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.

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.

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Data

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

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	$f_\text{o} = \frac{f_\text{s} v}{v \pm v_\text{s}}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ...$

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%

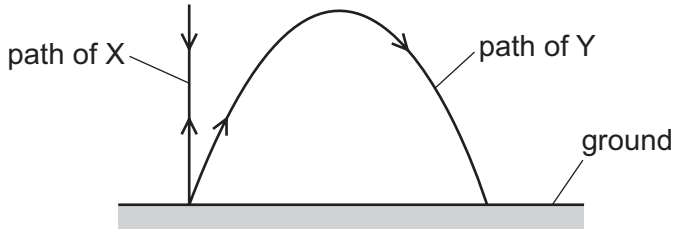
5 Forces of magnitudes 2 N, 4 N and 7 N combine to produce a resultant force.

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?

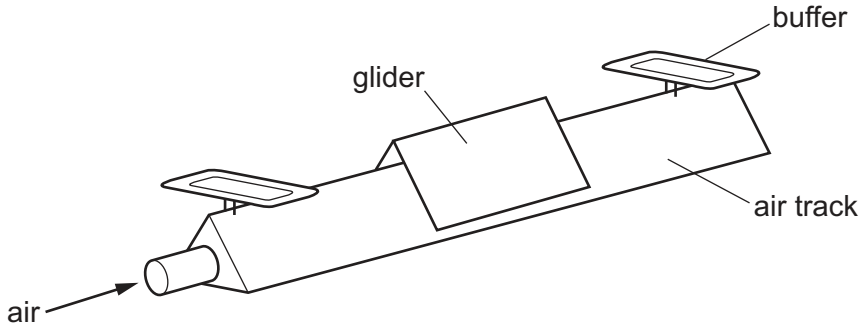
A X and Y are at rest at their maximum heights.

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.

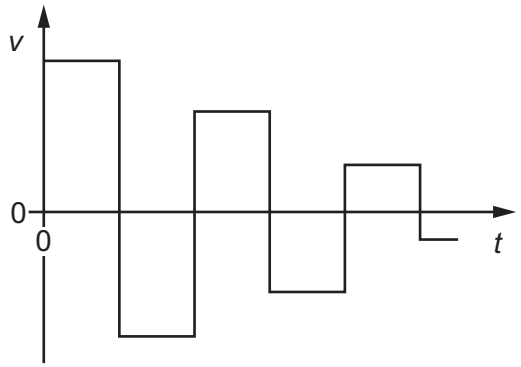


At each end of the air track, the glider has a perfectly elastic collision with a fixed buffer.

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?

A



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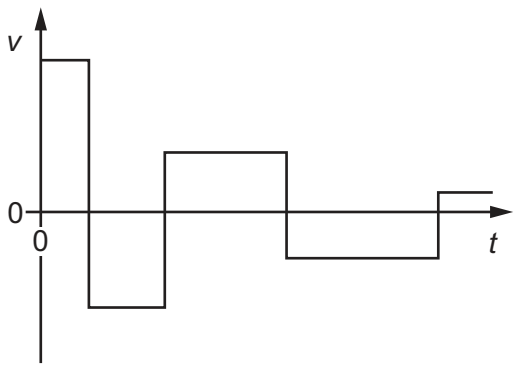
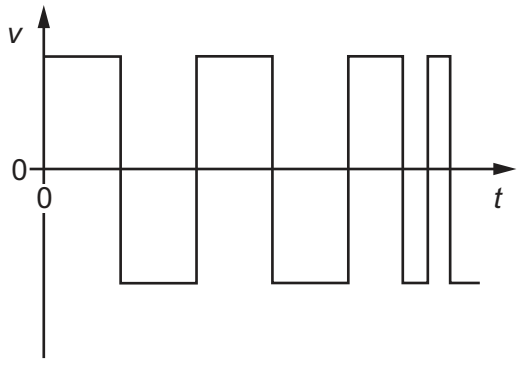
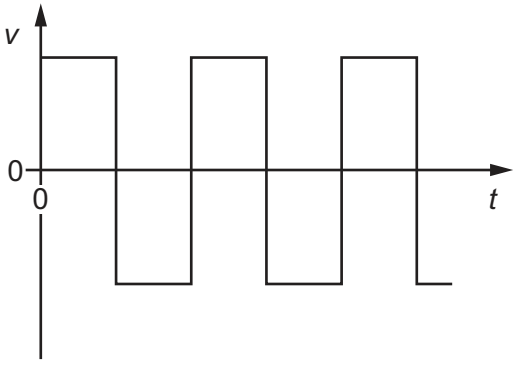


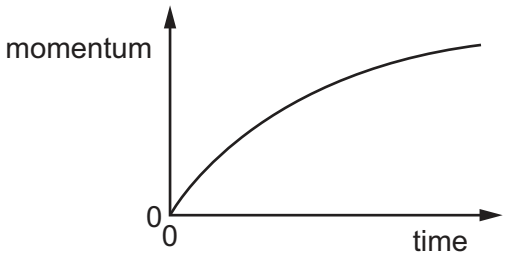
C



D



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

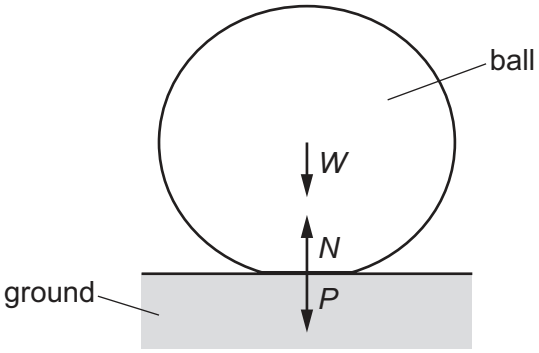
B the rate of change of kinetic energy of the car

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.

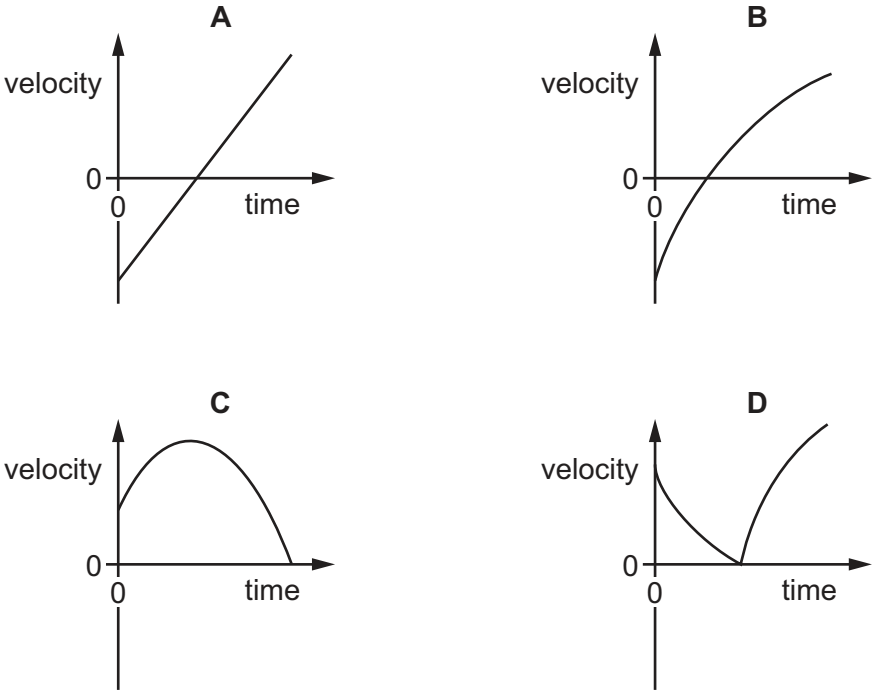
At this instant, which relationship is correct?

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?



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 $2.0\,m\,s^{-1}$ and the lighter skater is moving to the left at a speed of $1.0\,m\,s^{-1}$.

After the collision, the heavier skater moves to the right at a speed of $0.80\,m\,s^{-1}$.

What is the relative speed of separation of the two skaters?

A $0.6\,m\,s^{-1}$ **B** $1.4\,m\,s^{-1}$ **C** $2.2\,m\,s^{-1}$ **D** $2.6\,m\,s^{-1}$

12 Which statement describes the two forces in a couple?

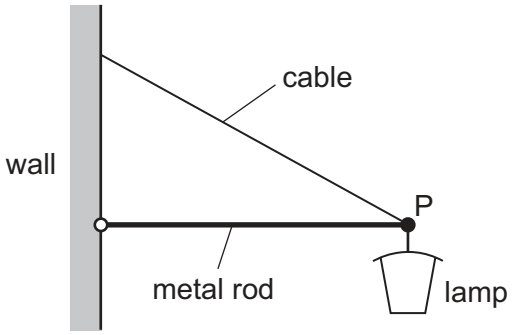
A They act in the same direction.

B They act through the same point.

C They produce zero resultant force.

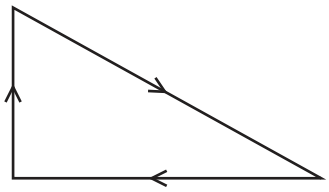
D They produce zero resultant moment.

13 A street lamp is fixed to a wall by a metal rod and a cable.

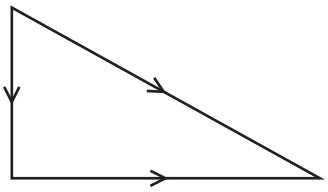


Which vector triangle could represent the forces acting on the end of the rod at point P?

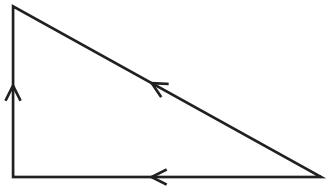
A



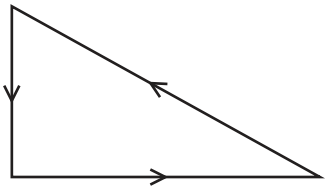
B



C

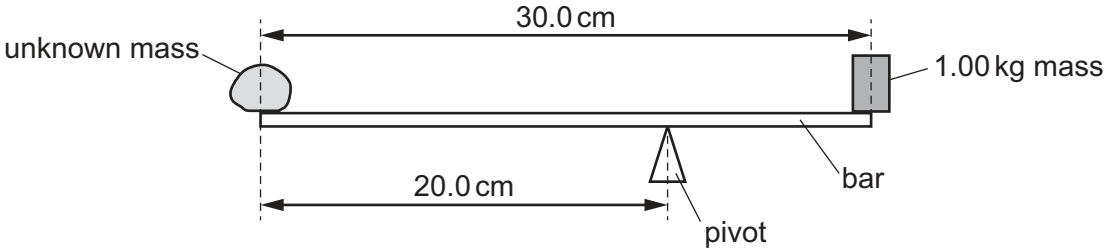


D



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.

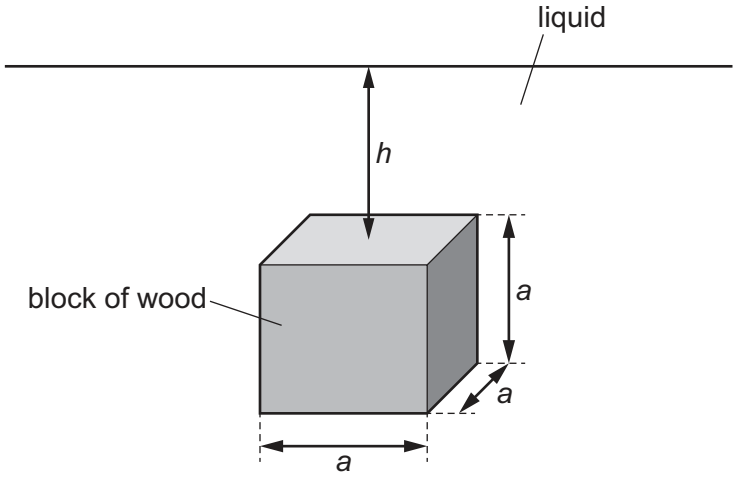


What is the unknown mass?

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?

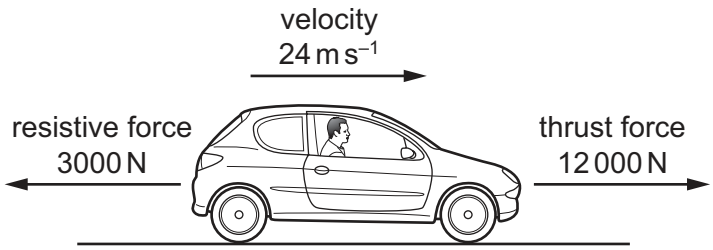
A the difference between the useful energy output from the system and the total energy input

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.

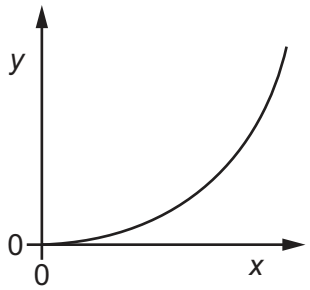


At one instant, the thrust force acting on the car from the engine is 12 000 N and the resistive force acting on the car is 3000 N. The velocity of the car at this instant is 24 m s^{-1}.

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?

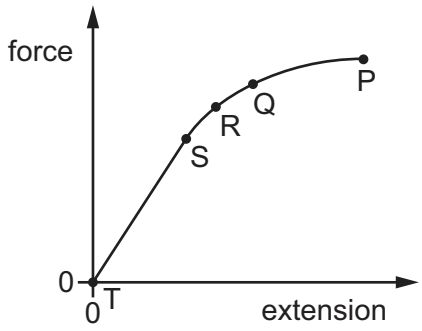
A 3.0×10^{-7} m

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.

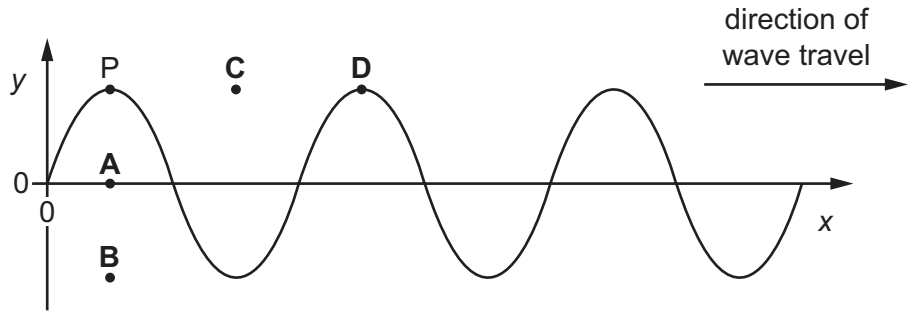
D The wire obeys Hooke's law up to a point between R and Q.

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.

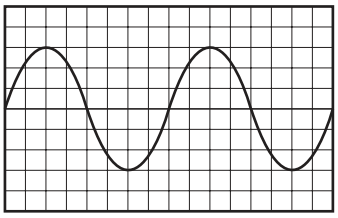
A point P on the rope is marked. The diagram shows the original position of P and four new positions.

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

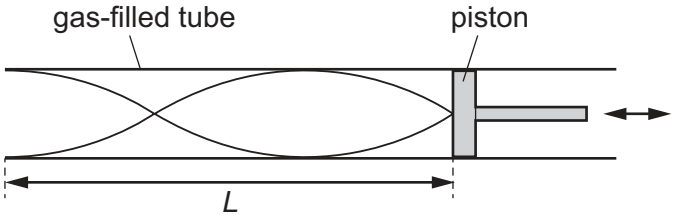
B displacement

C intensity

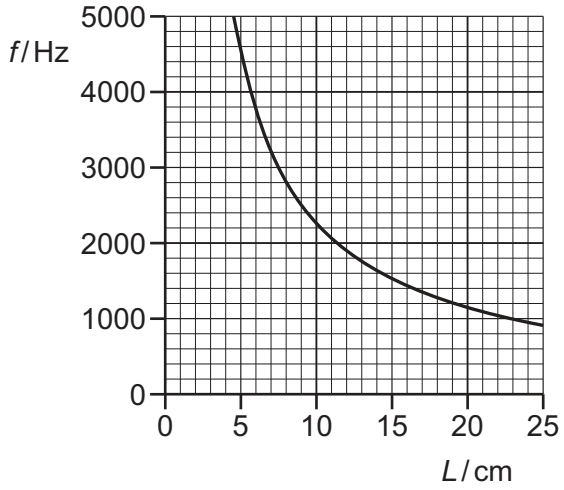
D wavelength

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.

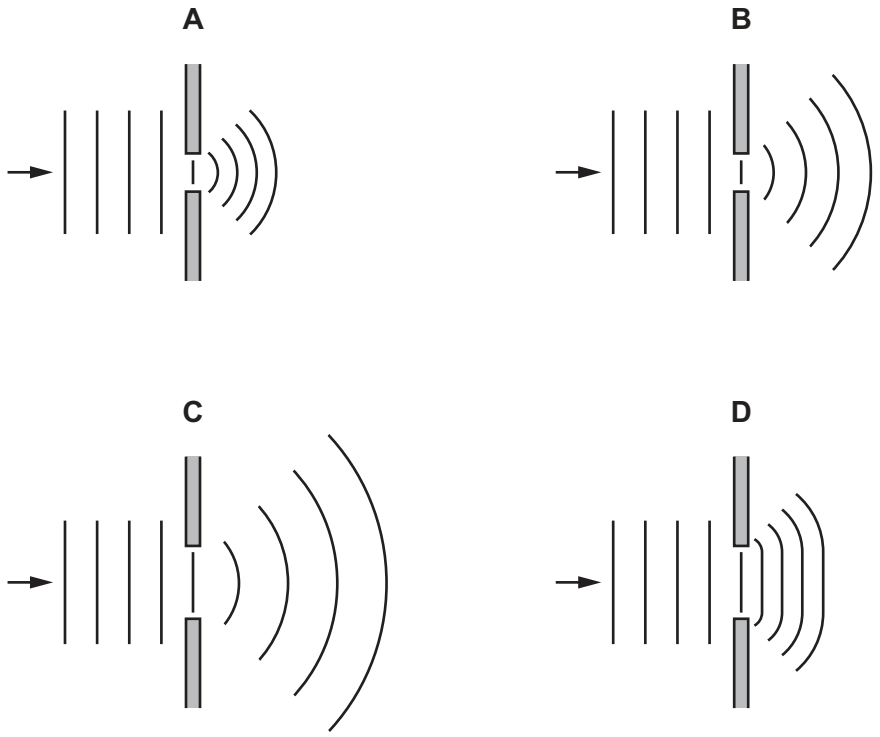


What is the speed of sound in the gas in the tube?

A $150\,m\,s^{-1}$ **B** $230\,m\,s^{-1}$ **C** $300\,m\,s^{-1}$ **D** $340\,m\,s^{-1}$

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.

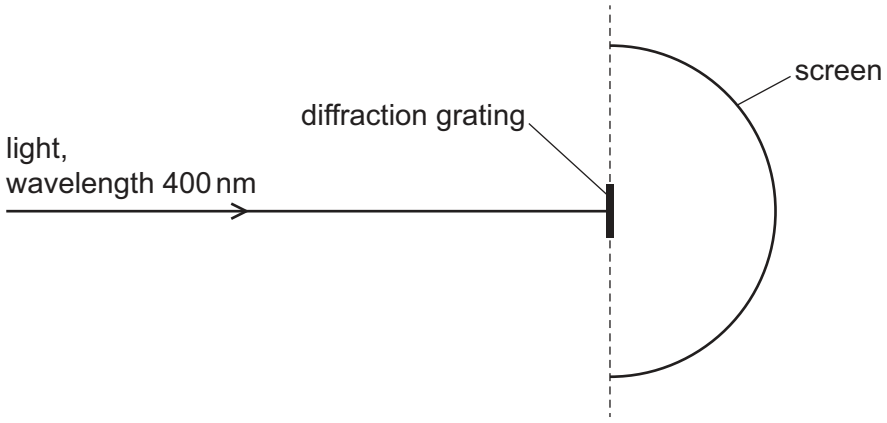
The separation of the two slits is *a*. The distance between the slits and the screen is *D*. The distance between the centres of two adjacent bright fringes is *x*.

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 $\frac{\text{average drift speed of free electrons in wire X}}{\text{average drift speed of free electrons in wire Y}}$?

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

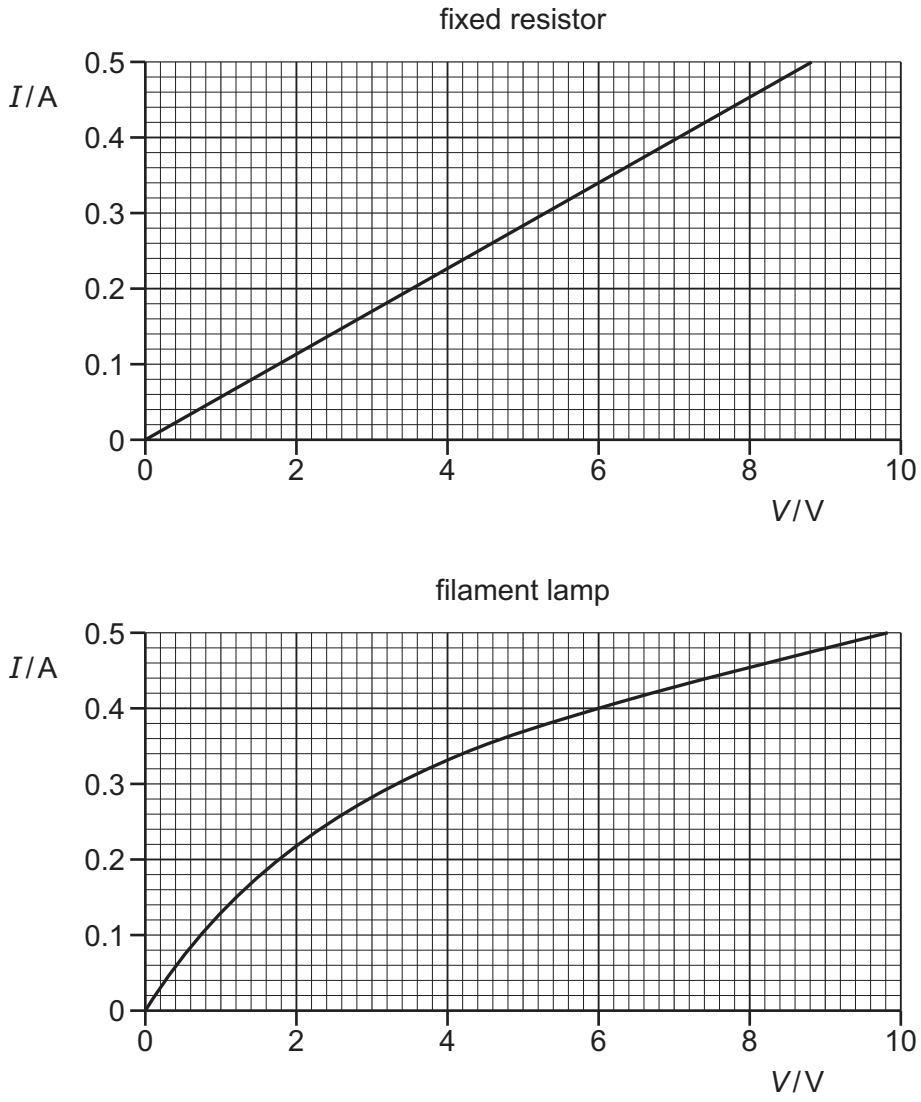
33 A resistor has resistance R. When the potential difference (p.d.) across the resistor is V, the current in the resistor is I. The power dissipated in the resistor is P. Work W is done when charge Q flows through the resistor.

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.

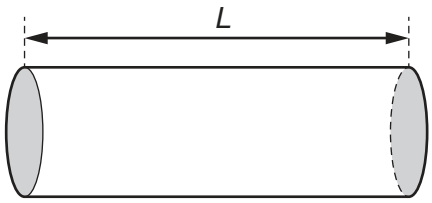
What is the resistance of the filament lamp?

A 0.081 Ω **B** 12 Ω **C** 15 Ω **D** 18 Ω

[Turn over

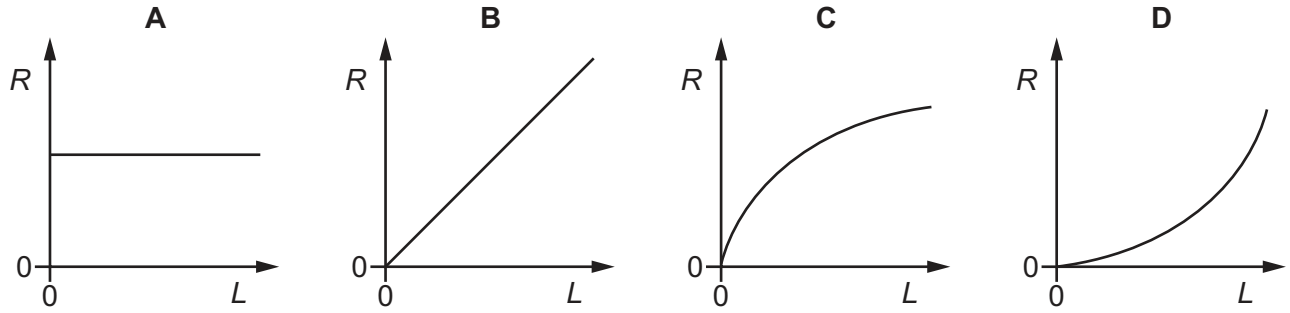
35 A piece of conducting putty (modelling clay) of constant resistivity is formed into a cylindrical shape.

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

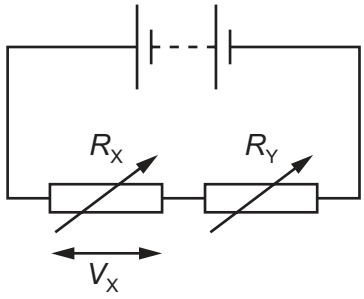
C loudspeaker

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.