Cambridge International AS & A Level

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.

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 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

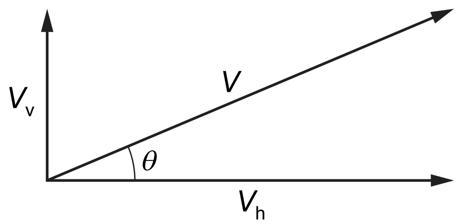
σ is a constant with units $W\,m^{-2}\,K^{-4}$.

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.

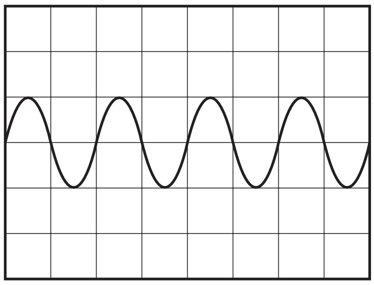
The components of the particle's velocity are V_v upwards in the vertical direction and V_h to the right in the horizontal direction, as shown.



What are expressions for the magnitude of V and for the angle θ?

	magnitude of V	θ
A	$\sqrt{(V_v^2 + V_h^2)}$	$\tan^{-1}\left(\dfrac{V_h}{V_v}\right)$
B	$\sqrt{(V_v^2 + V_h^2)}$	$\tan^{-1}\left(\dfrac{V_v}{V_h}\right)$
C	$\sqrt{(V_v^2 - V_h^2)}$	$\tan^{-1}\left(\dfrac{V_h}{V_v}\right)$
D	$\sqrt{(V_v^2 - V_h^2)}$	$\tan^{-1}\left(\dfrac{V_v}{V_h}\right)$

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?

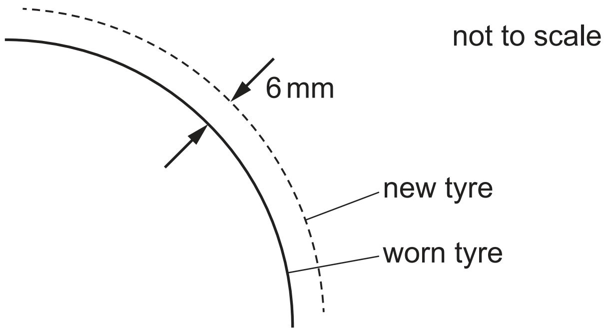
A 0.1 ms div^{-1} **B** 1 ms div^{-1} **C** 10 ms div^{-1} **D** 100 ms div^{-1}

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?

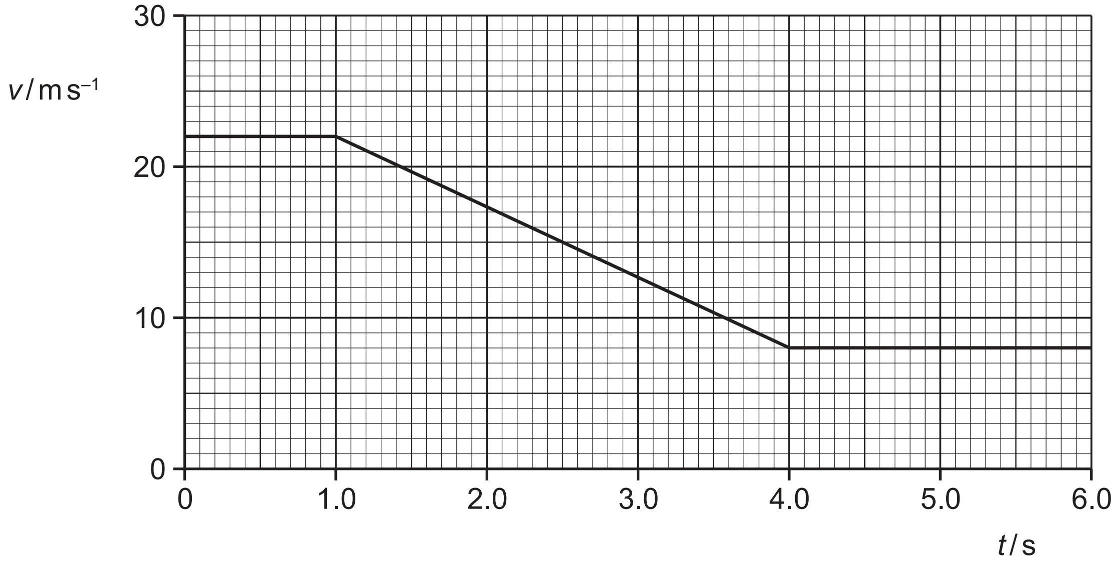
A The speed shown is too high by 1%.

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.



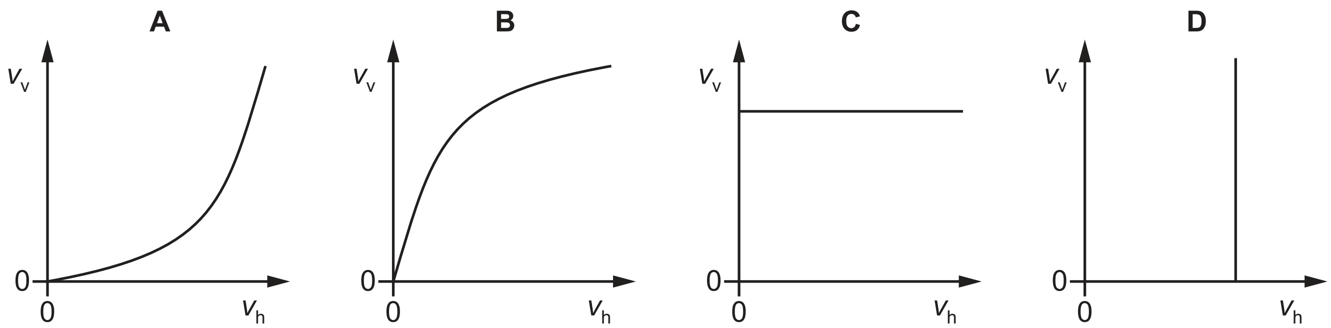
The brakes of the car are applied from t = 1.0 s to t = 4.0 s.

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

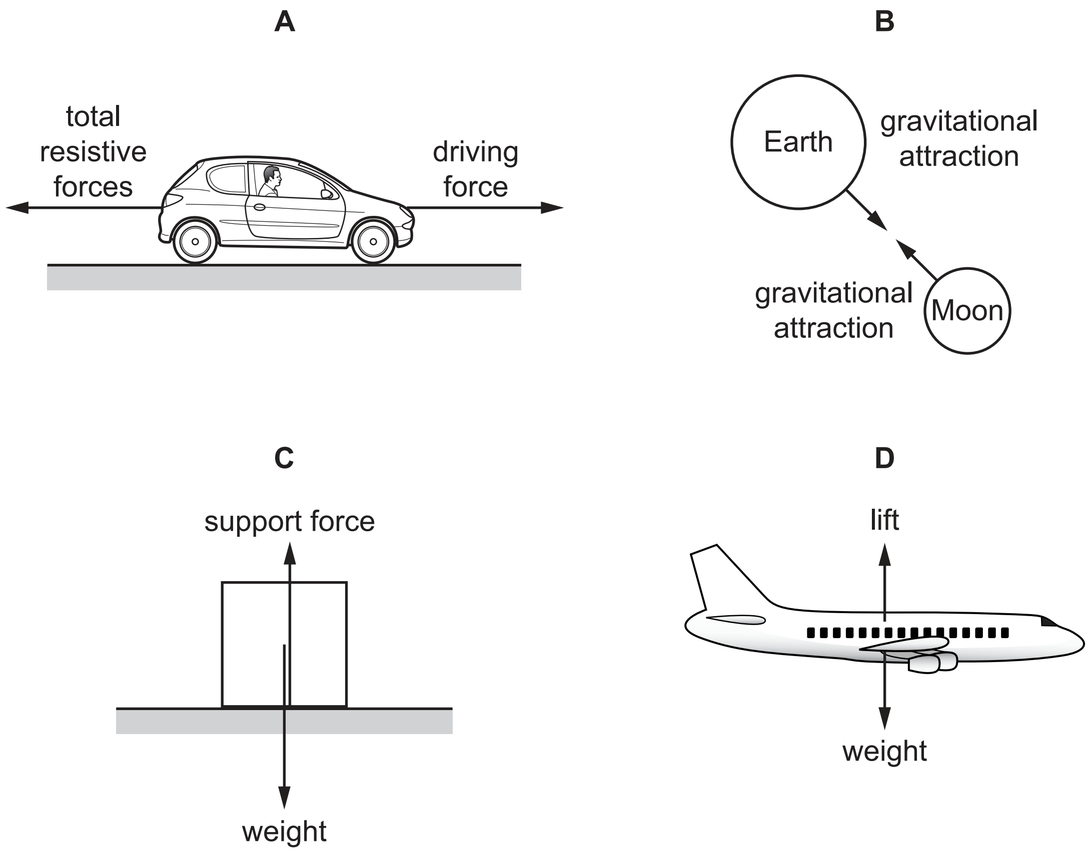
B 2.0×10^{-3} J

C 3.1×10^{-2} J

D 2.0 J

9 Each diagram illustrates a pair of forces of equal magnitude.

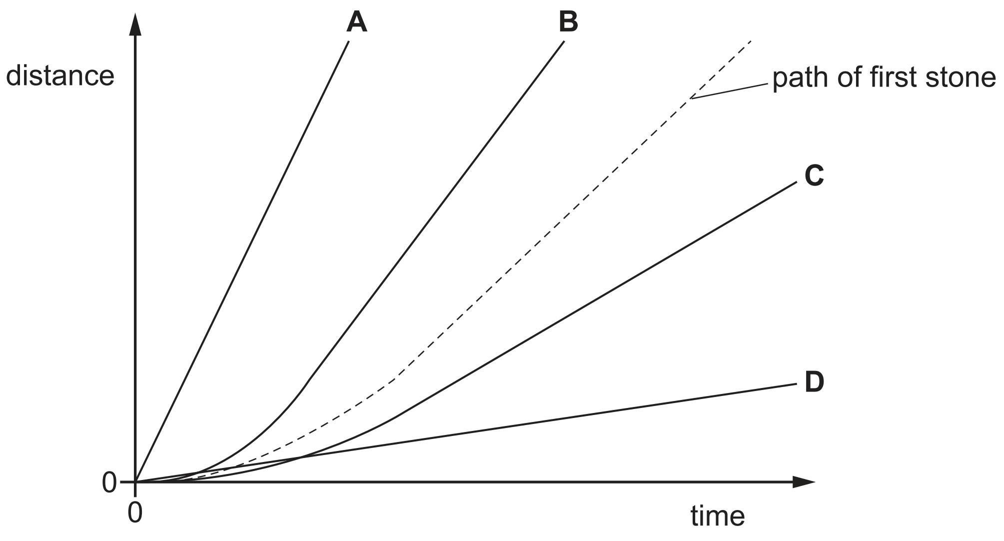
Which diagram gives an example of a pair of forces that is described by Newton's third law of motion?



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?

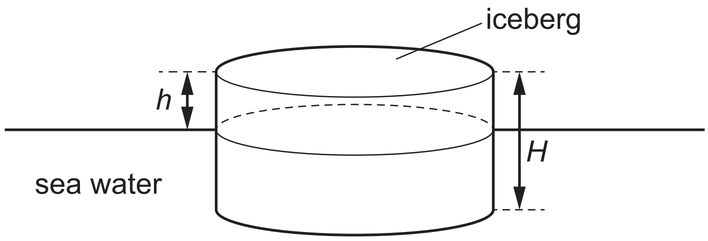


11 A helium atom of mass m collides normally with a wall. The atom arrives at the wall with speed v and then rebounds along its original path. Assume that the collision is perfectly elastic.

What is the change in the momentum of the atom during its collision?

A zero **B** $0.5mv$ **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.

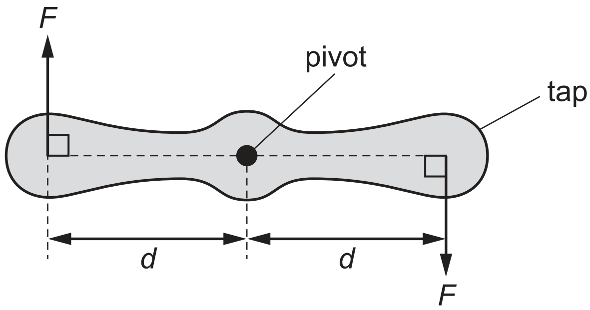


The density of ice is ρ_i and the density of sea water is ρ_w.

What is the height h of the iceberg above the sea water?

A $\left(1-\frac{\rho_i}{\rho_w}\right)H$ **B** $\left(\frac{\rho_i}{\rho_w}-1\right)H$ **C** $\frac{\rho_w}{\rho_i}H$ **D** $\frac{\rho_i}{\rho_w}H$

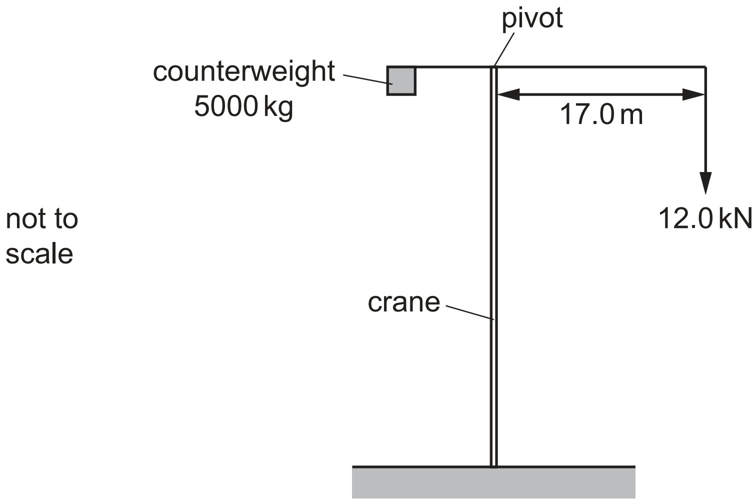
13 A couple is applied to a tap as shown.



What is the torque of the couple?

A $\frac{Fd}{2}$ **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.

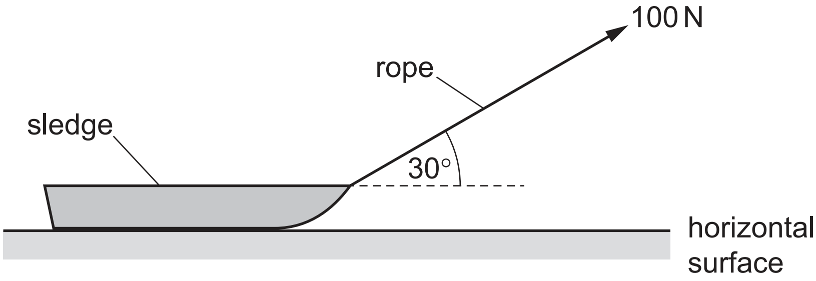
16 An empty glass beaker has a mass of 103 g. When filled with water, it has a total mass of 361 g. When filled with cooking oil, it has a total mass of 351 g.

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.

$$E_k = \tfrac{1}{2}mv^2$$

Which equation is **not** used in the derivation of this equation?

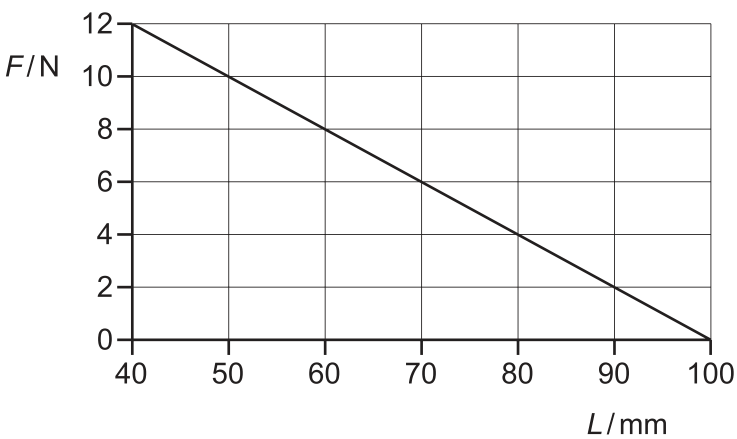
A $F = ma$ **B** $s = vt$ **C** $v^2 = u^2 + 2as$ **D** $W = Fs$

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 $3.0\,\text{m}\,\text{s}^{-1}$.

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

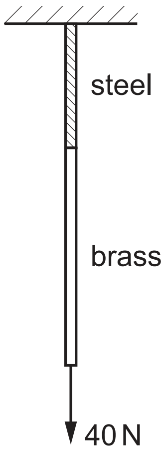
20 A spring of original length 100 mm is compressed by a force. The graph shows the variation of the compressing force F with the length L of the spring.



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 2.4×10^{-6} m^2.

The wires obey Hooke's law.

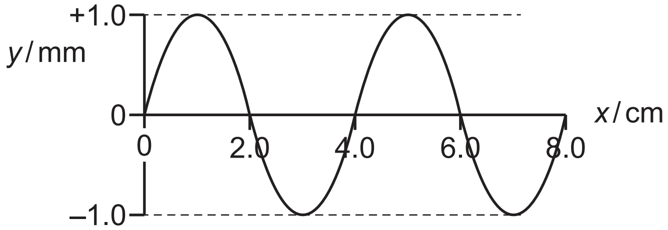
What is the total extension? Ignore the weights of the wires.

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.

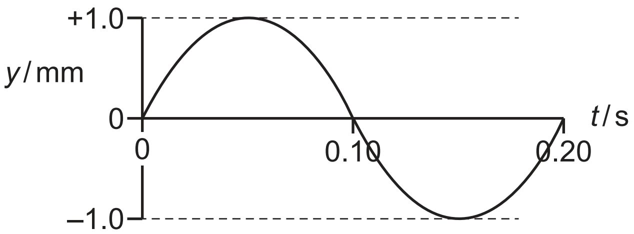
The speed of the wave is $20.0\,\text{cm}\,\text{s}^{-1}$.



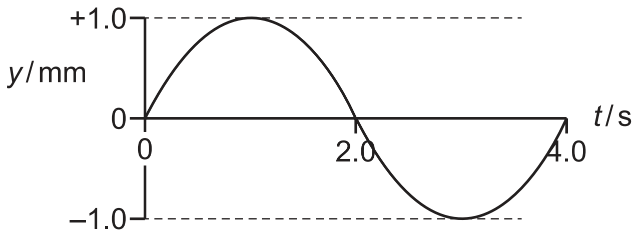
A particle of the medium oscillates vertically.

Which graph of vertical displacement y against time t best represents the motion of this particle?

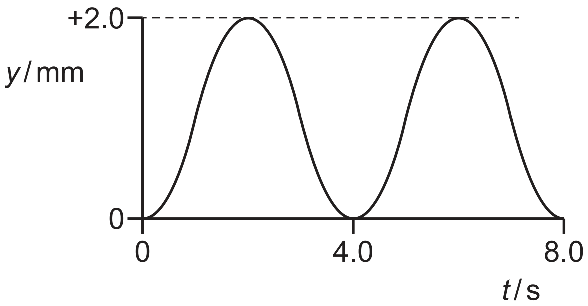
A



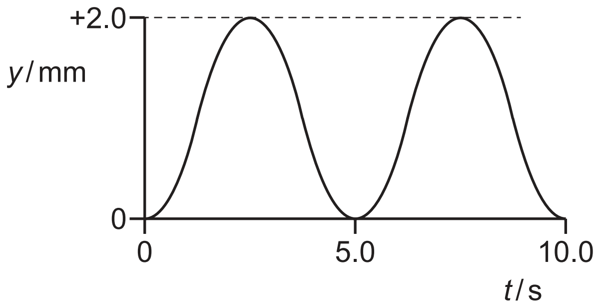
B



C

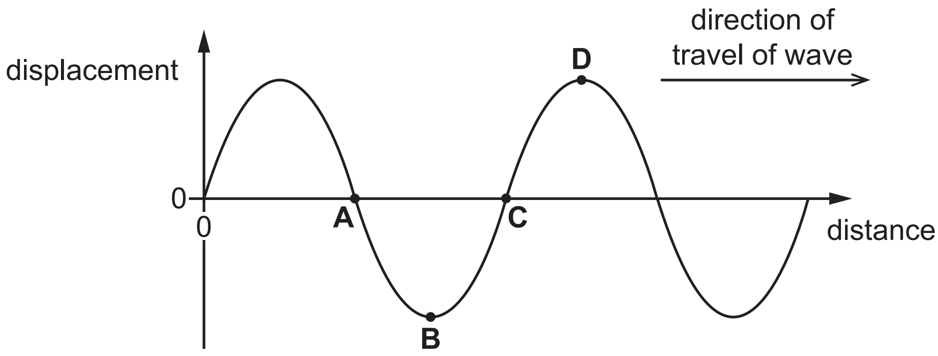


D



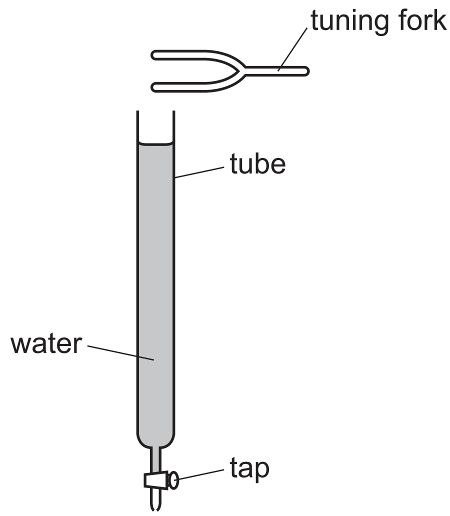
23 The graph shows the variation of the displacement of particles with distance along a transverse wave at an instant in time. The wave is moving to the right.

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.

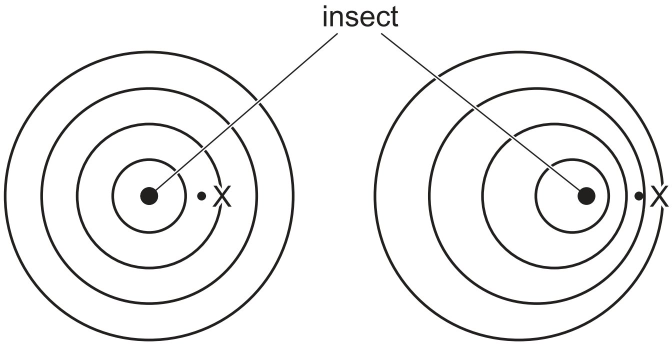


A louder sound is heard at intervals as the water runs out of the tube. The change in water level between louder sounds is 32 cm.

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 $1.5\,\text{m}\,\text{s}^{-1}$.

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 / $\text{m}\,\text{s}^{-1}$	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

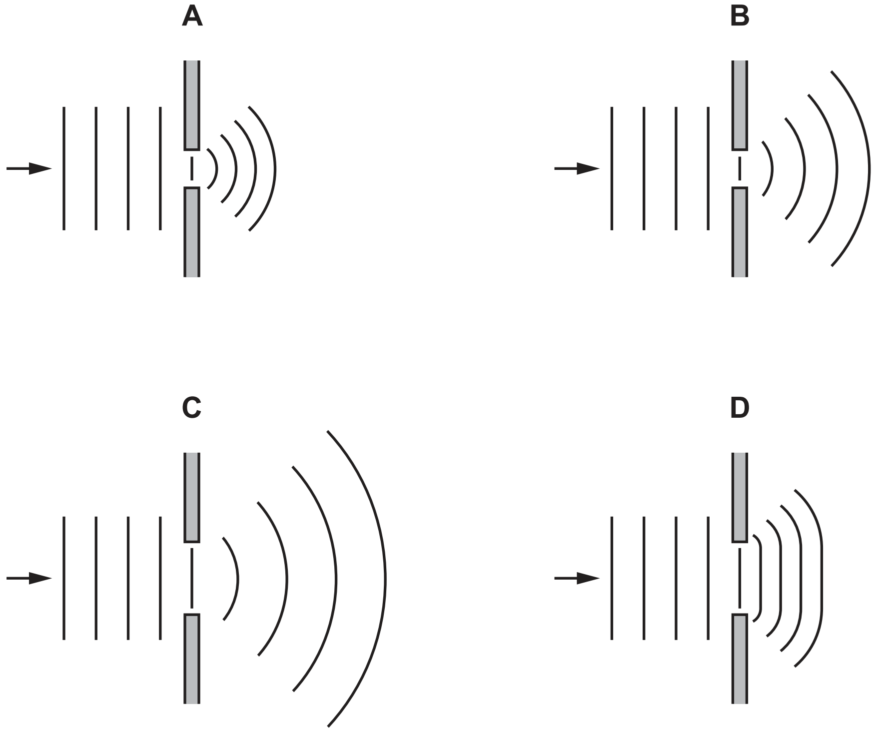
27 Two progressive waves of frequency 300 Hz superpose to produce a stationary wave in which adjacent nodes are 1.5 m apart.

What is the speed of the progressive waves?

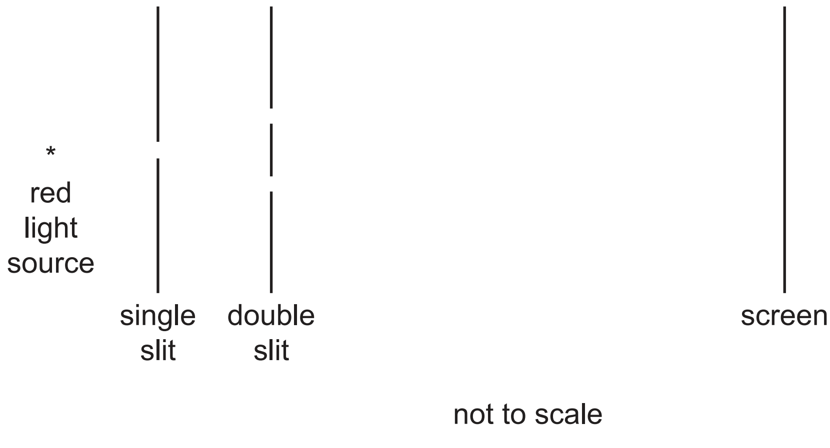
A $100\,\text{m}\,\text{s}^{-1}$ **B** $200\,\text{m}\,\text{s}^{-1}$ **C** $450\,\text{m}\,\text{s}^{-1}$ **D** $900\,\text{m}\,\text{s}^{-1}$

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

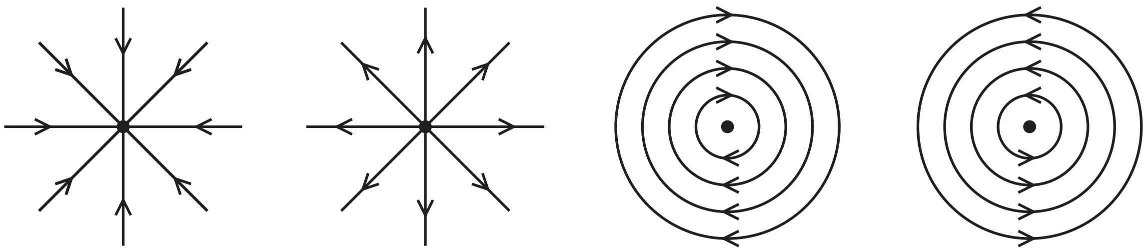
B 1.0×10^{-5} m

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?

A **B** **C** **D**



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?

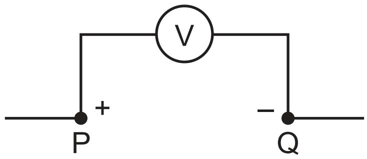
A -4.8×10^{-19} C

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?

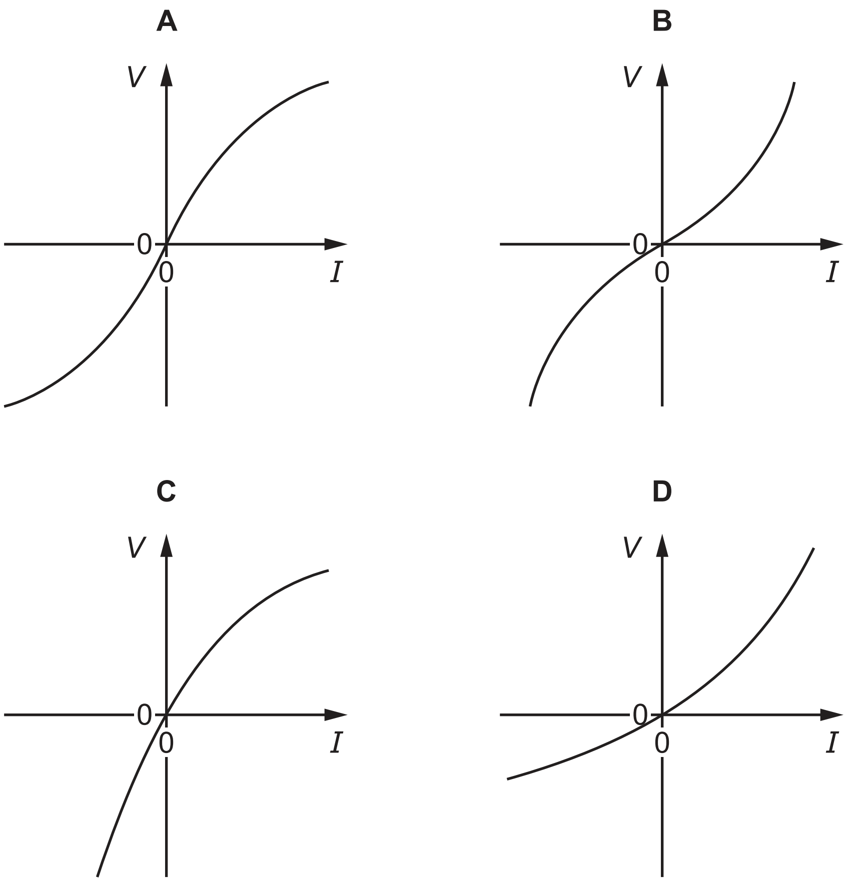
A The energy needed to move +1 C of charge from P to Q is 1 J.

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

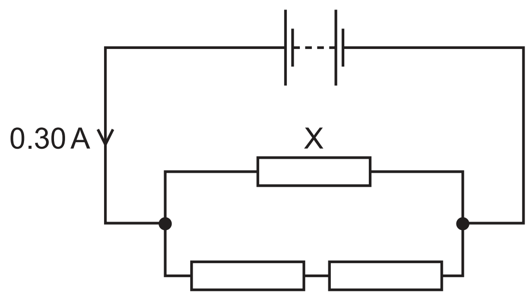
36 A cell is connected to a resistor of resistance 3.00 Ω. The current in the resistor is 1.00 A.

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.



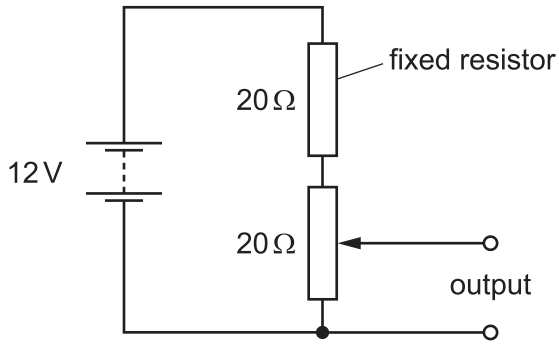
All three resistors have the same resistance.

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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