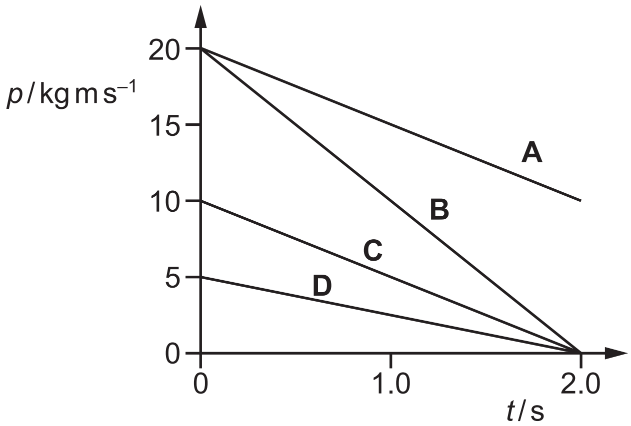
6 A sprinter runs a 100 m race. The sprinter has a constant acceleration from rest of $2.5\,\text{m}\,\text{s}^{-2}$ until reaching a speed of $10\,\text{m}\,\text{s}^{-1}$. The speed then remains constant until the end of the race.

Which time does it take the sprinter to run the race?

A 8.9 s **B** 10 s **C** 12 s **D** 14 s

7 A resultant force of 10 N acts on a body for a time of 2.0 s.

Which graph could show the variation with time t of the momentum p of the body?



8 The acceleration of free fall on the surface of planet P is one tenth of that on the surface of planet Q.

On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and the weight of the same body on the surface of planet Q?

	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

9 Two bodies travelling along the same straight line collide in a perfectly elastic collision.

Which statement **must** be correct?

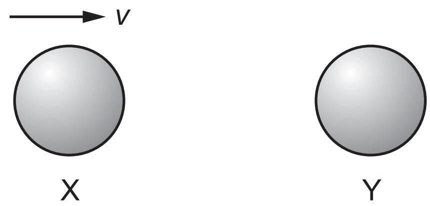
A The initial speed of one body will be the same as the final speed of the other body.

B The relative speed of approach between the two bodies equals their relative speed of separation.

C The total momentum is conserved but the total kinetic energy will be reduced.

D One of the bodies will be stationary at one instant.

10 The diagram shows two identical spheres X and Y.

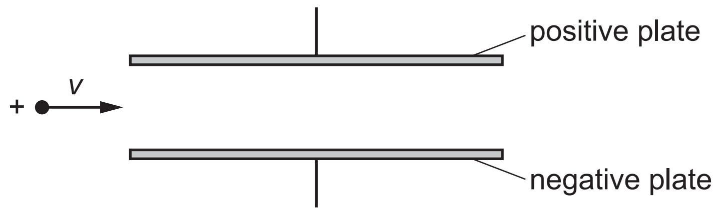


Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

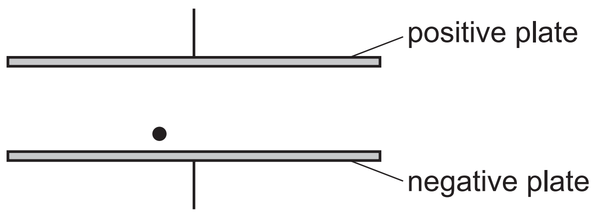
What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

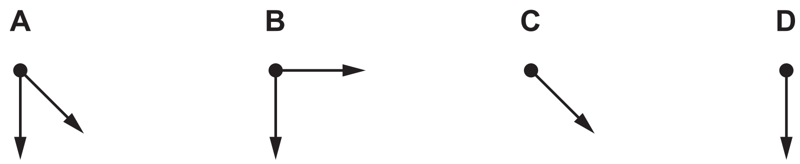
11 A positively-charged particle of negligible mass, moving at constant velocity v in a vacuum, enters a uniform electric field between two parallel plates, as shown.



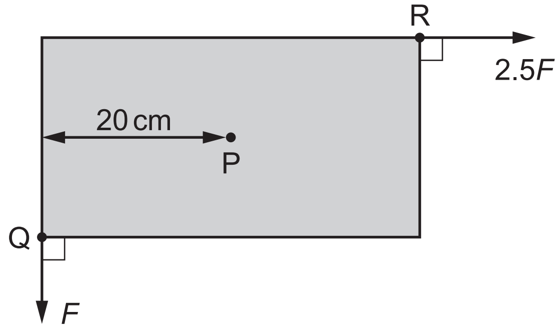
A short time later, the particle is at the position shown.



Which diagram represents the force or forces acting on the particle?



12 A uniform rectangular board is supported by a frictionless pivot at its centre point P.

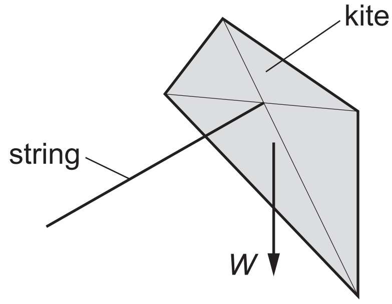


Two forces act in the plane of the board. Force F acts at corner Q and force $2.5F$ acts at corner R. The perpendicular distance between the line of action of force F and point P is 20 cm. The board is in equilibrium.

What is the area of the board?

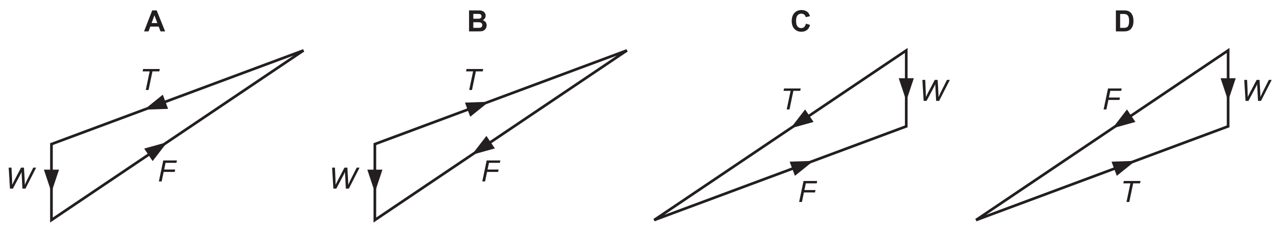
A $160\,\text{cm}^2$ **B** $320\,\text{cm}^2$ **C** $640\,\text{cm}^2$ **D** $1600\,\text{cm}^2$

13 A kite is in equilibrium at the end of a string, as shown.



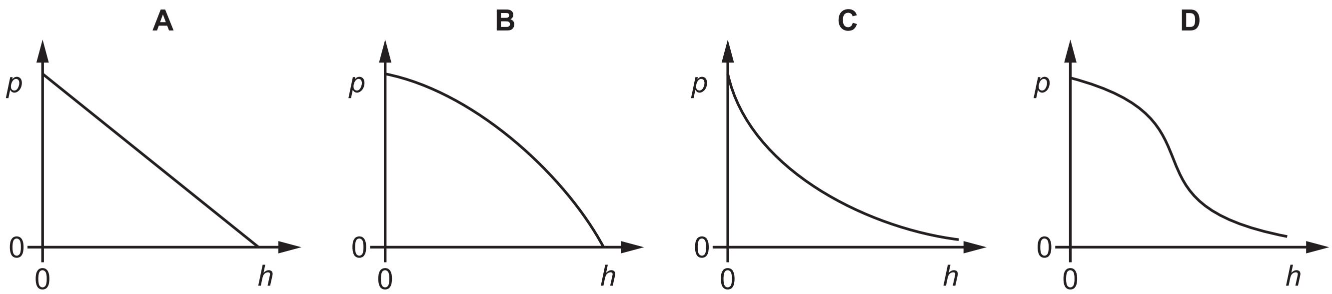
The kite has three forces acting on it: the weight W, the tension T in the string, and the force F from the wind.

Which vector diagram represents the forces acting on the kite?



14 The density of the air in the atmosphere decreases as the height h above the surface of the Earth increases.

Which graph best shows the variation with height h of the pressure p of the air?



15 A bungee jumper on a platform over a river is attached to an elastic rope that is 20 m long when unstretched. He falls towards the river and his lowest point is 30 m below the platform.

The initial gravitational potential energy of the jumper is transferred to other forms during the jump.

Which other forms of energy do the jumper and rope have when the jumper has fallen half-way and when he is at the lowest point of his jump?

	half-way	lowest point
A	kinetic energy and elastic potential energy	kinetic energy and elastic potential energy
B	kinetic energy and elastic potential energy	elastic potential energy only
C	kinetic energy only	kinetic energy and elastic potential energy
D	kinetic energy only	elastic potential energy only

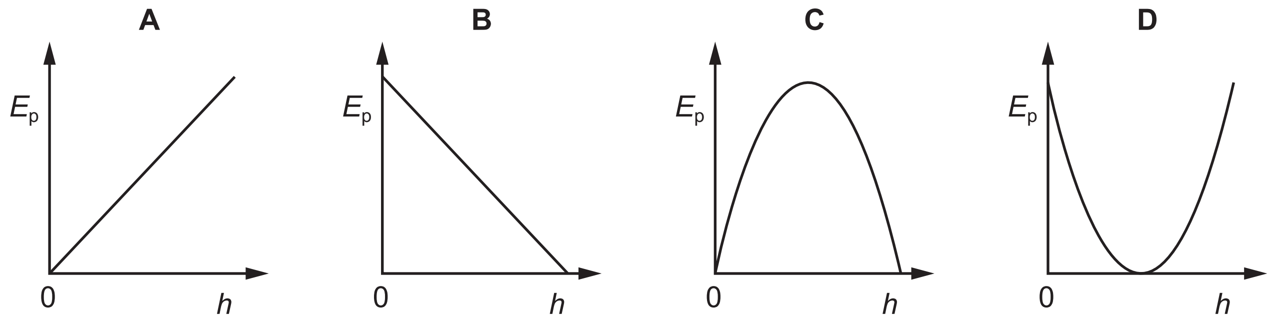
16 A cylinder contains a fixed mass of gas. The gas, at a constant pressure of 1.3×10^5 Pa, expands from a volume of $900\,cm^3$ to a volume of $1100\,cm^3$.

What is the work done by the gas during this expansion?

A 26 J **B** 130 J **C** 2600 J **D** 13 000 J

17 An object is thrown into the air.

Which graph shows how the gravitational potential energy E_p of the object varies with height h above the ground?



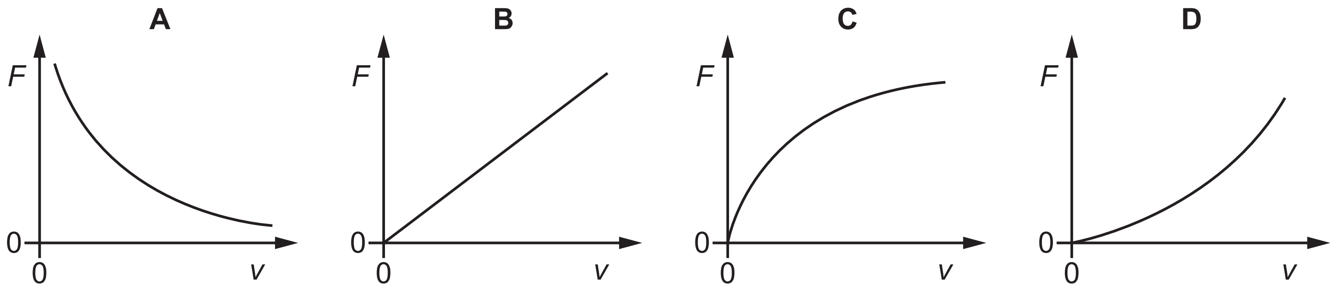
18 A car of mass 1800 kg accelerates along a horizontal road so that its speed increases from $20\,m\,s^{-1}$ to $25\,m\,s^{-1}$ in a time of 5.4 s.

What is the average useful power output of the car's engine?

A 4.2 kW **B** 38 kW **C** 120 kW **D** 1100 kW

19 A variable force is applied to ensure that a constant power is supplied to a train.

Which graph best shows the variation of the force F applied with the velocity v of the train?



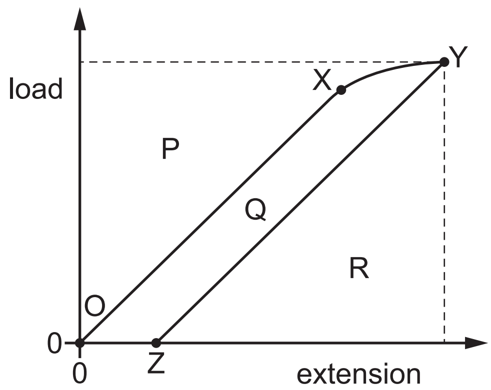
20 A metal cylinder is able to withstand a compressive force of 4.0 kN without deforming plastically.

The cylinder has cross-sectional area A and would be at its elastic limit when a stress σ is applied.

What is a possible pair of values for A and σ?

	A / m^2	σ / MPa
A	1.5×10^{-5}	50
B	1.5×10^{-5}	80
C	7.5×10^{-5}	50
D	7.5×10^{-5}	80

21 A wire has both elastic and plastic properties. When it is slowly loaded, its extension varies with load as shown by line OXY. The removal of the load is represented by line YZ. This creates areas P, Q and R on the graph.



Which area represents the maximum elastic potential energy stored in the wire?

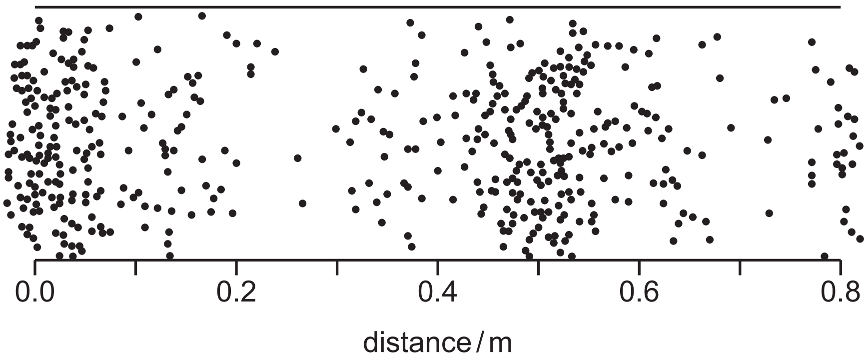
A P **B** Q **C** Q + R **D** R

22 A progressive wave on a wire has a frequency of 10 Hz. Two points on the wire, separated by a distance of 0.25 m, have a phase difference of 22.5°.

What is the maximum speed of the wave?

A $2.5\,m\,s^{-1}$ **B** $10\,m\,s^{-1}$ **C** $20\,m\,s^{-1}$ **D** $40\,m\,s^{-1}$

23 When a guitar string is plucked, it causes a longitudinal sound wave in the air, as shown.



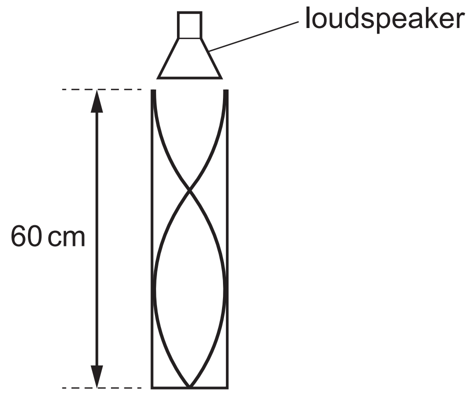
The speed of sound in the air is $340\,m\,s^{-1}$.

What is the approximate frequency of the sound wave shown?

A 430 Hz **B** 680 Hz **C** 1100 Hz **D** 1400 Hz

24 The sound from a loudspeaker placed above a tube causes resonance of the air in the tube.

A stationary wave is formed with two nodes and two antinodes as shown.



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

What is the frequency of the sound?

A 430 Hz **B** 570 Hz **C** 850 Hz **D** 1700 Hz

25 A police car has a two-tone siren emitting sound of frequencies of 700 Hz and 1000 Hz.

The police car is travelling at a speed of $40.0\,m\,s^{-1}$ towards a stationary observer. The speed of sound in the air is $340\,m\,s^{-1}$.

What is the difference between the two frequencies of the sound that is heard by the observer?

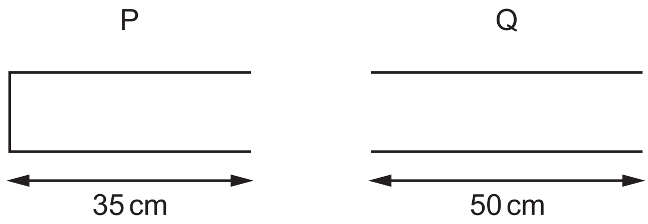
A 268 Hz **B** 300 Hz **C** 335 Hz **D** 340 Hz

26 A surveyor's device emits a pulse of light. The light is reflected from a wall 150 m away.

What is the time taken for the pulse to travel from the device to the wall and then back to the device?

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

27 Progressive sound waves of wavelength 20 cm enter the air columns in a closed pipe P and an open pipe Q. The lengths of the pipes are shown.



In which pipe or pipes are stationary waves formed?

A P and Q

B P only

C Q only

D neither P nor Q

28 What happens when waves pass through a gap equal to their wavelength?

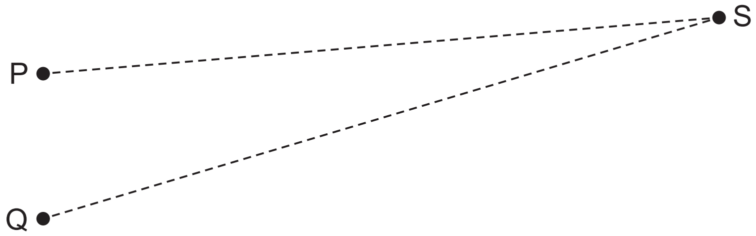
A There is diffraction and the wavelength decreases.

B There is diffraction and the wavelength stays the same.

C There is no diffraction and the wavelength decreases.

D There is no diffraction and the wavelength stays the same.

29 Two sources of microwaves P and Q produce coherent waves with a phase difference of 180°. The waves have the same wavelength λ.



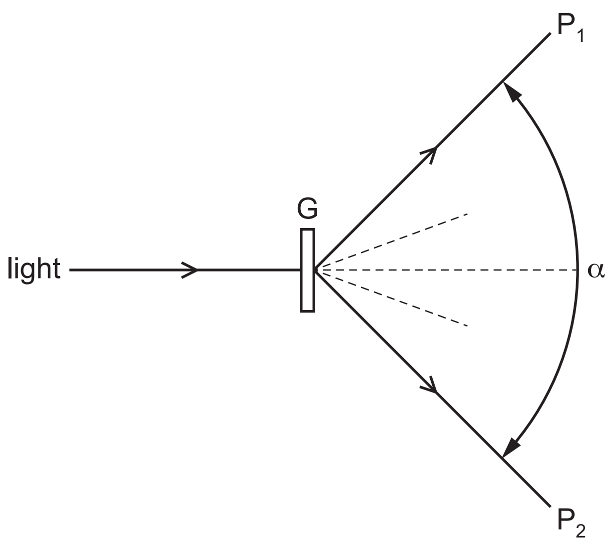
At the point S there is a minimum in the interference pattern produced by waves from the two sources. The distance (QS – PS) is called the path difference.

In the expressions shown, n is an integer.

Which expression represents the path difference?

A $n\lambda$ **B** $\frac{1}{2}n\lambda$ **C** $(n + \frac{1}{2})\lambda$ **D** $(2n + \frac{1}{2})\lambda$

30 A parallel beam of monochromatic light of wavelength λ is incident normally on a diffraction grating G. The angle between the directions of the two second-order diffracted beams at P_1 and at P_2 is α, as shown.

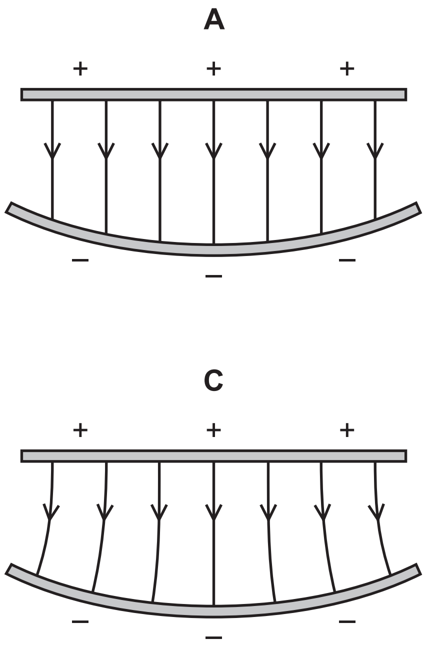


What is the spacing of the lines on the grating?

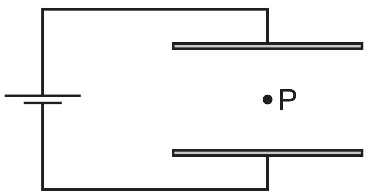
A $\dfrac{2\lambda}{\sin\alpha}$ **B** $\dfrac{\lambda}{\sin\alpha}$ **C** $\dfrac{2\lambda}{\sin(\alpha/2)}$ **D** $\dfrac{\lambda}{\sin(\alpha/2)}$

31 A flat plate is positively charged and a curved plate is negatively charged.

Which diagram shows the electric field lines between the two plates?



32 Two parallel metal plates are connected to a d.c. supply, as shown.

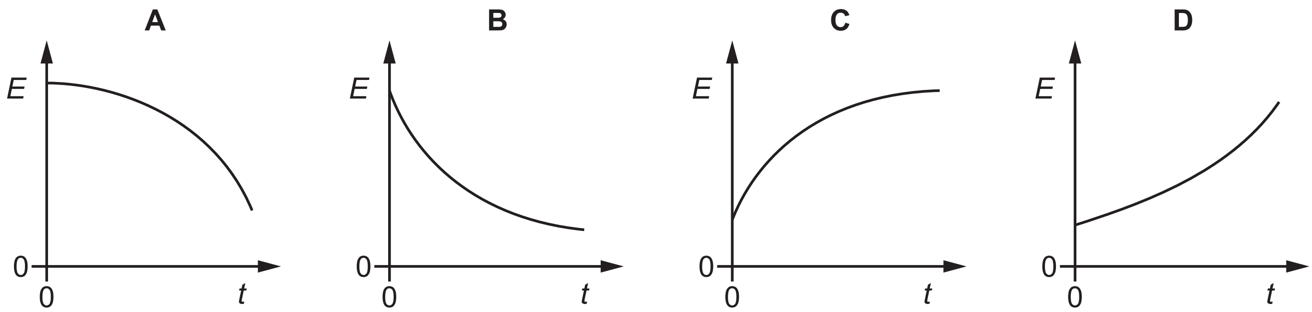


The two plates are moved towards each other at constant speed.

It may be assumed that the electric field between the plates is uniform.

Point P is mid-way between the two plates.

Which graph shows the variation with time t of the electric field strength E at point P?



33 Which two units are used to define the coulomb?

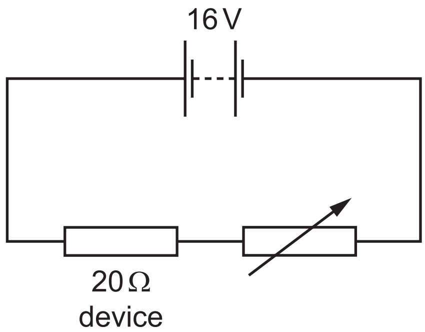
A ampere and second

B ampere and volt

C volt and ohm

D volt and second

34 An electrical device of fixed resistance 20 Ω is connected in series with a variable resistor and a battery of electromotive force (e.m.f.) 16 V and negligible internal resistance.



What is the resistance of the variable resistor when the power dissipated in the electrical device is 4.0 W?

A 16 Ω **B** 36 Ω **C** 44 Ω **D** 60 Ω

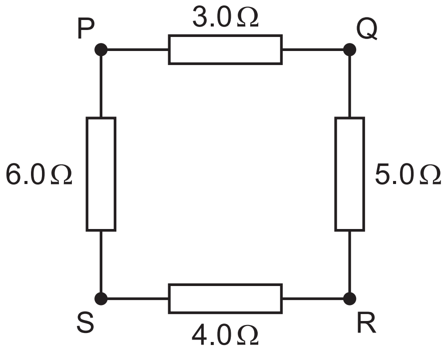
35 A wire of length L has resistance R. The cross-section of the wire is circular with radius r.

A second wire, also of circular cross-section, and of the same material, has resistance $\frac{1}{2}R$.

What could be the radius and the length of the second wire?

	radius	length
A	$\frac{r}{2}$	$\frac{L}{2}$
B	$\frac{r}{\sqrt{2}}$	$\frac{L}{2}$
C	$r\sqrt{2}$	$2L$
D	$2r$	$2L$

36 A battery of negligible internal resistance may be connected between any two points P, Q, R and S of the network of resistors shown.



Which connections will give the largest current and the smallest current in the battery?

	largest current	smallest current
A	PQ	PR
B	PQ	QS
C	RS	PR
D	RS	QS

37 Kirchhoff's second law is a consequence of a basic principle.

What is this principle?

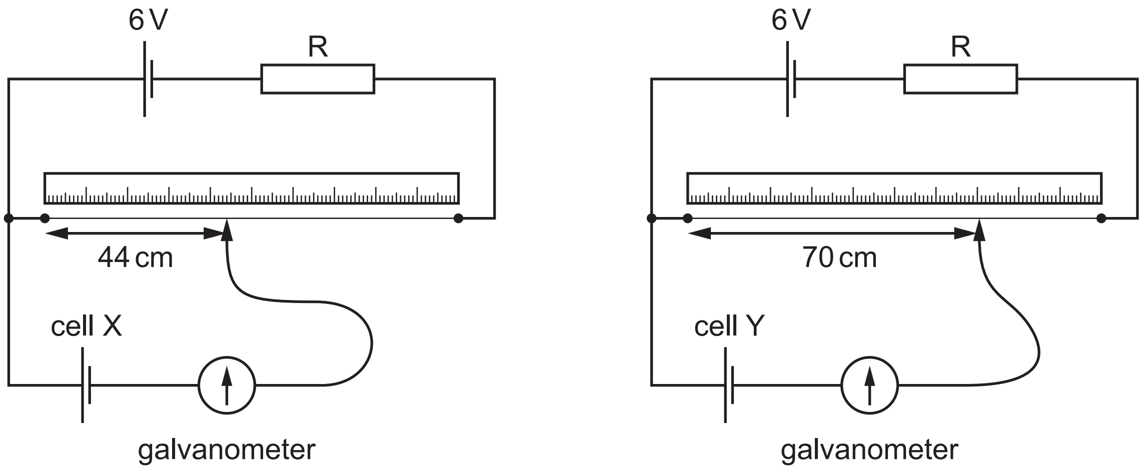
A The charge flowing in an electric circuit is conserved.

B The energy in an electric circuit is conserved.

C The sum of the electric currents entering a point in an electrical circuit is equal to the sum of the electric currents leaving that point.

D The sum of the potential differences in a circuit is equal to the sum of the products of the current and resistance.

38 Two cells are investigated using a potentiometer. At the balance point, cell X gives a reading of 44 cm and cell Y gives a reading of 70 cm.



Which statement is **not** correct?

A A potentiometer balance point results in zero current through the galvanometer.

B At the balance point, the current through resistor R in both circuits is the same.

C The electromotive force (e.m.f.) of cell X is larger than that of cell Y.

D The value of the e.m.f. of each of the cells X and Y is less than 6 V.

39 A proton in a nucleus undergoes β^+ decay. One of the products is a neutron.

What are the other products?

A an electron and a neutrino

B an electron and an antineutrino

C a positron and a neutrino

D a positron and an antineutrino

40 A certain type of hadron has zero charge. It is composed of a down quark, a strange quark and one other quark.

What could be the other quark?

A up

B down

C strange

D anti-strange

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2018**

1 hour 15 minutes

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

4302523063

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho g h$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which statement is **not** a reasonable estimate?

A Atmospheric pressure at sea level is about 1×10^5 Pa.

B Light takes 5×10^2 s to reach us from the Sun.

C The frequency of ultraviolet light is 3×10^{12} Hz.

D The lifespan of a man is about 2×10^9 s.

2 Three of these quantities have the same unit.

Which quantity has a different unit?

A $\dfrac{\text{energy}}{\text{distance}}$

B force

C power × time

D rate of change of momentum

3 Which group of quantities contains only vectors?

A acceleration, displacement, speed

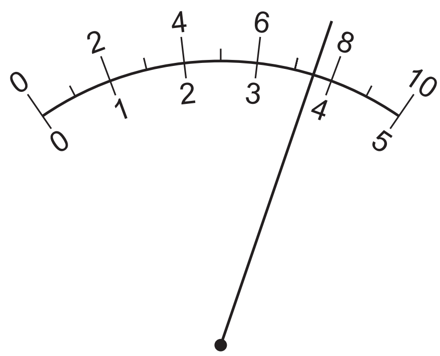
B acceleration, work, electric field strength

C displacement, force, velocity

D power, electric field strength, force

4 An ammeter is calibrated so that it shows a full-scale deflection when it measures a current of 2.0 A.

The diagram shows the display of this ammeter when it is measuring a current.



Which current is the ammeter measuring?

A 0.75 A **B** 1.5 A **C** 3.8 A **D** 7.5 A

5 The width of a table is measured as (50.3 ± 0.1) cm. Its length is measured as (1.40 ± 0.01) m.

What is the area of the table and its absolute uncertainty?

A $(0.7 \pm 0.1)\,\text{m}^2$

B $(0.704 \pm 0.006)\,\text{m}^2$

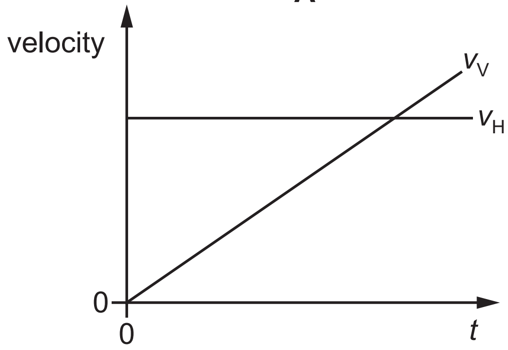
C $(0.704 \pm 0.011)\,\text{m}^2$

D $(70.4 \pm 0.6)\,\text{m}^2$

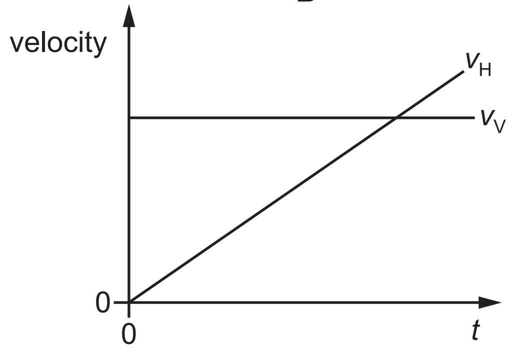
6 A stone is projected horizontally at time $t = 0$ and falls. Air resistance is negligible. The stone has a horizontal component of velocity v_H and a vertical component of velocity v_V.

Which graph shows how v_H and v_V vary with time t?

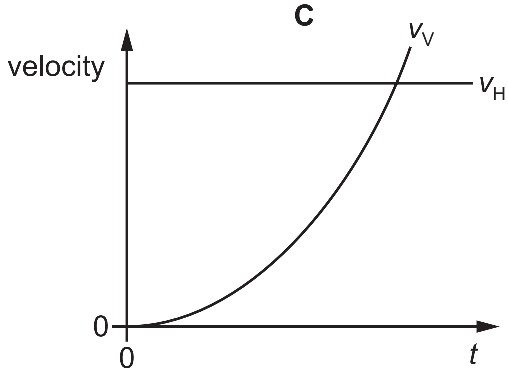
A



B



C



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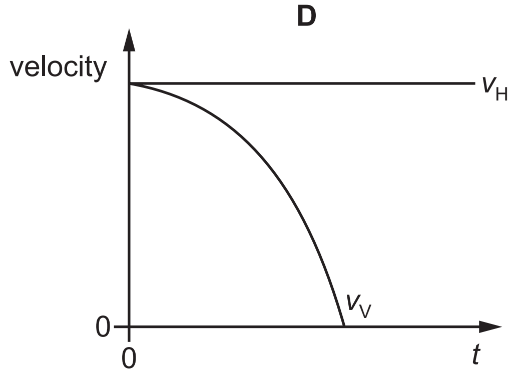


7 Two isolated spheres have masses 2.0 kg and 4.0 kg. The spheres collide and then move apart.

During the collision, the 2.0 kg mass has an average acceleration of $8.0\,\text{m}\,\text{s}^{-2}$.

What is the average acceleration of the 4.0 kg mass?

A $2.0\,\text{m}\,\text{s}^{-2}$ **B** $4.0\,\text{m}\,\text{s}^{-2}$ **C** $8.0\,\text{m}\,\text{s}^{-2}$ **D** $16\,\text{m}\,\text{s}^{-2}$

8 A mass is placed on a frictionless slope inclined at 30° to the horizontal. The mass is then released.

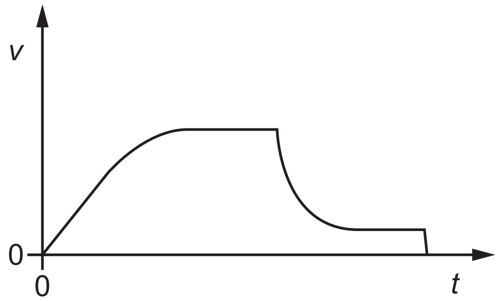
What is its acceleration down the slope?

A $4.9\,\mathrm{m\,s^{-2}}$ **B** $5.7\,\mathrm{m\,s^{-2}}$ **C** $8.5\,\mathrm{m\,s^{-2}}$ **D** $9.8\,\mathrm{m\,s^{-2}}$

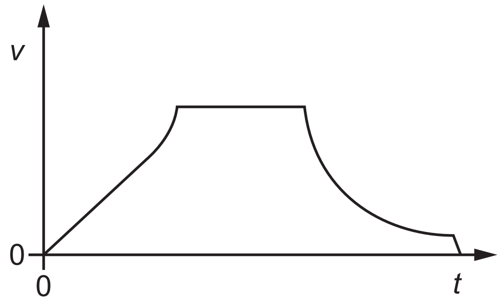
9 A parachutist falls vertically from rest at time t = 0 from a hot-air balloon. She falls for some distance before opening her parachute.

Which graph best shows the variation with time t of the speed v of the parachutist?

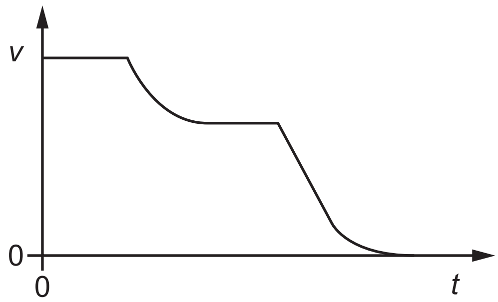
A



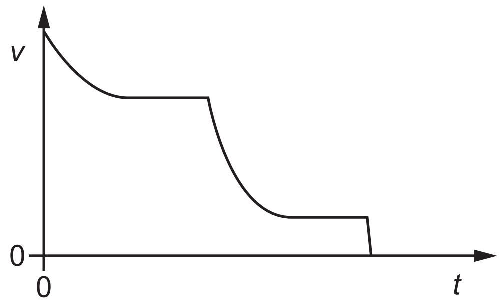
B



C



D



10 A ship of mass $8.4 \times 10^{7}\,\mathrm{kg}$ is approaching a harbour with speed $16.4\,\mathrm{m\,s^{-1}}$. By using reverse thrust it can maintain a constant total stopping force of 920 000 N.

How long will it take to stop?

A 15 seconds

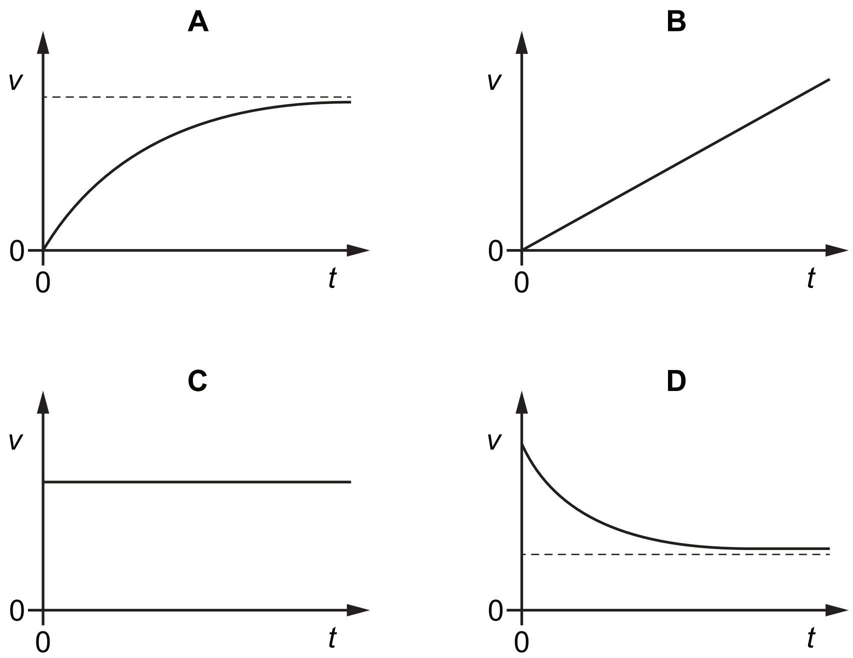
B 150 seconds

C 25 minutes

D 250 minutes

11 A rigid, hollow sphere is immersed deep in water and released from rest. It experiences an upthrust which propels it towards the surface of the water.

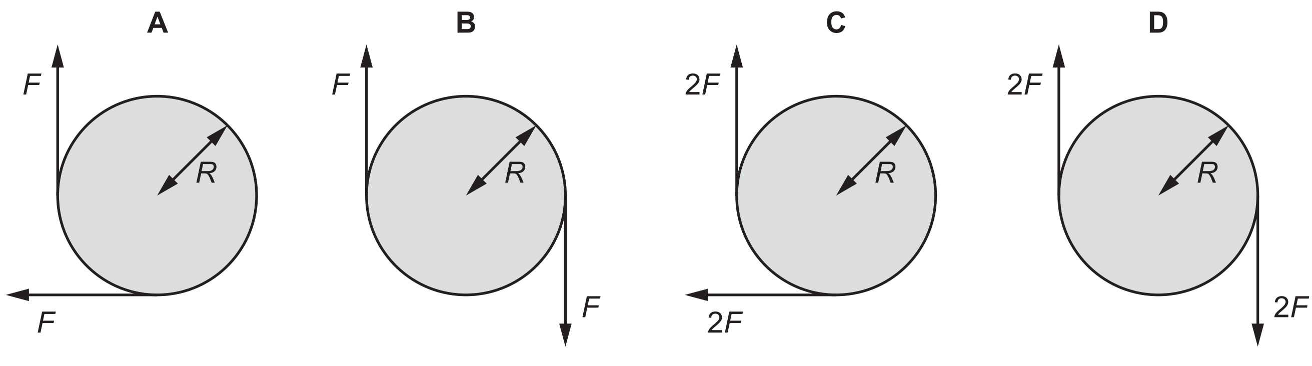
Which graph best shows the variation with time *t* of its upward velocity *v*?



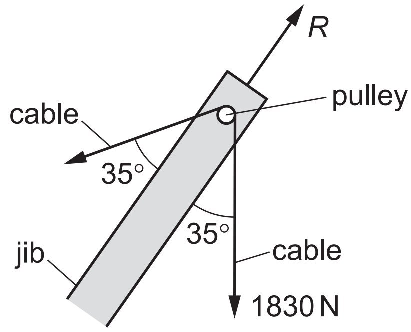
12 A flat metal disc has radius *R*.

Forces of magnitude *F* are applied tangentially at the edge of the disc. The forces are in the plane of the disc.

Which arrangement of forces produces only a torque of magnitude 2*FR*?



13 The diagram shows the jib of a crane at an angle of 35° to the vertical. A cable passes over a frictionless pulley and carries a load of 1830 N.



The force R that the pulley exerts on the cable is in line with the jib. The cable and the pulley are in equilibrium.

What is the value of R?

A 1000 N **B** 1500 N **C** 2100 N **D** 3000 N

14 What is a unit for density?

A N m^{-3} **B** g mm^{-1} **C** kg cm^{-2} **D** $\mu\text{g mm}^{-3}$

15 Which statement about energy is **not** correct?

A Energy is never lost but it may be transferred between different forms.

B In an inelastic collision, the total energy is constant.

C The efficiency of a system is the ratio of the useful energy output to the total energy input.

D When a machine does work, friction reduces the total energy.

16 An electric kettle is rated as having an input power of 1.50 kW and an efficiency of 65.0%.

The kettle is switched on for 2.00 minutes.

How much energy is transferred to the water in the kettle?

A 0.975 kJ **B** 117 kJ **C** 180 kJ **D** 277 kJ

17 On a planet, a gravitational force F acts on a mass of 6.0 kg. The mass is moved by force F a distance of 30 m in the direction of the gravitational field. The work done by the field is 450 J.

What is the force F on the mass and what is the acceleration of free fall g on the planet?

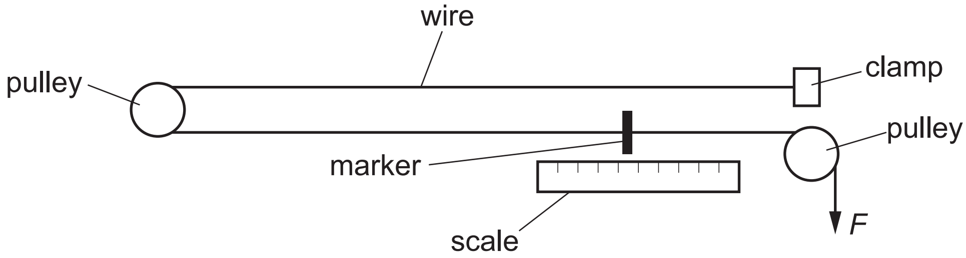
	F / N	g / m s^{-2}
A	0.067	0.011
B	0.067	0.40
C	15	2.5
D	15	90

18 A girl of mass 50 kg runs up a flight of 20 steps in 7.0 seconds. Each step is 25 cm high.

What is the useful average output power provided by the girl to climb the flight of steps?

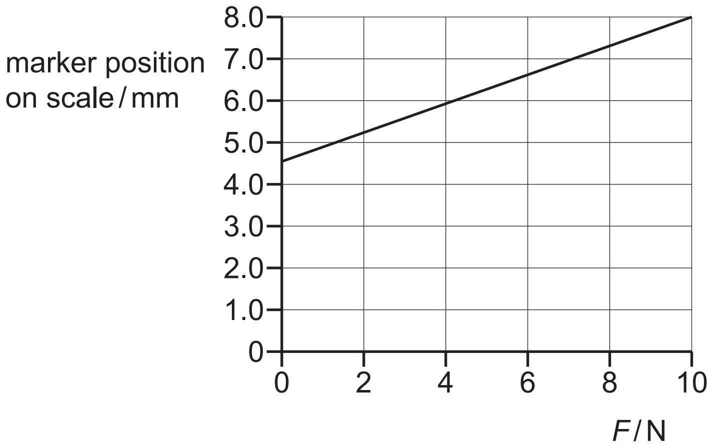
A 18 W **B** 36 W **C** 350 W **D** 2500 W

19 In an experiment to measure the Young modulus of a metal, a wire of the metal of diameter 0.25 mm is clamped, as shown.



The wire passes from a clamp, around a frictionless pulley, and then to a second frictionless pulley where loads F are applied to it. A marker is attached to the wire so that the total length of wire between the clamp and the marker is initially 3.70 m. A scale is fixed near to this marker.

The graph shows how the reading on the scale varies with F.



What is the Young modulus of the metal?

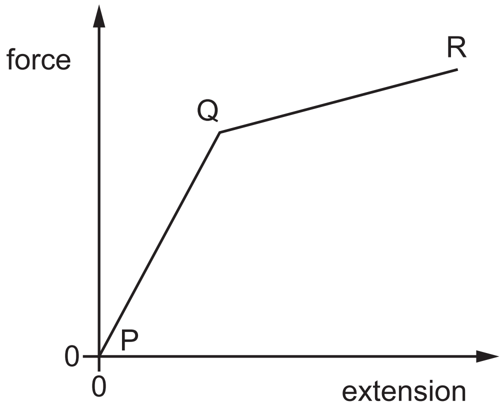
A 5.5×10^{10} Pa

B 9.4×10^{10} Pa

C 1.6×10^{11} Pa

D 2.2×10^{11} Pa

20 A scientist is investigating the properties of a new material. She plots a force-extension graph for the material up to its breaking point.



Which statement **must** be correct?

A The area under the graph from P to R is the strain energy stored in the material.

B The area under the graph from P to R is the work done in stretching the material.

C The material stretches elastically from Q to R.

D The material stretches plastically from P to Q.

21 A progressive sound wave in air has amplitude x_0 and intensity I.

The amplitude of the wave increases to $3x_0$.

What is the new intensity of the wave?

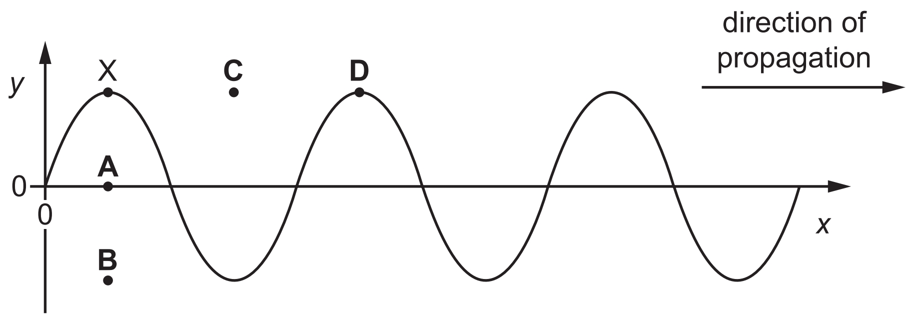
A $\frac{I}{9}$ **B** $\frac{I}{3}$ **C** $3I$ **D** $9I$

22 The variation with distance x of the displacement y of a transverse wave on a rope is shown at time $t = 0$.

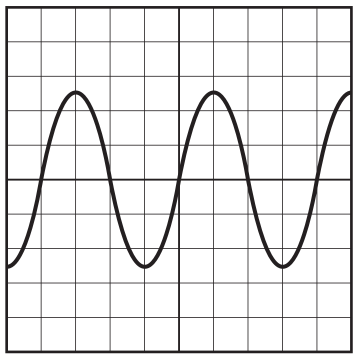
The wave has a frequency of 0.5 Hz.

A point X on the rope is marked. The diagram shows the original position of X and four new positions.

What is the position of X at time $t = 1$ s?



23 A sound wave is detected by a microphone. The output from the microphone is connected to the Y-input of a cathode-ray oscilloscope (c.r.o.). The trace on the c.r.o. is shown.



The time-base is set at 0.20 ms per division.

What is the frequency of the sound wave?

A 1000 Hz **B** 1250 Hz **C** 2000 Hz **D** 2500 Hz

24 A bat flies directly towards a fixed ultrasound detector at a speed of 25.0 m s^{-1} emitting pulses of ultrasound of frequency 40.0 kHz.

The speed of sound in air is 330 m s^{-1}.

Which frequency does the ultrasound detector record?

A 37.0 kHz **B** 37.2 kHz **C** 43.0 kHz **D** 43.3 kHz

25 An electromagnetic wave has a wavelength of 1.0×10^{-7} m.

To which region of the electromagnetic spectrum does this wave belong?

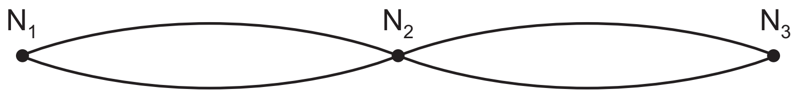
A infra-red

B ultraviolet

C visible

D X-ray

26 The diagram shows a stationary wave on a string. The stationary wave has three nodes N_1, N_2 and N_3.



Which statement is correct?

A All points on the string vibrate in phase.

B All points on the string vibrate with the same amplitude.

C Points equidistant from N_2 vibrate with the same frequency and in phase.

D Points equidistant from N_2 vibrate with the same frequency and the same amplitude.

27 In which situation does diffraction occur?

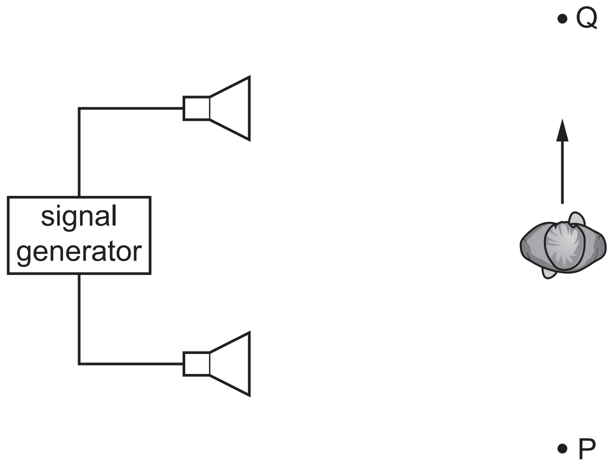
A A wave bounces back from a surface.

B A wave passes from one medium into another.

C A wave passes through an aperture.

D Waves from two identical sources are superposed.

28 A student connects two loudspeakers to a signal generator.



As the student walks from P to Q, he notices that the loudness of the sound rises and falls repeatedly.

What causes the loudness of the sound to vary?

A diffraction of the sound waves

B Doppler shift of the sound waves

C interference of the sound waves

D reflection of the sound waves

29 A parallel beam of white light is incident normally on a diffraction grating. The second-order and third-order spectra partially overlap.

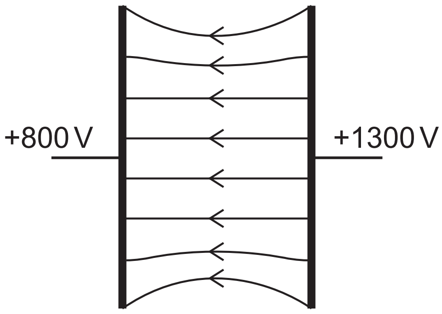
Which wavelength in the third-order spectrum appears at the same angle as the wavelength of 600 nm in the second-order spectrum?

A 300 nm **B** 400 nm **C** 600 nm **D** 900 nm

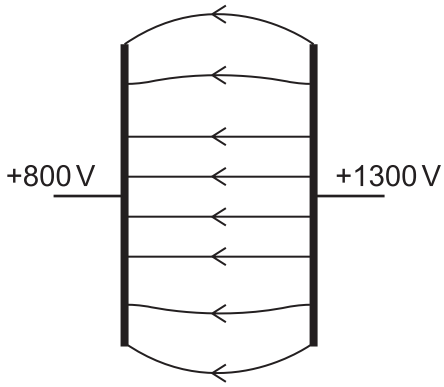
30 Two parallel metal plates are at electric potentials of +800 V and +1300 V.

Which diagram best represents the electric field between the metal plates?

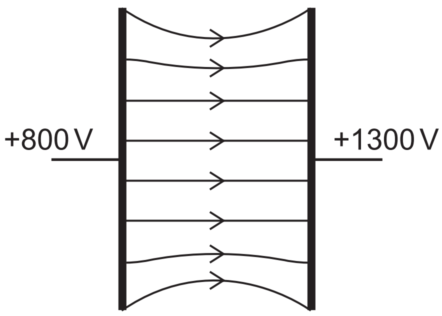
A



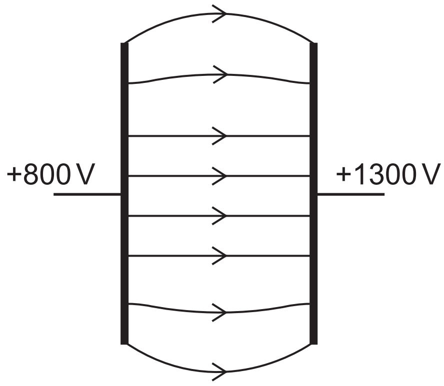
B



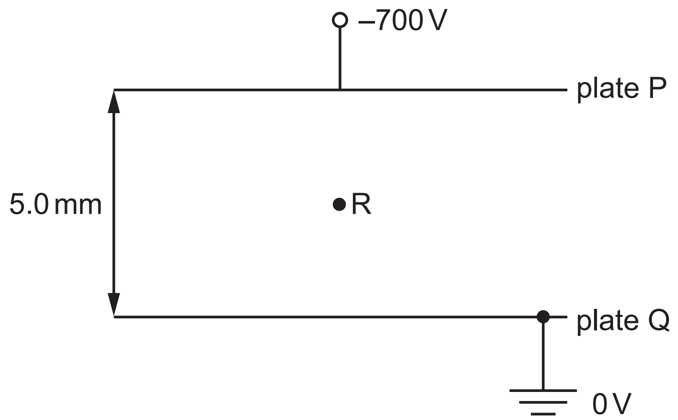
C



D



31 The diagram shows two metal plates P and Q. There is a potential difference of 700 V between the plates. Plate Q is earthed.



What is the magnitude and direction of the electric field at point R?

A $1.4 \times 10^2\,N\,C^{-1}$ from P towards Q

B $1.4 \times 10^2\,N\,C^{-1}$ from Q towards P

C $1.4 \times 10^5\,N\,C^{-1}$ from P towards Q

D $1.4 \times 10^5\,N\,C^{-1}$ from Q towards P

32 The current I in a copper wire can be calculated using the equation shown.

$$I = Anvq$$

What does the symbol v represent?

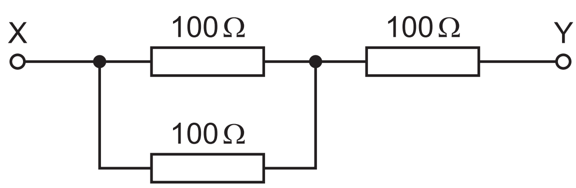
A the average drift velocity of the charge carriers

B the instantaneous velocity of the charge carriers

C the voltage applied across the wire

D the volume of the wire

33 Three resistors are to be connected into a circuit with the arrangement shown.



The power in any resistor must not be greater than 4.0 W.

What is the maximum voltage across XY?

A 24 V **B** 30 V **C** 40 V **D** 60 V

34 Gold is sometimes used to make very small connecting wires in electronic circuits.

A particular gold wire has length 2.50×10^{-3} m and cross-sectional area $6.25 \times 10^{-8}\,\text{m}^2$. Gold has resistivity $2.30 \times 10^{-8}\,\Omega\,\text{m}$.

What is the resistance of the wire?

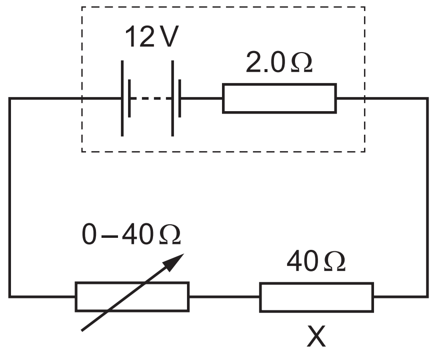
A $3.6 \times 10^{-18}\,\Omega$

B $5.8 \times 10^{-13}\,\Omega$

C $9.2 \times 10^{-4}\,\Omega$

D $6.8 \times 10^{-3}\,\Omega$

35 A resistor X of resistance $40\,\Omega$ and a variable resistor are connected to a battery of electromotive force (e.m.f.) 12 V and internal resistance $2.0\,\Omega$, as shown.

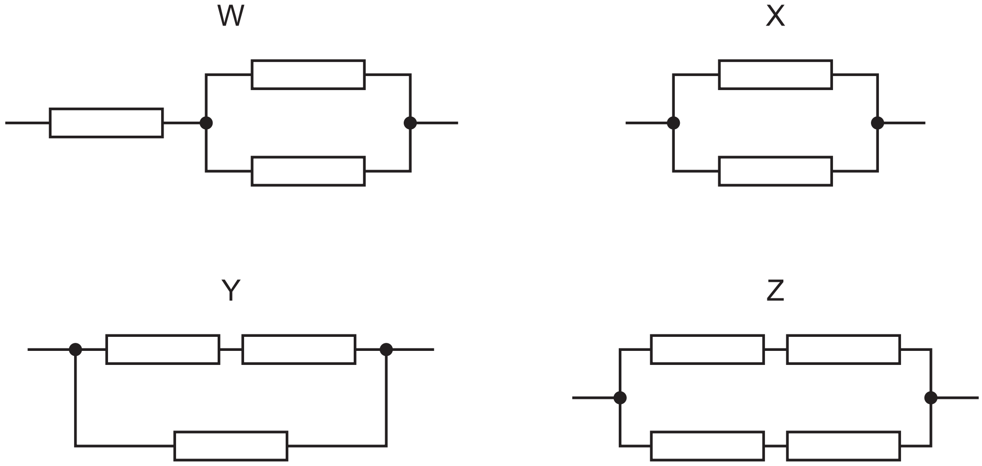


The resistance of the variable resistor is changed from 0 to $40\,\Omega$.

What is the change in power dissipated in resistor X?

A 2.4 W **B** 2.7 W **C** 3.6 W **D** 5.6 W

36 All the resistors shown in the resistor networks W, X, Y and Z have the same resistance.



Which list gives the networks in order of increasing total resistance?

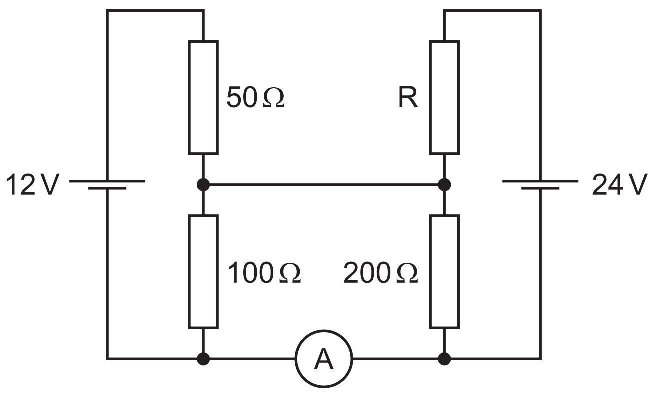
A W → Z → Y → X

B X → W → Y → Z

C X → Y → W → Z

D X → Y → Z → W

37 In the circuit shown, the ammeter reading is zero.



What is the resistance of resistor R?

A 100 Ω **B** 200 Ω **C** 400 Ω **D** 600 Ω

38 A neutron collides with a nucleus of uranium-235. One possible nuclear reaction that results is represented by the equation

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{154}_{60}\mathrm{Nd} + ^{80}_{32}\mathrm{Ge} + \mathrm{x}$$

where x represents one or more particles.

What does x represent?

A one neutron

B two electrons

C two neutrons

D two protons

39 A nucleus Q has the notation $^{y}_{x}\mathrm{Q}$.

Which of the following is an isotope of Q?

A $^{y-1}_{x}\mathrm{Q}$ **B** $^{y}_{x-1}\mathrm{Q}$ **C** $^{y}_{x+1}\mathrm{Q}$ **D** $^{y-1}_{x+1}\mathrm{Q}$

40 In β^- decay, a neutron inside a nucleus changes to a proton.

Which statement describes the quark composition of the nucleus during the decay?

A The number of down quarks decreases by one.

B The number of down quarks increases by one.

C The number of down quarks stays the same.

D The number of up quarks stays the same.

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Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2019**

1 hour 15 minutes

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

8952989673

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

IB19 11_9702_11/3RP

Cambridge Assessment International Education

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 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

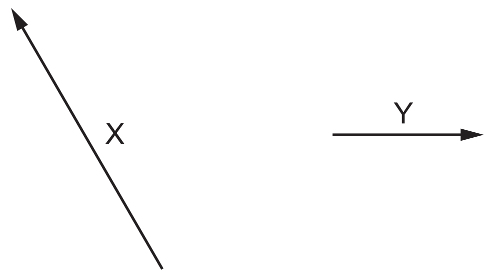
D wavelength of green light 500 nm

2 The speed of a wave in deep water depends on its wavelength L and the acceleration of free fall g.

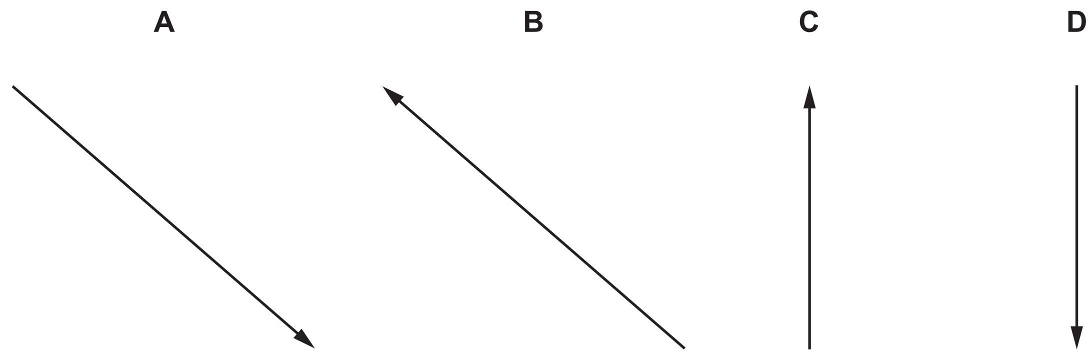
What is a possible equation for the speed v of the wave?

A $v = \sqrt{\left(\frac{gL}{2\pi}\right)}$ **B** $v = \frac{gL}{4\pi^2}$ **C** $v = 2\pi\sqrt{\left(\frac{g}{L}\right)}$ **D** $v = \frac{2\pi g}{L}$

3 The diagram shows two vectors X and Y, drawn to scale.



If X = Y – Z, which diagram best represents the vector Z?



4 A student intends to measure accurately the diameter of a wire (known to be approximately 1 mm) and the internal diameter of a pipe (known to be approximately 2 cm).

What are the most appropriate instruments for the student to use to make these measurements?

	wire	pipe
A	calipers	calipers
B	calipers	micrometer
C	micrometer	calipers
D	micrometer	micrometer

5 The power P dissipated in a resistor of resistance R is calculated using the expression

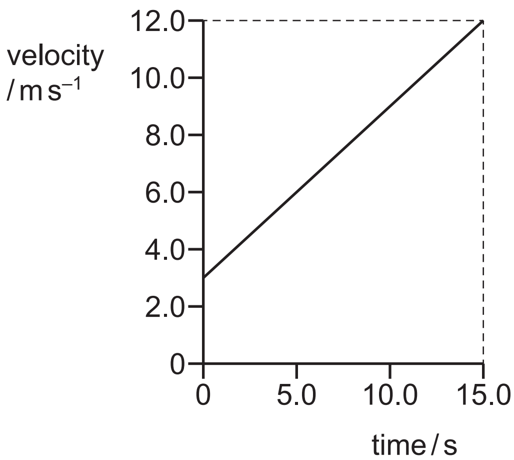
$$P = \frac{V^2}{R}$$

where V is the potential difference (p.d.) across the resistor. The percentage uncertainty in V is 5% and in R is 2%.

What is the percentage uncertainty in P?

A 3% **B** 7% **C** 8% **D** 12%

6 The velocity-time graph for an object of mass 2.5 kg is shown.



What is the resultant force acting on the object?

A 0.60 N **B** 0.80 N **C** 1.5 N **D** 2.0 N

7 Which statement follows directly from Newton's first law?

A A body remains at constant velocity unless acted upon by a resultant force.

B A satellite in circular motion about the Earth has a constant velocity.

C A water drop leaving a spinning umbrella travels at a constant velocity.

D The force acting on an object is equal to its change in momentum.

8 A resultant force causes an object to accelerate.

What is equal to the resultant force?

A the acceleration of the object per unit mass

B the change in kinetic energy of the object per unit time

C the change in momentum of the object per unit time

D the change in velocity of the object per unit time

9 A skydiver falls from an aircraft that is moving horizontally.

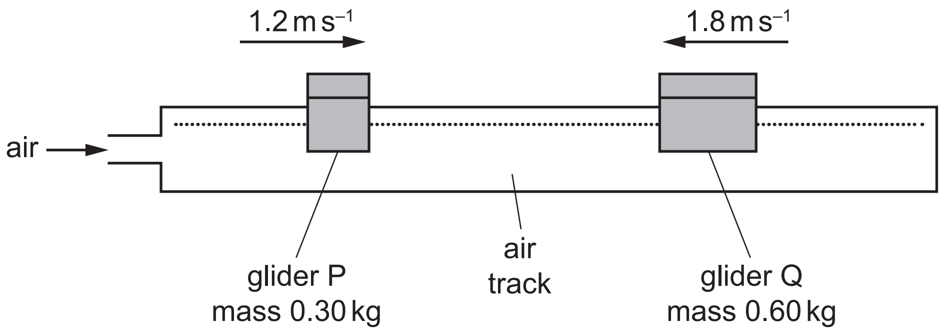
The vertical component of the velocity of the skydiver is v.

The vertical component of the acceleration of the skydiver is a.

Which row describes v and a during the first few seconds after the skydiver leaves the aircraft?

	v	a
A	constant	constant
B	constant	decreasing
C	increasing	constant
D	increasing	decreasing

10 Two gliders are travelling towards each other on a horizontal air track. Glider P has mass 0.30 kg and is moving with a constant speed of 1.2 $m s^{-1}$. Glider Q has mass 0.60 kg and is moving with a constant speed of 1.8 $m s^{-1}$.

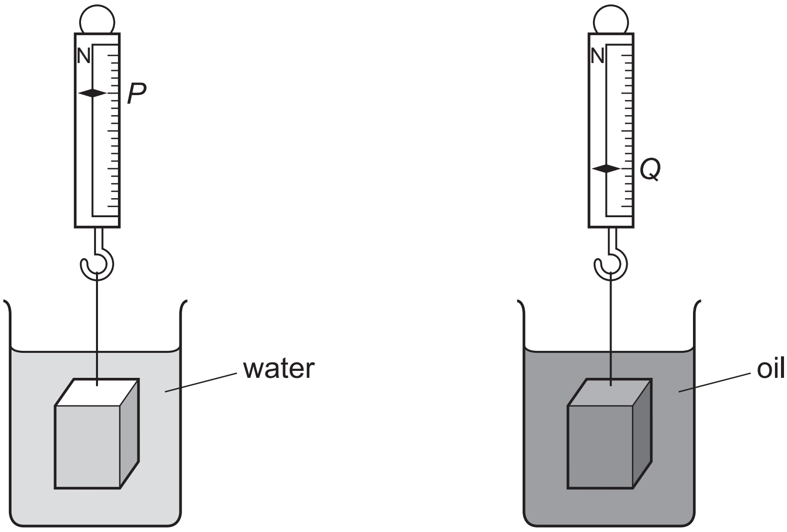


The gliders have a perfectly elastic collision.

What are the speeds of the two gliders after the collision?

	speed of P / $m s^{-1}$	speed of Q / $m s^{-1}$
A	1.2	0.6
B	2.0	1.4
C	2.8	0.2
D	3.6	0.6

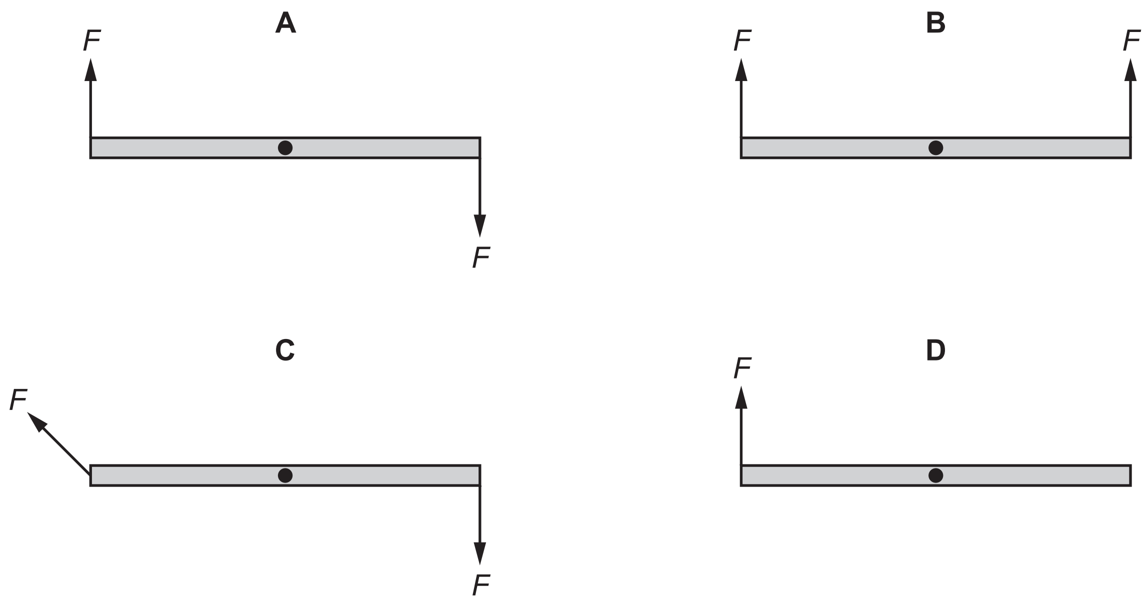
11 An object of weight W is suspended from a newton meter. When the object is completely immersed in water, the newton meter reads P. When the object is completely immersed in oil, the newton meter reads Q.



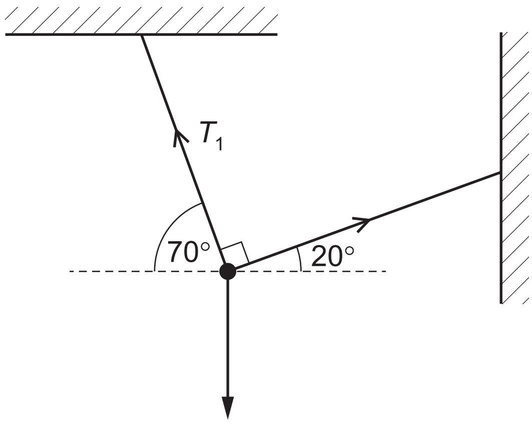
What is the ratio $\dfrac{\text{density of oil}}{\text{density of water}}$?

A $\dfrac{W-P}{Q-P}$ **B** $\dfrac{Q-P}{W-P}$ **C** $\dfrac{W-P}{W-Q}$ **D** $\dfrac{W-Q}{W-P}$

12 Which diagram shows a couple?



13 An object of weight 120 N is supported in equilibrium by two strings as shown.



What is the tension T_1 in the left-hand string?

A 41 N **B** 77 N **C** 113 N **D** 128 N

14 In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of:

1200 kg of oil of density 1100 kg m^{-3}

1500 kg of oil of density 860 kg m^{-3}

4000 kg of oil of density 910 kg m^{-3}.

What is the density of the mixture?

A 927 kg m^{-3} **B** 933 kg m^{-3} **C** 957 kg m^{-3} **D** 1045 kg m^{-3}

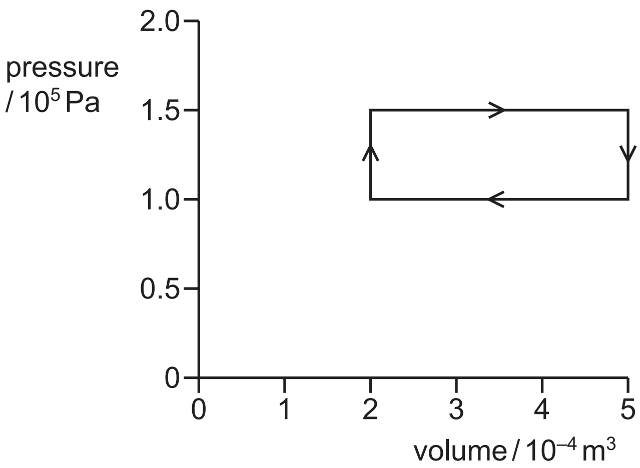
15 An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60%.

Which row is correct?

	electrical power input / W	waste heat power output / W
A	72	48
B	192	72
C	200	72
D	200	80

16 A fixed amount of a gas undergoes a series of changes to its pressure and volume.

In two of the changes, no work is done by or on the gas. In one change work is done by the gas on its surroundings. In another change work is done on the gas by its surroundings.



During the change when work is done on the gas by its surroundings, how much work is done on the gas?

A 15 J **B** 25 J **C** 30 J **D** 45 J

17 An object travelling with a speed of $10\,m\,s^{-1}$ has kinetic energy 1500 J.

The speed of the object is increased to $40\,m\,s^{-1}$.

What is the new kinetic energy of the object?

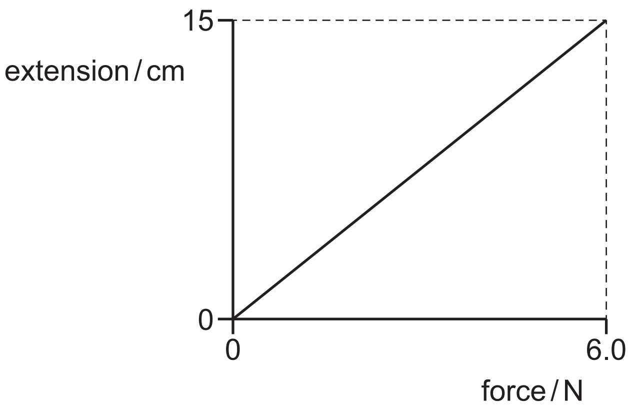
A 4500 J **B** 6000 J **C** 24 000 J **D** 1 350 000 J

18 The engine of a car exerts a force of 600 N in moving the car 1.0 km in 150 seconds.

What is the average useful output power of the engine?

A 4.0 W **B** 4.0 kW **C** 90 kW **D** 90 MW

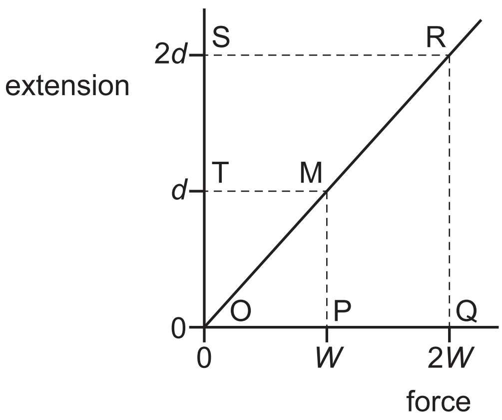
19 An extension–force graph for a spring is shown.



What is the spring constant of the spring?

A $0.025\,N\,m^{-1}$ **B** $0.40\,N\,m^{-1}$ **C** $2.5\,N\,m^{-1}$ **D** $40\,N\,m^{-1}$

20 A wire is extended by a force. The graph shows how the extension of the wire varies with the force applied.



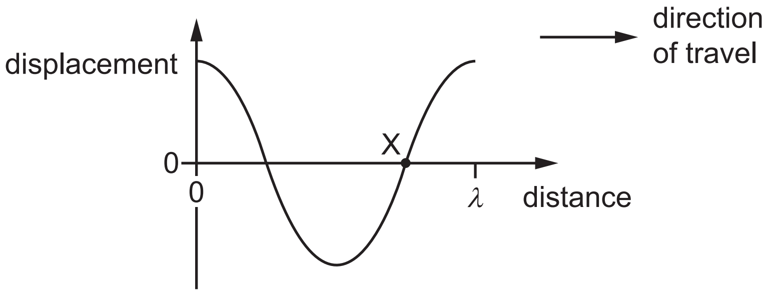
Initially a force *W* gives an extension *d*. The force is then increased to 2*W*. This increases the extension to 2*d*.

Which area of the graph represents the work done by the force when the force increases from *W* to 2*W*?

A ORQ **B** OQRS **C** ORS **D** TMRS

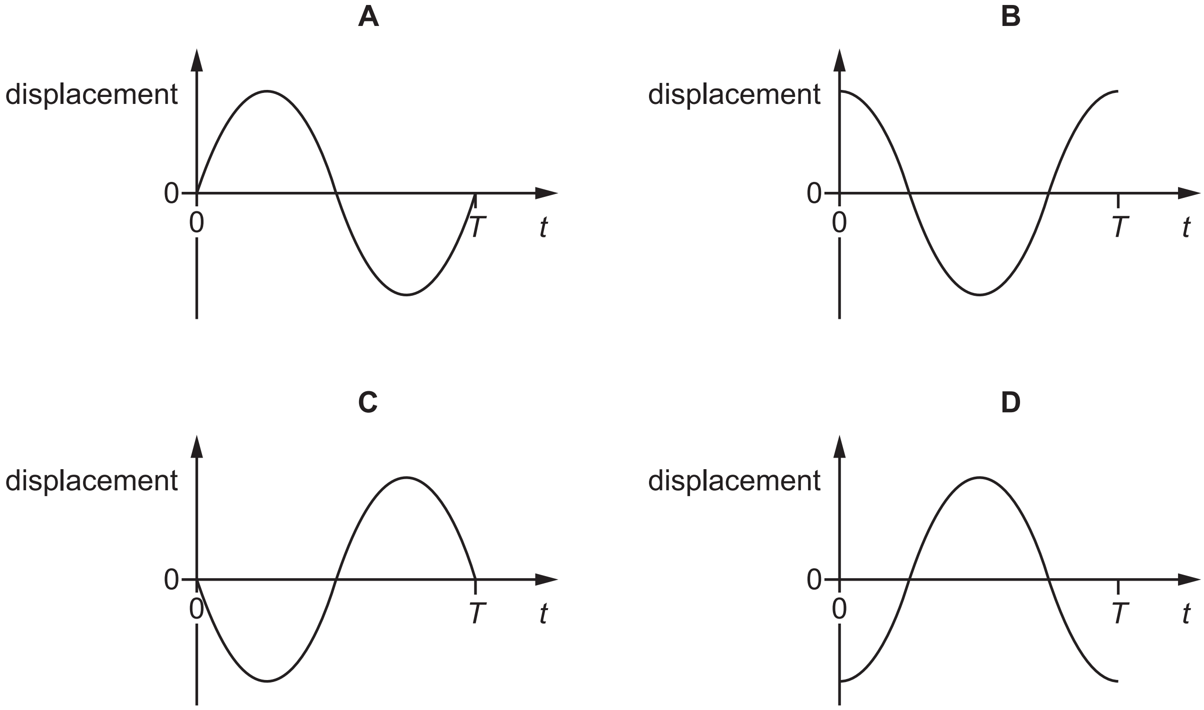
21 A transverse wave on a rope has wavelength λ and period T.

The graph shows the variation of the displacement of the particles of the rope with distance in the direction of travel of the wave at time t = 0.



A particle X is labelled.

Which graph shows the variation of the displacement of particle X with time t?



22 Which statement about all types of transverse waves is correct?

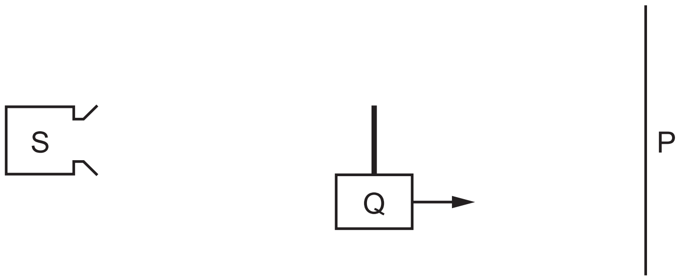
A They all have the same speed.

B They all have vibrations that are parallel to the direction of propagation of energy.

C They can all form stationary waves.

D They can all travel through a vacuum.

23 Source S emits microwaves with a constant amplitude. The microwaves hit a metal screen P and are reflected. A stationary wave is formed between S and P. The wavelength of the microwaves is much smaller than the distance between S and P.



A detector Q is moved at a slow, constant speed from S to P.

What happens to the amplitude of the signal detected by Q?

A decreases steadily

B increases and decreases regularly

C increases steadily

D remains constant

24 The siren of a moving police car emits a sound wave with a frequency of 440 Hz. A stationary observer hears sound of frequency 494 Hz. The speed of sound in the air is $340\,\mathrm{m\,s^{-1}}$.

What could be the speed and the direction of movement of the car?

A $37\,\mathrm{m\,s^{-1}}$ directly towards the observer

B $37\,\mathrm{m\,s^{-1}}$ directly away from the observer

C $42\,\mathrm{m\,s^{-1}}$ directly towards the observer

D $42\,\mathrm{m\,s^{-1}}$ directly away from the observer

25 An electromagnetic wave has a wavelength of 138 pm in a vacuum.

To which region of the electromagnetic spectrum does this wave belong?

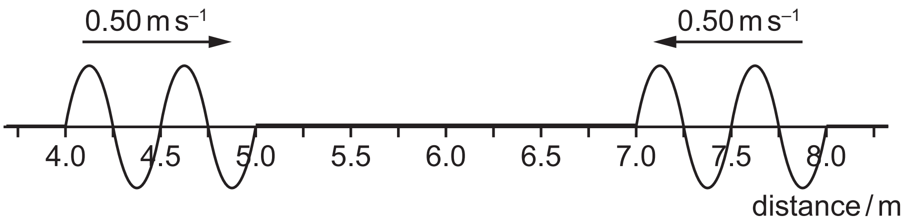
A radio wave

B microwave

C visible light

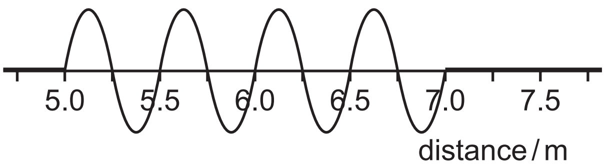
D X-ray

26 Two wave pulses are travelling towards each other on a long rope. The pulses have the same amplitude and wavelength and are travelling at a speed of $0.50\,\mathrm{m\,s^{-1}}$. The diagram shows the rope at time t = 0.

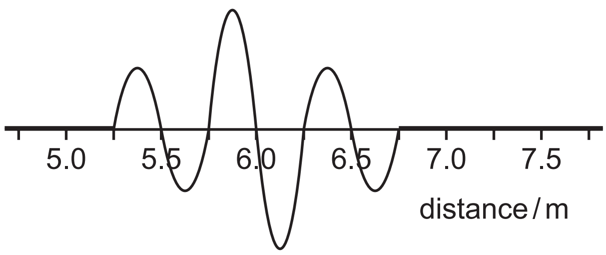


Which diagram shows the rope at time t = 3.0 s?

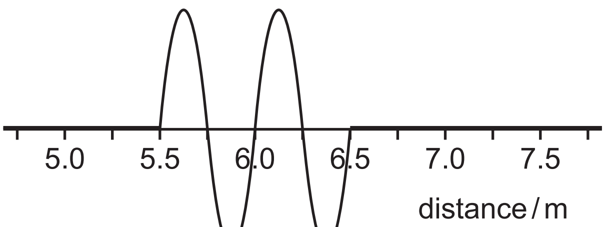
A



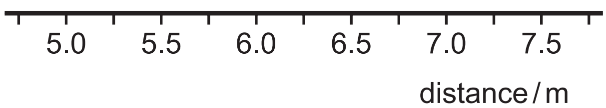
B



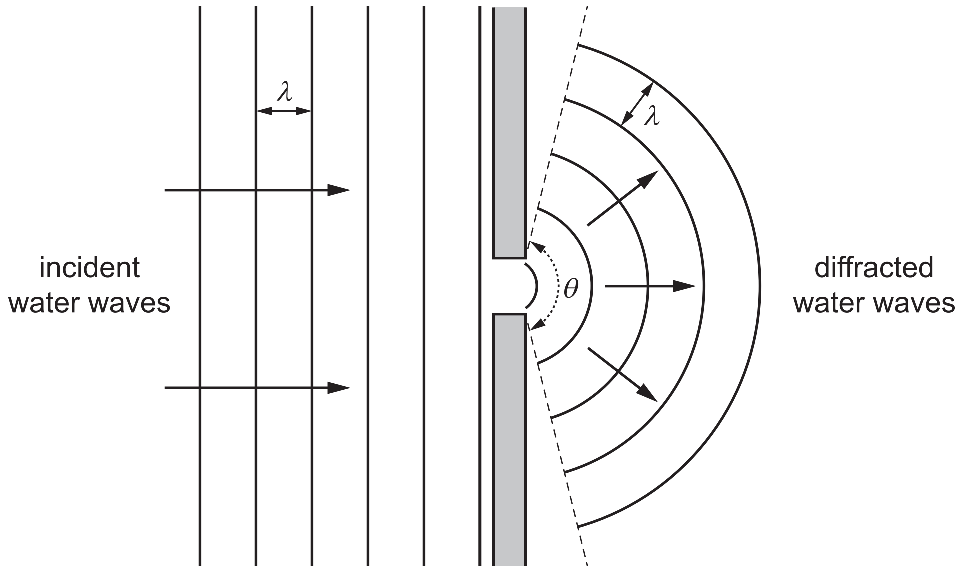
C



D



27 Water waves of wavelength λ are incident normally on an obstacle with a narrow gap. The width of the gap is equal to λ. The waves from the gap emerge over an angle θ as shown.



The gap is slowly widened.

Which changes, if any, occur to θ and to the wavelength of the emerging waves?

	θ	wavelength
A	decreases	remains the same
B	increases	remains the same
C	remains the same	decreases
D	remains the same	increases

28 Light of wavelength 720 nm from a laser X is incident normally on a diffraction grating and a diffraction pattern is observed. Light from a laser Y is then also incident normally on the same grating. The third-order maximum due to laser Y is seen at the same place as the second-order maximum due to laser X.

What is the wavelength of the light from laser Y?

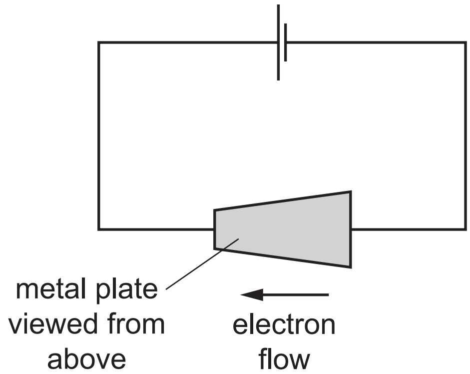
A 480 nm **B** 540 nm **C** 720 nm **D** 1080 nm

29 Monochromatic light of frequency *f* is incident on a diffraction grating of line spacing *d*. The speed of light is *c*.

Which expression can be used to determine the highest order of intensity maximum produced by the grating?

A $n = \dfrac{d}{cf}$ **B** $n = \dfrac{df}{c}$ **C** $n = \dfrac{dc}{f}$ **D** $n = \dfrac{c}{df}$

30 A metal plate of uniform thickness is connected to a cell as shown.



Electrons move clockwise around the circuit.

Which statement about the metal plate is correct?

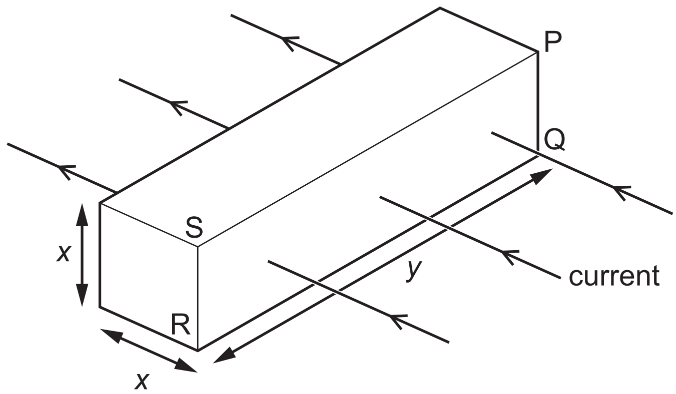
A The average drift speed of the conduction electrons decreases as they move from right to left through the plate.

B The average drift speed of the conduction electrons increases as they move from right to left through the plate.

C The number density of the conduction electrons decreases from right to left through the plate.

D The number density of the conduction electrons increases from right to left through the plate.

31 The diagram shows the direction of the current in a metal block. The charge carriers enter the block through the face PQRS and leave the block through the opposite face.



The number density of charge carriers is n. Each charge carrier has charge e. The average drift speed of the charge carriers is v.

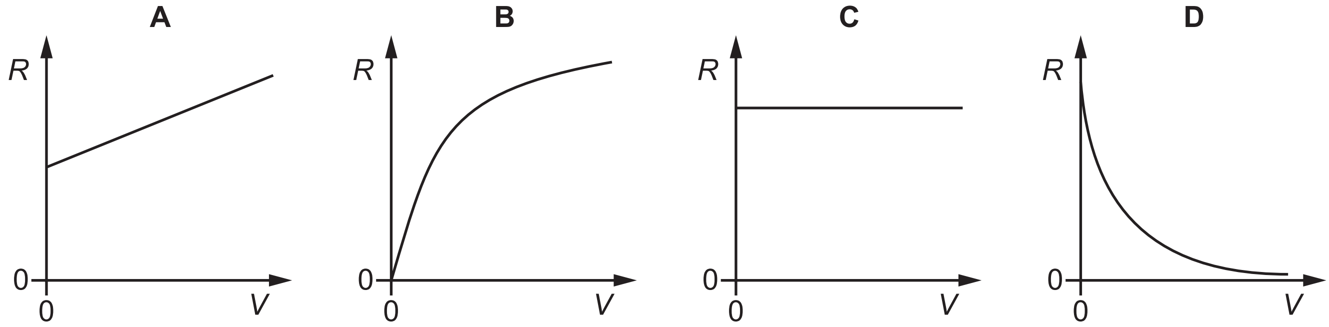
Which expression gives the current in the block?

A $envx^2$ **B** $envxy$ **C** $envx^3y^2$ **D** $envx^4y$

32 What could **not** be used as a unit of potential difference?

A $A\Omega$ **B** $N m^{-1} C^{-1}$ **C** $W A^{-1}$ **D** $(\Omega W)^{\frac{1}{2}}$

33 Which graph could show how the resistance *R* of a filament lamp varies with the applied potential difference (p.d.) *V*, as *V* is increased to the normal operating p.d.?

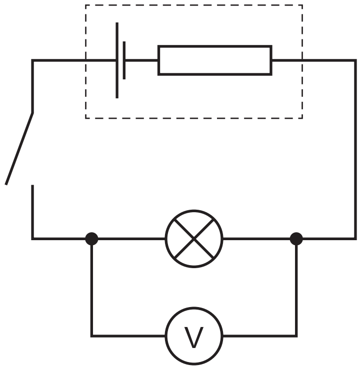


34 Kirchhoff's two laws for electric circuits can be derived by using conservation laws.

On which conservation laws do Kirchhoff's laws depend?

	Kirchhoff's first law	Kirchhoff's second law
A	charge	current
B	charge	energy
C	current	mass
D	energy	current

35 The diagram shows a circuit.



Which statement about the circuit is **not** correct?

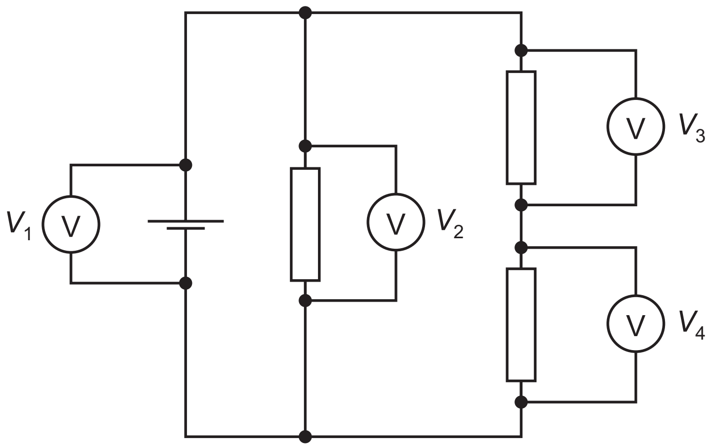
A Electromotive force is the energy transferred per unit charge.

B Energy is transferred from chemical potential energy in the cell to other forms when the switch is closed.

C The electromotive force of the cell is greater than the terminal potential difference when the switch is closed.

D When the switch is open, the voltmeter measures the electromotive force of the cell.

36 The diagram shows a circuit containing four voltmeters. The readings on the voltmeters are V_1, V_2, V_3 and V_4. All the readings are positive.



Which equation relating the voltmeter readings is correct?

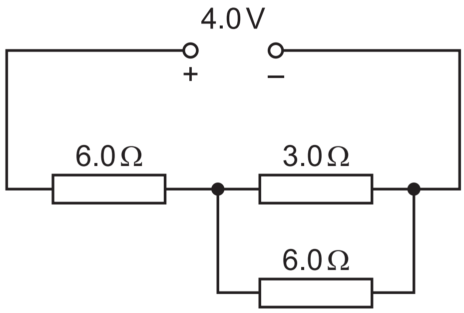
A $V_1 = V_2 + V_4$

B $V_1 = V_2 + V_3 + V_4$

C $V_2 + V_3 = V_4$

D $V_3 + V_4 - V_2 = 0$

37 A network consists of a 3.0 Ω resistor and two 6.0 Ω resistors, as shown.

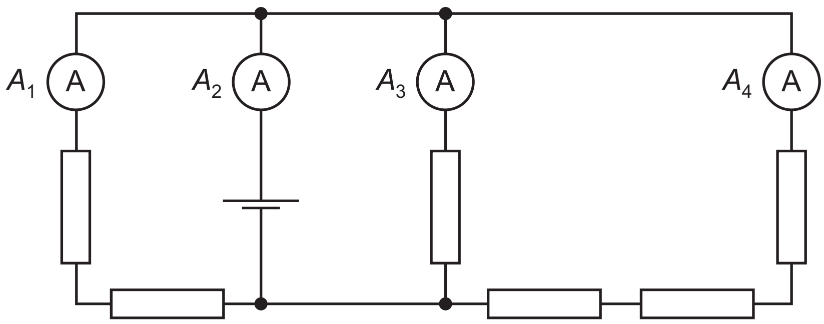


The potential difference (p.d.) across the network is 4.0 V.

What is the current through the 3.0 Ω resistor?

A 0.17 A **B** 0.25 A **C** 0.33 A **D** 1.3 A

38 In the circuit shown, all the resistors are identical and all the ammeters have negligible resistance.



The reading A_1 is 0.6 A.

What are the readings on the other ammeters?

	A_2 / A	A_3 / A	A_4 / A
A	1.0	0.3	0.1
B	1.4	0.6	0.2
C	1.8	0.9	0.3
D	2.2	1.2	0.4

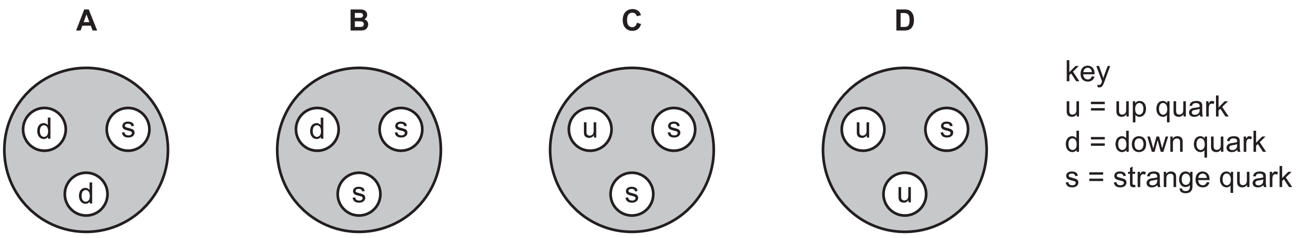
39 An unstable nucleus of an element decays by emitting an α-particle or a β^- particle to become a nucleus of a different element. This nucleus is also unstable and also emits an α-particle or a β^- particle. The process continues until an isotope of the original element is produced.

What is the minimum possible number of these particles emitted?

A 2 **B** 3 **C** 4 **D** 5

40 The diagrams show the quark composition of four different hadrons. One of the hadrons is a Σ^+ particle. It has a charge of +*e*, where *e* is the elementary charge.

Which hadron could be the Σ^+ particle?



Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2019**

1 hour 15 minutes

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

0358068952

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **18** printed pages and **2** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 A cyclist has a speed of $5\,\mathrm{m\,s^{-1}}$ and a small car has a speed of $12\,\mathrm{m\,s^{-1}}$.

Which statement does **not** give a reasonable estimate?

A The kinetic energy of the cyclist is $1 \times 10^{3}\,\mathrm{J}$.

B The kinetic energy of the car is $7 \times 10^{4}\,\mathrm{J}$.

C The momentum of the cyclist is $4 \times 10^{2}\,\mathrm{kg\,m\,s^{-1}}$.

D The momentum of the car is $2 \times 10^{5}\,\mathrm{kg\,m\,s^{-1}}$.

2 Which expression gives an SI base quantity?

A charge per unit time

B force per unit area

C mass per unit volume

D work done per unit distance

3 Which list contains only scalar quantities?

A area, length, displacement

B kinetic energy, speed, power

C potential energy, momentum, time

D velocity, distance, temperature

4 A micrometer is used to measure the 28.50 mm width of a plastic ruler. The micrometer reads to the nearest 0.01 mm.

What is the correct way to record this reading?

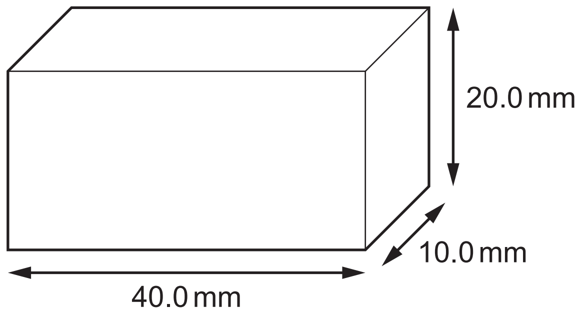
A $0.02850 \pm 0.01\,\mathrm{m}$

B $0.0285 \pm 0.001\,\mathrm{m}$

C $(2.850 \pm 0.001) \times 10^{-2}\,\mathrm{m}$

D $(2.850 \pm 0.001) \times 10^{-3}\,\mathrm{m}$

5 The sides of a wooden block are measured with calipers. The lengths of the sides are measured as 20.0 mm, 40.0 mm and 10.0 mm.



The calipers can measure with an absolute uncertainty of ± 0.1 mm.

What is the percentage uncertainty in the calculated volume of the block?

A 0.3% **B** 1.8% **C** 3.8% **D** 30%

6 A ball is thrown vertically upwards from ground level and reaches a maximum height of 12.7 m before falling back to ground level.

Assume air resistance is negligible.

What is the total time for which the ball is in the air?

A 1.61 s **B** 3.22 s **C** 3.88 s **D** 5.18 s

7 A snooker ball has a mass of 200 g. It hits the cushion of a snooker table and rebounds along its original path.

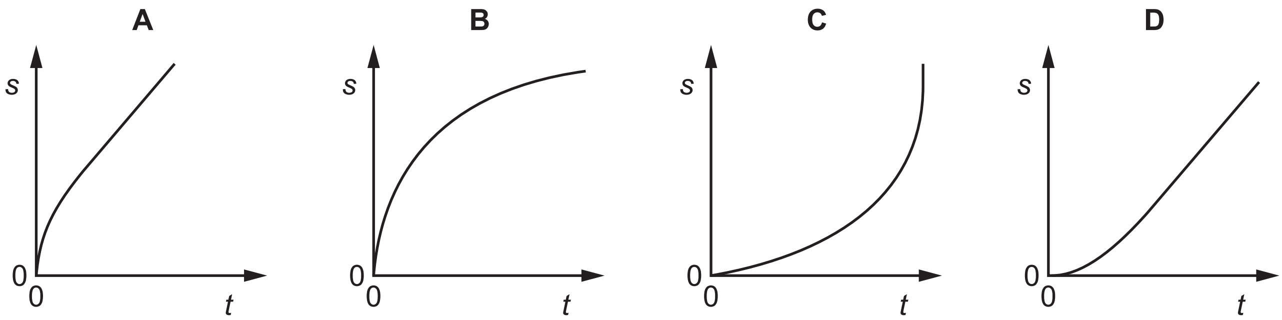
The ball arrives at the cushion with a speed of $14.0\,\mathrm{m\,s^{-1}}$ and then leaves it with a speed of $7.0\,\mathrm{m\,s^{-1}}$. The ball and the cushion are in contact for a time of 0.60 s.

What is the average force exerted on the ball by the cushion?

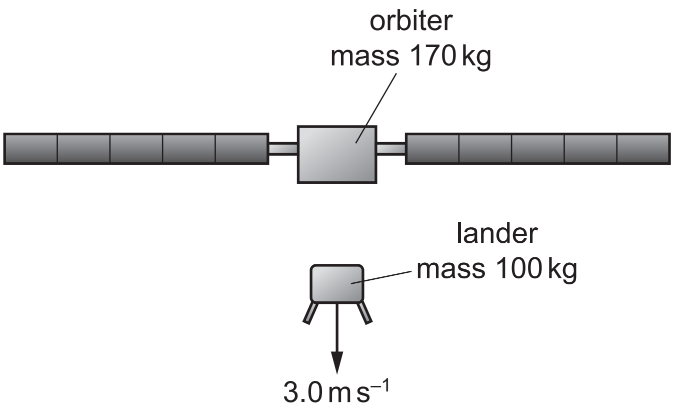
A 1.4 N **B** 2.3 N **C** 4.2 N **D** 7.0 N

8 A tennis ball is released from rest at time $t = 0$ and falls through air for a long time.

Which graph of its displacement s against time t best represents the motion of the ball?



9 The space probe Rosetta was designed to investigate a comet. The probe consisted of an orbiter and a lander. The orbiter had a mass of 170 kg and the lander had a mass of 100 kg. When the two parts separated, the lander was pushed towards the surface of the comet so that its change in velocity towards the comet was $3.0\,m\,s^{-1}$.



Assume that the orbiter and lander were an isolated system.

The orbiter moved away from the comet during the separation.

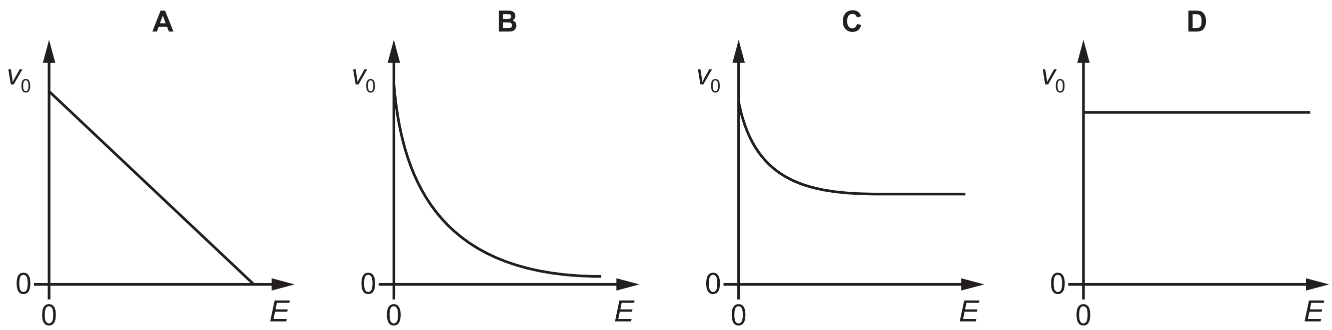
What was the change in the speed of the orbiter?

A $1.8\,m\,s^{-1}$ **B** $2.3\,m\,s^{-1}$ **C** $3.0\,m\,s^{-1}$ **D** $5.1\,m\,s^{-1}$

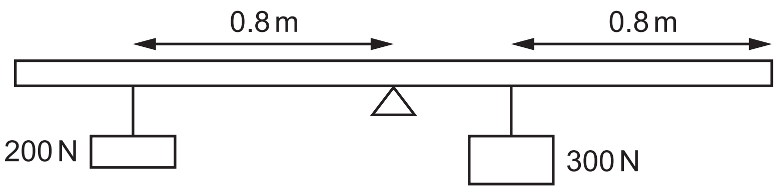
10 A positively charged oil droplet falls in air in a uniform electric field that is vertically upwards. The droplet has a constant terminal speed v_0 and the electric field strength is E.

The magnitude of the force due to air resistance acting on the droplet is proportional to the speed of the droplet.

Which graph shows the variation with E of v_0?



11 A rigid uniform bar of length 2.4 m is pivoted horizontally at its midpoint.



Weights are hung from two points on the bar as shown in the diagram. To maintain equilibrium, a couple is applied to the bar.

What is the torque and direction of this couple?

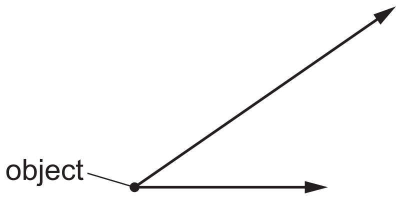
A 40 N m clockwise

B 40 N m anticlockwise

C 80 N m clockwise

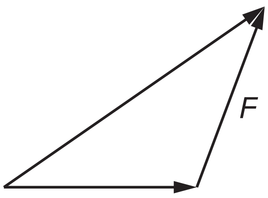
D 80 N m anticlockwise

12 Two coplanar forces act on an object as shown.

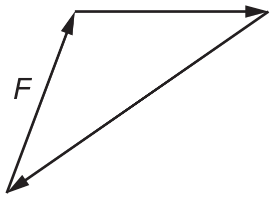


Which diagram shows the resultant F of these two forces?

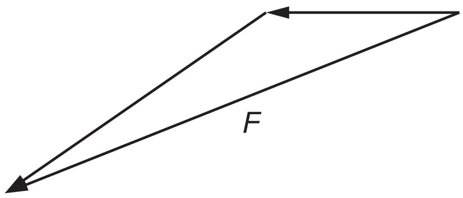
A



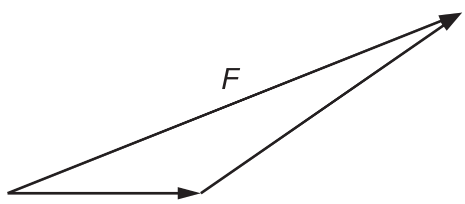
B



C

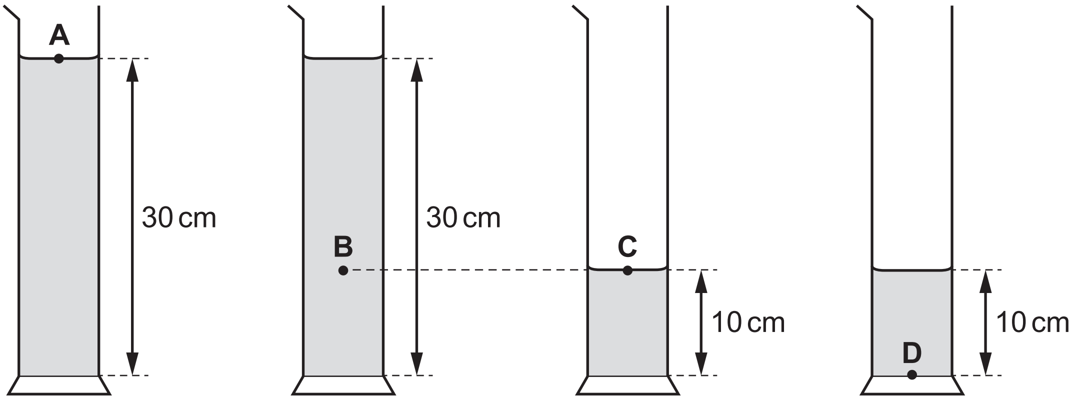


D

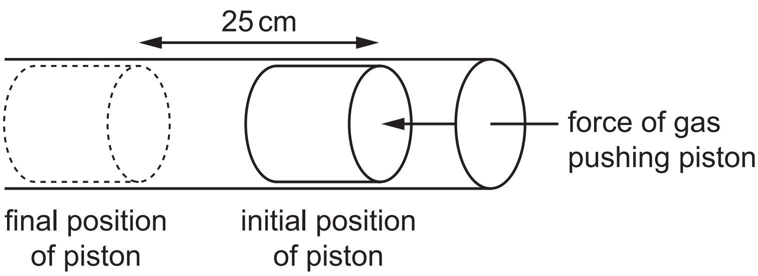


13 Four measuring cylinders are filled with the same liquid to the heights shown.

At which position is the pressure the greatest?



14 The gas in an engine does work on a piston of cross-sectional area $80\,cm^2$. The pressure on the piston has a constant value of $4.6 \times 10^5\,Pa$.



How much work is done by the gas on the piston when it moves through a distance of 25 cm?

A $9.2 \times 10^2\,J$ **B** $9.2 \times 10^4\,J$ **C** $9.2 \times 10^6\,J$ **D** $9.2 \times 10^8\,J$

15 A power station using coal as fuel has an average power output of 3000 MW. Coal is supplied by 20 trains each day. The efficiency of the station in converting the thermal energy released from the coal to electrical energy is 26%.

A mass of 1.0 kg of coal will release 33 MJ of thermal energy when burnt.

Which mass of coal does each train bring?

A $2.5 \times 10^4\,kg$ **B** $6.3 \times 10^4\,kg$ **C** $1.5 \times 10^6\,kg$ **D** $3.0 \times 10^7\,kg$

16 A wooden cylinder floats partially submerged in a bath of water. A force F is applied to the cylinder until it is just fully submerged.

Which statement is **not** correct?

A Some of the water gains gravitational potential energy.

B The cylinder loses gravitational potential energy.

C Work is done by force F on the cylinder.

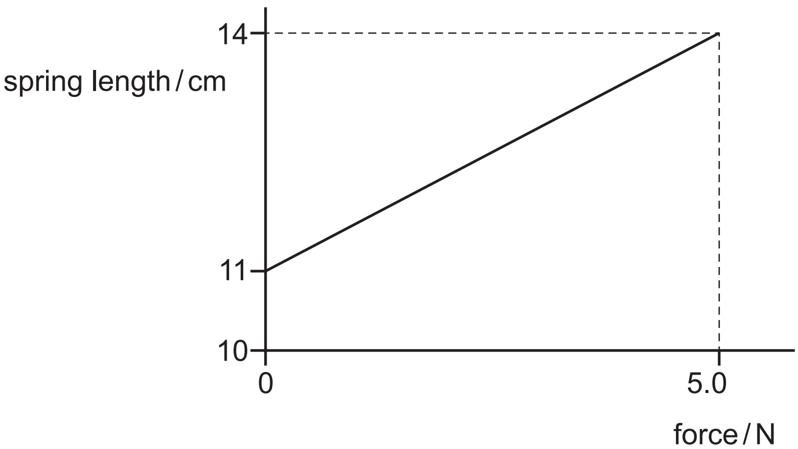
D Work is done by the upthrust on the cylinder.

17 The motor of a crane lifts a load of mass 600 kg. The load rises vertically at a constant speed of 12 m per minute.

What is the useful power output of the motor?

A 0.12 kW **B** 1.2 kW **C** 7.2 kW **D** 71 kW

18 The graph shows the effect of applying a force of up to 5.0 N to a spring.

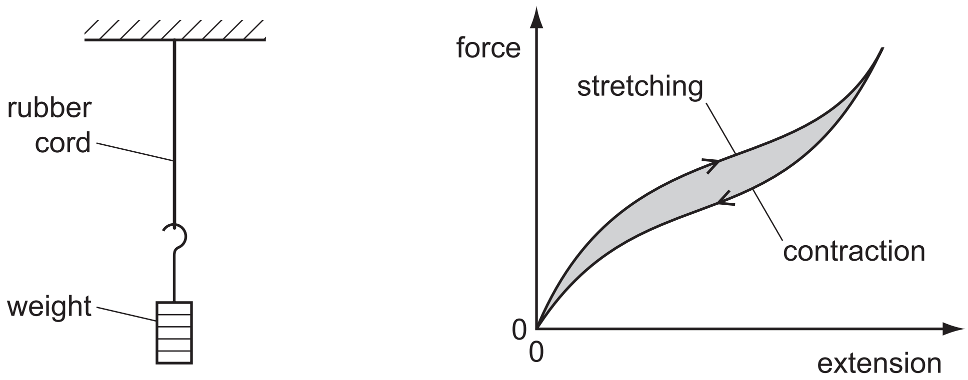


The spring obeys Hooke's law for forces up to 7.0 N.

What is the total extension of the spring produced by a 7.0 N force?

A 4.2 cm **B** 5.6 cm **C** 15 cm **D** 20 cm

19 A rubber cord hangs from a rigid support. A weight attached to its lower end is gradually increased from zero, and then gradually reduced to zero.



The force–extension curve for contraction is below the force–extension curve for stretching.

What does the shaded area between the curves represent?

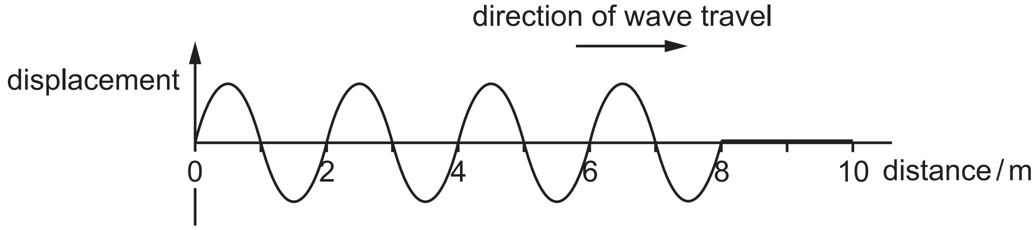
A the elastic potential energy stored in the rubber cord

B the thermal energy dissipated in the rubber cord

C the work done on the rubber cord during stretching

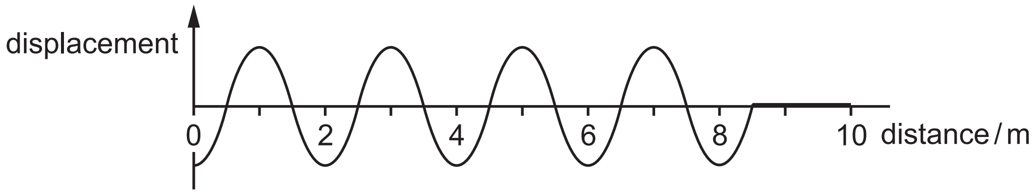
D the work done by the rubber cord during contraction

20 A transverse wave is travelling along a rope. The frequency of the wave is 2.0 Hz. The graph shows the variation with distance of the displacement of the wave at time t = 0.

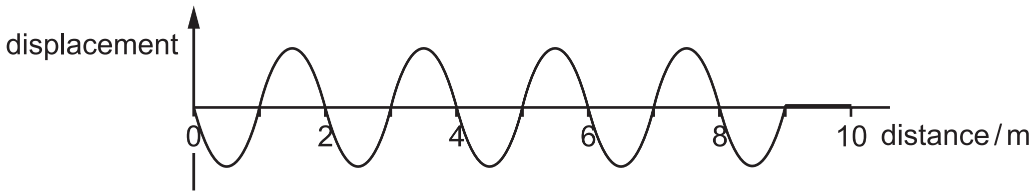


Which diagram shows the position of the wave at time t = 0.5 s?

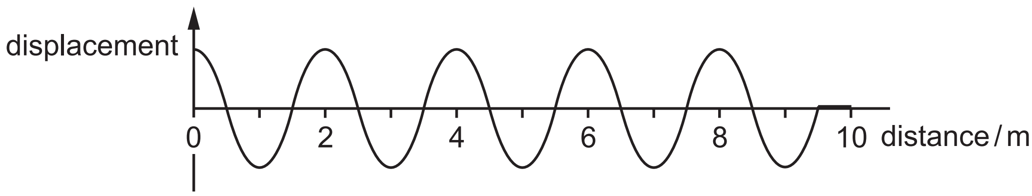
A



B



C



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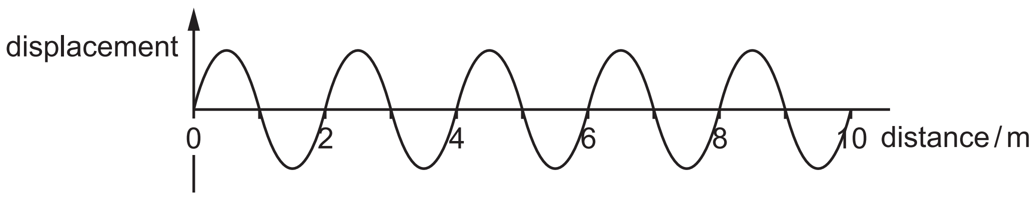
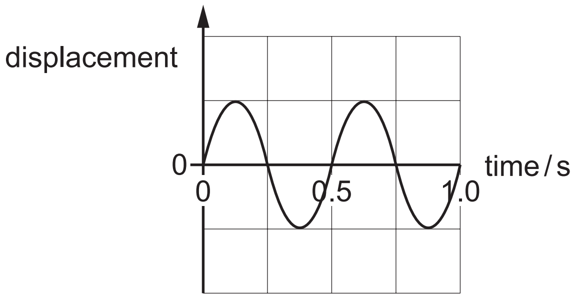
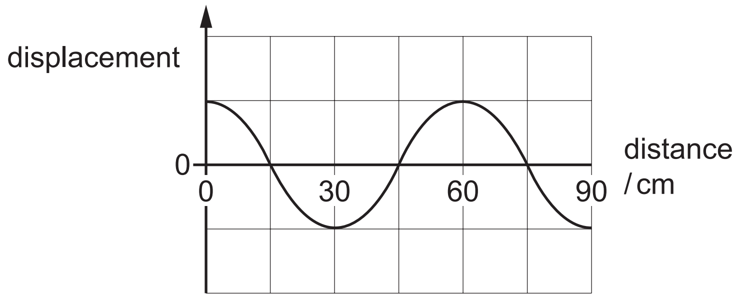


21 The two graphs represent the same wave.

Graph 1 shows the variation with time of the displacement at a particular distance. Graph 2 shows the variation with distance of the displacement at one instant.



graph 1

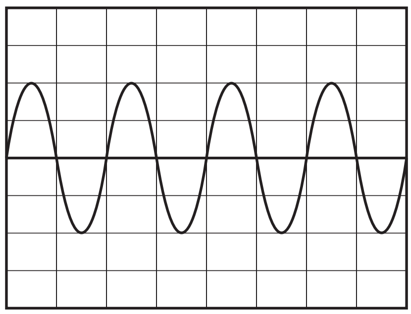


graph 2

What is the speed of the wave?

A 22.5 $cm\,s^{-1}$ **B** 30.0 $cm\,s^{-1}$ **C** 90.0 $cm\,s^{-1}$ **D** 120 $cm\,s^{-1}$

22 A microphone is connected to a cathode-ray oscilloscope (CRO). When a tuning fork is struck and then held next to the microphone, the following waveform is shown on the display of the CRO.



The time-base setting on the CRO is 2.00 ms per division.

What is the best estimate of the frequency of the sound produced by the tuning fork?

A 63 Hz **B** 170 Hz **C** 250 Hz **D** 500 Hz

23 A loudspeaker emitting a constant frequency of 2000 Hz is swung in a horizontal circle with a speed of 15.0 $m\,s^{-1}$.

A stationary observer is level with the loudspeaker and situated a long distance from the loudspeaker. The observer hears a sound of varying frequency. The maximum frequency heard is 2097 Hz.

What is the speed of the sound in the air?

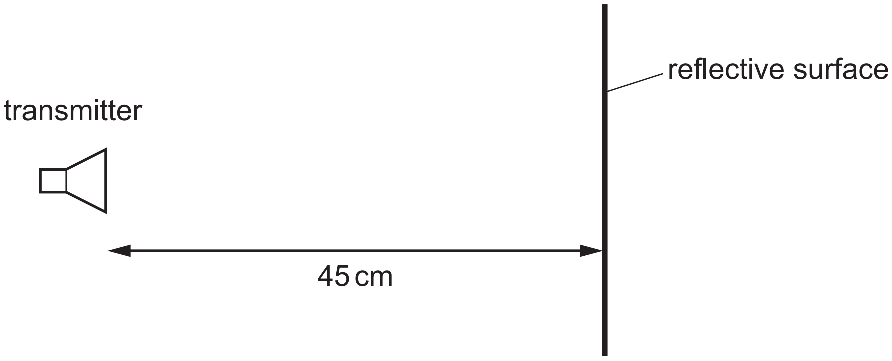
A 294 $m\,s^{-1}$ **B** 309 $m\,s^{-1}$ **C** 324 $m\,s^{-1}$ **D** 330 $m\,s^{-1}$

24 Two electromagnetic waves have wavelengths of 5.0×10^{-7} m and 5.0×10^{-2} m.

Which row identifies the regions of the electromagnetic spectrum to which the waves belong?

	wavelength 5.0×10^{-7} m	wavelength 5.0×10^{-2} m
A	ultraviolet	infrared
B	visible	microwave
C	ultraviolet	microwave
D	visible	infrared

25 A transmitter of electromagnetic waves is placed 45 cm from a reflective surface.



The emitted waves have a frequency of 1.00 GHz. A stationary wave is produced with a node at the transmitter and a node at the surface.

How many antinodes are in the space between the transmitter and the surface?

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

26 Which statement about a light wave and a sound wave is correct?

A Both can travel through free space.

B Both have a frequency inversely proportional to their wavelength.

C Both have an intensity proportional to their amplitude.

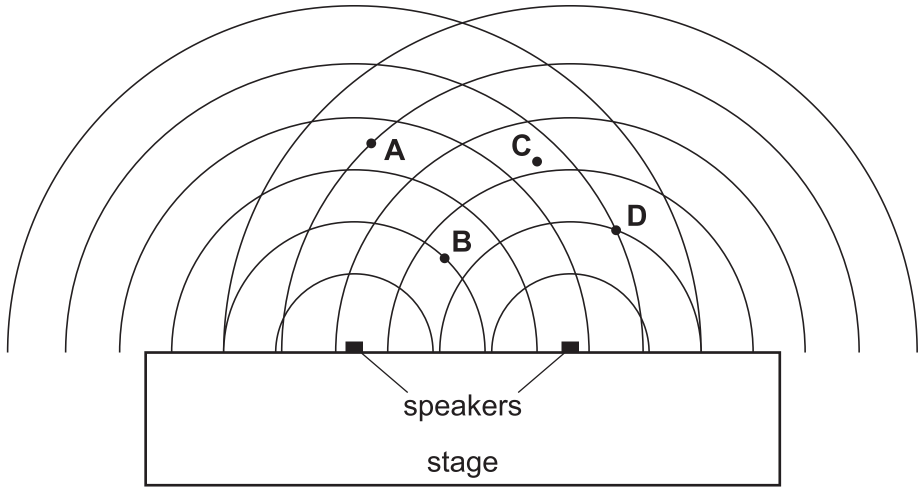
D Both have oscillations perpendicular to the direction of energy transfer.

27 An outdoor concert has two large speakers beside the stage for broadcasting music.

In order to test the speakers, they are made to emit sound of the same wavelength and the same amplitude.

The curved lines in the diagram represent wavefronts.

Where is the loudest sound heard?



28 An electromagnetic wave is incident normally on a diffraction grating.

A second-order maximum is produced at an angle of 30° to a normal to the grating.

The grating has 5000 lines per cm.

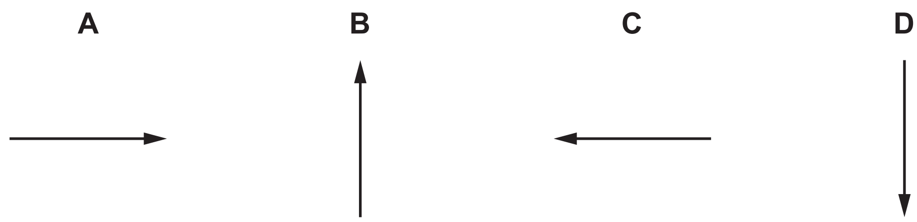
What is the wavelength of the wave?

A 2.5×10^{-7} m **B** 5.0×10^{-7} m **C** 1.0×10^{-6} m **D** 5.0×10^{-5} m

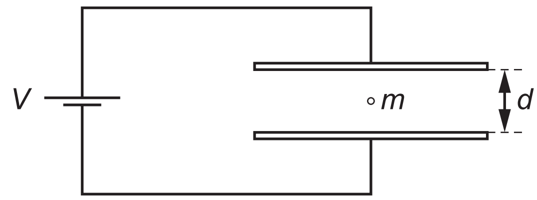
29 P is a point near to charge X as shown.

When a negatively charged test charge is placed at point P, it is found to experience a force of repulsion from X that is radially away from X.

Which arrow correctly shows the direction of the electric field at point P due to the charge X?



30 A charged oil drop of mass m, with n excess electrons, is held stationary in the uniform electric field between two horizontal plates separated by a distance d.



The voltage between the plates is V, the elementary charge is e and the acceleration of free fall is g.

What is the value of n?

A $\dfrac{eV}{mgd}$ **B** $\dfrac{mgd}{eV}$ **C** $\dfrac{meV}{gd}$ **D** $\dfrac{gd}{meV}$

31 When the current in a wire is 5.0 A, the average drift speed of the conduction electrons in the wire is $7.4 \times 10^{-4}\,\mathrm{m\,s^{-1}}$.

Which row gives a possible cross-sectional area and number of conduction electrons per unit volume for this wire?

	cross-sectional area / m^2	number of conduction electrons per unit volume / m^{-3}
A	7.2×10^{-7}	1.2×10^{28}
B	7.2×10^{-7}	5.9×10^{28}
C	2.3×10^{-6}	7.3×10^{26}
D	2.3×10^{-6}	3.7×10^{27}

32 A fixed resistor of resistance $12\,\Omega$ is connected to a battery. There is a current of 0.20 A in the resistor. The current is now doubled.

What is the new power dissipated in the resistor?

A 0.48 W **B** 0.96 W **C** 1.9 W **D** 4.8 W

33 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

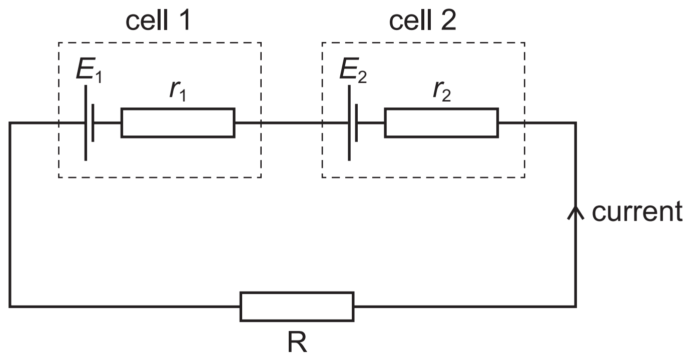
A the current in the resistor and the potential difference across the resistor

B the resistance of the resistor and the current in the resistor

C the total charge passing through the resistor and the potential difference across the resistor

D the total charge passing through the resistor and the resistance of the resistor

34 Two cells with electromotive forces E_1 and E_2 and internal resistances r_1 and r_2 are connected to a resistor R as shown.

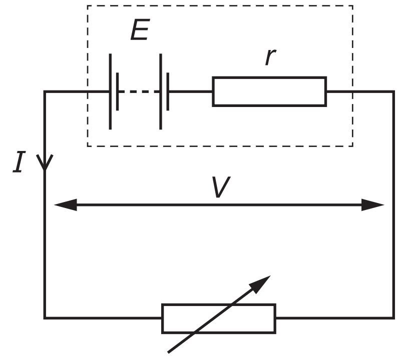


The terminal potential difference across cell 1 is zero.

Which expression gives the resistance of resistor R?

A $\dfrac{E_2r_1 - E_1r_2}{E_1}$ **B** $\dfrac{E_2r_1 - E_1r_2}{E_2}$ **C** $\dfrac{E_1r_2 - E_2r_1}{E_1}$ **D** $\dfrac{E_1r_2 - E_2r_1}{E_2}$

35 A battery has an electromotive force (e.m.f.) E and internal resistance r. The battery delivers a current I to a variable resistor and the potential difference (p.d.) across its terminals is V.



The variable resistor is adjusted so that I increases.

Why does V decrease?

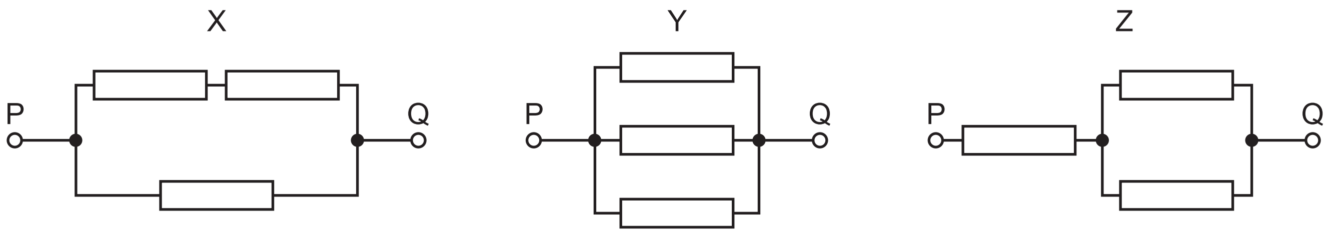
A The e.m.f. E decreases.

B The internal resistance r increases.

C The p.d. across r increases.

D The resistance of the variable resistor increases.

36 Three identical resistors are connected between terminals P and Q in different networks X, Y and Z as shown.



What is the order of increasing combined resistance between P and Q (lowest first)?

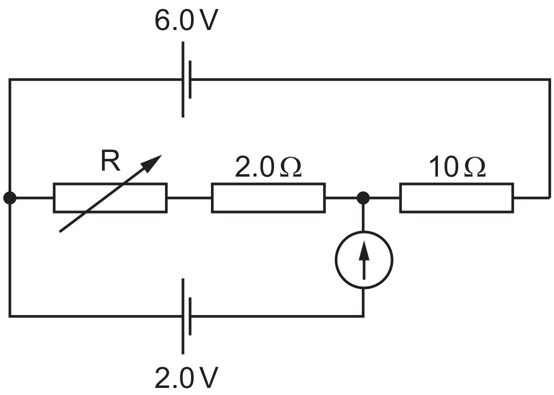
A X → Y → Z

B X → Z → Y

C Y → X → Z

D Y → Z → X

37 The diagram shows a variable resistor R and two fixed resistors connected in series in a circuit to act as a potential divider.



The cell of electromotive force (e.m.f.) 6.0 V has negligible internal resistance. A cell of e.m.f. 2.0 V and a galvanometer are connected into the potential divider. The resistance of R is varied until the galvanometer reads zero.

What is the resistance of resistor R?

A 3.0 Ω **B** 5.0 Ω **C** 8.0 Ω **D** 18 Ω

38 The table gives some data relating to four neutral (uncharged) atoms W, X, Y and Z.

	W	X	Y	Z
nucleon (mass) number	16	17	17	18
total number of particles (protons, neutrons and electrons) in the atom	24	26	25	28

Two of the atoms are isotopes of the same element.

What is the proton number of this element?

A 7 **B** 8 **C** 9 **D** 10

39 What is **not** a fundamental particle?

A electron

B neutrino

C neutron

D positron

40 An unstable nucleus decays and emits a β^- particle.

Which changes, if any, occur to the quark composition of the nucleus?

	quark changes	
	up quarks	down quarks
A	+1	0
B	+1	–1
C	–1	+1
D	0	+1

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2019**

1 hour 15 minutes

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

2329761207

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.
Electronic calculators may be used.

This document consists of **19** printed pages and **1** blank page.

IB19 11_9702_13/3RP

Cambridge Assessment International Education

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_{\mathrm{e}} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_{\mathrm{p}} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_{\mathrm{A}} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which quantity with its unit is correct?

A acceleration of a bicycle = $1.4\,\mathrm{m\,s^{-1}}$

B electric current in a lamp = $0.25\,\mathrm{A\,s^{-1}}$

C electric potential difference across a battery = $8.0\,\mathrm{J\,C^{-1}}$

D kinetic energy of a car = $4500\,\mathrm{N\,m^{-1}}$

2 Which two units are **not** equivalent to each other?

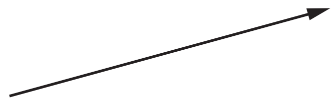
A $\mathrm{N\,m}$ and $\mathrm{kg\,m^2\,s^{-2}}$

B $\mathrm{N\,s}$ and $\mathrm{kg\,m\,s^{-1}}$

C $\mathrm{J\,s^{-1}}$ and $\mathrm{kg\,m^2\,s^{-3}}$

D Pa and $\mathrm{kg\,m\,s^{-2}}$

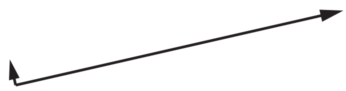
3 The arrow represents a vector R.



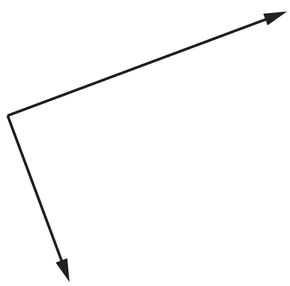
Which diagram does **not** represent R as two perpendicular components?

A

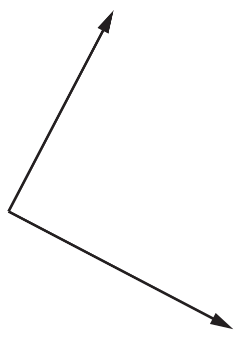
B



C



D



4 What could reduce systematic errors?

A averaging a large number of measurements

B careful calibration of measuring instruments

C reducing the sample size

D repeating measurements

5 The power loss P in a resistor is calculated using the formula $P = \dfrac{V^2}{R}$.

The percentage uncertainty in the potential difference V is 3% and the percentage uncertainty in the resistance R is 2%.

What is the percentage uncertainty in P?

A 4% **B** 7% **C** 8% **D** 11%

6 A lead sphere is released from rest at point X, a long way above the surface of a planet. The sphere falls in a vacuum. After a time of 4.0 s, it has fallen through a vertical distance of 3.0 m. Assume the acceleration of free fall is constant.

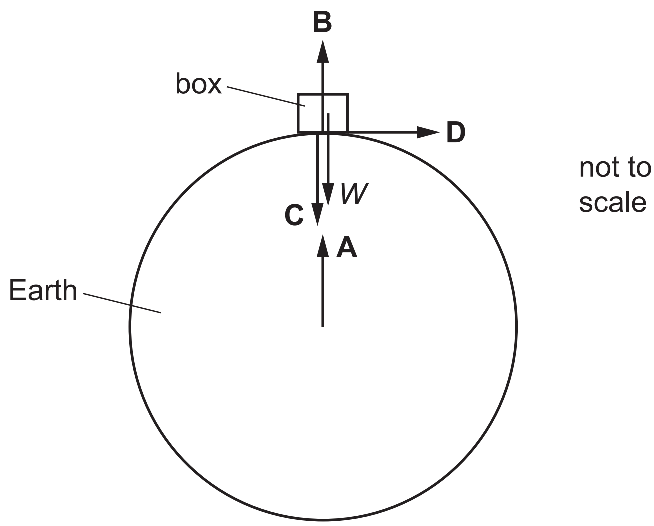
How far will the sphere have fallen from point X at a time of 20 s after its release?

A 15 m **B** 75 m **C** 80 m **D** 2000 m

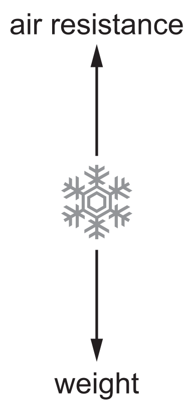
7 A box rests on the Earth, as shown.

Newton's third law describes how forces of the same type act in pairs. One of the forces of a pair is the weight W of the box.

Which arrow represents the other force of this pair?



8 A snowflake is falling from the sky on a still day. Its weight acts vertically downwards and air resistance acts vertically upwards. As the snowflake falls, air resistance increases until it is equal to the weight and there is no resultant force acting on the snowflake.



When the forces become equal, which statement is correct?

A The snowflake accelerates.

B The snowflake decelerates.

C The snowflake is stationary.

D The snowflake moves at a constant velocity.

9 Two objects X and Y in an isolated system undergo a perfectly elastic collision. The velocities of the objects before and after the collision are shown.

What is the speed v of Y after the collision?

A $2.0\,\mathrm{m\,s^{-1}}$ **B** $18\,\mathrm{m\,s^{-1}}$ **C** $22\,\mathrm{m\,s^{-1}}$ **D** $24\,\mathrm{m\,s^{-1}}$

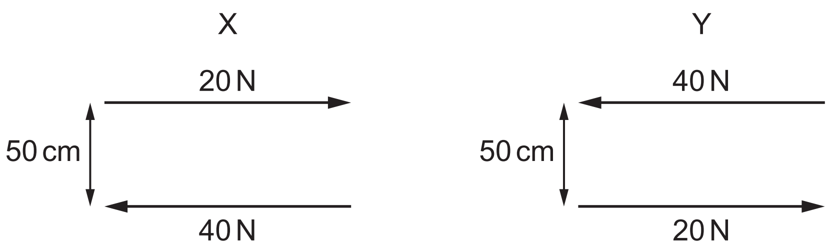
10 A solid sphere, which is less dense than water, is held completely immersed in water a few metres below the surface. The density of the water is uniform.

The sphere is released. Immediately after release, the sphere rises.

Which row correctly describes the changes in the upthrust on the sphere and the resultant force on the sphere?

	upthrust on the sphere	resultant force on the sphere
A	constant	increasing
B	constant	decreasing
C	decreasing	increasing
D	decreasing	decreasing

11 The diagram shows two pairs X and Y of parallel forces.



Which statement is correct?

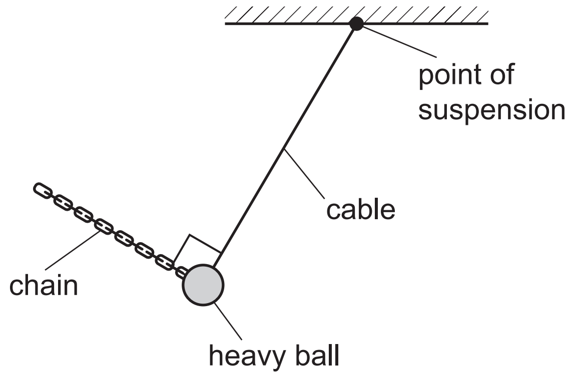
A X is equivalent to a clockwise torque of 10 N m and a force of 20 N to the left.

B X is equivalent to a clockwise torque of 20 N m only.

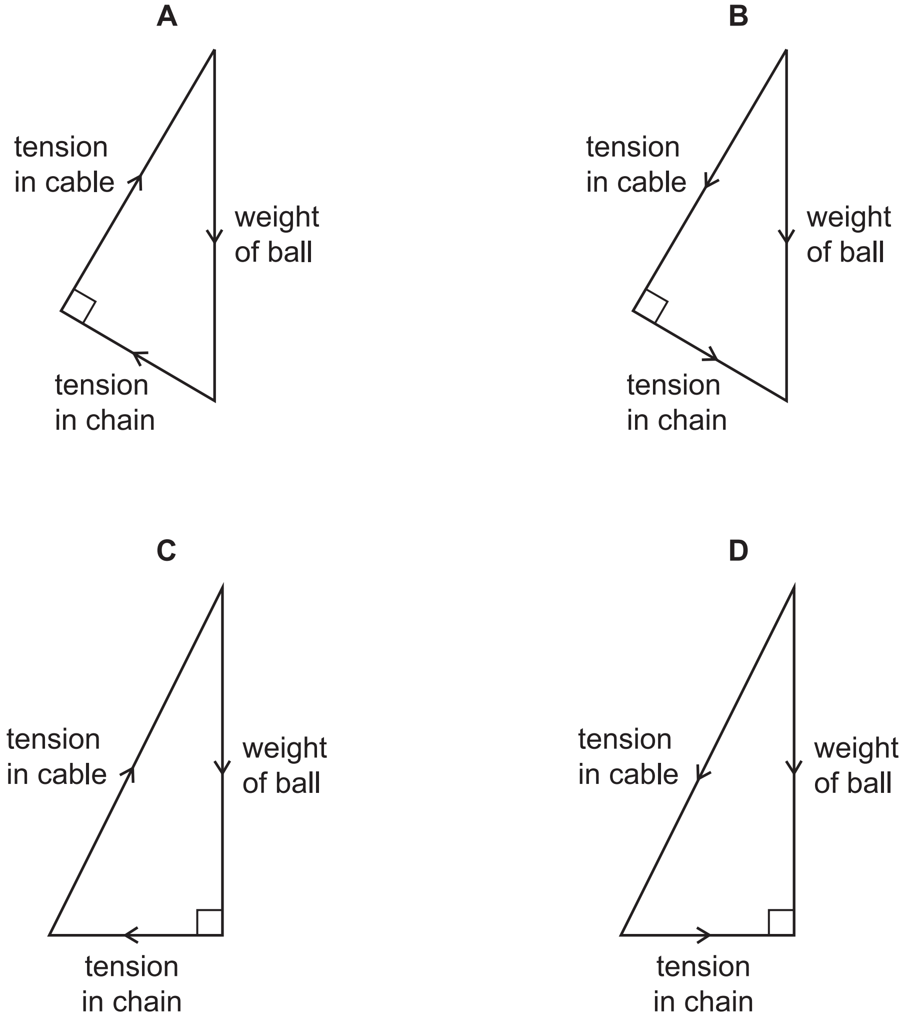
C Y is equivalent to an anticlockwise torque of 30 N m and a force of 20 N to the left.

D Y is equivalent to an anticlockwise torque of 30 N m only.

12 A heavy ball hanging from a cable is held in equilibrium by a chain, as shown.



Which vector diagram shows the three forces acting on the ball?



13 At sea level, atmospheric pressure is 100 kPa and the density of air is 1.3 kg m^{-3}.

Assume that the density of air decreases linearly with height above sea level.

What is an estimate of the total height of the atmosphere based on this information?

A 7.8 km **B** 16 km **C** 77 km **D** 150 km

14 Trains supply coal to a power station. The table shows quantities describing the operation of the power station.

	symbol	unit
power station average output	P	W
number of trains per day	N	
mass of coal on a train	M	kg
energy from 1 kg of coal	E	J
number of seconds in one day	S	

Which expression gives the efficiency of the power station?

A $\dfrac{PS}{NME}$ **B** $\dfrac{PSN}{ME}$ **C** $\dfrac{NME}{PS}$ **D** $\dfrac{NM}{PSE}$

15 A piston in a gas supply pump has an area of 500 cm^2 and it moves a distance of 30 cm.

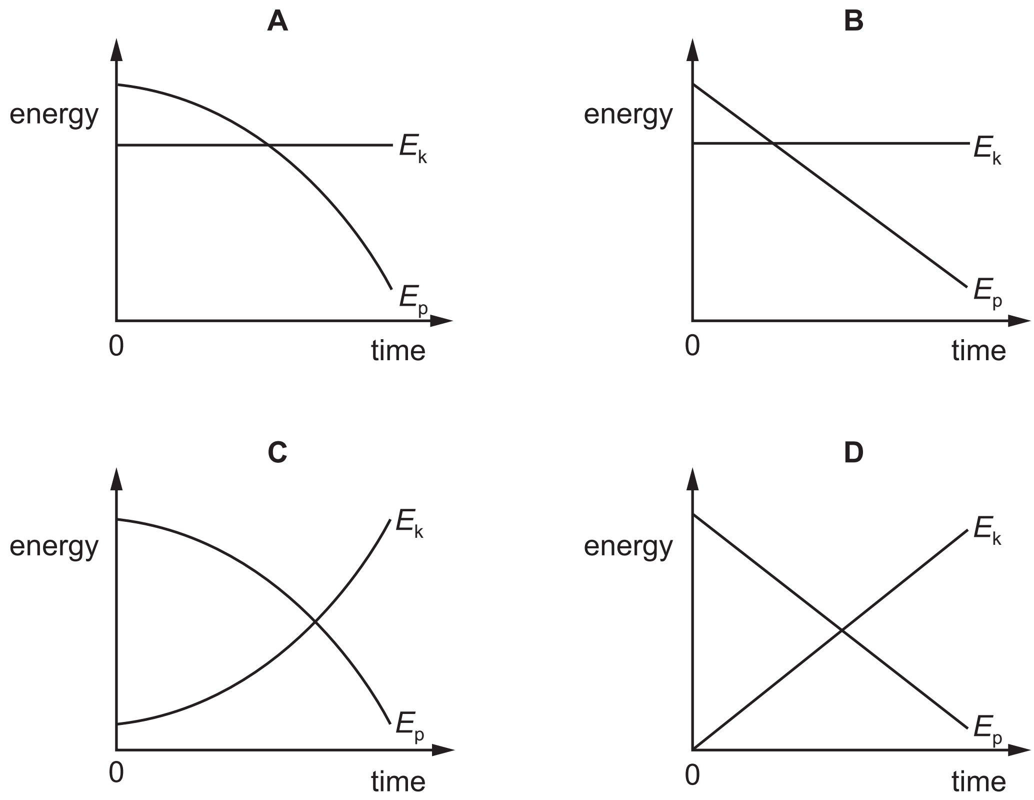
The pump moves the gas against a fixed pressure of 4000 Pa.

How much work is done by the piston?

A 60 J **B** 6.0×10^3 J **C** 6.0×10^5 J **D** 6.0×10^7 J

16 A steel ball is falling at constant speed in oil.

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?

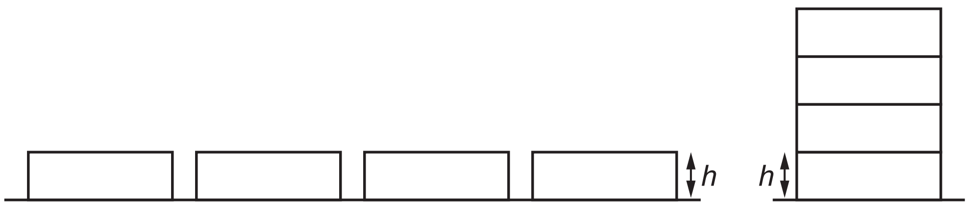


17 The maximum useful output power of a car travelling on a horizontal road is P. The total resistive force acting on the car is kv^2, where v is the speed of the car and k is a constant.

Which equation is correct when the car is travelling at maximum speed?

A $v^3 = \dfrac{P}{k}$ **B** $v^2 = \dfrac{P}{k}$ **C** $v = \left(\dfrac{P}{k}\right)^2$ **D** $v = \left(\dfrac{P}{k}\right)^3$

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

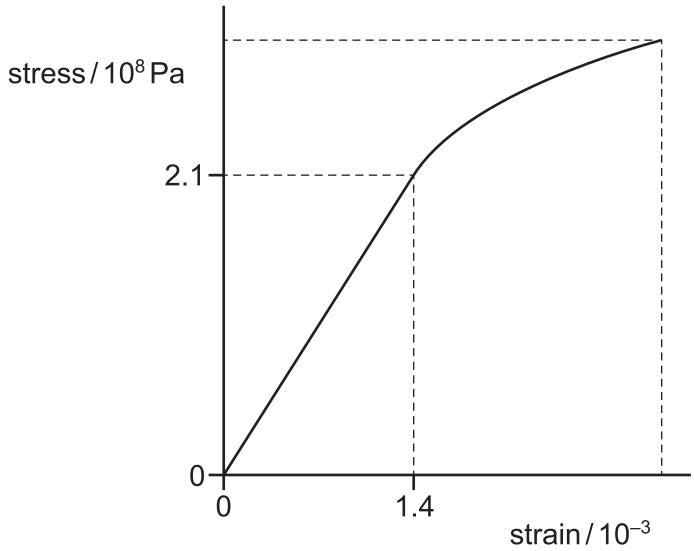


The acceleration of free fall is g.

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

19 The stress–strain graph for a wire is shown.



What is the Young modulus of the material of the wire?

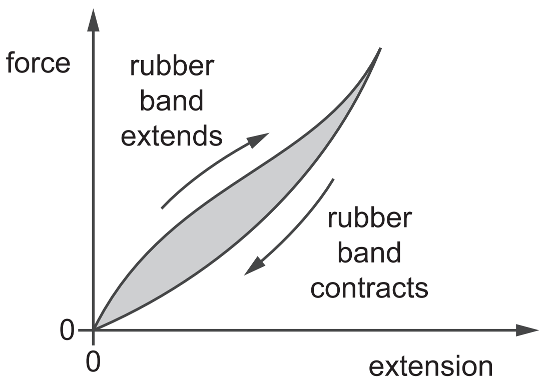
A 6.7×10^{-12} Pa

B 6.7×10^{-9} Pa

C 1.5×10^{8} Pa

D 1.5×10^{11} Pa

20 The diagram shows a force–extension graph for a rubber band as the band is extended and then the stretching force is decreased to zero.



What can be deduced from the graph?

A The rubber band does not return to its original length when the force is decreased to zero.

B The rubber band obeys Hooke's law for the extensions shown.

C The rubber band remains elastic for the extensions shown.

D The shaded area represents the work done in extending the rubber band.

21 Which statement about light waves and sound waves is **not** correct?

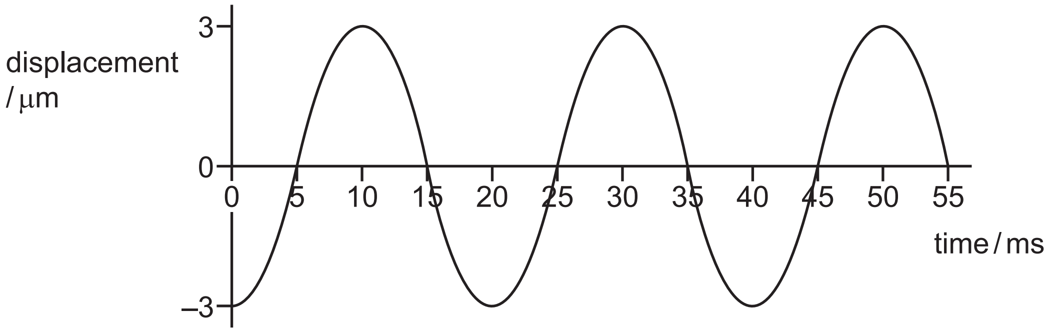
A Light waves and sound waves can both demonstrate the Doppler effect.

B Light waves are transverse waves and sound waves are longitudinal waves.

C Light waves can be diffracted but sound waves cannot.

D Light waves can travel in a vacuum but sound waves cannot.

22 The graph represents a sound wave.



Which statement is correct?

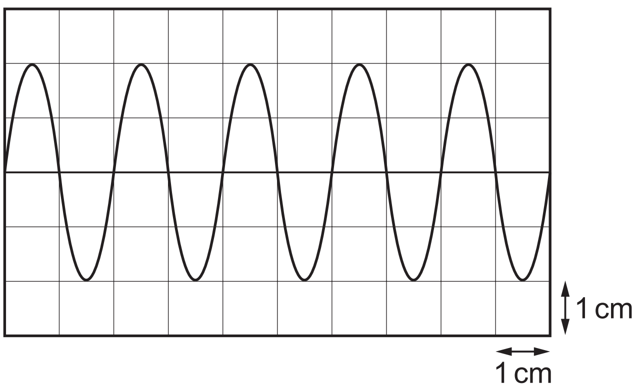
A The wave is longitudinal and has a period of 25 ms.

B The wave is longitudinal and has a frequency of 50 Hz.

C The wave is transverse and has an amplitude of 3 μm.

D The wave is transverse and has a wavelength of 20 ms.

23 A cathode-ray oscilloscope (CRO) is used to display a wave of frequency 5.0 kHz. The display is shown.



What is the time-base setting of the CRO?

A $10\,\mu s\,cm^{-1}$ **B** $100\,\mu s\,cm^{-1}$ **C** $10\,ms\,cm^{-1}$ **D** $100\,ms\,cm^{-1}$

24 A siren emits sound of frequency 1000 Hz. The siren moves at $20\,\mathrm{m\,s^{-1}}$ towards an observer who is standing still.

The speed of sound in the air is $330\,\mathrm{m\,s^{-1}}$.

Which expression would correctly give the frequency heard by the observer?

A $\dfrac{1000 \times 330}{330 + 20}$

B $\dfrac{1000 \times 330}{330 - 20}$

C $\dfrac{1000\,(330 + 20)}{330}$

D $\dfrac{1000\,(330 - 20)}{330}$

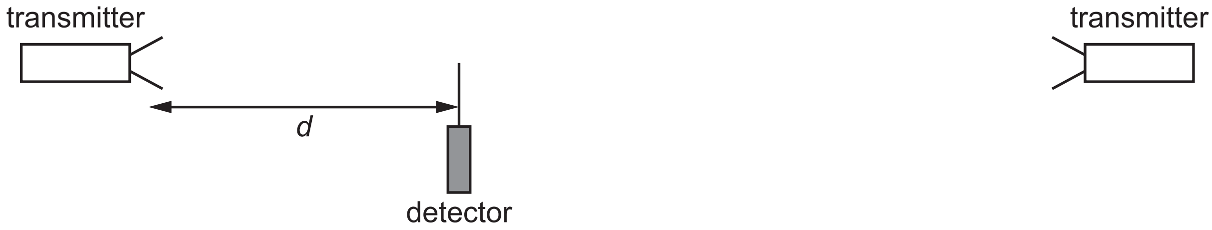
25 A source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

$$I = \frac{P}{4\pi r^2}.$$

How does the amplitude a of the vibrating air molecules vary with the distance r from the source?

A $a \propto \dfrac{1}{r}$ **B** $a \propto \dfrac{1}{r^2}$ **C** $a \propto r$ **D** $a \propto r^2$

26 In an experiment to demonstrate a stationary wave, two microwave transmitters, emitting waves of wavelength 4 cm, are set facing each other, as shown.



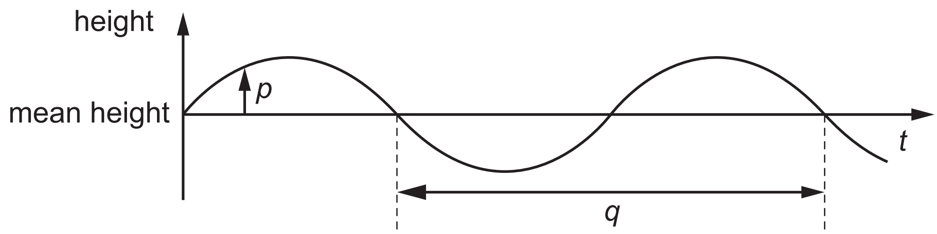
A detector is moved along a straight line between the transmitters. It detects positions of maximum and minimum signal. The detector is a distance *d* from the left-hand transmitter.

Assume that both transmitters are at antinodes of the stationary wave.

Which row gives a value of *d* for a maximum and for a minimum?

	value of *d* for a maximum / cm	value of *d* for a minimum / cm
A	46	48
B	47	48
C	48	47
D	49	47

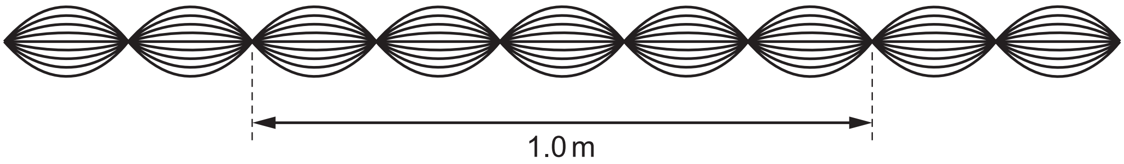
27 The graph shows how the height of the water surface at a point in a harbour varies with time *t* as waves pass the point.



What are *p* and *q*?

	p	*q*
A	displacement	period
B	displacement	wavelength
C	amplitude	period
D	amplitude	wavelength

28 The diagram shows a sketch of a wave pattern over a short period of time.



Which description of this wave is correct?

A The wave is longitudinal, has a wavelength of 20 cm and is stationary.

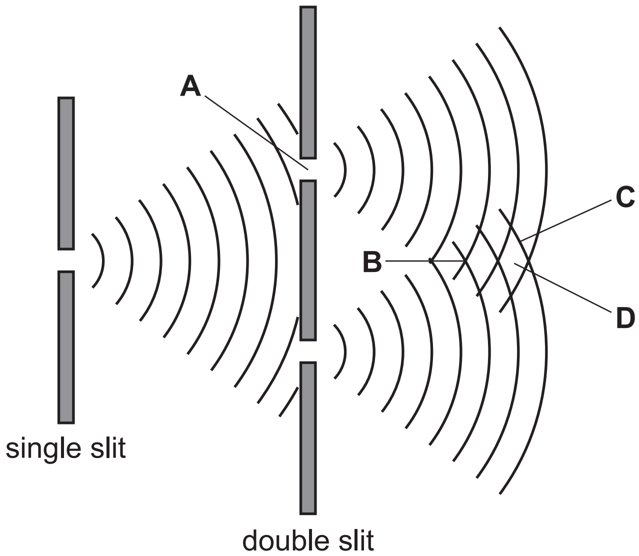
B The wave is transverse, has a wavelength of 20 cm and is stationary.

C The wave is transverse, has a wavelength of 40 cm and is progressive.

D The wave is transverse, has a wavelength of 40 cm and is stationary.

29 The double-slit experiment demonstrates interference between two coherent sources of light waves. In the diagram, the curved lines represent wavefronts.

At which point does complete destructive interference (a minimum) occur?

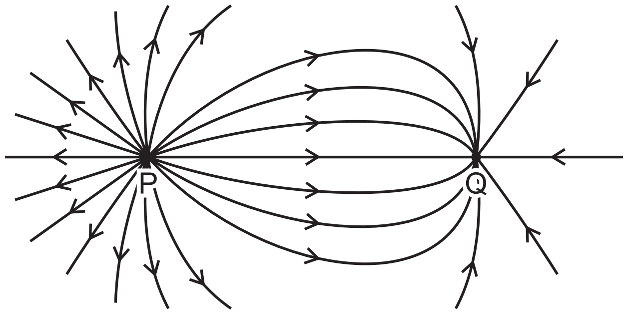


30 Light of wavelength 567 nm is incident normally on a diffraction grating. The grating has 400 lines per mm. A number of diffraction maxima are observed on the far side of the grating.

What is the angle between the second-order maximum and the third-order maximum?

A 13.1° **B** 13.9° **C** 15.9° **D** 27.0°

31 The diagram shows the electric field pattern between two opposite and unequal point charges P and Q.



Which statement about the charges is correct?

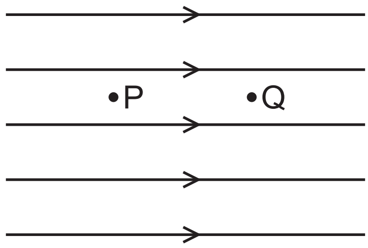
A P is negatively charged and has a smaller charge than Q.

B P is negatively charged and has a greater charge than Q.

C P is positively charged and has a smaller charge than Q.

D P is positively charged and has a greater charge than Q.

32 A uniform electric field is represented by five horizontal field lines.



P and Q are two points in the field. The field causes a positively charged particle in a vacuum to move from P to Q.

Which statement must be correct?

A The acceleration of the particle between P and Q is increasing.

B The kinetic energy of the particle at P is the same as the kinetic energy of the particle at Q.

C The force on the particle at Q is greater than the force on the particle at P.

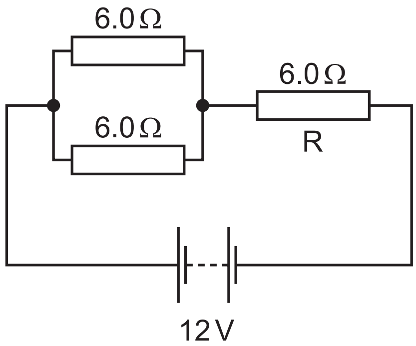
D Work is done on the particle as it moves from P to Q.

33 A metal electrical conductor has a resistance of $5.6\,\text{k}\Omega$. A potential difference (p.d.) of $9.0\,\text{V}$ is applied across its ends.

How many electrons pass a point in the conductor in one minute?

A 6.0×10^{20} **B** 1.0×10^{19} **C** 6.0×10^{17} **D** 1.0×10^{16}

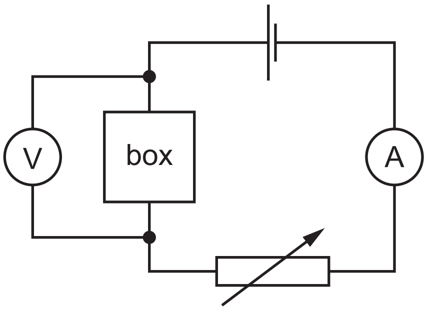
34 A battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected to three resistors, each of resistance 6.0 Ω, as shown.



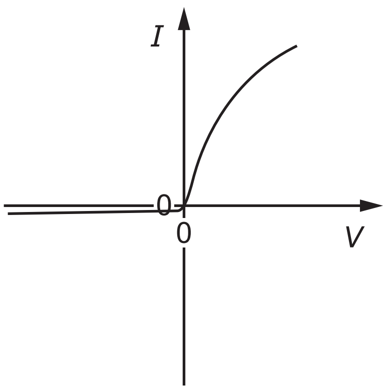
What is the power dissipated in resistor R?

A 2.7 W **B** 6.0 W **C** 11 W **D** 24 W

35 A box containing two electrical components is connected into a circuit.



The variable resistor is adjusted and measurements are taken to determine the I–V characteristic for the box, as shown.



Which arrangement of two electrical components in the box would create the best fit to the measured I–V characteristic?

A a filament lamp and a fixed resistor in parallel

B a filament lamp and a fixed resistor in series

C a semiconductor diode and a filament lamp in parallel

D a semiconductor diode and a filament lamp in series

36 A cell of internal resistance 0.5 Ω is connected to a fixed resistor of resistance 10 Ω.

The resistance of the resistor is changed to 20 Ω.

Which statement is **not** correct?

A The current in the circuit will halve.

B The e.m.f. of the cell will remain constant.

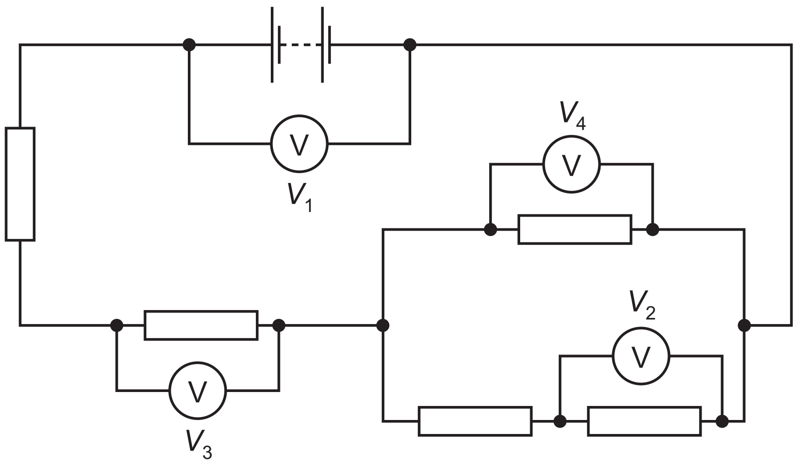
C The power dissipated by the fixed resistor will decrease.

D The terminal p.d. of the cell will increase.

37 Which row correctly describes Kirchhoff's laws?

	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy
B	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge
C	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge
D	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy

38 In the circuit shown, all the resistors are identical.



The reading V_1 is 8.0 V and the reading V_2 is 1.0 V.

What are the readings on the other voltmeters?

	V_3 / V	V_4 / V
A	1.5	1.0
B	3.0	2.0
C	4.5	3.0
D	6.0	4.0

39 A radioactive nucleus emits an α-particle or a β^- particle, creating a product nucleus.

Which decay could create the product nucleus stated?

	radioactive nucleus	decay	product nucleus
A	$^{226}_{88}Ra$	α	$^{224}_{86}Rn$
B	$^{238}_{92}U$	α	$^{242}_{94}Pu$
C	$^{228}_{88}Ra$	β^-	$^{228}_{87}Fr$
D	$^{231}_{90}Th$	β^-	$^{231}_{91}Pa$

40 Which statement is correct?

A Electrons and neutrinos are fundamental particles.

B Electrons and neutrinos are hadrons.

C Protons and neutrons are leptons.

D Protons and neutrons are quarks.

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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)

2899225506

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.

IB20 11_9702_11/2RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}}\right)$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho g h$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 Which quantity is a physical quantity?

A atomic number

B efficiency

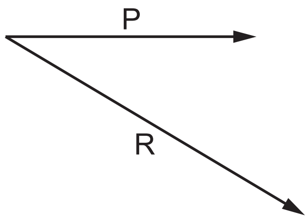
C number density of charge carriers

D strain

2 Which time interval is the shortest?

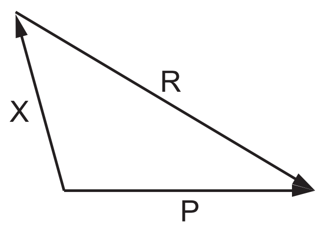
A 0.05 ms **B** 50 ns **C** 500 000 ps **D** 0.5 μs

3 P and R are coplanar vectors.

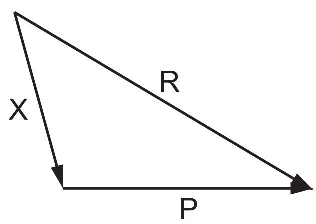


If X = P – R, which diagram best represents vector X?

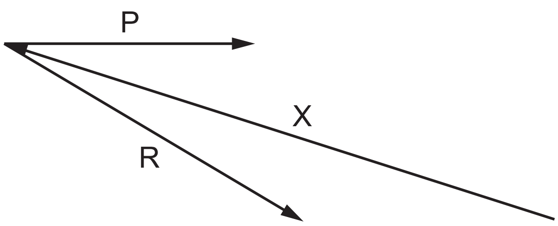
A



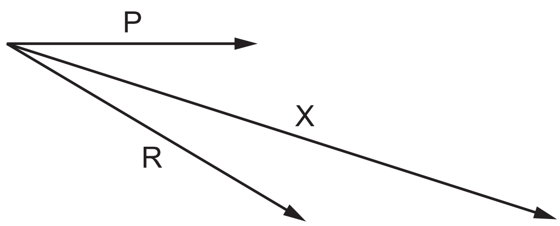
B



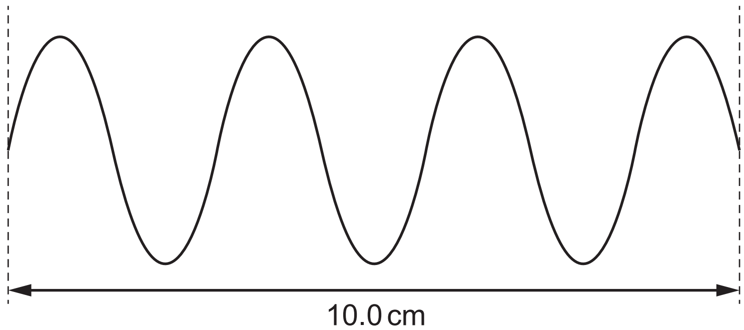
C



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

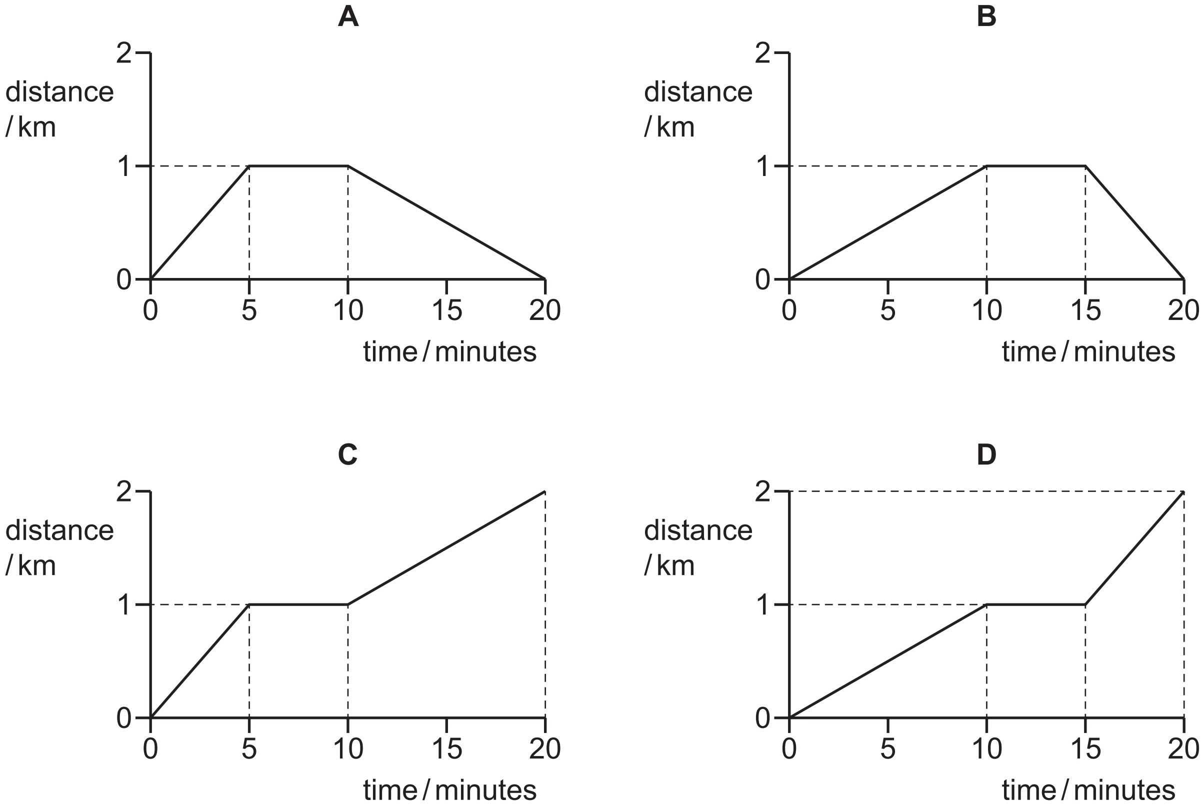
B $(36.35 \pm 0.03)\,\text{cm}^3$

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

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

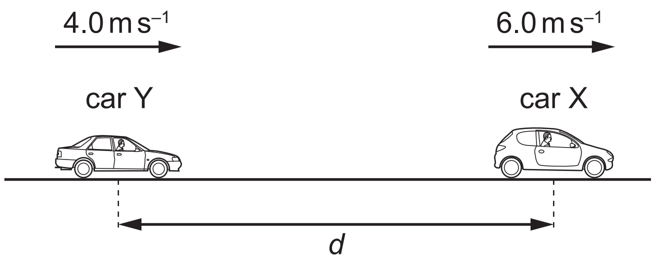
6 A student cycles uphill from home to a shop, taking 10 minutes. The student then spends 5 minutes in the shop, before cycling home downhill at twice the initial speed.

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



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

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

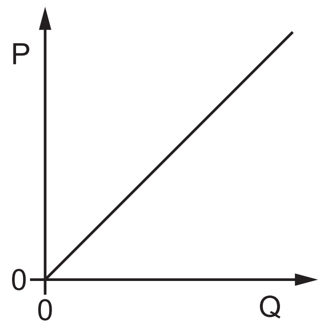


Car Y is level with car X after a time of 20 seconds.

What is the distance d?

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

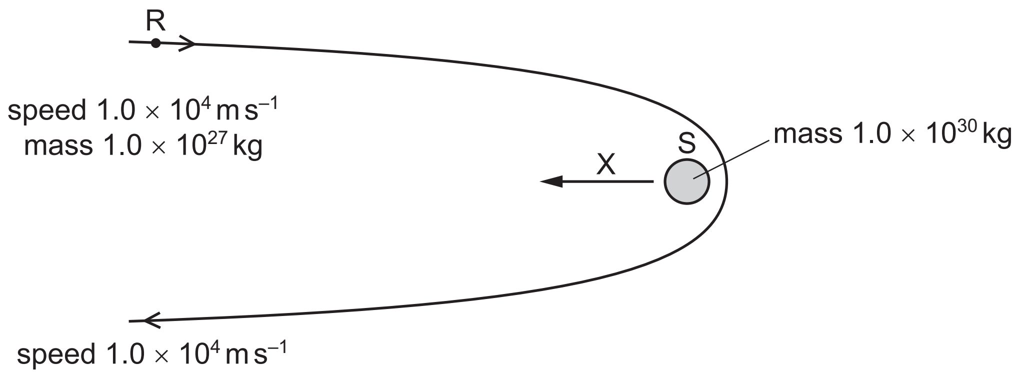
8 The graph shows how quantity P varies with quantity Q for an object falling in air for a long time in a uniform gravitational field.



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 $1.0 \times 10^{4}\,\text{m s}^{-1}$. 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 $20\,\text{m s}^{-1}$.

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.

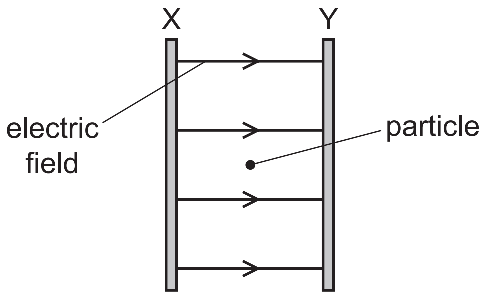
After the impact they move off together.

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?

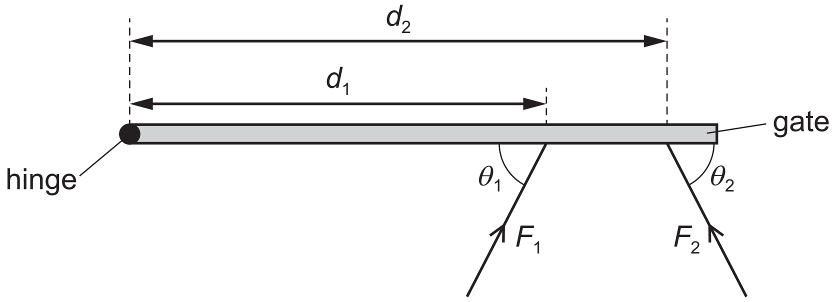
A alpha-particle

B electron

C neutron

D proton

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?

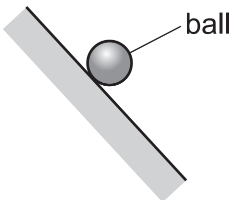
A $(d_1 \times F_1 \cos\theta_1) + (d_2 \times F_2 \cos\theta_2)$

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

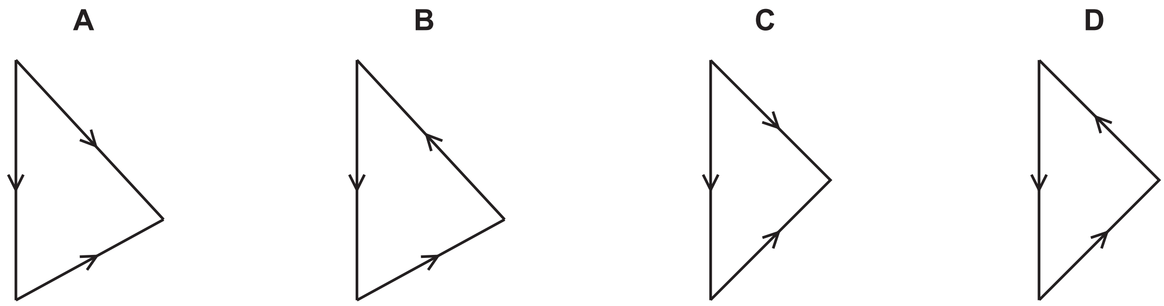
C $(d_1 \times F_1 \cos\theta_1) - (d_2 \times F_2 \cos\theta_2)$

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

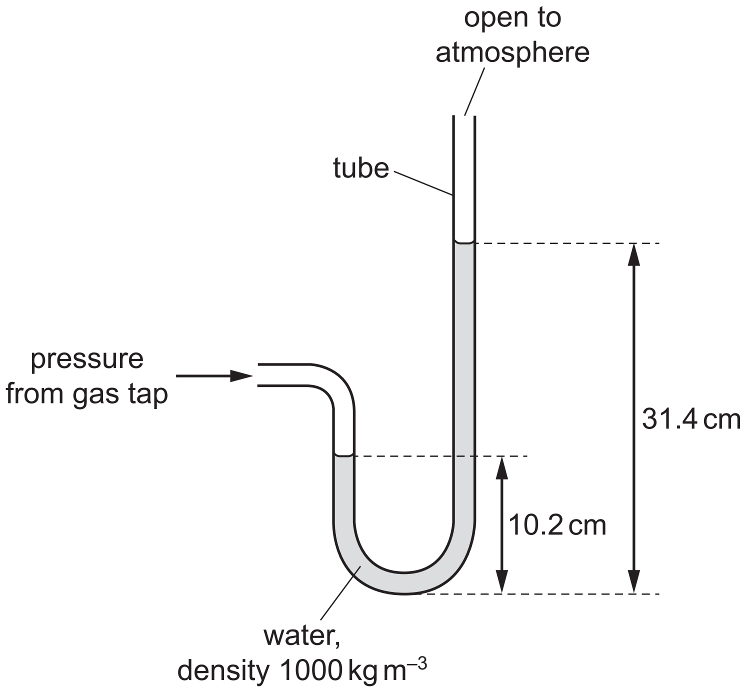
13 A ball is rolling down a slope at a constant speed. The three forces acting on the ball are its weight, the contact force normal to the slope and friction.



Which diagram could represent these three forces?



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.

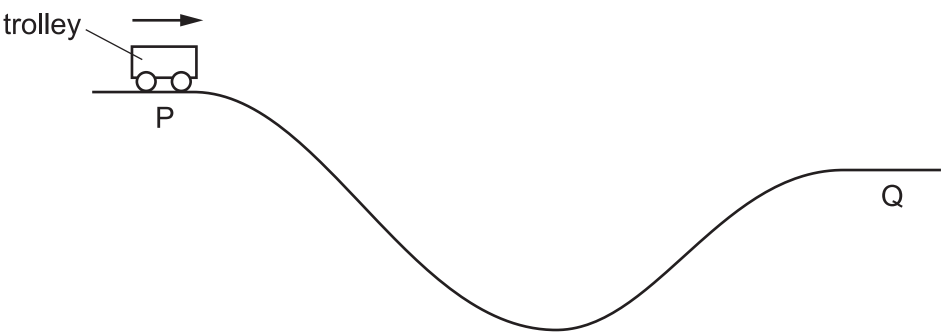


The atmospheric pressure is 101 kPa.

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

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 $1.5 \times 10^5\,kg\,s^{-1}$. 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 $20\,m\,s^{-1}$

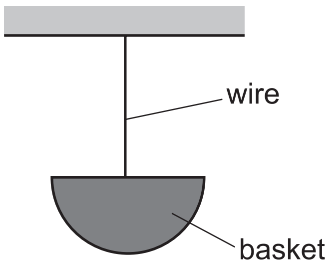
D the work done by a gas expanding against a constant external pressure of 120 kPa when its volume increases by $0.020\,m^3$

18 A train of mass 300 000 kg is accelerating at $0.80\,m\,s^{-2}$. At one instant, the speed of the train is $5.0\,m\,s^{-1}$ 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.



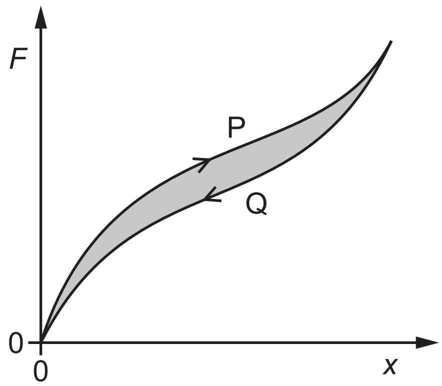
The Young modulus for the material of the wire is 2.5×10^{11} Pa.

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 7.2×10^{-7} m **B** 2.3×10^{-6} m **C** 8.5×10^{-4} m **D** 1.7×10^{-3} m

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

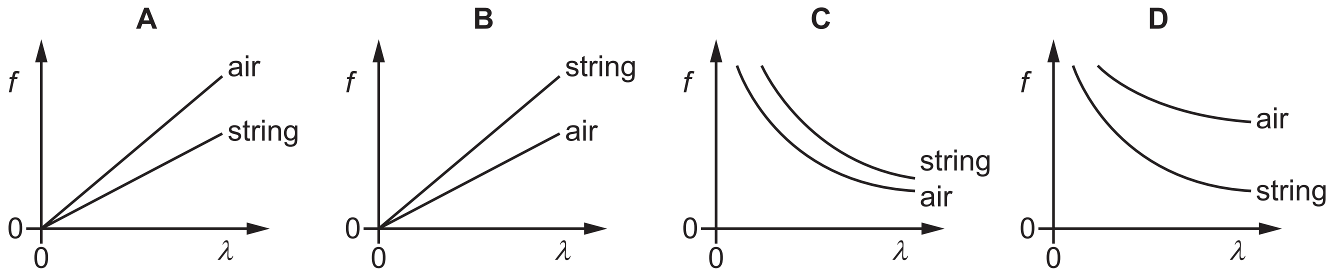
B the energy that causes plastic deformation

C the energy dissipated as heat

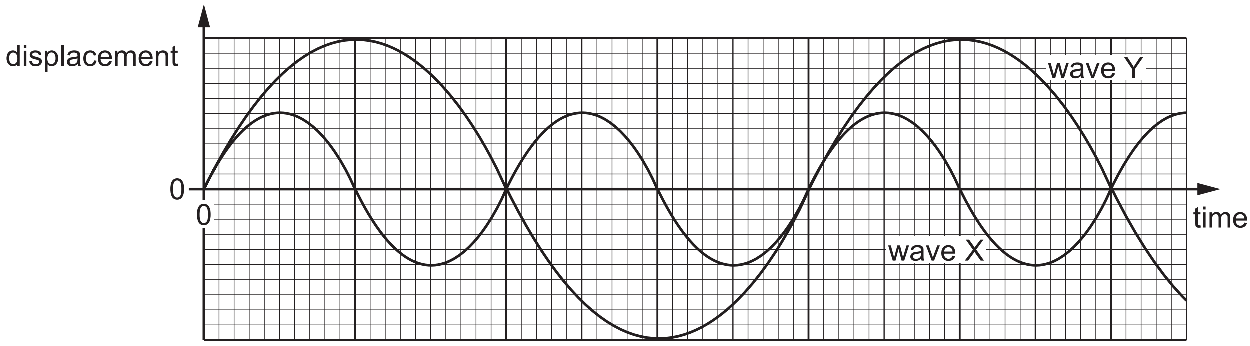
D the work done to extend the rubber cord

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

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



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

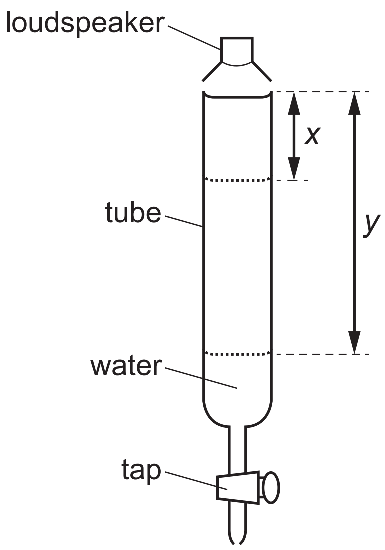


Wave X has frequency *f* and amplitude *A*.

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?

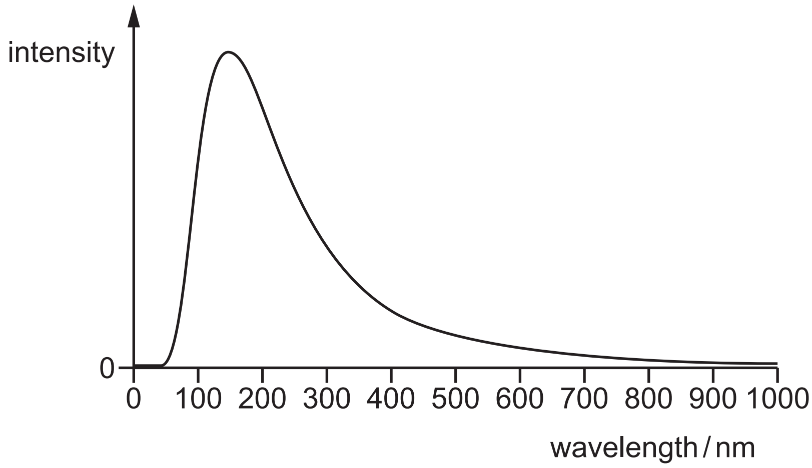
A $2x$ **B** $4y$ **C** $2(y - x)$ **D** $4(y - x)$

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

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.

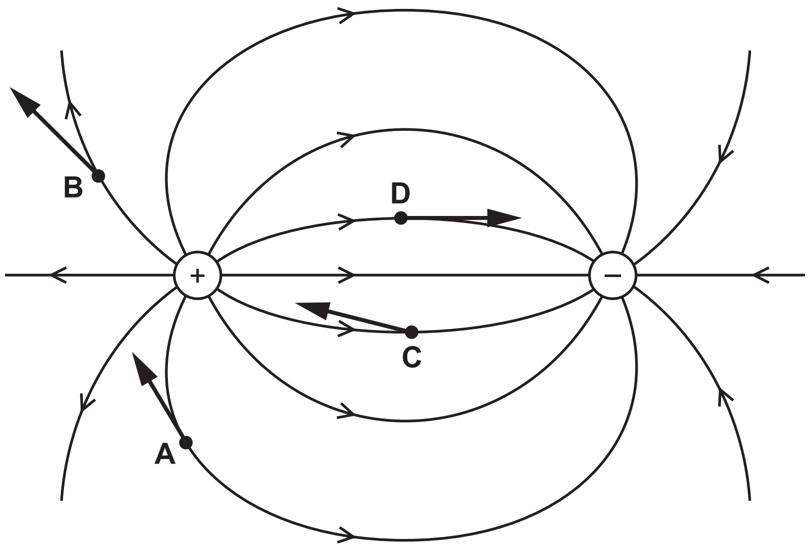
What is the wavelength of the blue light?

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

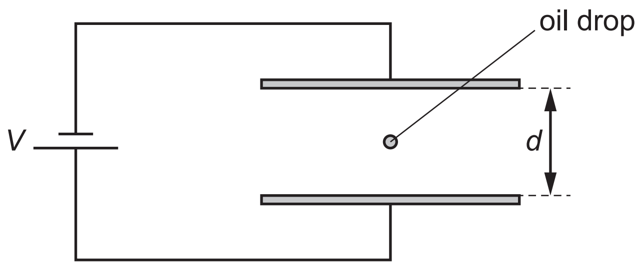
30 The diagram shows the electric field near a positively charged sphere and a negatively charged sphere.

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** $\frac{d}{Vg}$

32 Free electrons flow along a copper wire X of radius 5.0×10^{-5} m with an average drift speed of 2.8×10^{-2} 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 4.7×10^{-3} m s^{-1}

B 9.3×10^{-3} m s^{-1}

C 1.1×10^{-2} m s^{-1}

D 1.9×10^{-2} m s^{-1}

33 What is the definition of potential difference?

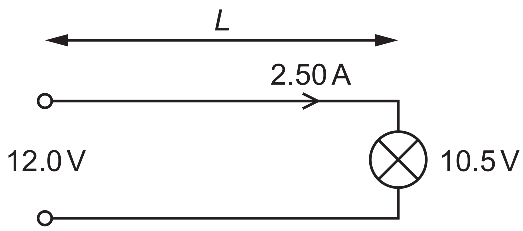
A power per unit current

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 $1.70 \times 10^{-8}\,\Omega$ m and has a cross-sectional area of 6.00×10^{-7} m^2.

What is the length *L* of the cable?

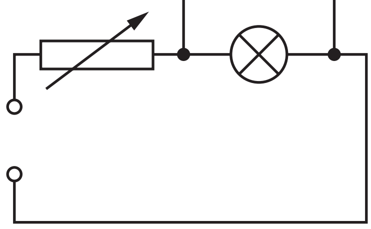
A 10.6 m **B** 21.2 m **C** 29.4 m **D** 58.8 m

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.

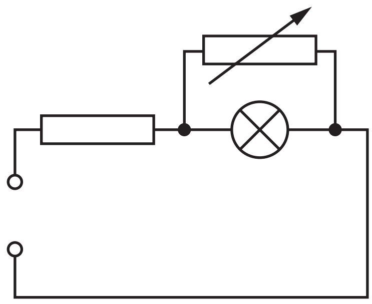
The resistance of the variable resistor is adjusted from zero to its maximum value.

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

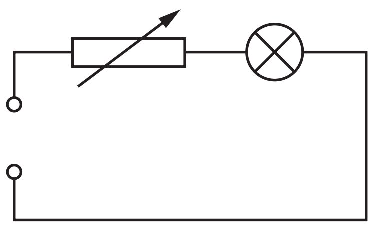
A



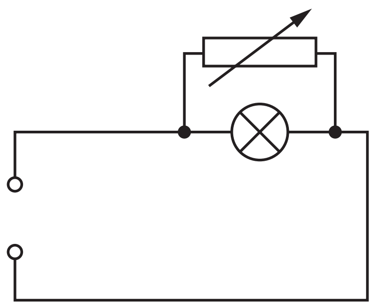
B



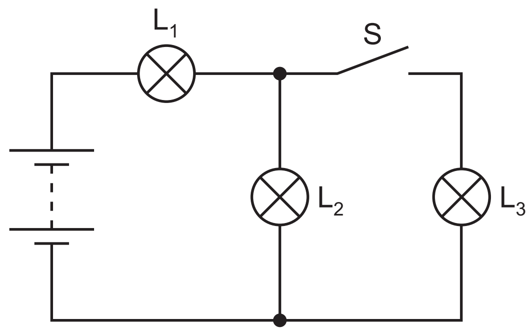
C



D



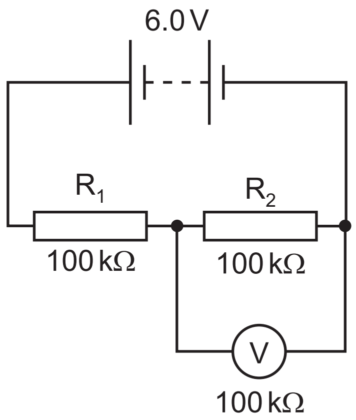
36 Three identical lamps L_1, L_2 and L_3 are connected to a battery with negligible internal resistance, as shown.



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.

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

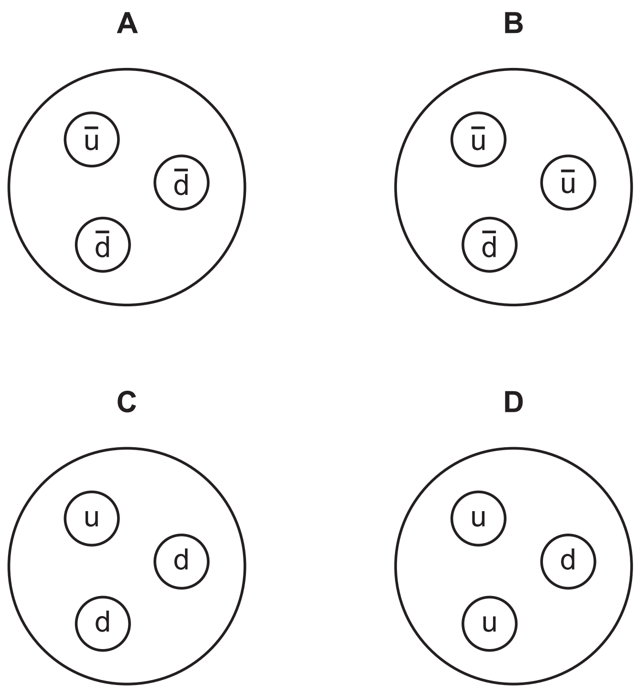
The nuclear reaction is shown.

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

What is nucleus X?

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

40 Which diagram represents the quark composition of an antineutron?



key
u up quark
d down quark
ū up antiquark
d̄ down antiquark

Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

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

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

0407237101

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 **24** pages. Blank pages are indicated.

IB20 11_9702_12/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

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

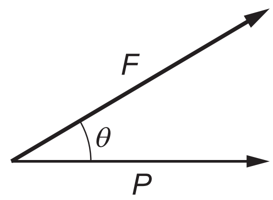
$$v = T^p \mu^q$$

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

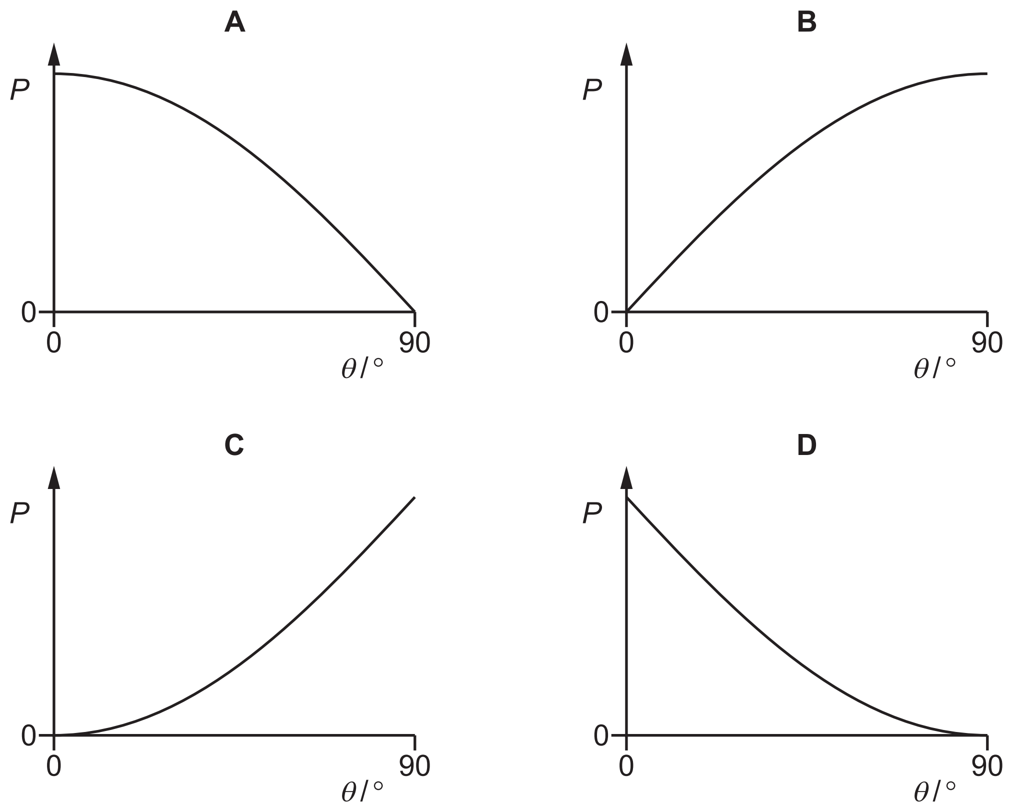
What are the values of p and q?

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

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.

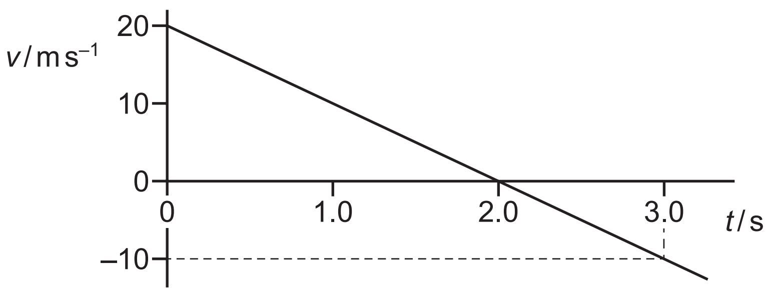
$$h = \tfrac{1}{2}gt^2$$

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 $t = 3.0\,\text{s}$?

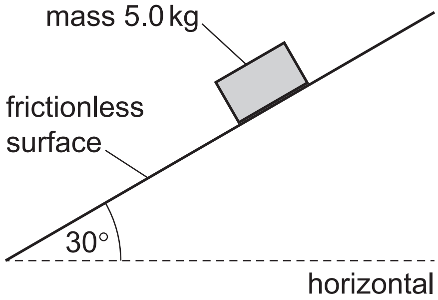
A 15 m above X

B 15 m below X

C 25 m above X

D 25 m below X

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.

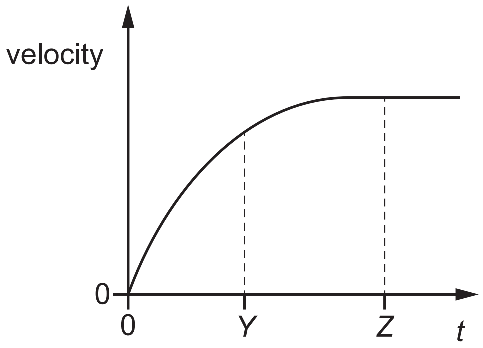
B If no resultant force acts on a body it has constant velocity.

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.

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

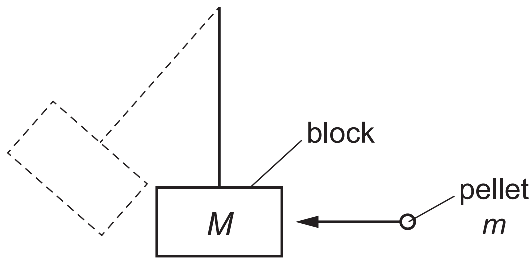
10 Two balls, one of mass $2m$ and one of mass m, collide.

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

Which collision is **not** elastic?

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

11 The diagram shows a 'ballistic pendulum'.



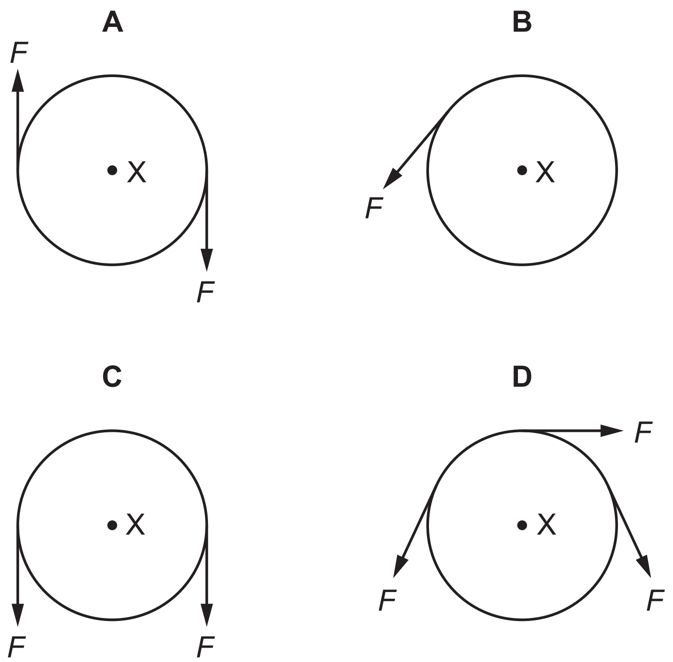
A pellet of mass *m* travelling at a speed *u* hits a stationary block of mass *M.* The pellet becomes embedded in the block and causes the block to move at a speed *v* immediately after the impact.

When a pellet of mass 2*m*, travelling at a speed 2*u*, hits a block of mass 2*M*, 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** $4v$

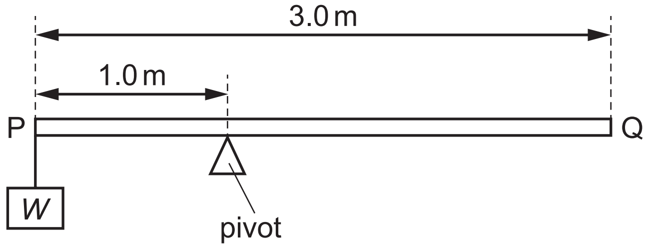
12 A rigid circular disc of radius *r* has its centre at X. A number of forces of equal magnitude *F* act at the edge of the disc. All the forces are in the plane of the disc.

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



[Turn over

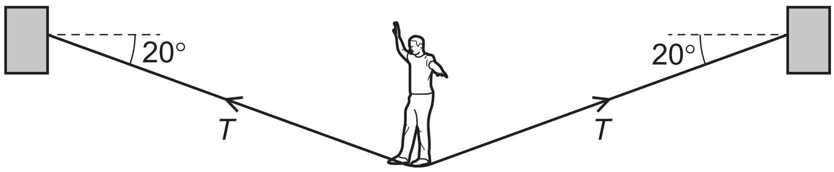
13 The diagram shows a uniform beam PQ. The length of the beam is 3.0 m and its weight is 50 N. The beam is supported on a pivot 1.0 m from end P. A load of weight *W* is hung from end P. The beam is in equilibrium.



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.



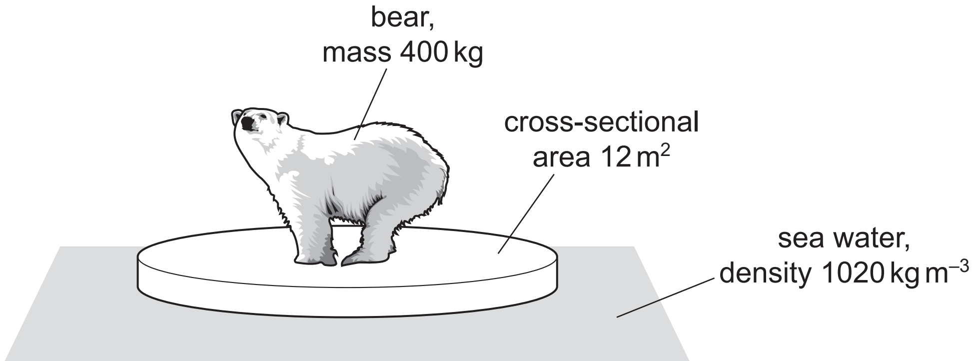
The wire on either side of the man is at an angle of 20° to the horizontal.

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

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 = $\frac{1}{2}$ × mass × (speed)^2

B moment = force × distance

C weight = mass × acceleration of free fall

D work done = power × 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

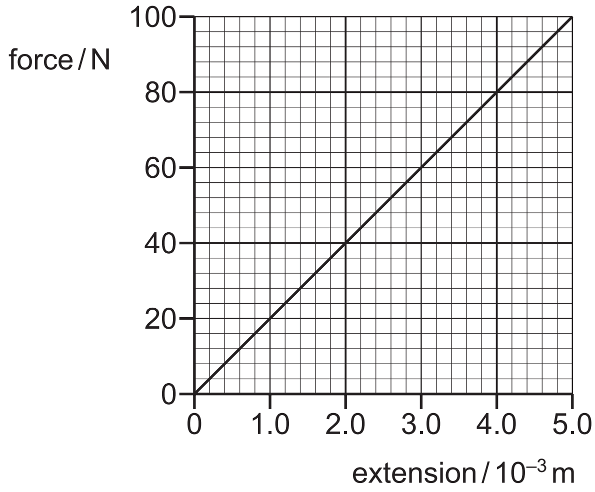
20 A mass of 60.0 g is suspended from a spring and the distance from the bottom of the spring to the floor is measured to be 16.4 cm.

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}

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?

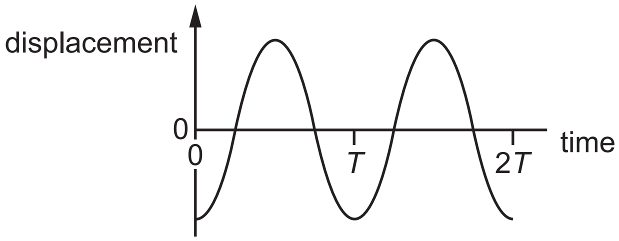
A f^2 against λ

B f against λ^2

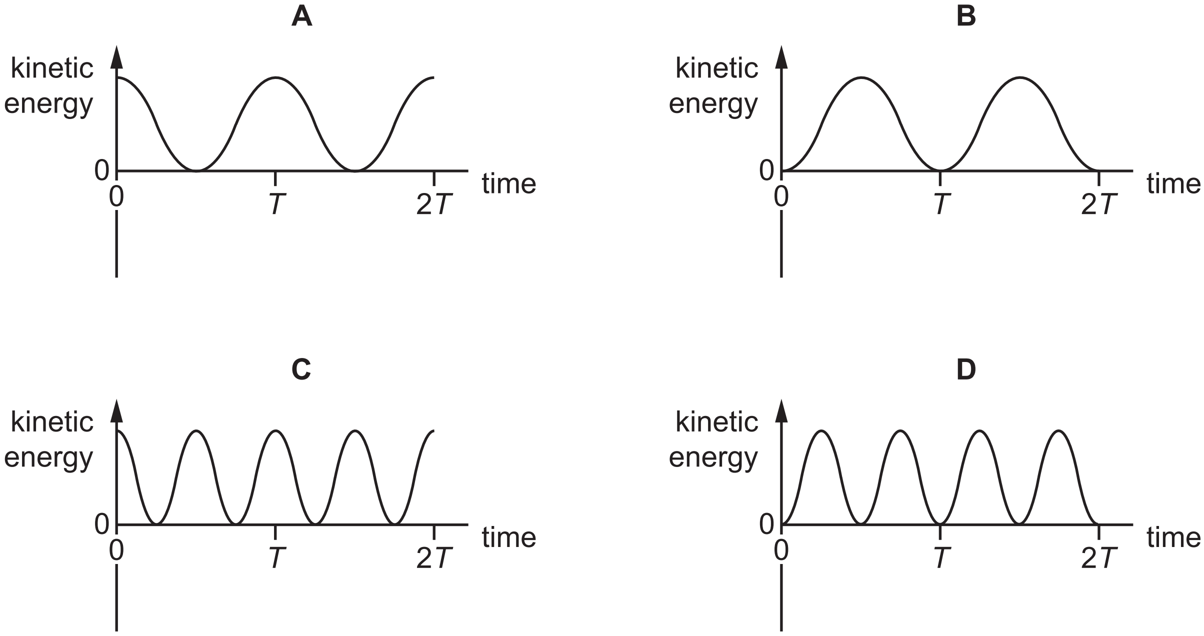
C f against $\frac{1}{\lambda}$

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

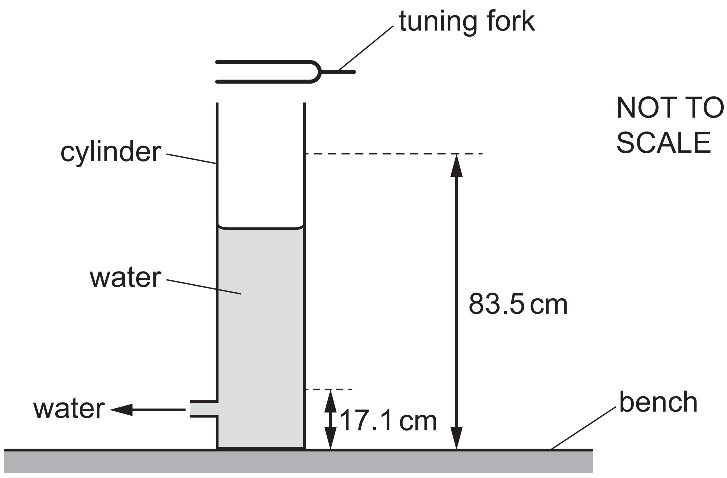
23 When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.



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



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.

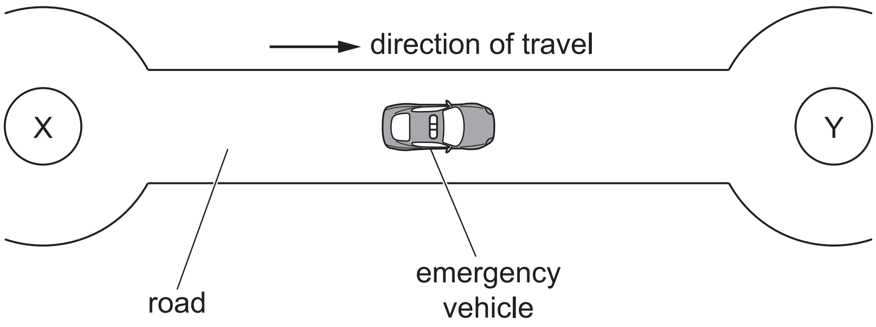


The speed of sound in air is $340\,m\,s^{-1}$.

What is the frequency of the tuning fork?

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

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.



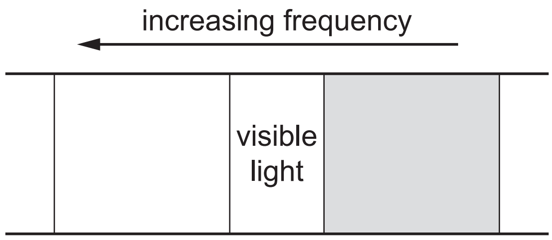
The frequency of the sound emitted by the siren is 750 Hz.

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.



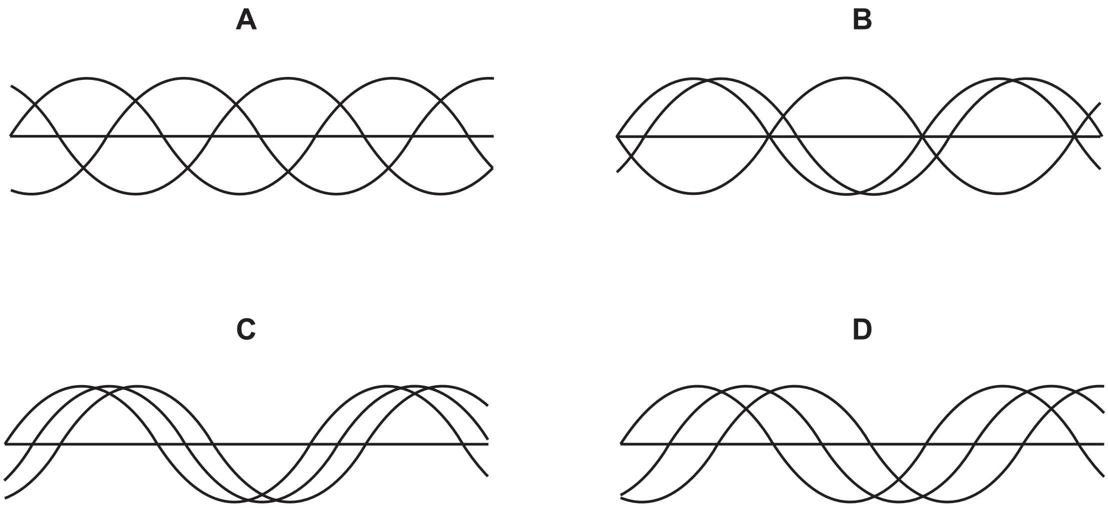
What is the name of the shaded region and what is the order of magnitude of a wavelength of a wave from this region?

	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?



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

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.

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?

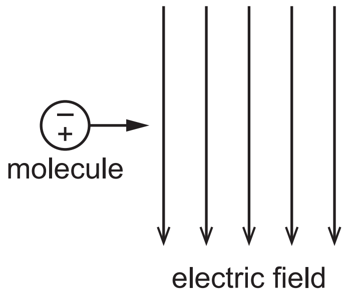
A Increase the distance between the grating and the screen.

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.

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.

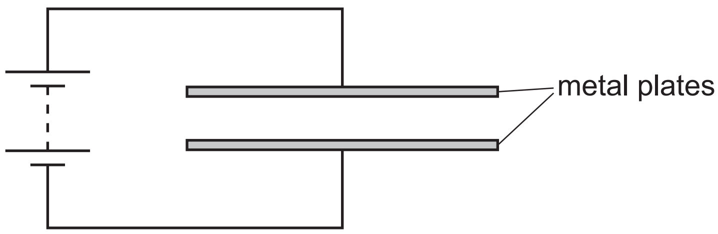


The positive and negative charges of the molecule enter the field at the same time.

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.



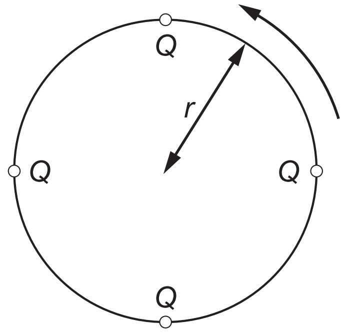
One of the plates is slowly moved towards the other.

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

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

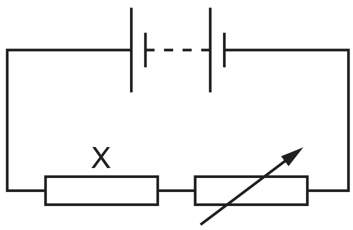
The disc rotates at a rate of n revolutions per unit time.



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.



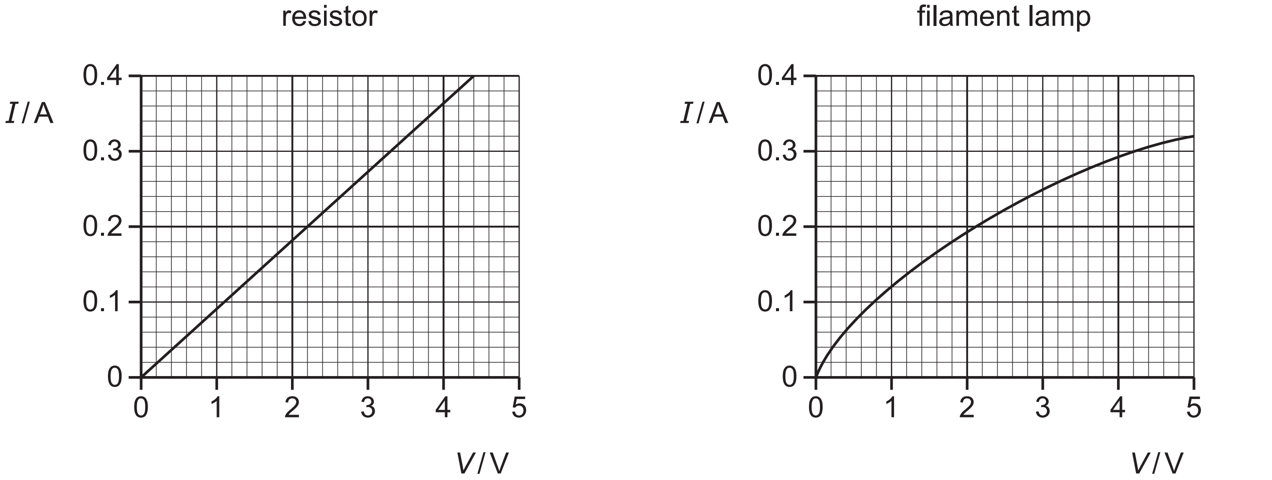
The power dissipated in resistor X is 7.2 W when a current of 3.0 A passes through it.

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

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.

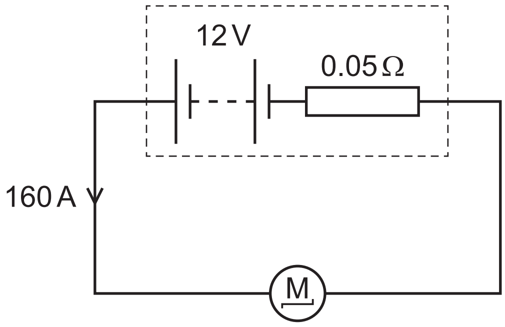


The potential difference (p.d.) across the resistor is 3.3 V.

What is the resistance of the lamp?

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

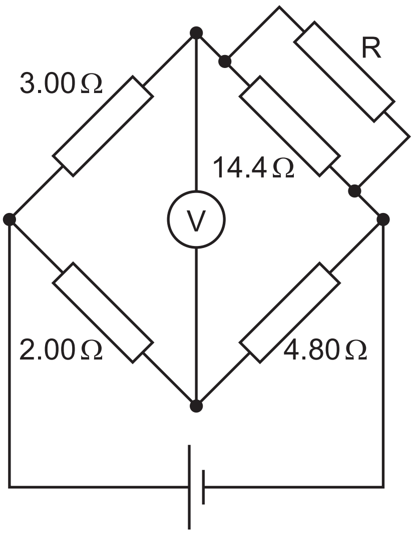
36 A car battery has an electromotive force (e.m.f.) of 12 V and an internal resistance of 0.05 Ω. The battery is connected to the starter motor of a car. The current in the motor is 160 A.



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.

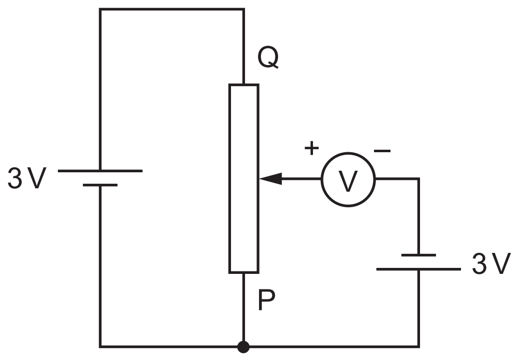


The reading on the voltmeter is zero.

What is the resistance of resistor R?

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

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	0V	3V
B	0V	6V
C	3V	3V
D	3V	6V

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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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/13**

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

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 0 0 8 9 2 6 6 4 0 6 *

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.

IB20 11_9702_13/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

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?

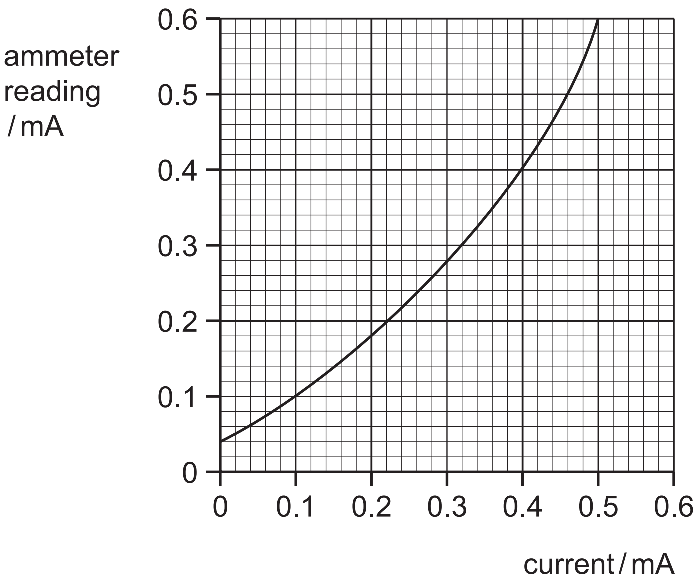
A displacement and distance

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

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.

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

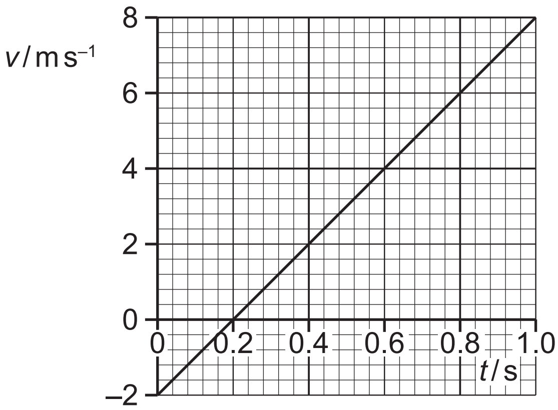
His measurements are shown.

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 $t = 0.80\,\text{s}$?

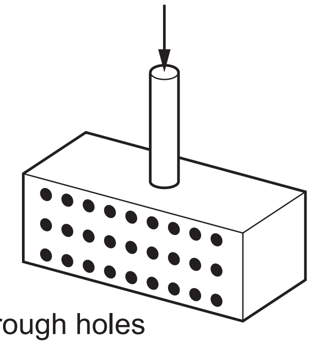
A 1.6 m **B** 1.8 m **C** 2.0 m **D** 3.2 m

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

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?

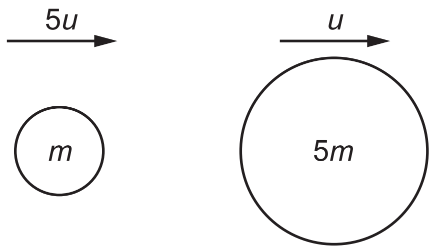
A The balloon decelerates continuously.

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.

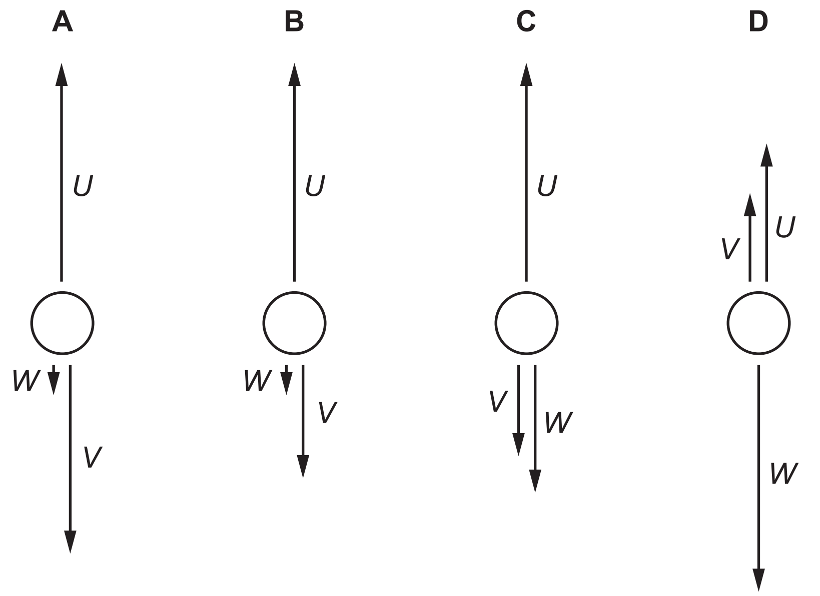


What is the speed with which the two objects travel together in the original direction?

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

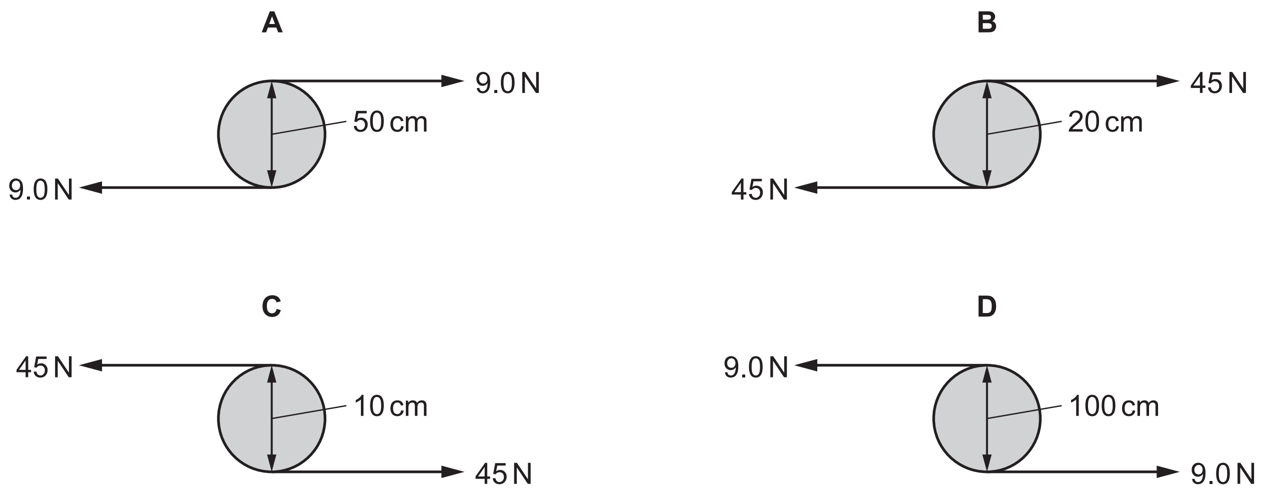
11 An air bubble is rising through a liquid at a constant speed. The forces on it are the upthrust U, the viscous drag V and its weight W.

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



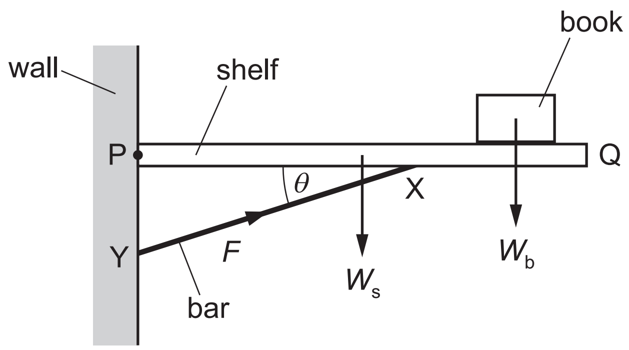
12 A couple applies a clockwise torque of 9.0 N m to a circular disc.

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.

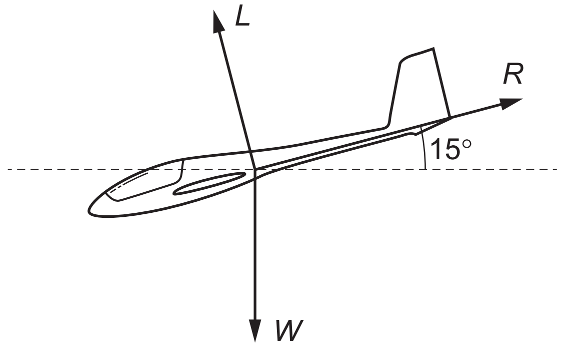
The bar is at an angle θ to the shelf and exerts a force F on the shelf.

The shelf is in equilibrium.

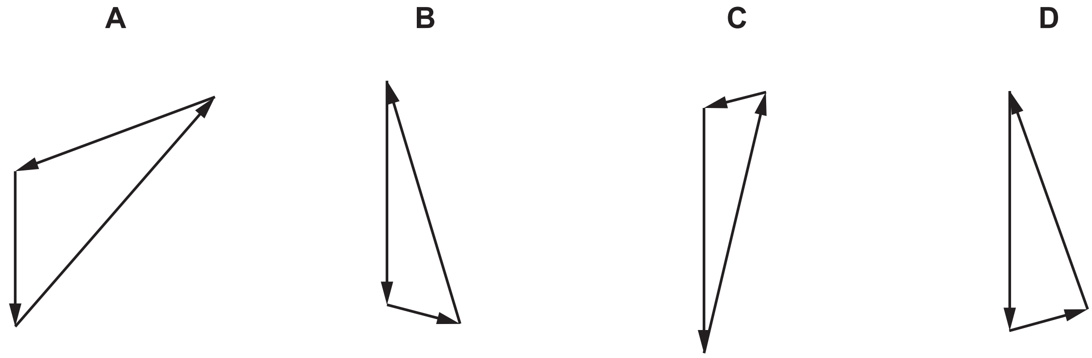
What are the magnitudes of the horizontal and the vertical components of the force of the wall on the shelf at P?

	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	$F\sin\theta$	$(W_s + W_b - F\sin\theta)$

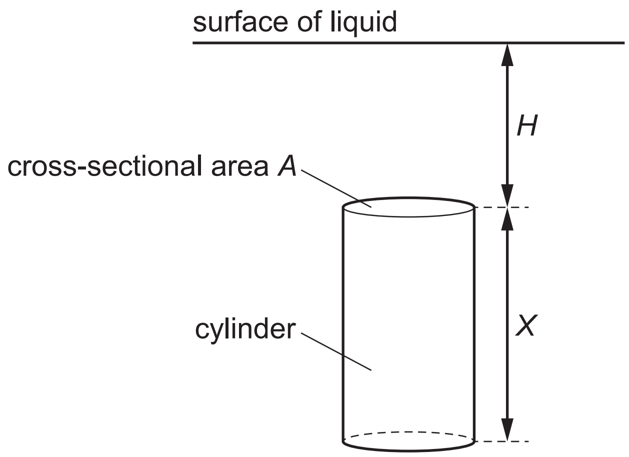
14 A glider is descending at constant speed at an angle of 15° to the horizontal. The diagram shows the directions of the lift L, air resistance R and weight W acting on the glider.



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



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.

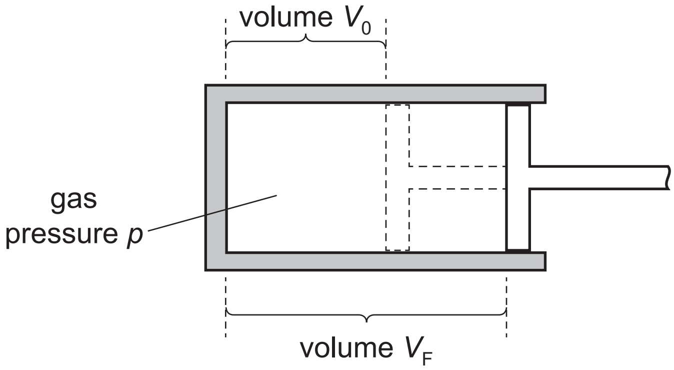
B The kinetic energy decreases to zero and then returns to its original value.

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

18 An object of mass 0.30 kg is thrown vertically upwards from the ground with an initial velocity of $8.0\,\text{m}\,\text{s}^{-1}$. 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?

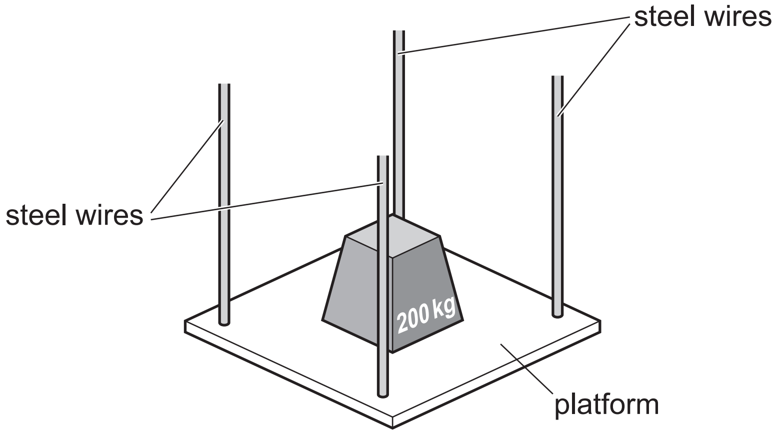
A 4.0 J **B** 5.6 J **C** 9.6 J **D** 15 J

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

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?

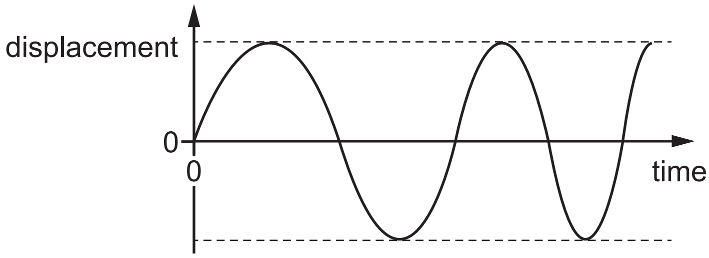
A 17.5 J **B** 35.0 J **C** 17.5 kJ **D** 35.0 kJ

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 $\dfrac{\text{maximum possible intensity}}{\text{minimum possible intensity}}$?

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?

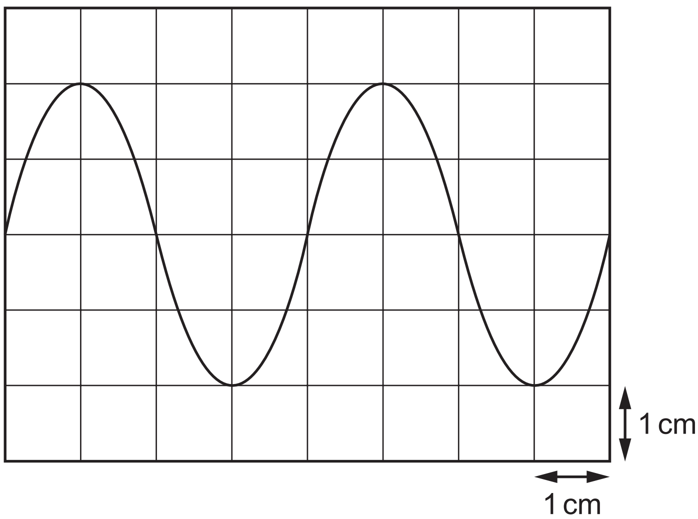
A amplitude

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 $2.5\,\text{ms}\,\text{cm}^{-1}$.

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** $\frac{1}{0.80}$

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

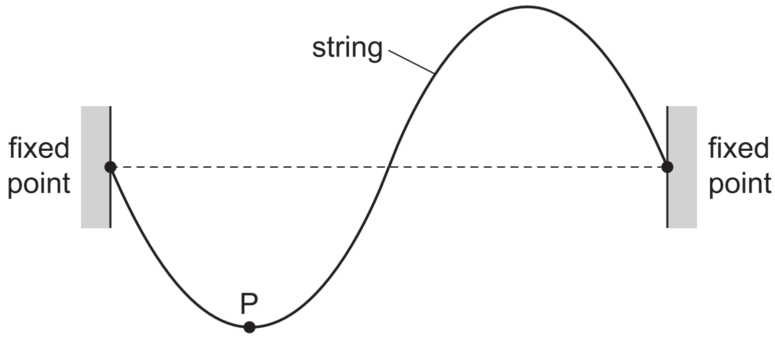
Satellite X transmits a microwave pulse towards satellite Y. The pulse takes time T to reach Y.

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.

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 $5.0 \times 10^{5}\,\text{V m}^{-1}$?

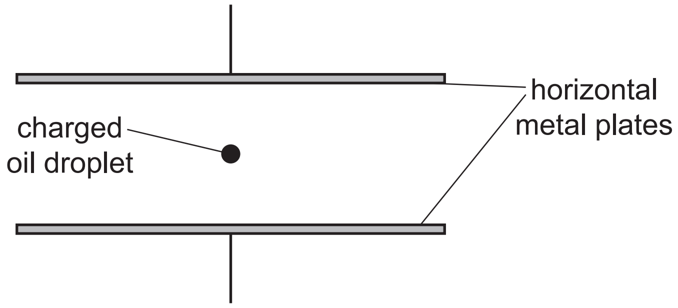
A a force of 1.6×10^{-14} N acting on an electron

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.



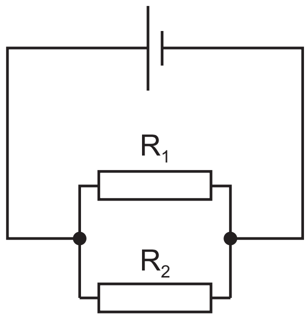
As some of the oil evaporates, the droplet loses mass and starts to accelerate. Its charge remains constant.

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

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 $\dfrac{\text{average drift speed of free electrons in } R_1}{\text{average drift speed of free electrons in } R_2}$?

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

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.

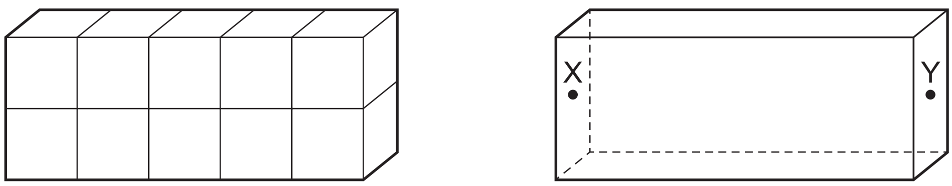
B It is from other forms into electrical energy.

C It only takes place inside a power supply.

D It only takes place inside resistors.

35 A metal cube has a resistance of $4.0\,\Omega$ between opposite faces.

Ten of these cubes are put together to make a cuboid of $1 \times 2 \times 5$ 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?

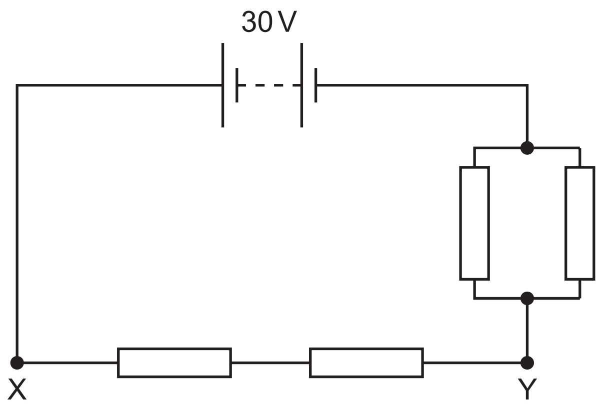
A $1.6\,\Omega$ **B** $2.0\,\Omega$ **C** $10\,\Omega$ **D** $40\,\Omega$

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.

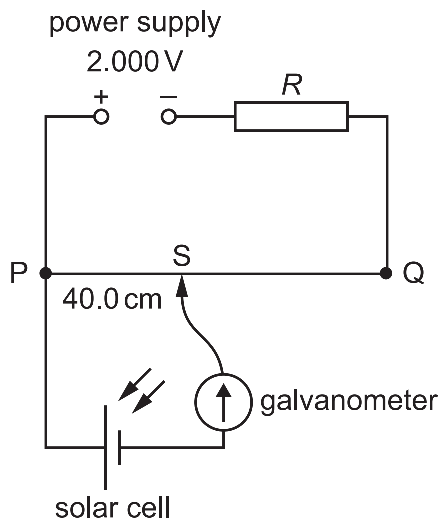


The battery has negligible internal resistance and an e.m.f. of 30 V.

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

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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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2021**

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

IB21 11_9702_11/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho g h$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 What is essential when recording a measurement of a physical quantity?

A the measurement has an SI unit

B the measurement has a unit and a number

C the measurement has a unit given as a base unit

D the measurement is from an analogue scale

2 The mobility μ of electrons travelling through a metal conductor can be calculated using the equation

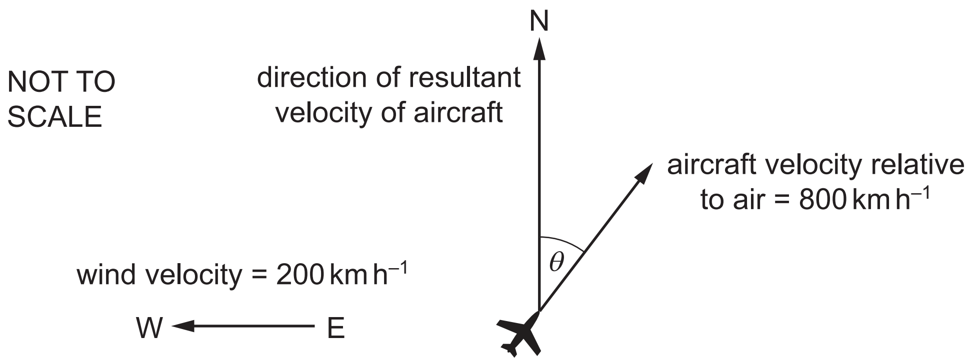
$$\mu = \left(\frac{e}{m}\right)\tau$$

where e is the charge on an electron and m is its mass. The average time between the collisions of an electron with the atoms in the metal is τ.

What are the SI base units of μ?

A $\mathrm{A\,kg^{-1}}$ **B** $\mathrm{A\,s^{2}\,kg^{-1}}$ **C** $\mathrm{A\,s\,kg^{-1}}$ **D** $\mathrm{A\,s^{-2}\,kg^{-1}}$

3 An aircraft heads in a direction at an angle θ east of north with a horizontal velocity relative to the air of $800\,\mathrm{km\,h^{-1}}$. The wind blows with a horizontal velocity of $200\,\mathrm{km\,h^{-1}}$ from east to west, as shown.



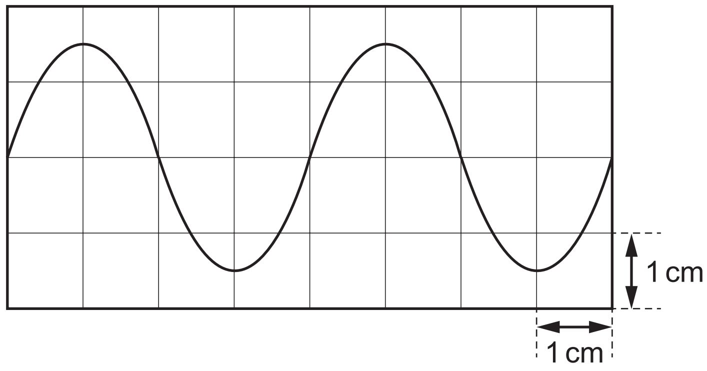
The resultant velocity of the aircraft is in a direction due north.

What is angle θ and what is the magnitude of the resultant velocity?

	θ / °	resultant velocity / $\mathrm{km\,h^{-1}}$
A	14	770
B	14	820
C	76	770
D	76	820

4 A cathode-ray oscilloscope (CRO) is used to display a sound wave of frequency 2000 Hz.

The display of the CRO is shown.



What is the time-base setting on the CRO?

A $125\,\mu s\,cm^{-1}$ **B** $250\,\mu s\,cm^{-1}$ **C** $500\,\mu s\,cm^{-1}$ **D** $1000\,\mu s\,cm^{-1}$

5 Four possible sources of error in a series of measurements are listed.

1 an analogue meter whose scale is read from different angles

2 a meter which always measures 5% too high

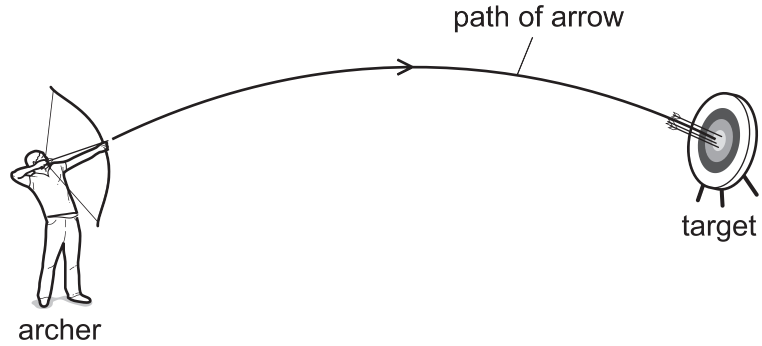
3 a meter with a needle that is not frictionless, so the needle sometimes sticks slightly

4 a meter with a zero error

Which errors are random and which are systematic?

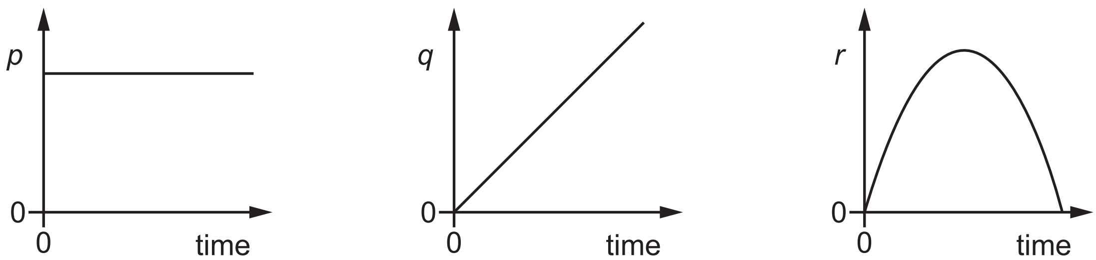
	random error	systematic error
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

6 An archer shoots an arrow at a target. The diagram shows the path of the arrow.



Air resistance is negligible.

The graphs show how three different quantities *p*, *q* and *r* vary with time.



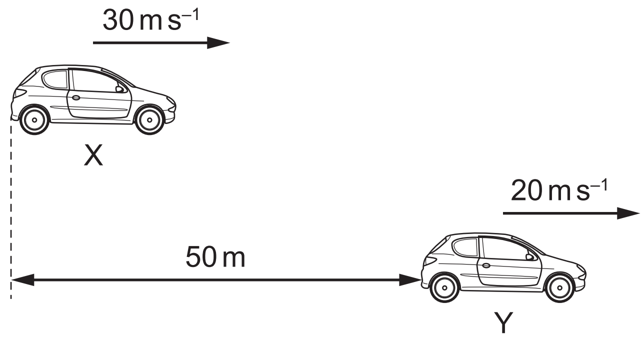
Which quantity could be the horizontal component of displacement and which quantity could be the vertical component of displacement of the arrow?

	horizontal component of displacement	vertical component of displacement
A	*p*	*q*
B	*q*	*r*
C	*r*	*p*
D	*r*	*q*

7 Two cars X and Y are positioned as shown at time $t = 0$.

They are travelling in the same direction.

X is 50 m behind Y and has a constant velocity of $30\,\text{m}\,\text{s}^{-1}$. Y has a constant velocity of $20\,\text{m}\,\text{s}^{-1}$.

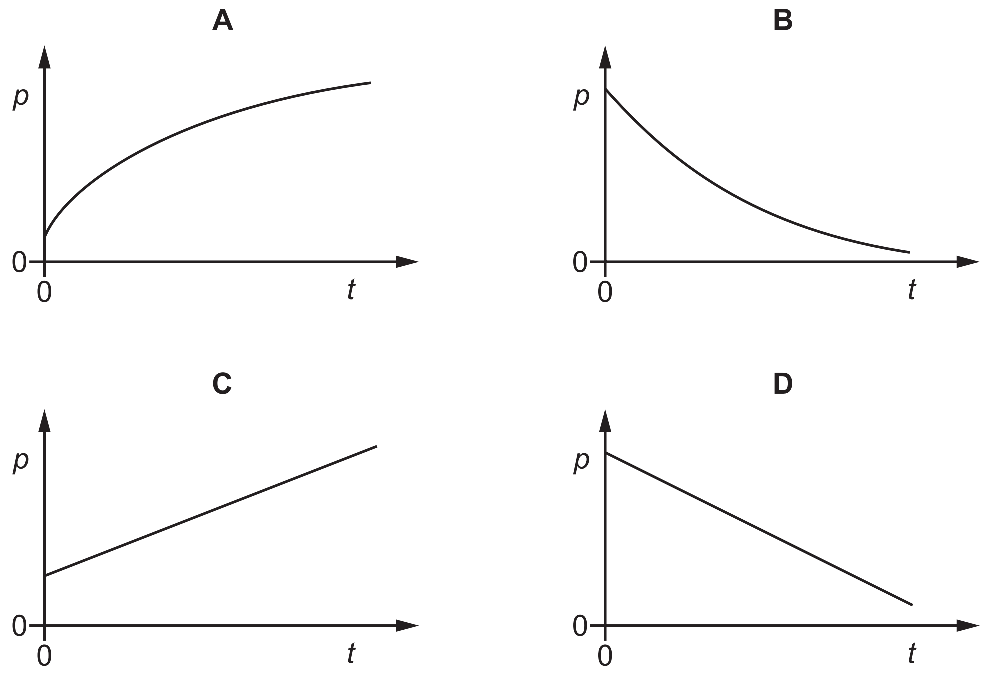


What is the value of t when X is level with Y?

A 1.0 s **B** 1.7 s **C** 2.5 s **D** 5.0 s

8 A constant resultant force acts on an object in the direction of the object's velocity.

Which graph could show the variation with time t of the momentum p of the object?



9 Which statement **must** be true for an object in a gravitational field?

A If the object has mass then the field causes it to accelerate.

B If the object has mass then the field causes it to have weight.

C If the object has weight then the field causes it to accelerate.

D If the object has weight then the field causes it to have mass.

10 A ball of mass 0.16 kg is travelling horizontally at a speed of $20\,\text{m}\,\text{s}^{-1}$.

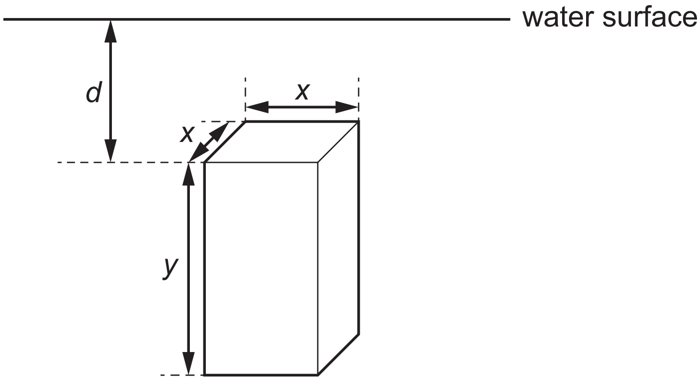
It collides with a wall and rebounds with a speed of $15\,\text{m}\,\text{s}^{-1}$ along its original path. The ball is in contact with the wall for a time of 1.0 ms.

What is the average force exerted by the wall on the ball?

A 800 N **B** 2400 N **C** 3200 N **D** 5600 N

11 A uniform solid block is fully submerged in a tank of water.

The dimensions of the block are *x* and *y*, as shown.



The block is held vertically in the position shown. The density of the block is the same as the density of the water.

If the block is always held at the same depth *d* below the surface of the water, which single change would **increase** the magnitude of the upthrust force on the block?

A decrease the density of the block

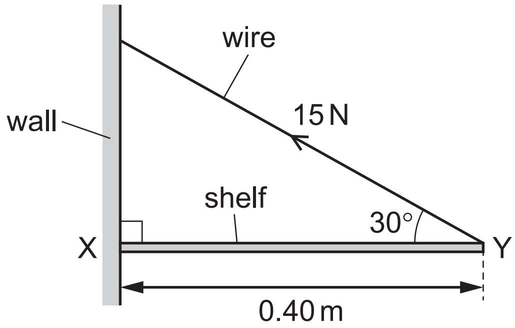
B hold the block horizontally

C increase dimension *y*

D increase the density of the block

12 A shelf XY is 0.40 m long and is attached to a wall at end X.

It is kept horizontal by a wire attached to Y and to the wall, as shown.



The tension force in the wire is 15 N at an angle of 30° to the horizontal.

What is the moment of this force about point X?

A 3.0 N m **B** 5.2 N m **C** 6.9 N m **D** 12 N m

13 A statement about the principle of moments with some words omitted is shown.

> 'For an object in a state of rotational equilibrium, the sum of the clockwise moments about any point is equal to the sum of the anticlockwise moments about ....'

Which words correctly complete the statement?

A any point

B the centre of gravity of the object

C the pivot

D the same point

14 A bird dives to a depth of 1.50 m below the surface of a lake. Atmospheric pressure is 101 kPa. The density of water is 1000 kg m^{-3}.

What is the pressure at this depth?

A 14.7 kPa **B** 86.3 kPa **C** 103 kPa **D** 116 kPa

15 Which statement about energy is **not** correct?

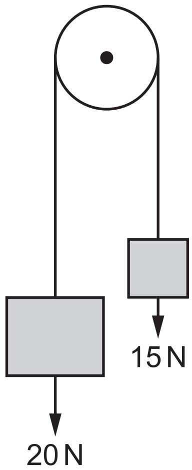
A Energy is never lost but it may be transferred between different forms.

B In an inelastic collision, the total energy is constant.

C The efficiency of a system is the ratio of the useful energy output to the total energy input.

D When a machine does work, friction reduces the total energy.

16 A pulley of radius 0.40 m supports weights of 20 N and 15 N by means of a thin string, as shown.



The weights are moved by slowly rotating the pulley clockwise through an angle of 60°.

What is the increase in the total gravitational potential energy of the weights?

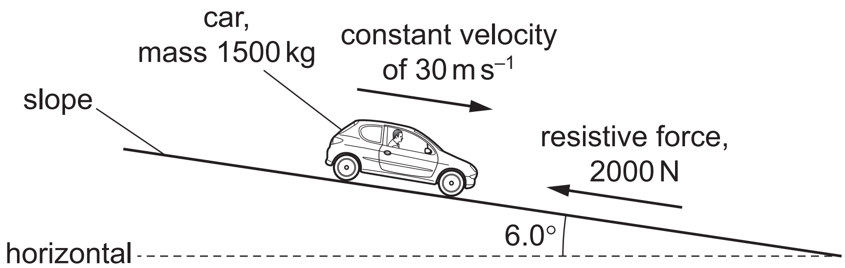
A 0.33 J **B** 2.0 J **C** 2.1 J **D** 15 J

17 A car of mass 1500 kg accelerates from an initial speed of 15 m s^{-1}. This acceleration causes the car to gain 3.0×10^5 J of kinetic energy.

What is the change in the speed of the car?

A 5.4 m s^{-1} **B** 10 m s^{-1} **C** 20 m s^{-1} **D** 25 m s^{-1}

18 A car of mass 1500 kg travels at a constant velocity of 30 m s^{-1} down a slope. The slope is at an angle of 6.0° to the horizontal, as shown.



The magnitude of the total resistive force acting on the car is 2000 N.

What is the power output of the car's engine?

A 14 kW **B** 60 kW **C** 110 kW **D** 380 kW

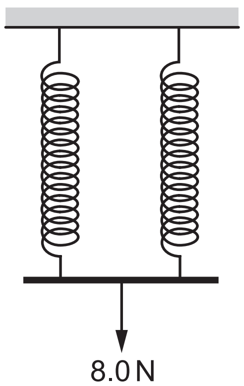
19 A metal wire, of cross-sectional area A and unstretched length l, is subjected to stress σ. As a result it has strain ε.

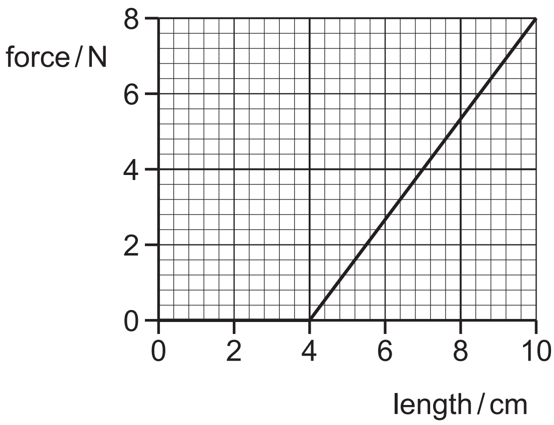
Which expression gives the Young modulus of the metal?

A $\dfrac{\varepsilon}{\sigma}$ **B** $\dfrac{\varepsilon A}{\sigma l}$ **C** $\dfrac{\sigma}{\varepsilon}$ **D** $\dfrac{\sigma l}{\varepsilon A}$

20 Two identical springs are connected in parallel.

A weight of 8.0 N is hung from the combination, as shown.





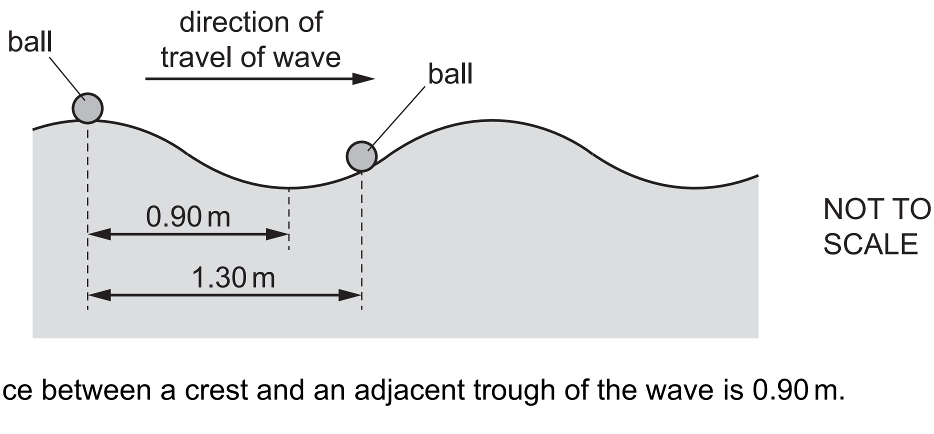
The graph shows the variation with length of the force applied to **one** of the springs.

What is the strain energy in **one** of the springs?

A 0.060 J **B** 0.12 J **C** 0.14 J **D** 0.24 J

21 Two balls float on the surface of the sea. The balls are separated by a distance of 1.30 m.

A wave travels on the surface of the sea so that the balls move vertically up and down.



The distance between a crest and an adjacent trough of the wave is 0.90 m.

What is the phase difference between the two balls?

A 55° **B** 110° **C** 160° **D** 260°

22 Which statement about transverse or longitudinal waves is **not** correct?

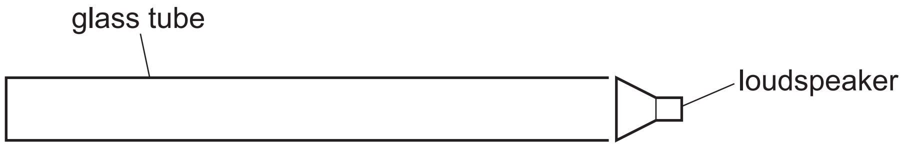
A Longitudinal waves can be used to demonstrate diffraction.

B Longitudinal waves can travel in a vacuum.

C Transverse waves can form stationary waves.

D Transverse waves can transfer energy.

23 A glass tube is closed at one end and has a loudspeaker at the other end.



A stationary wave is formed with a node at the closed end of the tube when the sound has frequency f_0. There are no other nodes.

The frequency of the sound is then slowly increased.

What is the frequency of the sound that produces the next stationary wave?

A $1.25f_0$ **B** $1.50f_0$ **C** $2.00f_0$ **D** $3.00f_0$

24 With which waves can the Doppler effect be observed?

A all waves including sound and light

B light waves only

C sound and light waves only

D sound waves only

25 Which radiation could consist of waves of wavelength 0.5 nm?

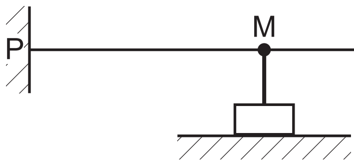
A γ-rays

B ultraviolet

C visible light

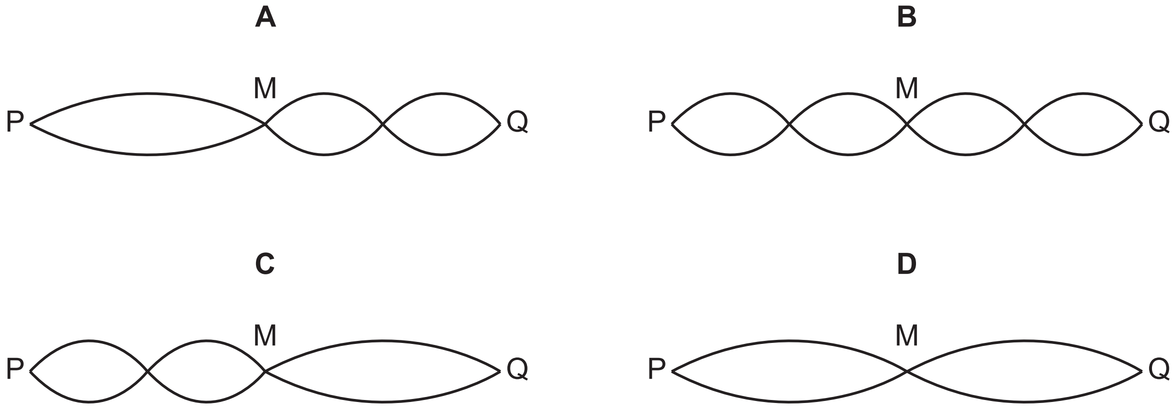
D X-rays

26 A string is fixed between point P and an oscillator M. Another string is fixed between M and point Q. M is midway between P and Q.



The frequency of the oscillator is adjusted until a stationary wave is formed on both strings. The speed of the wave between P and M is twice the speed of the wave between M and Q.

Which diagram could represent the stationary wave pattern?



27 A water wave in a ripple tank is diffracted as it passes through a gap in a barrier.

Which two factors affect the angle of diffraction of the wave?

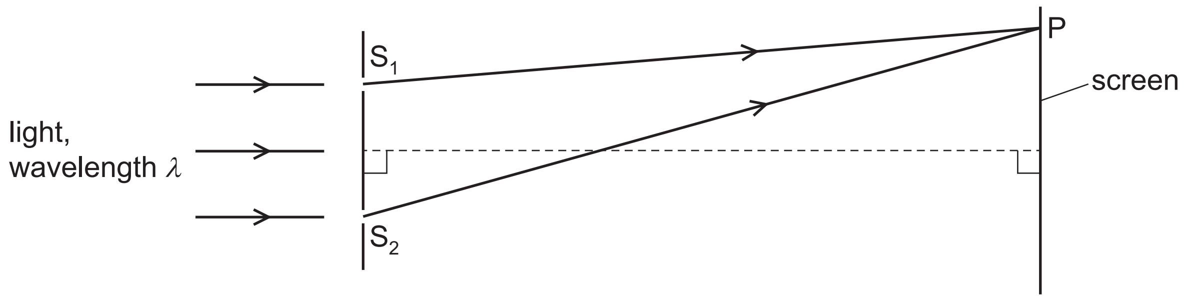
A the amplitude and frequency of the incident wave

B the amplitude of the incident wave and the width of the gap

C the wavelength and amplitude of the incident wave

D the wavelength of the incident wave and the width of the gap

28 Light of wavelength λ is incident normally on two narrow slits S_1 and S_2, a small distance apart. Bright and dark fringes are observed on a screen a long distance away from the slits.



The *n*th **dark** fringe from the central bright fringe is observed at point P on the screen.

Which equation is correct for all positive values of *n*?

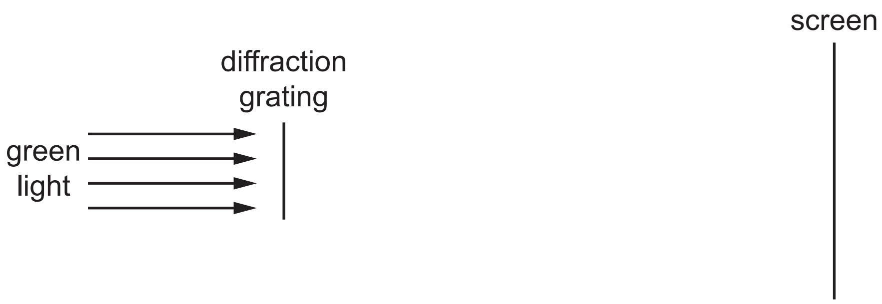
A $S_2P - S_1P = \dfrac{n\lambda}{2}$

B $S_2P - S_1P = n\lambda$

C $S_2P - S_1P = (n - \frac{1}{2})\lambda$

D $S_2P - S_1P = (n + \frac{1}{2})\lambda$

29 Green light is incident normally on a diffraction grating and forms a diffraction pattern on a distant screen.



Which change, on its own, would **decrease** the separation of the diffraction maxima on the screen?

A Increase the distance between the screen and the diffraction grating.

B Replace the diffraction grating with a grating that has a smaller separation between the slits.

C Replace the diffraction grating with a grating that has fewer slits per unit length.

D Replace the green light with red light.

30 What is meant by electric field strength?

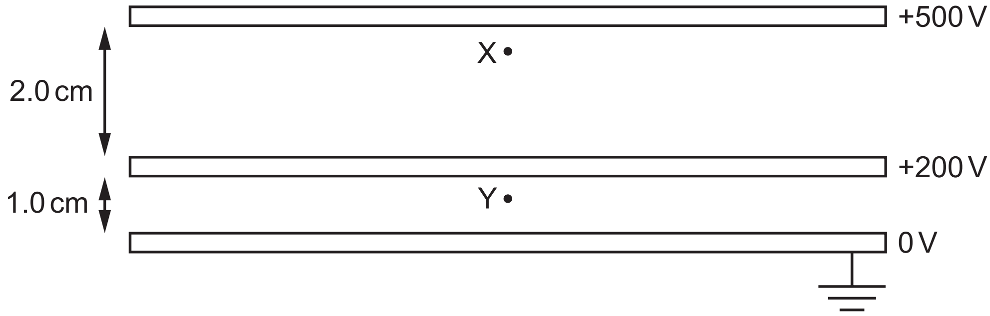
A force per unit charge acting on a small mass

B force per unit charge acting on a small positive charge

C force per unit mass acting on a small mass

D force per unit mass acting on a small positive charge

31 Three parallel metal plates of the same area are fixed with a separation of 2.0 cm between the top plate and the middle plate, and 1.0 cm between the middle plate and the bottom plate. The top plate is held at a potential of +500 V, the middle plate at +200 V and the bottom plate is earthed, as shown.



What is the value of the ratio $\dfrac{\text{magnitude of force on an electron at X}}{\text{magnitude of force on an electron at Y}}$?

A 0.75 **B** 1.00 **C** 1.25 **D** 1.50

32 The current I in a wire is given by the equation

$$I = nAvq$$

where n is the number density of the free electrons, A is the cross-sectional area of the wire, v is the average drift velocity of the free electrons and q is the charge of an electron.

Which relationship is **not** used in the derivation of this equation?

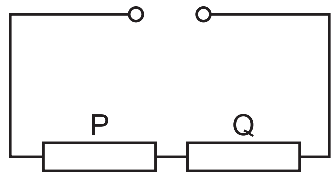
A charge = current × time

B distance = speed × time

C number = number density × area

D volume = length × area

33 A circuit contains two resistors, P and Q, and a power supply of negligible internal resistance, as shown.



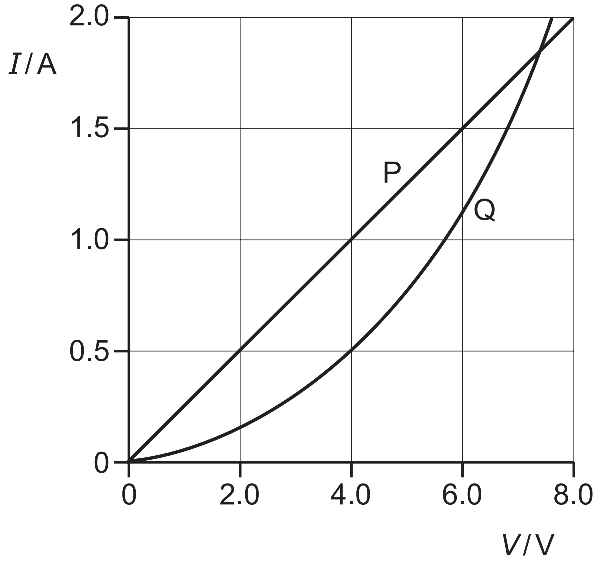
The current in resistor P is 2.0 A and the power dissipated by resistor P is 18 W.

Resistor Q dissipates 240 J of energy when a charge of 40 C passes through it.

What is the electromotive force (e.m.f.) of the power supply?

A 3.0 V **B** 6.0 V **C** 9.0 V **D** 15 V

34 The *I*–*V* characteristics of two electrical components P and Q are shown.



Which statement is correct?

A For a current of 0.5 A, the power dissipated in Q is double that in P.

B For a current of 1.9 A, the resistance of Q is approximately half that of P.

C The resistance of Q increases as the current in it increases.

D P is a fixed resistor and Q is a filament lamp.

35 Two copper wires S and T, of equal length, are connected in parallel. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

A potential difference is applied across the ends of this parallel arrangement.

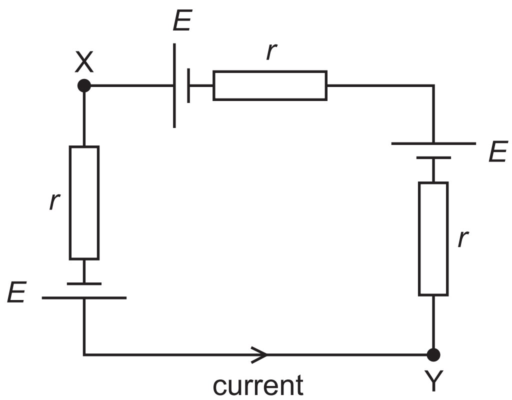
What is the value of the ratio $\frac{\text{current in S}}{\text{current in T}}$?

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

36 What is the circuit symbol for an oscilloscope?

A **B** **C** **D**

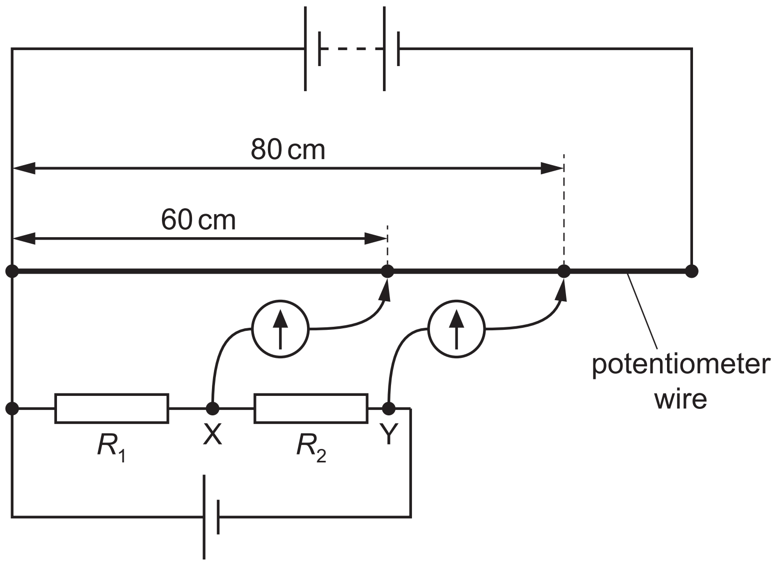
37 Three identical cells, each of electromotive force (e.m.f.) E and internal resistance r, are connected as shown.



What is the potential difference between points X and Y?

A 0 **B** E **C** $2E$ **D** $3E$

38 Potential differences across two resistors of resistances R_1 and R_2 are compared using a potentiometer wire (uniform resistance wire) in the electrical circuit shown.



One terminal of a galvanometer is connected to point X. The galvanometer reads zero when its other terminal is connected to a point that is a distance of 60 cm from one end of the potentiometer wire.

One terminal of a second galvanometer is connected to point Y. This galvanometer reads zero when its other terminal is connected to a point that is a distance of 80 cm from the same end of the potentiometer wire.

What is the ratio $\dfrac{R_2}{R_1}$?

A $\dfrac{1}{3}$ **B** $\dfrac{3}{4}$ **C** $\dfrac{3}{1}$ **D** $\dfrac{4}{3}$

39 A uranium-238 nucleus, ${}^{238}_{92}U$, undergoes a series of nuclear decays to form uranium-234, ${}^{234}_{92}U$.

Which series of decays could give this result?

A emission of four β^- particles

B emission of four γ-rays

C emission of one α-particle and two β^- particles

D emission of two α-particles and eight β^- particles

40 Which combination of up (u) and down (d) quarks forms a proton?

A u u u **B** u u d **C** u d d **D** d d d

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2021**

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.
- Any rough working should be done on this question paper.

This document has **24** pages. Any blank pages are indicated.

IB21 11_9702_12/3RP

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^2 - x^2)}$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 Which row shows what all physical quantities must have?

	magnitude	direction	unit
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✓
D	✗	✗	✓

2 What is an alternative way of expressing an energy of 43 dJ?

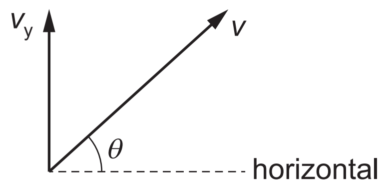
A 4.3×10^{3} mJ

B 4.3×10^{3} MJ

C 4.3×10^{-3} mJ

D 4.3×10^{-3} MJ

3 A tennis ball is hit so that it leaves the racket with velocity v at an angle θ to the horizontal.

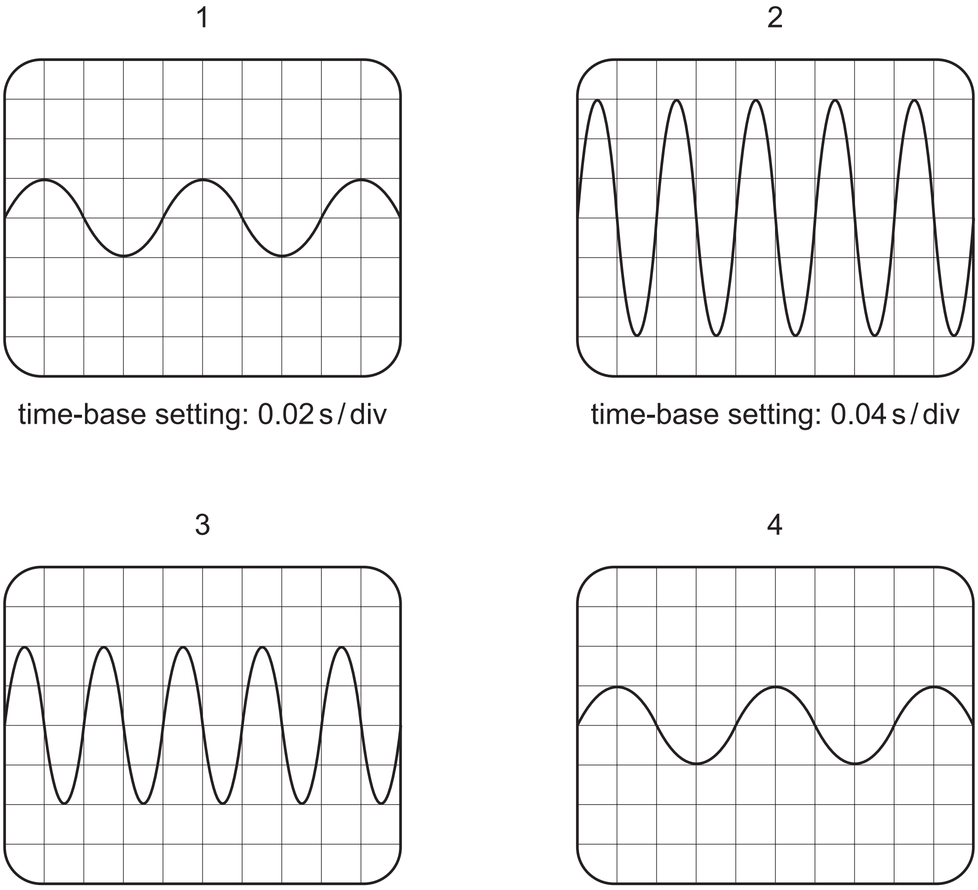


The vertical component of the velocity is v_y.

What is the magnitude of the horizontal component of v?

A $v\sin\theta$ **B** $v_y\cos\theta$ **C** $v_y\sin\theta$ **D** $(v^2 - v_y^2)^{\frac{1}{2}}$

4 Four cathode-ray oscilloscope (CRO) screens each display a waveform. The screen and the time-base setting of each CRO is shown.



time-base setting: 0.02 s / div

time-base setting: 0.04 s / div

time-base setting: 0.01 s / div

time-base setting: 0.08 s / div

Which screens show waveforms of the same frequency?

A 1 and 2 **B** 1 and 3 **C** 1 and 4 **D** 2 and 3

5 A student measures the time T for one complete oscillation of a pendulum of length l.

Her results are shown in the table.

l / m	T / s
0.420 ± 0.001	1.3 ± 0.1

She uses the formula

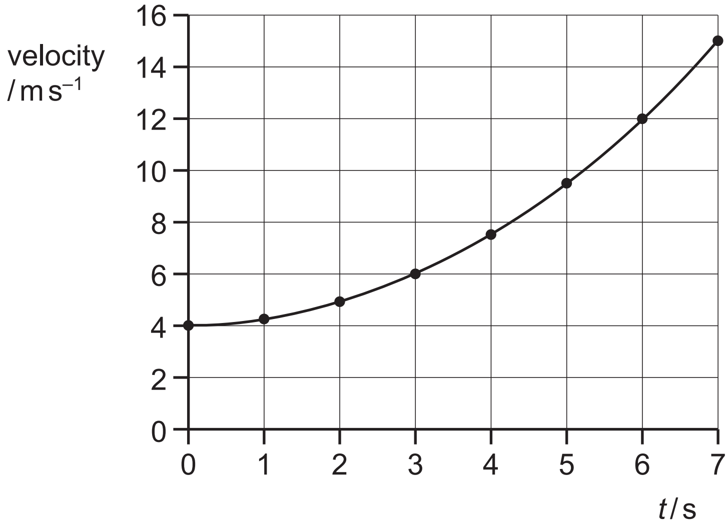
$$T = 2\pi\sqrt{\frac{l}{g}}$$

to calculate the acceleration of free fall g.

What is the best estimate of the percentage uncertainty in the value of g?

A 0.02% **B** 4% **C** 8% **D** 16%

6 The graph shows the variation with time t of the velocity of a vehicle moving in a straight line.



The vehicle, moving at $4.0\,\mathrm{m\,s^{-1}}$, begins to accelerate at time $t = 0$.

What is the vehicle's acceleration at time $t = 3.0\,\mathrm{s}$?

A $0.67\,\mathrm{m\,s^{-2}}$ **B** $1.0\,\mathrm{m\,s^{-2}}$ **C** $1.3\,\mathrm{m\,s^{-2}}$ **D** $2.0\,\mathrm{m\,s^{-2}}$

7 A stone is projected vertically upwards from the ground at an initial speed of $15\,\mathrm{m\,s^{-1}}$. Air resistance is negligible.

What is the maximum height reached by the stone?

A 0.76 m **B** 11 m **C** 23 m **D** 110 m

8 What is meant by the mass of an object?

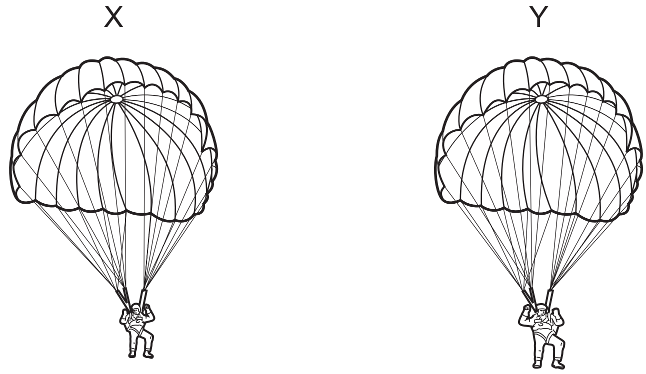
A the property of the object that resists a change in motion

B the pull of the Earth on the object

C the total number of atoms in the object

D the weight of the object

9 The diagram shows two parachutists, X and Y, moving vertically downwards.



The total mass of parachutist Y and his parachute is twice the total mass of parachutist X and his parachute. At this moment, the air resistance on parachute Y is twice the air resistance on parachute X. Neither parachutist has reached his constant (terminal) velocity.

Which statement describes the acceleration of Y compared with the acceleration of X?

A The acceleration of Y is half the acceleration of X.

B The acceleration of Y is the same as the acceleration of X.

C The acceleration of Y is more than the acceleration of X, but less than twice the value.

D The acceleration of Y is twice the acceleration of X.

10 The table shows four different collisions between two blocks, each of mass 0.50 kg.

Which collision is perfectly elastic?

	before collision		after collision	
A	$4.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg	$0.0\,\mathrm{m\,s^{-1}}$ 0.50 kg	$2.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg 0.50 kg	
B	$2.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg	$\leftarrow 2.0\,\mathrm{m\,s^{-1}}$ 0.50 kg	$0.0\,\mathrm{m\,s^{-1}}$ 0.50 kg 0.50 kg	
C	$2.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg	$\leftarrow 1.0\,\mathrm{m\,s^{-1}}$ 0.50 kg	$\leftarrow 2.0\,\mathrm{m\,s^{-1}}$ 0.50 kg	$3.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg
D	$4.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg	$1.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg	$1.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg	$4.0\,\mathrm{m\,s^{-1}} \rightarrow$ 0.50 kg

11 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.

What is the upthrust on the block?

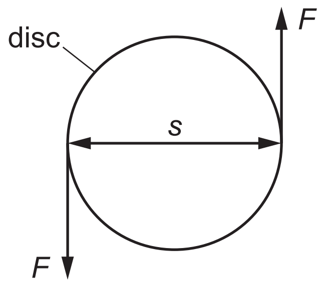
A $(p_b - p_t)$

B $(p_b - p_t)A$

C $(p_b - p_t)A - W$

D $(p_b - p_t)A + W$

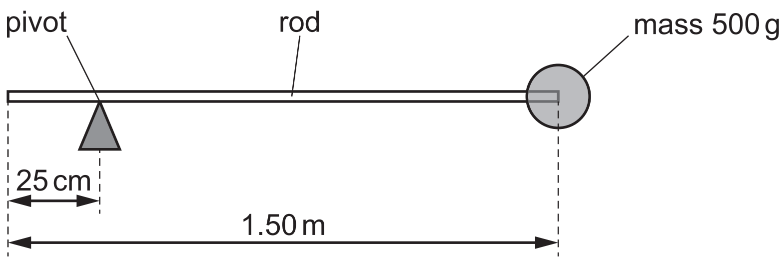
12 Two forces, each of magnitude F, act on a disc of diameter s, as shown.



What is the torque exerted on the disc?

A zero **B** $\frac{1}{2}Fs$ **C** Fs **D** $2Fs$

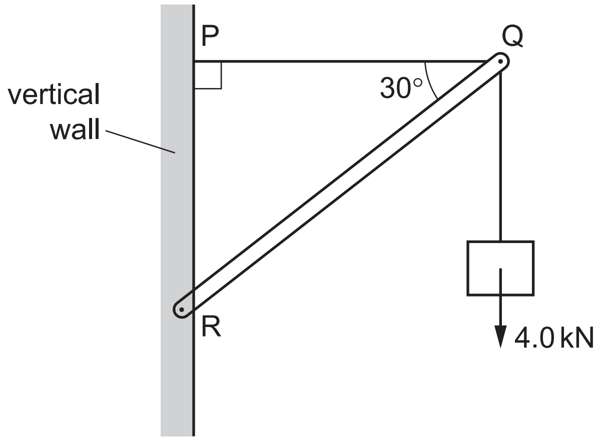
13 A mass of 500 g is attached at one end of a rod of length 1.50 m. The rod is pivoted at a distance of 25 cm from the other end. The rod is horizontal.



What is the moment about the pivot due to the mass?

A 0.63 N m **B** 1.2 N m **C** 6.1 N m **D** 7.4 N m

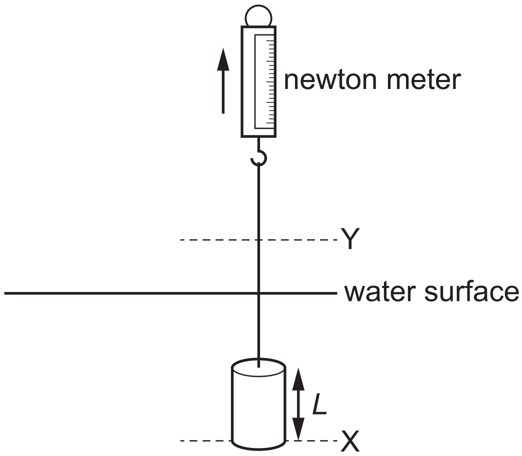
14 A beam QR is held in position by a wire PQ. The structure is used to form a crane supporting a stationary load of 4.0 kN, as shown.



What is the force exerted by the beam QR on point Q?

A 4.0 kN **B** 4.6 kN **C** 6.9 kN **D** 8.0 kN

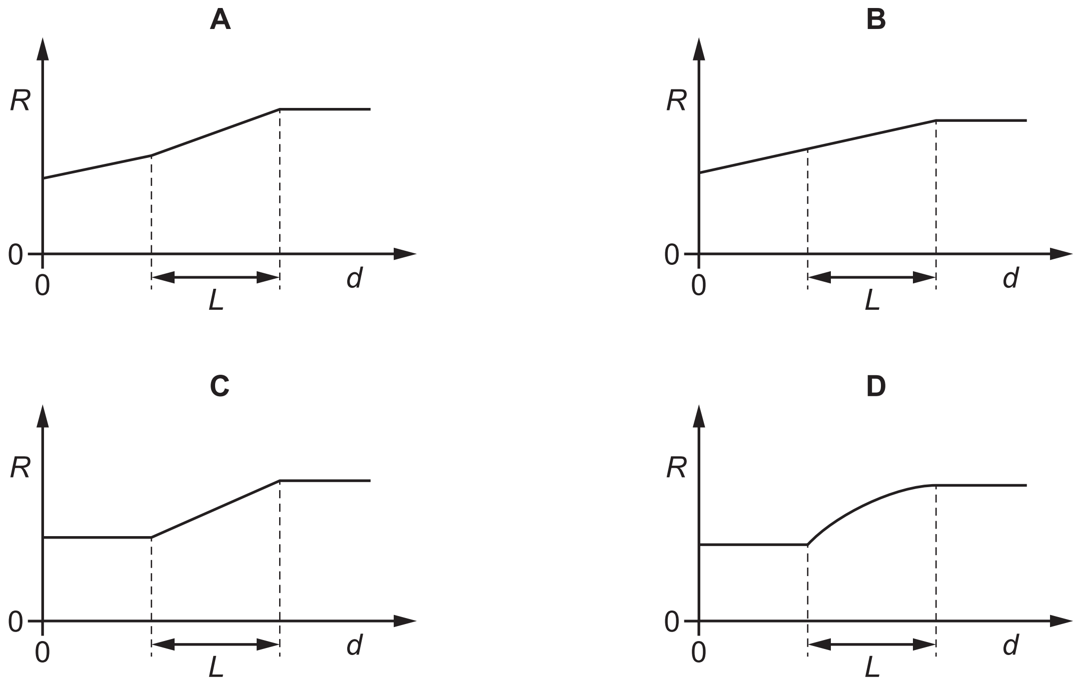
15 A metal cylinder, totally immersed in water, is hung from a newton meter.



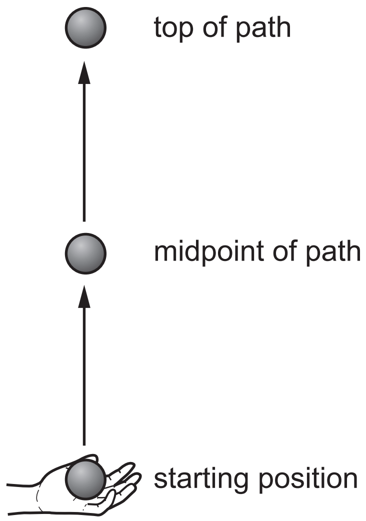
The cylinder, of height L, is slowly raised vertically by lifting the newton meter.

As the base of the cylinder moves from line X in the water to line Y above the surface of the water, the reading R on the newton meter is recorded. The velocity of the cylinder is constant.

Which graph best shows the variation of R with the distance d of the base of the cylinder from line X?



16 A ball is thrown vertically upwards into the air. It rises to the top of its path before beginning to fall vertically downwards.



Assume that the gravitational potential energy of the ball is zero at its starting position.

Which statement about the ball is **not** correct?

A As it rises, its kinetic energy is transferred to gravitational potential energy.

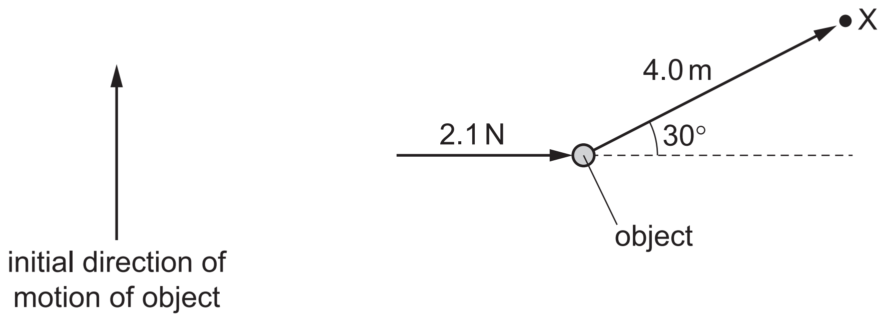
B At the midpoint of its path, its gravitational potential energy is equal to its initial kinetic energy.

C At the top of its path, its kinetic energy is zero.

D At the top of its path, its total energy is less than its initial total energy.

17 An object slides with constant velocity across a horizontal sheet of ice. Friction is negligible.

A constant horizontal force of 2.1 N is then applied to the object as shown.



A short time after applying the force, the object reaches point X at a displacement of 4.0 m from its position when the force was first applied.

What is the work done by the force on the object as it travels to point X?

A 4.2 J **B** 4.8 J **C** 7.3 J **D** 8.4 J

18 The energy conversions inside a power station burning fossil fuel can be simplified as shown.

chemical energy $W \rightarrow$ thermal energy $X \rightarrow$ electrical energy Y

Which expression gives the efficiency of the power station?

A $\dfrac{Y}{W}$ **B** $\dfrac{Y}{(W+X)}$ **C** $\dfrac{Y}{X}$ **D** $\dfrac{Y}{(W+X+Y)}$

19 Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.

Which statement is correct?

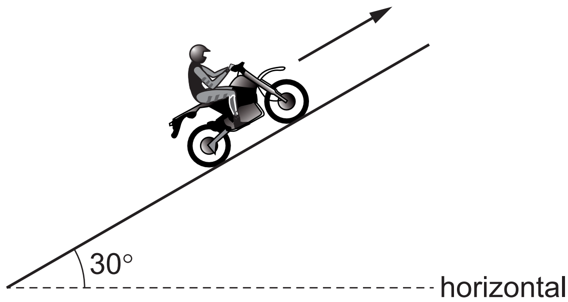
A Car X has half the kinetic energy of car Y.

B Car X has one quarter of the kinetic energy of car Y.

C Car X has twice the kinetic energy of car Y.

D The two cars have the same kinetic energy.

20 The total weight of a motorbike and rider is 1800 N. The motorbike travels in a straight line at constant speed up a hill at an angle of 30° to the horizontal.

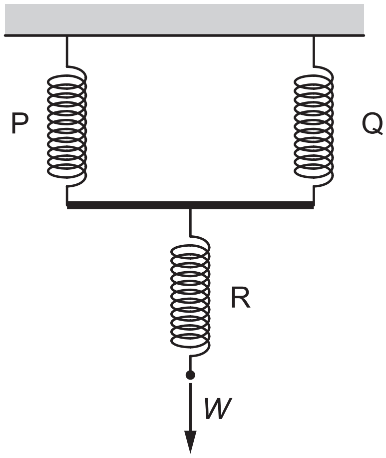


The useful output power of the motorbike is 36 000 W. The total resistive force due to air resistance and friction on the motorbike and rider is 2400 N.

What is the speed of the motorbike?

A $8.6\,m\,s^{-1}$ **B** $11\,m\,s^{-1}$ **C** $15\,m\,s^{-1}$ **D** $24\,m\,s^{-1}$

21 Three springs are arranged vertically as shown.

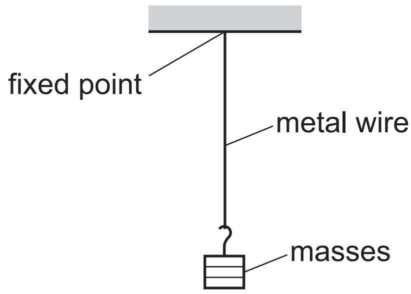


Springs P and Q are identical and each has spring constant k. Spring R has spring constant $3k$.

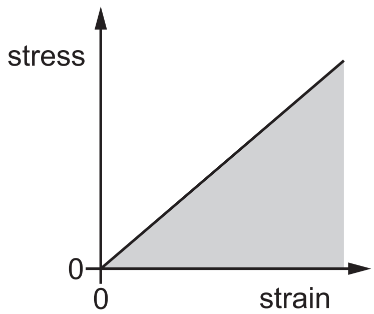
What is the increase in the overall length of the arrangement when a force W is applied as shown?

A $\frac{5}{6}\frac{W}{k}$ **B** $\frac{4}{3}\frac{W}{k}$ **C** $\frac{7}{2}kW$ **D** $4kW$

22 A length of metal wire is attached to a fixed point and hangs vertically. Masses are then suspended from the wire. Assume that the cross-sectional area of the wire remains constant.



A stress–strain graph for the wire is plotted, as shown.



What is represented by the shaded area under the graph?

A strain energy in the wire

B $\dfrac{\text{strain energy in the wire}}{\text{cross-sectional area of the wire}}$

C $\dfrac{\text{strain energy in the wire}}{\text{original length of the wire}}$

D $\dfrac{\text{strain energy in the wire}}{\text{original volume of the wire}}$

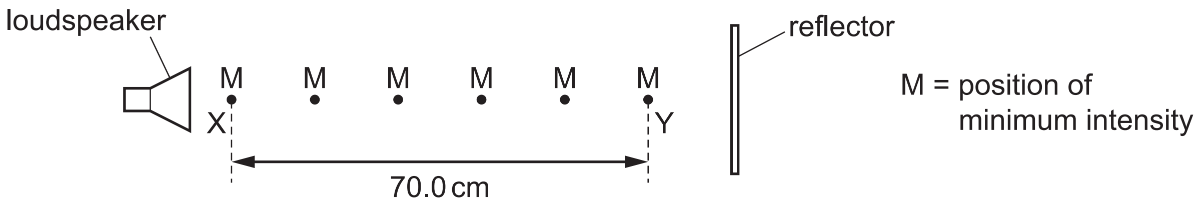
23 The table contains descriptions and examples of waves.

Which row is correct?

	description of wave	example
A	oscillations are parallel to the direction of energy transfer	gamma-rays
B	oscillations are parallel to the direction of energy transfer	ultraviolet waves
C	oscillations are perpendicular to the direction of energy transfer	sound waves
D	oscillations are perpendicular to the direction of energy transfer	X-rays

24 A sound wave from a loudspeaker is reflected back along its original path by a reflector.

A microphone is initially at point X where the sound intensity is a minimum, as shown.



The microphone is moved towards the reflector and passes through four more intensity minima until reaching a fifth minimum at point Y. The distance XY is 70.0 cm.

What is the wavelength of the sound?

A 11.7 cm **B** 14.0 cm **C** 23.3 cm **D** 28.0 cm

25 A train travels in a straight line at a constant speed of $30\,\text{m}\,\text{s}^{-1}$. The train's horn continuously emits sound of frequency 2400 Hz.

A stationary observer stands next to the train track. The train approaches the stationary observer, passes him and then moves away.

The speed of sound is $340\,\text{m}\,\text{s}^{-1}$.

What is the maximum difference in the frequencies of the sound heard by the stationary observer?

A 190 Hz **B** 230 Hz **C** 430 Hz **D** 460 Hz

26 Electromagnetic waves of frequency 30 THz are in a vacuum.

In which region of the electromagnetic spectrum are the waves?

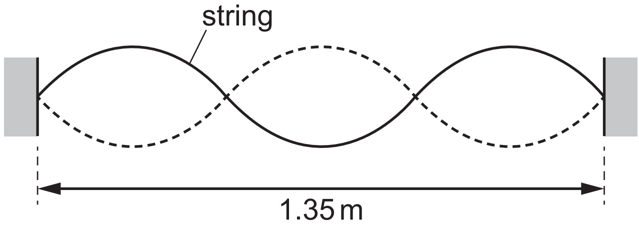
A infrared

B microwave

C ultraviolet

D visible light

27 A stationary wave is produced on a string that is stretched between two fixed points that are a distance of 1.35 m apart, as shown.

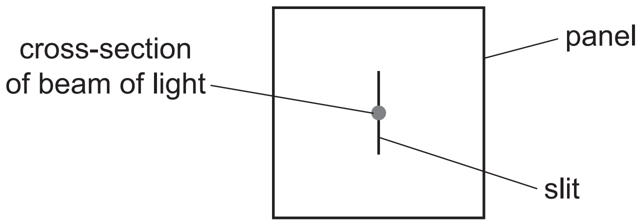


The speed of the waves on the string is 450 m s^{-1}.

What is the frequency of oscillation of the stationary wave?

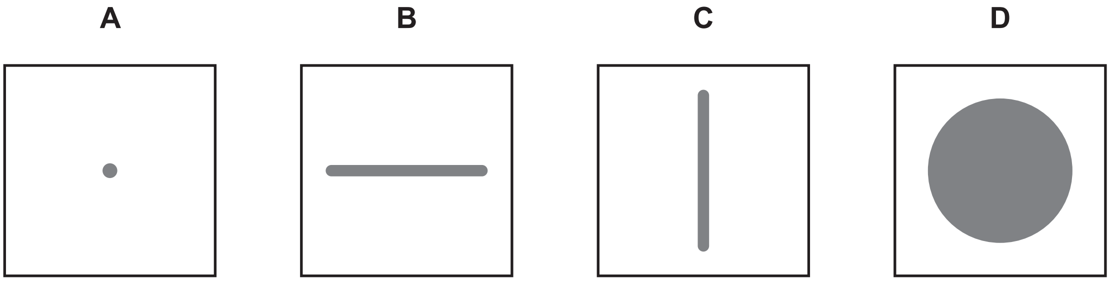
A 333 Hz **B** 405 Hz **C** 500 Hz **D** 1000 Hz

28 A beam of laser light is directed towards a narrow slit.



After emerging from the other side of the slit, the diffracted light then falls on a screen.

What is the pattern of light seen on the screen?



29 Two waves, each with a constant amplitude, interfere and produce an interference pattern. The pattern has minima at fixed points where the displacement is zero at all times.

Which statement describes the two waves?

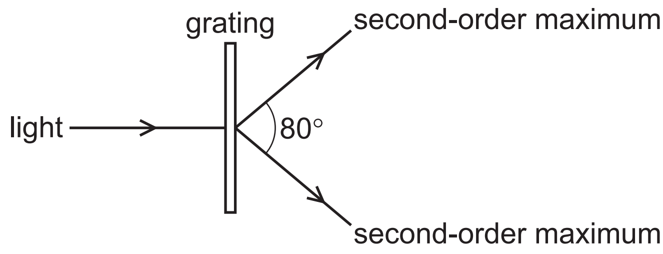
A They must be coherent and of the same amplitude.

B They must be coherent but not necessarily of the same amplitude.

C They must be of the same amplitude but not necessarily coherent.

D They must not be coherent or of the same amplitude.

30 Light of wavelength 5.5×10^{-7} m is incident normally on a diffraction grating.



The angle between the second-order diffraction maxima is 80°, as shown.

What is the number of lines per metre of the diffraction grating?

A 5.8×10^{5} lines per metre

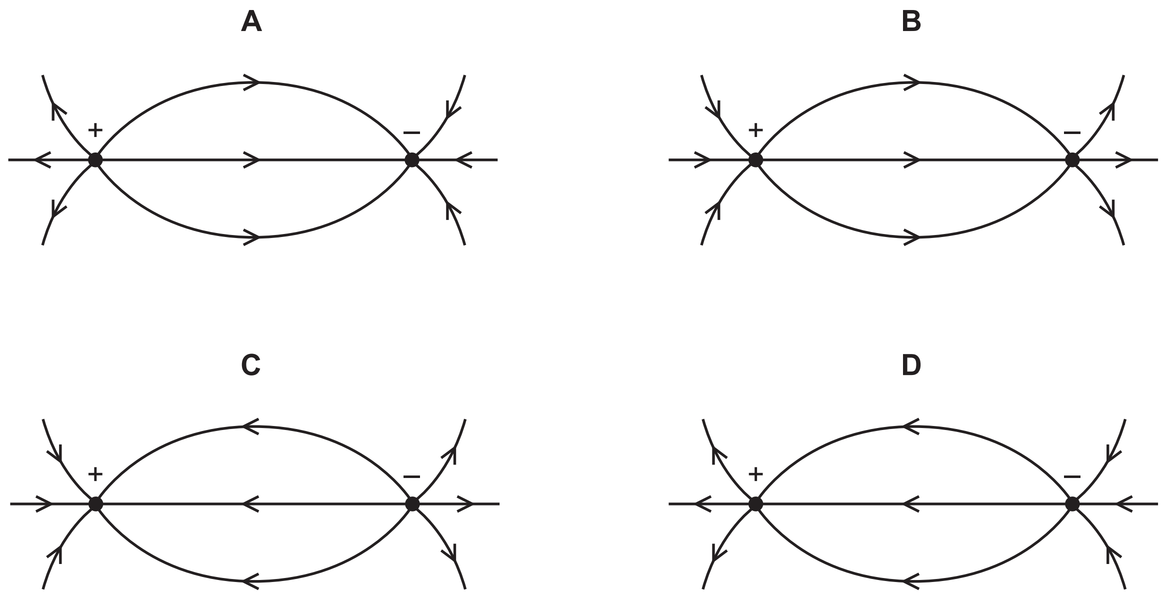
B 9.0×10^{5} lines per metre

C 1.2×10^{6} lines per metre

D 2.3×10^{6} lines per metre

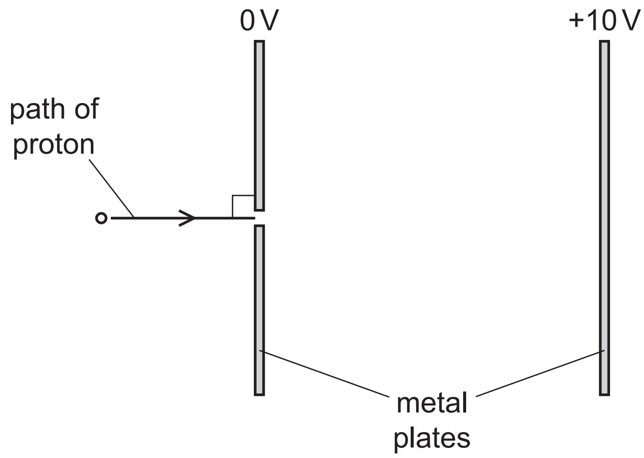
31 Four diagrams representing the electric field between two oppositely charged point charges are shown.

Which diagram correctly shows the electric field lines?



32 A proton enters the uniform electric field between two parallel vertical metal plates in a vacuum.

One plate is at a potential of 0 V and the other plate is at a potential of +10 V, as shown.



What is the initial change in the motion of the proton caused by the electric field, immediately after the proton enters the field?

A It begins to move downwards.

B It begins to move upwards.

C Its speed decreases.

D Its speed increases.

33 What is a description of the coulomb?

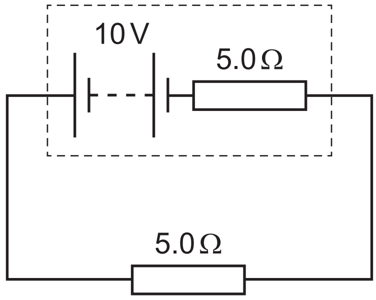
A the electric charge of one electron

B the electric charge transferred by a current of one ampere in one second

C the kinetic energy gained by an electron accelerated through a potential difference of one volt

D the kinetic energy of an electron moving at a speed of one metre per second

34 A battery of electromotive force (e.m.f.) 10 V and internal resistance 5.0 Ω is connected to a 5.0 Ω load resistor.



Which change occurs when the 5.0 Ω load resistor is replaced with a 50 Ω load resistor?

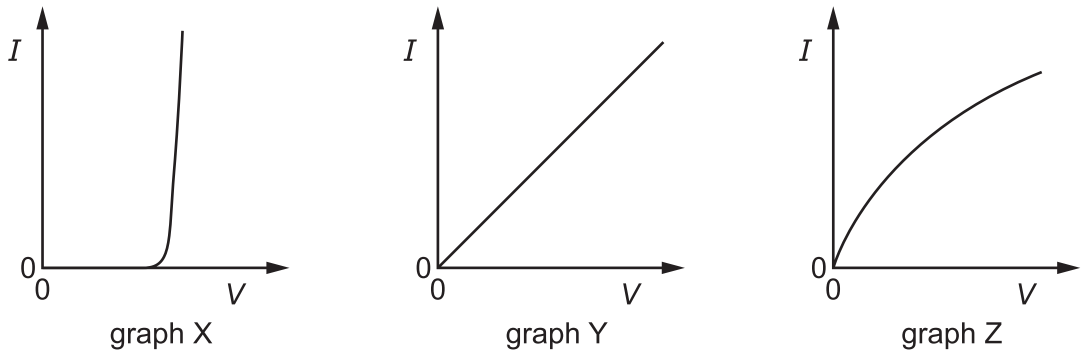
A The current in the circuit increases.

B The potential difference across the load resistor increases.

C The power dissipated in the internal resistance of the battery increases.

D The total power dissipated in the circuit increases.

35 The graphs show the variation with potential difference V of the current I for three circuit components.



The components are a metal wire at constant temperature, a semiconductor diode and a filament lamp.

Which row correctly identifies these graphs?

	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

36 The electromotive force (e.m.f.) of a cell is 6.0 V. It has negligible internal resistance and is connected across a resistor. The potential difference (p.d.) across the resistor is also 6.0 V.

The e.m.f. and the p.d. have the same numerical value but represent different processes.

Which statement about the different processes is correct?

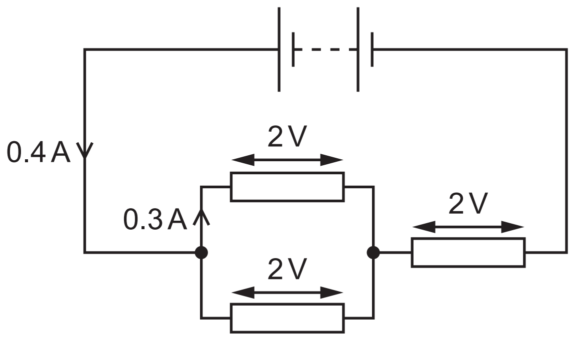
A The e.m.f. is the energy transferred from chemical energy to electrical energy in the cell and the p.d. is the energy transferred from electrical energy to thermal energy in the resistor.

B The p.d. is the energy transferred from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred from electrical energy to thermal energy in the resistor.

C The e.m.f. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the p.d. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.

D The p.d. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.

37 A battery of negligible internal resistance is connected to three resistors, as shown.



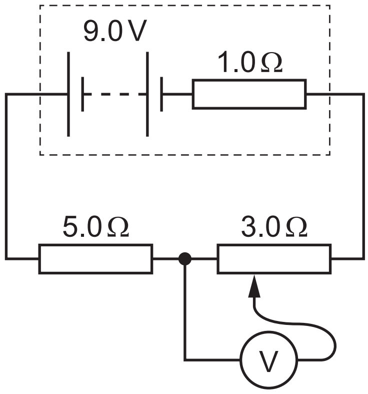
The potential difference across each resistor is 2 V.

The current from the battery is 0.4 A and the current through one of the resistors connected in parallel is 0.3 A.

What is the current through the other resistor connected in parallel and what is the electromotive force (e.m.f.) of the battery?

	current / A	e.m.f. / V
A	0.1	4
B	0.3	4
C	0.1	6
D	0.3	6

38 A battery of electromotive force (e.m.f.) 9.0 V and internal resistance 1.0 Ω is connected to a fixed resistor of resistance 5.0 Ω and a potentiometer of maximum resistance 3.0 Ω, as shown.



The sliding contact of the potentiometer is moved over its full range of movement.

What is the maximum value of the potential difference that is measured by the voltmeter?

A 3.0 V **B** 3.4 V **C** 4.5 V **D** 5.4 V

39 An unstable nucleus decays by emitting a β^+ particle.

Which statement is correct?

A An antineutrino is also emitted.

B A neutron changes into a proton.

C Mass–energy is conserved.

D The nucleon number is not conserved.

40 Which statement is **not** correct?

A An antineutrino is a fundamental particle.

B An electron is made up of a quark and an antiquark.

C A neutrino is a lepton.

D A neutron is composed of three quarks.

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Cambridge International AS & A Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2021**

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

IB21 11_9702_13/3RP

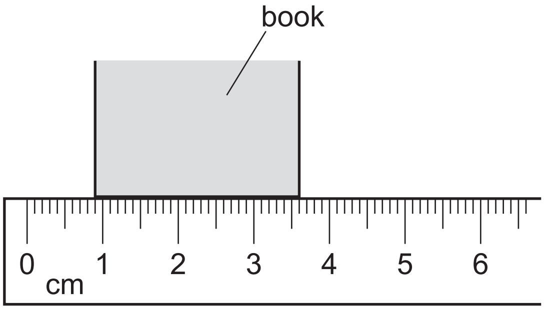
Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
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	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

1 A paperback book contains 210 sheets of paper (pages). Its thickness is measured with a ruler, as shown.



What is the average thickness of one sheet of the paper in the book?

A 0.013 mm **B** 0.017 mm **C** 0.13 mm **D** 0.17 mm

2 What is the unit of resistance when expressed in SI base units?

A $kg^{-1}\,m^{-2}\,s\,A^2$

B $kg^{-1}\,m^{-2}\,s^3\,A^2$

C $kg\,m^2\,s^{-1}\,A^{-2}$

D $kg\,m^2\,s^{-3}\,A^{-2}$

3 Which list consists only of scalar quantities?

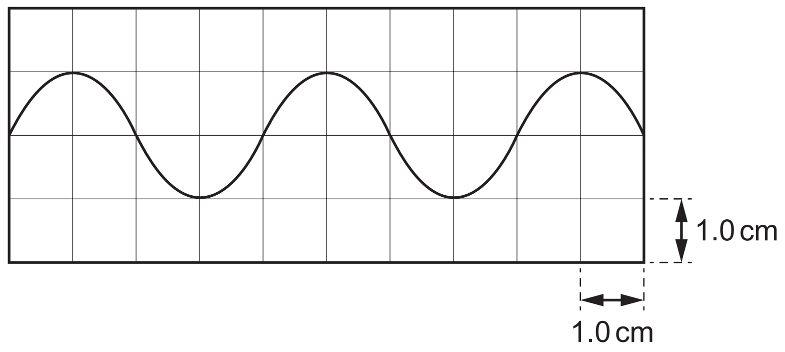
A acceleration, displacement, force, weight

B density, energy, frequency, velocity

C distance, pressure, temperature, time

D momentum, power, volume, wavelength

4 The output of a signal generator is connected to a cathode-ray oscilloscope (CRO). A trace is shown on the screen.



The time-base of the CRO is set at 2.00 ms cm^{-1}.

What is the frequency of the signal?

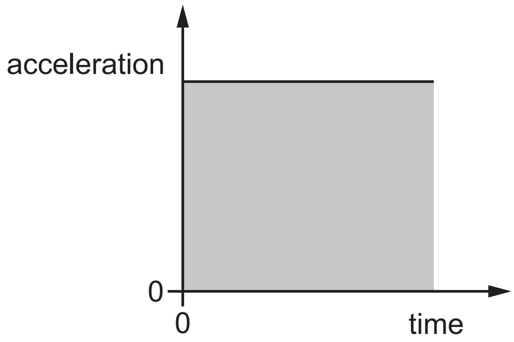
A 50 Hz **B** 125 Hz **C** 250 Hz **D** 500 Hz

5 After measuring the width of a shelf to be 305 mm, it is found that the graduations on the ruler used are 1.0% further apart than they should be.

Which type of measurement error is this and what is the true width of the shelf?

	type of error	true width / mm
A	random	302
B	random	308
C	systematic	302
D	systematic	308

6 The graph shows the variation with time of the acceleration of a car.



What **must** the shaded area under the graph represent?

A the average velocity of the car

B the change in velocity of the car

C the final velocity of the car

D the initial velocity of the car

7 A stone is thrown horizontally off a cliff and then lands in the sea. Air resistance is negligible.

Which statement about the stone's motion is **not** correct?

A The final displacement of the stone depends upon its initial horizontal velocity.

B The stone travels with a constant horizontal component of velocity until it hits the water.

C The stone travels with an increasing vertical component of velocity.

D The time taken for the stone to hit the surface of the water depends on its initial horizontal velocity.

8 Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of $20\,\mathrm{m\,s^{-1}}$.

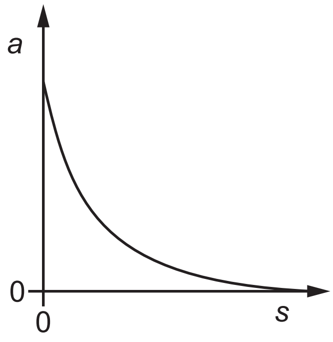
What is the minimum force required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 110 000 N

9 A skydiver leaves a stationary balloon and falls vertically through a long distance.

Which graph best represents the variation of the acceleration a of the skydiver with the distance s travelled as she falls through the air?

A



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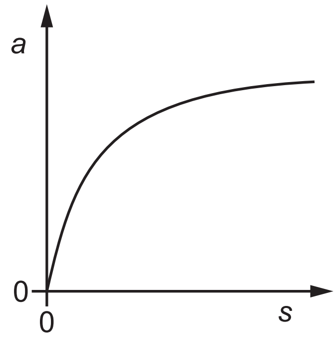

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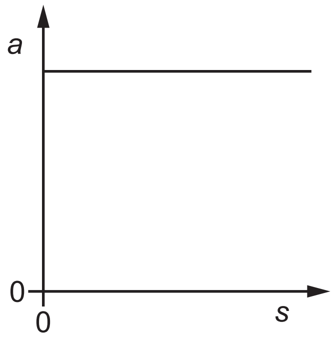
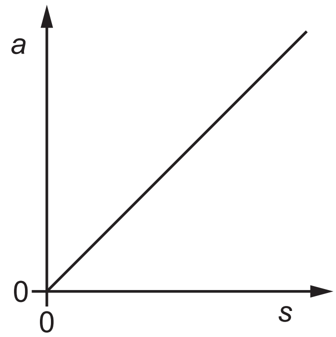


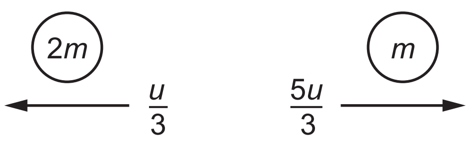
D



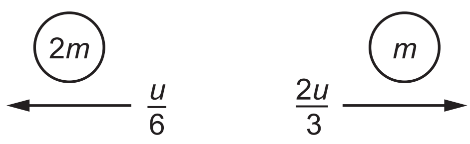
10 The diagram shows two spheres approaching each other head-on. Each sphere has speed u. One sphere has mass $2m$ and the other has mass m.

Which diagram shows the result of a perfectly elastic collision?

A

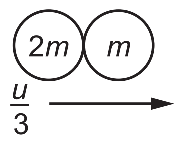


B



C

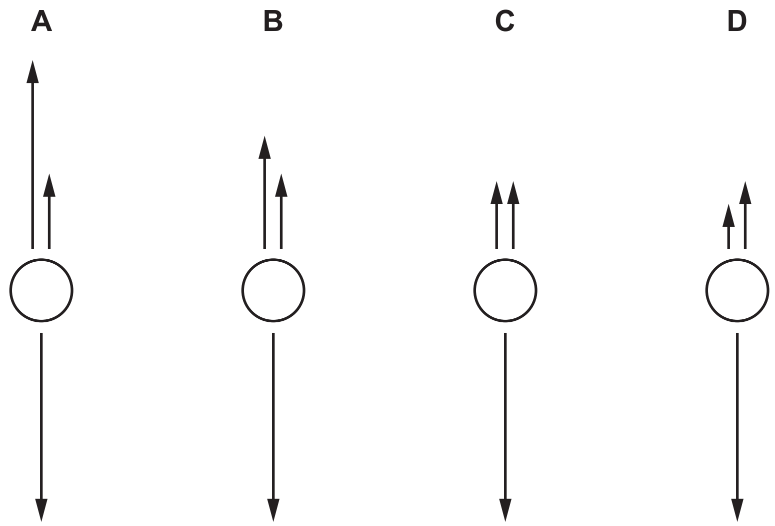
D



the spheres stick together

11 A spherical object falls through water at a constant speed. Three forces act on the object.

Which diagram, showing these three forces to scale, is correct?



12 Two forces act as a couple.

Which statement about the two forces must **not** be correct?

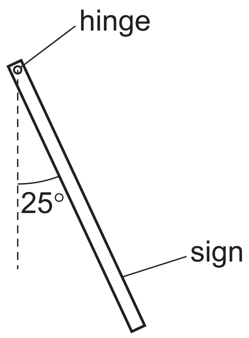
A They act along the same straight line.

B They act in opposite directions.

C They are the same type of force.

D They have the same magnitude.

13 A sign outside a shop is suspended from a rusty horizontal hinge at its top end. The sign hangs in equilibrium at an angle of 25° to the vertical, as shown.

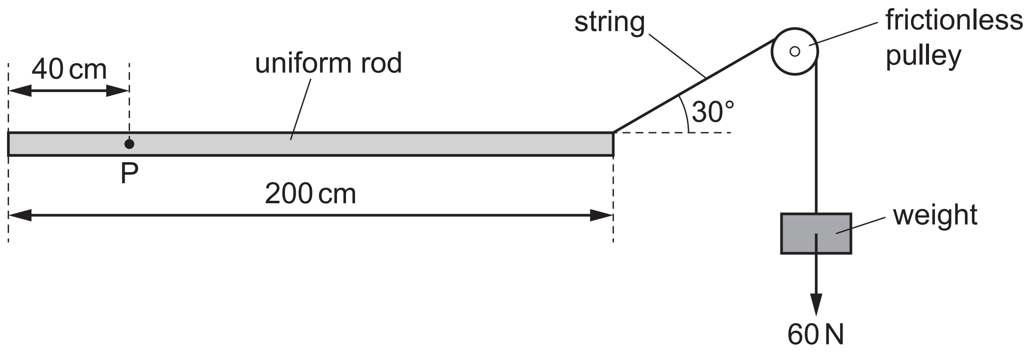


The sign is a square of side length 52 cm and uniform thickness. It has a mass of 36 kg.

What is the moment of the weight of the sign about the hinge?

A 39 N m **B** 78 N m **C** 83 N m **D** 92 N m

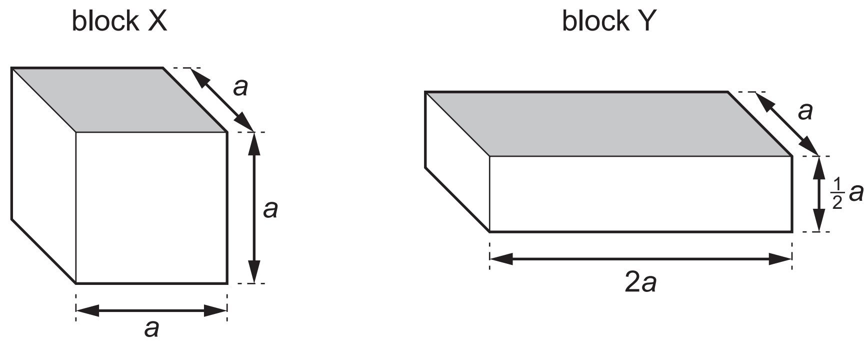
14 A uniform rod of length 200 cm is freely pivoted at point P. The rod is held horizontally in equilibrium by a 60 N weight that is attached to the rod by a string passing over a frictionless pulley.



What is the weight of the rod?

A 30 N **B** 60 N **C** 80 N **D** 140 N

15 The diagram shows two blocks X and Y.



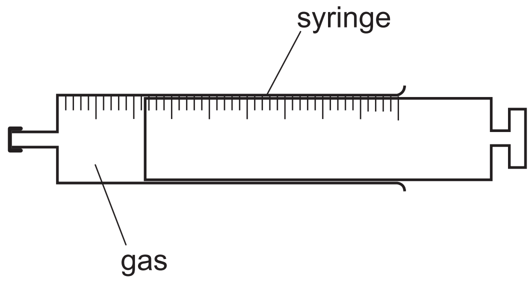
Block X has sides of length a. When block X is placed in a liquid of density ρ with the shaded face level with the liquid surface, it experiences an upthrust U.

Block Y has horizontal sides of length a and $2a$ and height $\frac{1}{2}a$. Block Y is placed in a liquid of density 2ρ, also with the shaded face level with the liquid surface.

What is the upthrust on block Y?

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

16 A gas is contained inside a syringe, as shown.



The initial volume of the gas is 2.00 cm^3.

Atmospheric pressure is 101 kPa.

What is the work done by the gas on the atmosphere when the gas is heated and expands to a volume of 6.00 cm^3?

A 404 μJ **B** 404 mJ **C** 404 J **D** 404 kJ

17 A mechanical device does useful work at rate X and wastes energy at rate Y.

Which expression gives the efficiency of this device?

A $\frac{X}{Y}$ **B** $\frac{(X-Y)}{Y}$ **C** $\frac{X}{(X+Y)}$ **D** $\frac{(X-Y)}{(X+Y)}$

18 Car P has kinetic energy 240 kJ.

Car Q has half the mass and twice the speed of car P.

What is the kinetic energy of car Q?

A 120 kJ **B** 240 kJ **C** 480 kJ **D** 960 kJ

19 A water pump is driven by an engine. The pump raises a volume of 0.50 m^3 of water in 1.0 minute from a depth of 30 m. The pump has an efficiency of 70%.

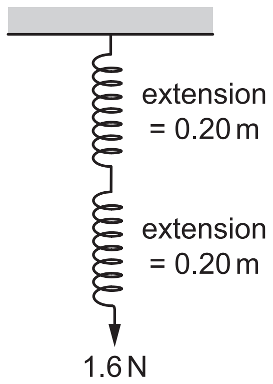
The density of water is 1000 kg m^{-3}.

What is the useful output power from the engine?

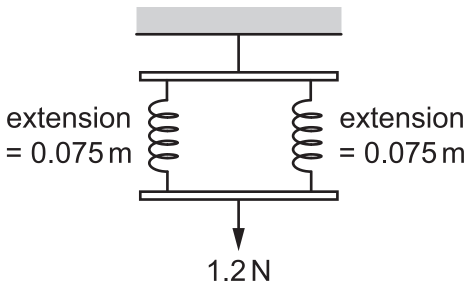
A 2.5 kW **B** 3.5 kW **C** 150 kW **D** 210 kW

20 Which spring combination has an overall spring constant of $8.0\,N\,m^{-1}$?

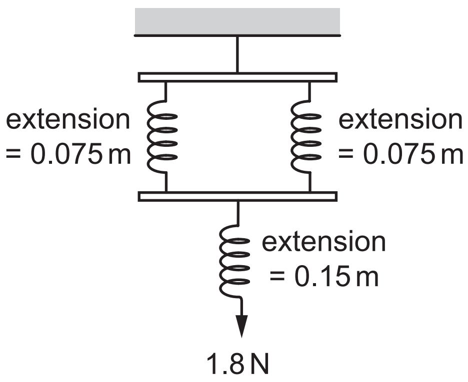
A



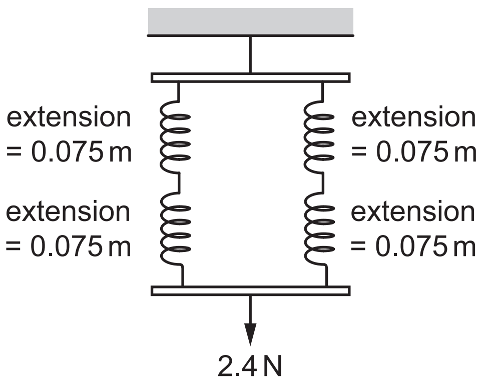
B



C

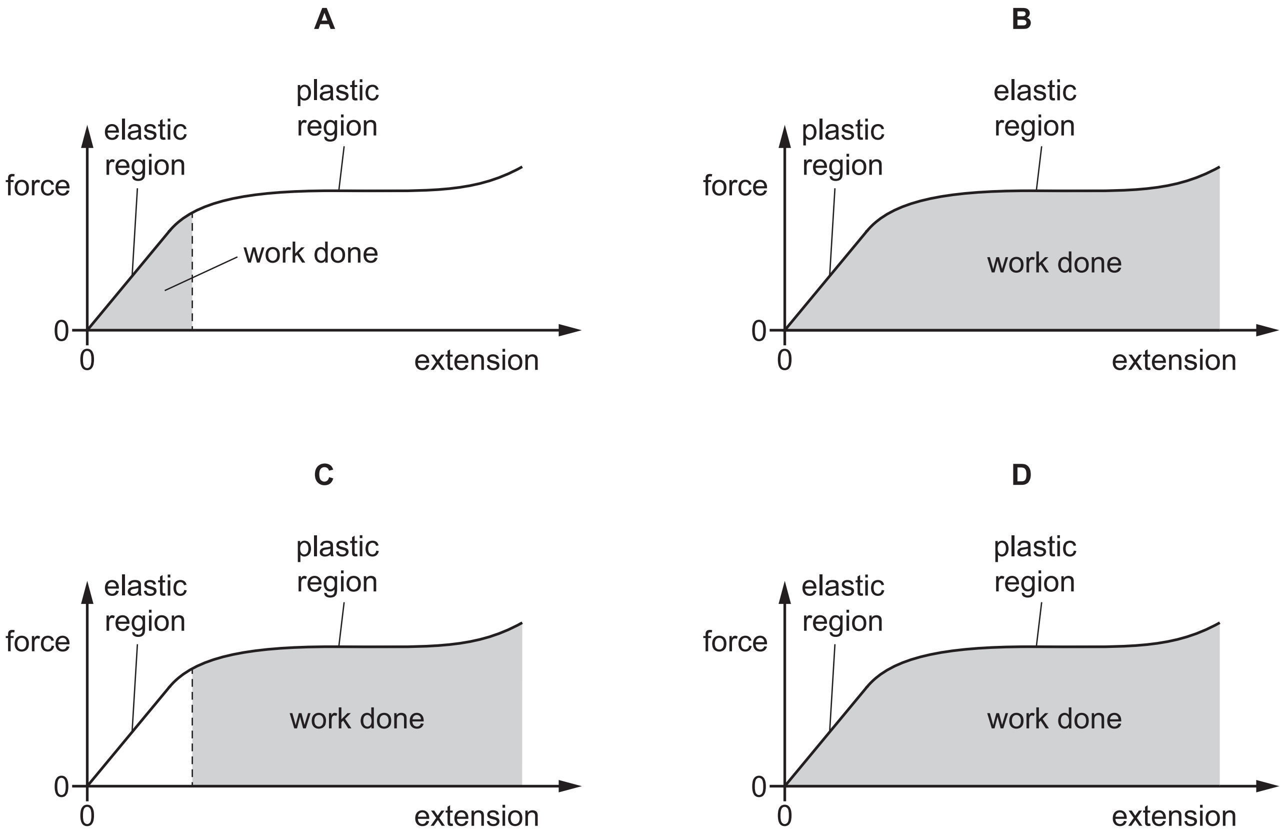


D



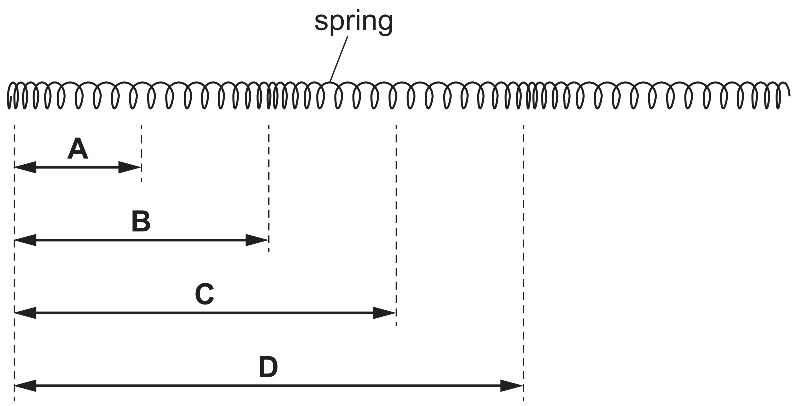
21 A metal wire is stretched to breaking point and the force–extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?



22 A longitudinal wave travels through a long spring. The spring is shown at one instant.

What is the wavelength of the wave?



23 Which statement about waves is correct?

A Both longitudinal and transverse waves can travel through a vacuum.

B Both longitudinal and transverse waves transfer matter.

C Longitudinal progressive waves consist of alternate nodes and antinodes.

D The particles of a transverse wave vibrate perpendicular to the direction of energy propagation.

24 A stationary sound wave is formed in a pipe that is closed at one end and open at the other end. The wave has two antinodes. One of these antinodes is at the open end of the pipe.

The length of the pipe is 0.600 m. The speed of sound in the air column in the pipe is $340\,m\,s^{-1}$.

What is the frequency of the sound wave?

A 425 Hz **B** 850 Hz **C** 1130 Hz **D** 2270 Hz

25 A train travels at constant speed along a straight track. The train's horn emits sound of frequency 500 Hz.

A person standing by the side of the track hears sound of frequency 450 Hz.

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

What is the speed of the train and in which direction is it travelling relative to the person?

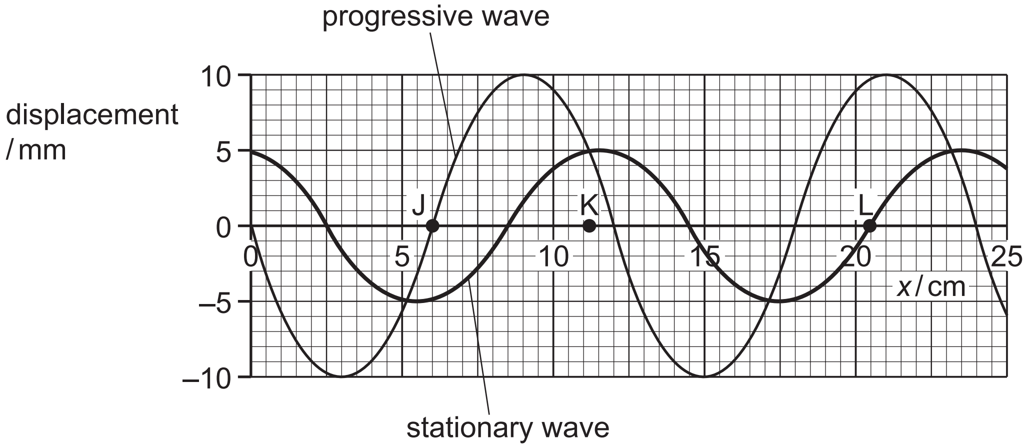
	speed / $m\,s^{-1}$	direction
A	34	away from the person
B	34	towards the person
C	38	away from the person
D	38	towards the person

26 A smooth surface has bumps on the surface that are smaller than the wavelength of visible light.

What is the approximate maximum size of the largest bumps on the surface?

A 20 nm **B** 350 nm **C** 720 nm **D** 5.0 μm

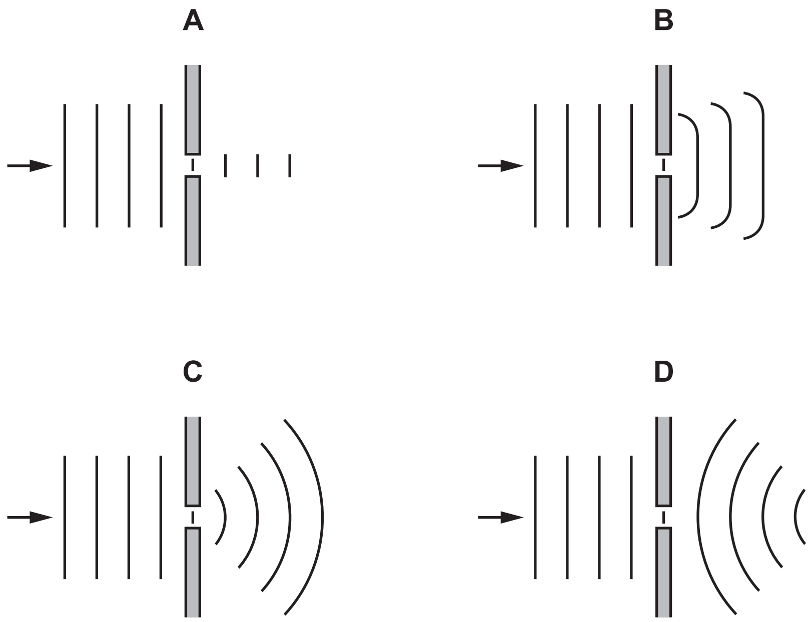
27 Two progressive waves travel in opposite directions and form a stationary wave. The graph shows the variation with distance x of the displacement of the stationary wave and of one of the two progressive waves at the same instant in time.



What are the approximate displacements of the **other** progressive wave at the positions J, K and L?

	displacement / mm		
	J	K	L
A	–5	0	–10
B	–5	+5	0
C	0	+5	+10
D	+5	–5	0

28 Which diagram shows the diffraction of water waves in a ripple tank?

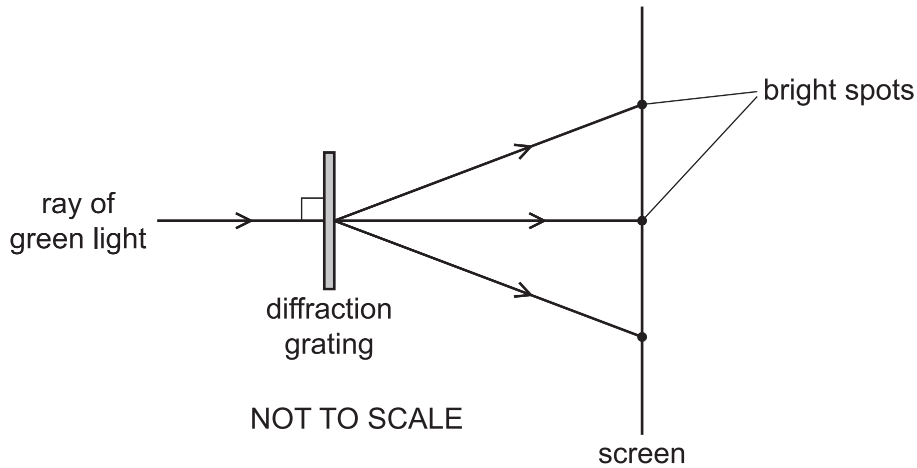


29 Interference fringes are produced on a screen by double-slit interference using light of wavelength 600 nm. The fringe separation is 4.0 mm and the separation of the slits is 0.60 mm.

What is the distance between the double slit and the screen?

A 0.25 m **B** 0.40 m **C** 2.5 m **D** 4.0 m

30 A ray of green light is incident normally on a diffraction grating. Several bright spots are produced on a screen on the other side of the grating, as shown.



Which pair of changes could result in bright spots at exactly the same angles as previously?

A Use blue light and increase the distance between the grating and the screen.

B Use blue light and increase the number of lines per unit length in the grating.

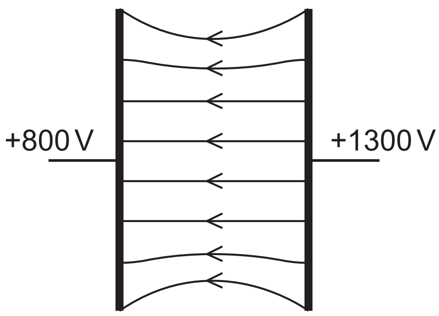
C Use red light and increase the distance between the grating and the screen.

D Use red light and increase the number of lines per unit length in the grating.

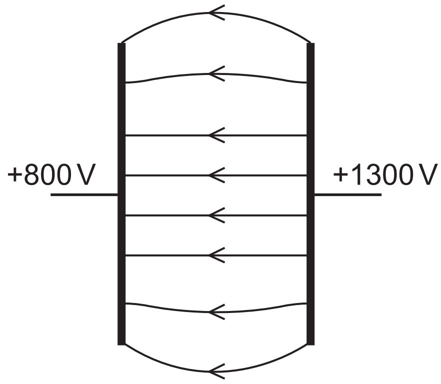
31 Two parallel metal plates are at electric potentials of +800 V and +1300 V.

Which diagram best represents the electric field between the metal plates?

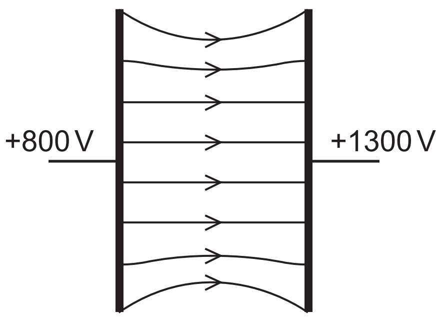
A



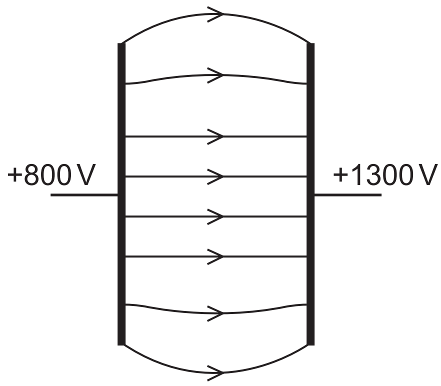
B



C



D



32 An electron is in a uniform electric field of field strength $1500\,\text{V m}^{-1}$.

What is the acceleration of the electron due to the electric field?

A $8.5 \times 10^{-9}\,\text{m s}^{-2}$

B $1.6 \times 10^{-5}\,\text{m s}^{-2}$

C $1.4 \times 10^{11}\,\text{m s}^{-2}$

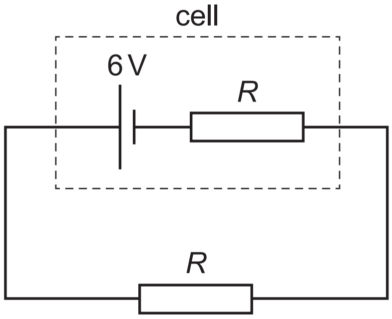
D $2.6 \times 10^{14}\,\text{m s}^{-2}$

33 A lightning strike transfers 1×10^{20} electrons past a point in a time of $30\,\mu\text{s}$.

What is the average current during the lightning strike?

A 0.5 mA **B** 0.5 A **C** 500 A **D** 500 kA

34 A cell has an electromotive force (e.m.f.) of 6 V and internal resistance *R*. An external resistor, also of resistance *R*, is connected across this cell, as shown.



Power *P* is dissipated by the external resistor.

The cell is replaced by a different cell that has an e.m.f. of 6 V and negligible internal resistance.

What is the new power that is dissipated in the external resistor?

A 0.5*P* **B** *P* **C** 2*P* **D** 4*P*

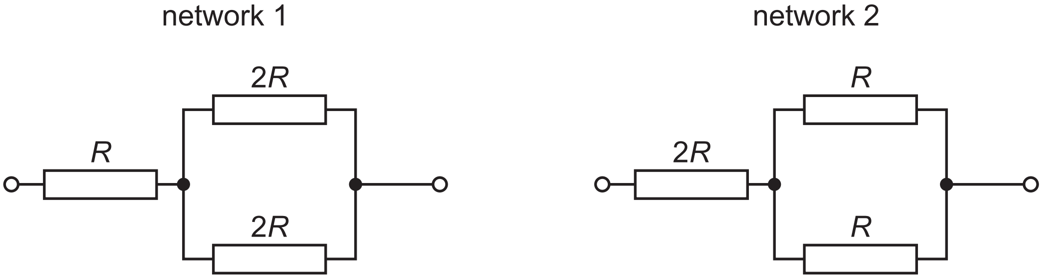
35 A wire of uniform cross-section has resistance *R*.

A second wire is made of the same material but is twice as long and has twice the diameter of the first wire.

What is the resistance of the second wire?

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

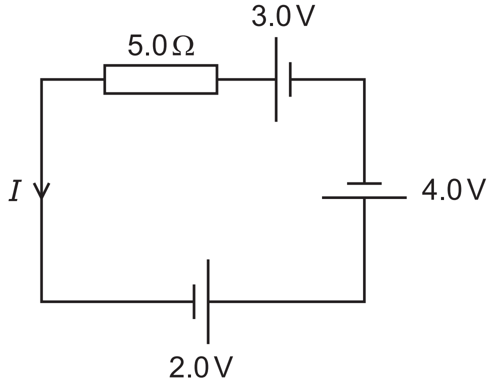
36 The diagram shows two resistor networks.



What is the ratio $\frac{\text{total resistance of network 1}}{\text{total resistance of network 2}}$?

A $\frac{4}{5}$ **B** $\frac{5}{4}$ **C** $\frac{1}{2}$ **D** $\frac{2}{1}$

37 The circuit shown contains three cells of electromotive forces 3.0 V, 2.0 V and 4.0 V, in series with a resistor of resistance 5.0 Ω. The cells have negligible internal resistance.



What is the current I in the circuit?

A 0.20 A　　**B** 0.60 A　　**C** 1.0 A　　**D** 1.8 A

38 When α-particles are fired at a thin metal foil, most of the particles pass straight through but a few are deflected by a large angle.

Which change would increase the **proportion** of α-particles deflected by a large angle?

A using α-particles with greater kinetic energy

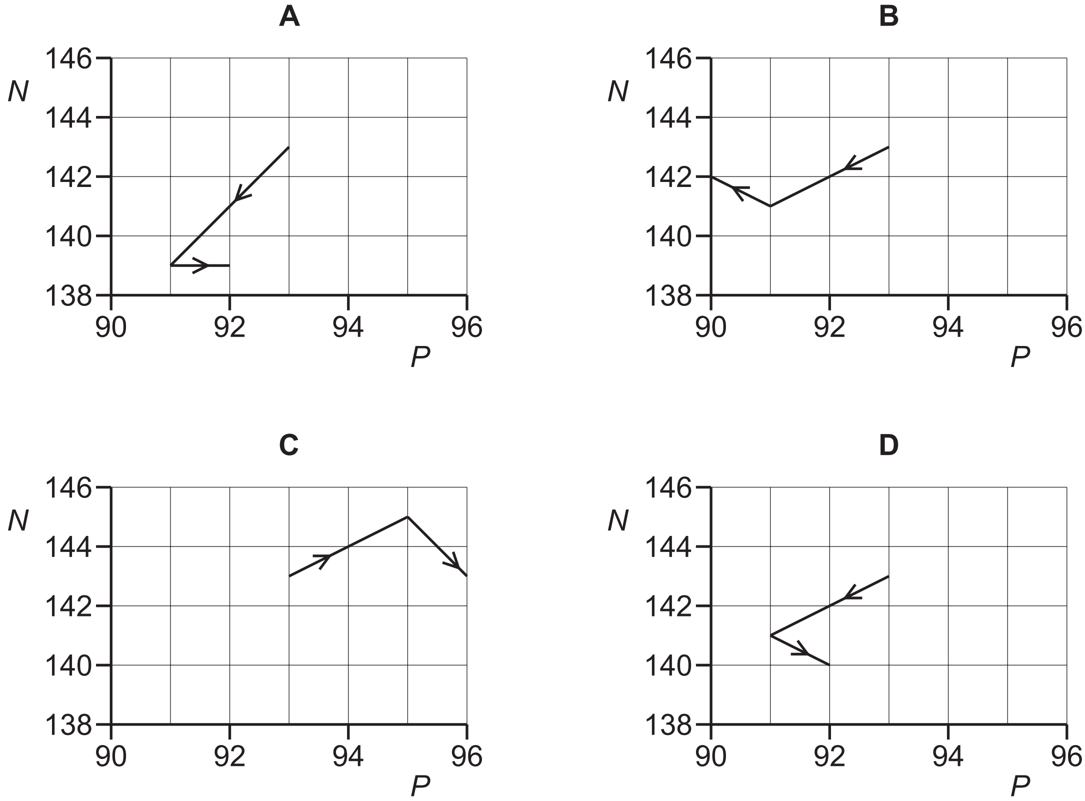
B using a double thickness foil

C using a foil made of a metal with fewer protons in its nuclei

D using a source emitting more α-particles per unit time

39 A nucleus of neptunium-236 contains 93 protons and 143 neutrons. This nucleus decays with the emission of an α-particle. The nucleus formed then emits a β^- particle.

Which diagram shows the changes in the number *P* of protons and the number *N* of neutrons in these nuclei?



40 Which combination of quarks could **not** be the quark composition of the hadron shown?

p = proton

n = neutron

Σ^- = sigma particle of charge $-e$

Σ^+ = sigma particle of charge $+e$

u = up quark

d = down quark

s = strange quark

	hadron	quark composition
A	Σ^-	dds
B	Σ^+	uds
C	p	uud
D	n	udd

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 9 2 9 1 6 9 1 1 2 5 *

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.
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- 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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

Data

acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$
speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_\mathrm{o} = \dfrac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 What is needed to accurately represent all physical quantities?

A a base unit and a number

B a unit and a number expressed in standard form (scientific notation)

C a unit and a numerical magnitude

D an SI unit and a numerical magnitude

2 A voltmeter connected across a resistor in a circuit reads 3.6 V.

What could be the current in the resistor and the resistance of the resistor?

	current	resistance
A	150 mA	0.24 kΩ
B	15 mA	2.4 kΩ
C	1.5 mA	0.24 MΩ
D	15 μA	240 kΩ

3 In an experiment to determine the acceleration of free fall *g*, the time *t* taken for a ball to fall through distance *s* is measured. The percentage uncertainty in the measurement of *s* is 2%. The percentage uncertainty in the measurement of *t* is 3%.

The value of *g* is determined using the equation shown.

$$g = \frac{2s}{t^2}$$

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

A 1% **B** 5% **C** 8% **D** 11%

4 Which quantity is a vector?

A momentum

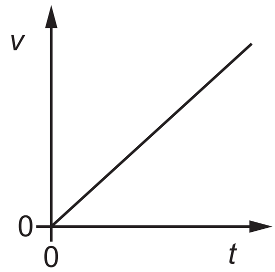
B speed

C temperature

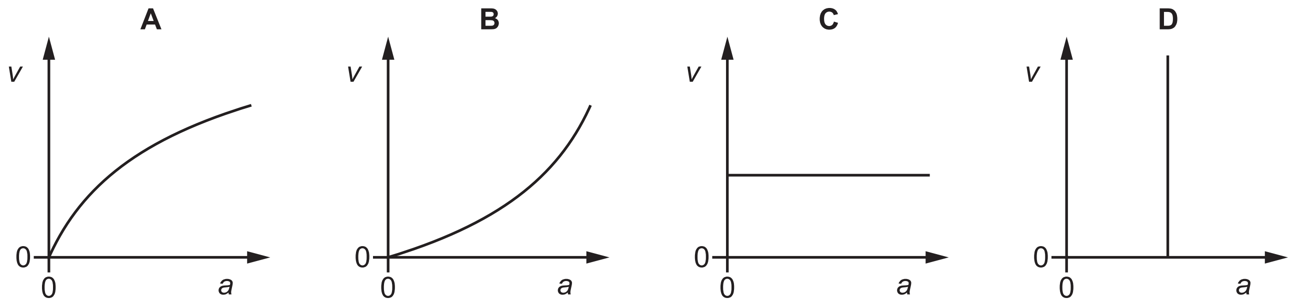
D Young modulus

5 A particle accelerates from rest.

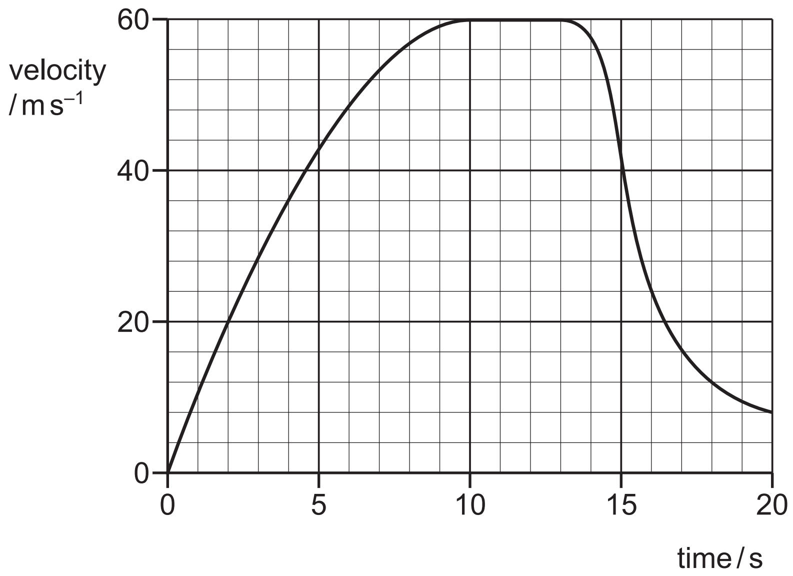
The graph shows the variation of the velocity *v* of the particle with time *t*.



Which graph shows the variation of the velocity *v* with the acceleration *a* of the particle?



6 The graph shows the vertical velocity of a parachutist during the first 20 s of her jump.



Approximately how far does she fall **before** opening the parachute?

A 390 m **B** 570 m **C** 710 m **D** 770 m

7 What is the definition of linear momentum?

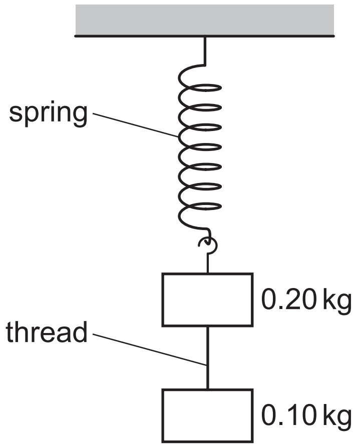
A force per unit time

B product of force and time

C product of velocity and mass

D velocity per unit mass

8 A mass of 0.20 kg is suspended from the lower end of a light spring. A second mass of 0.10 kg is suspended from the first mass by a thread. The arrangement is allowed to come into static equilibrium and then the thread is cut.



Immediately after the thread is cut, what is the upward acceleration of the 0.20 kg mass?

A $4.9\,\mathrm{m\,s^{-2}}$ **B** $6.5\,\mathrm{m\,s^{-2}}$ **C** $9.8\,\mathrm{m\,s^{-2}}$ **D** $15\,\mathrm{m\,s^{-2}}$

9 A snowflake and a raindrop are in still air. They both fall from rest at the same time and from the same height, far above the ground.

The snowflake and raindrop contain the same mass of water. Assume that there is no evaporation or melting. Also assume that, for a given speed, the drag force acting on the snowflake is greater than the drag force acting on the raindrop.

Which statement about the snowflake and raindrop is correct?

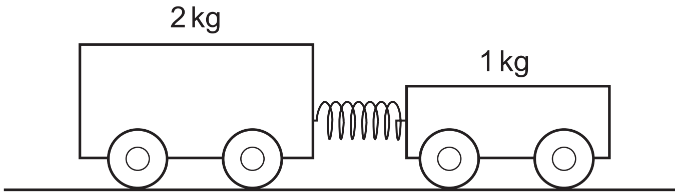
A The raindrop takes more time than the snowflake to reach terminal velocity.

B The raindrop takes more time than the snowflake to reach the ground.

C They reach the same terminal velocity.

D They take the same amount of time to reach the ground.

10 Two trolleys are held together on a horizontal surface with a compressed spring between them.



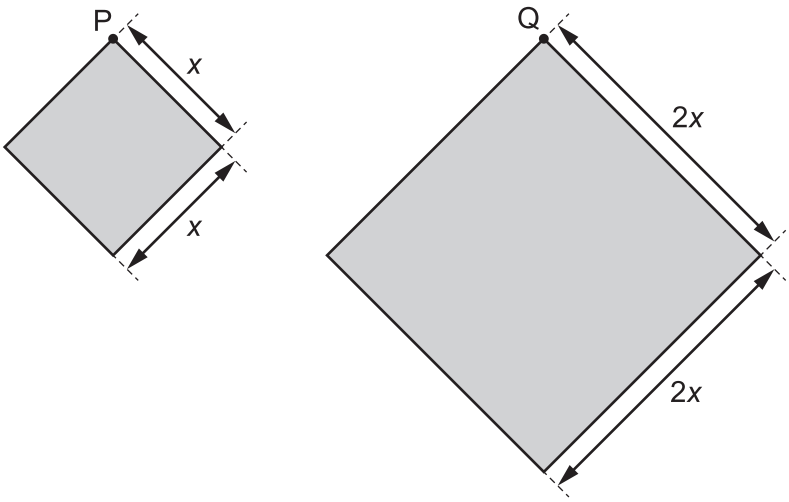
When they are released, the trolleys lose contact with the spring. The trolley of mass 2 kg moves to the left at a final speed of $2\,\mathrm{m\,s^{-1}}$.

How much elastic potential energy was stored in the spring?

A 4 J **B** 6 J **C** 8 J **D** 12 J

11 A square board, of side length x, hangs freely from a nail P, as shown.

The board has uniform thickness and is made from material of uniform density.



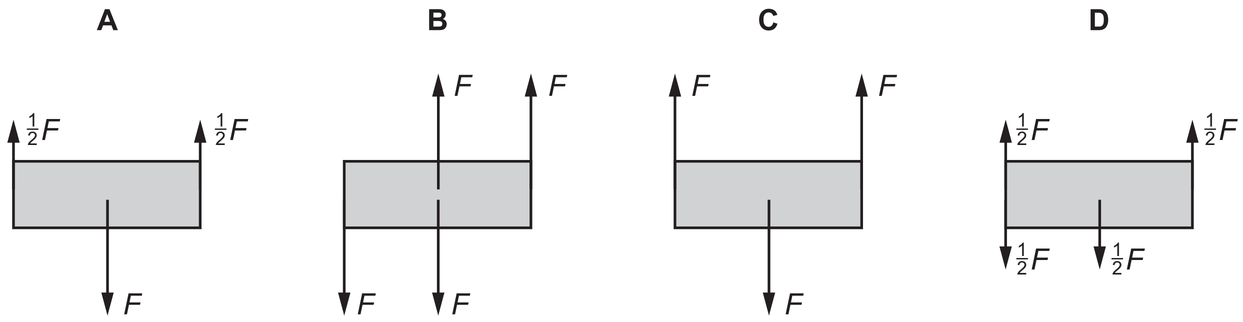
A second square board, of side length $2x$, is made of the same material and has the same thickness as the original board. This second board is then hung from a nail Q. Nails P and Q are at the same height.

What is the vertical distance between the positions of the centres of gravity of the two boards?

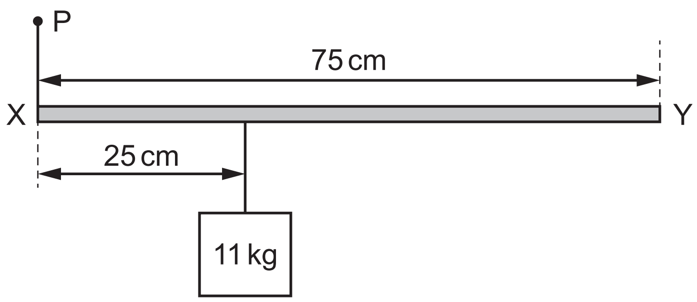
A 0 **B** $\dfrac{x}{\sqrt{2}}$ **C** x **D** $x\sqrt{2}$

12 Forces are applied to a rigid object. The forces all act in the same plane.

In which diagram is the object in equilibrium?



13 A rigid rod XY has negligible mass and length 75 cm. The rod is suspended from a fixed point P by a string attached to end X. An object of mass 11 kg is suspended by a string that is attached to the rod at a distance of 25 cm from end X, as shown.



Which vertically upward force acting on end Y of the rod would hold the rod horizontally in equilibrium?

A 3.7 N **B** 33 N **C** 36 N **D** 320 N

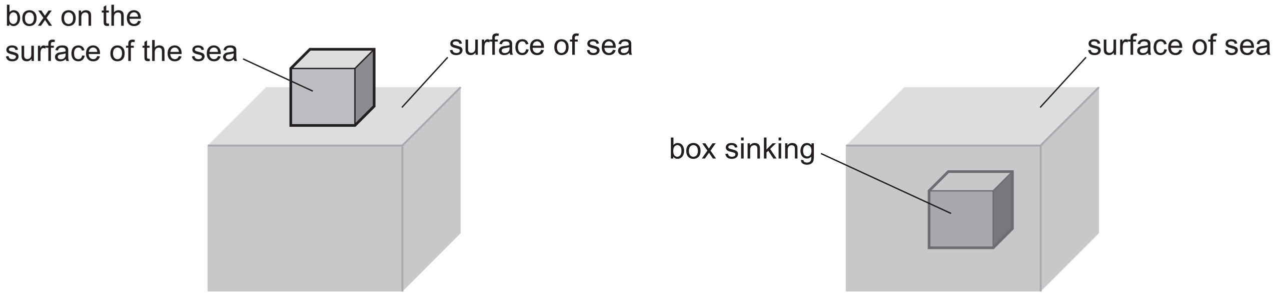
14 The density of water is $1.0\,g\,cm^{-3}$ and the density of glycerine is $1.3\,g\,cm^{-3}$.

Water is added to a measuring cylinder containing $40\,cm^3$ of glycerine so that the density of the mixture is $1.1\,g\,cm^{-3}$. Assume that the mixing process does not change the total volume of the liquid.

What is the volume of water added?

A $40\,cm^3$ **B** $44\,cm^3$ **C** $52\,cm^3$ **D** $80\,cm^3$

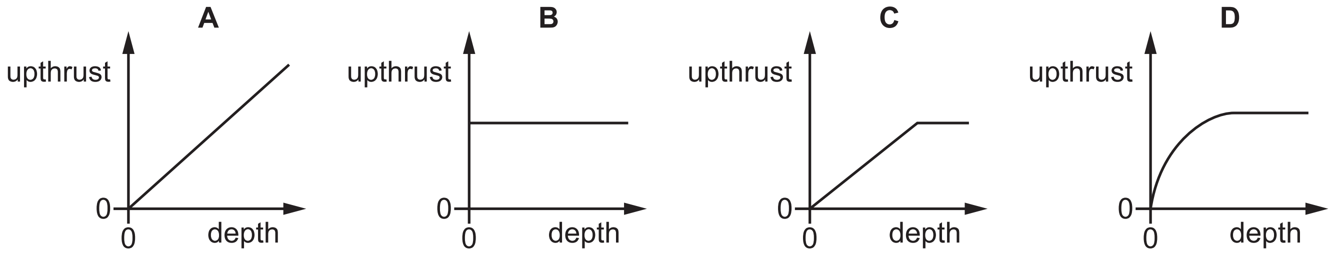
15 A box, in the shape of a cube, falls from a ship into the sea. The box lands with its lower face level with the surface of the sea.



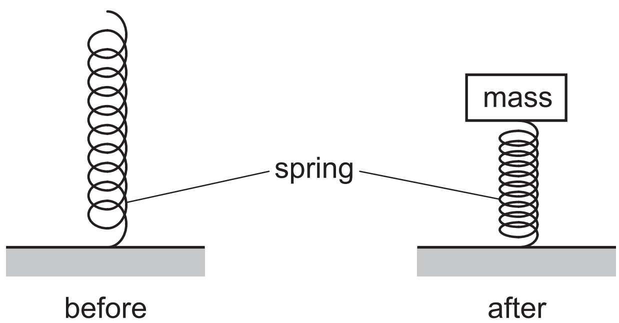
The box begins to sink, becomes totally submerged and then sinks deeper into the sea.

As the box sinks, its lower face is always parallel to the surface of the sea.

Which graph best represents the variation of the upthrust acting on the box with the depth of its lower face below the surface of the sea?



16 A spring is compressed by a mass, as shown.



Which statement describes the changes to the energy of the spring when it is compressed by the mass?

A The spring gains both gravitational potential energy and elastic potential energy.

B The spring gains gravitational potential energy and loses elastic potential energy.

C The spring loses both gravitational potential energy and elastic potential energy.

D The spring loses gravitational potential energy and gains elastic potential energy.

17 A man of mass 75 kg runs up a staircase consisting of 30 steps. Each step is 20 cm high.

The man takes a time of 7.0 s to run from the bottom of the staircase to the top.

What is the average rate of increase of gravitational potential energy of the man?

A 64 W **B** 450 W **C** 630 W **D** 4400 W

18 An alpha-particle has 2.2×10^{-13} J of kinetic energy.

What is the speed of the alpha-particle?

A $4.1 \times 10^{6}\,\mathrm{m\,s^{-1}}$

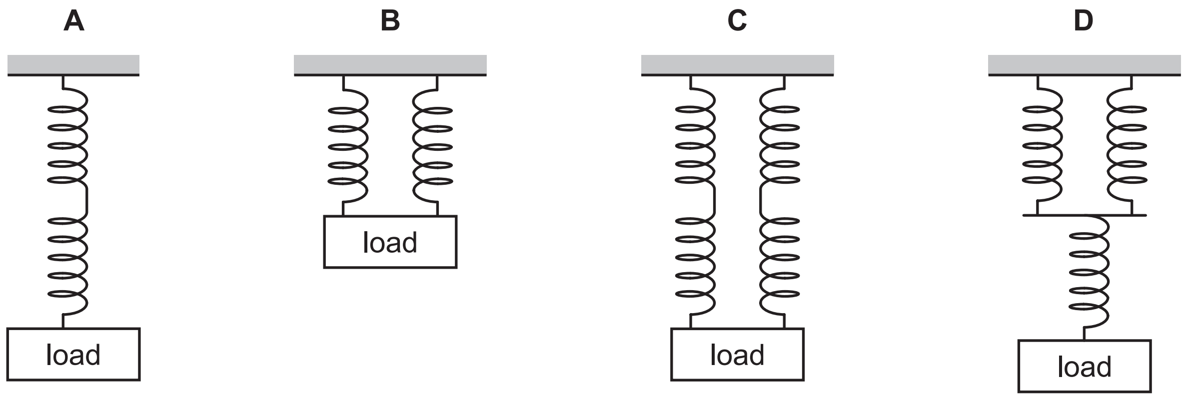
B $5.8 \times 10^{6}\,\mathrm{m\,s^{-1}}$

C $8.1 \times 10^{6}\,\mathrm{m\,s^{-1}}$

D $1.2 \times 10^{7}\,\mathrm{m\,s^{-1}}$

19 Identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



20 An unstretched spring has a length of 2.0 cm.

The spring is then stretched within its limit of proportionality by a tensile force of 1.5 N so that the elastic potential energy stored in the spring is 0.045 J.

What is the stretched length of the spring?

A 3.0 cm **B** 5.0 cm **C** 6.0 cm **D** 8.0 cm

21 A signal generator, amplifier and loudspeaker are used to produce different sound waves in the air of a room. The relationships between the properties of these waves are investigated.

Which relationship is **not** correct?

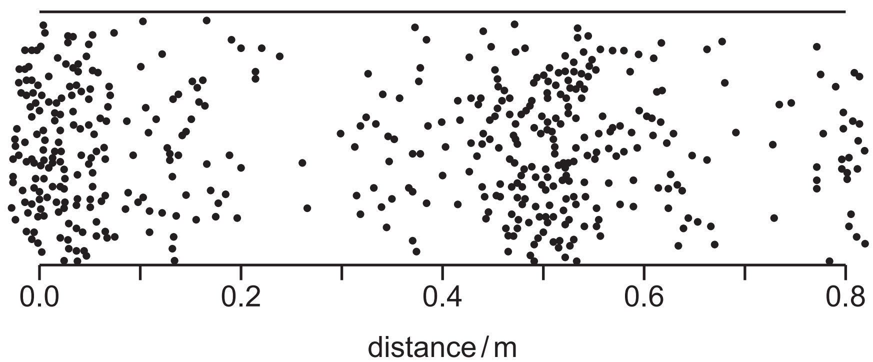
A Amplitude is proportional to wavelength.

B Frequency is inversely proportional to wavelength.

C Intensity is proportional to amplitude squared at a given frequency.

D Period is equal to the reciprocal of frequency.

22 When a guitar string is plucked, it causes a longitudinal sound wave in the air, as shown.



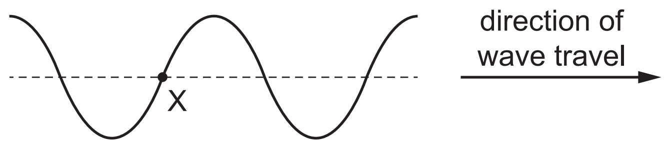
The speed of sound in the air is $340\,\text{m}\,\text{s}^{-1}$.

What is the approximate frequency of the sound wave shown?

A 430 Hz **B** 680 Hz **C** 1100 Hz **D** 1400 Hz

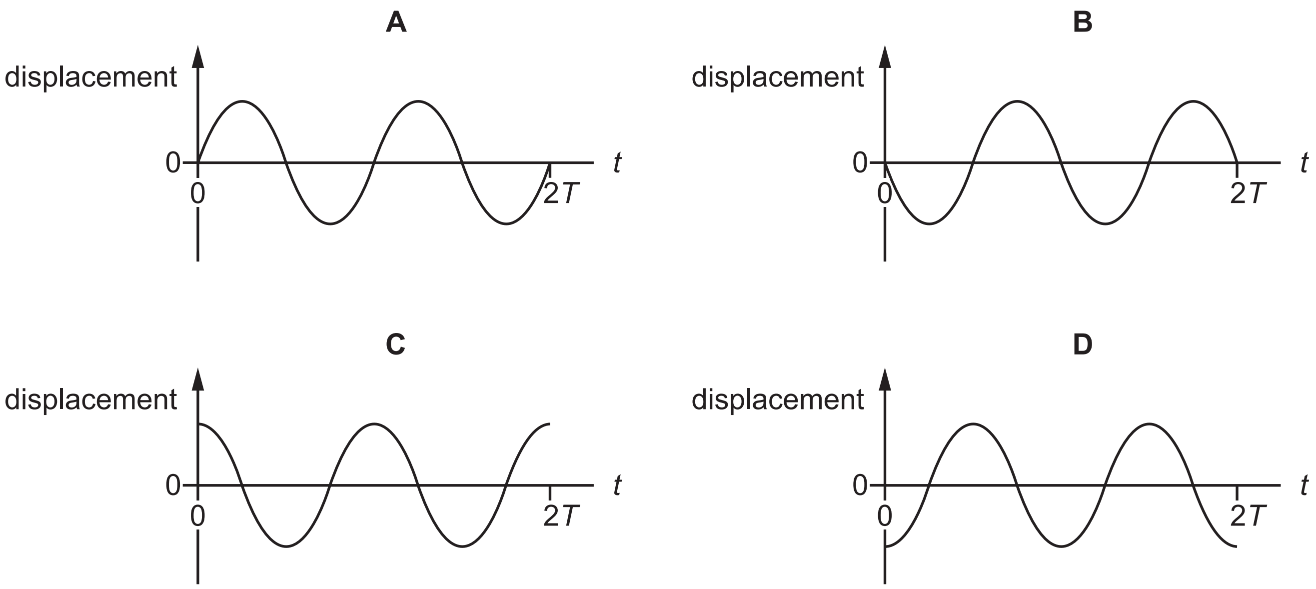
23 A transverse wave travels along a rope. The diagram shows the rope at time $t = 0$.

The wave is travelling from left to right. The period of the wave is T.



One particle of the rope is labelled X.

Which graph shows the variation with time of the displacement of particle X between $t = 0$ and $t = 2T$?



24 A jet aircraft travels at a speed of $0.80v$, where v is the speed of sound. The aircraft directly approaches a stationary observer. The frequency of sound emitted by the aircraft is 100 Hz.

Which frequency does the observer hear?

A 56 Hz **B** 180 Hz **C** 400 Hz **D** 500 Hz

25 A telescope detects and analyses some electromagnetic radiation of wavelength 2 cm.

Which type of telescope is it?

A microwave telescope

B optical telescope

C radio telescope

D X-ray telescope

26 Two waves of the same type overlap.

When does the principle of superposition apply?

A always

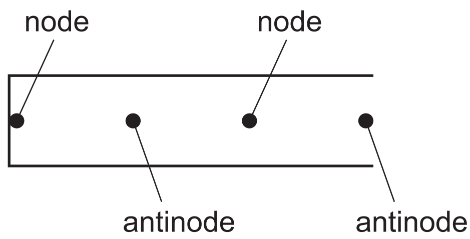
B only when the waves have the same amplitude

C only when the waves have the same frequency

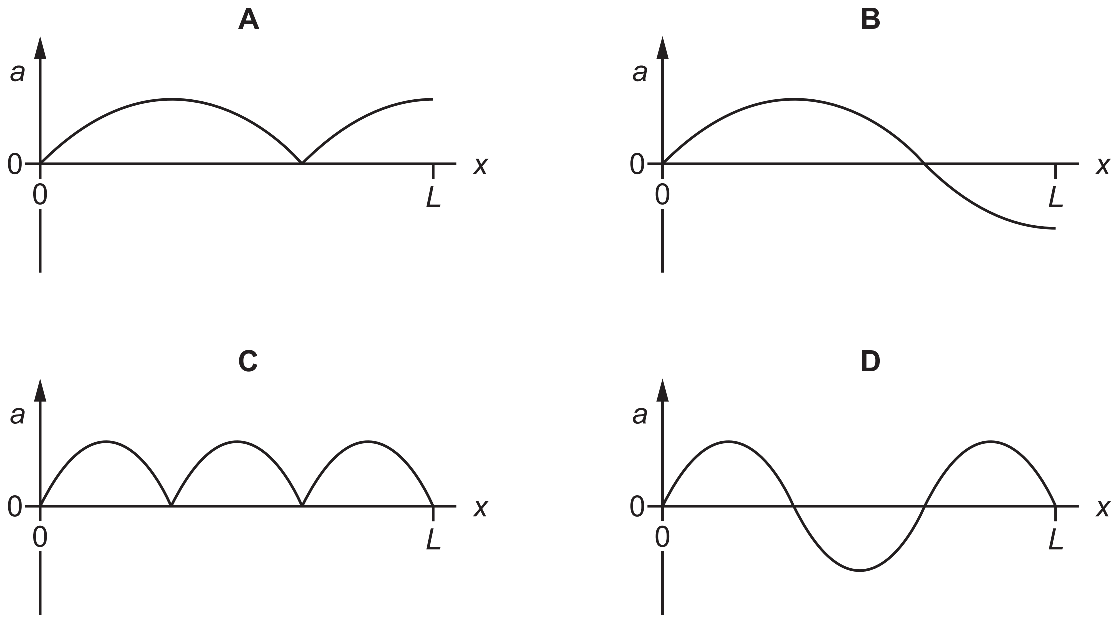
D only when the waves travel in opposite directions

27 A stationary sound wave is formed in a tube of length L that is closed at one end.

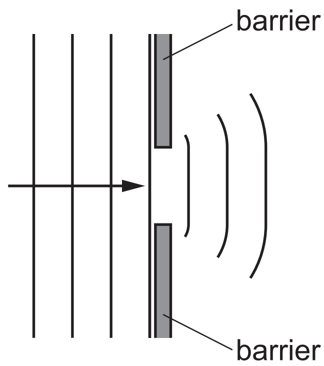
The diagram shows the positions of the nodes and antinodes of the stationary wave.



Which graph shows the variation of the amplitude a of the wave with distance x measured from the closed end of the tube?



28 A wave on the surface of water passes through a gap between two barriers and is diffracted, as shown.



What happens when the frequency of the wave is halved?

A Less diffraction is observed.

B More diffraction is observed.

C There is no diffraction.

D The same amount of diffraction is observed.

29 Observable interference fringes are produced using light from a double slit. The intensity of the light emerging from each slit is initially the same.

The intensity of the light emerging from one of the slits is now reduced.

How does this affect the interference pattern?

A The bright fringes and the dark fringes all become brighter.

B The bright fringes and the dark fringes all become darker.

C The bright fringes become brighter and the dark fringes become darker.

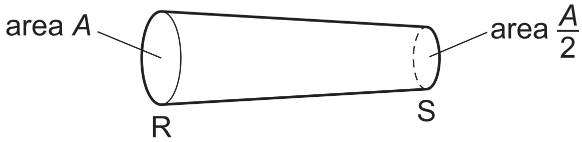
D The bright fringes become darker and the dark fringes become brighter.

30 A diffraction grating has 4.00×10^5 lines per metre. A beam of light of wavelength 589×10^{-9} m is incident normally on the diffraction grating.

What is the angle between the second-order maximum and the direction of the incident beam of light?

A 13.6° **B** 27.3° **C** 28.1° **D** 56.2°

31 A length of wire RS has a circular cross-section.



At end R of the wire, the cross-sectional area is A.

At end S of the wire, the cross-sectional area is $\frac{A}{2}$.

Charge Q takes time t to pass through end R of the wire. There is a constant electric current in the wire.

How much charge will pass through end S in a time interval of $\frac{t}{4}$?

A $\frac{Q}{8}$ **B** $\frac{Q}{4}$ **C** $\frac{Q}{2}$ **D** Q

32 A power supply is connected to a component by connecting wires of total resistance 4.9 Ω.

The power supply has an output power of 3.6 W and a terminal potential difference of 12 V.

How much thermal energy is dissipated in the connecting wires in a time of 1.0 hour?

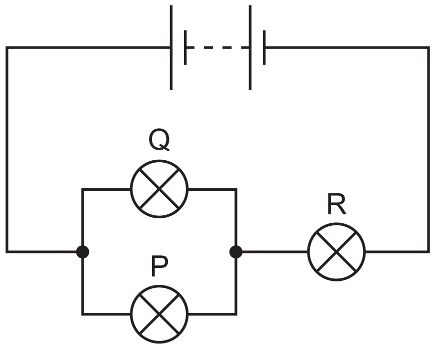
A 0.44 J **B** 29 J **C** 1.6 kJ **D** 11 kJ

33 A copper wire is to be replaced by an aluminium alloy wire of the same length and resistance. Copper has half the resistivity of the alloy.

What is the ratio $\dfrac{\text{diameter of alloy wire}}{\text{diameter of copper wire}}$?

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

34 Three identical filament lamps, P, Q and R, are connected to a battery of negligible internal resistance, as shown.



The filament wire in lamp Q breaks so that it no longer conducts.

What are the changes in the brightness of lamps P and R?

	lamp P	lamp R
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

35 Which ratio has the same units as electromotive force (e.m.f.)?

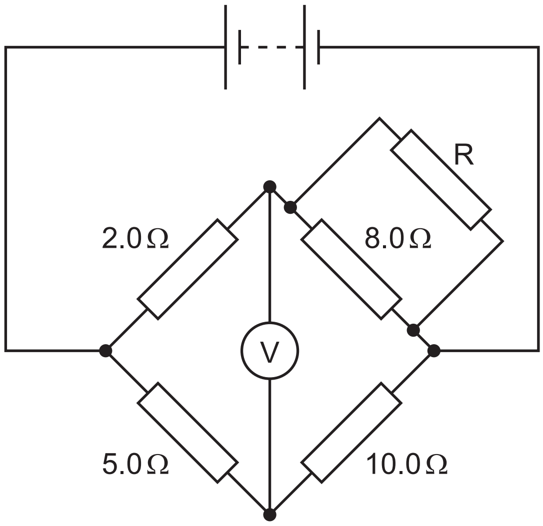
A charge per unit energy transferred

B charge per unit time

C energy transferred per unit charge

D energy transferred per unit time

36 A circuit consists of a battery, a voltmeter and five fixed resistors, as shown.



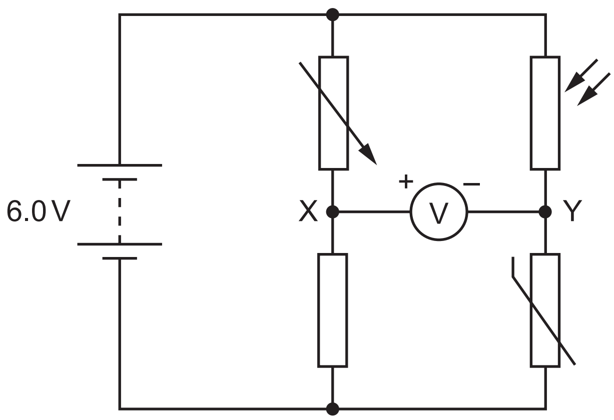
The voltmeter reading is zero.

What is the resistance of resistor R?

A 1.1Ω **B** 2.1Ω **C** 4.0Ω **D** 8.0Ω

37 A battery of electromotive force (e.m.f.) 6.0V and negligible internal resistance is connected to a voltmeter and four other components, as shown.

The voltmeter is connected between points X and Y. The positive terminal of the voltmeter is connected to X and the negative terminal of the voltmeter is connected to Y.



Initially, the resistance of each of the four components is 1.0kΩ.

Which change, on its own, will cause the voltmeter to show a positive reading?

A Decrease the temperature of the thermistor.

B Increase the resistance of the variable resistor.

C Reduce the intensity of light incident on the light-dependent resistor (LDR).

D Replace the fixed resistor with a 500Ω resistor.

38 An α-particle passes close to a gold nucleus and is deflected through an angle greater than 90°.

Which property of the α-particle changes as a result of the deflection?

A charge

B momentum

C nucleon number

D proton number

39 A nucleus of $^{238}_{92}U$ decays in stages by emitting α-particles and β^- particles, eventually forming a nucleus of $^{206}_{82}Pb$.

How many α-particles and how many β^- particles are emitted during the decay chain?

	α-particles	β^- particles
A	8	6
B	8	10
C	16	6
D	16	22

40 Which list of particles contains **only** fundamental particles?

A antineutrino, beta, meson

B baryon, neutrino, positron

C electron, neutrino, alpha

D lepton, quark, positron

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 2 1 5 1 6 2 7 5 4 5 *

You will need: Multiple choice answer sheet
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- 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.
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rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
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upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_\mathrm{o} = \dfrac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 Which quantity is a physical quantity?

A flavour

B kelvin

C minute

D potential difference

2 What is a power of 3.7 MW when expressed in kilowatts?

A 3.7×10^{-3} kW

B 3.7×10^{-3} KW

C 3.7×10^{3} kW

D 3.7×10^{3} KW

3 A spring is suspended from a fixed point and a force is applied. The position of a pointer attached to the bottom of the spring against a vertical ruler is recorded.

Before the force is applied, the position of the pointer is (225 ± 2) mm.

After the force is applied, the position of the pointer is (250 ± 2) mm.

The extension of the spring is determined.

What is the percentage uncertainty in the extension?

A 1.6% **B** 1.8% **C** 8.0% **D** 16%

4 What is the difference between a scalar quantity and a vector quantity?

A A scalar quantity has direction but a vector quantity does not.

B A scalar quantity has magnitude but a vector quantity does not.

C A vector quantity has direction but a scalar quantity does not.

D A vector quantity has magnitude but a scalar quantity does not.

5 A toy car travels on a circular track at a constant speed of $0.50\,\mathrm{m\,s^{-1}}$. It passes a point on the track at time $t = 0$ and takes a time of 40 s to travel once around the track.

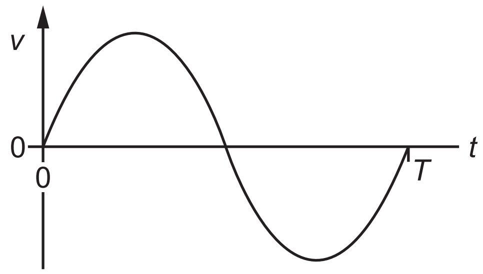
The magnitude of the average velocity of the car between $t = 0$ and $t = 20\,\mathrm{s}$ is v_{20}.

The magnitude of the average velocity of the car between $t = 0$ and $t = 40\,\mathrm{s}$ is v_{40}.

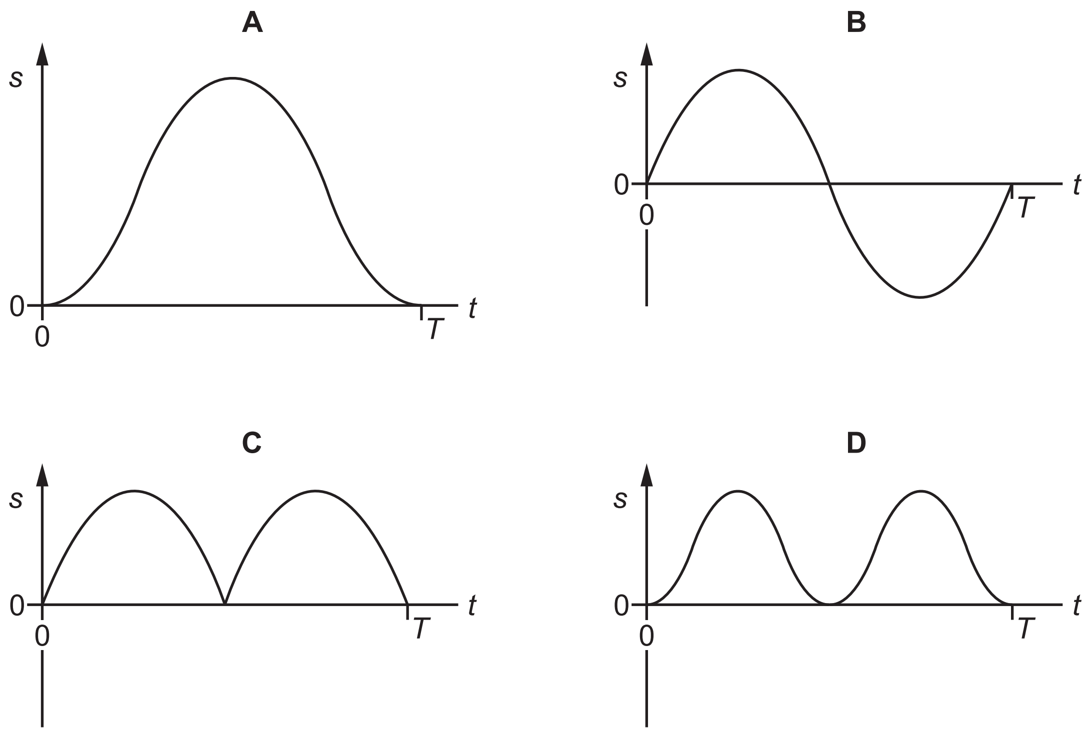
What are v_{20} and v_{40}?

	$v_{20}\,/\,\mathrm{m\,s^{-1}}$	$v_{40}\,/\,\mathrm{m\,s^{-1}}$
A	0.32	0
B	0.32	0.32
C	0.50	0
D	0.50	0.50

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



Which graph could represent the displacement s of the object from time $t = 0$ to $t = T$?



7 A goods train passes through a station at a steady speed of $10\,m\,s^{-1}$ at time $t = 0$. An express train is at rest at the station. The express train leaves the station with a uniform acceleration of $0.5\,m\,s^{-2}$ just as the goods train goes past. Both trains move in the same direction on straight, parallel tracks.

At which time t does the express train overtake the goods train?

A 6 s **B** 10 s **C** 20 s **D** 40 s

8 A constant resultant force F acts on an object of mass m for time t.

What is the change in momentum of the object?

A $\frac{F}{t}$ **B** $\frac{Ft}{m}$ **C** Ft **D** $\frac{F}{mt}$

9 The acceleration of free fall on the surface of planet P is one-tenth of that on the surface of planet Q.

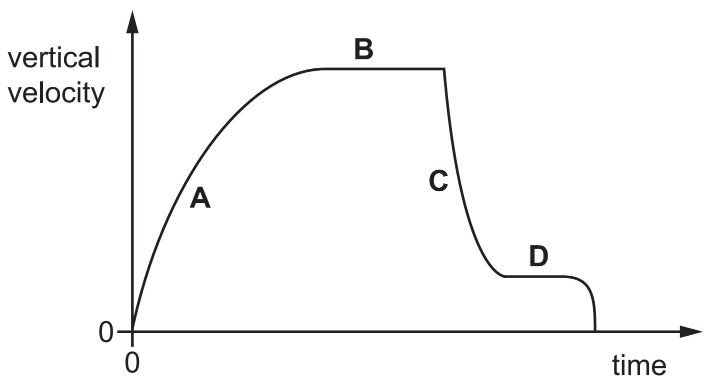
On the surface of P, an object has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and the weight of the same object on the surface of planet Q?

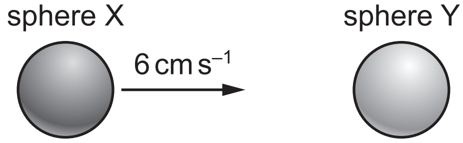
	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

10 A parachutist falls from rest from a balloon. The variation with time of the vertical velocity of the parachutist is shown.

In which region is the force due to air resistance much greater than the weight of the parachutist?



11 Two solid spheres form an isolated system. Sphere X moves with speed $6\,cm\,s^{-1}$ in a straight line directly towards a stationary sphere Y, as shown.



The spheres have a perfectly elastic collision. After the collision, sphere X moves with speed $2\,cm\,s^{-1}$ in the same direction as before the collision.

What is the speed of sphere Y?

A $2\,cm\,s^{-1}$ **B** $4\,cm\,s^{-1}$ **C** $6\,cm\,s^{-1}$ **D** $8\,cm\,s^{-1}$

12 What is **not** a necessary requirement of the forces in a couple?

A They act in opposite directions.

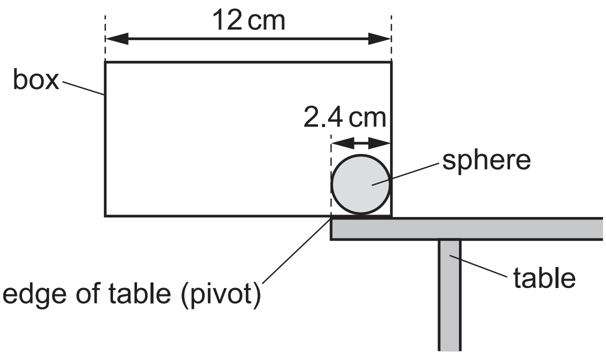
B They act along different lines.

C They have the same magnitude.

D They produce a resultant force.

13 A box of length 12 cm and weight 0.43 N is placed on a horizontal table, with the greater part of its length overhanging the edge of the table. The edge of the table acts as a pivot. The centre of gravity of the box is at its geometric centre.

To balance the box, a uniform sphere of diameter 2.4 cm is placed inside the box, touching one end, as shown.

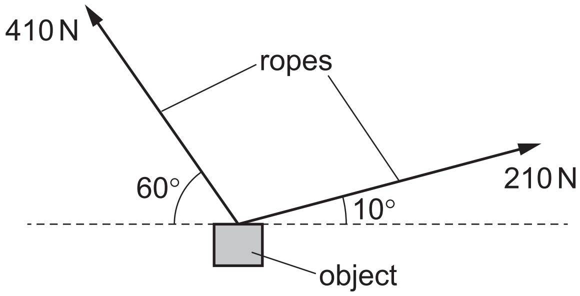


Assume that the forces acting on the box are in the plane of the diagram.

What is the minimum mass of the sphere that is needed to maintain the system in equilibrium?

A 0.066 kg **B** 0.13 kg **C** 0.22 kg **D** 1.3 kg

14 An object is suspended by two ropes. One rope has a tension of 410 N at an angle of 60° to the horizontal. The other rope has a tension of 210 N at an angle of 10° to the horizontal.



The object is in equilibrium.

What is the mass of the object?

A 40 kg **B** 42 kg **C** 390 kg **D** 410 kg

15 A solid cube is floating in equilibrium in liquid mercury. The cube is made of iron of density 7900 kg m^{-3}.

The cube floats with 42% of its volume above the surface of the mercury.

What is the density of the mercury?

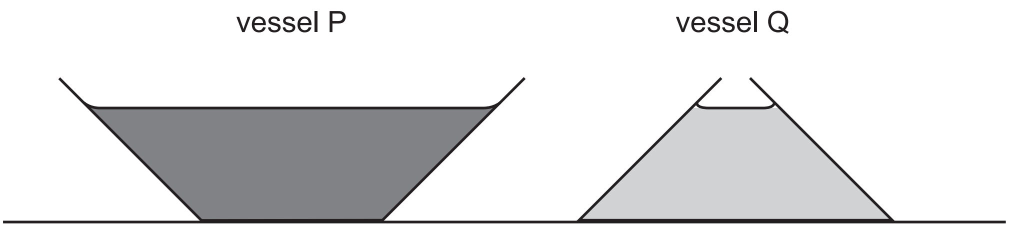
A 3300 kg m^{-3}

B 4600 kg m^{-3}

C 14 000 kg m^{-3}

D 19 000 kg m^{-3}

16 The diagram shows two vessels, P and Q, both with sides inclined at 45° to the horizontal.



Vessel P tapers outwards and vessel Q tapers inwards, as shown.

Both vessels contain a liquid. The depth of the liquid in the vessels is the same. The liquid in vessel P is twice as dense as the liquid in vessel Q.

What is the ratio $\dfrac{\text{pressure due to the liquid on the base of P}}{\text{pressure due to the liquid on the base of Q}}$?

A $\dfrac{2}{1}$ **B** $\dfrac{\sqrt{2}}{1}$ **C** $\dfrac{1}{\sqrt{2}}$ **D** $\dfrac{1}{2}$

17 A motor is used to lift a load vertically upwards.

The load has weight W.

The motor produces useful power output P.

The load is lifted at constant velocity v.

Which expression gives the time taken for the motor to lift the load vertically upwards through a distance d?

A $\dfrac{P}{Wd}$ **B** $\dfrac{Wv}{P}$ **C** $\dfrac{Wd}{P}$ **D** $\dfrac{Pv}{W}$

18 A lamp is switched on for 2.0 hours. The power input to the lamp is 1.0 W. The energy given out by the lamp as light is 7.0×10^3 J.

How much energy is converted to other forms by the lamp?

A 120 J **B** 200 J **C** 3400 J **D** 7200 J

19 An object of mass m is dropped onto the surface of two planets, X and Y, which have no atmosphere.

The height from which the object is dropped and the change in gravitational potential energy of the object, for each planet, are given in the table.

	height / m	change in gravitational potential energy
planet X	3	ΔE
planet Y	4	$4\Delta E$

The acceleration of free fall near the surface of planet X is g_X.

What is the acceleration of free fall near the surface of planet Y?

A $\dfrac{3}{4}g_X$ **B** $\dfrac{4}{3}g_X$ **C** $3g_X$ **D** $4g_X$

20 A known tensile force acts on a metal wire. The wire does not exceed its limit of proportionality.

Which two measurements enable the strain of the wire to be calculated?

A the unstretched length of the wire and the cross-sectional area of the wire

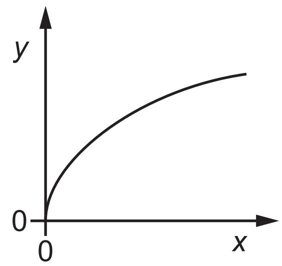
B the unstretched length of the wire and the extension of the wire

C the Young modulus of the metal and the extension of the wire

D the Young modulus of the metal and the unstretched length of the wire

21 A wire is extended by different forces. The wire obeys Hooke's law.

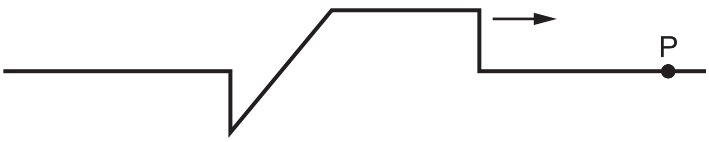
A graph is plotted to show the variation of a quantity *y* with a quantity *x*.



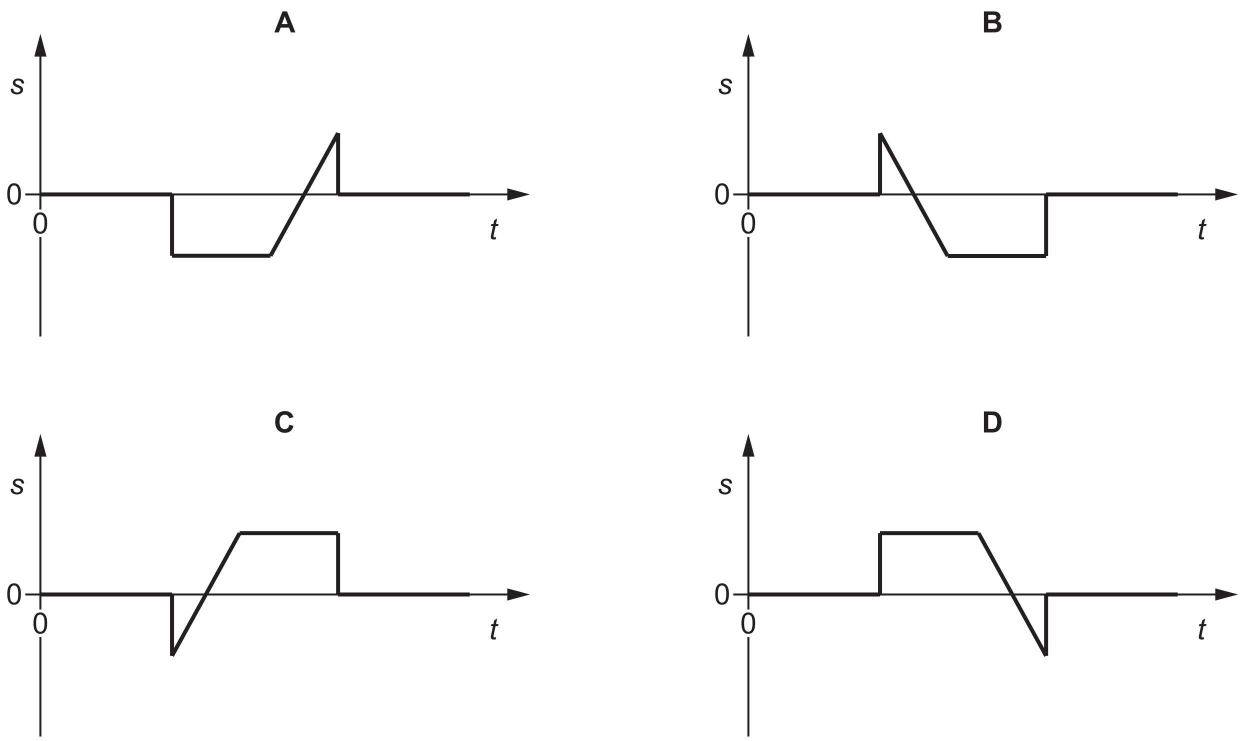
What could *x* and *y* represent?

	x	*y*
A	elastic potential energy	extension
B	extension	force
C	force	extension
D	extension	elastic potential energy

22 A wave pulse moves along a stretched rope in the direction shown.



Which diagram shows the variation with time *t* of the displacement *s* of the particle P in the rope?



23 Which statement about progressive transverse and longitudinal waves is correct?

A Particles in a transverse wave have fixed equilibrium positions but those in longitudinal waves do not.

B Transverse waves can be polarised but longitudinal waves cannot.

C Transverse waves transfer energy but longitudinal waves do not.

D Two-source interference can be demonstrated with transverse waves but not with longitudinal waves.

24 A miniature loudspeaker, initially at rest, falls vertically from a window in a high building. When the speaker has fallen a distance of 10.0 m, it emits a very short pulse of sound of constant frequency 256 Hz in all directions. The pulse of sound, travelling at a speed of 330 m s^{-1}, is heard by a person leaning out of the window.

Air resistance is negligible.

What is the frequency of the pulse of sound heard by the person?

A 246 Hz **B** 249 Hz **C** 267 Hz **D** 313 Hz

25 Two electromagnetic waves have wavelengths of 5.0×10^{-7} m and 5.0×10^{-2} m in a vacuum.

Which row identifies the regions of the electromagnetic spectrum to which the waves belong?

	wavelength 5.0×10^{-7} m	wavelength 5.0×10^{-2} m
A	ultraviolet	infrared
B	visible	microwave
C	ultraviolet	microwave
D	visible	infrared

26 The wavelength of sound in air may be determined by using stationary waves.

In one experiment, a loudspeaker produces a sound wave of constant frequency which is reflected directly back along its original path by a metal plate approximately 1 m away. A microphone connected to a cathode-ray oscilloscope (CRO) is moved between the loudspeaker and plate to identify regions of high sound intensity ('loud' spots) and low sound intensity ('quiet' spots).

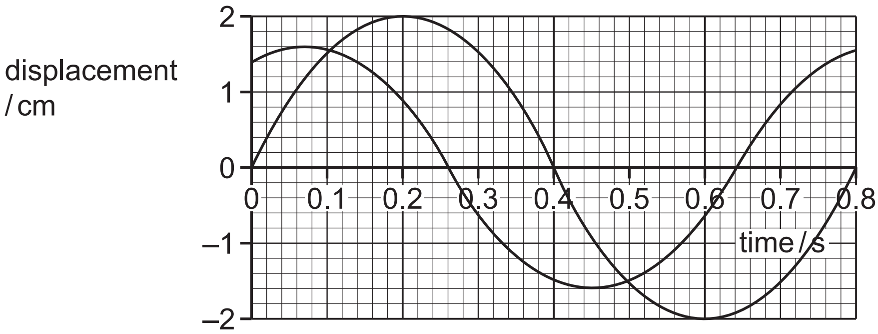
The wavelength of the sound is determined using the **least** possible number of measured quantities.

Which row shows the quantities that are needed?

	frequency of sound	mean separation of 'quiet' spots	speed of sound in air
A	✓	✓	✗
B	✓	✗	✓
C	✓	✗	✗
D	✗	✓	✗

key
✓ = needed
✗ = not needed

27 Two progressive waves meet at a fixed point P. The variation with time of the displacement of each wave at point P is shown.



The two waves superpose at point P.

What is the resultant displacement at time 0.38 s?

A +1.0 cm **B** –1.0 cm **C** +1.8 cm **D** –1.8 cm

28 In which situation does diffraction occur?

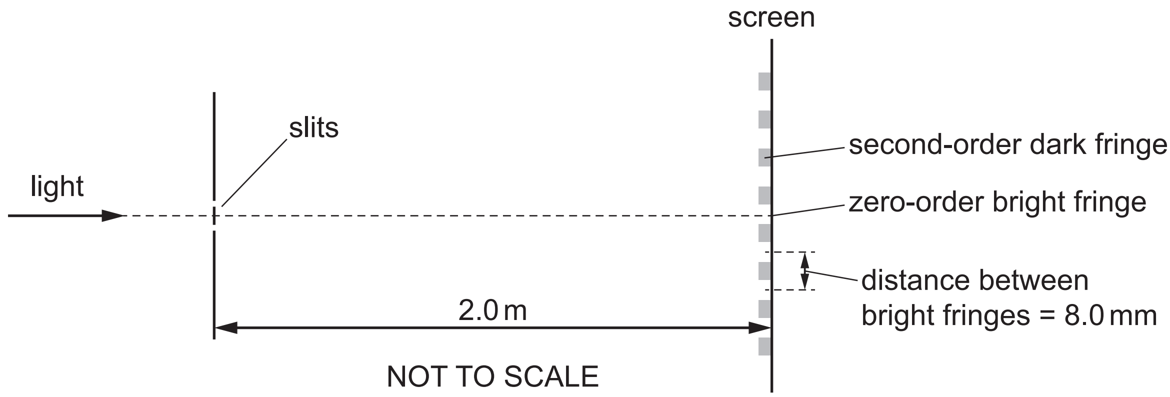
A A wave bounces back from a surface.

B A wave passes from one medium into another.

C A wave passes through a gap in a barrier.

D Waves from two identical sources are superposed.

29 Light of a single frequency is incident on a pair of narrow slits that are a distance of 0.10 mm apart. A series of bright and dark fringes is observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference of the light waves from the two slits that meet at the second-order **dark** fringe?

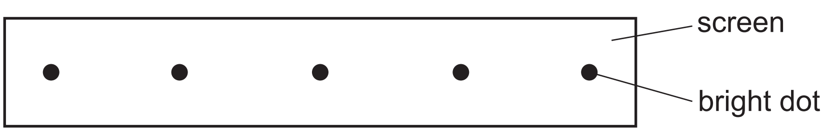
A 2.0×10^{-7} m

B 4.0×10^{-7} m

C 6.0×10^{-7} m

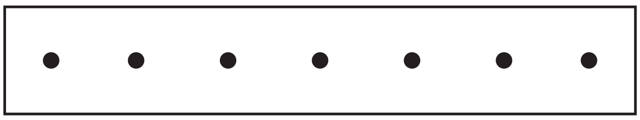
D 8.0×10^{-7} m

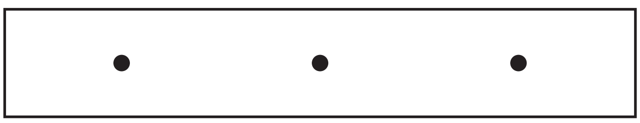
30 Red light of a single wavelength passes through a diffraction grating. Bright dots are formed on a screen, as shown.

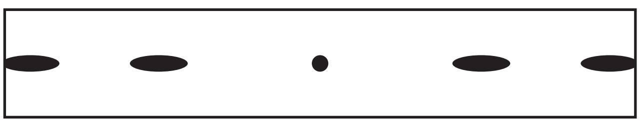


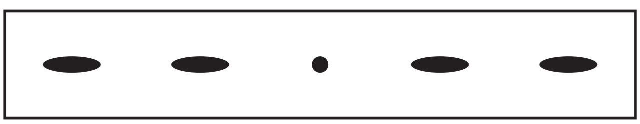
The red light is replaced with white light.

Which diagram, drawn to the same scale, shows a possible pattern of bright light on the screen?

A


B


C


D


31 A nichrome wire has a resistance of 15 Ω and a diameter of 3.0 mm. The number density of the free electrons in nichrome is $9.0 \times 10^{28}\,m^{-3}$.

A potential difference (p.d.) of 6.0 V is applied between the ends of the wire.

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

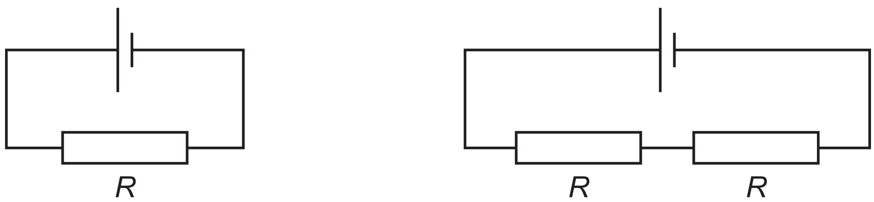
A $9.8 \times 10^{-7}\,m\,s^{-1}$

B $3.9 \times 10^{-6}\,m\,s^{-1}$

C $6.1 \times 10^{-6}\,m\,s^{-1}$

D $2.5 \times 10^{-5}\,m\,s^{-1}$

32 The diagrams show two different circuits.



The cells in each circuit have the same electromotive force (e.m.f.) and negligible internal resistance. The three resistors each have the same resistance *R*.

In the circuit on the left, the power dissipated in the resistor is *P*.

What is the total power dissipated in the circuit on the right?

A $\frac{P}{4}$ **B** $\frac{P}{2}$ **C** P **D** $2P$

33 The potential difference (p.d.) across a filament lamp is increased.

Which statement is correct?

A The resistance of the lamp decreases because the temperature decreases.

B The resistance of the lamp decreases because the temperature increases.

C The resistance of the lamp increases because the temperature decreases.

D The resistance of the lamp increases because the temperature increases.

34 A metal wire has resistance *R*.

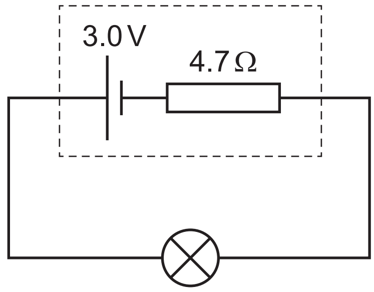
The wire is stretched so that its diameter decreases to 94.0% of the original diameter.

The volume of the wire is unchanged.

What is the resistance of the stretched wire?

A $1.06R$ **B** $1.13R$ **C** $1.20R$ **D** $1.28R$

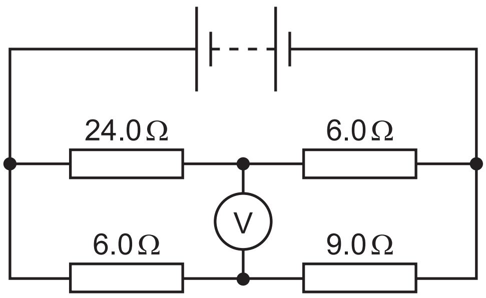
35 The diagram shows a cell of electromotive force (e.m.f.) 3.0 V and internal resistance 4.7 Ω connected across a lamp. The lamp has a resistance of 9.3 Ω.



What is the power dissipated by the internal resistance of the cell?

A 0.22 W **B** 0.43 W **C** 0.64 W **D** 1.0 W

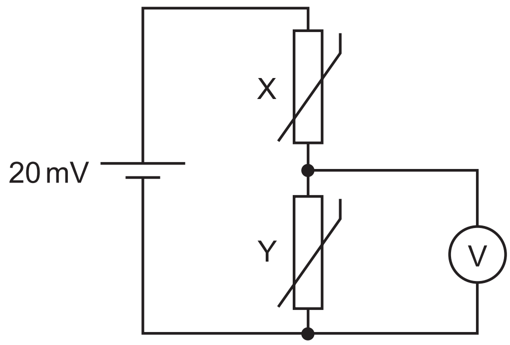
36 A circuit consists of a battery, a high-resistance voltmeter and four fixed resistors, as shown. The battery has an electromotive force (e.m.f.) of 15.0 V and negligible internal resistance.



What is the reading on the voltmeter?

A 3.0 V **B** 6.0 V **C** 9.0 V **D** 12.0 V

37 A potential divider circuit is designed to detect the difference in temperature between two different places.



The cell has electromotive force (e.m.f.) 20 mV and negligible internal resistance.

Initially, thermistors X and Y are at the same temperature and have the same resistance. The voltmeter reads 10 mV. X is then placed in a cold environment and its resistance doubles. Y is placed in a warm environment and its resistance halves.

What is the new reading on the voltmeter?

A 4 mV **B** 5 mV **C** 15 mV **D** 16 mV

38 In the α-particle scattering experiment, a beam of α-particles is aimed at a thin gold foil. Most of the α-particles go straight through or are deflected by a small angle. A very small proportion are deflected by more than 90°, effectively rebounding towards the source of the α-particles.

Which conclusion about the structure of atoms **cannot** be drawn from this experiment alone?

A Most of the atom is empty space.

B Most of the mass of an atom is concentrated in the nucleus.

C The nucleus contains both protons and neutrons.

D The nucleus is charged.

39 Which two particles have opposite charges?

A alpha-particle and helium nucleus

B antiproton and beta-plus particle

C beta-minus particle and electron

D positron and proton

40 Which particle is a lepton?

A meson

B positron

C proton

D quark

Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2022**

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)

7056058865

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.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

Data

acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$
speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of proton	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$
Avogadro constant	$N_\mathrm{A} = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_\mathrm{o} = \dfrac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

1 A train of mass 600 000 kg moves with a speed of $100\,\text{km}\,\text{h}^{-1}$.

What is the order of magnitude of the kinetic energy of the train?

A 10^{6} J **B** 10^{8} J **C** 10^{10} J **D** 10^{12} J

2 What are the SI base units of electromotive force (e.m.f.)?

A $\text{kg}\,\text{m}^{2}\,\text{s}^{-1}\,\text{A}^{-1}$

B $\text{kg}\,\text{m}^{2}\,\text{s}^{-3}\,\text{A}^{-1}$

C $\text{kg}\,\text{m}^{2}\,\text{s}^{-1}\,\text{A}$

D $\text{kg}\,\text{m}\,\text{s}^{-3}\,\text{A}^{-1}$

3 A digital meter is used to measure the current in an electric circuit.

The reading on the meter fluctuates (varies) between 3.04 A and 3.08 A. The readings on the meter have an accuracy of $\pm 1\%$.

What is the true value of the current, with its uncertainty?

A (3.06 ± 0.02) A

B (3.06 ± 0.04) A

C (3.06 ± 0.05) A

D (3.06 ± 0.07) A

4 Which quantity is a vector quantity?

A density

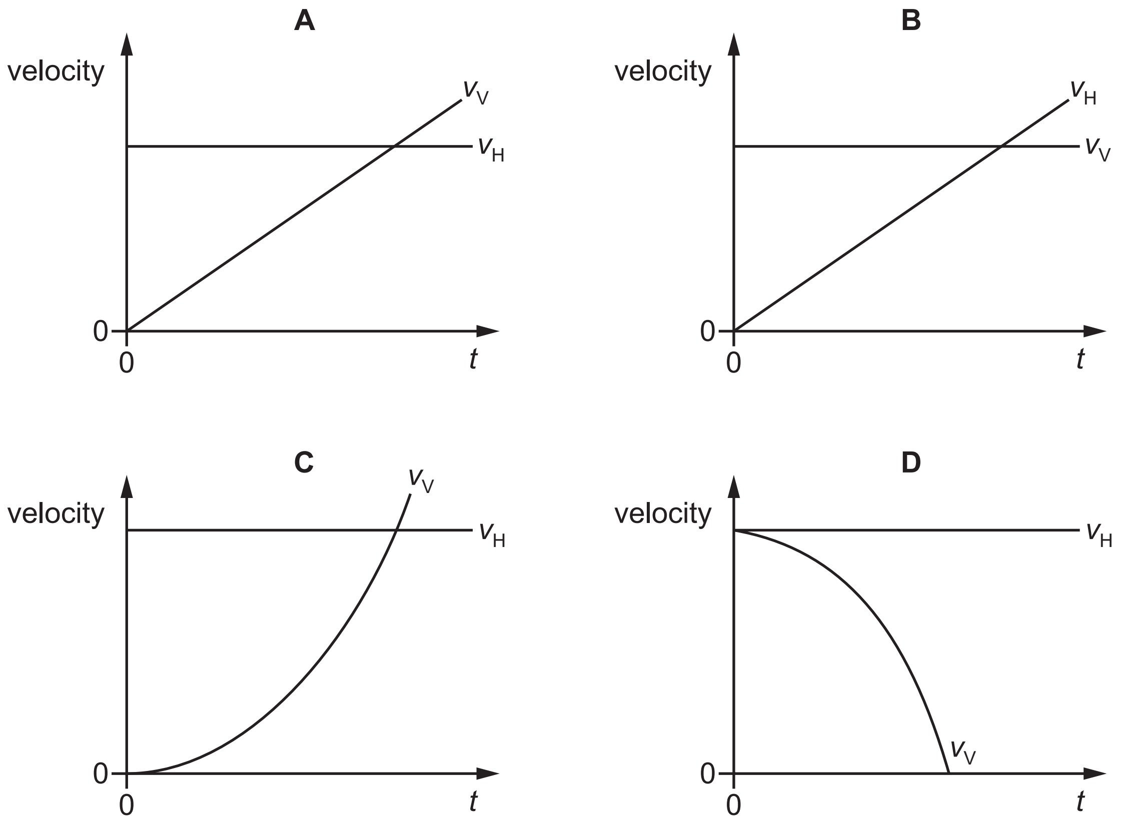
B mass

C volume

D weight

5 A stone is projected horizontally at time $t = 0$ and falls. Air resistance is negligible. The stone has a horizontal component of velocity v_H and a vertical component of velocity v_V.

Which graph shows how v_H and v_V vary with time t?



6 On the Earth, an object takes time T_E to fall from rest through a vertical distance h.

On the Moon, the same object takes time T_M to fall from rest through the same vertical distance h.

The ratio $\dfrac{\text{acceleration of free fall on the Earth}}{\text{acceleration of free fall on the Moon}}$ is equal to 6.

Air resistance is negligible for the object on the Earth and on the Moon.

What is the ratio $\dfrac{T_E}{T_M}$?

A $\dfrac{1}{6}$ **B** $\dfrac{1}{\sqrt{6}}$ **C** $\sqrt{6}$ **D** 6

7 A cyclist in still air pedals as hard as she can. She reaches a maximum speed. However, after a certain time her maximum speed increases.

What could be a possible cause for this?

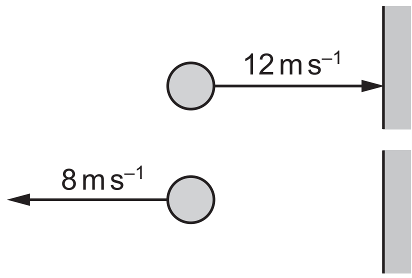
A She cycles into a wind.

B She cycles over rougher ground.

C She sits more upright on the bicycle.

D She starts to travel downhill.

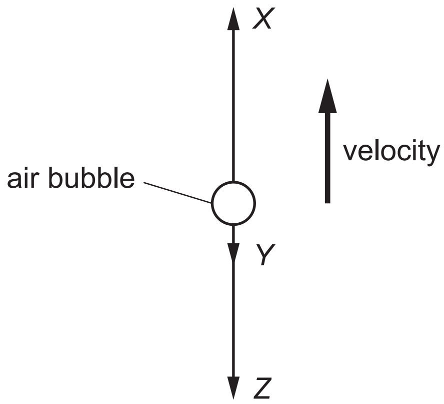
8 A ball of mass 0.5 kg hits a vertical wall at a speed of $12\,\text{m}\,\text{s}^{-1}$. It bounces back along its original path with a speed of $8\,\text{m}\,\text{s}^{-1}$. The collision lasts for 0.10 s.



What is the average force on the ball due to the collision?

A 0.2 N **B** 1 N **C** 20 N **D** 100 N

9 An air bubble in a tank of water is rising with terminal (constant) velocity. The forces acting on the bubble are X, Y and Z, as shown.



The upthrust on the bubble is X.

Which statement about the forces is correct?

A Z is the viscous force on the bubble, Y is the weight of the bubble and $X = Y + Z$.

B Z is the viscous force on the bubble, Y is the weight of the bubble and $X > Y + Z$.

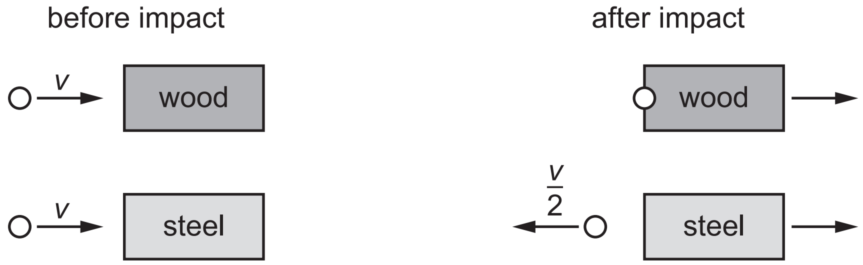
C Z is the weight of the bubble, Y is the viscous force on the bubble and $X = Y + Z$.

D Z is the weight of the bubble, Y is the viscous force on the bubble and $X > Y + Z$.

10 Two blocks are at rest on a frictionless horizontal surface. One block is made of wood and the other block is made of steel.

A steel ball is fired horizontally with a speed v at the wooden block. The ball embeds itself in the block, and the ball and block move together after impact.

A second identical steel ball is fired horizontally with speed v at the steel block. The steel ball then rebounds back along its original path with speed $\frac{v}{2}$.



The wooden block and the steel block have equal mass.

Which statement about the blocks immediately after the collisions is correct?

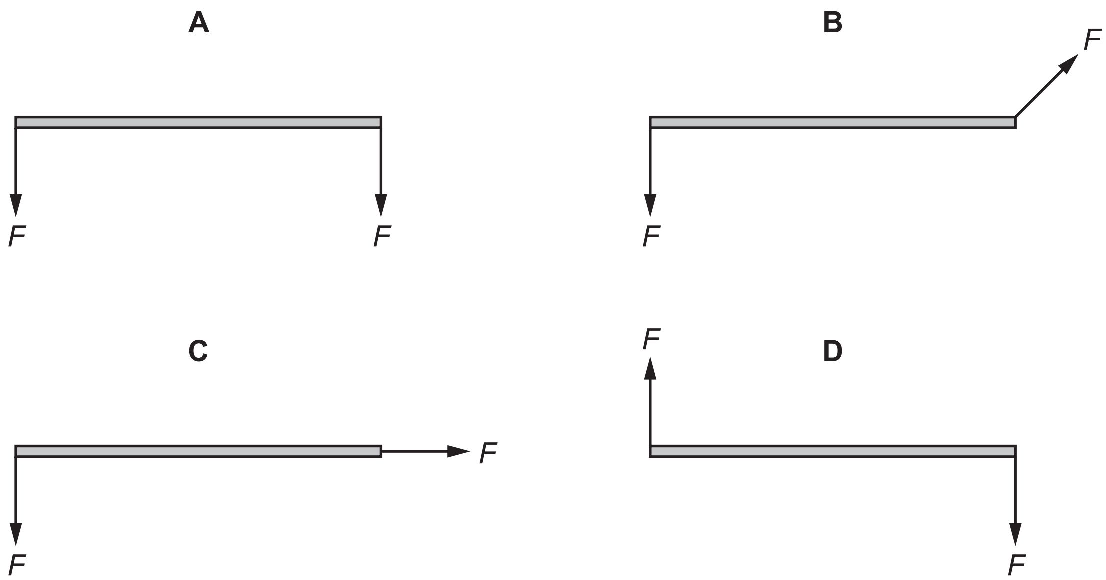
A Both blocks must travel with the same speed.

B The steel block must travel faster than the wooden block.

C The wooden block must travel faster than the steel block.

D The masses of the blocks and the steel ball are needed to determine which block travels faster.

11 Which diagram shows a couple formed by two forces, each of magnitude F, acting on a rod?



12 A student states that:

> 'If an object is in equilibrium, the sum of the clockwise moments about a point X is equal to the sum of the anticlockwise moments about a point Y.'

Which condition would make the student's statement correct?

A Either X or Y is the centre of gravity of the object.

B Either X or Y is the pivot of the object.

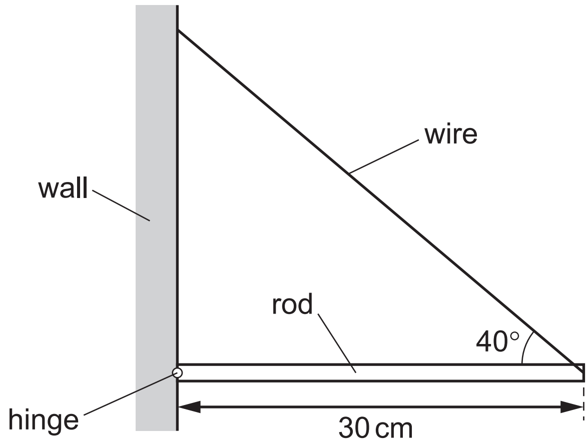
C X and Y are at opposite ends of the object.

D X and Y are the same point on the object.

13 A uniform rod of length 30 cm and weight 5.2 N is attached to a wall by a hinge at one end.

The other end of the rod is supported by a wire so that the rod is horizontal and in equilibrium.

The wire is at an angle of 40° to the horizontal.



What is the tension in the wire?

A 3.4 N **B** 4.0 N **C** 6.8 N **D** 8.1 N

14 Water is pumped through a nozzle at the end of a hose. The nozzle has a circular cross-section of diameter 50 mm. A mass of 100 kg of water takes a time of 2.0 s to move through the nozzle. The density of water is 1000 kg m^{-3}.

What is the speed of the water in the nozzle?

A 6.4 $m s^{-1}$ **B** 13 $m s^{-1}$ **C** 25 $m s^{-1}$ **D** 51 $m s^{-1}$

15 A solid wooden cube rests on a horizontal surface.

What gives the pressure exerted by the weight of the cube on the horizontal surface?

A the product of the acceleration of free fall and the density of the cube

B the product of the acceleration of free fall, the density and the side length of the cube

C the product of the acceleration of free fall, the density and the area of one face of the cube

D the product of the acceleration of free fall, the density and the volume of the cube

16 Which expression could be used to calculate power?

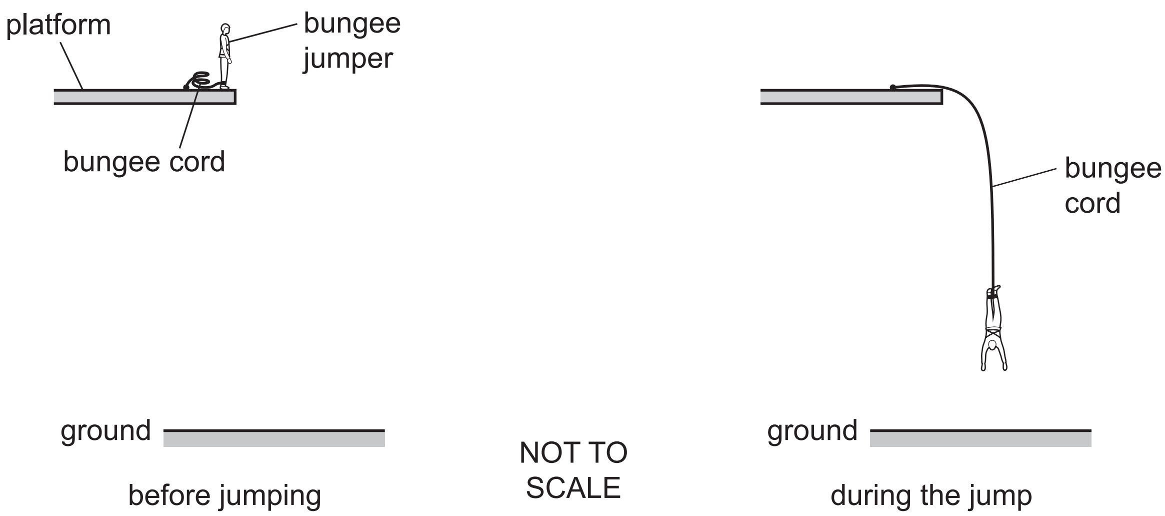
A $\dfrac{(\text{current})^2}{\text{resistance}}$

B $\dfrac{\text{force} \times \text{displacement}}{\text{time}}$

C $\text{current} \times (\text{resistance})^2$

D $\dfrac{\text{weight}}{\text{time}}$

17 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



When the jumper makes the jump, his initial gravitational potential energy is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

A on the platform before the jump

B on the way down before the cord has started to extend

C on the way down as he decelerates

D at the bottom of the jump when he is stationary

18 An object is displaced horizontally to the right in a uniform vertical gravitational field.

Which statement describes the change in the gravitational potential energy of the object?

A It decreases in direct proportion to the displacement.

B It does not change with the displacement.

C It increases in direct proportion to the displacement.

D It increases in direct proportion to the square of the displacement.

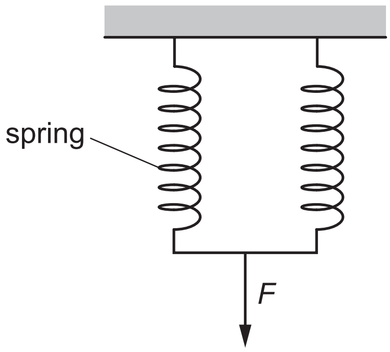
19 A copper wire of length 3.6 m and diameter 1.22 mm is stretched by a force of 37 N. The wire obeys Hooke's law. The Young modulus of copper is 1.17×10^{11} Pa.

Which extension is caused by this force?

A 0.24 mm **B** 0.76 mm **C** 0.97 mm **D** 3.1 mm

20 A spring has spring constant k. The spring obeys Hooke's law and experiences extension x when a force F is applied to it. The resulting elastic potential energy of the spring is E_P.

The diagram shows two of these springs joined together in parallel and hanging from a fixed beam.

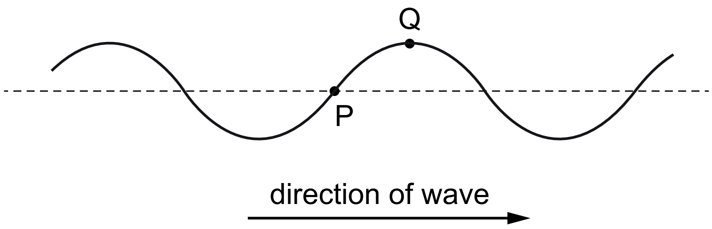


What is the extension and total elastic potential energy of this arrangement when the same force F is applied?

	extension	total elastic potential energy
A	$\frac{1}{2}x$	$\frac{1}{2}E_P$
B	$\frac{1}{2}x$	$\frac{1}{4}E_P$
C	x	$\frac{1}{2}E_P$
D	x	$\frac{1}{4}E_P$

21 The diagram shows a transverse wave on a rope. The wave is travelling from left to right.

At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.



Which row describes the direction of motion, if any, of the points P and Q at this instant?

	point P	point Q
A	downwards	stationary
B	stationary	downwards
C	stationary	upwards
D	upwards	stationary

22 The period of an electromagnetic wave in a vacuum 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}

23 An observer is standing on a railway platform. A train passes the observer at constant speed while emitting sound of constant frequency *f* from its whistle.

What does the observer hear?

A sound of a decreasing frequency as the train approaches and of an increasing frequency as it moves away

B sound of a higher frequency than *f* as the train approaches and of a lower frequency than *f* as the train moves away

C sound of a lower frequency than *f* as the train approaches and of a higher frequency than *f* as the train moves away

D sound of an increasing frequency as the train approaches and as it moves away

24 Which microorganisms have a length that is equal to the wavelength in free space of an electromagnetic wave that is visible to the human eye?

A algae of length 0.5 μm

B bacteria of length 5.0 μm

C fungi of length 50 μm

D protozoa of length 100 μm

25 Two progressive waves overlap.

What is an essential condition for the two waves to form a stationary wave?

A The waves are longitudinal.

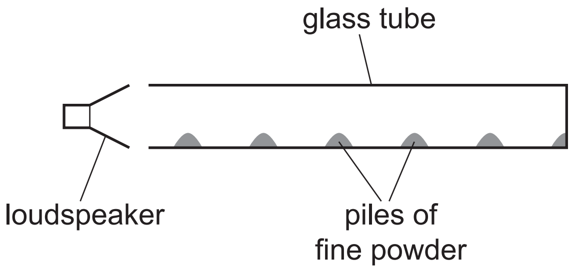
B The waves are polarised.

C The waves travel in opposite directions.

D The waves travel in the same direction.

26 In an experiment to produce a stationary sound wave in air, a fine powder is initially evenly distributed along the length of a horizontal glass tube which is closed at one end.

At the open end of the tube, a loudspeaker emits a sound wave of a constant wavelength. A stationary wave is formed and the powder accumulates in regularly spaced piles, as shown.



Which statement explains the positions of the piles of powder within the tube?

A The piles are where the air molecules vibrate with maximum amplitude.

B The piles are where the air molecules vibrate with minimum amplitude.

C The piles are where the air molecules vibrate with the highest frequency.

D The piles are where the air molecules vibrate vertically.

27 A sound wave of wavelength 0.50 m passes through a doorway of width 1.0 m between two rooms.

Which change increases the amount of diffraction that takes place?

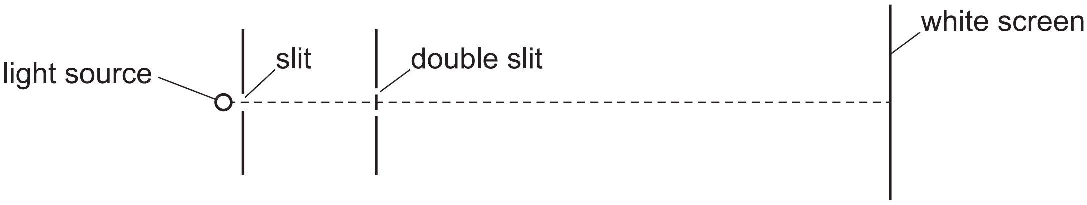
A Double the amplitude of the sound wave.

B Double the width of the doorway.

C Halve the frequency of the sound wave.

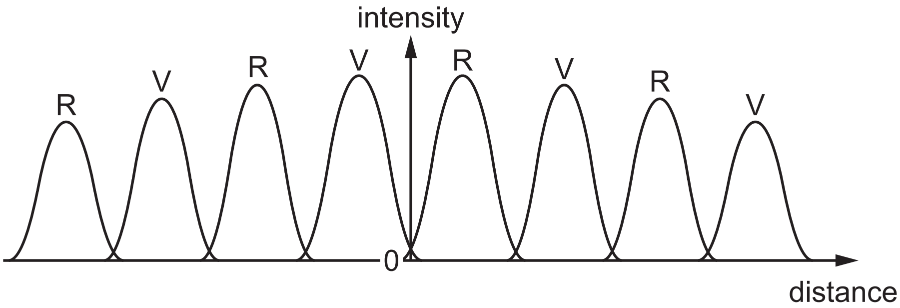
D Halve the period of the sound wave.

28 A light source consists of a vertical slit illuminated by red light (R) and violet light (V). The wavelength of R is approximately twice the wavelength of V. A parallel vertical double slit is placed nearby. A white screen is placed so that fringes are formed on it.



Which graph best represents the interference fringes formed on the screen?

A



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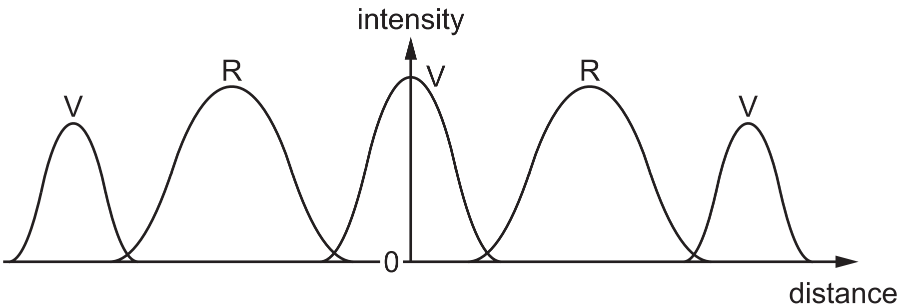
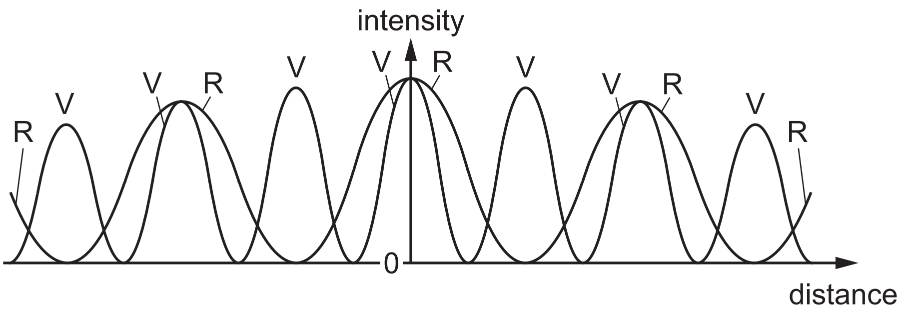
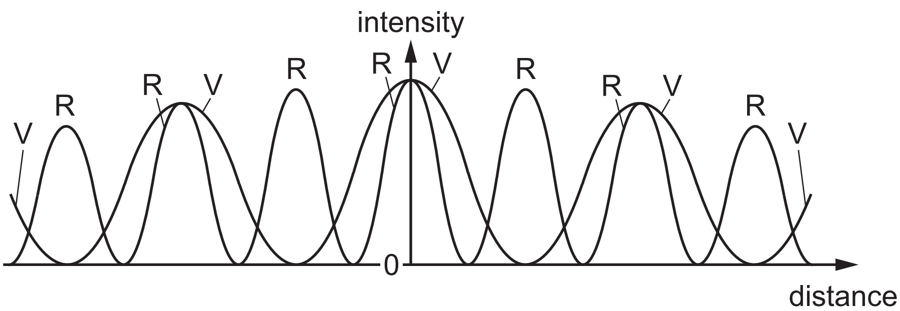


C



D



29 Which property of a light wave can be determined using a diffraction grating?

A amplitude

B intensity

C speed

D wavelength

30 There is an electric current in a copper wire.

Which statement describing the average drift speed of the charge carriers in the wire is correct?

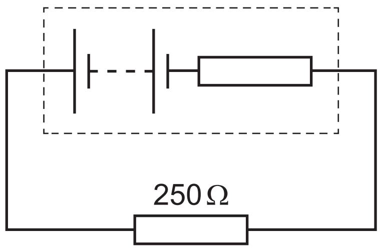
A It is nearly $3 \times 10^8\,\mathrm{m\,s^{-1}}$.

B It is proportional to the cross-sectional area of the wire.

C It is proportional to the length of the wire.

D It is proportional to the magnitude of the current.

31 A battery with a constant internal resistance is connected to a resistor of resistance $250\,\Omega$, as shown.

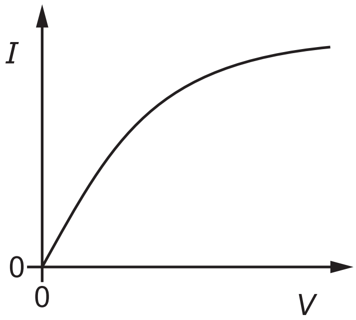


The current in the resistor is 40 mA for a time of 60 s. During this time 6.0 J of energy is dissipated by the internal resistance.

What is the energy supplied to the external resistor during the 60 s and the electromotive force (e.m.f.) of the battery?

	energy / J	e.m.f. / V
A	30	2.5
B	30	7.5
C	24	10.0
D	24	12.5

32 Which component has the I–V graph shown?



A filament lamp

B metallic conductor at constant temperature

C resistor of fixed resistance

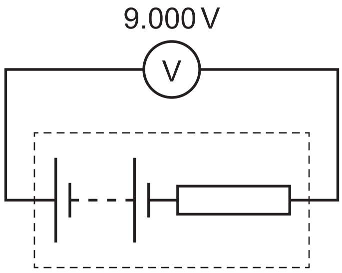
D semiconductor diode

33 Two wires, P and Q, have the same resistance. Wire Q is made of material that has twice the resistivity of the material used to make wire P. The diameter of wire Q is twice the diameter of wire P.

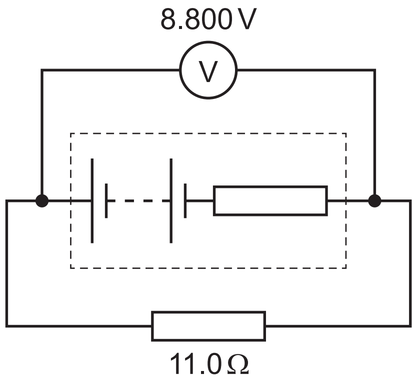
What is the ratio $\dfrac{\text{length of wire P}}{\text{length of wire Q}}$?

A $\dfrac{1}{8}$ **B** $\dfrac{1}{4}$ **C** $\dfrac{1}{2}$ **D** $\dfrac{2}{1}$

34 A voltmeter reads 9.000 V when it is connected across the terminals of a battery.



When a resistor of resistance 11.0 Ω is connected in parallel with the battery, the voltmeter reading changes to 8.800 V.



What is the internal resistance of the battery?

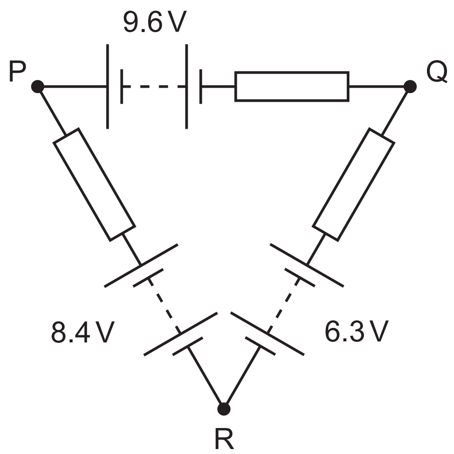
A 0.244 Ω **B** 0.250 Ω **C** 10.8 Ω **D** 11.3 Ω

35 Each of Kirchhoff's laws is linked to the conservation of a physical quantity.

Which conserved physical quantities are used in the derivation of Kirchhoff's first law and of Kirchhoff's second law?

	Kirchhoff's first law	Kirchhoff's second law
A	energy	charge
B	energy	momentum
C	charge	energy
D	momentum	energy

36 Three batteries and three identical resistors are connected in a circuit PQR, as shown.

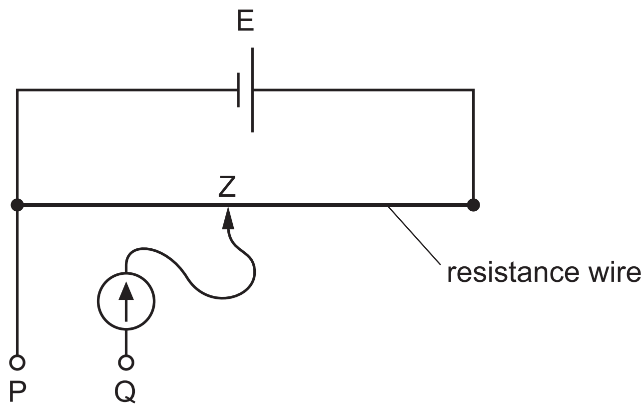


The batteries have negligible internal resistance.

What is the potential difference between points P and Q?

A 1.5 V **B** 2.1 V **C** 7.1 V **D** 12.1 V

37 A cell E, of electromotive force (e.m.f.) 2 V and negligible internal resistance, is connected to a uniform resistance wire of resistance 10 Ω and length 1.0 m.



Z is a connection that may be made at any position along the resistance wire. A galvanometer is connected between Z and a point Q.

A new source of e.m.f. of approximately 8 mV is connected between points P and Q. The e.m.f. of the new source is determined by changing the position of Z until the reading on the galvanometer is zero.

Which change to the circuit allows a much more precise value for the e.m.f. of the new source to be obtained?

A Add a resistor of resistance 0.1 Ω in series with cell E.

B Add a resistor of resistance 1000 Ω in series with cell E.

C Add a resistor of resistance 10 Ω in series with the new source.

D Add a resistor of resistance 800 Ω in series with the new source.

38 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?

A A tiny proportion of the alpha-particles are deflected through large angles.

B Slower alpha-particles are deflected through larger angles.

C The kinetic energies of the deflected alpha-particles are unchanged.

D The number of alpha-particles deflected depends on the thickness of the foil.

39 A nucleus X undergoes β^+ decay.

The products are a nucleus Y with proton number *Z*, a β^+ particle and another particle P.

$$X \rightarrow {}_{Z}Y + \beta^+ + P$$

What is particle P and what is the proton number of nucleus X?

	P	proton number of nucleus X
A	antineutrino	$Z - 1$
B	antineutrino	$Z + 1$
C	neutrino	$Z - 1$
D	neutrino	$Z + 1$

40 A particle consists of two up quarks and a charm quark.

What is the charge of this particle, expressed in terms of the elementary charge *e*?

A $-2e$ **B** $-e$ **C** $+e$ **D** $+2e$

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