



Cambridge International AS & A Level

PHYSICS

9702/11

Paper 1 Multiple Choice

May/June 2024

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.
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- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **16** 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	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

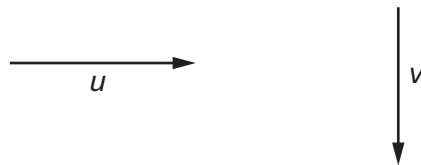
1 Which unit is an SI base unit?

- A ampere
- B coulomb
- C degree Celsius
- D gram

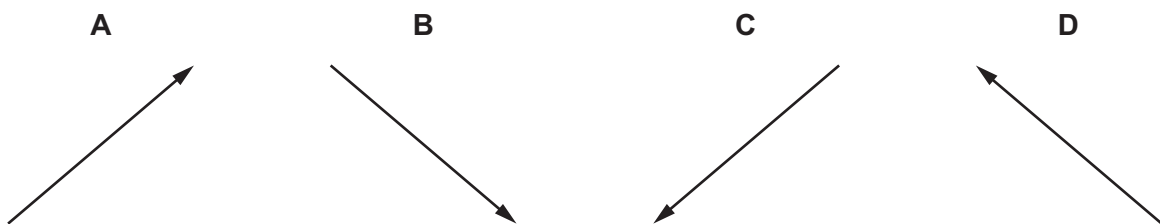
2 Which of the following could have the same units as force?

- A $\frac{\text{energy}}{\text{distance}}$
- B $\frac{\text{energy}}{\text{time}}$
- C momentum $\times$ distance
- D momentum $\times$ time

3 The velocity of an object changes from an initial velocity u to a final velocity v . The vectors represent these velocities.



Which single vector represents the change in velocity of the object?



4 An object is moving with initial velocity u . The object then moves with uniform acceleration a for time t until it reaches final velocity v .

Which equation describes the motion of the object?

- A $u = v - 2at$
- B $u = v - at$
- C $v = u + at^2$
- D $v = u + 2at^2$

5 Which calculation produces a vector quantity?

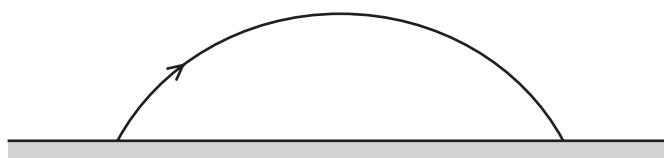
- A current $\times$ time
- B final displacement – initial displacement
- C $\frac{\text{work done}}{\text{time}}$
- D $\frac{1}{2} \times \text{mass} \times (\text{speed})^2$

6 A thermometer can be read to an accuracy of $\pm 0.5^\circ\text{C}$. This thermometer is used to measure a temperature rise from 40°C to 100°C .

What is the percentage uncertainty in the measurement of the temperature rise?

- A 0.5% B 0.8% C 1.3% D 1.7%

7 The diagram shows the path of a golf ball.



Which row describes changes in the horizontal and vertical components of the golf ball's velocity when air resistance is ignored?

	horizontal	vertical
A	constant deceleration	constant acceleration downwards
B	constant deceleration	acceleration decreases upwards then increases downwards
C	constant velocity	constant acceleration downwards
D	constant velocity	acceleration decreases upwards then increases downwards

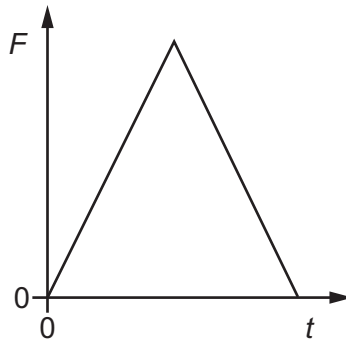
8 An aircraft flies from London to Sydney in a time of 21 hours 40 minutes.

The distance travelled is 17 000 km.

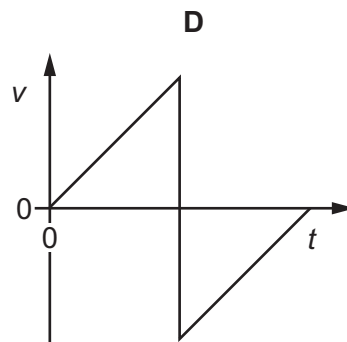
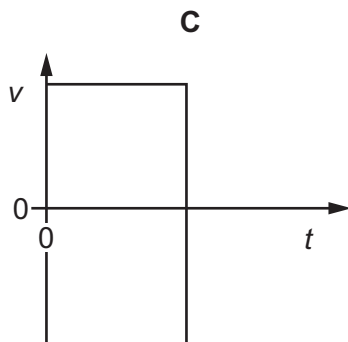
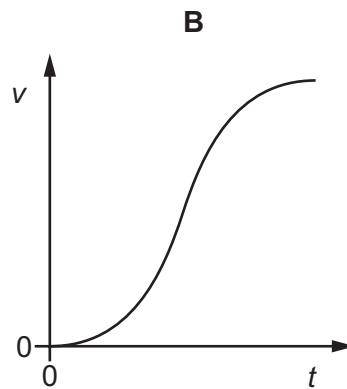
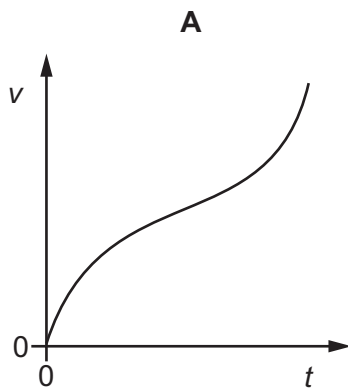
What is the average speed of the aircraft?

- A 2.2 m s^{-1}
- B $2.2 \times 10^7 \mu\text{m s}^{-1}$
- C $2.2 \times 10^{11} \text{ nm s}^{-1}$
- D $2.2 \times 10^6 \text{ mm s}^{-1}$

- 9 A golf club hits a golf ball. The graph shows how the force F on the ball varies with time t .



Which graph shows how the velocity v of the ball varies with time t ?



- 10 What is meant by the mass and by the weight of an object on the Earth?

	mass	weight
A	its momentum divided by its velocity	the work done in lifting it one metre
B	the gravitational force on it	the property that resists its acceleration
C	the pull of the Earth on it	its mass divided by the acceleration of free fall
D	the property that resists its acceleration	the pull of the Earth on it

- 11 A thin horizontal plate of area 0.036 m^2 is beneath the surface of a liquid of density 930 kg m^{-3} . The force on one side of the plate due to the pressure of the liquid is 290 N .

What is the depth of the plate beneath the surface of the liquid?

- A 0.88 m B 1.1 m C 1.8 m D 8.7 m

- 12 Spheres X and Y form an isolated system. The mass of Y is greater than the mass of X.

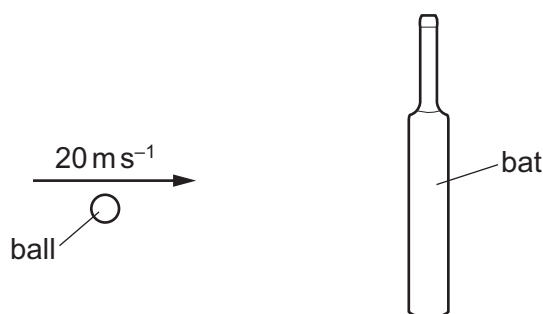
Sphere Y is initially stationary.

Sphere X collides elastically with sphere Y.

The speed of sphere X before the collision is u .

Which statement **must** be correct?

- A Sphere X rebounds with a speed that is greater than u , and sphere Y moves off with a speed that is less than u .
- B Sphere X rebounds with a speed that is less than u , and sphere Y moves off with a speed that is also less than u .
- C Sphere X rebounds with speed u , and sphere Y remains stationary.
- D Sphere X remains stationary, and sphere Y moves off with a speed that is less than u .
- 13 A ball of mass 0.10 kg is thrown towards a stationary vertical bat. The ball hits the bat with a horizontal velocity of 20 m s^{-1} .



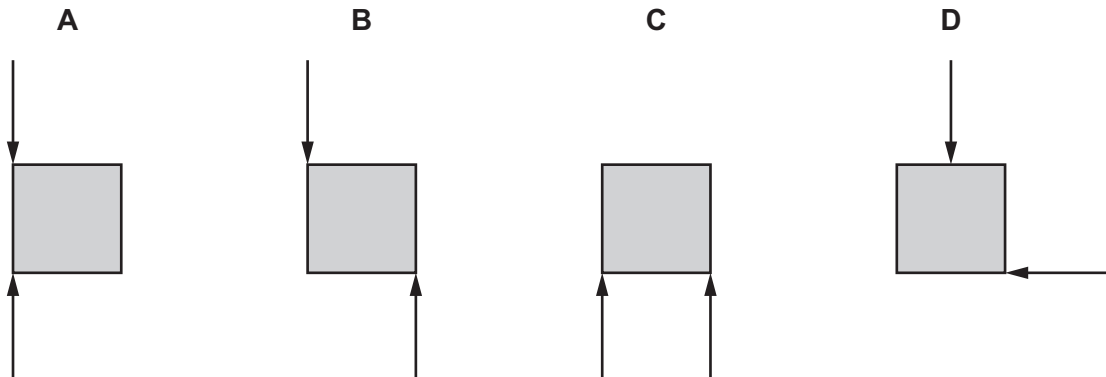
The ball rebounds and leaves the bat with a horizontal velocity of 15 m s^{-1} .

What is the change in momentum of the ball?

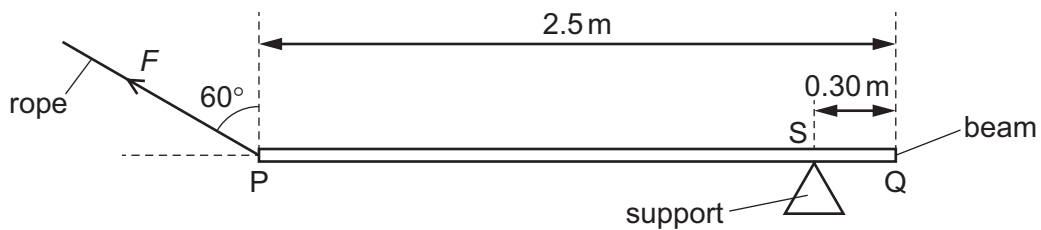
- A 0.20 Ns B 0.50 Ns C 1.5 Ns D 3.5 Ns

- 14 An isolated object of negligible weight is acted on by two coplanar forces of the same magnitude.

In which diagram is the object in equilibrium?



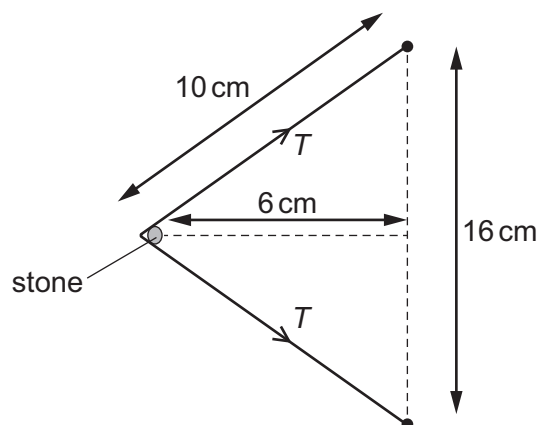
- 15 A uniform beam PQ rests horizontally on a support at point S.



A rope is attached at one end of the beam. The rope is at an angle of 60° to the vertical and exerts a force F , in newtons, on the beam.

What is the moment, in N m, of the force F about the point S?

- A $1.1F$ B $1.3F$ C $1.9F$ D $2.2F$
- 16 The diagram shows the dimensions of an elastic cord used to project a stone. The tension in the cord is T when the cord is pulled into the shape shown.



Which force does the elastic cord exert on the stone?

- A $\frac{3}{5}T$ B $\frac{6}{5}T$ C $\frac{8}{5}T$ D $2T$

- 17 A box of weight 40 N is pushed with a horizontal force of 20 N along level ground for a distance of 2.4 m.

The box is then lifted at constant velocity through a height of 1.6 m by a vertical force.

What is the total work done on the box by the two forces?

- A 80 J B 110 J C 120 J D 160 J

- 18 Which statement about efficiency is correct?

- A Efficiency does **not** have a unit.
B The joule is a unit of efficiency.
C The metre is a unit of efficiency.
D The watt is a unit of efficiency.

- 19 A plane wave of amplitude A is incident on a surface of area S placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time reaching the surface is E .

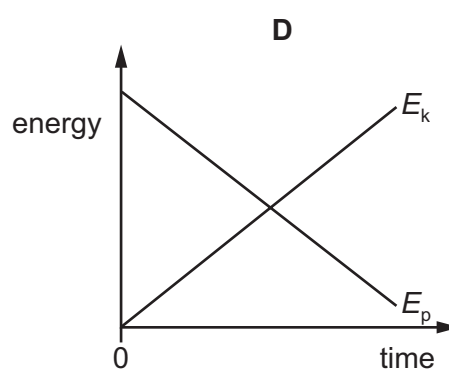
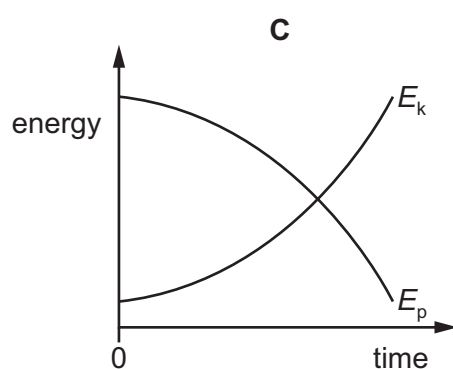
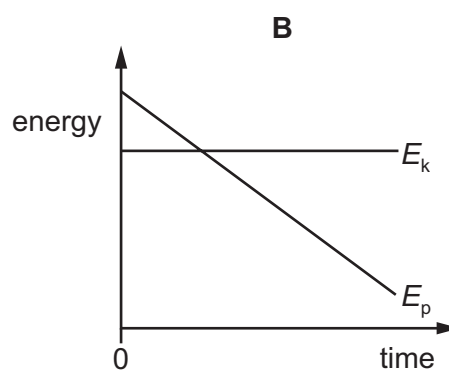
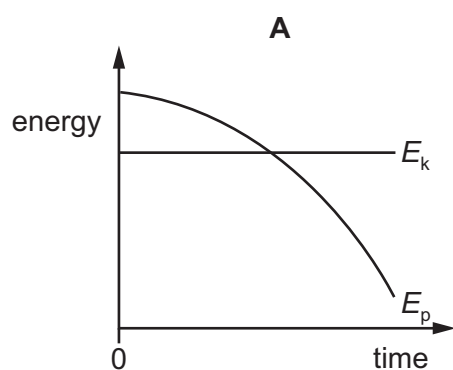
The amplitude of the wave is increased to $2A$ and the area of the surface is reduced to $\frac{1}{2}S$.

How much energy per unit time reaches this smaller surface?

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

- 20** A steel ball is falling at constant speed in oil.

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?



- 21** When a force of 0.80 N is applied to a spring, the length of the spring is 90 mm.

When a force of 1.30 N is applied to the same spring, its length is 115 mm.

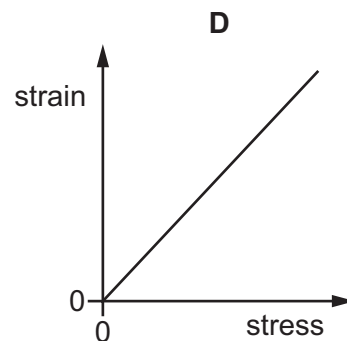
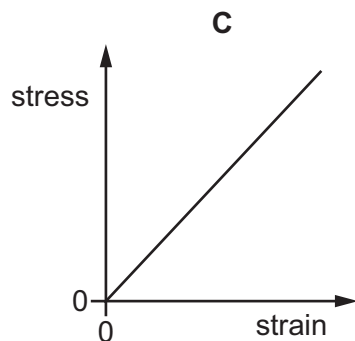
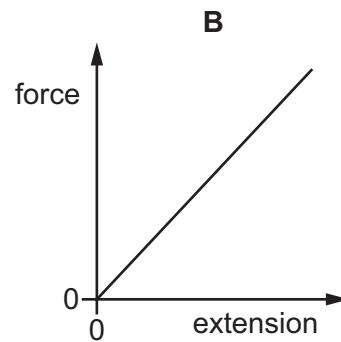
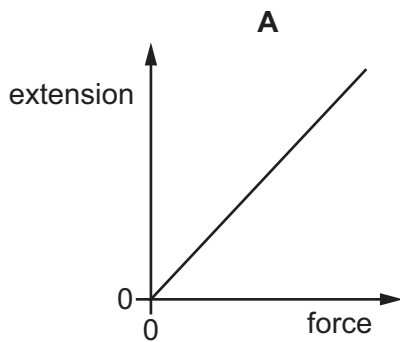
The spring obeys Hooke's law.

What is the spring constant of the spring?

- A** 8.9 N m^{-1} **B** 10 N m^{-1} **C** 11 N m^{-1} **D** 20 N m^{-1}

- 22** An experiment is carried out using a metal wire to investigate how it responds to a varying tensile force. The cross-sectional area of the wire is constant.

Which graph has a gradient that is equal to the Young modulus of the metal?



- 23** For a wire, Hooke's law is obeyed for a tension F and extension x . The Young modulus for the material of the wire is E .

Which expression represents the elastic potential energy stored in the wire?

- A** $\frac{1}{2}Ex$ **B** Ex **C** $\frac{1}{2}Fx$ **D** Fx

- 24** A plane polarised wave has amplitude A . The wave is incident normally on a polarising filter.

The transmission axis of the filter is at angle θ to the plane of polarisation of the incident wave.

What is the amplitude of the wave that emerges from the filter?

- A** $A \cos \theta$ **B** $A \cos^2 \theta$ **C** $A^2 \cos \theta$ **D** $A^2 \cos^2 \theta$

- 25 An electromagnetic wave is travelling through a vacuum.

What could be the wavelength and period of the electromagnetic wave?

	wavelength	period
A	$1.2 \times 10^{-10} \text{ Tm}$	2.5 Ms
B	1.2 pm	$2.5 \times 10^{11} \text{ Gs}$
C	$1.2 \times 10^2 \text{ pm}$	$4.0 \times 10^{-10} \text{ ns}$
D	$1.2 \times 10^3 \mu\text{m}$	4.0 ns

- 26 Light of frequency $6.7 \times 10^{14} \text{ Hz}$ in a vacuum is incident normally on a diffraction grating that contains $4.0 \times 10^5 \text{ lines m}^{-1}$.

What is the angle between the adjacent second and third order intensity maxima?

- A** 12° **B** 21° **C** 33° **D** 54°

- 27 The siren of a moving police car emits a sound wave with a frequency of 440 Hz. A stationary observer hears sound of frequency 494 Hz. The speed of sound in the air is 340 m s^{-1} .

What could be the speed and the direction of movement of the car?

- A** 37 m s^{-1} directly away from the observer
B 37 m s^{-1} directly towards the observer
C 42 m s^{-1} directly away from the observer
D 42 m s^{-1} directly towards the observer

- 28 The diagram shows the shape at one instant in time of part of a stretched string as a wave travels along it from left to right.



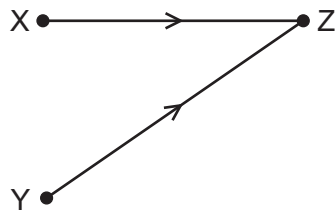
What are the directions of the velocities of the points 1, 2 and 3 on the string at this instant in time?

	point 1	point 2	point 3
A	→	→	→
B	→	←	→
C	↑	↓	↑
D	↓	↑	↓

29 Which wave **cannot** be a longitudinal wave?

- A a diffracted wave
- B a polarised wave
- C a reflected wave
- D a stationary wave

30 Microwaves are emitted from two sources at points X and Y. The two waves meet at point Z. The diagram shows the paths of the two waves.



The waves emitted from points X and Y are coherent.

What is a direct consequence of the two waves being coherent?

- A There is a constant difference in the path lengths YZ and XZ.
- B There is a constant difference in phase between the two waves at Z.
- C There is a constant non-zero difference in frequency of the two waves at Z.
- D There is a constant non-zero difference in amplitude of the two waves at Z.

31 What is the unit of resistivity?

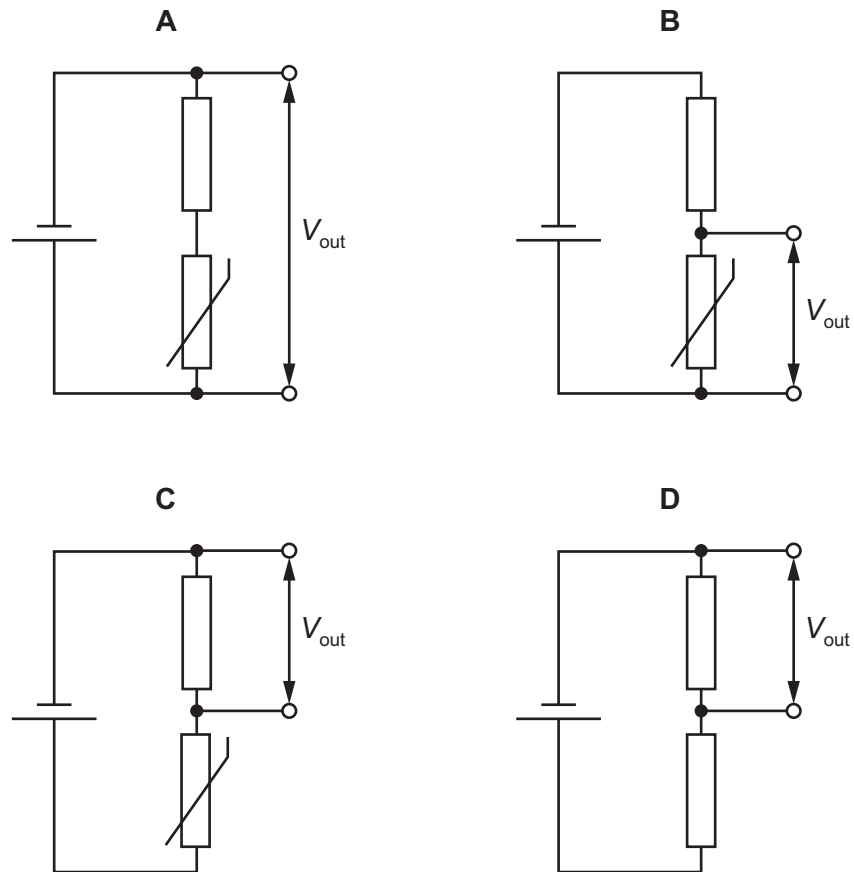
- A $\Omega \text{ m}^{-2}$
- B $\Omega \text{ m}^{-1}$
- C Ω
- D $\Omega \text{ m}$

32 A kettle is connected to a 250 V mains supply.

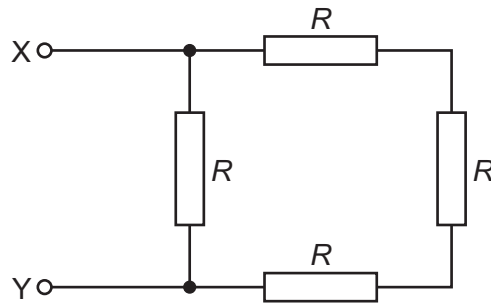
What are possible values for the power of the kettle and the current in the kettle?

	power / W	current / A
A	500	0.5
B	500	5.0
C	2500	0.1
D	2500	10

33 Which circuit results in output voltage V_{out} increasing with increasing temperature?



34 Four resistors, each of resistance R , are connected as shown.

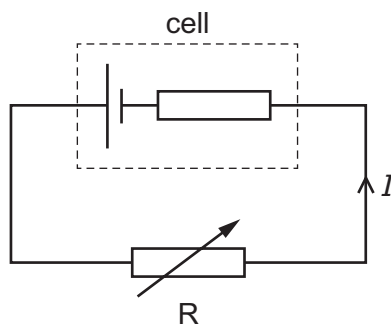


The total resistance between point X and point Y is $120\ \Omega$.

What is the magnitude of the resistance R ?

- A** $30\ \Omega$ **B** $90\ \Omega$ **C** $160\ \Omega$ **D** $480\ \Omega$

- 35 A cell with internal resistance is connected to a variable resistor R as shown.



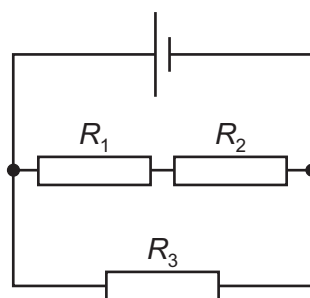
The resistance of R is gradually decreased.

How do the current I and the terminal potential difference (p.d.) across the cell change?

	current I	terminal p.d. across cell
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

- 36 The diagram shows a circuit with a cell and three resistors with resistances R_1 , R_2 and R_3 .

The cell has negligible internal resistance.



The total resistance of the circuit is R_T .

Which equation for R_T is correct?

A $R_T = R_1 + R_2 + R_3$

B $R_T = \frac{1}{R_1 + R_2} + \frac{1}{R_3}$

C $\frac{1}{R_T} = \frac{1}{R_1 + R_2 + R_3}$

D $\frac{1}{R_T} = \frac{1}{R_1 + R_2} + \frac{1}{R_3}$

- 37 Hydrogen and deuterium can be represented by the nuclide symbols ${}^1_1\text{H}$ and ${}^2_1\text{H}$ respectively.

What is a difference between hydrogen and deuterium?

- A The deuterium atom has twice the number of electrons as the hydrogen atom.
- B The deuterium nucleus has a charge, but the hydrogen nucleus has no charge.
- C The deuterium nucleus has less mass than the hydrogen nucleus.
- D The deuterium nucleus has half the charge per unit mass of the hydrogen nucleus.

- 38 A radioactive sample decays by emitting β^- particles.

The energy released in the decay process is the same for each nucleus that decays, but the β^- particles emitted have a continuous range of kinetic energies.

Which statement explains why the β^- particles are emitted with a continuous range of kinetic energies?

- A Some of the energy released is given to the remaining nucleons in the nucleus.
- B Some of the energy released is taken by an emitted antineutrino.
- C Some of the energy released is used to create the β^- particle.
- D Some of the energy released is used to create a new nucleon.

- 39 Which particle is **not** a fundamental particle?

- A electron
- B neutrino
- C neutron
- D top quark

- 40 What is the charge of an anti-top quark?

- A $-\frac{2}{3}e$ B $-\frac{1}{3}e$ C $+\frac{1}{3}e$ D $+\frac{2}{3}e$

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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 What is a scalar quantity?

- A a quantity that can be represented as two perpendicular components
- B a quantity that does **not** require a unit
- C a quantity without a direction
- D a quantity without a magnitude

2 The value of quantity X has a percentage uncertainty of 2%.

The value of quantity Y has a percentage uncertainty of 4%.

The value of a quantity W is calculated from the values of X and Y .

The value of W has a percentage uncertainty of 8%.

What could be the relationship between W , X and Y ?

- A $W = XY$ B $W = 2XY$ C $W = \frac{X}{Y^2}$ D $W = \frac{Y}{X^2}$

3 A football is kicked so that it moves vertically upwards through the air.

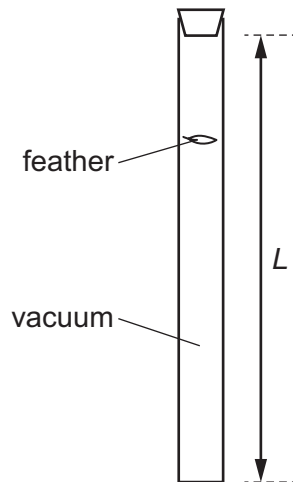
What is the variation in the air resistance and the resultant force acting on the ball as it moves vertically upwards?

	air resistance	resultant force
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

4 Which statement is **not** correct?

- A Acceleration can be determined from the gradient of a velocity–time graph.
- B Acceleration is the rate of change of velocity.
- C Displacement can be determined from the area under a velocity–time graph.
- D Velocity is the rate of change of distance.

- 5 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length L .

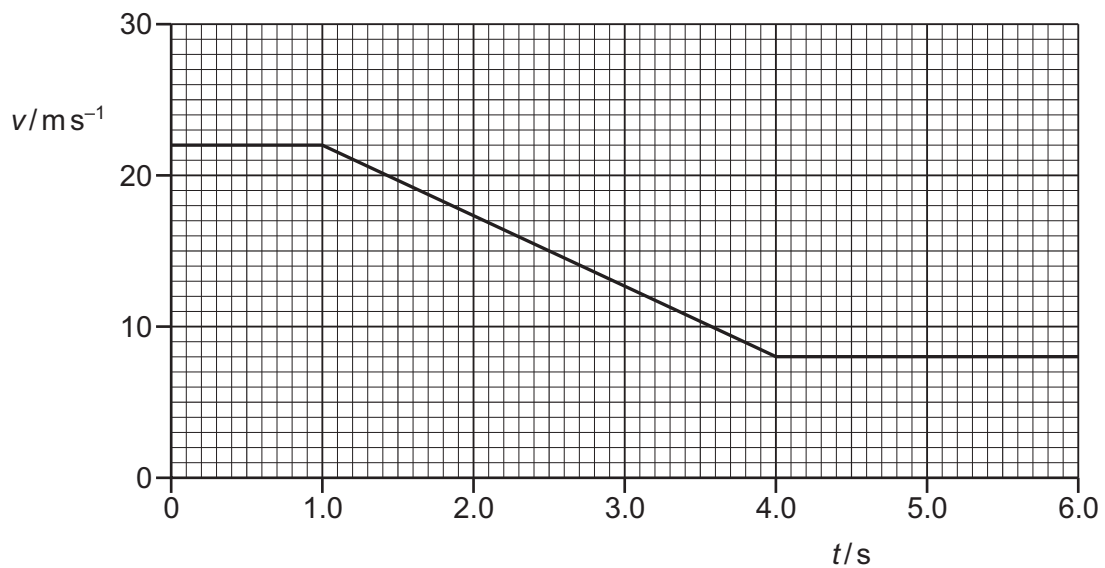


The feather takes time T to fall from the top to the bottom of the tube.

How far does the feather fall from the top of the tube in time $0.50T$?

- A** $0.13L$ **B** $0.25L$ **C** $0.38L$ **D** $0.50L$

- 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 Two satellites in deep space collide inelastically.

What happens to the total kinetic energy and total momentum?

	total kinetic energy	total momentum
A	conserved	conserved
B	conserved	reduced
C	reduced	conserved
D	reduced	reduced

- 8 What is a reasonable estimate of the momentum of a family car travelling at 25 kilometres per hour?

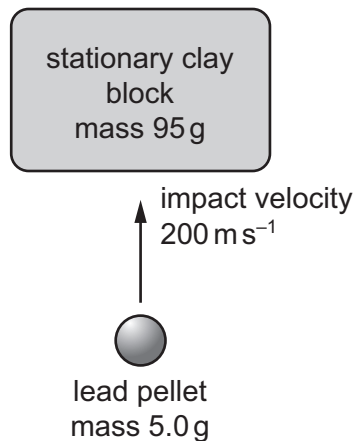
- A** $1 \times 10^4 \text{ kg m s}^{-1}$
B $1 \times 10^5 \text{ kg m s}^{-1}$
C $1 \times 10^6 \text{ kg m s}^{-1}$
D $1 \times 10^7 \text{ kg m s}^{-1}$

- 9 A ball collides with a wall. Before the collision, the ball moves with velocity 8 m s^{-1} to the right. After the collision, it moves with velocity 3 m s^{-1} to the left.

What is the change in velocity of the ball during the collision?

- A** 5 m s^{-1} to the left
B 5 m s^{-1} to the right
C 11 m s^{-1} to the left
D 11 m s^{-1} to the right

- 10** A lead pellet is shot vertically upwards into a clay block that is stationary at the moment of impact, but is able to rise freely after impact.



The mass of the pellet is 5.0 g and the mass of the clay block is 95 g.

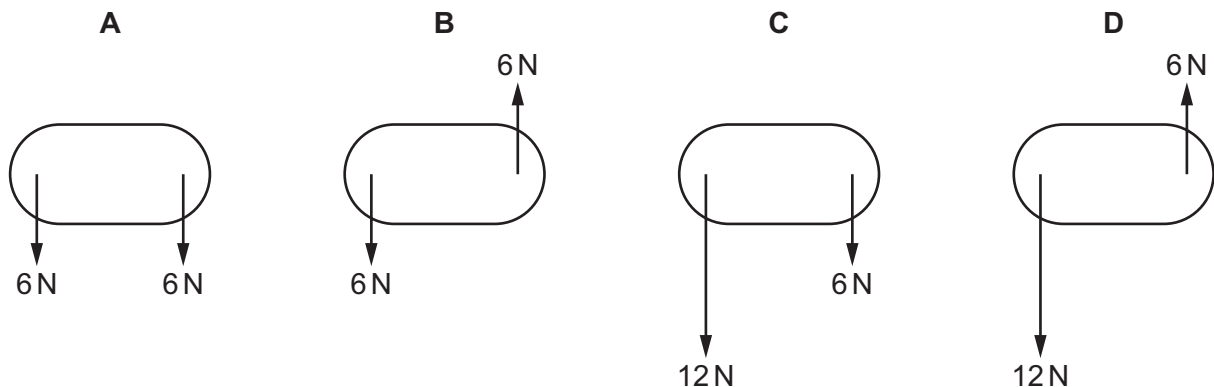
The pellet hits the block with an initial vertical velocity of 200 m s^{-1} . It embeds itself in the block and does not emerge.

How high above its initial position will the block rise?

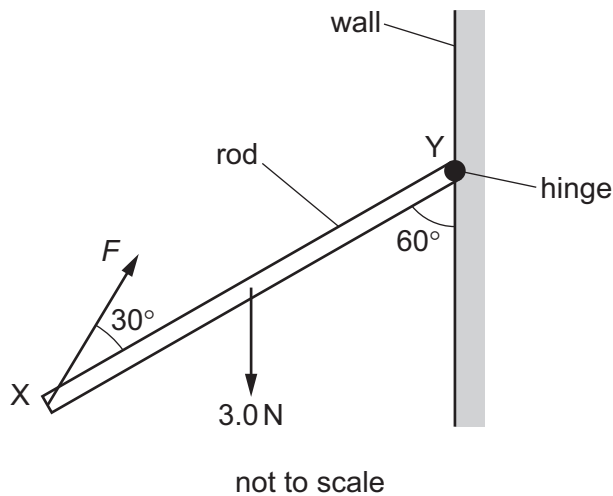
- A** 5.1 m **B** 5.6 m **C** 10 m **D** 100 m

- 11** Two forces act on an object.

Which diagram represents a couple?



- 12 The diagram shows a uniform rod, XY, that is freely hinged to a vertical wall at end Y. The rod is at an angle of 60° to the wall.



A force F acts at an angle of 30° to the rod at end X. The rod has a weight of 3.0 N and is in equilibrium.

What is the magnitude of force F ?

- A** 0.87 N **B** 1.5 N **C** 2.6 N **D** 5.2 N

- 13 Water has a density of 1.0 g cm^{-3} .

Glycerine has a density of 1.3 g cm^{-3} .

A student measures out a volume of 40 cm^3 of glycerine into a container.

The student adds water to the container to make a mixture of water and glycerine. Assume that the total volume of water and glycerine does not change when the two liquids are mixed.

Which volume of water needs to be added to make a mixture of density 1.1 g cm^{-3} ?

- A** 4.0 cm^3 **B** 8.0 cm^3 **C** 34 cm^3 **D** 80 cm^3

- 14 The force resisting the motion of a car is proportional to the square of the car's speed. The magnitude of the force at a speed of 20.0 m s^{-1} is 800 N .

What useful output power is required from the car's engine to maintain a steady speed of 40.0 m s^{-1} ?

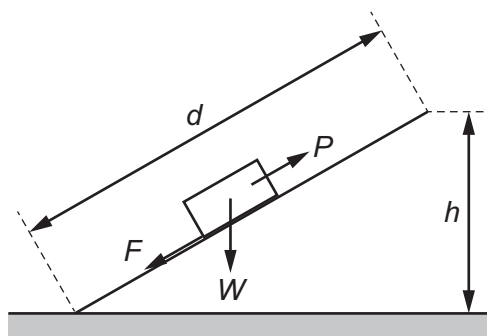
- A** 32 kW **B** 64 kW **C** 128 kW **D** 512 kW

- 15** A box of weight W is pulled by a force P along a slope.

The length of the slope is d , and the box rises a height h .

The frictional force between the box and the slope is F .

The diagram shows the directions of the forces.



The purpose of the slope is to raise the box vertically.

Which expression gives the efficiency of the slope?

- A** $\frac{Fd}{Wh}$ **B** $\frac{Pd}{Wh}$ **C** $\frac{Wh}{Fd}$ **D** $\frac{Wh}{Pd}$

- 16** The kinetic energy of a particle is increased by a factor of 4.

By what factor does its speed increase?

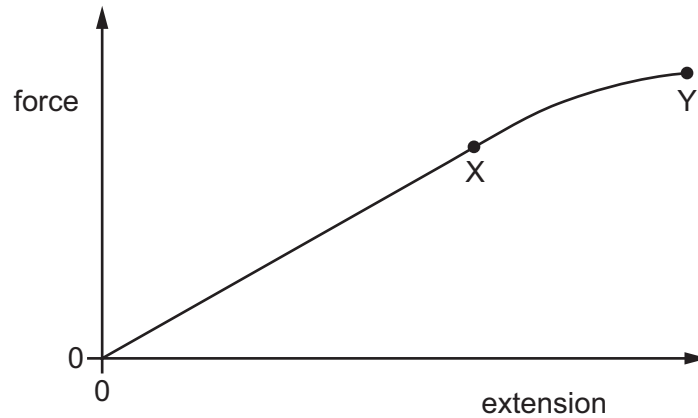
- A** 2 **B** 4 **C** 8 **D** 16

- 17** A mass of 28 g is raised vertically upwards through a distance of 4.6 m.

What is the change in gravitational potential energy of the mass?

- A** 0.13 J **B** 1.3 J **C** 130 J **D** 1300 J

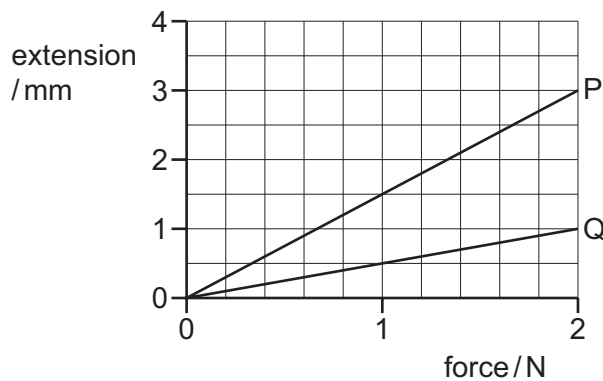
- 18 A sample of metal is subjected to a force which increases to a maximum value and then decreases back to zero. A force–extension graph for the sample is shown.



When the sample contracts, it follows the same force–extension curve as when it was being stretched.

What is the behaviour of the metal between X and Y?

- A both elastic and plastic
 - B **not** elastic and **not** plastic
 - C elastic but **not** plastic
 - D plastic but **not** elastic
- 19 Two wires, P and Q, made of the same material, are stretched with an increasing force. A graph is plotted of the variation with force of the extension of each wire.

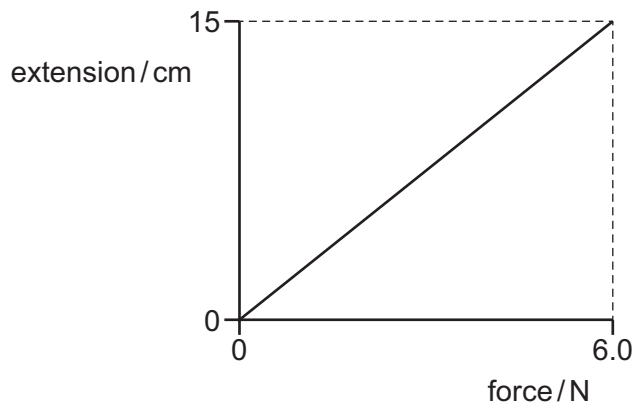


The wires have the same original length but different diameters.

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

- A $\frac{1}{3}$
- B $\frac{1}{\sqrt{3}}$
- C $\sqrt{3}$
- D 3

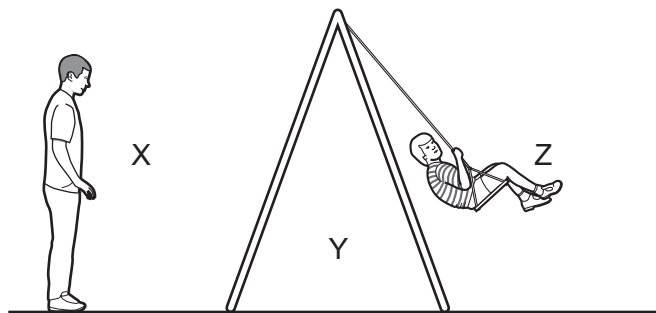
20 An extension–force graph for a spring is shown.



What is the spring constant of the spring?

- A** 0.025 N m^{-1} **B** 0.40 N m^{-1} **C** 2.5 N m^{-1} **D** 40 N m^{-1}

21 A man stands stationary in front of a swing. A child sits and swings.



The child blows a whistle that emits a sound at a constant frequency.

The man observes the frequency of the sound when the swing is at positions X, Y and Z.

When will the man hear the highest frequency?

- A** when the swing is at X
B when the swing is at Y and moving away from the man
C when the swing is at Y and moving towards the man
D when the swing is at Z

- 22** A loudspeaker is playing music in a room. The door to the room is open and has a width of 0.80 m.

Sound waves of many different frequencies pass through the doorway and diffract. The speed of sound in air is 340 m s^{-1} .

Which frequency of sound wave diffracts the most as it passes through the doorway?

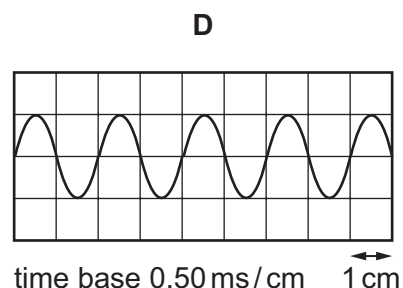
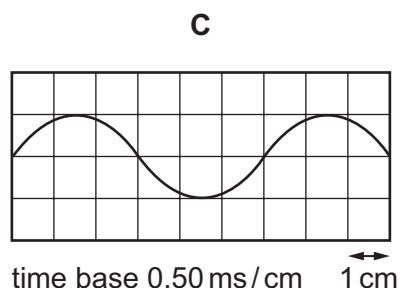
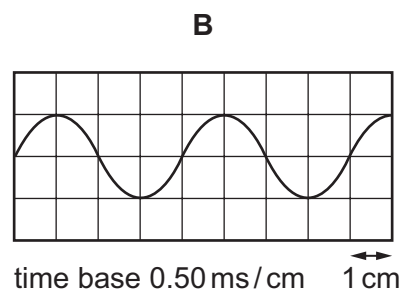
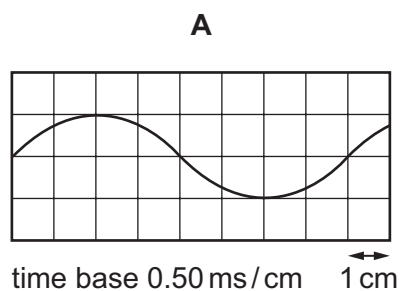
- A** $2.4 \times 10^{-3} \text{ Hz}$
- B** $8.0 \times 10^{-1} \text{ Hz}$
- C** $2.7 \times 10^2 \text{ Hz}$
- D** $4.3 \times 10^2 \text{ Hz}$

- 23** A stationary sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (CRO) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the CRO rises to a maximum at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

The distance between X and Y is 33 cm. The speed of sound in air is 330 m s^{-1} .

Which diagram could represent the CRO trace of the sound received at X?



- 24 Polarisation is associated with certain waves.

Which waves **cannot** be polarised?

- A radio waves from a transmitter
- B sound waves from a moving source
- C ultraviolet rays from the Sun
- D X-rays from an X-ray emitter

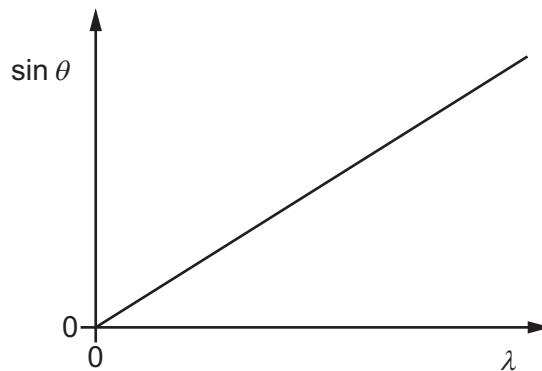
- 25 A guitar string is plucked.

Which statement describes the resulting waves?

- A Longitudinal waves on the string cause longitudinal waves in the air.
- B Longitudinal waves on the string cause transverse waves in the air.
- C Transverse waves on the string cause longitudinal waves in the air.
- D Transverse waves on the string cause transverse waves in the air.

- 26 A diffraction grating with N lines per metre is used to diffract light of various wavelengths λ .

The graph shows the relation between the diffraction angle θ and λ for different wavelengths in the n^{th} order interference pattern.



What is the gradient of the graph?

- A Nn
- B $\frac{N}{n}$
- C $\frac{n}{N}$
- D $\frac{1}{Nn}$

- 27 A stationary sound wave is formed in the air column inside a tube that is open at both ends.

The stationary wave has three nodes.

How many antinodes does it have?

- A 1
- B 2
- C 3
- D 4

- 28 Interference fringes of separation x are observed on a screen at a distance of 1.00 m from a double slit that is illuminated by yellow light of wavelength 600 nm.

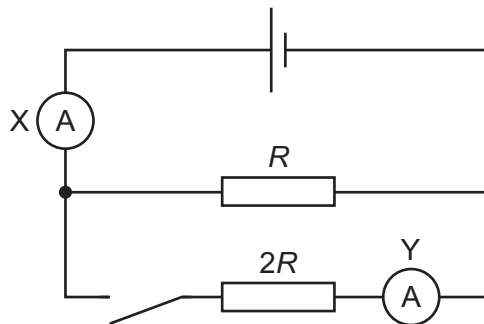
At which distance from the double slit would interference fringes of the same separation x be observed when using blue light of wavelength 400 nm?

- A** 0.33 m **B** 0.67 m **C** 0.75 m **D** 1.50 m

- 29 What is the definition of potential difference across a component?

- A** energy transferred per unit charge
B energy transferred per unit current
C energy transferred per unit distance
D energy transferred per unit time

- 30 The diagram shows a cell of negligible internal resistance connected to a switch and two resistors of resistances R and $2R$.



The circuit also contains two ammeters X and Y .

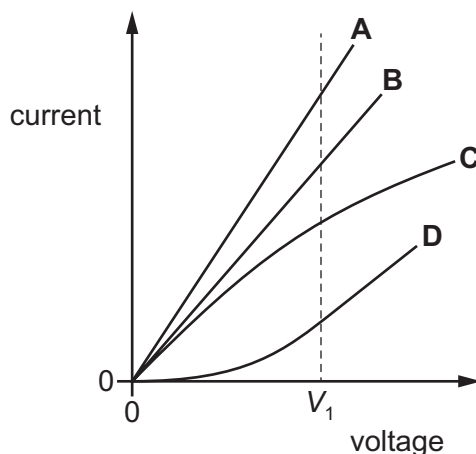
The reading on X is 4.0 A when the switch is open.

What are the readings on X and Y after the switch is closed?

	reading on X/A	reading on Y/A
A	4.0	1.3
B	4.0	2.7
C	6.0	2.0
D	6.0	4.0

- 31 The I – V characteristics for four components, **A**, **B**, **C** and **D**, are shown.

Which component has the greatest resistance when the potential difference across it is V_1 ?



- 32 A cylindrical wire has cross-sectional area A and number density of free electrons n . The wire has current I and the free electrons have average drift speed v .

A second cylindrical wire has cross-sectional area $0.5A$ and number density of free electrons $2n$. In this wire, the free electrons have average drift speed $2v$.

What is the current in the second wire?

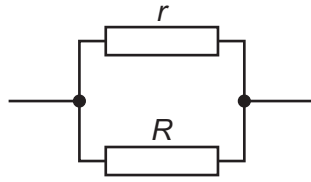
- A** $0.5I$ **B** I **C** $2I$ **D** $4I$
- 33 An electric current is formed by moving charge carriers.

What is **not** a possible charge on a charge carrier?

- A** $-4.8 \times 10^{-19} \text{ C}$
B $-2.4 \times 10^{-19} \text{ C}$
C $+1.6 \times 10^{-19} \text{ C}$
D $+3.2 \times 10^{-19} \text{ C}$
- 34 Which description of Kirchhoff's first law is correct?
- A** It considers the currents at a junction in a circuit and is a consequence of the conservation of charge.
B It considers the currents at a junction in a circuit and is a consequence of the conservation of energy.
C It considers the electromotive forces and potential differences in a circuit loop and is a consequence of the conservation of charge.
D It considers the electromotive forces and potential differences in a circuit loop and is a consequence of the conservation of energy.

- 35 Two resistors of resistances r and R are connected in parallel.

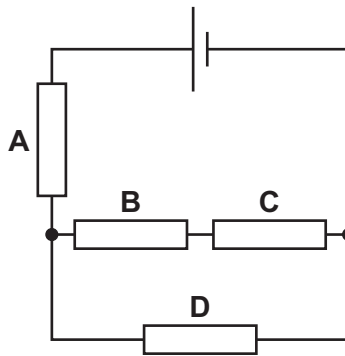
The value of r is less than that of R .



Which statement about the combined resistance of the two resistors is correct?

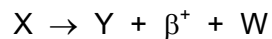
- A It is between r and R .
 - B It is equal to $(r + R)$.
 - C It is greater than $(r + R)$.
 - D It is less than r .
- 36 The diagram shows four identical resistors connected in a circuit.

Which resistor dissipates the most power?



- 37 Nuclide X with proton number Z undergoes β^+ decay to form nuclide Y.

The decay may be represented by the equation shown.



What is the proton number of Y and which particle is represented by the symbol W?

	proton number of Y	particle represented by W
A	$Z - 1$	antineutrino
B	$Z - 1$	neutrino
C	$Z + 1$	antineutrino
D	$Z + 1$	neutrino

38 Which fundamental particles form a hadron?

- A leptons
- B nucleons
- C photons
- D quarks

39 The unstable nuclide ${}^{218}_{84}\text{X}$ decays through a sequence of emissions of α and β^{-} particles to form the stable nuclide ${}^{210}_{83}\text{Y}$.

How many α and β^{-} particles are emitted during this decay process?

	α -particles	β^{-} particles
A	1	1
B	2	1
C	2	3
D	3	2

40 Which statement about radioactive decay is correct?

- A Neutrinos are always emitted during α -decay.
- B The α -particles emitted from a radioactive sample have a continuous range of kinetic energies.
- C The β^{-} particles emitted from a radioactive sample have a continuous range of kinetic energies.
- D The proton number of a nucleus decreases by four when it undergoes α -decay.

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Cambridge International AS & A Level

PHYSICS

9702/13

Paper 1 Multiple Choice

May/June 2024

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 What is equal to 0.000005 J?

- A 5 mJ B 5 MJ C 5 μ J D 5 nJ

2 The measurement of a physical quantity may be subject to random errors and to systematic errors.

Which statement is correct?

- A A systematic error **cannot** be reduced by adjusting the apparatus.
 B A systematic error results in a different reading each time the measurement is taken.
 C Random errors are always caused by the person taking the measurement.
 D Random errors can be reduced by taking the average of several measurements.

3 The Young modulus of the material of a wire is to be found. The Young modulus E is given by the equation shown.

$$E = \frac{4FL}{\pi d^2 x}$$

The wire is extended by a known force and the following measurements are made.

Which measurement has the largest effect on the uncertainty in the value of the calculated Young modulus?

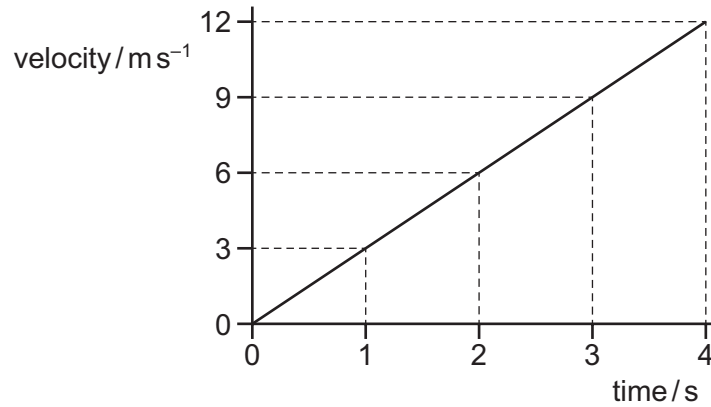
	measurement	symbol	value
A	length of wire before force applied	L	2.043 ± 0.002 m
B	diameter of wire	d	0.54 ± 0.02 mm
C	force applied	F	19.62 ± 0.01 N
D	extension of wire with force applied	x	5.2 ± 0.2 mm

4 Two physical quantities combined together as a product can produce a scalar quantity or a vector quantity.

Which product of two quantities produces a scalar quantity?

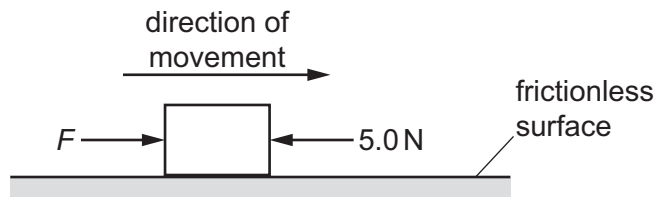
- A (force) $\times$ (displacement of an object in the direction of the force)
 B (mass) $\times$ (acceleration of the mass)
 C (pressure) $\times$ (area on which the pressure acts)
 D (velocity) $\times$ (time for which an object has that velocity)

- 5 The diagram shows a velocity–time graph for an object moving in a straight line.

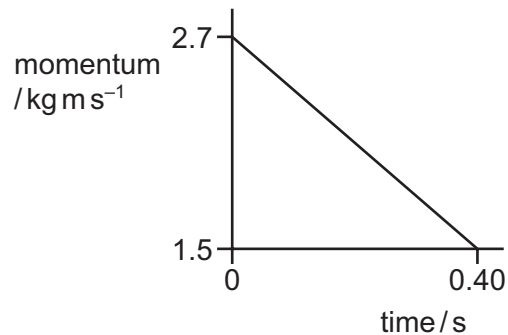


What is the displacement during the last 2 seconds of the motion?

- A** 6 m **B** 12 m **C** 18 m **D** 24 m
- 6 A block is moving along a horizontal frictionless surface. A constant force F and a constant resistive force of 5.0 N act on the block as it is moving in the direction of the force F , as shown.



The graph shows the variation with time of the momentum of the block.



What is the magnitude of force F ?

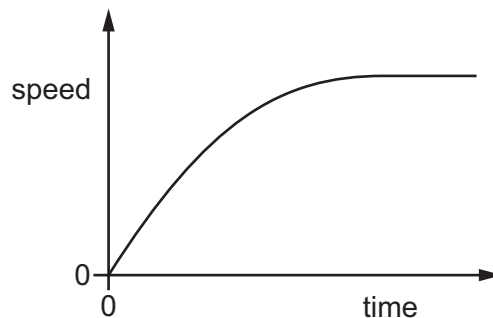
- A** 2.0 N **B** 3.0 N **C** 5.0 N **D** 8.0 N

- 7 Newton's third law describes two forces that are equal in magnitude and form a pair.

Which description of the two forces in such a pair is **not** correct?

- A They act in opposite directions.
- B They act on different objects.
- C They are the same type of force.
- D They cause an object to be in equilibrium.

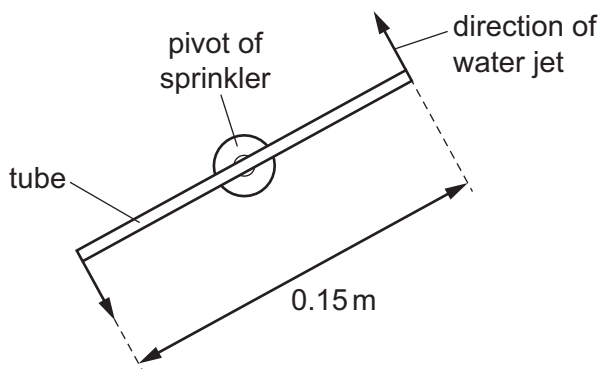
- 8 The graph shows the variation with time of the speed of a raindrop falling vertically through air.



Which statement is correct?

- A The acceleration decreases to produce a steady speed.
 - B The acceleration increases as the speed increases.
 - C The air resistance decreases as the speed increases.
 - D The resultant force increases as the speed increases.
- 9 Which statement about a perfectly elastic collision between two objects is correct?
- A Total kinetic energy is conserved and the relative speed of approach equals the relative speed of separation.
 - B Total kinetic energy is conserved but the relative speed of approach does **not** equal the relative speed of separation.
 - C Total kinetic energy is **not** conserved and the relative speed of approach does **not** equal the relative speed of separation.
 - D Total kinetic energy is **not** conserved but the relative speed of approach does equal the relative speed of separation.

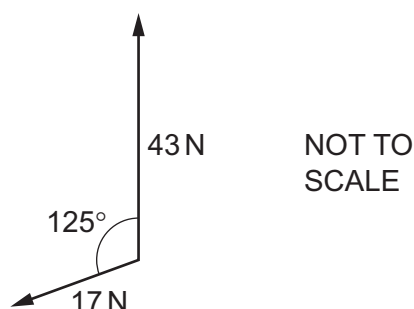
- 10 The diagram shows the view from above of a sprinkler system used to water a garden.



The sprinkler consists of a tube of length 0.15 m. The tube is pivoted in the middle and spins in a horizontal plane as it lets out jets of water from each end. The two water jets are in opposite directions to each other. Each water jet exerts a horizontal force of 3.0 N on the tube at right angles to the tube.

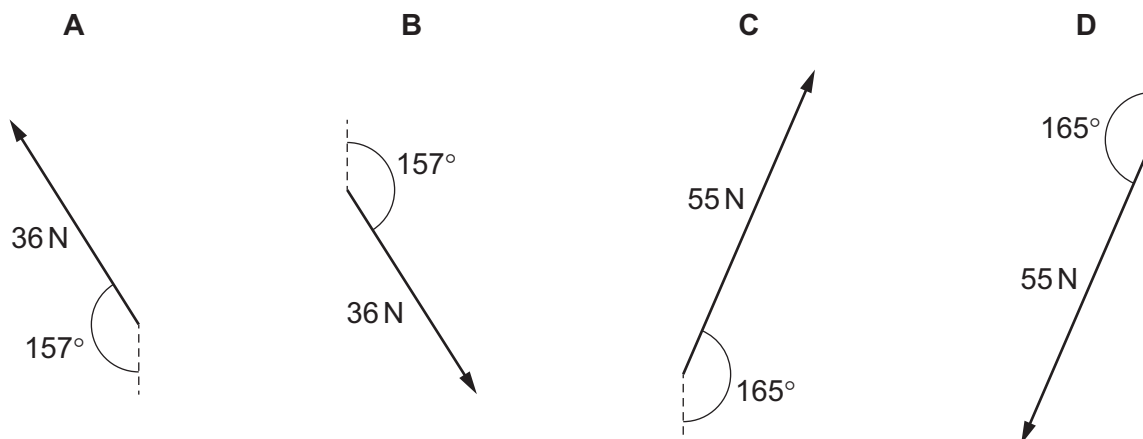
What is the magnitude of the torque on the tube from the water jets?

- A** 0 N m **B** 0.23 N m **C** 0.45 N m **D** 0.90 N m
- 11 An object is held in equilibrium by three forces. The forces all act in the same plane. The diagram shows two of the forces that act on the object.



The third force is missing from the diagram.

What is the third force?



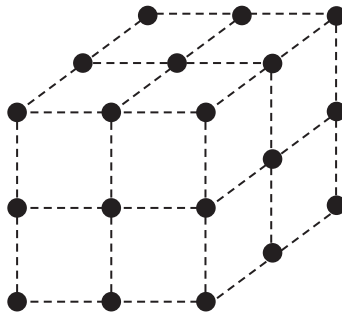
- 12 The total number of forces acting on an object is two. The object is in equilibrium.

Which statements about the forces are correct?

- 1 The two forces must have equal magnitudes.
- 2 The two forces must act in the same direction.
- 3 The two forces must act through the same point.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

- 13 The diagram shows the arrangement of atoms in a particular crystal.



Each atom is at the corner of a cube.

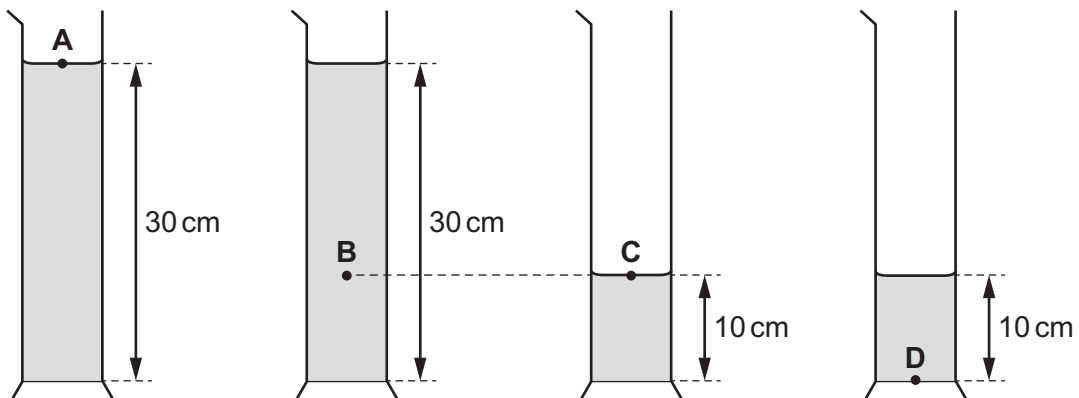
The mass of each atom is 3.5×10^{-25} kg. The density of the crystal is 9.2×10^3 kg m⁻³.

What is the shortest distance between the centres of two adjacent atoms?

- A** 3.8×10^{-29} m
B 6.2×10^{-15} m
C 3.4×10^{-10} m
D 3.0×10^{-9} m

- 14 Four measuring cylinders are filled with the same liquid to the heights shown.

At which position is the pressure the greatest?



- 15** In many filament lamps, as much as 92 J of energy is emitted as thermal energy for every 8 J of energy emitted as light.

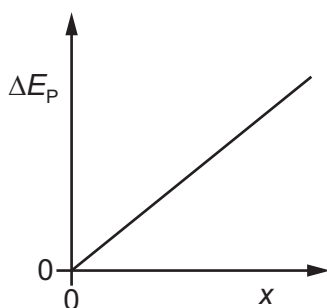
What is the efficiency of a filament lamp, as the percentage of electrical energy converted to light energy?

- A** 8% **B** 9% **C** 91% **D** 92%

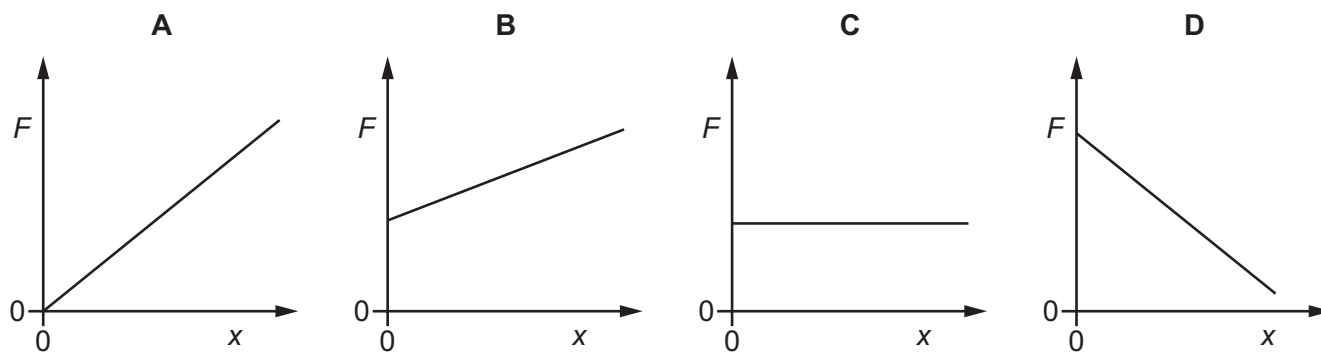
- 16** What is a unit of power?

- A** JC^{-1} **B** Jm^{-1} **C** JN^{-1} **D** Js^{-1}

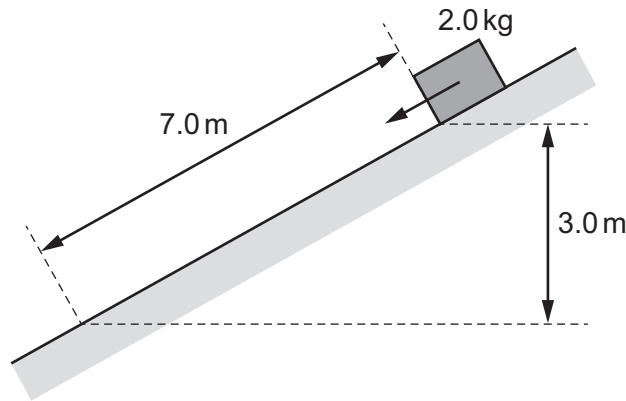
- 17** An object is in a uniform gravitational field. The graph shows how the change in gravitational potential energy ΔE_p of the object varies with the vertical distance x moved by the object from a fixed point.



Which graph shows how the gravitational force F acting on the object varies with distance x ?



- 18 A block of mass 2.0 kg is released from rest on a slope. It travels 7.0 m down the slope and falls a vertical distance of 3.0 m . The block experiences a frictional force parallel to the slope of 5.0 N .



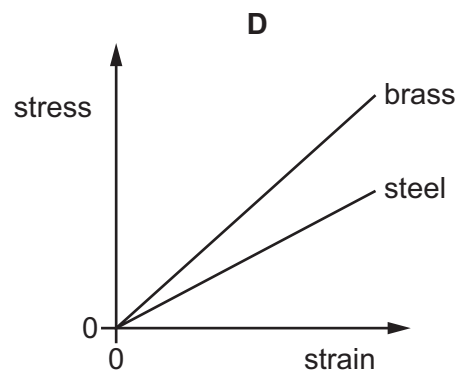
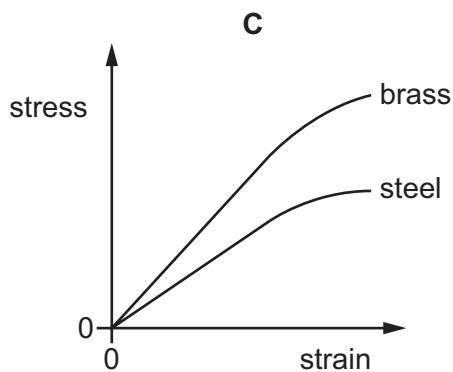
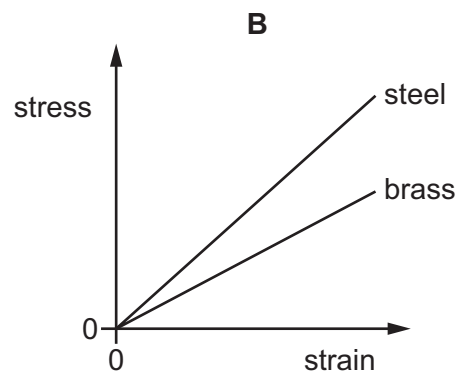
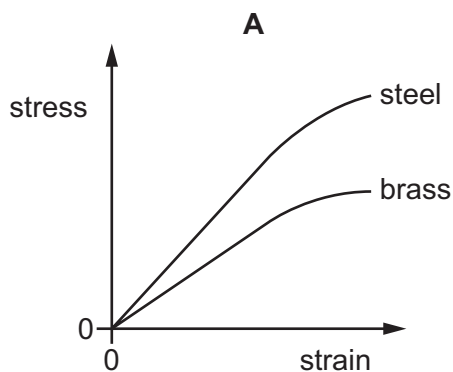
What is the speed of the block after falling this distance?

- A 4.9 ms^{-1} B 6.6 ms^{-1} C 8.6 ms^{-1} D 10 ms^{-1}

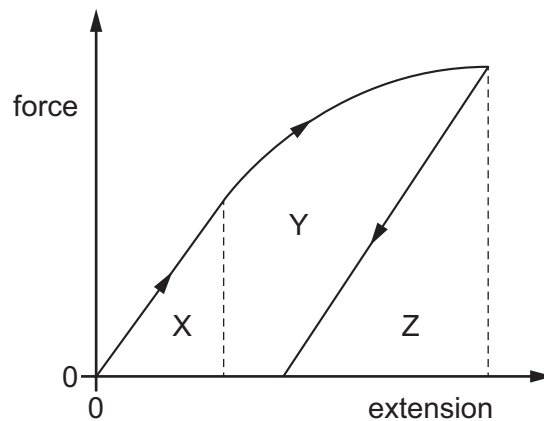
- 19 Two wires, one made of brass and the other of steel, are stretched in an experiment. Both wires obey Hooke's law during this experiment.

The Young modulus for brass is less than the Young modulus for steel.

Which graph shows how the stress varies with strain for both wires in this experiment?



- 20 A sample of material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The force–extension graph is shown.



Which area represents the net work done on the sample?

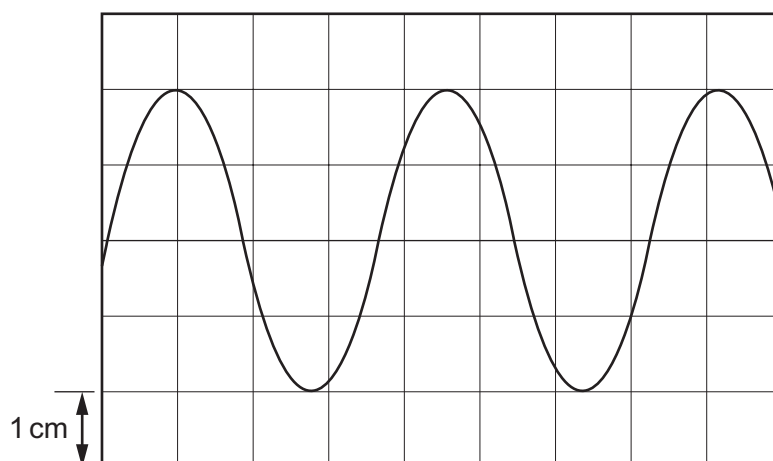
- A** X **B** X + Y **C** Y + Z **D** Z
- 21 A wire is fixed at one end and is extended by a force F_1 acting on the other end. This causes the wire to have an elastic potential energy of 0.15 J.

The force applied to the wire is now changed to a force F_2 . This causes the wire to have a new elastic potential energy of 0.60 J.

The wire obeys Hooke's law.

What is the relationship between F_1 and F_2 ?

- A** $F_1 = 2F_2$ **B** $F_1 = 4F_2$ **C** $2F_1 = F_2$ **D** $4F_1 = F_2$
- 22 The diagram shows a representation of a wave on the screen of an oscilloscope.



The y-gain is set to 3.5 mV cm^{-1} .

What is the amplitude of the wave?

- A** 0.57 mV **B** 3.5 mV **C** 7.0 mV **D** 14 mV

- 23 A transverse progressive wave on a string has a wavelength of 12 cm and an amplitude of 1.5 cm. The speed of the wave on the string is 48 cm s^{-1} .

What is the distance travelled by a point on the string in a time of 2.0 s?

- A 12 cm B 24 cm C 48 cm D 96 cm

- 24 An ambulance siren emits a sound with a single frequency f .

The ambulance travels towards, passes close to, and then travels away from a stationary observer.

Which statement describes the frequency of the sound detected by the observer as the ambulance **passes** the observer?

- A equal to f and decreasing
B equal to f and increasing
C greater than f and constant
D less than f and constant

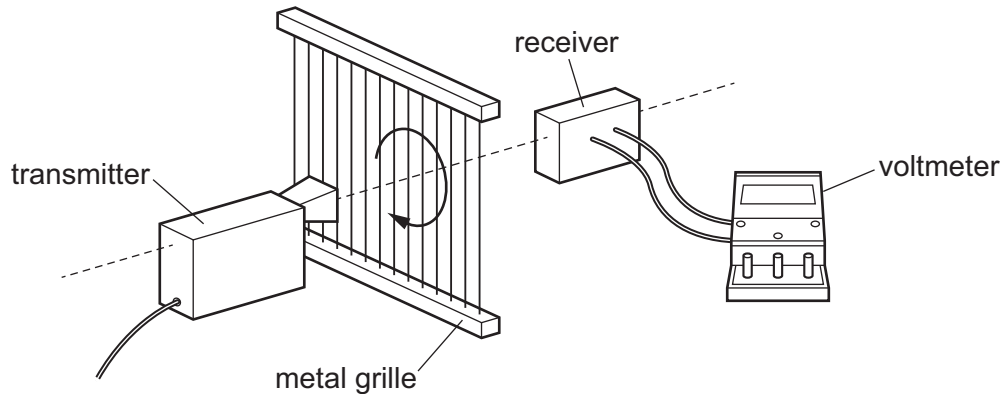
- 25 An electromagnetic wave has a wavelength of 138 pm in a vacuum.

To which region of the electromagnetic spectrum does this wave belong?

- A radio wave
B microwave
C visible light
D X-ray

- 26 A student investigates the polarisation of microwaves. The microwaves from the transmitter are vertically polarised. A metal grille acts as a polarising filter when placed between the microwave transmitter and the receiver. The reading on the voltmeter is proportional to the intensity of microwaves transmitted through the grille.

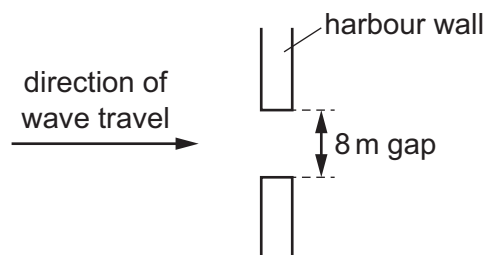
When the transmission axis of the grille is vertical, the voltmeter reads 3.50 V.



The grille is then rotated through an angle θ . The voltmeter now reads 2.20 V.

What is θ ?

- A 37.5° B 39.0° C 51.0° D 52.5°
- 27 Two waves superpose. A resultant wave pattern is formed.
- Which statement about the two waves **must** be correct?
- A They have the same amplitude.
 B They are of the same type.
 C They are transverse waves.
 D They travel in opposite directions.
- 28 A water wave passes through a gap in a harbour wall and diffracts. The gap has a width of 8 m.

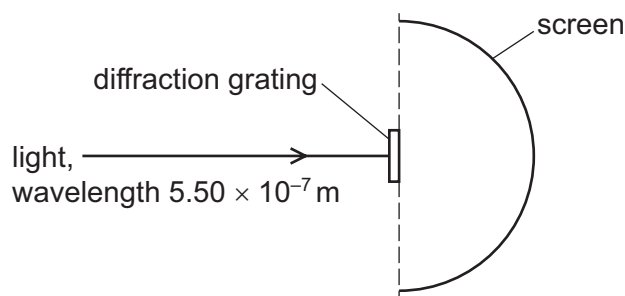


The wave travels directly towards the gap.

For which wavelength is the diffraction of the wave greatest?

- A 1 m B 2 m C 4 m D 8 m

- 29 Light of wavelength $5.50 \times 10^{-7} \text{ m}$ from a laser is incident normally on a diffraction grating. The diffracted light is incident on a semicircular screen, as shown in the view from above.



view from above

A total of 9 bright dots are formed on the screen.

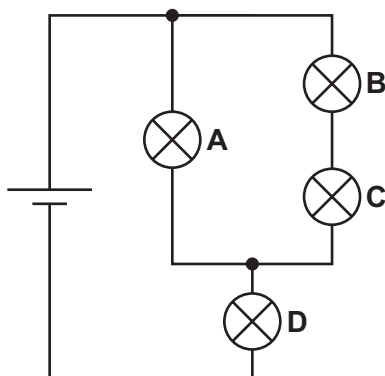
The grating is at the centre of the semicircle. The lines of the grating are vertical. The separation between adjacent lines in the grating is d .

What is a possible value of d ?

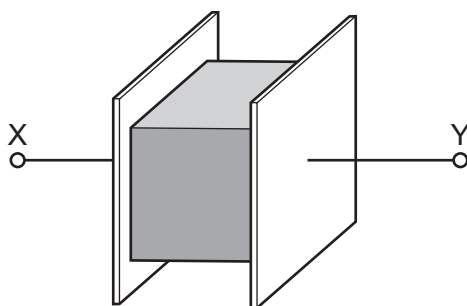
- A** $2.25 \times 10^{-6} \text{ m}$ **B** $2.80 \times 10^{-6} \text{ m}$ **C** $4.40 \times 10^{-6} \text{ m}$ **D** $4.95 \times 10^{-6} \text{ m}$
- 30 Which quantity is given by the product of charge and electric potential difference?
- A** current
B energy transferred
C power dissipated
D resistance
- 31 The current in a filament lamp is increased.
- Which statement about the lamp is correct?
- A** The brightness of the lamp decreases.
B The potential difference across the filament decreases.
C The resistance of the filament decreases.
D The temperature of the filament increases.

32 A student builds the circuit shown. All the lamps are identical.

Which lamp dissipates the most power?



33 The resistance of a metal cube is measured by placing it between two parallel plates, as shown.



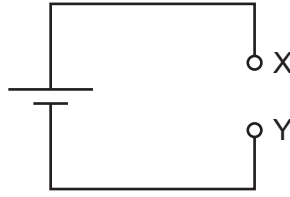
The cube has volume V and is made of a material with resistivity ρ . The connections to the cube have negligible resistance.

Which expression gives the electrical resistance of the metal cube between X and Y?

- A** $\rho V^{\frac{1}{3}}$
B $\rho V^{\frac{2}{3}}$
C $\frac{\rho}{V^{\frac{1}{3}}}$
D $\frac{\rho}{V^{\frac{2}{3}}}$

- 34** A circuit needs to be completed by connecting two resistors between points X and Y, as shown.

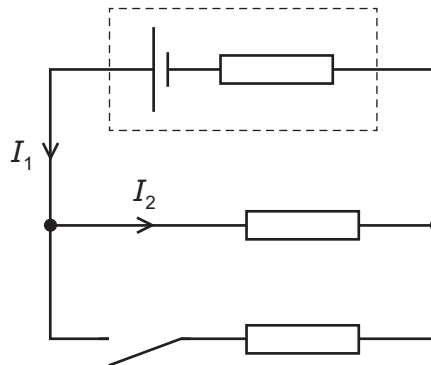
The resistors can be connected in series or in parallel with each other.



Which combination of resistors produces the least resistance between X and Y?

	resistances of resistors / Ω	type of combination
A	20 and 40	parallel
B	40 and 100	parallel
C	20 and 40	series
D	40 and 100	series

- 35** The diagram shows a circuit that includes a cell with internal resistance.

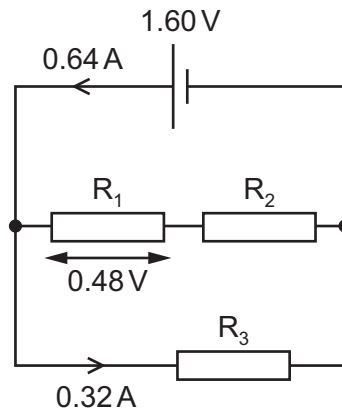


The switch is initially open.

Which row describes the effects on currents I_1 and I_2 of closing the switch?

	I_1	I_2
A	decreases	decreases
B	decreases	stays the same
C	increases	decreases
D	increases	stays the same

- 36 The diagram shows a circuit consisting of a cell and three resistors R_1 , R_2 and R_3 .



The cell has electromotive force (e.m.f.) 1.60 V and negligible internal resistance. The current in the cell is 0.64 A.

The potential difference across R_1 is 0.48 V.

The current in R_3 is 0.32 A.

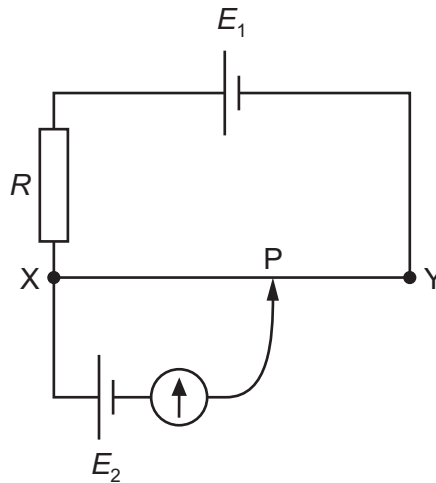
What is the resistance of R_2 ?

- A** $1.5\ \Omega$ **B** $2.5\ \Omega$ **C** $3.5\ \Omega$ **D** $5.0\ \Omega$

- 37 The diagram shows a potentiometer circuit used to compare the electromotive forces (e.m.f.), E_1 and E_2 , of two cells.

XY is a uniform resistance wire. The fixed resistor has resistance R .

A sliding contact is moved along the wire XY. When the sliding contact is at position P, the galvanometer reads zero.



The circuit is changed so that the galvanometer reads zero when the sliding contact is at a new position to the left of P.

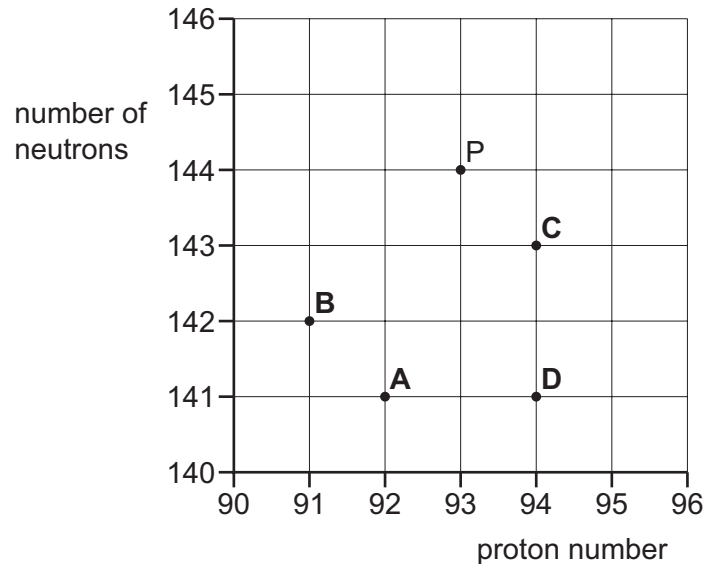
Which change could have been made to the circuit?

- A The wire XY was replaced with one of lower resistance.
- B E_2 was increased.
- C E_1 was decreased.
- D R was decreased.

- 38** Nucleus P has 144 neutrons and 93 protons. Nucleus P is unstable and undergoes α -decay to form nucleus Q. Nucleus Q then undergoes β^- decay to form nucleus R.

Nucleus P is represented by point P on the graph.

Which point on the graph represents nucleus R?



- 39** The diagrams show the quark composition of four different hadrons. One of the hadrons is a Σ^+ particle. It has a charge of $+e$, where e is the elementary charge.

Which hadron could be the Σ^+ particle?

A

B

C

D

key

u = up quark

d = down quark

s = strange quark

- 40** Which type of particle is comprised of the most quarks?

- A** antiquark
- B** baryon
- C** lepton
- D** meson

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