



Cambridge International AS & A Level

PHYSICS

9702/11

Paper 1 Multiple Choice

May/June 2021

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

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

This document has **20** pages.



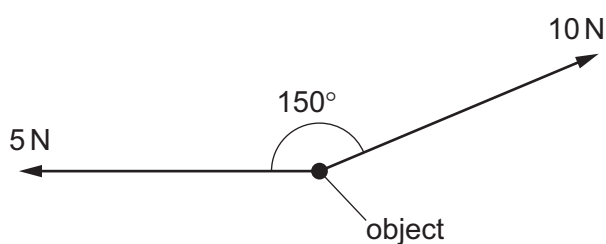
Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

- 1 What is a reasonable estimate of the volume of an adult person?
A 0.10 m^3 **B** 0.50 m^3 **C** 1.0 m^3 **D** 2.0 m^3
- 2 Which combination of units could be used for expressing the power dissipated in a resistor?
A newton per second (N s^{-1})
B newton second (Ns)
C newton metre (Nm)
D newton metre per second (Nm s^{-1})
- 3 A force of 10 N and a force of 5 N act on an object.



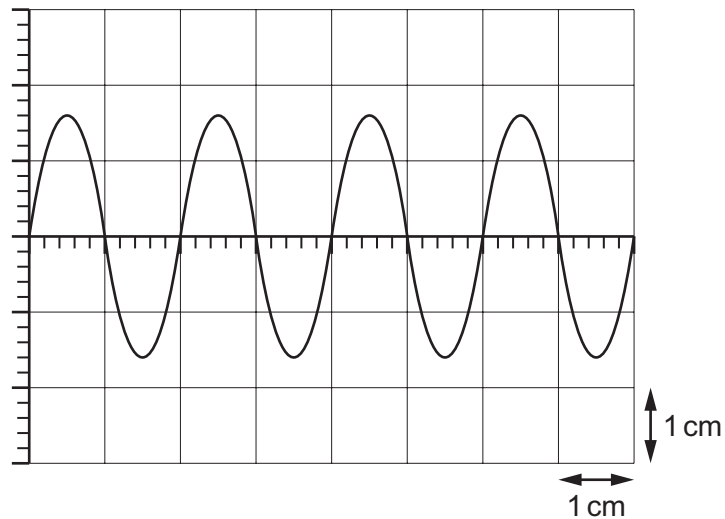
The angle between the forces is 150° .

The resultant force on the object can be resolved into a pair of perpendicular components.

Which row shows numerical expressions for a possible pair of perpendicular components?

	force component / N	force component / N
A	$10 \cos 30^\circ - 5$	$10 \cos 30^\circ$
B	$10 \sin 30^\circ - 5$	$10 \cos 30^\circ$
C	$10 - 5 \cos 30^\circ$	$5 \sin 30^\circ$
D	$10 - 5 \sin 30^\circ$	$5 \cos 30^\circ$

- 4 A signal of frequency 25 Hz is displayed on the screen of a cathode-ray oscilloscope.



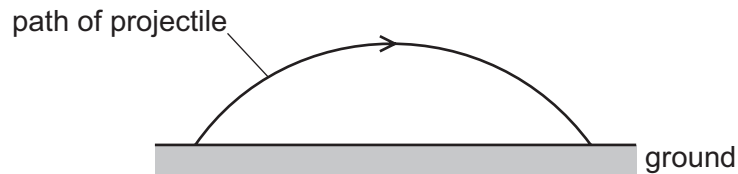
What is the time-base setting?

- A** 10 ms cm^{-1} **B** 20 ms cm^{-1} **C** 25 ms cm^{-1} **D** 40 ms cm^{-1}
- 5 A micrometer screw gauge is used to measure the diameter of a wire.
- The reading on the micrometer with the jaws closed is $(-0.05 \pm 0.02) \text{ mm}$.
- The reading with the wire in position between the two jaws is $(+1.03 \pm 0.02) \text{ mm}$.

What is the diameter of the wire?

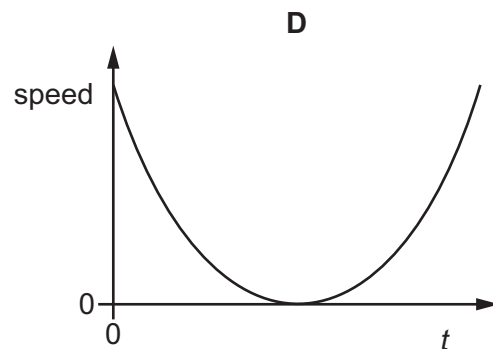
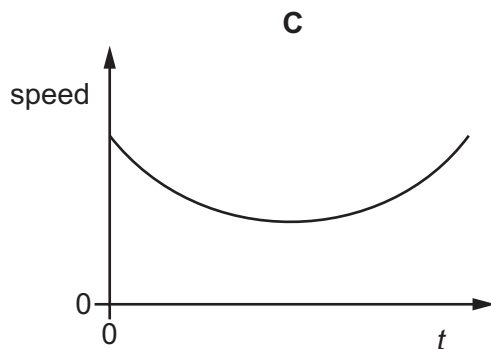
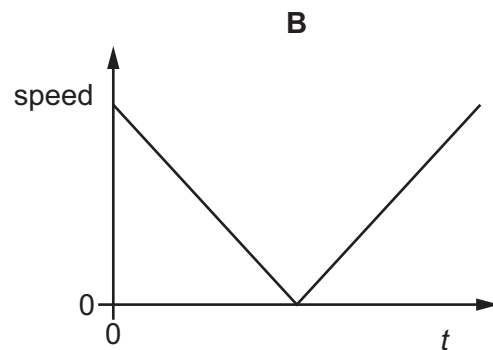
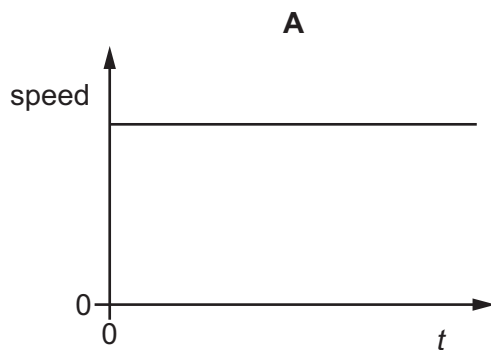
- A** $(0.98 \pm 0.02) \text{ mm}$
- B** $(1.08 \pm 0.02) \text{ mm}$
- C** $(0.98 \pm 0.04) \text{ mm}$
- D** $(1.08 \pm 0.04) \text{ mm}$

- 6 A projectile is launched at an angle to the horizontal at time $t = 0$. It travels over horizontal ground, as shown.



Air resistance is negligible.

Which graph best shows the variation with t of the speed of the projectile from when it is launched to when it lands on the ground?



- 7 A train, initially at rest at a station, has a uniform acceleration of 0.20 ms^{-2} until it reaches a speed of 20 ms^{-1} . It travels for a time at this constant speed and then has a uniform deceleration of 0.40 ms^{-2} until it comes to rest at the next station. The distance between the two stations is 3000 m.

What is the time taken by the train to travel between the two stations?

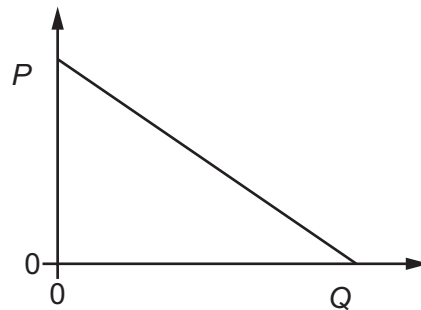
- A** 75 s **B** 150 s **C** 230 s **D** 300 s

- 8 A rocket is fired from the Earth into space.

Newton's third law of motion describes how forces act in pairs. One of the forces of a pair is the weight of the rocket.

What is the other force of this pair?

- A** air resistance
B force of the exhaust gases on the rocket
C force of the rocket on the exhaust gases
D gravitational force of the rocket on the Earth
- 9 The graph shows how quantity P varies with quantity Q for a body falling vertically downwards in a uniform gravitational field with air resistance.



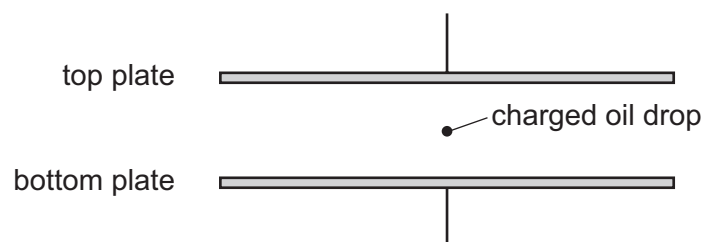
Which pair of quantities could be represented by P and Q ?

	P	Q
A	acceleration	force of air resistance
B	acceleration	time
C	velocity	force of air resistance
D	velocity	time

- 10 Which quantities are conserved in an inelastic collision?

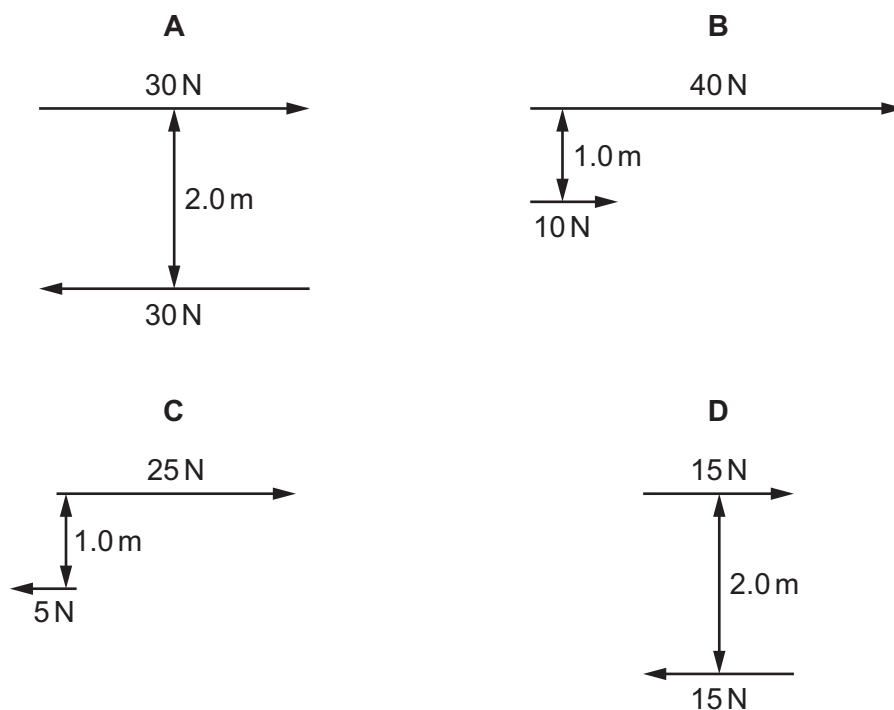
	kinetic energy	total energy	linear momentum
A	conserved	not conserved	conserved
B	conserved	not conserved	not conserved
C	not conserved	conserved	conserved
D	not conserved	conserved	not conserved

- 11 A charged oil drop is held stationary between two charged parallel plates.



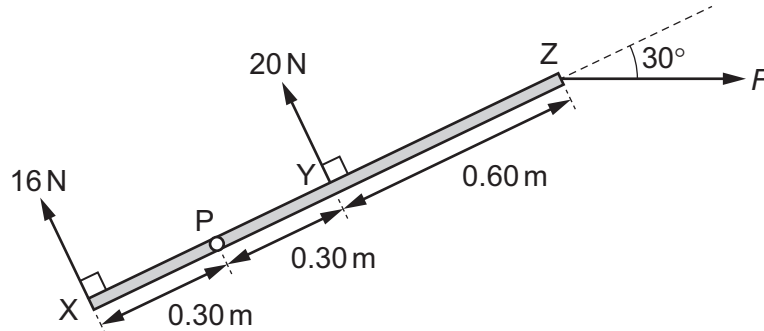
Which forces act on the oil drop?

- A** both electric and gravitational
 - B** electric only
 - C** gravitational only
 - D** neither electric nor gravitational
- 12 Which pair of forces forms a couple with a torque of 30 N m ?



- 13** A uniform rigid bar XZ with negligible mass is 1.20 m long. The bar is pivoted at point P. Three coplanar forces act on the bar as shown. Forces of 16 N and 20 N act perpendicularly to the bar at points X and Y respectively. Force F acts at point Z at an angle of 30° to the axis of the bar.

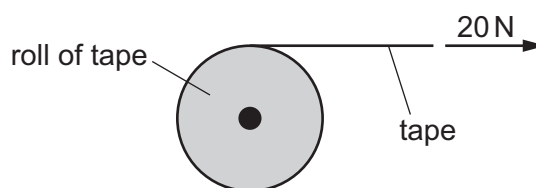
The distances along the bar of the pivot and of the forces are shown.



The bar experiences a resultant moment about P of 6.0 N m in a clockwise direction.

What is the magnitude of F ?

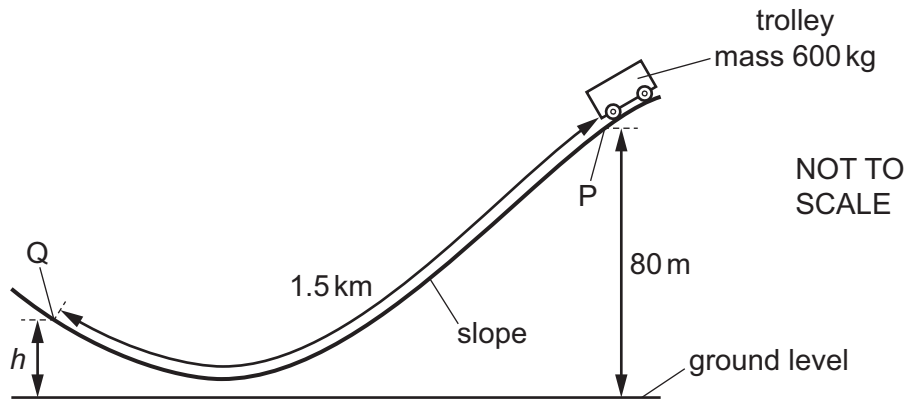
- A** 9.2 N **B** 11 N **C** 16 N **D** 24 N
- 14** Water of depth 9.0 cm is covered by oil of depth 5.0 cm in a measuring cylinder.
The density of the water is 1000 kg m^{-3} and the density of the oil is 800 kg m^{-3} .
What is the total pressure exerted on the base of the measuring cylinder due to the oil and water?
- A** 390 Pa **B** 880 Pa **C** 1200 Pa **D** 1300 Pa
- 15** A rocket is fired upwards.
As it accelerates upwards after leaving the launch pad, which forms of energy are changing?
- A** chemical energy, gravitational potential energy and kinetic energy
B chemical energy and gravitational potential energy only
C chemical energy and kinetic energy only
D gravitational potential energy and kinetic energy only
- 16** A roll of tape of length 50 m requires a constant force of 20 N to unwrap it.



What is the work done in unwrapping the whole roll?

- A** 0.4 J **B** 2.5 J **C** 500 J **D** 1000 J

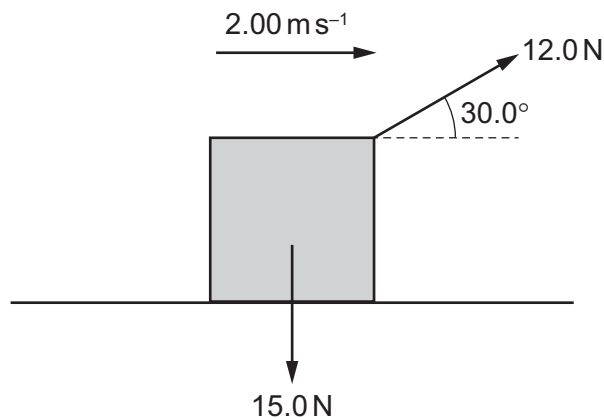
- 17** A trolley of mass 600 kg is initially at point P on a slope, at a height of 80 m above ground level, as shown. The trolley is released from rest and moves along the slope, first coming to rest at point Q, at height h above ground level.



The total distance PQ moved by the trolley along the slope is 1.5 km. A constant resistive force of 300 N opposes the motion of the trolley on the slope.

What is h ?

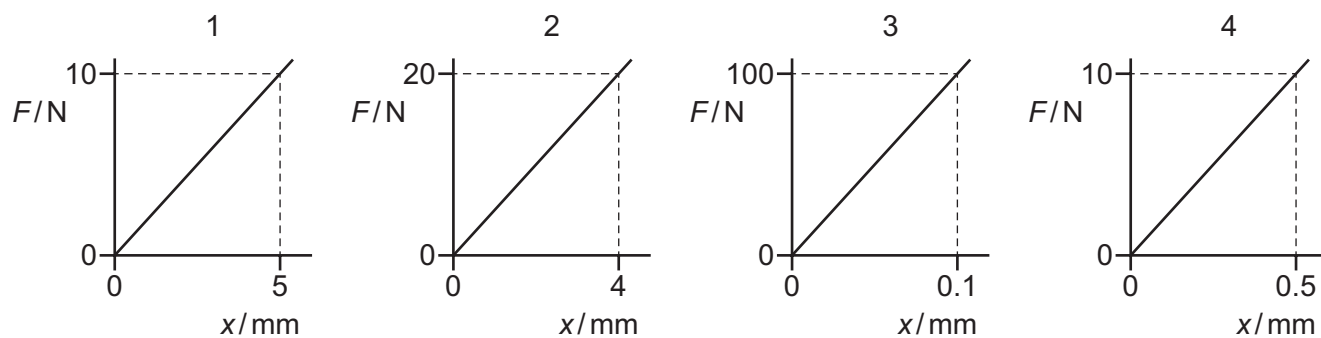
- A** 3.5 m **B** 76 m **C** 79 m **D** 80 m
- 18** An object of weight 15.0 N is pulled along a horizontal surface at a constant velocity of 2.00 m s^{-1} . The force pulling the object is 12.0 N at 30.0° to the horizontal, as shown.



What is the power used to move the object?

- A** 12.0 W **B** 20.8 W **C** 24.0 W **D** 30.0 W

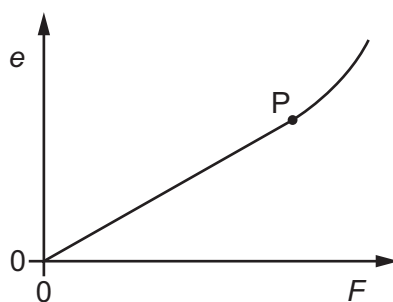
- 19 The spring constants of four springs are determined by plotting the following graphs of force F against extension x .



Which order of the graphs shows **decreasing** spring constants?

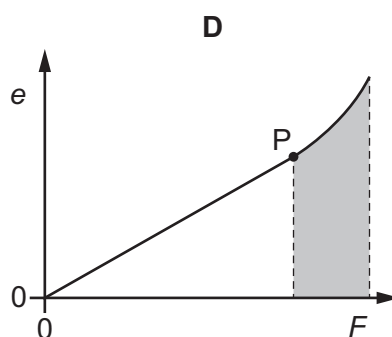
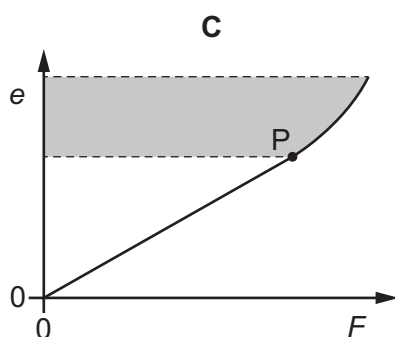
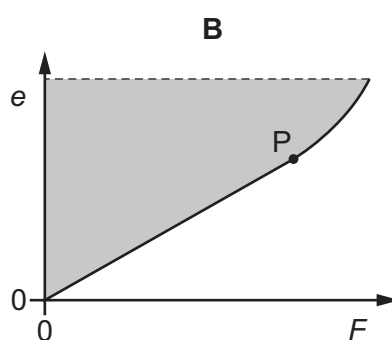
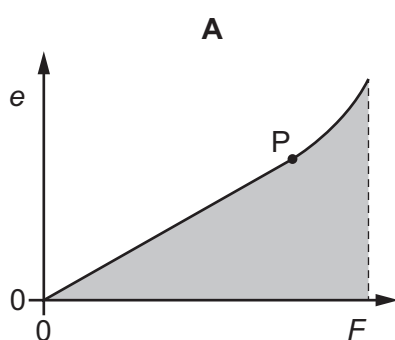
- A** $2 \rightarrow 1 \rightarrow 3 \rightarrow 4$
- B** $3 \rightarrow 4 \rightarrow 2 \rightarrow 1$
- C** $4 \rightarrow 2 \rightarrow 1 \rightarrow 3$
- D** $4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

- 20 Forces are applied to the ends of a rod so that its length increases. The variation with force F of the extension e of the rod is shown.

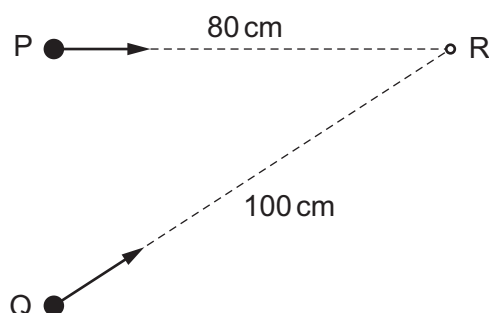


The point P is the elastic limit.

Which shaded area represents the work done during the plastic deformation of the rod?



- 21 Two identical waves are produced by sources at points P and Q. The waves travel along different paths to reach point R, as shown.



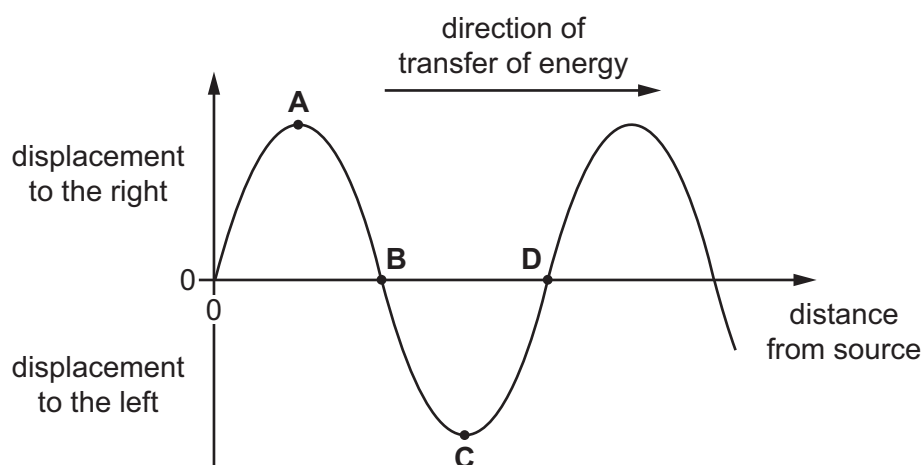
Both waves have a wavelength of 6.0 cm. The waves are in phase at point R.

What is the phase difference between the waves as they leave points P and Q?

- A** 0° **B** 60° **C** 90° **D** 120°
- 22 A longitudinal wave travelling from left to right has vibrations parallel to the direction of transfer of energy by the wave.

The wave can be represented on a graph showing the variation with distance of the displacement of the particles from their equilibrium positions at one instant.

Which point on the graph is the centre of a compression?



- 23 A stationary wave is formed from two identical sound waves.

A microphone is placed at a position of maximum loudness. It is then moved along the stationary wave from this first position of maximum loudness to the fourth position of maximum loudness. The microphone moves a distance of 12 cm.

The speed of sound is 330 ms^{-1} .

What is the frequency of the sound waves?

- A** 4100 Hz **B** 5500 Hz **C** 8300 Hz **D** 11 000 Hz

- 24** An ambulance has a siren that emits sound of a constant frequency. The ambulance is moving directly towards a stationary observer.

The ambulance decelerates as it is approaching the observer and then accelerates after it has passed the observer.

How does the frequency of the sound heard by the observer change as the ambulance is approaching and as it is moving away from the observer?

	approaching observer	moving away from observer
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

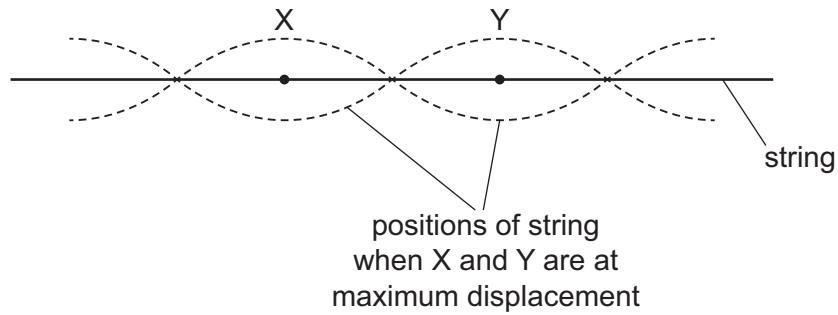
- 25** Microwaves in a vacuum travel at speed X and have wavelength of order of magnitude Y .

What are the speed and a possible order of magnitude of wavelength of X-rays in a vacuum?

	speed	wavelength
A	X	$10^{-8} Y$
B	X	$10^{-4} Y$
C	$10^4 X$	Y
D	$10^8 X$	Y

26 The diagram shows part of a stationary wave on a string.

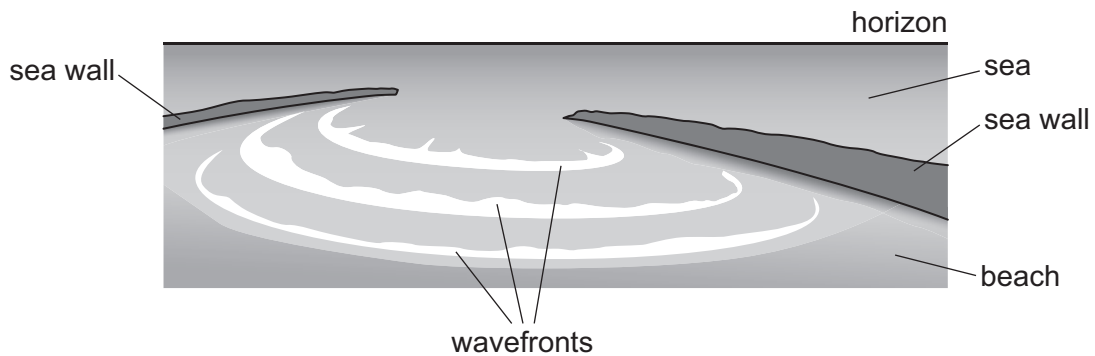
X and Y are points on the string. The vibrations at X and Y are 180° out of phase.



What is the distance between X and Y?

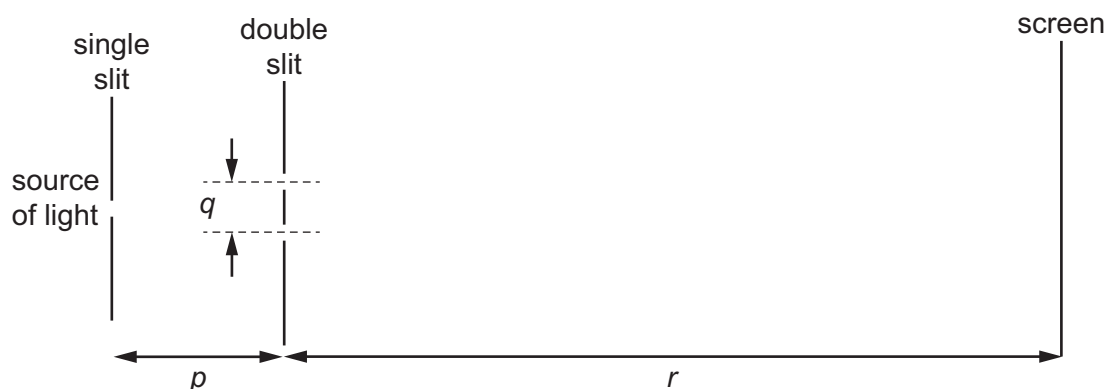
- A** one-quarter of a wavelength
- B** half a wavelength
- C** one wavelength
- D** two wavelengths

27 Which wave behaviour is shown in the diagram?



- A** diffraction
- B** Doppler shift
- C** interference
- D** superposition

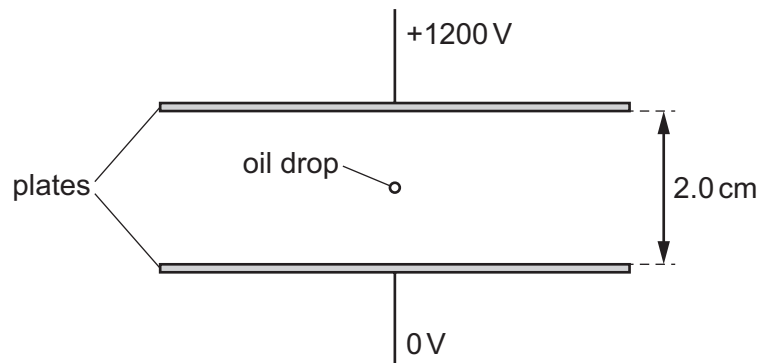
- 28 A teacher sets up the apparatus shown to demonstrate a double-slit interference pattern on a screen.



Which change to the apparatus will increase the fringe spacing?

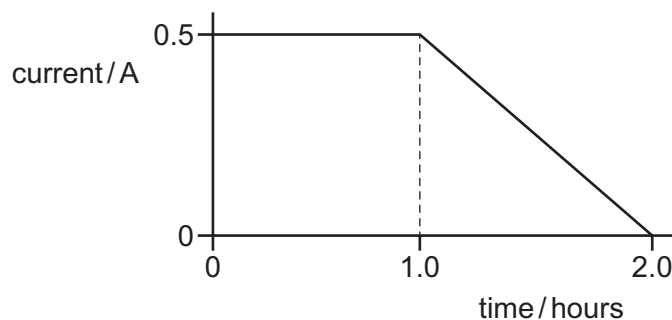
- A** decrease the distance p
- B** decrease the distance q
- C** decrease the distance r
- D** decrease the wavelength of the light
- 29 Light of a single unknown wavelength and blue light of a single wavelength are both incident normally on a diffraction grating. Two diffraction patterns are produced, one for each wavelength of light.
- The third-order maximum for the blue light occurs at the same angle as the second-order maximum for the light of unknown wavelength. The wavelength of the blue light is 480 nm.
- What is the unknown wavelength?
- A** 320 nm **B** 720 nm **C** 960 nm **D** 1440 nm
- 30 What is the electric field strength in a region where a proton accelerates at 2.00 m s^{-2} due to the field?
- A** 11.4 pV m^{-1} **B** 5.22 nV m^{-1} **C** 10.4 nV m^{-1} **D** 20.9 nV m^{-1}

- 31** An oil drop of mass 2.6×10^{-15} kg and with a charge of -4.8×10^{-19} C is in a vacuum between two horizontal plates. The plates have a separation of 2.0 cm and a potential difference (p.d.) between them of 1200 V, as shown.



Which statement describes the motion of the oil drop?

- A** It is stationary.
- B** It has a downward acceleration of 9.7 m s^{-2} .
- C** It has an upward acceleration of 1.3 m s^{-2} .
- D** It has an upward acceleration of 11 m s^{-2} .
- 32** Which two units are used to define the coulomb?
- A** ampere and second
- B** ampere and volt
- C** volt and ohm
- D** volt and second
- 33** A mobile phone battery is charged by connecting it to a constant potential difference of 5.0 V. After a time of 1.0 hour, the initial current of 0.50 A slowly decreases to zero, as shown.



What is the best estimate of the energy transferred to the battery during the time of 2.0 hours shown in the graph?

- A** 2700 J **B** 9000 J **C** 14 000 J **D** 18 000 J

- 34** A length of wire is connected into an electric circuit. The current in the wire is measured.

Which change on its own could increase the current in the wire?

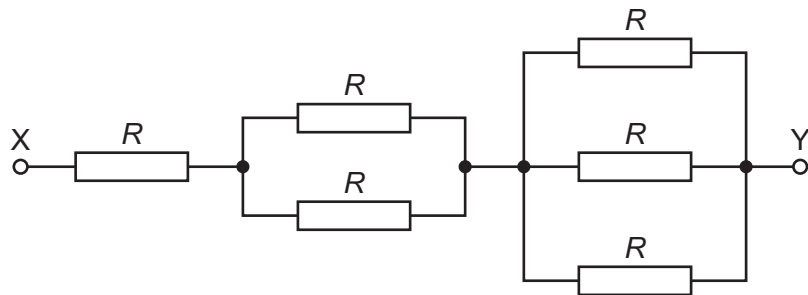
- A** an increase in the length of the wire
- B** an increase in the radius of the wire
- C** an increase in the resistance of the wire
- D** an increase in the resistivity of the wire

- 35** A cell is described as having an electromotive force (e.m.f.) of 6 V.

What does this mean?

- A** 1 coulomb of charge always dissipates 6 J of energy in the internal resistance of the cell.
- B** 1 electron gains 6 J of energy when passing through the cell.
- C** There is a potential difference of 6 V applied across any external circuit connected to the cell.
- D** When 1 coulomb of charge passes through the cell, 6 J of chemical energy is transformed.

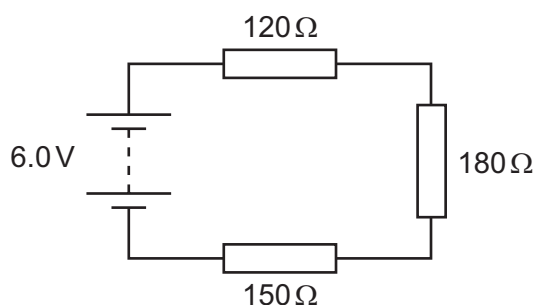
- 36** The diagram shows a network of resistors. Each resistor has resistance R .



What is the total resistance of the network between points X and Y?

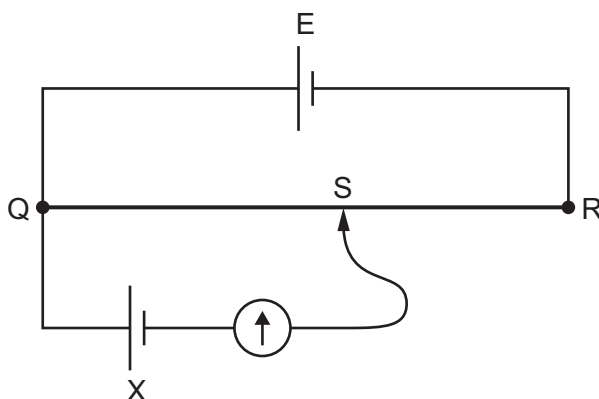
- A** $\frac{R}{6}$
- B** $\frac{6R}{11}$
- C** $\frac{11R}{6}$
- D** $6R$

- 37 Three resistors are connected in series with a battery, as shown. The battery has negligible internal resistance.



What is the potential difference across the $180\ \Omega$ resistor?

- A 1.6 V B 2.4 V C 3.6 V D 4.0 V
- 38 A potentiometer circuit is used to determine the unknown electromotive force (e.m.f.) of a cell X.
- In the circuit shown, E is a cell with an e.m.f. that is known accurately. QR is the potentiometer wire, which has a movable contact S. Contact S is connected to a galvanometer and to cell X.



What is **not** a necessary requirement to determine the e.m.f. of X from the circuit?

- A The e.m.f. of cell X must be lower than the e.m.f. of cell E.
 B The internal resistance of cell X must be known.
 C The lengths QS and QR must be determined accurately.
 D The resistance of the wire QR must be proportional to its length.
- 39 A nucleus of uranium, $^{235}_{92}\text{U}$, undergoes a series of decays. During the series of decays, two α -particles and one β^- particle are emitted.

As a result, a nucleus of actinium, Ac, is formed.

What is the correct notation for the nuclide of actinium that is formed?

- A $^{227}_{87}\text{Ac}$ B $^{227}_{89}\text{Ac}$ C $^{231}_{87}\text{Ac}$ D $^{231}_{89}\text{Ac}$

40 Which particle is a fundamental particle?

- A electron
- B hadron
- C neutron
- D proton

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1 hour 15 minutes

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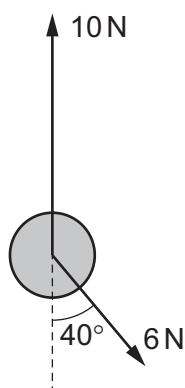
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molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

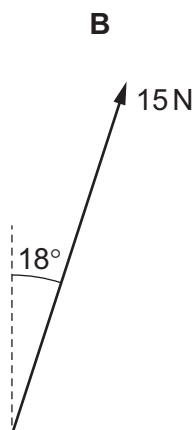
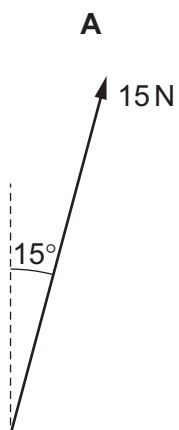
Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

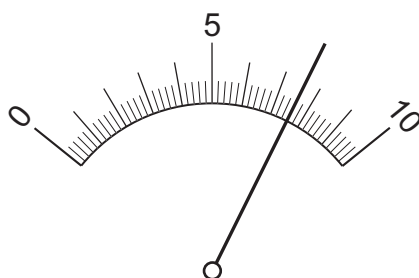
- 1 What is **not** a reasonable estimate of the physical property indicated?
- A $2 \times 10^3 \text{ W}$ for the power dissipated by the heating element of an electric kettle
- B $4 \times 10^2 \text{ m}^3$ for the volume of water in a swimming pool
- C $5 \times 10^5 \text{ N s}$ for the momentum of a lorry moving along a road
- D $6 \times 10^2 \text{ N}$ for the weight of a fully grown racehorse
- 2 Which quantity could have units of N m V^{-1} ?
- A acceleration
- B charge
- C current
- D resistance
- 3 An object is acted upon by two forces, 10 N in the vertical direction and 6 N at 40° to the vertical, as shown.



What is the resultant force acting on the object?



- 4 An analogue ammeter with a range of 0–250 mA is connected into an electrical circuit. The diagram shows the ammeter's display.

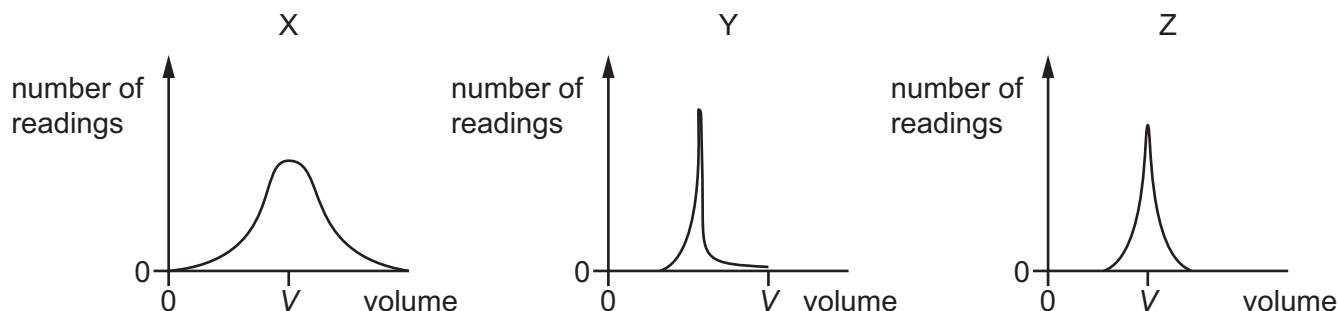


What is the reading on the ammeter?

- A** 76 mA **B** 165 mA **C** 183 mA **D** 190 mA
- 5 Students take readings of the volume of a liquid using three different pieces of measuring equipment X, Y and Z.

The true value of the volume of the liquid is V .

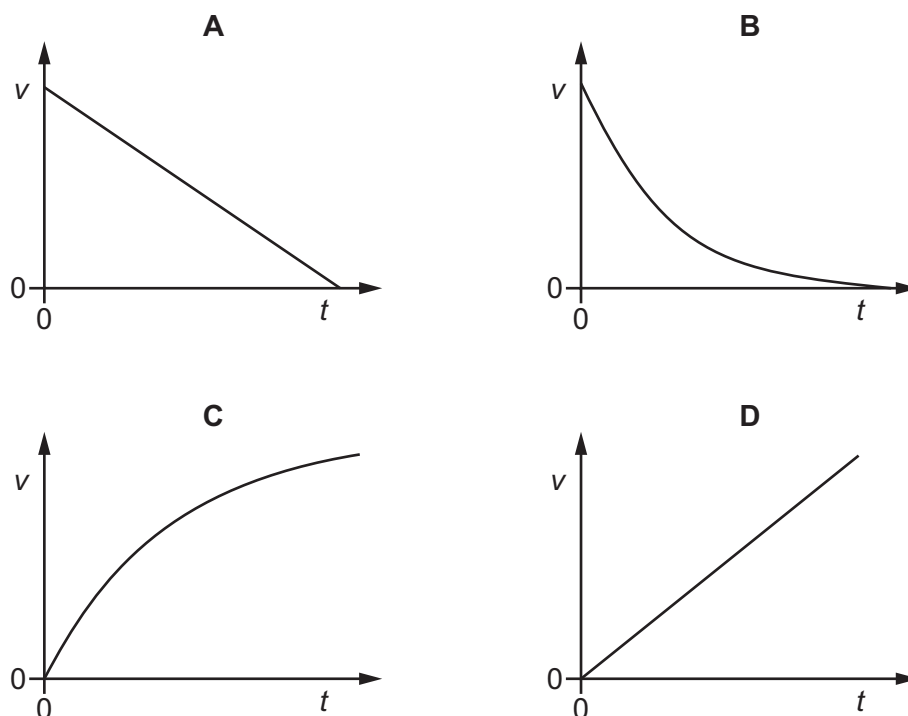
The students' results are shown.



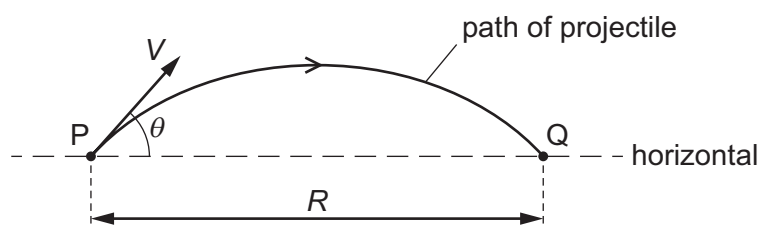
How many pieces of equipment are precise and how many are accurate?

	number of precise pieces of equipment	number of accurate pieces of equipment
A	1	1
B	1	2
C	2	1
D	2	2

- 6 Which graph shows the variation with time t of the velocity v of an object falling vertically downwards in a vacuum?



- 7 A projectile is fired from point P with velocity V at an angle θ to the horizontal. It lands at point Q, a horizontal distance R from P. Air resistance is negligible.

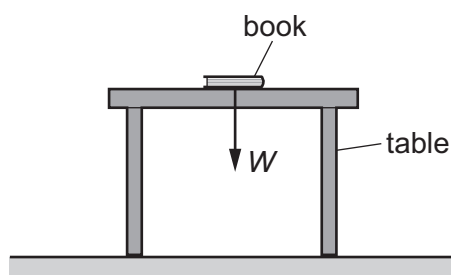


The acceleration of free fall is g .

Which equation for R is correct?

- A $R = \frac{V^2 \sin \theta \cos \theta}{g}$
- B $R = \frac{2V^2 \sin \theta \cos \theta}{g}$
- C $R = \frac{V^2 \sin \theta \cos \theta}{2g}$
- D $R = \frac{V^2 g \sin \theta \cos \theta}{2}$

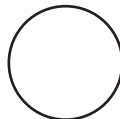
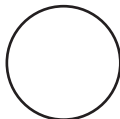
- 8 A book of weight W is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

- A the force W acting downwards on the Earth from the table
 - B the force W acting upwards on the book from the table
 - C the force W acting upwards on the Earth from the book
 - D the force W acting upwards on the table from the floor
- 9 Four balls are dropped at the same time from the top of a very tall tower. There is no wind blowing.

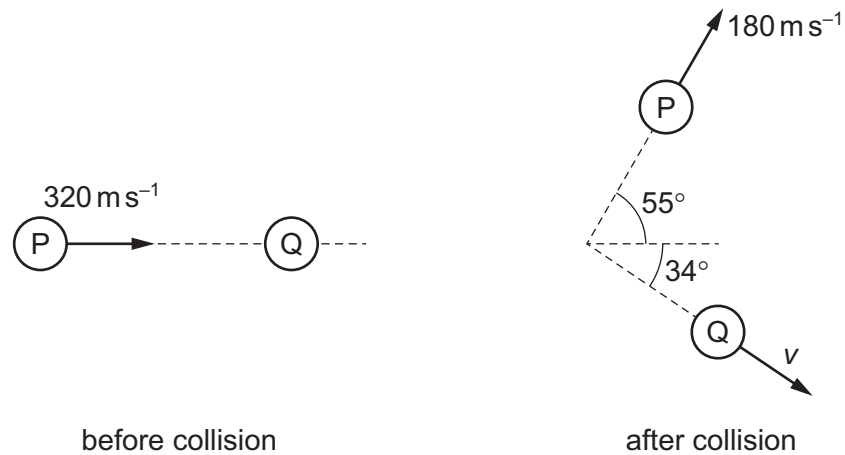
Which ball hits the ground first?

A	B	C	D
			
mass M diameter D	mass $4M$ diameter D	mass M diameter $2D$	mass $4M$ diameter $2D$

- 10** A nitrogen molecule P travelling at a speed of 320 m s^{-1} in a vacuum collides with a stationary nitrogen molecule Q.

After the collision, P travels at a velocity of 180 m s^{-1} at an angle of 55° to its original path.

Q travels in a direction at an angle of 34° to the initial path of P.



Assume that there are no external forces acting on the molecules.

What is the magnitude v of the velocity of Q after the collision?

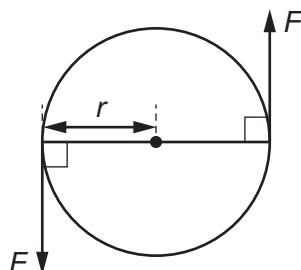
- A** 120 m s^{-1} **B** 140 m s^{-1} **C** 180 m s^{-1} **D** 260 m s^{-1}

- 11** A charged particle is placed in a uniform field of force. The direction of the force on the particle is opposite to the direction of the field.

What is the field and what is the charge on the particle?

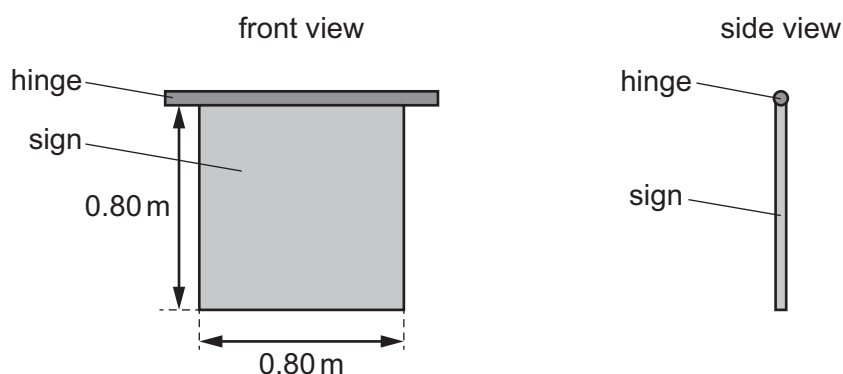
	field	charge on particle
A	electric	negative
B	electric	positive
C	gravitational	negative
D	gravitational	positive

- 12 A disc of radius r is acted upon by two opposite forces, each of magnitude F . The forces form a couple, as shown.



What is the torque of this couple?

- A $\frac{1}{2}Fr$ B Fr C $2Fr$ D $4Fr$
- 13 A uniform square sign of weight 40 N is suspended vertically from its top edge by a horizontal hinge, as shown.



The hinge is not frictionless. When the sign is displaced from the vertical by an external force and then released, it does not return to the vertical position.

The maximum torque exerted by the hinge on the sign is 6.0 N m. The sign is displaced by 90° so that it is horizontal and then gradually released.

At which angle to the vertical does the sign hang after release?

- A 11° B 22° C 68° D 79°
- 14 Each foot of an elephant has a circular cross-section with a circumference of 1.4 m. The elephant has a mass of 5400 kg.

The elephant is standing still with all four feet on the ground. Assume the pressure under each foot is the same.

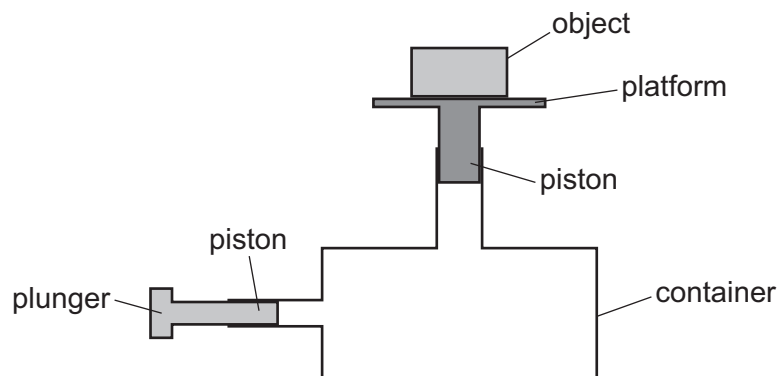
What is the approximate pressure exerted on the ground by each of the elephant's feet?

- A 8.7 kPa B 35 kPa C 85 kPa D 340 kPa

- 15** A stone is falling vertically through the air at a constant (terminal) velocity.

Which energy change is occurring?

- A** gravitational potential energy to thermal energy
 - B** gravitational potential energy to kinetic energy of the stone
 - C** kinetic energy to gravitational potential energy of the stone
 - D** kinetic energy of the stone to thermal energy
- 16** An object of weight 12 N rests on a platform on top of a container with two pistons, as shown. The container contains a fixed mass of gas, and the pistons are free to move.

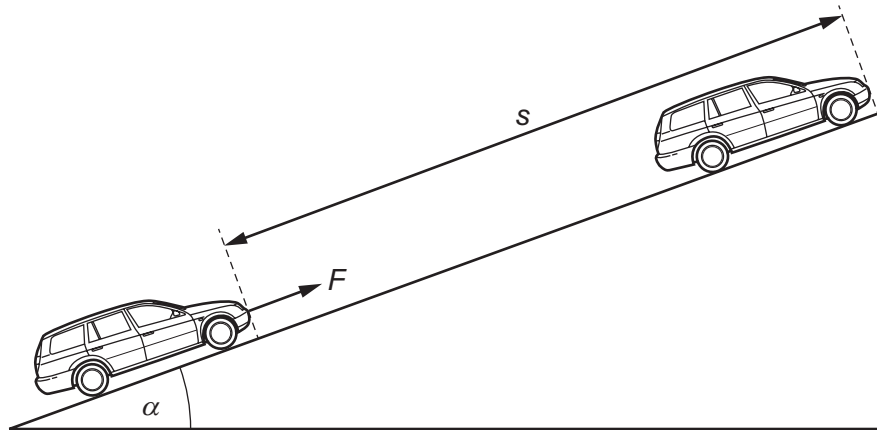


The plunger is slowly pushed 4.0 cm to the right. As a result, the object slowly moves upwards a distance 0.50 cm.

How much work is done on the object?

- A** 0.060 J **B** 0.48 J **C** 6.0 J **D** 48 J

- 17 A constant force F , acting on a car of mass m , moves the car up a slope through a distance s at constant velocity v . The angle of the slope to the horizontal is α .



The acceleration of free fall is g .

What is the ratio $\frac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

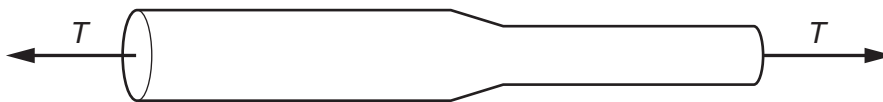
- A $\frac{mgs \sin \alpha}{Fv}$ B $\frac{mv}{Fs}$ C $\frac{mv^2}{2Fs}$ D $\frac{mg \sin \alpha}{F}$

- 18 What is the definition of power?

- A Power is the product of force and velocity.
 B Power is the product of force and work done per unit time.
 C Power is the product of force per unit time and velocity.
 D Power is the rate at which work is done.

- 19 A steel bar of circular cross-section is under tension T , as shown.

The diameter of the wide portion is double the diameter of the narrow portion.



What is the value of $\frac{\text{stress in the wide portion}}{\text{stress in the narrow portion}}$?

- A 0.25 B 0.50 C 2.0 D 4.0

- 20 Two guitar strings are stretched by tensile forces.

String X is stretched by a tensile force F that causes an extension x .

String Y is stretched by a tensile force $2F$ that causes an extension $2x$.

The strings obey Hooke's law.

What is the ratio $\frac{\text{strain energy in stretched string X}}{\text{strain energy in stretched string Y}}$?

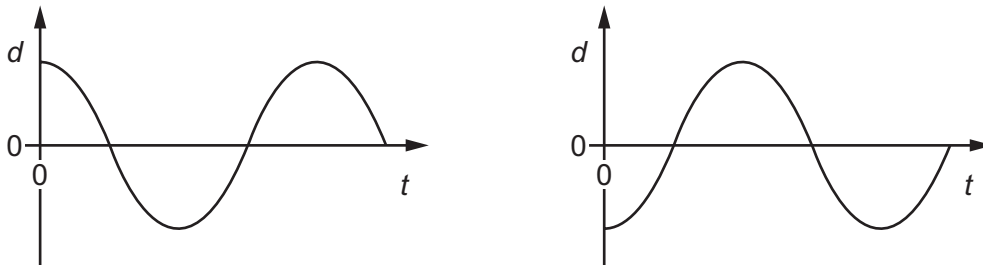
- A 4 B 2 C $\frac{1}{2}$ D $\frac{1}{4}$

- 21 Two lasers emit light in a vacuum. One laser emits red light and the other emits green light.

Which property of the light from the two lasers **must** be different?

- A amplitude
B frequency
C intensity
D speed

- 22 Two particles in a progressive wave are a distance 10 cm apart. The two graphs show the variation with time t of the displacement d of the two particles.

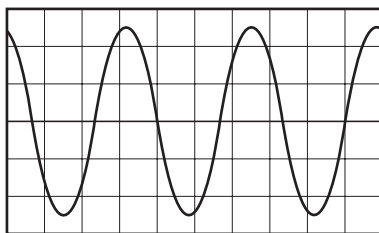


What could be represented by the two graphs?

- A particles in a longitudinal wave with a compression and the nearest rarefaction separated by 10 cm
B particles in a longitudinal wave with a compression and the nearest rarefaction separated by 20 cm
C particles in a transverse wave with a peak and the nearest trough separated by 20 cm
D particles in a transverse wave with two adjacent peaks separated by 10 cm

- 23** A sound wave is detected by a microphone that is connected to a cathode-ray oscilloscope (CRO).

The screen of the CRO displays a waveform, as shown.



The time-base is set to $20\ \mu\text{s div}^{-1}$.

What is the frequency of the sound wave?

- A** 15 Hz **B** 15 000 Hz **C** 20 000 Hz **D** 30 000 Hz
- 24** A person stands at the side of a straight railway track. A train moves towards the person and emits sound from its whistle. The person hears a sound of frequency 1690 Hz as the train approaches him.

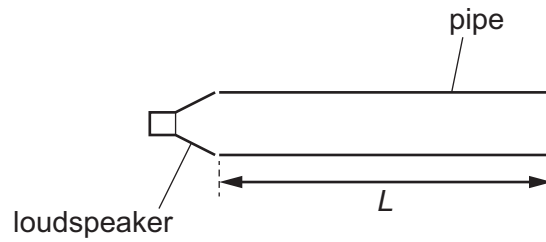
The person then hears sound of frequency 1500 Hz as the train moves away from him. The speed of sound in air is $340\ \text{m s}^{-1}$.

What is the speed of the train?

- A** $20\ \text{m s}^{-1}$ **B** $38\ \text{m s}^{-1}$ **C** $41\ \text{m s}^{-1}$ **D** $43\ \text{m s}^{-1}$
- 25** Which list shows electromagnetic waves in order of decreasing frequency?

- A** gamma-rays $\rightarrow$ infrared $\rightarrow$ ultraviolet $\rightarrow$ radio waves
B gamma-rays $\rightarrow$ ultraviolet $\rightarrow$ infrared $\rightarrow$ radio waves
C radio waves $\rightarrow$ infrared $\rightarrow$ ultraviolet $\rightarrow$ gamma-rays
D radio waves $\rightarrow$ ultraviolet $\rightarrow$ infrared $\rightarrow$ gamma-rays

- 26** A pipe of length L is open at one end and closed at the other end. A loudspeaker is at the open end and emits a sound wave into the pipe.

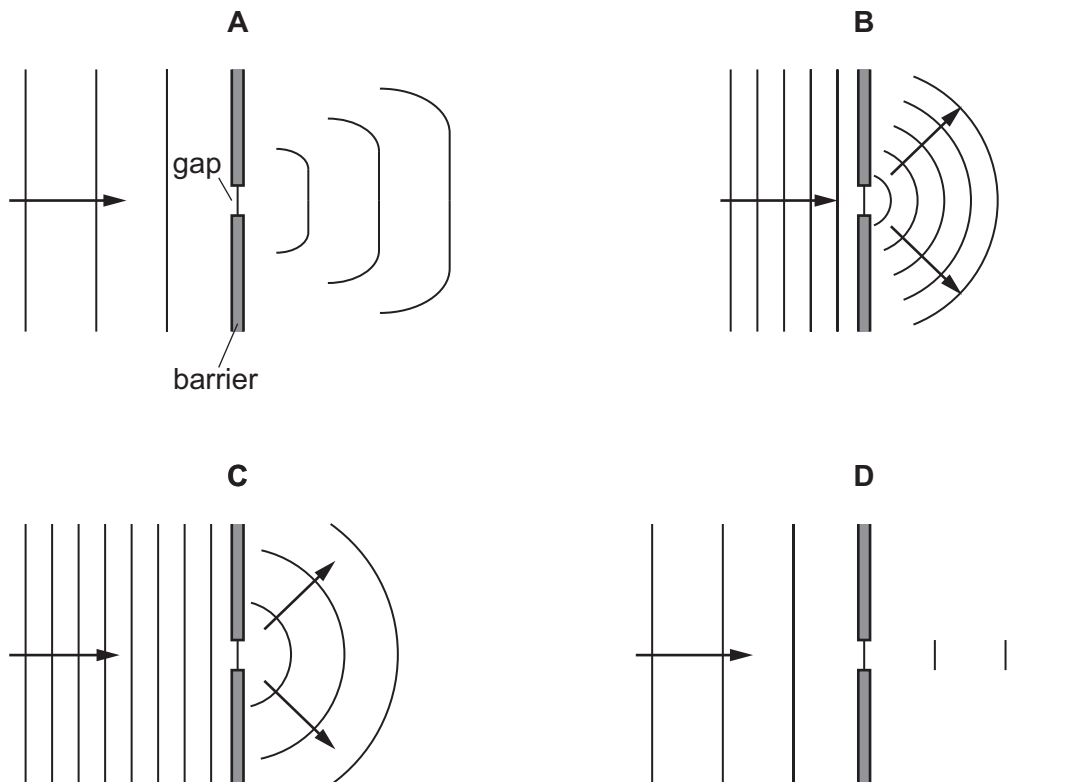


When a stationary wave is formed, there is an antinode at the open end of the pipe.

Which wavelength of sound could be used to produce a stationary wave?

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

- 27** Which diagram best shows how water waves diffract when they pass through a gap in a barrier?

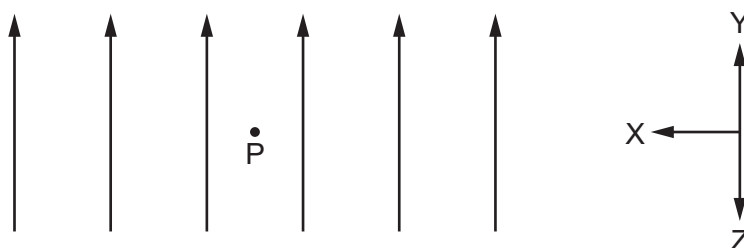


- 28** In a two-source interference experiment, light of a single frequency is incident on a double slit.

The light waves emerging from the slits are coherent.

What is meant by *coherent*?

- A** The waves are in phase.
 - B** The waves have a constant phase difference.
 - C** The waves have the same amplitude.
 - D** The waves interfere constructively wherever they overlap.
- 29** A parallel beam of light consists of light of wavelength 420 nm and light of wavelength 630 nm.
- The light is incident normally on a diffraction grating.
- The diffraction maxima for the two wavelengths overlap only at an angle of 31° from the direction of the incident light beam.
- What could be the line spacing of the diffraction grating?
- A** $1.2\ \mu\text{m}$
 - B** $1.6\ \mu\text{m}$
 - C** $2.4\ \mu\text{m}$
 - D** $3.7\ \mu\text{m}$
- 30** A positively charged particle P is in an electric field, as shown.

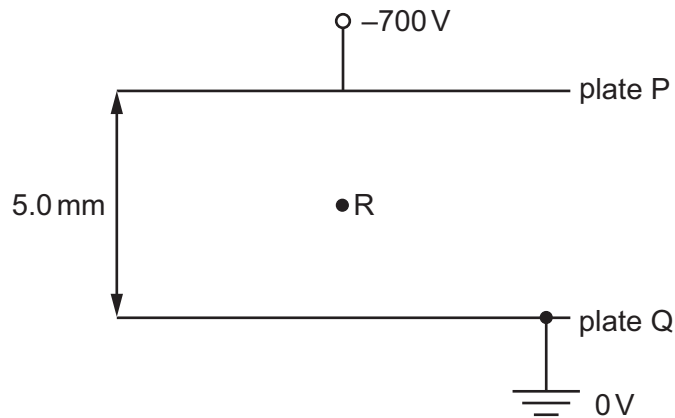


The field lines (lines of force) are evenly spaced and parallel.

Which statement is correct?

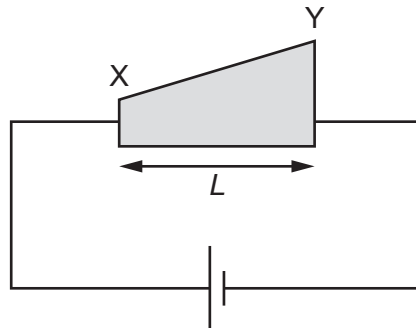
- A** Moving P a small distance in any direction will not change the electric force on P.
- B** Moving P a small distance in direction Y will increase the electric force on P.
- C** Moving P a small distance in direction Z will increase the electric force on P.
- D** Moving P a small distance in direction X will increase the electric force on P.

- 31 The diagram shows two parallel metal plates P and Q, separated by a distance of 5.0 mm. There is a potential difference of 700 V between the plates. Plate Q is earthed.

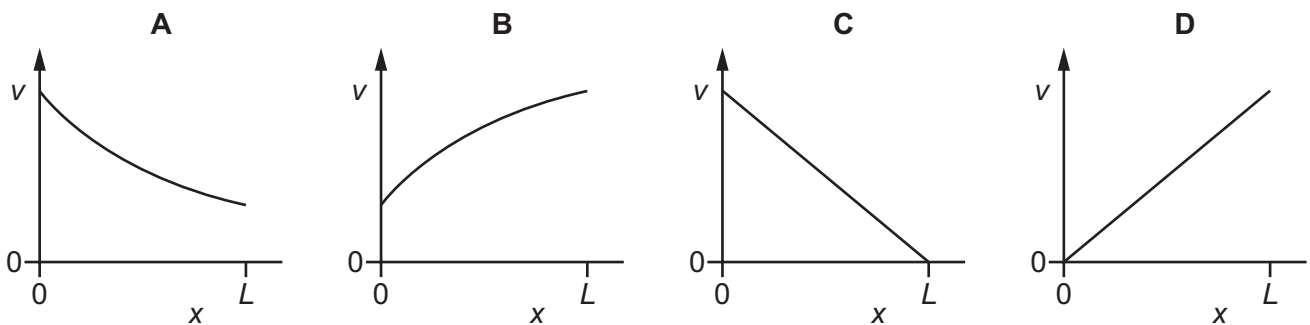


What is the magnitude and direction of the electric field at point R?

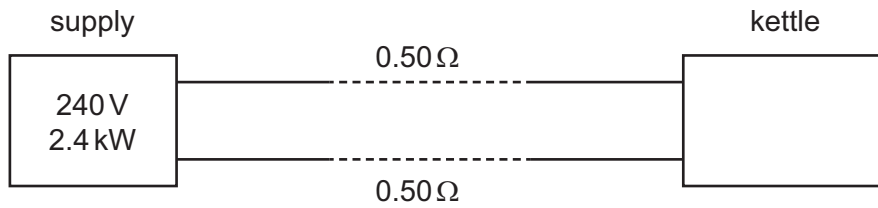
- A** $1.4 \times 10^2 \text{ NC}^{-1}$ from P towards Q
B $1.4 \times 10^2 \text{ NC}^{-1}$ from Q towards P
C $1.4 \times 10^5 \text{ NC}^{-1}$ from P towards Q
D $1.4 \times 10^5 \text{ NC}^{-1}$ from Q towards P
- 32 A wedge-shaped metal conductor of length L , varying width and uniform thickness is connected to a cell, as shown.



Which graph best shows how the average drift velocity v of electrons in the conductor varies with distance x from end X?



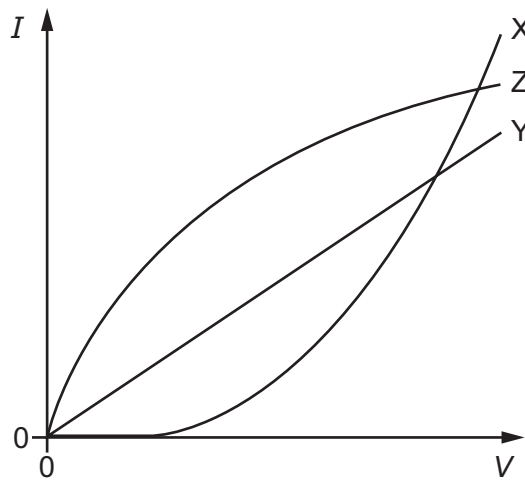
- 33** The power output of an electrical supply is 2.4 kW at a potential difference (p.d.) of 240 V. The two wires between the supply and a kettle each have a resistance of $0.50\ \Omega$, as shown.



What is the power supplied to the kettle and what is the p.d. across the kettle?

	power/kW	p.d./V
A	2.3	230
B	2.3	235
C	2.4	230
D	2.4	235

- 34** The graph shows the variation with potential difference V of the current I in components X, Y and Z.



Which row correctly identifies the components?

	metallic conductor at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	Y	X

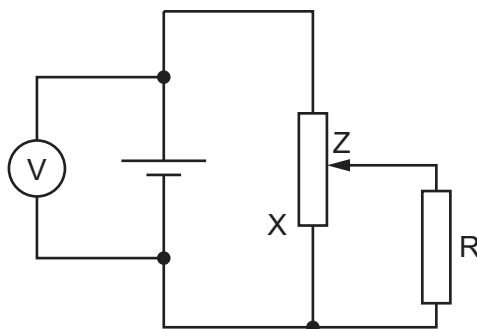
- 35 A wire of resistance $9.55\ \Omega$ has a diameter of $0.280\ \text{mm}$.

It is made of metal of resistivity $4.90 \times 10^{-7}\ \Omega\text{m}$.

What is the length of the wire?

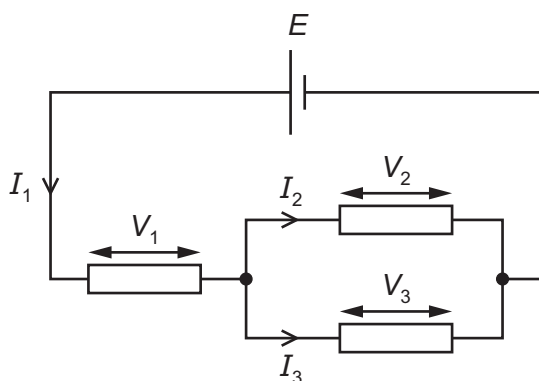
- A** 1.20 m **B** 4.80 m **C** 19.0 m **D** 76.0 m

- 36 A cell of constant electromotive force (e.m.f.) but with internal resistance is connected to a fixed resistor R using a potentiometer. A voltmeter measures the potential difference (p.d.) between the terminals of the cell.



Which statement explains the change to the reading of the voltmeter as contact Z is moved towards end X of the potentiometer?

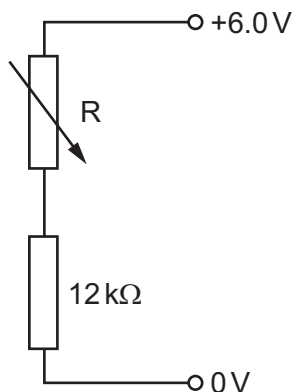
- A** The voltmeter reading decreases because the current through the cell decreases.
B The voltmeter reading decreases because the current through the cell increases.
C The voltmeter reading increases because the current through the cell decreases.
D The voltmeter reading increases because the current through the cell increases.
- 37 A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected to a circuit. The circuit has currents I_1 , I_2 and I_3 , and potential differences V_1 , V_2 and V_3 , as shown.



Which equation represents a statement of Kirchhoff's first law?

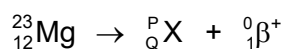
- A** $I_1 = I_2 + I_3$ **B** $I_1 = I_2 = I_3$ **C** $E = V_1 + V_2$ **D** $V_1 = V_2 = V_3$

- 38 Two resistors are connected in series with a 6.0 V power supply, as shown.



What is the resistance of the variable resistor R to give a potential difference of 1.0 V across the 12 kΩ resistor?

- A 2.0 kΩ B 10 kΩ C 60 kΩ D 72 kΩ
- 39 A nucleus of magnesium decays into a nucleus X by emitting a β^+ particle. The decay is represented by the equation shown.



What are the values of P and Q?

	P	Q
A	22	11
B	22	13
C	23	11
D	23	13

- 40 In β^- decay, a neutron inside a nucleus changes to a proton.

Which statement describes the quark composition of the nucleus during the decay?

- A The number of down quarks decreases by one.
 B The number of down quarks increases by one.
 C The number of down quarks stays the same.
 D The number of up quarks stays the same.

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Cambridge International AS & A Level

PHYSICS**9702/13**

Paper 1 Multiple Choice

May/June 2021**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.

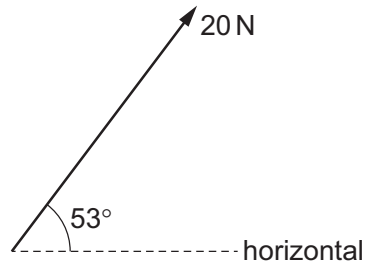
Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

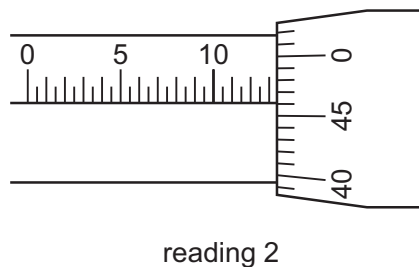
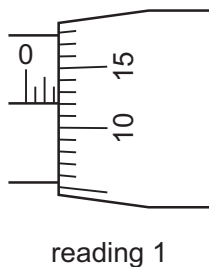
Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

- 1 What is a reasonable estimate of the kinetic energy of an Olympic athlete sprinting in a 100 m race?
- A 40 J B 400 J C 4000 J D 40 000 J
- 2 What is a unit of momentum?
- A kg m s^{-2} B N s^{-1} C N s D kg s m^{-1}
- 3 What is the horizontal component of the force shown?



- A 12 N B 16 N C 25 N D 27 N
- 4 The diagram shows two readings on a micrometer.



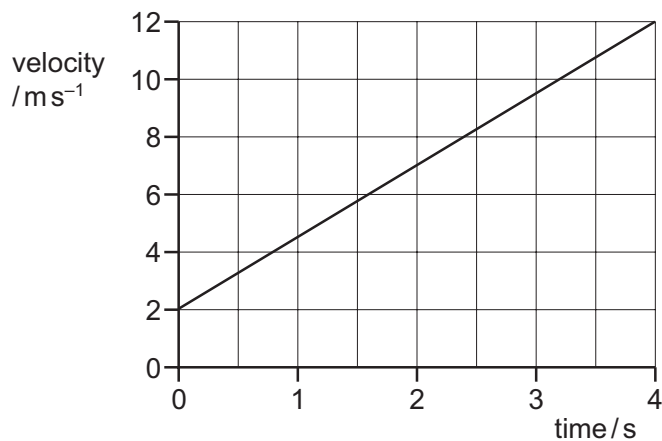
What is the difference between the two readings?

- A 10.34 mm B 11.84 mm C 12.34 mm D 12.84 mm
- 5 The diameter of a circular disc is measured as (7.0 ± 0.1) mm.

What is the area of the disc and the absolute uncertainty in the area?

	area of disc / mm^2	absolute uncertainty / mm^2
A	38.5	± 0.5
B	38	± 1
C	154	± 2
D	154	± 4

- 6 The diagram shows a velocity–time graph for a car.

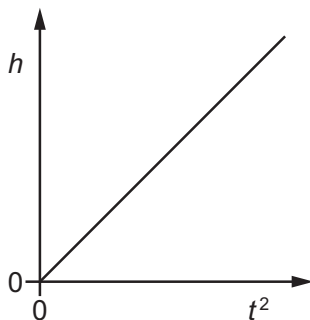


What is the distance travelled during the first 4.0 s?

- A** 2.5 m **B** 3.0 m **C** 20 m **D** 28 m
- 7 A steel ball is dropped from rest from a height h above the ground. The ball hits the ground after a time t .

This is repeated for a number of different heights.

The graph shows the variation of h with t^2 for the ball.

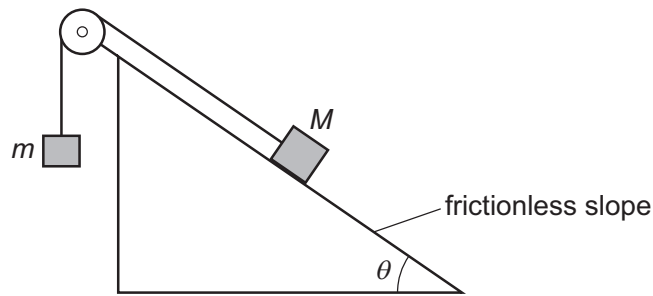


The gradient of the graph is G .

Which expression gives the acceleration of the ball?

- A** $\frac{G}{2}$ **B** G **C** $2G$ **D** G^2

- 8 Two masses, M and m , are connected by an inextensible string which passes over a frictionless pulley. Mass M rests on a frictionless slope, as shown.



The slope is at an angle θ to the horizontal.

The two masses are initially held stationary and then released. Mass M accelerates down the slope.

Which expression **must** be correct?

- A $\sin \theta < \frac{m}{M}$ B $\cos \theta < \frac{m}{M}$ C $\sin \theta > \frac{m}{M}$ D $\cos \theta > \frac{m}{M}$
- 9 The weights and masses of four different objects on the surfaces of four different planets are shown.

Which planet has the lowest value of acceleration of free fall at its surface?

	weight	mass
A	40 mN	6.0 g
B	3.0 N	500 g
C	10 N	1 kg
D	2.6 kN	750 kg

- 10 A rock in deep space is travelling towards a distant star and collides with a stationary spacecraft.

What is **not** a possible outcome of the collision?

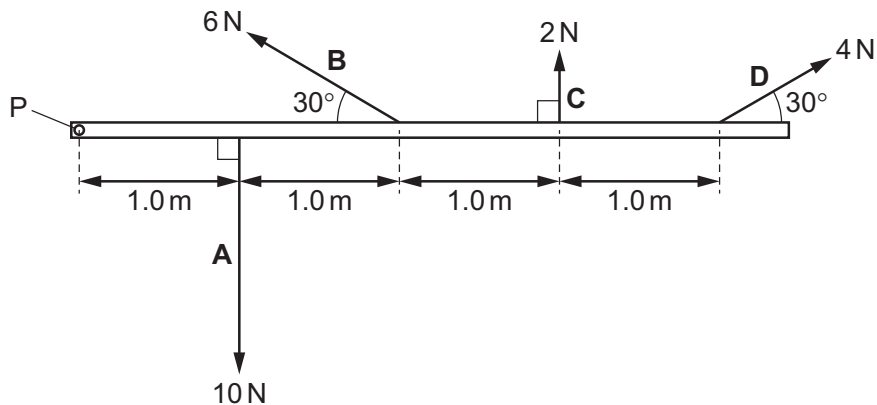
- A The rock becomes stationary and the spacecraft moves towards the star.
 B The rock moves away from the star and so does the spacecraft.
 C The rock moves away from the star and the spacecraft moves towards the star.
 D The rock moves towards the star and so does the spacecraft.

- 11** A steel ball is falling at a constant (terminal) speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

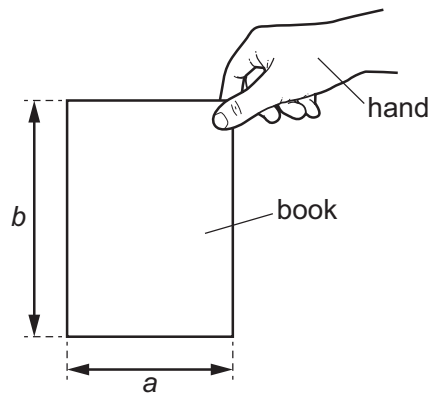
What is the order of increasing magnitude of these three forces?

- A** upthrust $\rightarrow$ viscous drag $\rightarrow$ weight
B viscous drag $\rightarrow$ upthrust $\rightarrow$ weight
C viscous drag $\rightarrow$ weight $\rightarrow$ upthrust
D weight $\rightarrow$ upthrust $\rightarrow$ viscous drag
- 12** What is a couple?
- A** a pair of equal forces acting in the same direction but along different lines
B a pair of forces that are equal and opposite but acting along different lines
C a pair of forces that produce no resultant force and no resultant moment
D a pair of unequal forces acting in opposite directions but along the same line
- 13** Four coplanar forces act on a rigid rod, as shown. The rod is hinged at P.

Which force produces the greatest moment about point P?



- 14 A book of weight W has a rectangular shape and is of uniform thickness. The book is held in a vertical plane so that the longer sides of the book are vertical, as shown.



Which expression gives the approximate torque exerted by the hand on the book?

- A $\frac{Wa}{2}$ clockwise
 - B $\frac{Wb}{2}$ anticlockwise
 - C Wa clockwise
 - D Wb anticlockwise
- 15 The derivation of the pressure equation $\Delta p = \rho g \Delta h$ uses a number of relationships between quantities.

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

- A density = $\frac{\text{mass}}{\text{volume}}$
- B potential energy = mass $\times$ acceleration of free fall $\times$ height
- C pressure = $\frac{\text{force}}{\text{area}}$
- D weight = mass $\times$ acceleration of free fall

- 16** A spring is initially neither compressed nor extended.

A force can be applied to this spring so that it is either compressed to a shorter length or extended to a longer length.

What is the change in the elastic potential energy in the spring when it is extended and when it is compressed?

	change in the elastic potential energy	
	spring is extended	spring is compressed
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

- 17** A sample of gas is sealed in a cylinder by a piston. The frictionless piston is free to move, so that the pressure of the gas remains constant at $1.80 \times 10^5 \text{ Pa}$.

The gas initially occupies a volume of $2.40 \times 10^{-4} \text{ m}^3$.

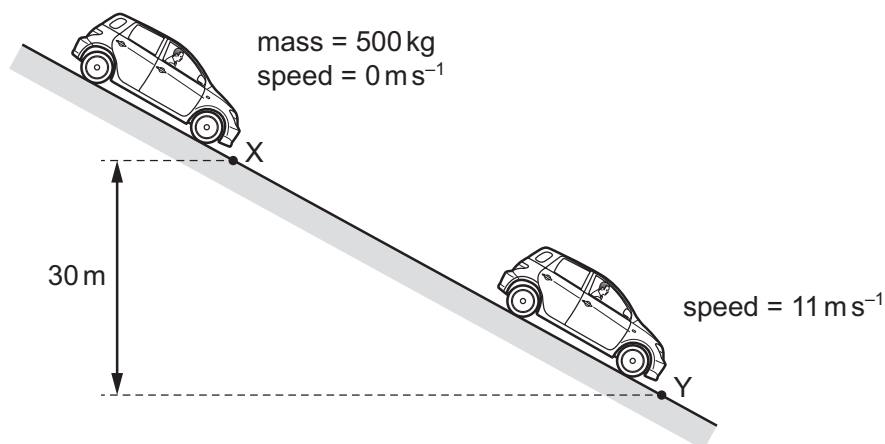
The gas now does 14.4 J of work.

What is the volume of the gas after doing this work?

- A** $0.80 \times 10^{-4} \text{ m}^3$
B $1.60 \times 10^{-4} \text{ m}^3$
C $3.20 \times 10^{-4} \text{ m}^3$
D $4.00 \times 10^{-4} \text{ m}^3$

- 18 A car of mass 500 kg is at rest at point X on a slope, as shown.

The car's brakes are released and the car rolls down the slope with its engine switched off. At point Y the car has moved through a vertical height of 30 m and has a speed of 11 m s^{-1} .



What is the energy dissipated by frictional forces when the car moves from X to Y?

- A $3.0 \times 10^4 \text{ J}$ B $1.2 \times 10^5 \text{ J}$ C $1.5 \times 10^5 \text{ J}$ D $1.8 \times 10^5 \text{ J}$
- 19 Which expression **cannot** be used to calculate power?
- A $\frac{(\text{force} \times \text{displacement})}{\text{time}}$
- B $\text{force} \times \text{velocity}$
- C $\frac{\text{work done}}{\text{time}}$
- D $\text{work done} \times \text{velocity}$
- 20 The stress σ in a material is given by the equation shown.

$$\sigma = \frac{F}{A}$$

The strain ε in the same material is given by the equation shown.

$$\varepsilon = \frac{x}{L}$$

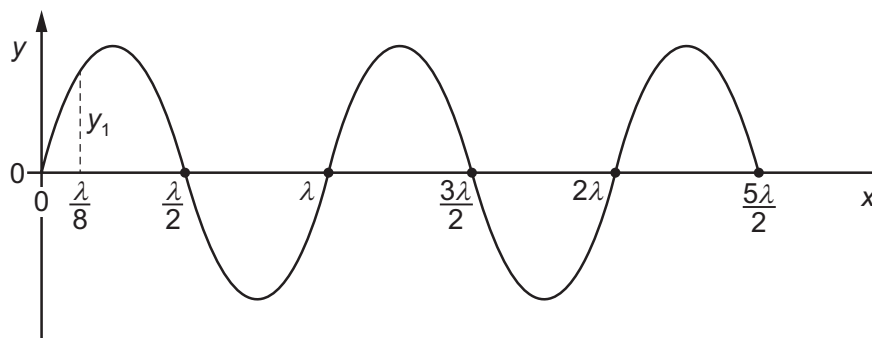
Which expression gives the Young modulus of the material?

- A $\frac{\varepsilon}{\sigma}$ B $\frac{Fx}{AL}$ C $\frac{\sigma x}{L}$ D $\frac{F}{A\varepsilon}$

21 What is an example of plastic deformation?

- A A rubber ball is momentarily compressed every time it hits the ground.
- B A spoon stirring some coffee in a ceramic mug hits its surface and makes a clinking sound.
- C A toolbox is left on a horizontal plank. When the toolbox is removed, the plank is no longer straight.
- D The spring in some bathroom weighing scales is compressed by a person standing on the scales.

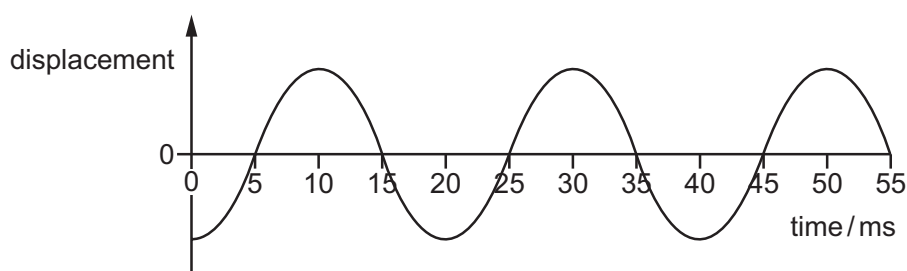
22 A transverse progressive wave of wavelength λ is set up on a stretched string. The graph shows the variation of displacement y with distance x at a particular instant of time. The wave has displacement $+y_1$ at distance $x = \frac{\lambda}{8}$.



What are the next two values of x where the displacement y is again equal to $+y_1$?

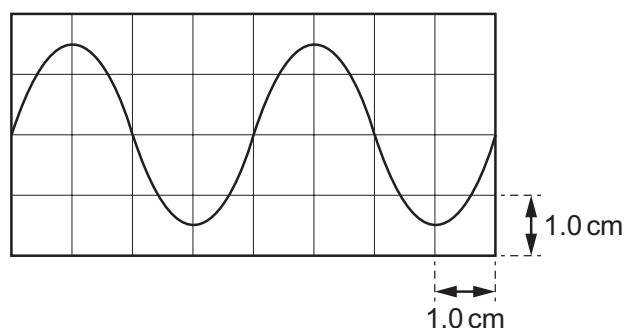
- A $\frac{3\lambda}{8}$ and $\frac{5\lambda}{8}$
- B $\frac{3\lambda}{8}$ and $\frac{9\lambda}{8}$
- C $\frac{5\lambda}{8}$ and $\frac{9\lambda}{8}$
- D $\frac{9\lambda}{8}$ and $\frac{17\lambda}{8}$

- 23** The graph shows the variation with time of the displacement of an air particle as a progressive sound wave passes through the air. The speed of sound in air is 330 m s^{-1} .



What is the wavelength of the wave?

- A** 6.6 m **B** 8.3 m **C** 20 m **D** 25 m
- 24** A microphone is connected to a cathode-ray oscilloscope (CRO). A sound wave of constant frequency is detected by the microphone. The screen of the CRO is shown.



The time-base is set at 1.0 ms cm^{-1} .

What is the frequency of the sound wave?

- A** 250 Hz **B** 500 Hz **C** 670 Hz **D** 4000 Hz
- 25** A train's whistle is emitting sound of frequency 500 Hz as the train moves with a speed of 20 m s^{-1} along a straight track. The train moves directly towards a stationary observer standing next to the track and then passes the observer.

The speed of sound in air is 330 m s^{-1} .

What is the difference between the frequencies of the sound heard by the observer before and after the train has passed the observer?

- A** 29 Hz **B** 32 Hz **C** 40 Hz **D** 61 Hz

- 26 Gamma-rays, microwaves, visible light and X-rays are four regions of the electromagnetic spectrum.

Which list shows these four regions in order of increasing wavelength?

- A microwaves → visible light → X-rays → gamma-rays
 - B gamma-rays → X-rays → visible light → microwaves
 - C X-rays → gamma-rays → microwaves → visible light
 - D microwaves → visible light → gamma-rays → X-rays
- 27 To produce a stationary wave, two waves must travel in opposite directions through the same space.

Which statement about the properties of the two waves **must** also be correct?

- A The waves must have equal frequencies, but different speeds and wavelengths.
 - B The waves must have equal speeds, but different wavelengths and frequencies.
 - C The waves must have equal speeds, frequencies and wavelengths.
 - D The waves must have equal wavelengths, but different speeds and frequencies.
- 28 The speed of sound in air is 330 m s^{-1} .

Which size of architectural features in a large concert hall would best diffract sound waves of frequency 0.44 kHz?

- A 1.3 mm
 - B 750 mm
 - C 7.5 m
 - D 17 m
- 29 A double-slit interference pattern using red light of wavelength $7.0 \times 10^{-7} \text{ m}$ has a fringe spacing of 3.5 mm.

Which fringe spacing would be observed for the same arrangement of apparatus but using blue light of wavelength $4.5 \times 10^{-7} \text{ m}$?

- A 2.3 mm
- B 3.5 mm
- C 5.4 mm
- D 9.0 mm

- 30 A beam of light of a single wavelength is incident normally on a diffraction grating.

The angle of diffraction θ is measured for each order of diffraction n . The distance between adjacent slits in the diffraction grating is d .

A graph is plotted to determine the wavelength of the light.

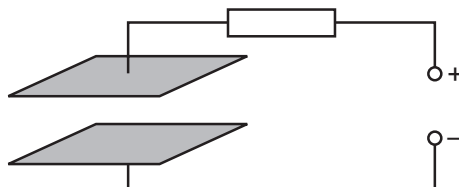
Which graph should be plotted and how is the wavelength determined from the graph?

	y-axis	x-axis	wavelength
A	n	$d \sin \theta$	gradient
B	n	$d \sin \theta$	$1/\text{gradient}$
C	$\sin \theta$	d/n	gradient
D	$\sin \theta$	$d \times n$	$1/\text{gradient}$

- 31 A particle has a charge of $+2.0 \text{ mC}$ and is in a vertical uniform electric field. An electric force of $1.0 \times 10^{-2} \text{ N}$ acts upwards on the particle.

What is the electric field strength?

- A 0.20 V m^{-1} downwards
 B 0.20 V m^{-1} upwards
 C 5.0 V m^{-1} downwards
 D 5.0 V m^{-1} upwards
- 32 The diagram shows two parallel metal plates connected to a d.c. power supply through a resistor.



There is a uniform electric field in the region between the plates.

Which change would cause a **decrease** in the strength of the electric field?

- A a small increase in the distance between the plates
 B a small increase in the potential difference between the plates
 C a small increase in the resistance of the resistor
 D a small increase to the area of both plates

- 33** A wire has a length of 12 cm and contains a total of 5.1×10^{22} free electrons.

When a potential difference is applied across the ends of the wire, the free electrons move with an average drift speed of $4.0 \times 10^{-6} \text{ m s}^{-1}$.

What is the current in the wire?

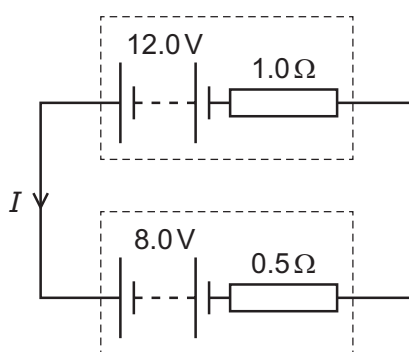
- A** 0.0027 A **B** 0.0039 A **C** 0.27 A **D** 0.39 A

- 34** A battery is marked 9.0 V.

What does this mean?

- A** Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.
B The battery supplies 9.0 J of electrical energy to an external circuit for each coulomb of charge.
C The potential difference across any component connected to the battery will be 9.0 V.
D There will always be a potential difference of 9.0 V across the battery terminals.

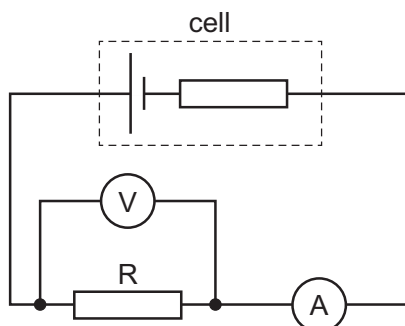
- 35** The diagram shows a circuit containing two batteries connected together.



What is the current I ?

- A** 2.7 A **B** 4.0 A **C** 8.0 A **D** 13 A

- 36 The circuit shown includes a cell of constant internal resistance and an external resistor R .

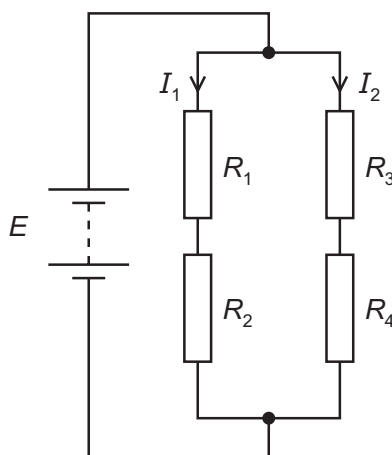


A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

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

- 37 A battery of electromotive force (e.m.f.) E and negligible internal resistance is connected to four resistors of resistances R_1 , R_2 , R_3 and R_4 .



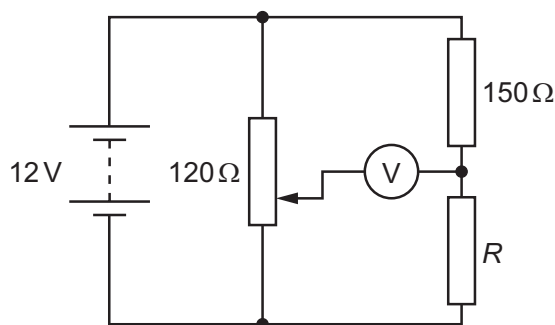
The currents I_1 and I_2 in the resistors are as shown.

Which equation is correct?

- A** $0 = I_1(R_1 + R_2) + I_2(R_3 + R_4)$
B $0 = I_1(R_1 + R_2) - I_2(R_3 + R_4)$
C $E = I_1(R_1 + R_2) + I_2(R_3 + R_4)$
D $E = I_1(R_1 + R_2) - I_2(R_3 + R_4)$

- 38** In the circuit shown, a potentiometer of total resistance $120\ \Omega$ is connected in parallel with a resistor of resistance $150\ \Omega$ and a resistor of resistance R .

The battery has electromotive force (e.m.f.) 12 V and negligible internal resistance.



The voltmeter reads 0 V when the slider of the potentiometer is $\frac{1}{4}$ of the way from its lower end, as shown.

What is resistance R ?

- A** $30\ \Omega$ **B** $38\ \Omega$ **C** $50\ \Omega$ **D** $450\ \Omega$
- 39** A beam of α -particles is incident on a thin gold foil. One α -particle collides head-on with a gold nucleus and is deflected back along its original path.
- Which statement could explain why the recoil speed of the gold nucleus is small compared with the recoil speed of the α -particle?
- A** Most α -particles are only slightly deflected as they pass through the gold foil.
B The α -particle and the gold nucleus repel each other.
C The mass of the gold nucleus is much greater than the mass of the α -particle.
D The momentum of the α -particle decreases as it approaches the gold nucleus.
- 40** A hadron is composed of three quarks. The hadron has a charge.

What is a possible quark composition of the hadron?

- A** down, down, up
B down, up, strange
C up, strange, strange
D up, up, strange

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