



Cambridge International AS & A Level

PHYSICS

9702/11

Paper 1 Multiple Choice

May/June 2023

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 unit is **not** an SI base unit?

- A** A **B** kg **C** C **D** s

2 What is the best estimate of the number of atoms in a piece of metal of volume 50 cm^3 ?

- A** 5×10^{15} **B** 5×10^{25} **C** 5×10^{29} **D** 5×10^{31}

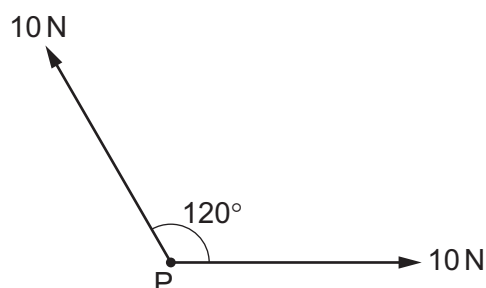
3 A copper pipe has a true diameter of 42.03 mm.

A builder measures the diameter of the pipe five times using digital calipers. The measurements are shown.

diameter / mm
48.01
47.99
48.01
48.00
47.99

What describes the builder's measurements?

- A** accurate and precise
B accurate but not precise
C not precise and not accurate
D precise but not accurate
- 4 Two forces, each of 10 N, act at a point P, as shown. The angle between the directions of the forces is 120° .

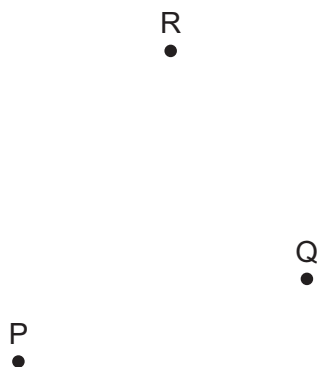


What is the magnitude of the resultant force?

- A** 5 N **B** 10 N **C** 17 N **D** 20 N

4

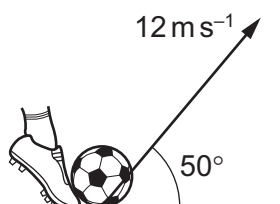
- 5 One object moves directly from P to R.



In a shorter time, a second object moves from P to Q to R.

Which statement about the two objects is correct for the journey from P to R?

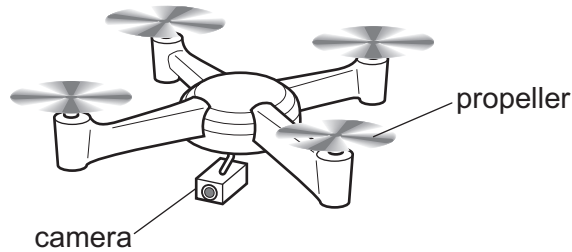
- A They have the same average speed.
 - B They have the same average velocity.
 - C They have the same displacement.
 - D They travel the same distance.
- 6 A ball is kicked so that it has an initial velocity of 12 m s^{-1} at an angle of 50° to horizontal ground. Assume that air resistance is negligible.



What is the maximum height above the ground that is reached by the ball?

- A 0.47 m B 3.0 m C 4.3 m D 7.3 m

- 7 A camera drone of mass 1.20 kg hovers at a fixed point above the ground. The drone has four propellers.



In a time of 1.00 s, each propeller pushes a mass of 0.400 kg of air vertically downwards.

Assume that the air above the propellers is stationary.

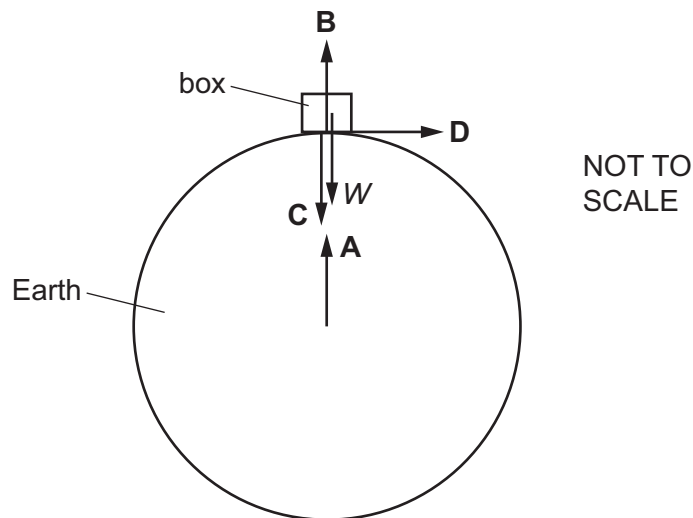
What is the speed of the air leaving each propeller?

- A** 0.750 ms^{-1} **B** 3.00 ms^{-1} **C** 7.36 ms^{-1} **D** 29.4 ms^{-1}

- 8 A box rests on the Earth, as shown.

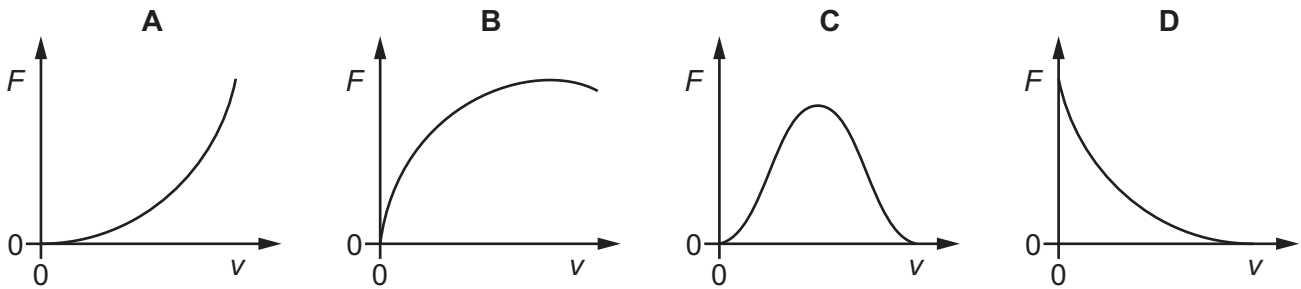
Newton's third law describes how forces of the same type act in pairs. One of the forces of a pair is the weight W of the box.

Which arrow represents the other force of this pair?

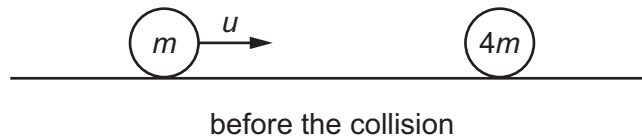


- 9 A small ball is held at the surface of liquid oil in a container. The ball is released from rest and falls through the oil. The ball has velocity v . A viscous (drag) force F acts on the ball.

Which graph could show the variation with v of F ?



- 10 An object of mass m , moving at speed u along a frictionless horizontal surface, collides head-on with a stationary object of mass $4m$.

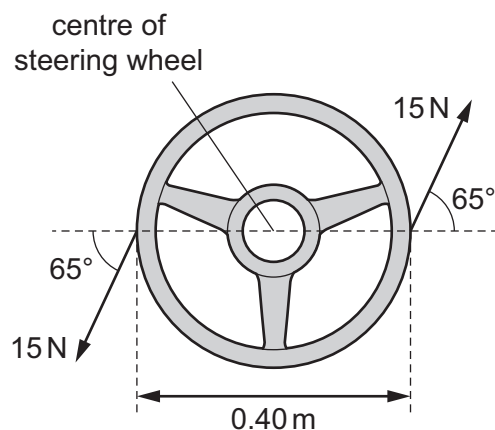


After the collision, the object of mass m rebounds along its initial path with $\frac{1}{4}$ of its kinetic energy before the collision.

What is the speed of the object of mass $4m$ after the collision?

- A $\frac{u}{8}$ B $\frac{3u}{16}$ C $\frac{5u}{16}$ D $\frac{3u}{8}$

- 11 The driver of a car applies two parallel forces to a steering wheel, as shown.

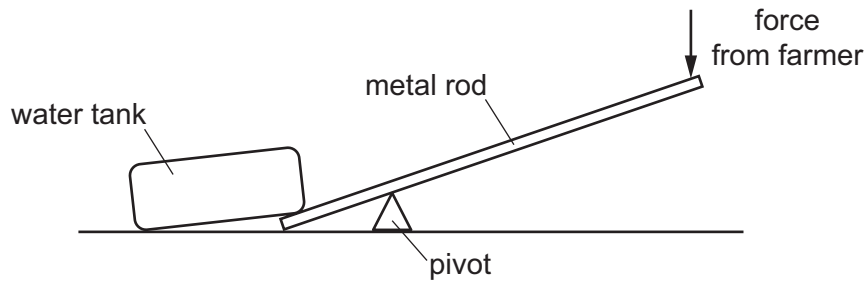


Each force has a magnitude of 15 N and acts in the direction shown. The steering wheel has a diameter of 0.40 m.

What is the torque exerted on the steering wheel?

- A 1.3 N m B 2.5 N m C 2.7 N m D 5.4 N m

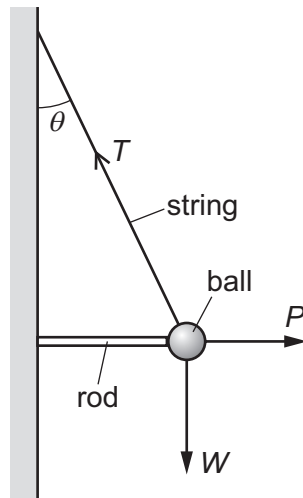
- 12 A farmer is trying to lift the corner of a large water tank. She uses a metal rod as a lever.



The vertical force from the farmer is constant and is always applied to the end of the rod.

Which change **must** increase the upward force on the water tank?

- A using a longer rod and moving the pivot closer to the tank
 - B using a longer rod and moving the pivot further away from the tank
 - C using a shorter rod and moving the pivot closer to the tank
 - D using a shorter rod and moving the pivot further away from the tank
- 13 The diagram shows a ball of weight W hanging in equilibrium from a string.



The string is at an angle θ to the vertical. The tension in the string is T . The ball is held away from the wall by a horizontal force P from a metal rod.

Which relationship between the magnitudes of T , P and W is correct?

- A $P = T \cos \theta$ and $W = T \sin \theta$
- B $T = P + W$
- C $T^2 = P^2 + W^2$
- D $W = P \tan \theta$ and $W = T \cos \theta$

14 Which expression for pressure is correct?

- A force per unit area
- B force per unit volume
- C mass per unit area
- D mass per unit volume

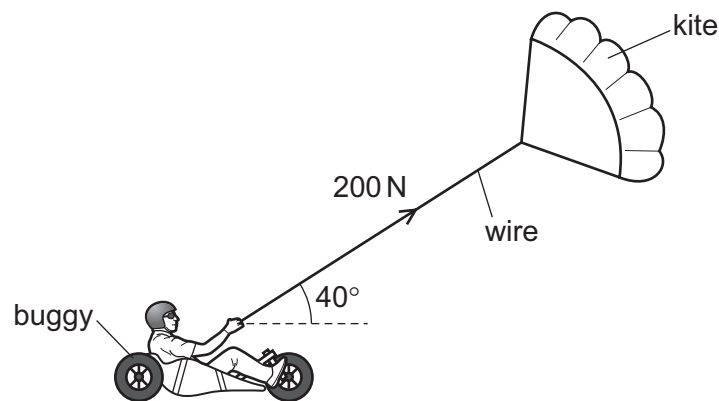
15 A ball has a mass of 0.50 kg and a volume of $1.3 \times 10^{-3} \text{ m}^3$. The ball is floating in equilibrium on still water. The two forces that act on the ball are its weight and the upthrust due to the water.

The density of the water is $1.0 \times 10^3 \text{ kg m}^{-3}$.

What is the percentage of the volume of the ball above the surface of the water?

- A 3.9%
- B 38%
- C 62%
- D 96%

16 A man sits on a buggy that is pulled along by a wire attached to a kite. The wire is at an angle of 40° to the horizontal and has a constant tension of 200 N. The man and buggy travel a distance of 20 m along a straight horizontal path. The wire and the path of the buggy are in the same vertical plane.



What is the work done by the tension force on the man and buggy?

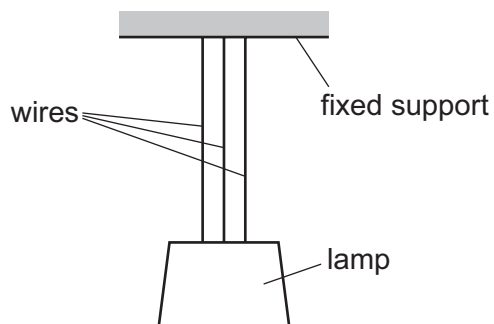
- A 2.6 kJ
- B 3.1 kJ
- C 3.4 kJ
- D 4.0 kJ

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

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

- A The kinetic energy of the ball decreases as the gravitational potential energy decreases.
- B The kinetic energy of the ball decreases as the gravitational potential energy increases.
- C The kinetic energy of the ball increases as the gravitational potential energy decreases.
- D The total energy of the ball increases.

- 18 A lamp is suspended in equilibrium from a fixed support by three long identical wires.



The weight of the lamp causes each wire to have an extension of 0.40 cm. The height h of the lamp above the floor is measured.

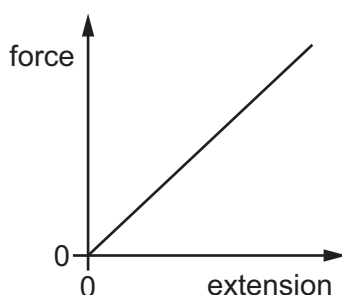
The middle wire suddenly breaks and the lamp falls a small distance as the extensions of the remaining two wires increase. The wires obey Hooke's law.

When the lamp is in equilibrium, the height h of the lamp above the floor is measured again.

What is the difference between the two values of h ?

- A** 0.20 cm **B** 0.27 cm **C** 0.40 cm **D** 0.60 cm

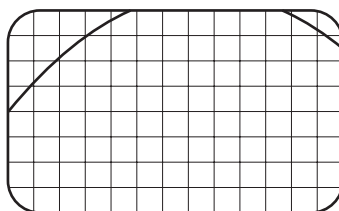
- 19 The force–extension graph for a spring is shown.



What represents the work done to extend the spring?

- A** the area under the graph
B the gradient of the graph
C the reciprocal of the gradient of the graph
D twice the area under the graph

- 20 In an experiment, a student uses a microphone and a cathode-ray oscilloscope (CRO) to analyse a sound wave. The diagram shows the trace on the screen of the CRO.

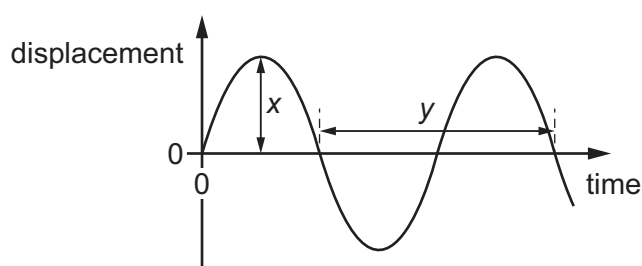


The student is expecting a sinusoidal waveform to be shown on the screen.

Which changes should the student make to the time-base and the y -gain of the CRO so that the screen shows a continuous trace for one complete cycle of the waveform?

	time-base	y -gain
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

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



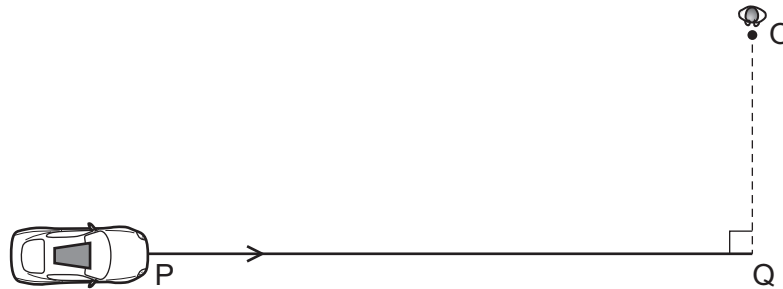
Two measurements, x and y , are labelled on the graph.

What do x and y represent?

	x	y
A	amplitude	period
B	frequency	period
C	amplitude	wavelength
D	frequency	wavelength

- 22** A car travels at a constant speed along a straight line PQ.

A loudspeaker attached to the car emits sound of constant frequency f . A stationary observer is at point O.



What does the observer hear as the car moves from P towards Q?

- A** a frequency less than f that decreases as the car moves from P towards Q
- B** a frequency less than f that increases as the car moves from P towards Q
- C** a frequency more than f that decreases as the car moves from P towards Q
- D** a frequency more than f that increases as the car moves from P towards Q

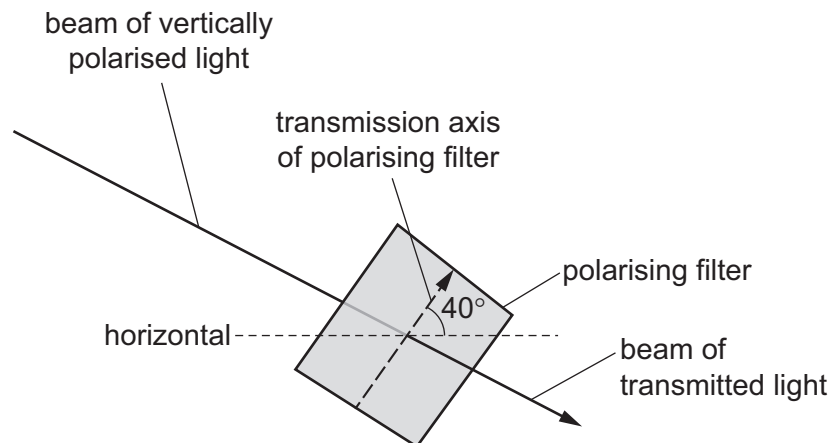
- 23** Some sources of electromagnetic waves in free space are listed.

- 1 a radio wave transmitter
- 2 a source of X-rays
- 3 a 30 mm wavelength radar transmitter
- 4 a light-emitting diode that emits red light

Which list gives the sources in order of increasing wavelength, from left to right, of the waves emitted by the sources?

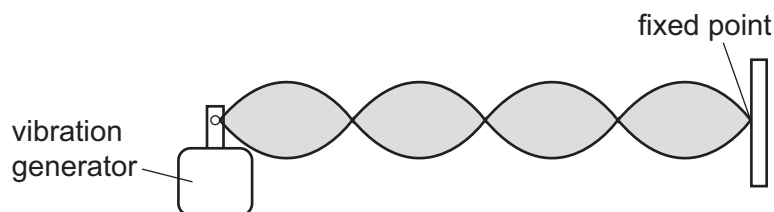
- A** 1 → 3 → 4 → 2
- B** 2 → 4 → 1 → 3
- C** 2 → 4 → 3 → 1
- D** 3 → 1 → 4 → 2

- 24** A vertically polarised beam of light is incident normally on a polarising filter. The transmission axis of the filter is at an angle of 40° to the horizontal.



What is the ratio $\frac{\text{amplitude of transmitted beam}}{\text{amplitude of incident beam}}$?

- A** 0.41 **B** 0.59 **C** 0.64 **D** 0.77
- 25** Two progressive waves meet at a point.
- Which condition must be met for superposition of the waves to occur?
- A** The waves must be coherent.
B The waves must be of the same type.
C The waves must be travelling in opposite directions.
D The waves must meet in phase.
- 26** A string is stretched between a vibration generator and a fixed point.

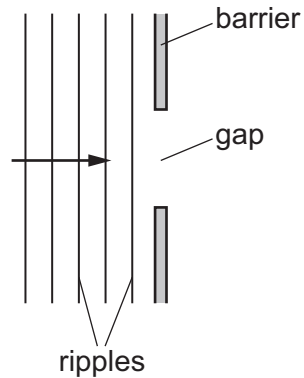


The frequency of vibration of the vibration generator is slowly increased.

What is the next frequency that produces a stationary wave on the string?

- A** $1.25f$ **B** $1.50f$ **C** $1.75f$ **D** $2.00f$

- 27** A ripple tank and a barrier with a single gap are used to demonstrate the diffraction of surface ripples on water. Initially, the wavelength of the ripples is five times smaller than the gap in the barrier.



Which change increases the amount of diffraction observed?

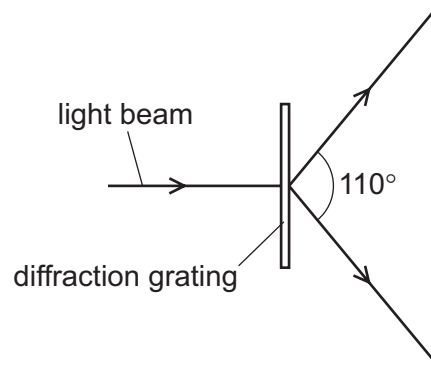
- A** double the amplitude of the ripples
 - B** double the width of the gap
 - C** halve the frequency of the ripples
 - D** halve the wavelength of the ripples
- 28** A laser produces a beam of light of wavelength 650 nm. The beam is incident normally on two slits that are a distance of 0.12 mm apart.

A screen is placed parallel to the slits. The bright interference fringes on the screen have a separation of 7.5 cm.

What is the distance between the screen and the two slits?

- A** 1.4 m **B** 2.8 m **C** 7.0 m **D** 14 m

- 29 A beam of light from a laser is incident normally on a diffraction grating.

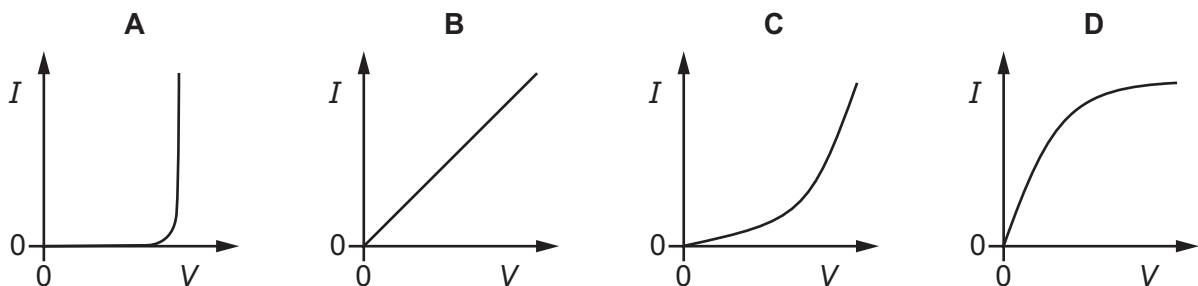


The diagram shows only the **second-order** maxima that are produced.

The grating has a line spacing of 1.0×10^{-6} m. The angle between the two second-order maxima is 110° .

What is the wavelength of the light?

- A** 4.1×10^{-7} m
B 4.7×10^{-7} m
C 8.2×10^{-7} m
D 9.4×10^{-7} m
- 30 The electric current in a metal wire is 4.0 mA.
- How many electrons pass a fixed point in the wire in a time of 10 hours?
- A** 2.5×10^{17} **B** 2.5×10^{20} **C** 9.0×10^{20} **D** 9.0×10^{23}
- 31 What is the definition of the potential difference across an electrical component?
- A** the charge per unit time passing through the component
B the energy transferred per unit charge
C the force per unit charge
D the resistance per unit current
- 32 Which graph shows the I – V characteristic of a filament lamp?



- 33** A metal wire has a length of 2.50 m and a cross-sectional area of $4.50 \times 10^{-6} \text{ m}^2$. The resistivity of the metal is $3.50 \times 10^{-7} \Omega \text{ m}$.

The wire is stretched so that its length increases to 2.65 m. The wire remains cylindrical and the **volume** of the wire remains constant.

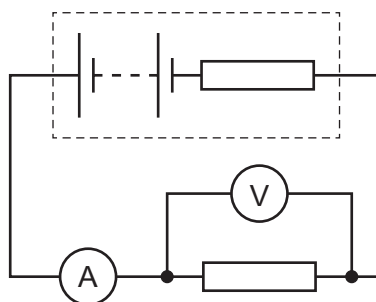
What is the change in the resistance of the wire?

- A** 0.012Ω **B** 0.024Ω **C** 0.19Ω **D** 0.22Ω

- 34** Which circuit symbol represents a microphone?



- 35** A battery with internal resistance is connected to a fixed resistor, an ammeter and a voltmeter, as shown.



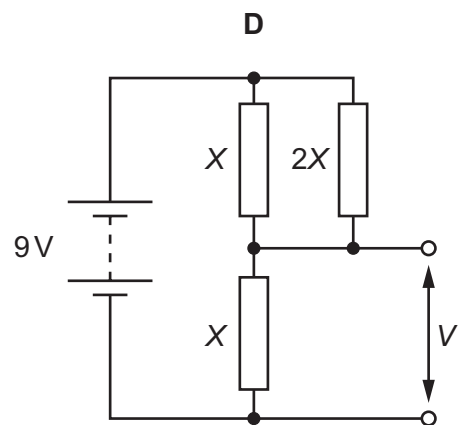
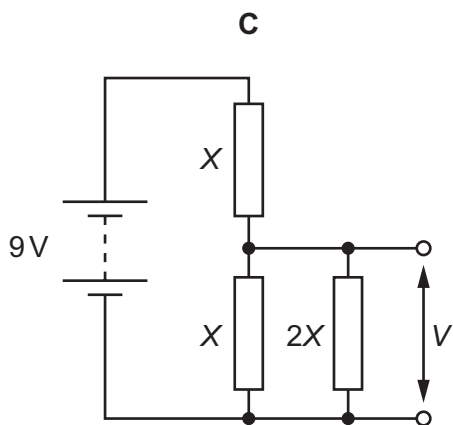
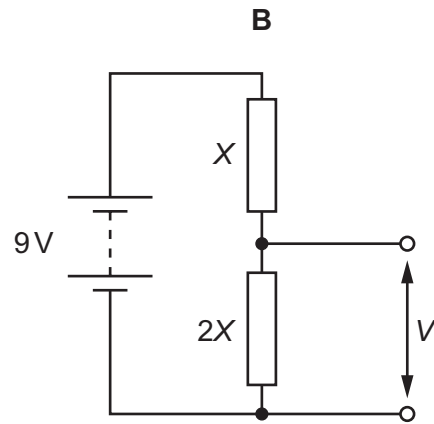
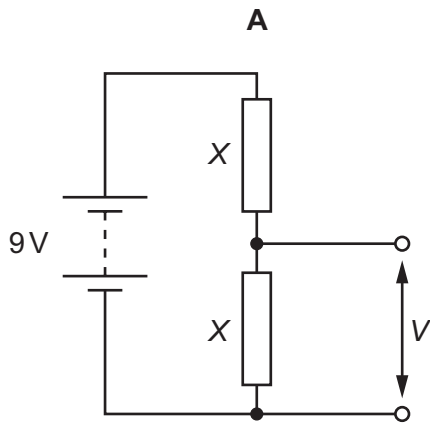
The battery is replaced by a different battery that has the same electromotive force (e.m.f.) but a greater internal resistance.

What happens to the readings on the ammeter and voltmeter?

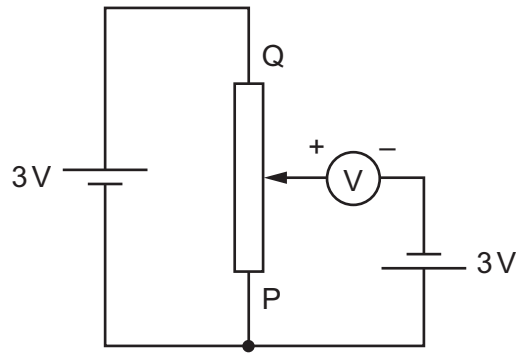
	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	stays the same	decreases
D	stays the same	stays the same

- 36** Four potential divider circuits each consist of a battery of electromotive force (e.m.f.) 9V and negligible internal resistance connected to a combination of resistors. Each of the resistors in the circuits has a resistance of X or $2X$.

Which circuit has the largest output voltage V ?



- 37 A voltmeter is connected into a circuit with the polarity shown.



The sliding contact is moved to end P of the potentiometer and then to end Q.

What are the two readings of the voltmeter?

	sliding contact at end P	sliding contact at end Q
A	0 V	3 V
B	0 V	6 V
C	3 V	3 V
D	3 V	6 V

- 38 A proton has mass m_p and charge $+e$.

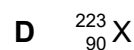
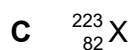
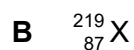
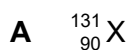
What are the mass and charge of an antiproton?

	mass	charge
A	$-m_p$	$+e$
B	$-m_p$	$-e$
C	m_p	$+e$
D	m_p	$-e$

- 39 A uranium nucleus has 92 protons and 143 neutrons.

The nucleus emits a total of 3 α -particles and 4 β^- particles to form nucleus X.

How can nucleus X be represented?



40 Which statement about a proton is correct?

- A** A proton is a baryon but not a meson.
- B** A proton is a meson but not a hadron.
- C** A proton is both a hadron and a meson.
- D** A proton is both a meson and a baryon.

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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 A stone sinks in water.

What is a possible value for the density of the stone?

- A** $8 \times 10^2 \text{ kg m}^{-3}$
B $2 \times 10^3 \text{ kg m}^{-3}$
C $8 \times 10^3 \text{ N m}^{-3}$
D $2 \times 10^4 \text{ N m}^{-3}$

- 2 Gm, Tm, μm and pm are all units of length.

Which unit is the largest and which unit is the smallest?

	largest unit	smallest unit
A	Gm	μm
B	Gm	pm
C	Tm	μm
D	Tm	pm

- 3 Two measurements for a solid sphere are shown.

$$\text{mass} = (32.5 \pm 0.1) \text{ g}$$

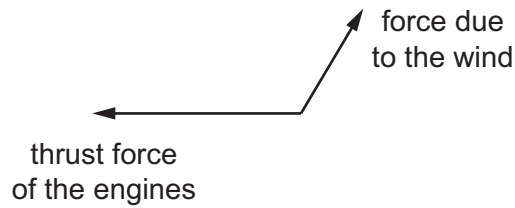
$$\text{diameter} = (1.87 \pm 0.04) \text{ cm}$$

These values are used to determine the density of the sphere.

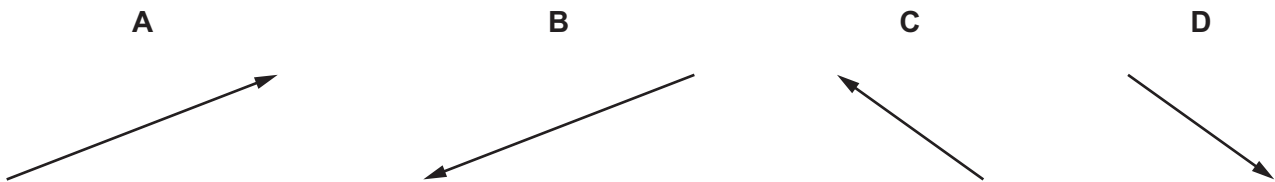
What is the percentage uncertainty in the density?

- A** 2.4% **B** 4.6% **C** 6.1% **D** 6.7%

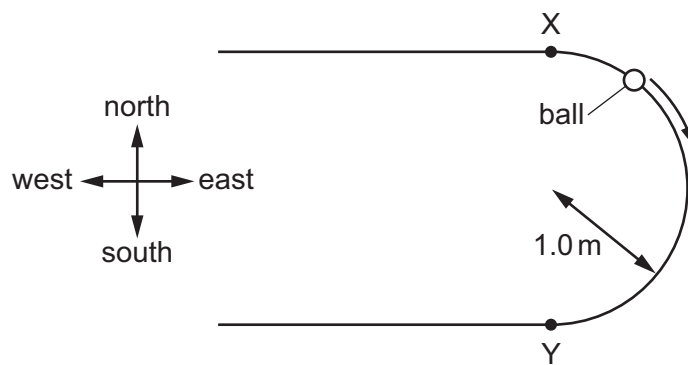
- 4 An aircraft travels along a horizontal path. Two of the forces that act horizontally on the aircraft are the thrust force of the engines and the force due to the wind. The vector diagram for these forces is shown.



Which vector represents the resultant horizontal force acting on the aircraft due to these two forces?



- 5 A ball travels from point X to point Y around a semicircular track of radius 1.0 m, as shown.

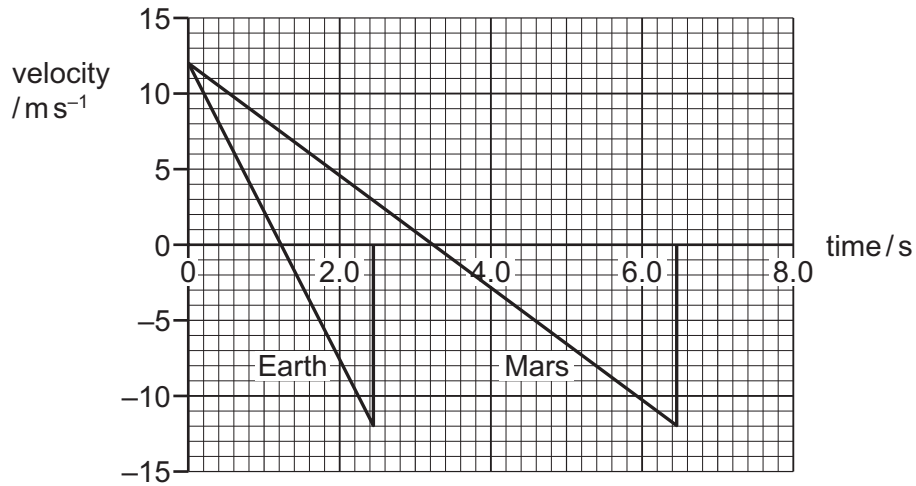


What is the displacement of the ball from X to Y?

- A 2.0 m
- B 2.0 m due south
- C 3.1 m
- D 3.1 m due south

- 6 A rock is launched vertically upwards from the surface of the Earth and an identical rock is launched vertically upwards from the surface of Mars. Each rock is launched with an initial velocity of 12 m s^{-1} .

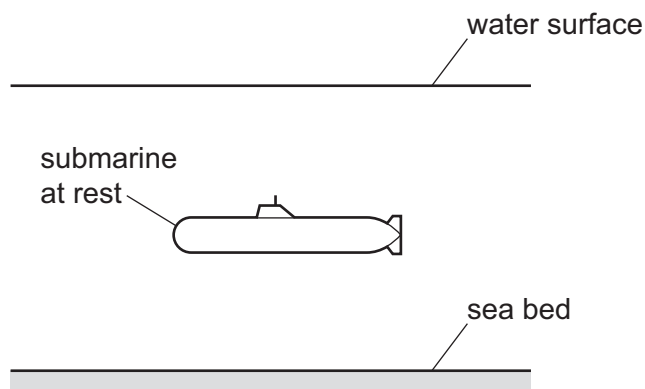
Each rock then reaches its maximum height above the surface before returning back down to the surface. The velocity–time graph for each rock is shown. In both cases, air resistance is negligible.



What is the difference in the maximum heights of the two rocks?

- A** 12 m **B** 15 m **C** 19 m **D** 24 m
- 7 Which statement describes the mass of an object?
- A** the force the object experiences due to gravity
- B** the momentum of the object before a collision
- C** the resistance of the object to changes in motion
- D** the weight of the object as measured by a balance

- 8 A submarine of total mass 3200 kg is at rest underwater.

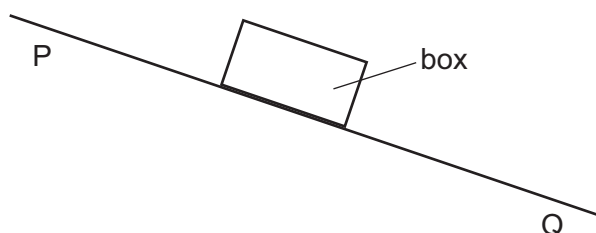


The total mass of the submarine is suddenly decreased by 200 kg by pumping water out of the submarine horizontally in a negligible time. The upthrust acting on the submarine is unchanged.

The change in the total weight of the submarine causes it to accelerate vertically upwards.

What is the initial upwards acceleration of the submarine?

- A** 0.613 ms^{-2} **B** 0.654 ms^{-2} **C** 9.81 ms^{-2} **D** 10.5 ms^{-2}
- 9 A box in air slides with increasing speed down a rough slope from point P to point Q.



The slope surface exerts a constant frictional force on the box.

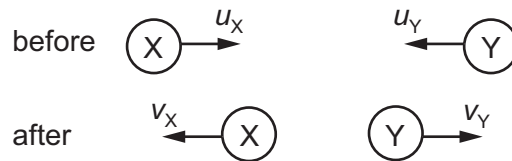
As the box moves from P to Q, there are changes to the magnitudes of its acceleration and the total resistive force acting on it.

Which row describes the changes?

	magnitude of acceleration	magnitude of total resistive force
A	increases	decreases
B	decreases	decreases
C	increases	increases
D	decreases	increases

- 10 Two balls, X and Y, approach each other along the same straight line and collide. The collision is perfectly elastic.

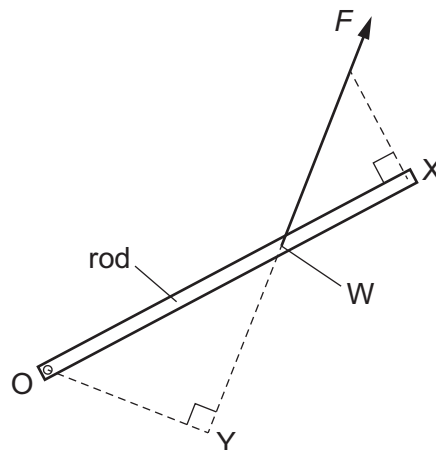
Their initial speeds are u_X and u_Y respectively. After the collision they move apart with speeds v_X and v_Y respectively. Their directions are shown.



Which equation is correct?

- A $u_X + u_Y = v_X + v_Y$
 - B $u_X + u_Y = v_X - v_Y$
 - C $u_X - u_Y = v_X + v_Y$
 - D $u_X - u_Y = v_X - v_Y$
- 11 A rod is pivoted at point O.

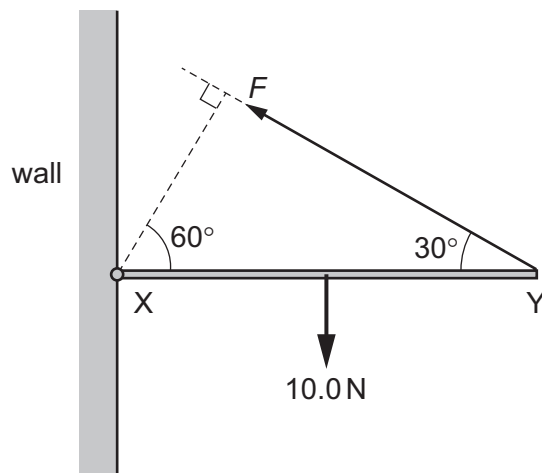
A force F is applied to the rod at point W, as shown.



What is the moment of the force F about O?

- A $F \times \text{distance OX}$
- B $F \times \text{distance OY}$
- C $F \times \text{distance WO}$
- D $F \times \text{distance WX}$

- 12 A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force F acting from Y at an angle of 30° to the horizontal, as shown.



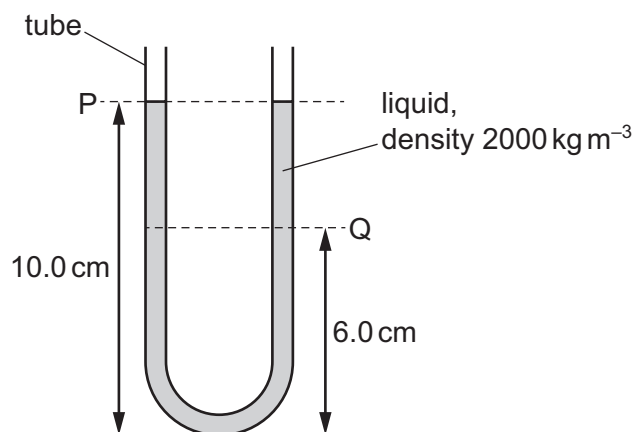
What is the value of F ?

- A 5.0 N B 8.7 N C 10 N D 20 N
- 13 Two solid cubes X and Y are made of material of the same density. Cube X has twice the mass of cube Y.

Cube X has sides of length x . Cube Y has sides of length y .

What is the ratio $\frac{x}{y}$?

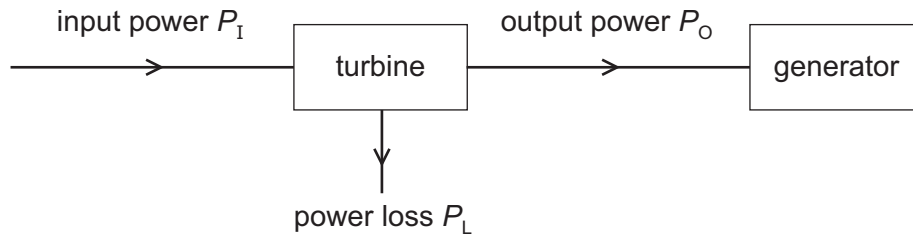
- A 1.26 B 1.41 C 2.00 D 8.00
- 14 A U-shaped glass tube contains liquid of density 2000 kg m^{-3} , as shown.



What is the difference in pressure due to the liquid between levels P and Q?

- A 780 Pa B 1200 Pa C 1600 Pa D 2000 Pa

- 15** A steam turbine is used to drive a generator. The input power to the turbine is P_I and the output power is P_O . The power loss in the turbine is P_L , as shown.

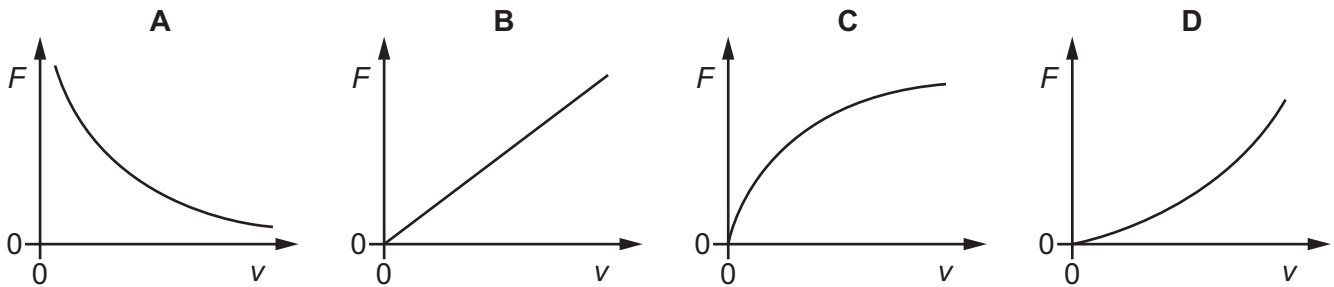


What is the efficiency of the turbine?

- A** $\frac{P_L}{P_O}$ **B** $\frac{P_I}{P_O}$ **C** $\frac{P_L}{P_I}$ **D** $\frac{P_O}{P_I}$

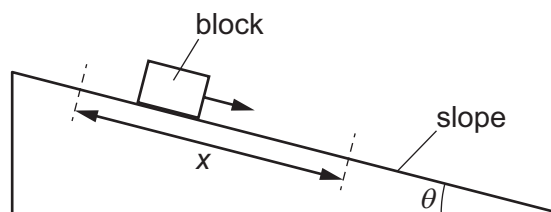
- 16** A variable force is applied to ensure that a constant power is supplied to a train.

Which graph best shows the variation of the force F applied with the velocity v of the train?



- 17** A block is released from rest and slides a distance x down a straight slope.

The slope is at an angle θ to the horizontal.



The slope is frictionless and air resistance is negligible.

The acceleration of free fall is g .

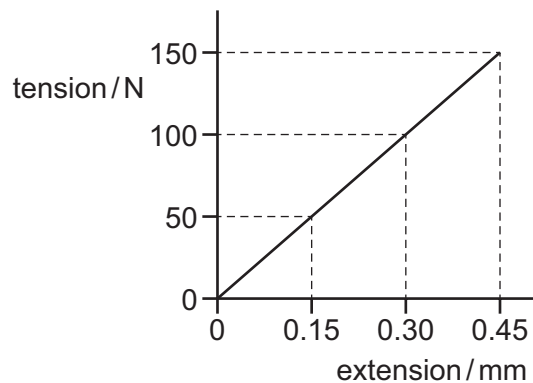
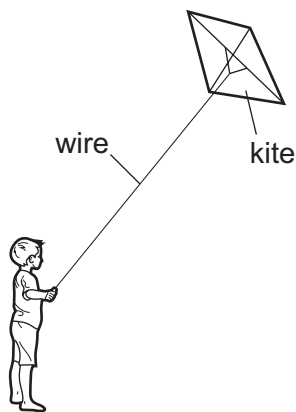
Which expression gives the final speed of the block?

- A** $\sqrt{\frac{gx \sin \theta}{2}}$ **B** $\sqrt{2gx \sin \theta}$ **C** $\sqrt{2gx}$ **D** $2gx \sin \theta$

18 What is meant by the spring constant of a spring?

- A extension per unit force
- B $\frac{1}{2} \times \text{force} \times \text{extension}$
- C force $\times$ extension
- D force per unit extension

19 A child holds a thin metal wire that is attached to a kite. The graph shows how the extension of the wire varies with its tension.



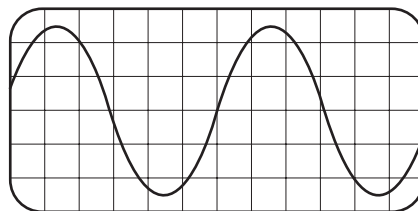
A gust of wind increases the tension from 100 N to 150 N.

What is the change in the elastic potential energy of the wire caused by the gust of wind?

- A 3.8 mJ
- B 19 mJ
- C 34 mJ
- D 38 mJ

20 A microphone detects a sound wave. The microphone is connected to a cathode-ray oscilloscope (CRO).

The shape of the trace on the screen of the CRO is shown.



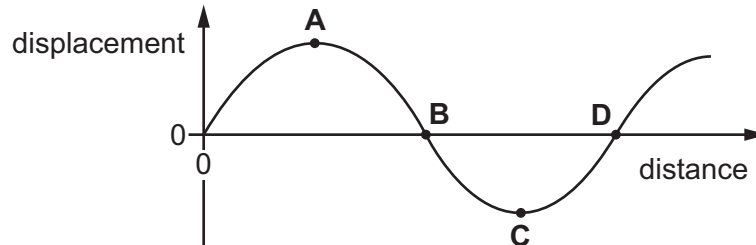
Which property of the sound wave can be determined by using only the measurement of a horizontal distance on the screen and the value of a control setting of the CRO?

- A amplitude
- B frequency
- C speed
- D wavelength

- 21** A longitudinal wave is travelling from left to right. The graph shows the variation of the displacement of the particles with distance along the wave at one instant in time.

Displacements to the right are positive; displacements to the left are negative.

Which labelled point represents a compression?



- 22** A source X emits a sound wave of constant frequency f .

The wave is subsequently received at a stationary detector Y.

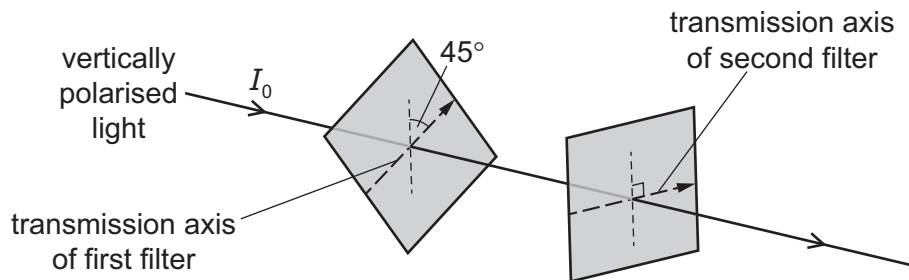
The frequency of the wave that is detected by Y is less than f .

What could be the reason for this?

- A** Between X and Y, the wave undergoes diffraction.
 - B** Between X and Y, the wave undergoes reflection.
 - C** X is moving away from Y.
 - D** X is moving towards Y.
- 23** A beam of visible light is in a vacuum.
- What could be the frequency of the light?
- A** $5.0 \times 10^5 \text{ Hz}$ **B** $5.0 \times 10^8 \text{ Hz}$ **C** $5.0 \times 10^{11} \text{ Hz}$ **D** $5.0 \times 10^{14} \text{ Hz}$

- 24** A vertically polarised beam of light of intensity I_0 is incident normally on a polarising filter.

The transmission axis of the filter is at 45° to the vertical. The beam of light transmitted by this filter is then incident normally on a second filter. The transmission axis of the second filter is horizontal.

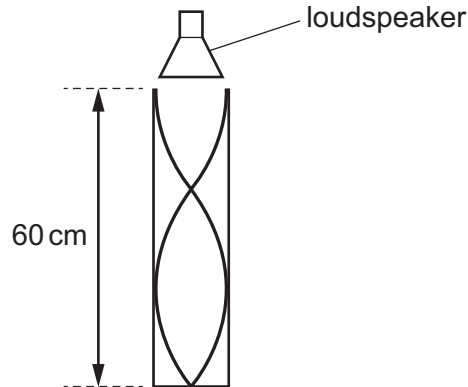


What is the intensity of the beam of light after transmission through the second filter?

- A** 0 **B** $\frac{1}{4} I_0$ **C** $\frac{1}{2} I_0$ **D** I_0
- 25** A stationary wave is formed by two progressive waves travelling in opposite directions along the same line of travel.
- Which statement about the two progressive waves is **not** correct?
- A** They must have a constant phase difference.
B They must have the same frequency.
C They must have the same wavelength.
D They must travel at the same speed.

- 26** The sound from a loudspeaker placed above a tube causes resonance of the air in the tube.

A stationary wave is formed with two nodes and two antinodes, as shown.



The tube has height 60 cm.

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

What is the frequency of the sound?

- A** 430 Hz **B** 570 Hz **C** 850 Hz **D** 1700 Hz
- 27** A continuous progressive water wave in a ripple tank passes through a gap in a barrier and diffracts.

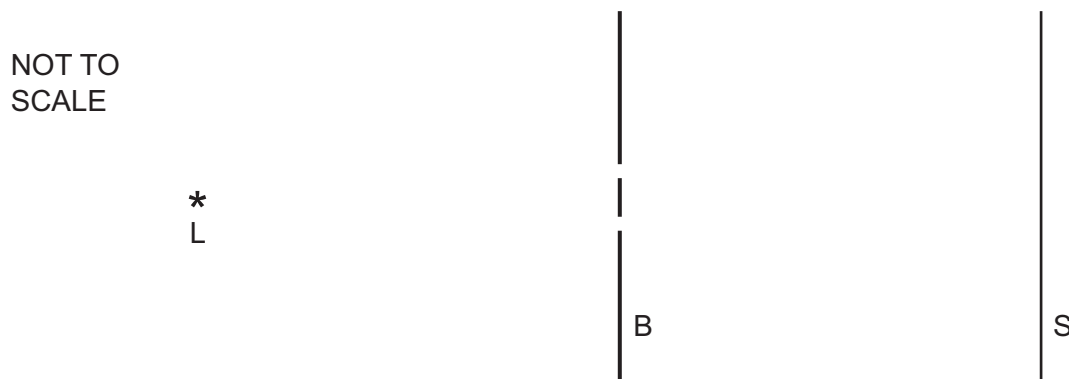
The width of the gap is greater than the wavelength of the wave.

Which change causes the wave to spread over a larger angle as it passes through the gap?

- A** a small decrease in the wavelength of the wave
B a small decrease in the width of the gap
C a small increase in the frequency of the wave
D a small increase in the height of the barrier

- 28 The diagram shows a view from above of a double-slit interference demonstration.

L is a monochromatic light source with a vertical filament. B is a barrier with two narrow vertical slits and S is a screen upon which interference fringes form.



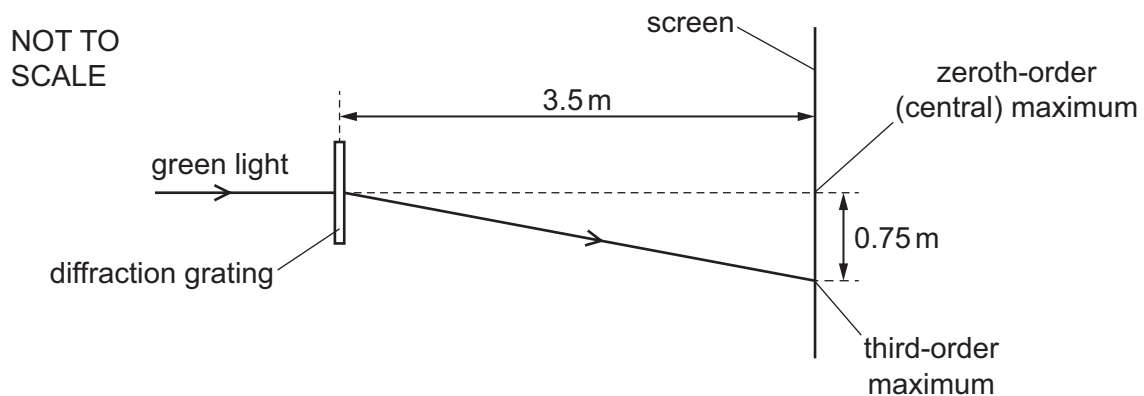
The intensity is I at the point on the screen where the centre of the fringe pattern forms.

When one of the slits is covered, what is the intensity at the same point on the screen?

- A $\frac{I}{\sqrt{2}}$ B $\frac{I}{2}$ C $\frac{I}{2\sqrt{2}}$ D $\frac{I}{4}$

- 29 Green light of wavelength 550 nm is incident normally on a diffraction grating and produces a diffraction pattern on a screen placed 3.5 m from the diffraction grating.

The **third**-order maximum on the screen is a distance of 0.75 m from the zeroth-order (central) maximum.



What is the distance between two adjacent slits in the diffraction grating?

- A $2.6 \times 10^{-6} \text{ m}$
 B $7.7 \times 10^{-6} \text{ m}$
 C $7.9 \times 10^{-6} \text{ m}$
 D $1.0 \times 10^{-5} \text{ m}$

30 Which charge can be carried by a charge carrier?

- A $1.1 \times 10^{-19} \text{ C}$
- B $4.0 \times 10^{-19} \text{ C}$
- C $4.8 \times 10^{-19} \text{ C}$
- D $9.1 \times 10^{-19} \text{ C}$

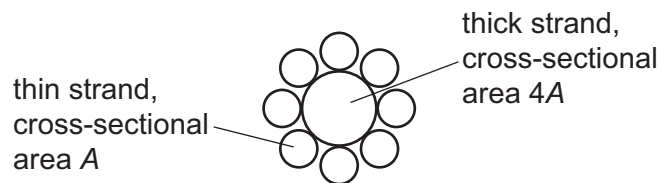
31 A resistor of resistance R is connected across a cell of electromotive force (e.m.f.) E and negligible internal resistance.

Which single change to the circuit would lead to the largest increase in the power dissipated in the resistor?

- A doubling the value of E
- B doubling the value of R
- C halving the value of E
- D halving the value of R

32 An electrical cable is made up of one thick strand of copper wire that is surrounded by eight thin strands of copper wire. All nine strands of wire are connected in parallel with each other.

A cross-section of the cable is shown.



Each thin strand of wire has cross-sectional area A and length L .

The thick strand of wire has cross-sectional area $4A$ and length L .

The cable has total resistance R .

Which expression gives the resistivity of copper?

- A $\frac{4A}{33RL}$
- B $\frac{12A}{RL}$
- C $\frac{4AR}{L}$
- D $\frac{12AR}{L}$

- 33** A car has sensors for detecting the light intensity and temperature of its environment.

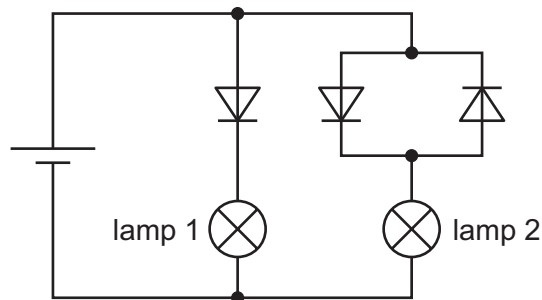
The sensors make use of a light-dependent resistor (LDR) and a thermistor.

The car moves from a warm and dark environment into a cold and bright environment.

What are the changes to the resistances of the LDR and thermistor?

	resistance of LDR	resistance of thermistor
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

- 34** A student assembles the circuit shown.



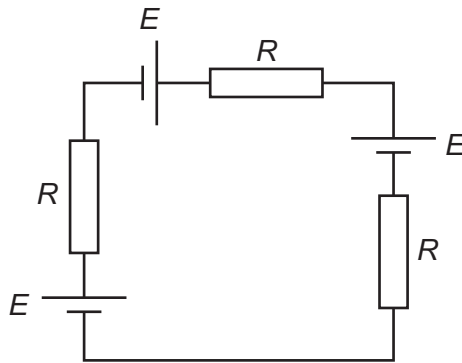
Which row describes the state of the two lamps?

	lamp 1	lamp 2
A	off	off
B	on	off
C	off	on
D	on	on

- 35** Kirchhoff's first law is a consequence of the conservation of which quantity?

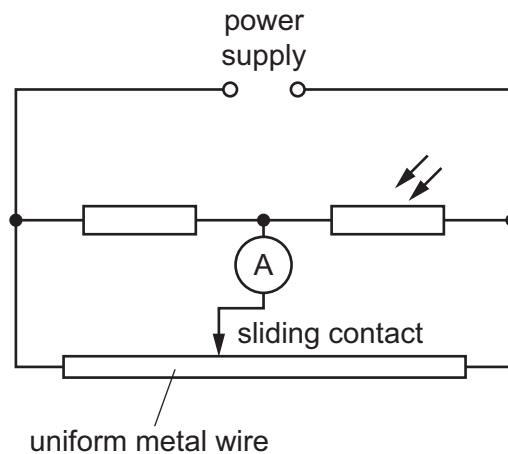
- A** charge
- B** energy
- C** momentum
- D** potential difference

- 36 Three identical cells each have electromotive force (e.m.f.) E and negligible internal resistance. The cells are connected to three identical resistors, each of resistance R , as shown.



What is the potential difference across one of the resistors?

- A 0 B $\frac{E}{3}$ C $\frac{2E}{3}$ D E
- 37 In the potentiometer circuit shown, the reading on the ammeter is zero.



The light-dependent resistor (LDR) is then covered and the ammeter gives a non-zero reading.

Which change could return the ammeter reading to zero?

- A decreasing the supply voltage
 B increasing the supply voltage
 C moving the sliding contact to the left
 D moving the sliding contact to the right

38 What are isotopes?

- A nuclei of different elements with the same number of neutrons
- B nuclei of different elements with the same number of nucleons
- C nuclei of the same element with different numbers of neutrons
- D nuclei of the same element with different numbers of protons

39 A neutron ${}_0^1\text{n}$ is fired at a ${}_{92}^{235}\text{U}$ nucleus. The neutron is absorbed by the nucleus which then splits to form nuclei of ${}_{56}^{141}\text{Ba}$ and ${}_{36}^{92}\text{Kr}$.

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

- A 0 B 1 C 2 D 3

40 A π^+ meson has a charge of $+e$, where e is the elementary charge. It consists of an up quark and one other quark.

What could be the other quark in the π^+ meson?

- A anti-down
- B anti-up
- C bottom
- D charm

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Cambridge International AS & A Level

PHYSICS

9702/13

Paper 1 Multiple Choice

May/June 2023

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 **must** be included in a record of a physical quantity?

- A an integer value for the quantity
- B an SI unit
- C a numerical value for the quantity
- D a unit expressed in base units

2 What is the ohm expressed in SI base units?

- A $\text{kg m}^2 \text{s}^{-3} \text{A}^{-2}$ B $\text{kg}^{-1} \text{m}^{-2} \text{s}^3 \text{A}^2$ C $\text{J C}^{-1} \text{A}^{-1}$ D W A^{-2}

3 A desk has a true width of 50.0 cm.

Two students, X and Y, measure the width of the desk.

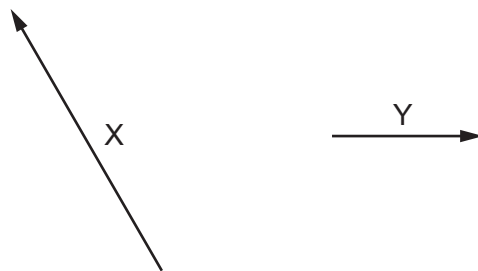
Student X uses a tape measure and records a width of $(49.5 \pm 0.5) \text{ cm}$.

Student Y uses a metre rule and records a width of $(51.4 \pm 0.1) \text{ cm}$.

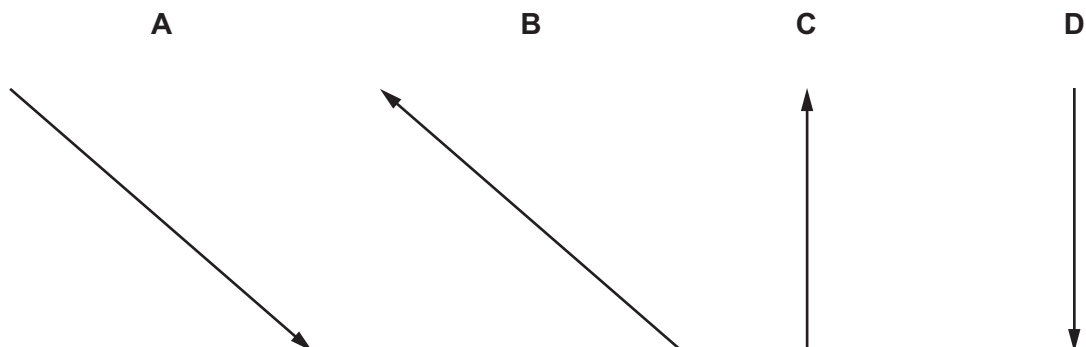
Which statement about the measurement of student X is correct?

- A It is less accurate and less precise than the measurement of student Y.
- B It is less accurate but more precise than the measurement of student Y.
- C It is more accurate and more precise than the measurement of student Y.
- D It is more accurate but less precise than the measurement of student Y.

4 The diagram shows two vectors, X and Y, drawn to scale.



If $X = Y - Z$, which diagram represents the vector Z?



- 5 Which equation, representing uniformly accelerated motion in a straight line, can be determined using **only** the definition of acceleration?

A $s = ut + \frac{1}{2}at^2$

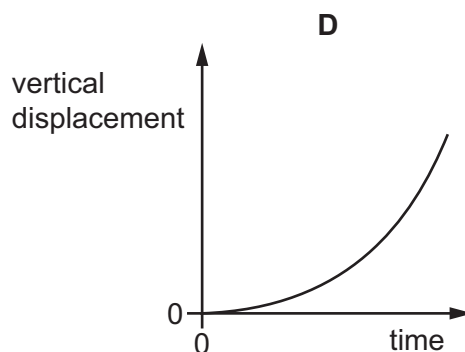
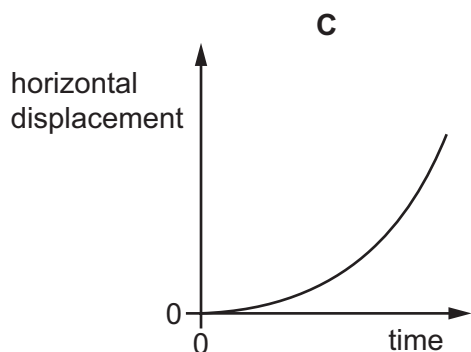
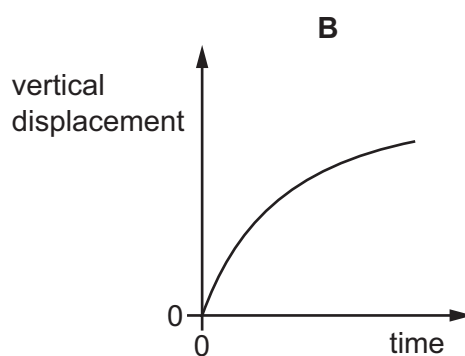
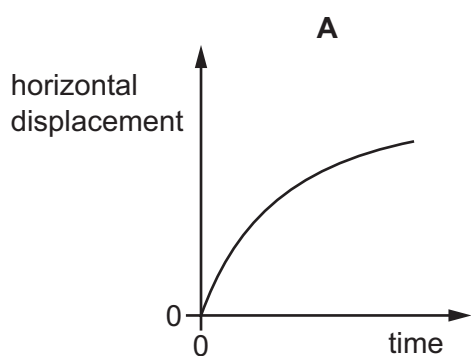
B $s = \frac{1}{2}(u + v)t$

C $v = u + at$

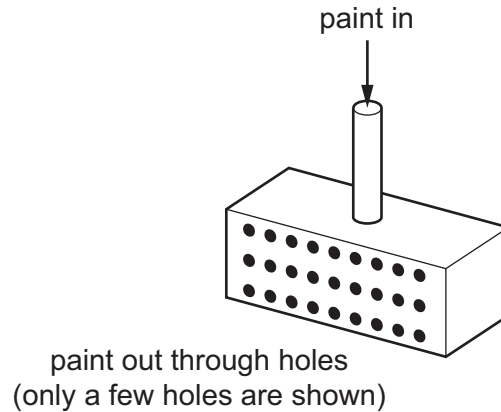
D $v^2 = u^2 + 2as$

- 6 An object moves from rest with uniform velocity horizontally and uniform acceleration vertically.

Which graph showing the variation with time of the displacement of the object from its initial position is correct?



- 7 A device for spraying paint consists of a box with its faces horizontal and vertical. One of its vertical faces contains small holes. Paint is fed into the box under pressure via a vertical tube and exits through the holes as fine streams moving horizontally.



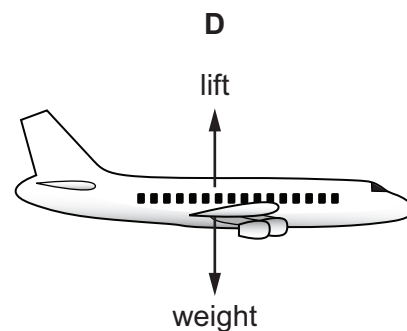
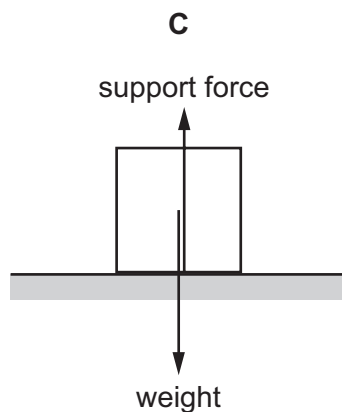
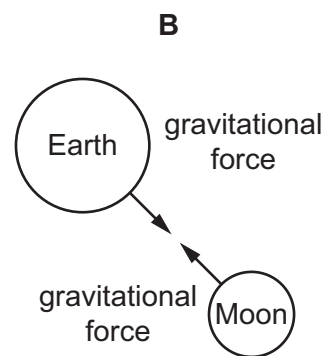
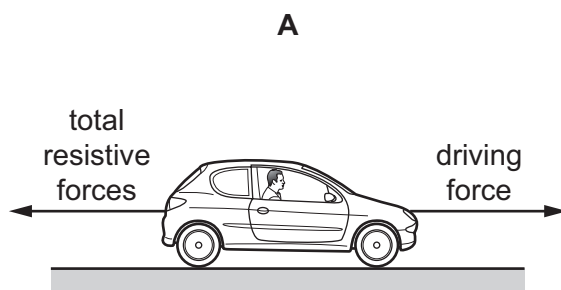
The paint is ejected at a speed of 2.5 m s^{-1} through 400 holes, each of area 0.4 mm^2 . The density of the paint is 900 kg m^{-3} .

What is the horizontal force required to hold the device stationary as it ejects the paint?

- A** 0.36 N **B** 0.90 N **C** 2.3 N **D** 900 N

- 8 Each diagram illustrates a pair of forces of equal magnitude.

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



- 9 Two balls of identical shape and size but different masses are falling through the same liquid.

The sum of the drag force and upthrust acting on each ball is equal to its weight.

Which statement about the two balls is correct?

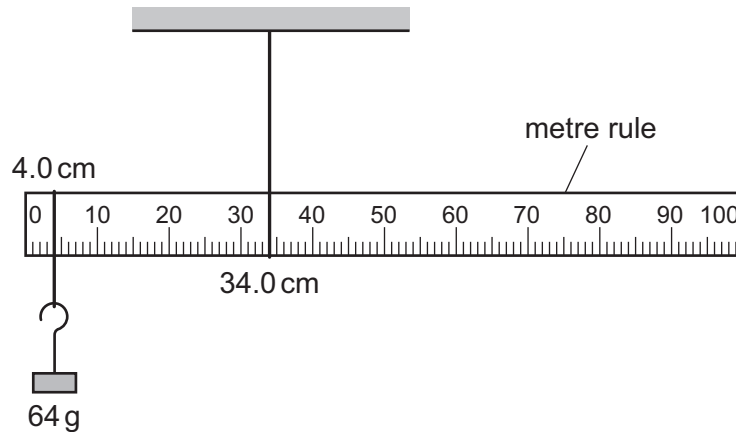
- A** The heavier ball has a larger acceleration than the lighter ball.
B The heavier ball has a smaller deceleration than the lighter ball.
C The heavier ball is falling at the same speed as the lighter ball.
D The heavier ball is falling at a larger speed than the lighter ball.
- 10 A perfectly elastic collision occurs between two objects X and Y. The mass of X is m and the mass of Y is $4m$. Object X travels at speed v before the collision and speed $\frac{3v}{5}$ in the opposite direction after the collision. Object Y is stationary before the collision.



What is the kinetic energy of Y after the collision?

- A** $\frac{8}{10}mv^2$ **B** $\frac{34}{50}mv^2$ **C** $\frac{16}{50}mv^2$ **D** $\frac{1}{5}mv^2$
- 11 What is **not** a requirement for two forces to act as a couple?
- A** The two forces act in opposite directions.
B The two forces act through the same point.
C The two forces combine to produce zero resultant force.
D The two forces have equal magnitude.

- 12 A uniform metre rule is pivoted at the 34.0 cm mark, as shown.



The rule balances when a 64 g mass is hung from the 4.0 cm mark.

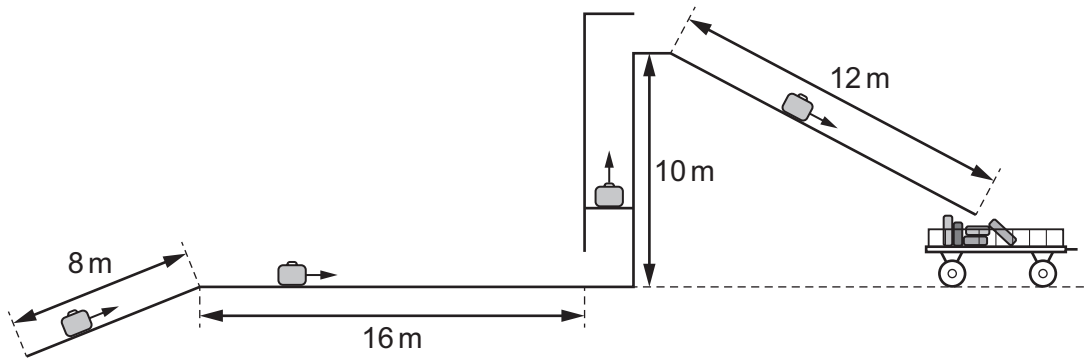
What is the mass of the metre rule?

- A** 38 g **B** 44 g **C** 120 g **D** 136 g
- 13 A volume of 1.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3} .
- The volume of the mixture is 2.0 m^3 .
- What is the density of the mixture?
- A** 850 kg m^{-3} **B** 900 kg m^{-3} **C** 940 kg m^{-3} **D** 950 kg m^{-3}
- 14 An object is falling at a constant speed through a viscous liquid. F_U is the upthrust on the object due to the liquid. W_L is the weight of the liquid displaced by the object. W_O is the weight of the object.

Which equation **must** be correct?

- A** $F_U = W_L$
- B** $F_U = W_O - W_L$
- C** $F_U = W_O$
- D** $F_U = W_O + W_L$

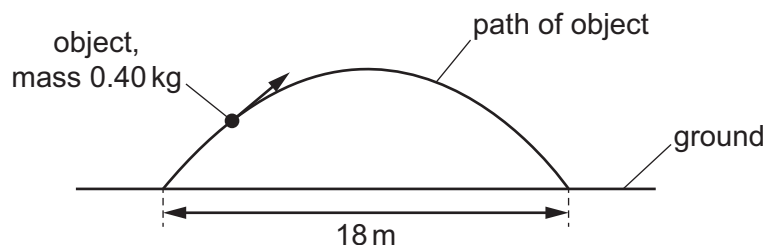
- 15** An airport has a mechanical system for moving luggage. The system uses a horizontal conveyor belt, a sloping conveyor belt, a lift and a frictionless slide. A suitcase is moved around the airport using this system.



Resistive forces opposing the motion of the suitcase are negligible.

For which movement of the suitcase is the net work done on the suitcase greatest?

- A** moving the suitcase a distance of 8 m at a constant speed up the sloping conveyor belt
- B** moving the suitcase a distance of 16 m at a constant speed along the horizontal conveyor belt
- C** moving the suitcase a distance of 10 m at a constant speed vertically upwards on the lift
- D** moving the suitcase a distance of 12 m at increasing speed downwards on the slide
- 16** A car moves along a horizontal road with a constant velocity v against a resistive force F .
The engine of the car has an efficiency of 25%.
What is the input power to the engine?
- A** $\frac{Fv}{4.0}$ **B** $\frac{4.0}{Fv}$ **C** $4.0Fv$ **D** $\frac{4.0F}{v}$
- 17** An object of mass 0.40 kg is projected into the air and follows a curved path above horizontal ground.



The object takes a time of 1.5 s to move along its path. The object lands a horizontal distance of 18 m from its initial position. Air resistance is negligible.

What is the kinetic energy of the object at its maximum height?

- A** 0 J **B** 2.4 J **C** 11 J **D** 29 J

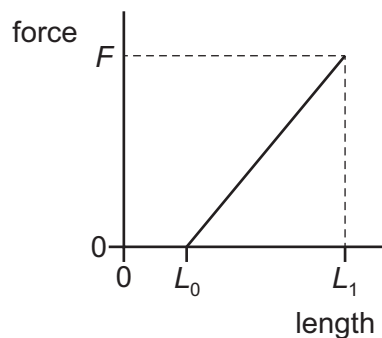
- 18** A metal wire has length 5.2 m and diameter 1.0 mm. The metal has Young modulus 360 GPa.

The wire is fixed at one end and a force is applied to the other end. The force extends the wire by 7.2 mm. The wire obeys Hooke's law.

What is the force applied to the wire?

- A** $1.2 \times 10^2 \text{ N}$
B $3.9 \times 10^2 \text{ N}$
C $5.0 \times 10^2 \text{ N}$
D $1.6 \times 10^3 \text{ N}$

- 19** The graph shows how the length of a spring varies with the force applied to it.



The spring has unstretched length L_0 . When a force F is applied, the spring has length L_1 .

What is the work done in stretching the spring to length L_1 ?

- A** $\frac{1}{2}FL_1$ **B** $\frac{1}{2}F(L_1 - L_0)$ **C** FL_1 **D** $F(L_1 - L_0)$

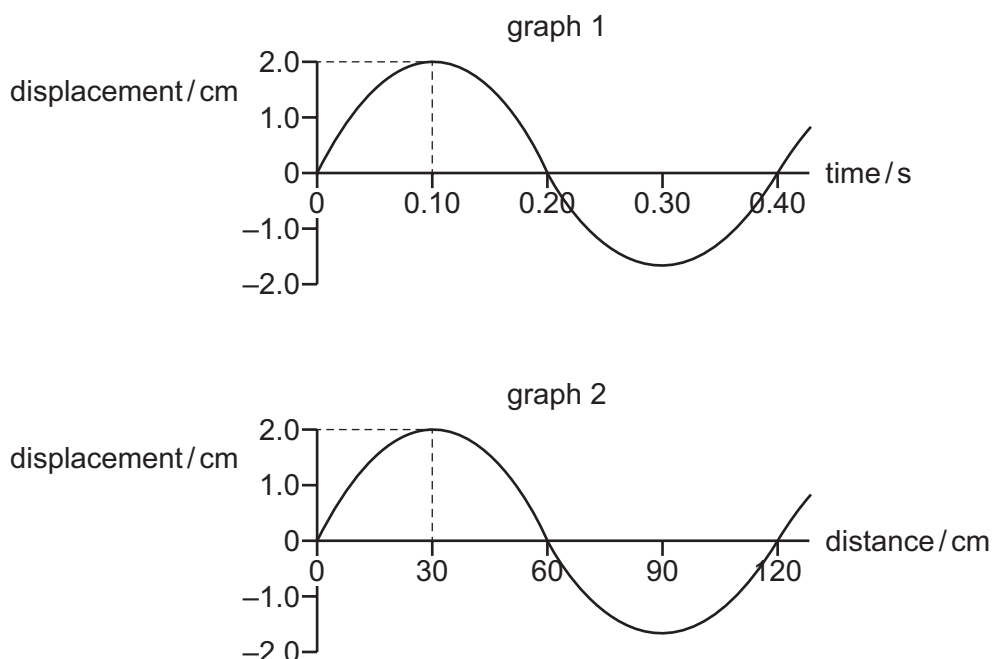
- 20** A progressive wave of frequency 1.5 kHz travels in a medium at a speed of 340 m s^{-1} .

What is the minimum distance between two points on the wave that have a phase difference of 70° ?

- A** 4.4 cm **B** 8.8 cm **C** 18 cm **D** 23 cm

- 21** Graph 1 shows the variation with time of displacement at a fixed distance along a progressive wave.

Graph 2 represents the same wave and shows the variation with distance of displacement at an instant in time.



What is the speed of the wave?

- A** 5.0 cm s^{-1} **B** 48 cm s^{-1} **C** 150 cm s^{-1} **D** 300 cm s^{-1}
- 22** A vehicle moves with constant velocity along a road directly towards an observer. The observed frequency of the sound from the vehicle changes as the vehicle moves past the observer.

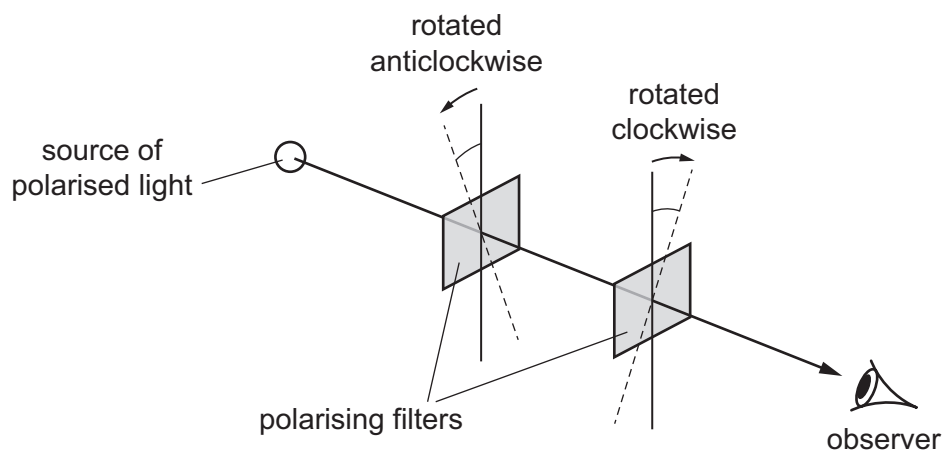
Which phenomenon explains the change in frequency?

- A** diffraction
B interference
C polarisation
D the Doppler effect
- 23** An electromagnetic wave has a wavelength of 2.1 cm in a vacuum.

Which region of the electromagnetic spectrum contains this wave?

- A** infrared
B microwave
C radio wave
D visible light

24 A source of plane polarised light is observed through two polarising filters.

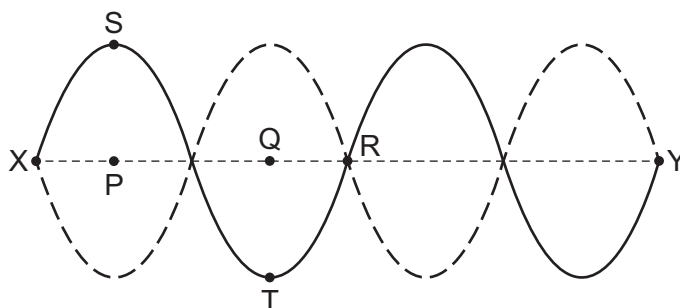


The filters are positioned so that the source appears at its brightest. One of the filters is then rotated clockwise and the other filter is rotated anticlockwise through the same angle.

How does the source appear when both filters have been rotated 90° and 180° from their initial positions?

	90°	180°
A	brightest	brightest
B	brightest	darkest
C	darkest	brightest
D	darkest	darkest

- 25 The diagram shows a string stretched between fixed points X and Y. There is a stationary wave on the string.

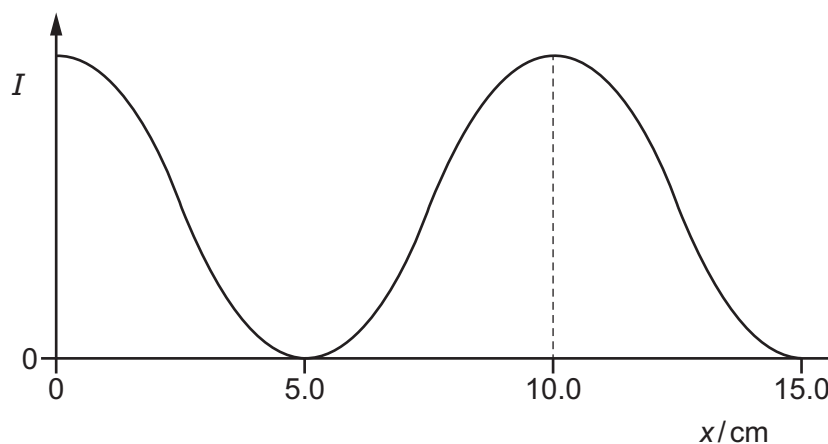


The solid curve shows the string at a position of maximum displacement at time t_0 . The dashed curve shows the other position of maximum displacement. The straight central dashed line shows the mean position of the string.

Point S on the string is directly above point P. Point T on the string is directly below point Q.

Which statement is correct?

- A A short time after t_0 , point R on the string will be displaced.
 - B A short time after t_0 , points S and T on the string move in opposite directions.
 - C The distance between P and Q is one wavelength.
 - D Two moving points on the string that are equal distances from point R vibrate in phase.
- 26 The variation with distance x of the intensity I along a stationary sound wave in air is shown.



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

What is the frequency of the sound wave?

- A 1700 Hz
- B 2300 Hz
- C 3400 Hz
- D 6800 Hz

- 27 An experiment is set up to demonstrate the diffraction of water waves in a ripple tank.

The waves pass through a gap of width w and some diffraction of the waves is observed.

The wavelength of the waves is now doubled.

What is the new gap width needed to cause the same amount of diffraction as before?

- A $0.5w$ B w C $2w$ D $4w$

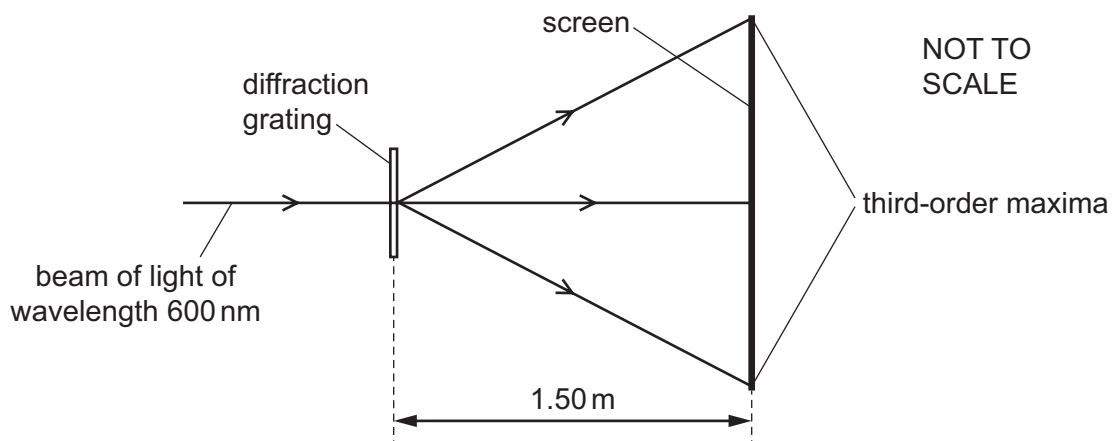
- 28 Two coherent electromagnetic waves are travelling in a vacuum. The two waves meet at a point. At this point, the two waves have different intensities.

Which statement about the waves is **not** correct?

- A They have a constant phase difference at the point.
 B They have the same amplitude at the point.
 C They have the same frequency.
 D They travel at the same speed.

- 29 A parallel beam of light of wavelength 600 nm is incident normally on a diffraction grating.

The distance between adjacent slits in the grating is 2.0×10^{-6} m. A screen is placed parallel to the grating, at a distance of 1.50 m from the grating. **Third-order** diffraction maxima are observed at the two ends of the screen, as shown.



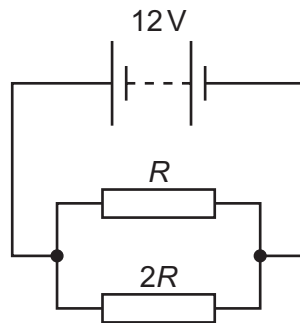
What is the distance between the two ends of the screen?

- A 1.4 m B 2.7 m C 3.1 m D 6.2 m

- 30** A metal wire is connected between the terminals of a cell so that there is a current in the wire.

Which statement is correct?

- A** Negatively charged electrons in the wire move from the negative terminal to the positive terminal.
 - B** Negatively charged nuclei in the wire move from the negative terminal to the positive terminal.
 - C** Positively charged electrons in the wire move from the positive terminal to the negative terminal.
 - D** Positively charged nuclei in the wire move from the positive terminal to the negative terminal.
- 31** Two resistors of resistances R and $2R$ are connected in parallel with a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance.



The total power dissipated by the two resistors is 36 W .

What is the value of R ?

- A** $0.50\ \Omega$
 - B** $2.7\ \Omega$
 - C** $4.0\ \Omega$
 - D** $6.0\ \Omega$
- 32** A wire has a length of 3.0 m and is made of metal of resistivity $4.9 \times 10^{-7}\ \Omega\text{ m}$.
- A potential difference (p.d.) of 12 V is applied across the wire so that it has a current of 1.4 A .
- What is the cross-sectional area of the wire?

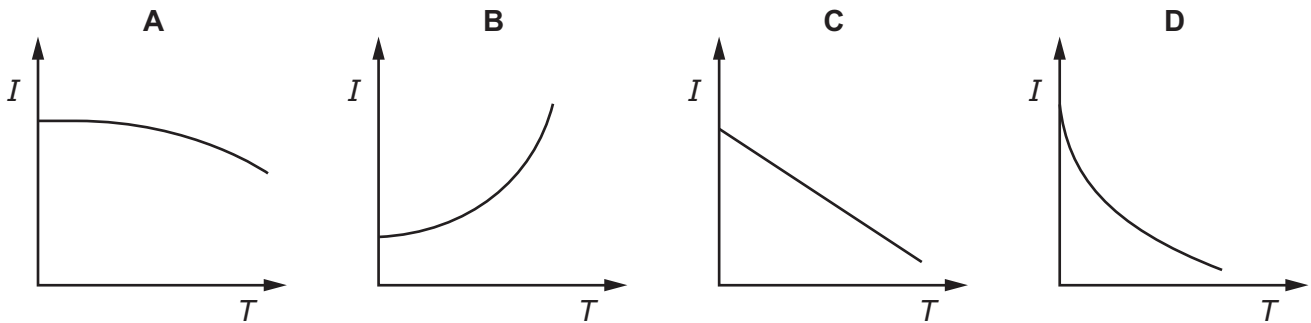
- A** $1.2 \times 10^{-7}\text{ m}^2$
- B** $1.7 \times 10^{-7}\text{ m}^2$
- C** $1.1 \times 10^{-6}\text{ m}^2$
- D** $1.3 \times 10^{-5}\text{ m}^2$

- 33** A cell of negligible internal resistance is connected in series with a thermistor, a fixed resistor and an ammeter.

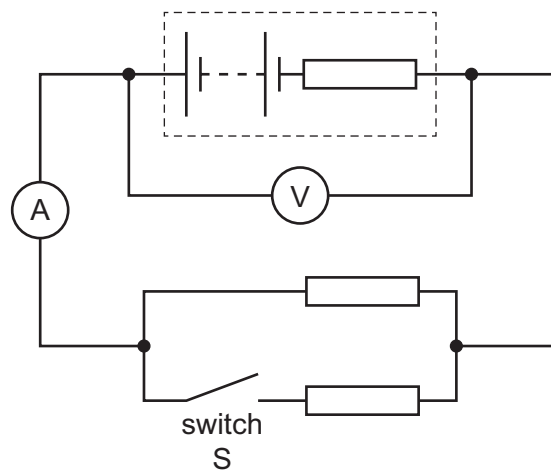
The thermistor is placed in a beaker of water and the temperature of the water is slowly increased.

A graph of current I against the temperature T of the thermistor is plotted.

Which graph could show the variation of I with T ?



- 34** A battery with internal resistance is connected to a parallel arrangement of two resistors and a switch S, as shown.



Initially, switch S is open.

What happens to the voltmeter and ammeter readings when switch S is closed?

	voltmeter reading	ammeter reading
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

- 35 Kirchhoff's first law states that the sum of the currents entering a junction in a circuit is equal to the sum of the currents leaving it.

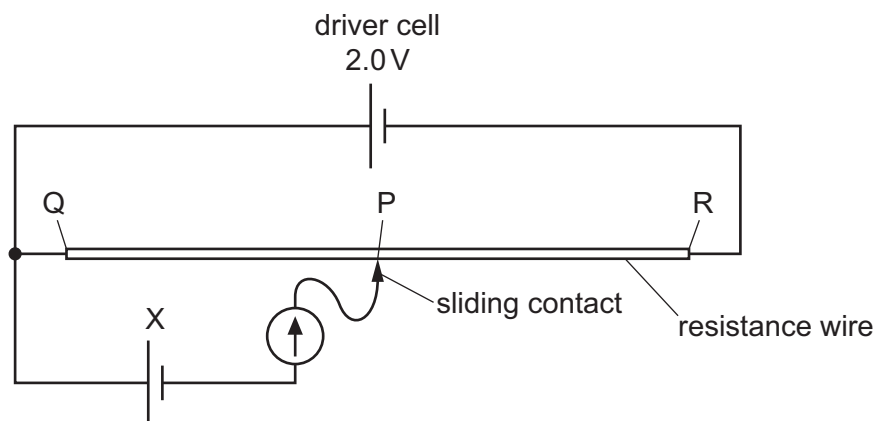
The law is based on the conservation of a physical quantity.

What is this physical quantity?

- A charge
B energy
C mass
D momentum
- 36 Two resistors have a combined resistance of $34\ \Omega$ when connected in series. The same resistors have a combined resistance of $7.4\ \Omega$ when connected in parallel.

What is the resistance of one of the resistors?

- A $15\ \Omega$ B $17\ \Omega$ C $23\ \Omega$ D $27\ \Omega$
- 37 A potentiometer circuit is used to investigate the electromotive force (e.m.f.) of a cell X.



The e.m.f. of cell X is known to be approximately 0.50 V.

The driver cell has negligible internal resistance and an e.m.f. of 2.0 V. The sliding contact is moved along the uniform resistance wire between ends Q and R to a point P where the reading on the galvanometer is zero.

What is an expression for the approximate length QP?

- A $\frac{QR}{4}$ B $\frac{QR}{3}$ C $\frac{2QR}{3}$ D $\frac{3QR}{4}$

38 The table contains data for four different nuclei P, Q, R and S.

nucleus	number of neutrons	nucleon number
P	5	10
Q	6	10
R	6	14
S	8	16

Which two nuclei are isotopes of the same element?

- A** P and Q **B** P and S **C** Q and R **D** R and S

39 Which statement about β^- decay is correct?

- A** A neutron changes to a proton in the nucleus and an electron and an antineutrino are emitted.
B A neutron changes to a proton in the nucleus and an electron and a neutrino are emitted.
C A proton changes to a neutron in the nucleus and an electron and an antineutrino are emitted.
D A proton changes to a neutron in the nucleus and an electron and a neutrino are emitted.

40 What is the quark composition of a hydrogen-3 nucleus, ${}^3_1\text{H}$?

	number of quarks	
	up	down
A	4	5
B	5	4
C	5	7
D	7	5

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