



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.

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

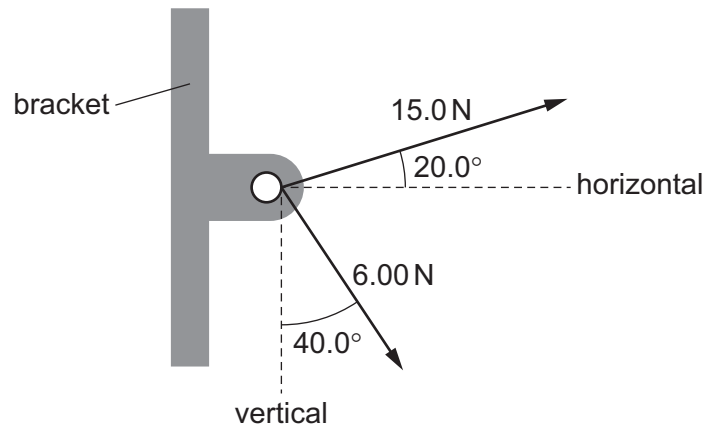
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
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	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
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	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

- 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 JC^{-1} and $\text{kg m}^2 \text{A}^{-1} \text{s}^{-2}$
 - B Js and $\text{kg m}^2 \text{s}^{-1}$
 - C Nm and $\text{kg m}^3 \text{s}^{-2}$
 - D Ns and kg m s^{-3}
- 3 A value for the acceleration of free fall on Earth is given as $(10 \pm 2) \text{ms}^{-2}$.
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.

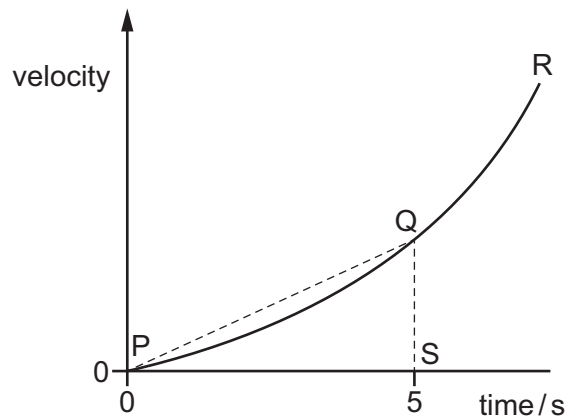
- 4 Two cables are attached to a bracket and exert forces as shown.



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 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?

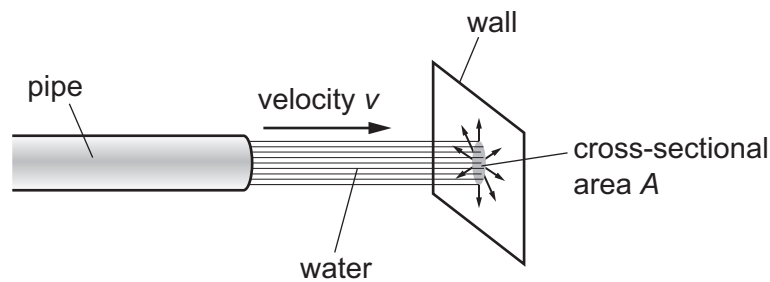
- A 10 m s^{-1} B 29 m s^{-1} C 31 m s^{-1} D 39 m s^{-1}

- 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.



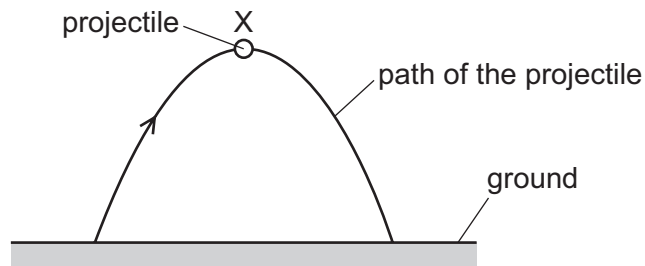
When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A .

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?

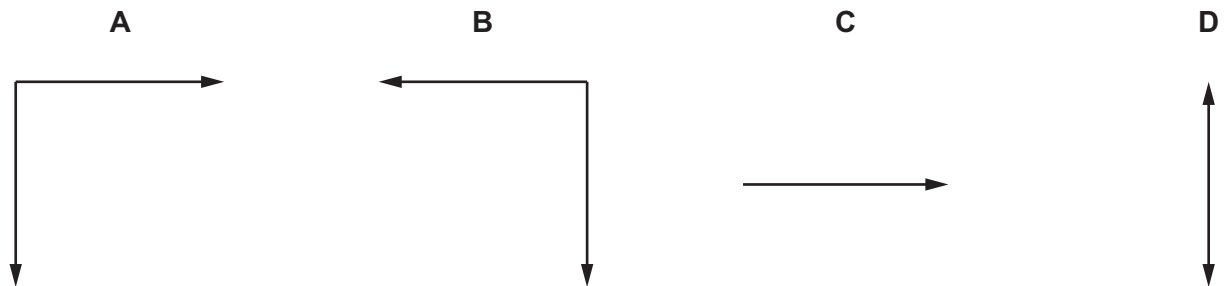
- A $\frac{\rho v}{A}$ B $\frac{\rho v^2}{A}$ C $\rho A v$ D $\rho A v^2$

- 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.

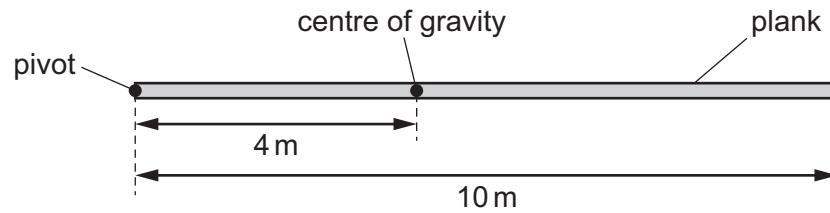
Which diagram shows the **directions** of the force or forces acting on the projectile at position X?



- 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.



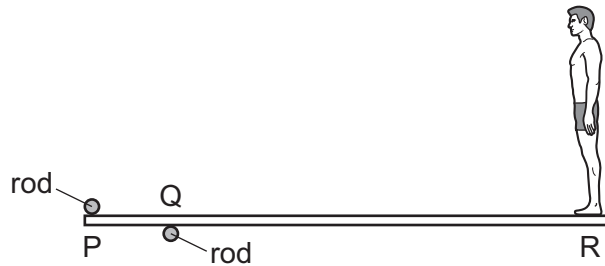
The plank has a mass of 100 kg and a length of 10 m. The centre of gravity of the plank is a distance of 4 m from the pivot.

What is the moment of the weight of the plank about the pivot?

- A** $4 \times 10^2 \text{ Nm}$ **B** $5 \times 10^2 \text{ Nm}$ **C** $4 \times 10^3 \text{ Nm}$ **D** $5 \times 10^3 \text{ Nm}$
- 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.

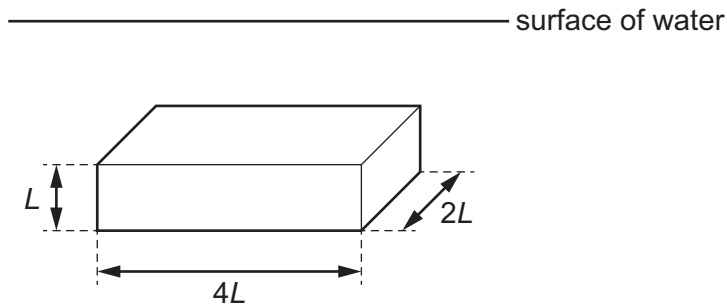


The forces exerted by the rods on the board are vertical. The board remains in equilibrium as the person slowly moves towards point Q from end R.

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}

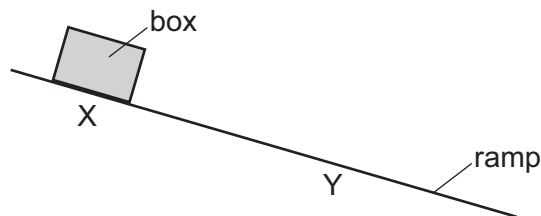
4000 kg of oil of density 910 kg m^{-3} .

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

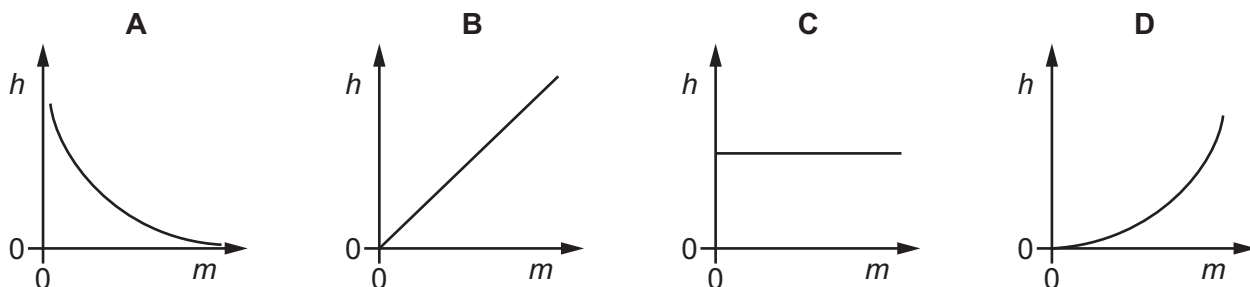
- 17** The total energy supplied to an electric motor is E . Energy Q is wasted and the remaining energy does useful work.

What is the efficiency of the motor?

- A** $\frac{Q}{E}$ **B** $\left(\frac{Q}{E}\right) - 1$ **C** $1 - \left(\frac{Q}{E}\right)$ **D** $\frac{(1-Q)}{E}$

- 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.

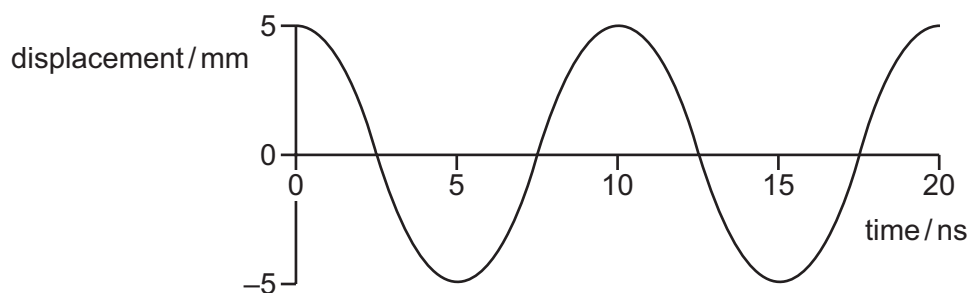
What is the ratio $\frac{\text{extension of wire P}}{\text{extension of wire Q}}$?

- 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.

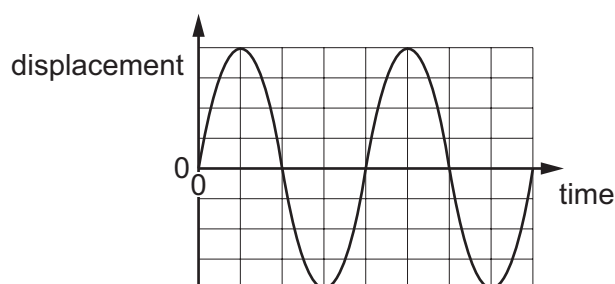
- 21 The graph shows the variation with time of the displacement of a particle as a progressive wave passes.



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

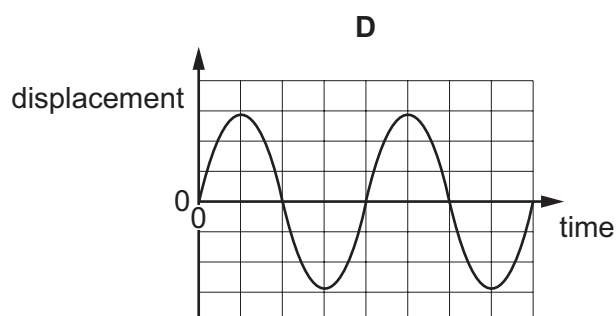
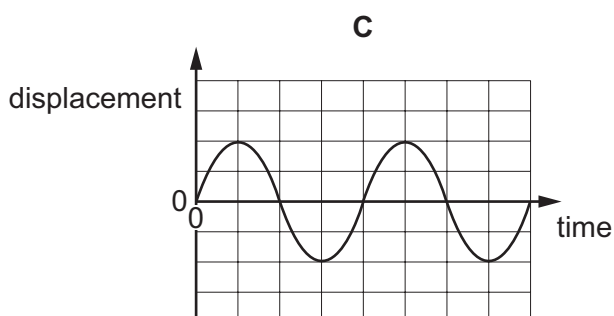
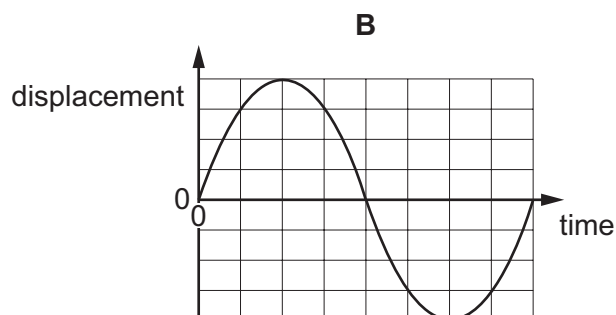
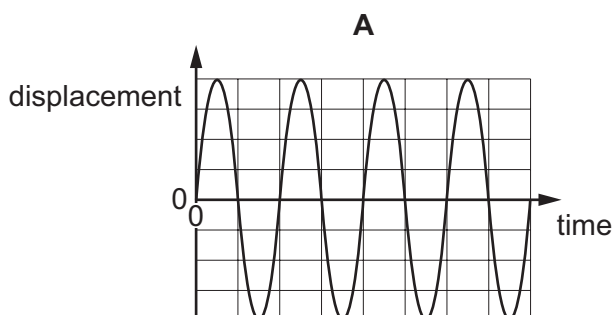
- 22** The graph shows the variation of the displacement of an air particle with time as a sound wave passes through air.



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.

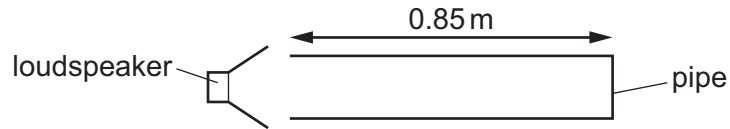
At one instant, the appearance of the string is as shown.



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.



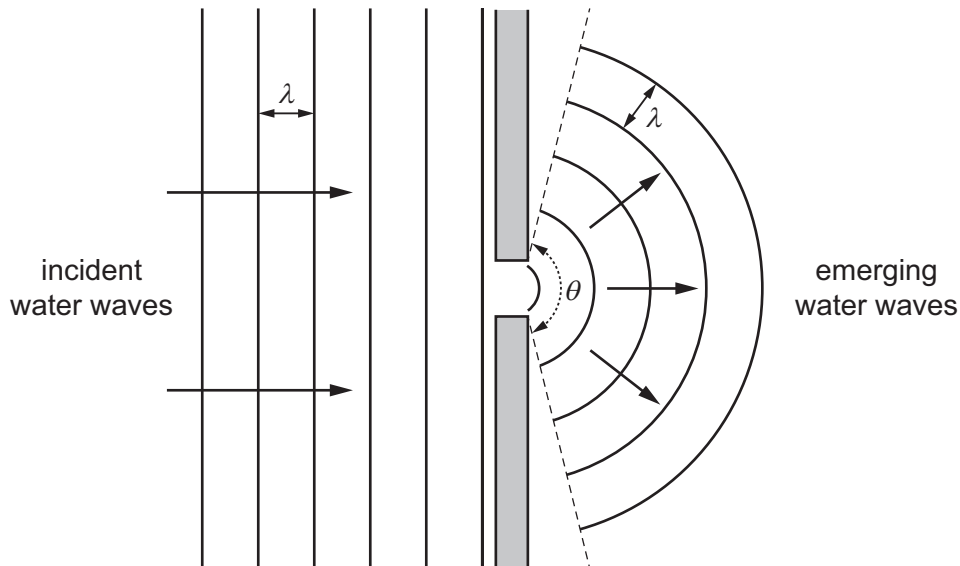
The length of the pipe is 0.85 m.

The speed of sound in air is 340 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?

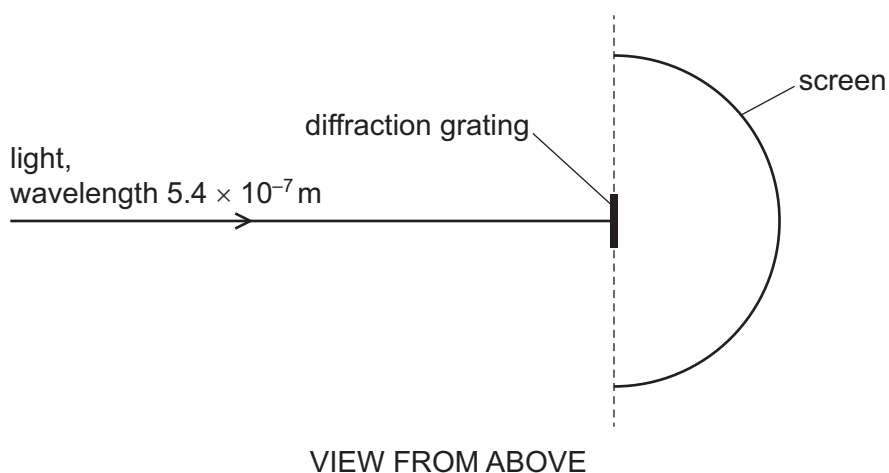
	θ	wavelength
A	decreases	remains the same
B	increases	remains the same
C	remains the same	decreases
D	remains the same	increases

- 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 $5.4 \times 10^{-7} \text{ m}$ is incident normally on a diffraction grating.

The separation between adjacent lines in the grating is $2.0 \times 10^{-6} \text{ m}$. 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.

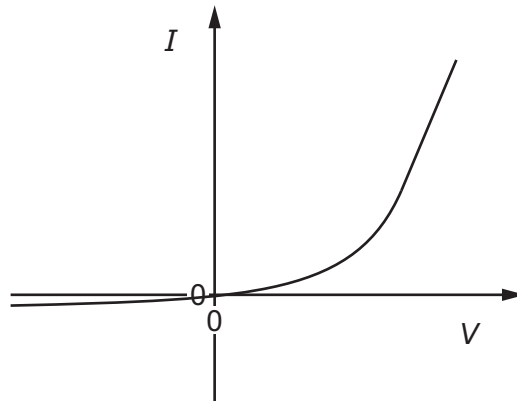
How many bright dots are formed on the screen?

- A 3
 - B 4
 - C 6
 - D 7
- 31 A straight copper wire of diameter $0.42 \times 10^{-3} \text{ m}$ has a number density of free electrons of $8.5 \times 10^{28} \text{ m}^{-3}$. 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 $3.3 \times 10^{-8} \text{ m}$
 - B $2.0 \times 10^{-5} \text{ m}$
 - C $8.0 \times 10^{-5} \text{ m}$
 - D $2.5 \times 10^{-4} \text{ m}$
- 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.

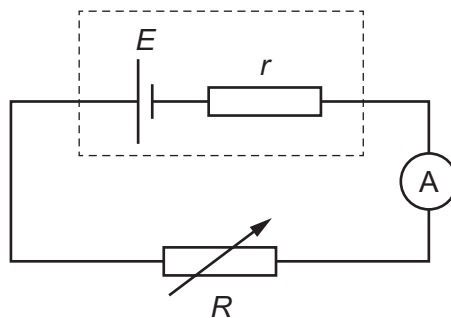


Which statement can be deduced from the graph?

- 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 $0.3\ \text{A}$.

When R is $5\ \Omega$ the ammeter reads $0.4\ \text{A}$.

What is the value of E ?

- A $0.5\ \text{V}$
- B $2\ \text{V}$
- C $3\ \text{V}$
- D $6\ \text{V}$

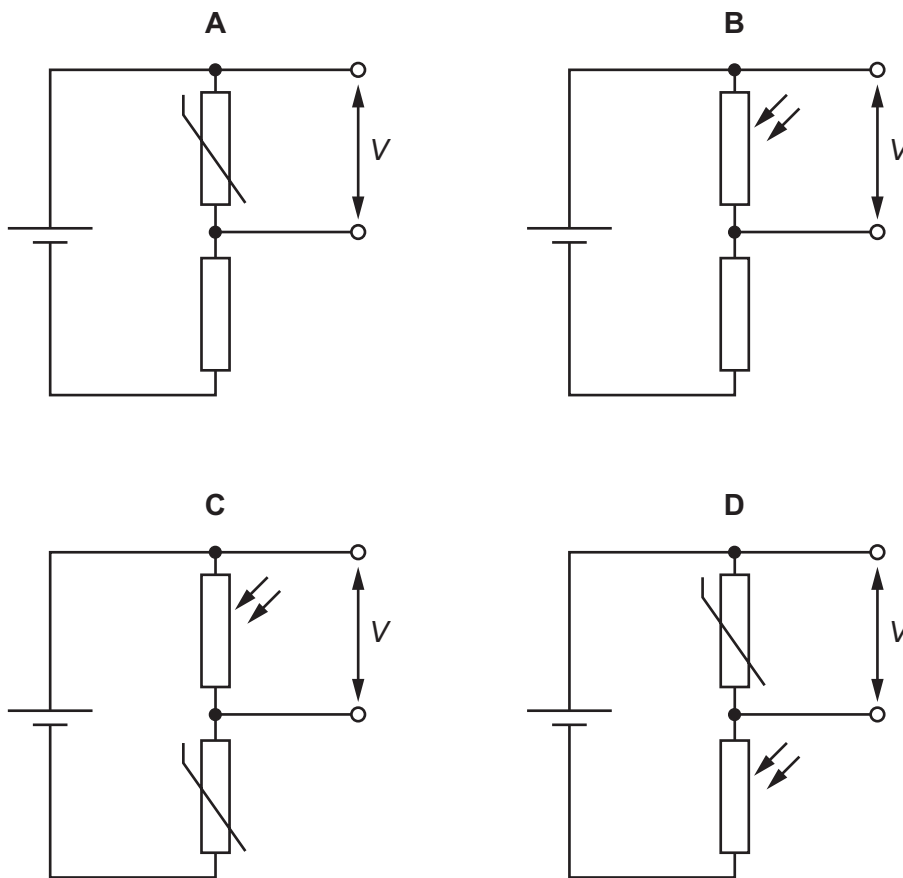
- 36** The sum of the currents entering a junction in an electrical circuit is always equal to the sum of the currents leaving the junction.

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 ${}^9_4\text{Be}$?

	hadrons	baryons	mesons
A	9	4	5
B	9	5	4
C	9	9	0
D	13	9	0

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Cambridge International AS & A Level

PHYSICS

9702/12

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May/June 2022

1 hour 15 minutes

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rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
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molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
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upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

1 Which estimate is reasonable?

- A 1×10^{-3} kg for the mass of a grain of sand
- B 1×10^{-2} m³ 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 m s^{-1} to the right. The velocity of the object changes so that its final velocity is 3.0 m s^{-1} downwards, as shown.

initial velocity
 4.0 m s^{-1}

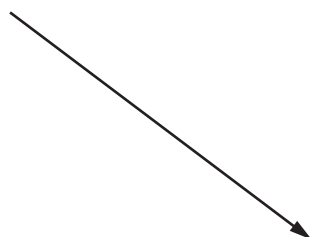


final velocity
 3.0 m s^{-1}

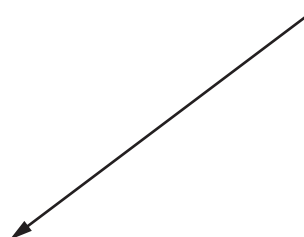


Which arrow represents the change in velocity of the object?

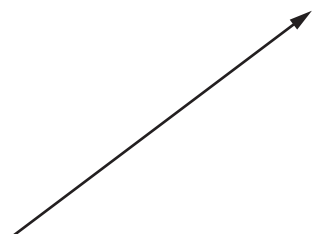
A



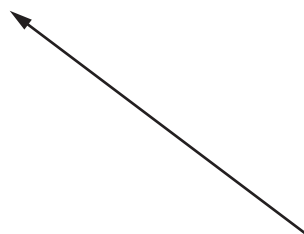
B



C

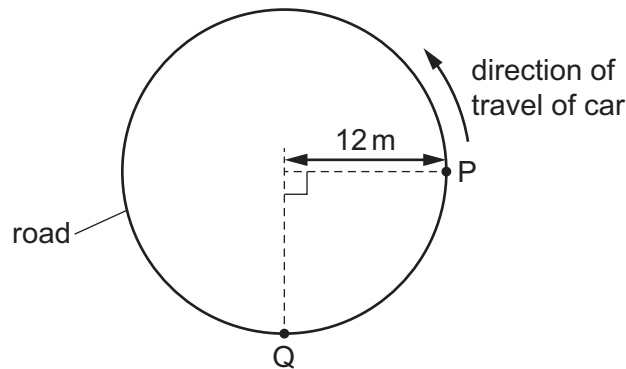


D



- 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.

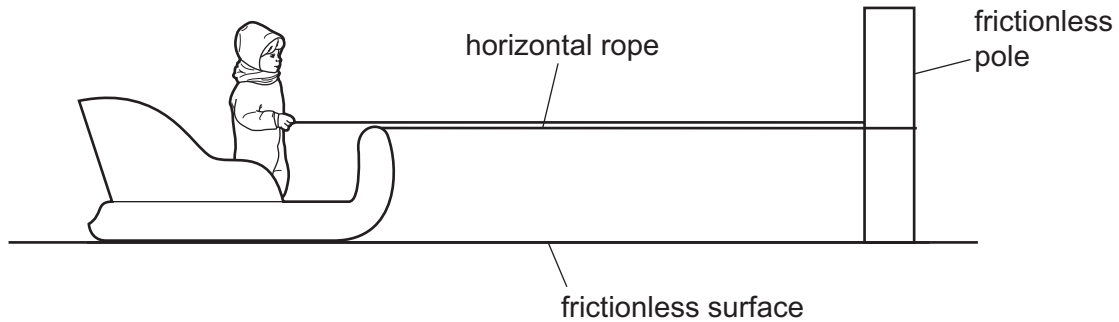


What is the magnitude of the average velocity of the car for the journey from P to Q?

- A** 4.2 ms^{-1} **B** 4.7 ms^{-1} **C** 6.0 ms^{-1} **D** 14 ms^{-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 ms^{-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.

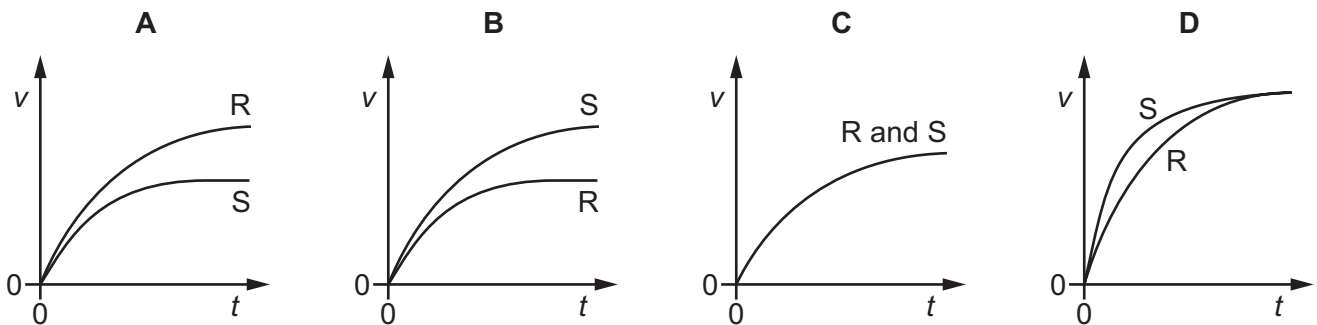


The rope is horizontal. The child pulls on the rope with a horizontal force of 12 N. This causes the child and the sledge to move with equal acceleration towards the pole.

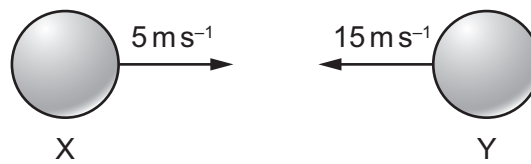
What is the frictional force between the child and the sledge?

- 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 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?

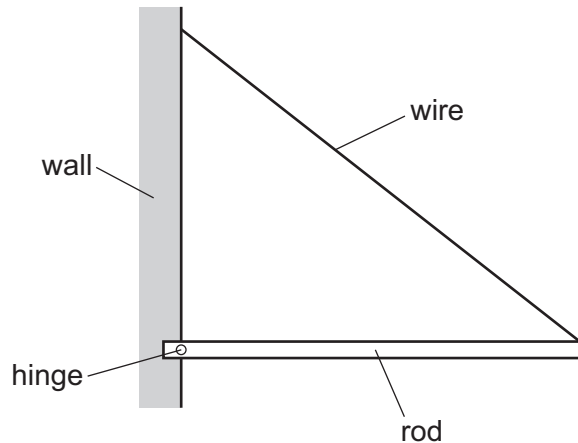
- A 3 m s^{-1} to the left
- B 13 m s^{-1} to the left
- C 3 m s^{-1} to the right
- D 13 m s^{-1} to the right

- 11 Two forces form a couple.

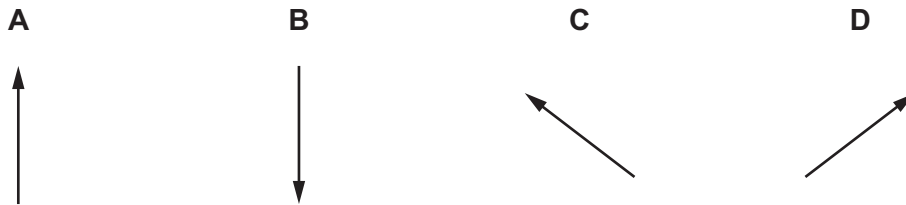
Which statement describes the two forces?

- 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.

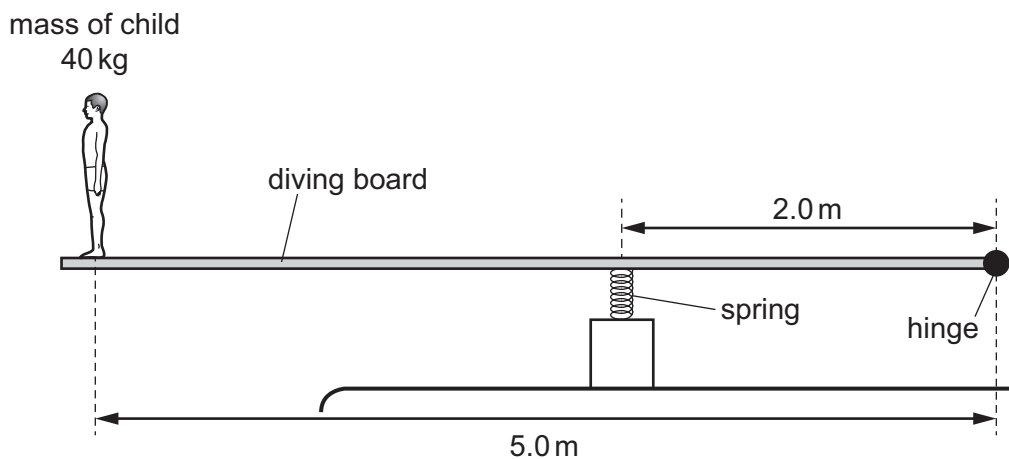
- 12** A uniform rod is attached by a hinge at one end to a wall. The other end of the rod is supported by a wire so that the rod is horizontal and in equilibrium.



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

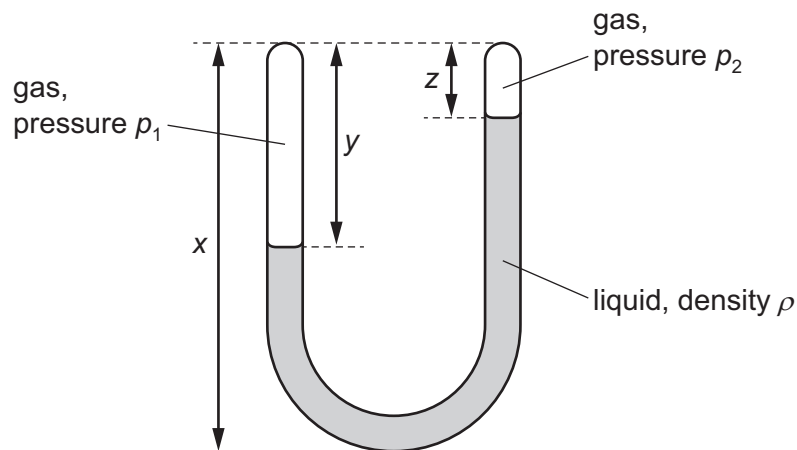
- 14 A granite rock at the surface of the Earth has density ρ . The rock is transported to the surface of another planet.

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 $p_1 = \rho g y$
 B $p_2 = \rho g(x - z)$
 C $p_1 - p_2 = \rho g(y - z)$
 D $p_1 + p_2 = \rho g x$
- 16 Which product of two quantities is equal to power?
- A force $\times$ distance
 B force $\times$ velocity
 C work done $\times$ time
 D work done $\times$ 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 $\frac{\text{input power to new type of lamp}}{\text{input power to old type of lamp}}$?

- 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 $7.2 \times 10^3 \text{ N m}^{-1}$
 B $2.3 \times 10^4 \text{ N m}^{-1}$
 C $2.9 \times 10^4 \text{ N m}^{-1}$
 D $9.0 \times 10^4 \text{ N m}^{-1}$

- 20 A wire is being stretched by a tensile force.

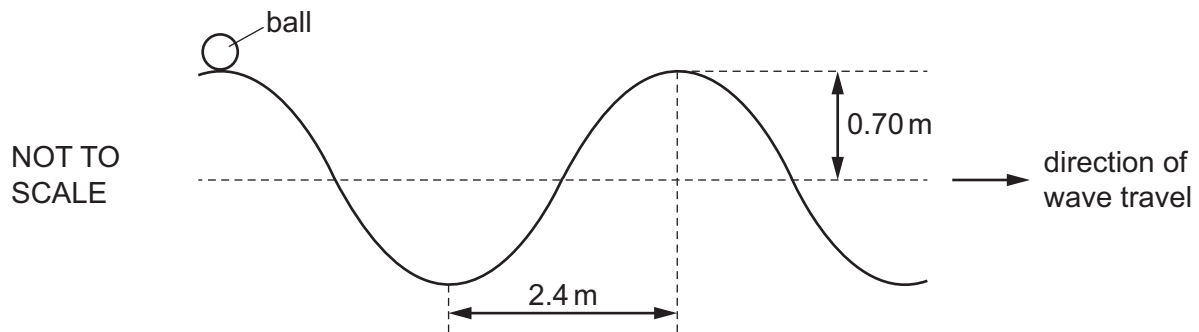
Which statement about the elastic limit **must** be correct?

- 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.

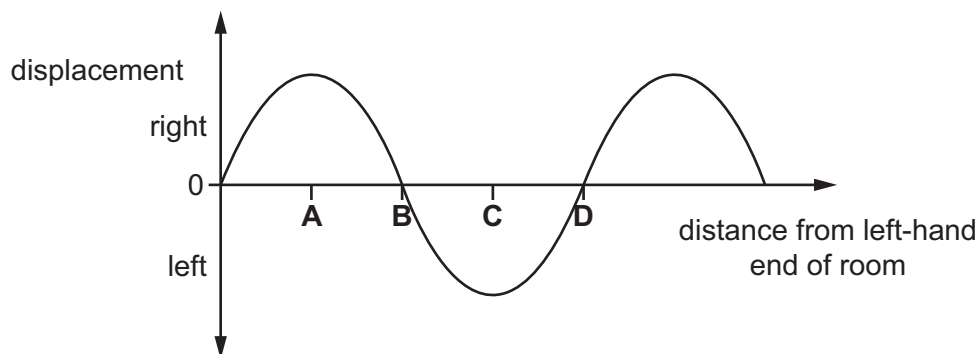


The wave has a frequency of 0.20 Hz and an amplitude of 0.70 m. The distance between a trough and an adjacent peak is 2.4 m.

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.

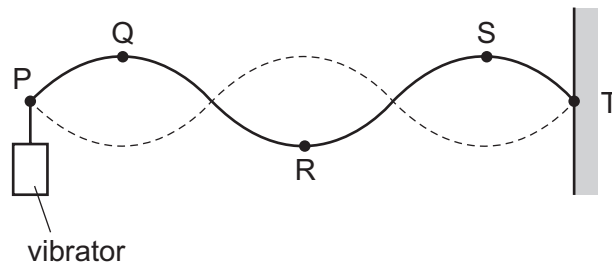
The second polarising filter has its transmission axis at an angle of 20° to the vertical. The angle between the transmission axes of the two polarising filters is 30° .

A beam of vertically polarised light of intensity 8.0 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 W m^{-2}
- C** 2.9 W m^{-2}
- D** 6.0 W m^{-2}

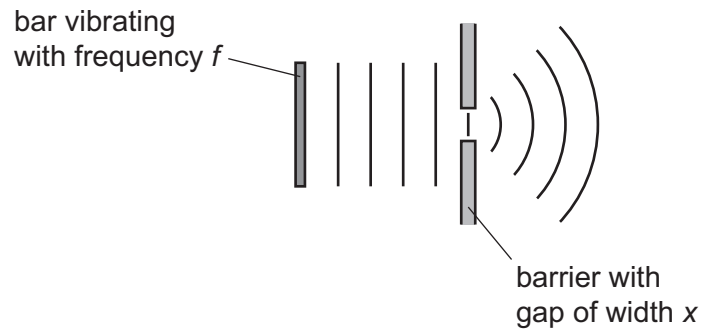
- 27** A stationary wave on a stretched string is set up between two points P and T.



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?

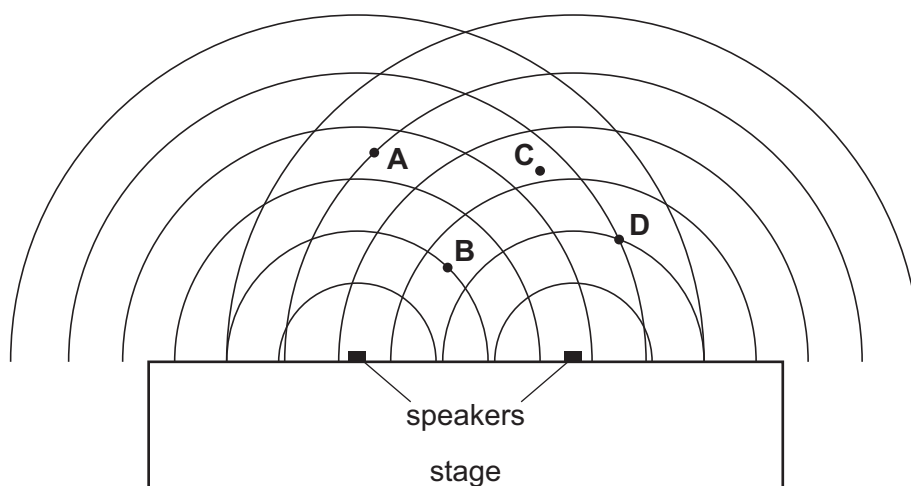
	vibration frequency	gap width
A	$\frac{f}{2}$	$\frac{x}{2}$
B	$\frac{f}{2}$	$2x$
C	$2f$	$\frac{x}{2}$
D	$2f$	$2x$

- 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

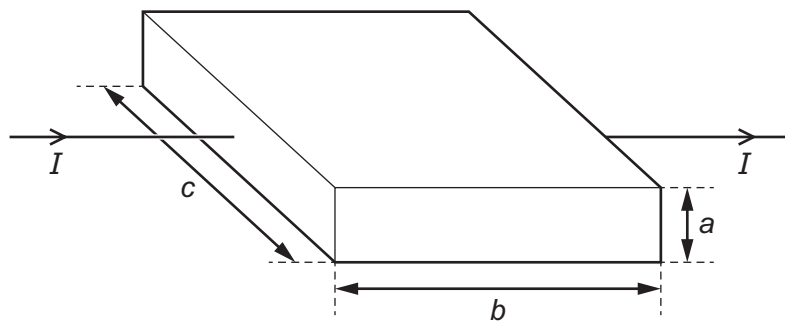
$$\lambda = \frac{d \sin \theta}{n}$$

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.

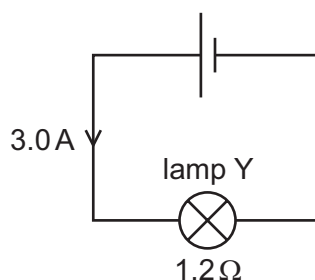
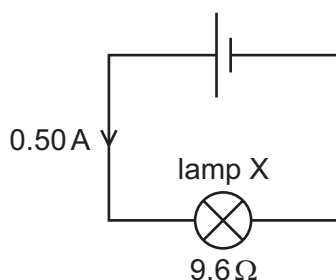


The block has sides of length a , b and c as shown, and its volume is V . Each charge carrier has a charge $-q$ and the number density of the charge carriers in the metal is n . It takes each charge carrier an average time of t to pass through the block.

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 $9.6\ \Omega$. The current in lamp Y is 3.0 A and its resistance is $1.2\ \Omega$.



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

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

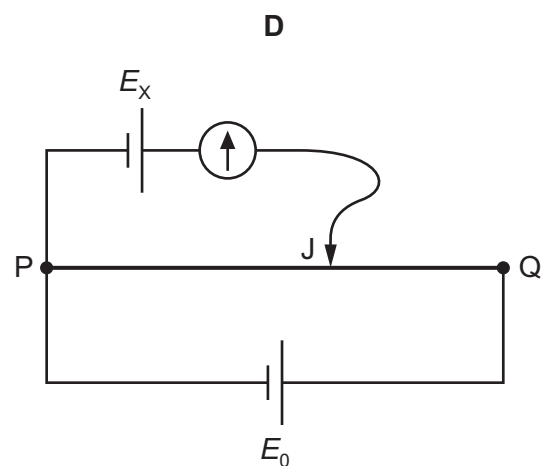
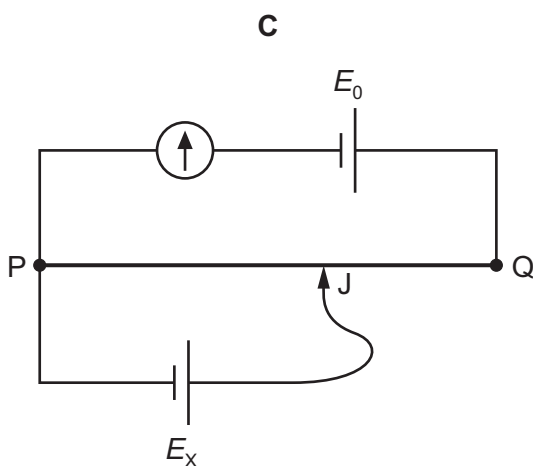
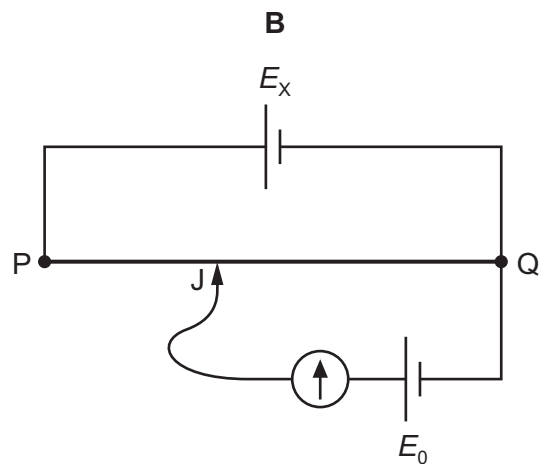
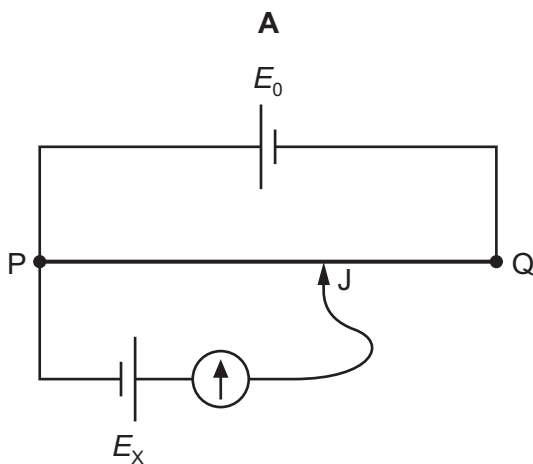
	Kirchhoff's first law	Kirchhoff's second law
A	charge	energy
B	energy	current
C	current	charge
D	energy	charge

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 ?



- 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.



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 $\bar{\nu}_e$.)

- A** $d \rightarrow u + \beta^- + \nu_e$
- B** $d \rightarrow u + \beta^- + \bar{\nu}_e$
- C** $u \rightarrow d + \beta^+ + \nu_e$
- D** $u \rightarrow d + \beta^+ + \bar{\nu}_e$

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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.



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	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
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	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
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	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

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 $5.00 \text{ mm} \pm 0.01 \text{ mm}$.

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%

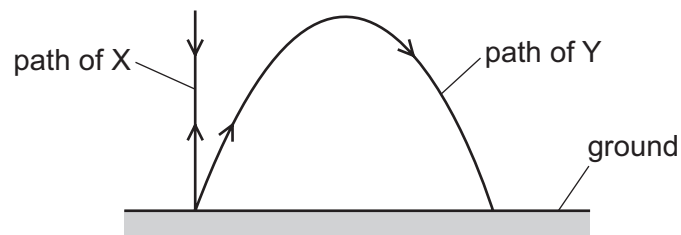
5 Forces of magnitudes 2 N, 4 N and 7 N combine to produce a resultant force.

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.



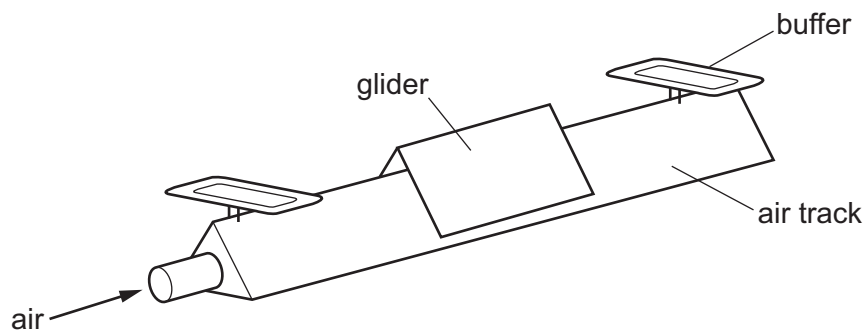
Projectile X is fired vertically upwards and projectile Y is fired at an angle to the horizontal.

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.

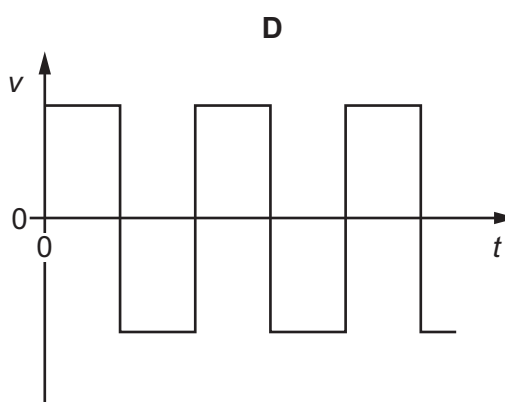
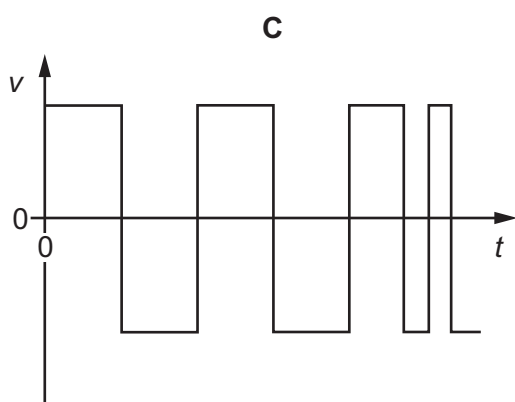
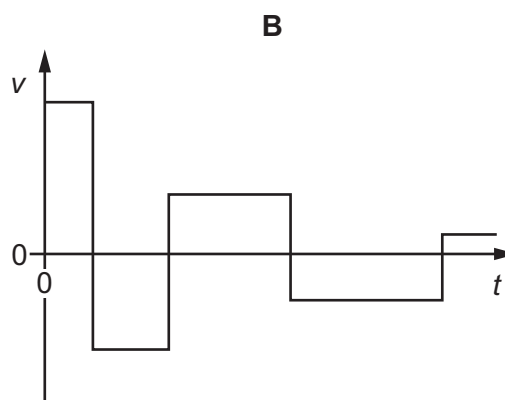
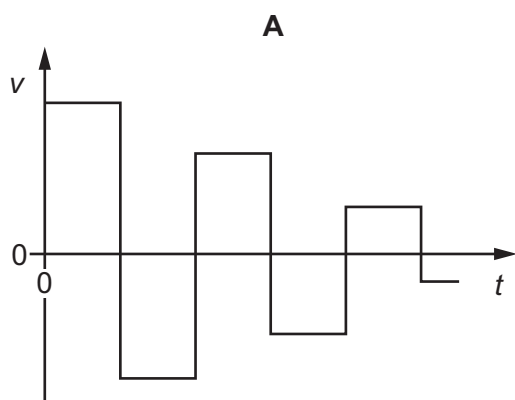
- 7 A small glider moves along a horizontal air track as shown.



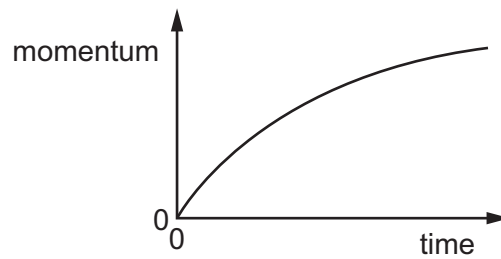
At each end of the air track, the glider has a perfectly elastic collision with a fixed buffer.

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?

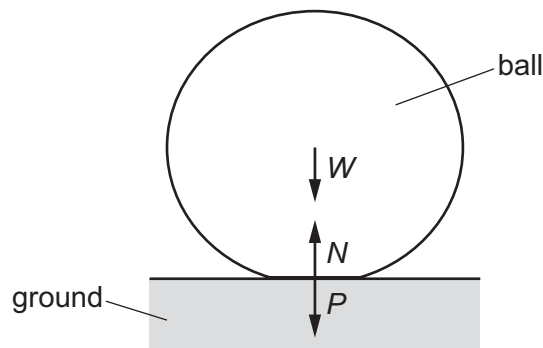


- 8 A car accelerates from rest. The graph shows the variation of the momentum of the car with time.



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.

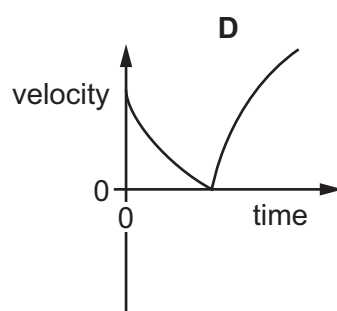
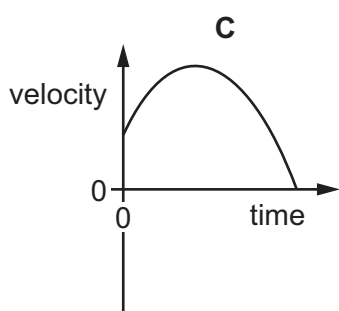
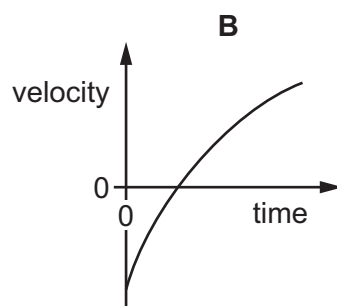
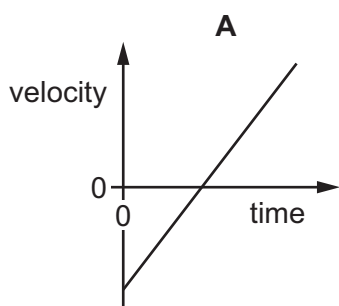
At this instant, which relationship is correct?

- 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?



- 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} .

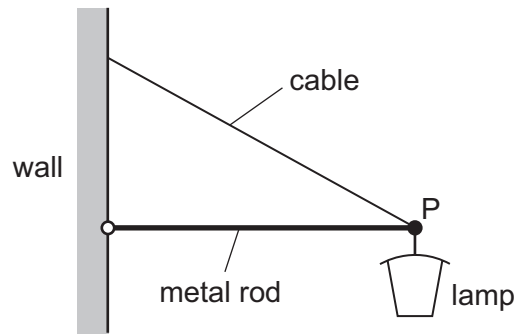
What is the relative speed of separation of the two skaters?

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

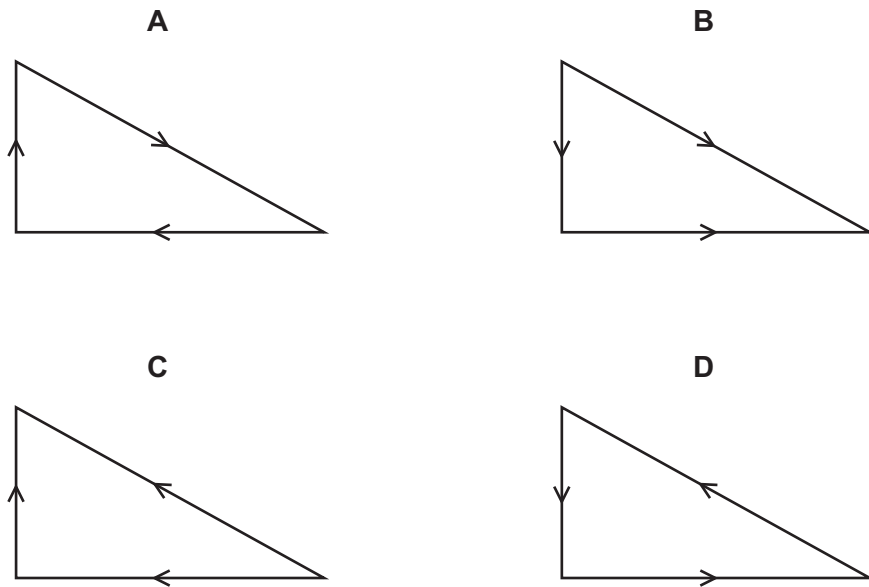
- 12** Which statement describes the two forces in a couple?

- 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.

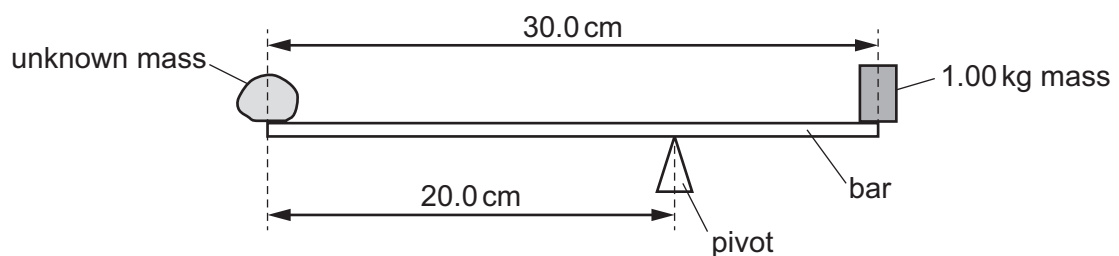


Which vector triangle could represent the forces acting on the end of the rod at point P?



- 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.

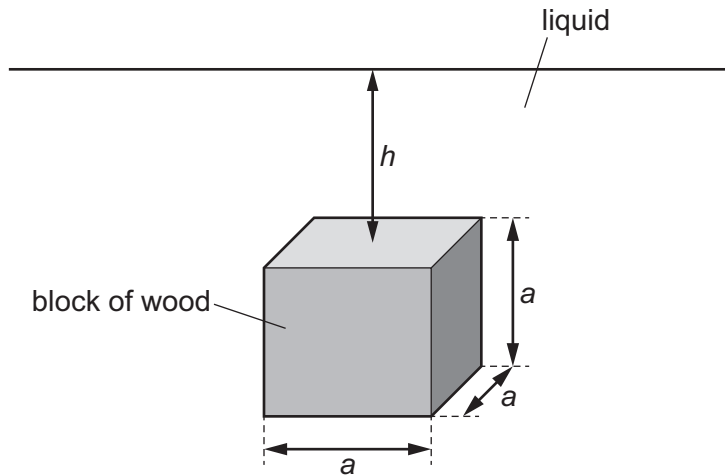


What is the unknown mass?

- 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** $\rho_L h g$ **D** $\rho_L a g$

- 16** A technical article about diesel engines expresses the energy available from diesel fuel both as 41.8 MJ kg^{-1} and as 34.9 GJ m^{-3} .

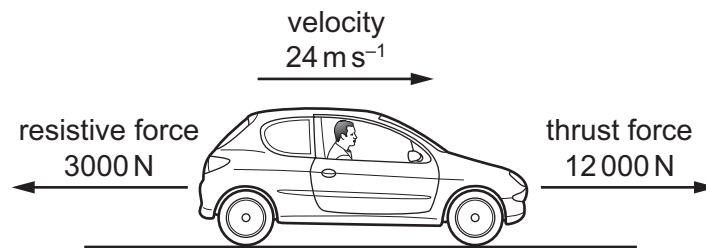
What is the density of diesel fuel?

- A** $8.35 \times 10^2 \text{ kg m}^{-3}$
B $1.20 \times 10^3 \text{ kg m}^{-3}$
C $8.35 \times 10^5 \text{ kg m}^{-3}$
D $1.20 \times 10^6 \text{ kg m}^{-3}$

- 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

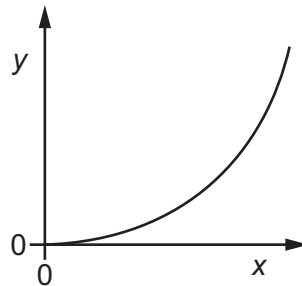
- 18 A car of weight 15 000 N is travelling along a horizontal road.



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?

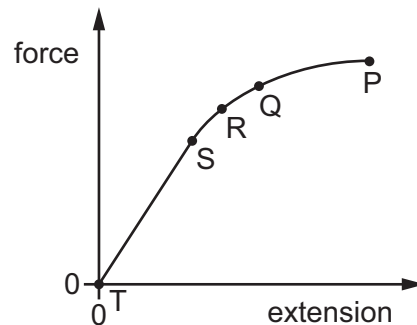
	x	y
A	mass for different objects moving at the same speed	kinetic energy
B	speed for an object of constant mass	kinetic energy
C	vertical distance fallen for an object of constant mass	change of gravitational potential energy
D	mass for different objects falling the same vertical distance	change of gravitational 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 $2.0 \times 10^{11} \text{ Pa}$.

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 $3.0 \times 10^{-7} \text{ m}$
 B $3.0 \times 10^{-5} \text{ m}$
 C $3.0 \times 10^{-4} \text{ m}$
 D $3.0 \times 10^{-2} \text{ m}$
- 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?

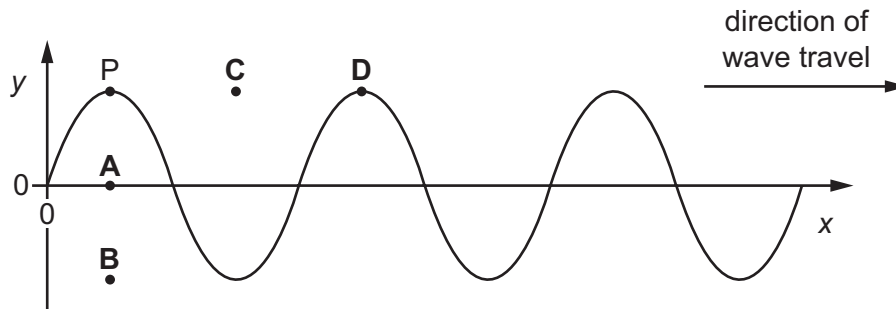
- A Point R is the limit of proportionality.
 B The elastic potential energy of the wire at point S is given by the area under the graph between points T and S.
 C There is no plastic deformation between points Q and P.
 D The wire obeys Hooke's law up to a point between R and Q.

- 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.

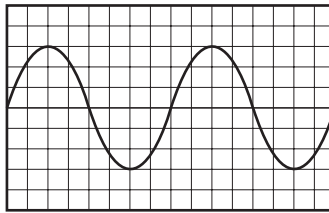
A point P on the rope is marked. The diagram shows the original position of P and four new positions.

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

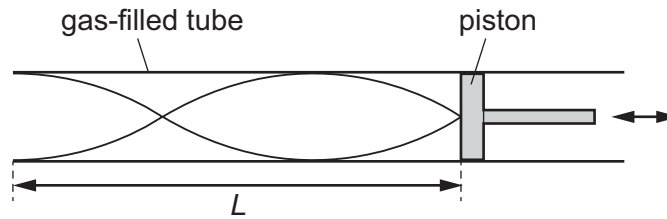
- 27** The principle of superposition states that a certain quantity is added when two or more waves meet at a point.

What is this quantity?

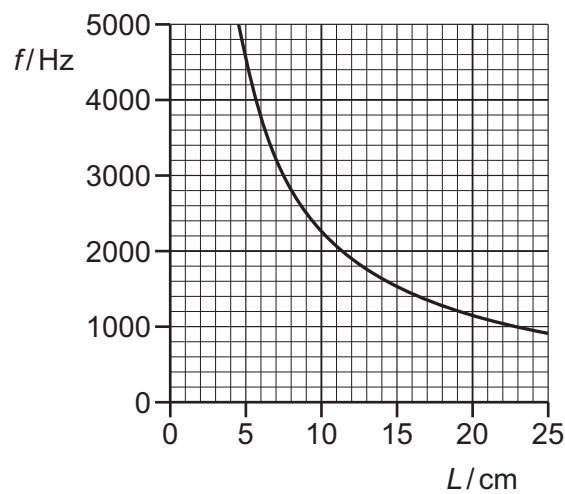
- A** amplitude
B displacement
C intensity
D wavelength

- 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.

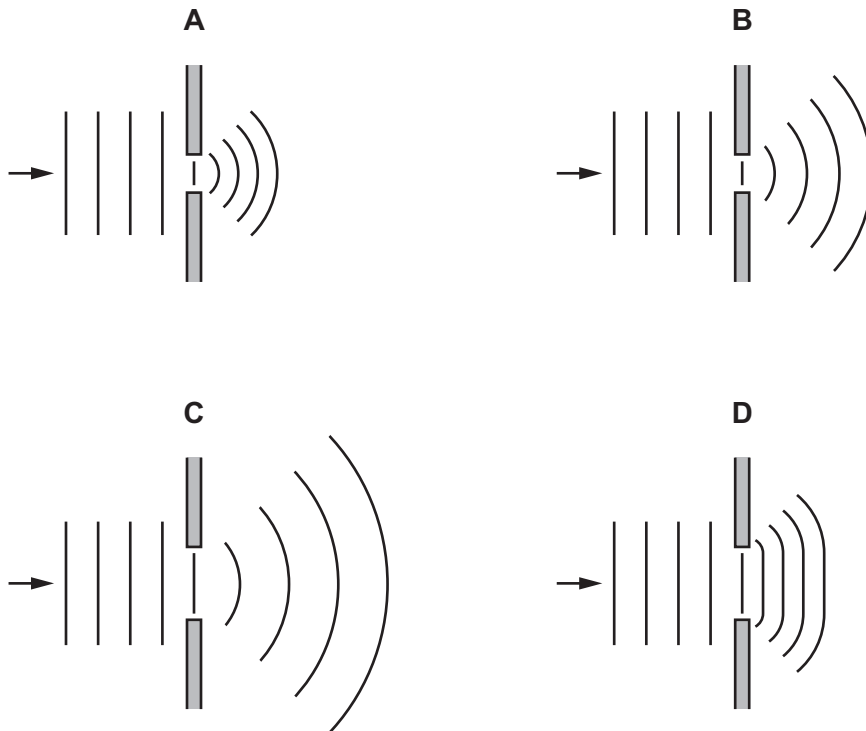


What is the speed of sound in the gas in the tube?

- A** 150 ms^{-1} **B** 230 ms^{-1} **C** 300 ms^{-1} **D** 340 ms^{-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.

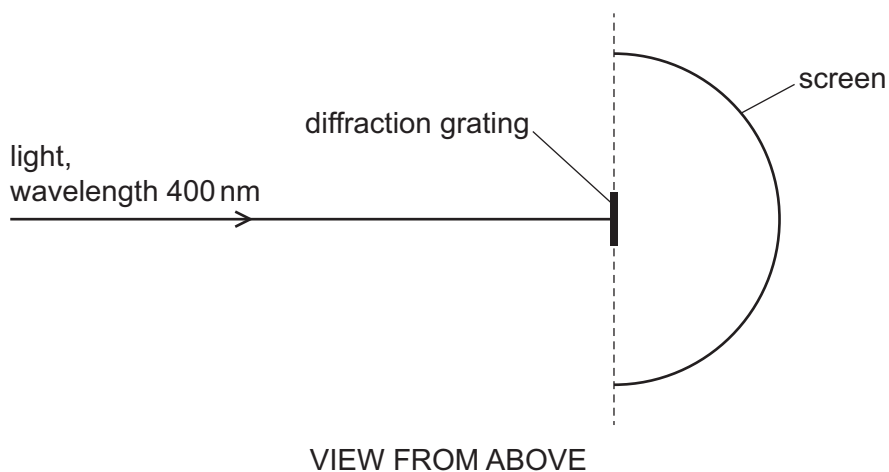
The separation of the two slits is a . The distance between the slits and the screen is D . The distance between the centres of two adjacent bright fringes is x .

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.



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

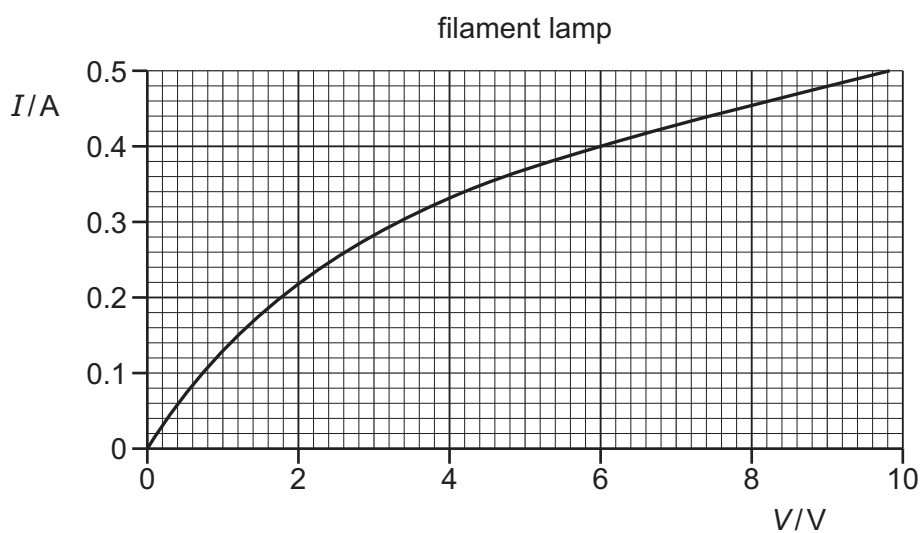
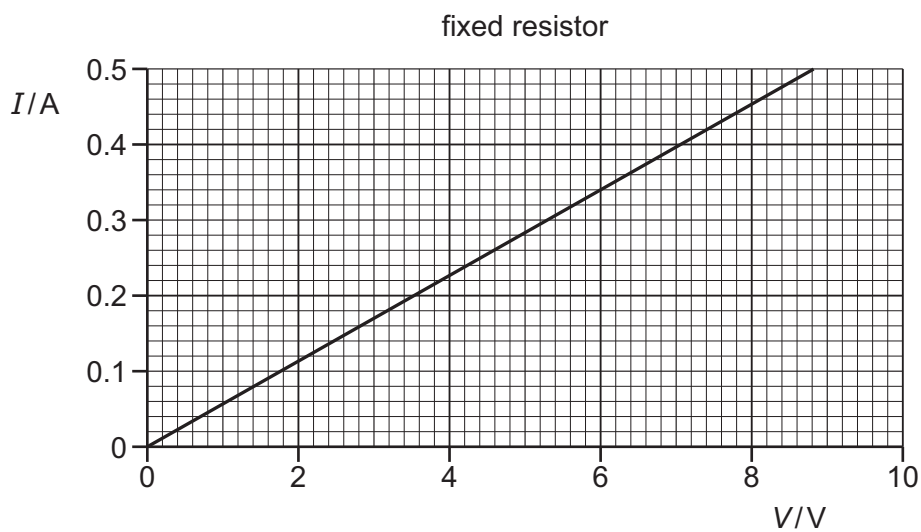
- A** $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$
- 33 A resistor has resistance R . When the potential difference (p.d.) across the resistor is V , the current in the resistor is I . The power dissipated in the resistor is P . Work W is done when charge Q flows through 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.



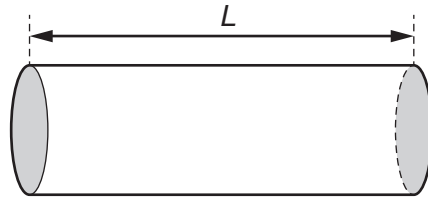
The current in the fixed resistor is 0.34 A.

What is the resistance of the filament lamp?

- A** $0.081\ \Omega$ **B** $12\ \Omega$ **C** $15\ \Omega$ **D** $18\ \Omega$

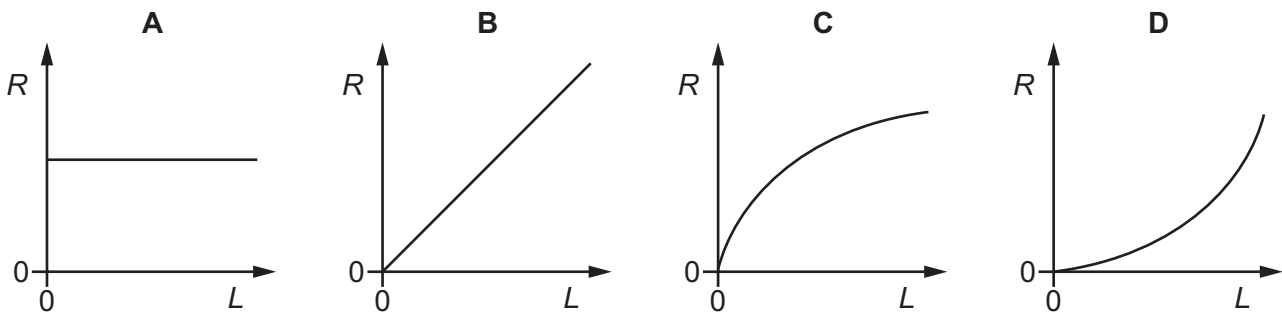
- 35** A piece of conducting putty (modelling clay) of constant resistivity is formed into a cylindrical shape.

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?

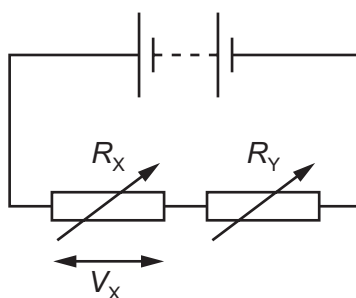
	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit 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

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- 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.