



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2013

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO NOT WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any working should be done in this booklet.

Electronic calculators may be used.

This document consists of **24** printed 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 constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
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.,

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{(x_0^2 - x^2)}$$

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,

$$W = \frac{1}{2}QV$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

alternating current/voltage,

$$x = x_0 \sin \omega t$$

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

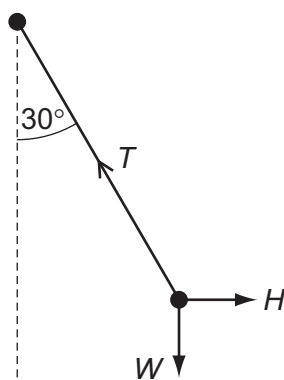
decay constant,

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

- 1 Which row shows an SI base quantity with its correct unit?

	SI base quantity	unit
A	charge	coulomb
B	current	ampere
C	potential difference	volt
D	temperature	degree Celsius

- 2 A pendulum bob is held stationary by a horizontal force H . The three forces acting on the bob are shown in the diagram.



The tension in the string of the pendulum is T . The weight of the pendulum bob is W .

Which statement is correct?

- A** $H = T \cos 30^\circ$
- B** $T = H \sin 30^\circ$
- C** $W = T \cos 30^\circ$
- D** $W = T \sin 30^\circ$

Space for working

- 3 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. It is given by the equation

$$C_d = \frac{2F}{\rho v^n A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n ?

- A 1 B 2 C 3 D 4

- 4 A signal that repeats periodically is displayed on the screen of a cathode-ray oscilloscope.



The screen has 1 cm squares and the time base is set at 2.00 ms cm^{-1} .

What is the frequency of this periodic signal?

- A 50 Hz B 100 Hz C 125 Hz D 200 Hz

Space for working

- 5 A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The micrometer reading is $5.00 \text{ mm} \pm 0.01 \text{ mm}$.

What will be the percentage uncertainty in a calculation of the volume of the sphere, using these values?

- A 0.2% B 0.4% C 0.6% D 1.2%

- 6 One object moves directly from P to R.



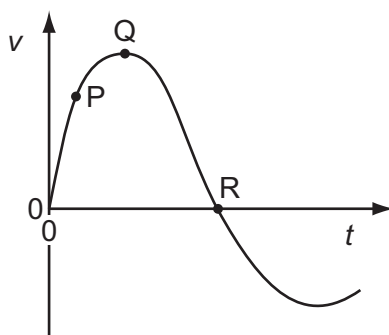
In a shorter time, a second object moves from P to Q to R.

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.

Space for working

- 7 The graph shows how velocity v varies with time t for a bungee jumper.



At which point is the bungee jumper momentarily at rest and at which point does she have zero acceleration?

	jumper at rest	jumper with zero acceleration
A	Q	P
B	Q	R
C	R	Q
D	R	R

- 8 An aeroplane travels at an average speed of 600 km h^{-1} on an outward flight and at 400 km h^{-1} on the return flight over the same distance.

What is the average speed of the whole flight?

- A** 111 ms^{-1} **B** 167 ms^{-1} **C** 480 km h^{-1} **D** 500 km h^{-1}

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

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

Space for working

- 10** An astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

What is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

- A** $1.2mg$ **B** mg **C** $0.8mg$ **D** 0

- 11** A beam of α -particles collides with a lead sheet. Each α -particle in the beam has a mass of $6.6 \times 10^{-27} \text{ kg}$ and a speed of $1.5 \times 10^7 \text{ m s}^{-1}$.

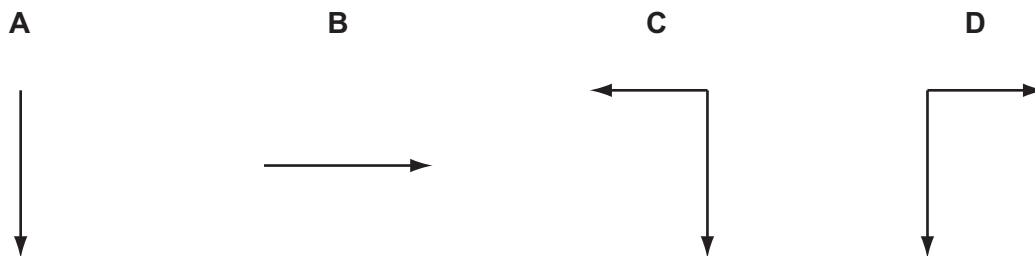
5.0×10^4 α -particles per second collide with an area of 1.0 cm^2 of lead. Almost all of the α -particles are absorbed by the lead so that they have zero speed after collision.

What is an estimate of the average pressure exerted on the lead by the α -particles?

- A** $5.0 \times 10^{-15} \text{ Pa}$
B $5.0 \times 10^{-13} \text{ Pa}$
C $5.0 \times 10^{-11} \text{ Pa}$
D $5.0 \times 10^{-9} \text{ Pa}$

- 12** An object in air is thrown upwards and towards the left.

Which diagram shows the force(s) acting on the body when it is at its highest point?



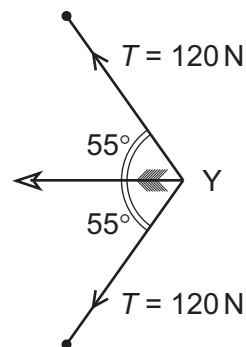
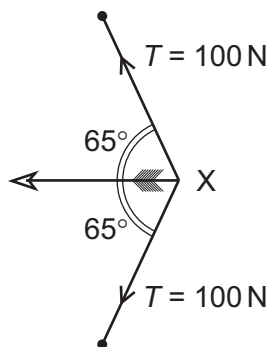
Space for working

- 13** A particle is in a uniform field. The particle experiences a force in the opposite direction to the field.

Which field is the particle in, and on which property of the particle is the field acting?

	field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

- 14** An archer draws his bowstring back to position X. The bowstring and arrow are shown. The tension T in the string is also shown. Then he draws the bowstring back further to position Y.



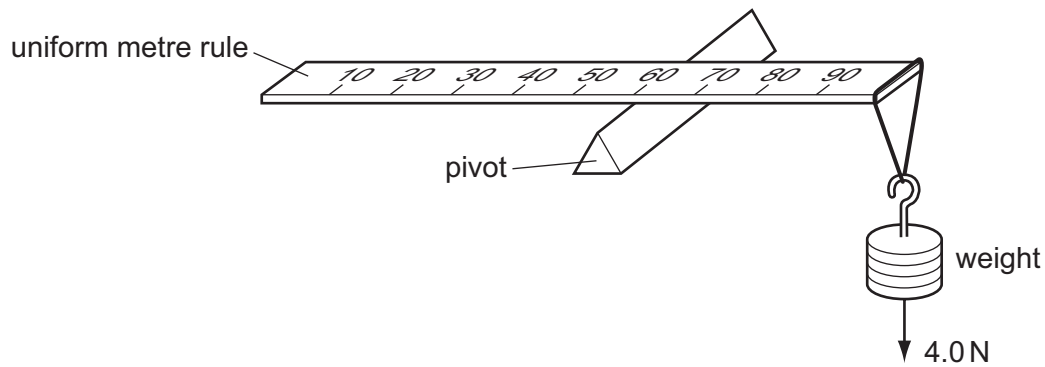
The resultant force on the arrow is greater when the arrow is released from position Y.

What is the increase in force?

- A** 15 N **B** 27 N **C** 40 N **D** 53 N

Space for working

- 15** A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N weight is suspended from one end, causing the rule to rotate about the pivot.

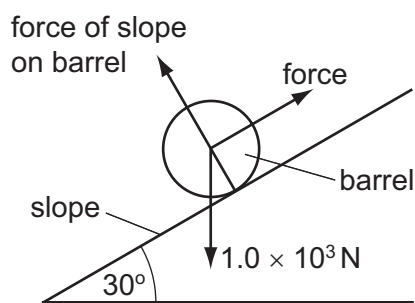


At the instant when the rule is horizontal, what is the resultant turning moment about the pivot?

- A** zero **B** 1.4 Nm **C** 1.6 Nm **D** 1.8 Nm
- 16** What is the internal energy of a system?
- A** the amount of heat supplied to the system
- B** the random energy of the atoms of the system
- C** the total kinetic energy of the system
- D** the total potential energy of the system

Space for working

- 17 The diagram shows a barrel of weight $1.0 \times 10^3 \text{ N}$ on a frictionless slope inclined at 30° to the horizontal.



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

What is the work done in moving the barrel a distance of 5.0 m up the slope?

- A** $2.5 \times 10^3 \text{ J}$ **B** $4.3 \times 10^3 \text{ J}$ **C** $5.0 \times 10^3 \text{ J}$ **D** $1.0 \times 10^4 \text{ J}$
- 18 A car travelling on a level road at a steady 20 m s^{-1} against a constant resistive force develops a power of 40 kW.

What is the magnitude of the resistive force?

- A** 200 N **B** 800 N **C** 2000 N **D** 4000 N
- 19 A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

The overall efficiency of the turbine and generator system is 90%.

What is the output power of the power station? (The density of water is 1000 kg m^{-3} .)

- A** 0.15 MW **B** 1.5 MW **C** 1.7 MW **D** 90 MW

Space for working

20 Below are four short paragraphs describing the molecules in a beaker of water at 50°C.

Which paragraph correctly describes the molecules?

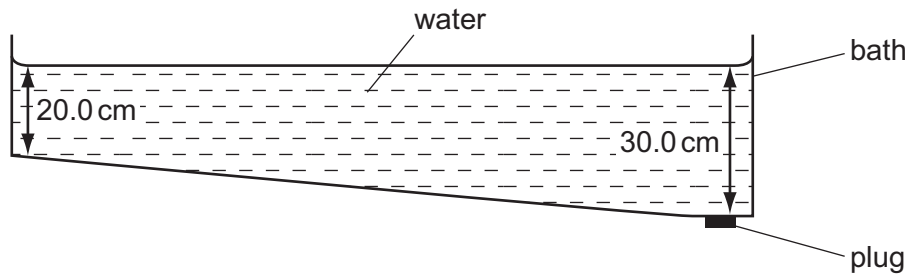
- A** The molecules all travel at the same speed. This speed is not large enough for any of the molecules to leave the surface of the water. There are attractive forces between the molecules.
- B** The molecules have a range of speeds. Some molecules travel sufficiently fast to leave the surface of the water. There are no forces between the molecules.
- C** The molecules have a range of speeds. The fastest molecules are unable to leave the surface of the water. There are attractive forces between the molecules.
- D** The molecules have a range of speeds. Some molecules travel sufficiently fast to leave the surface of the water. There are attractive forces between the molecules.

21 Which two substances are normally both crystalline?

- A** copper and diamond
- B** copper and glass
- C** diamond and glass
- D** diamond and rubber

Space for working

- 22 Water in a bath varies in depth from 20.0 cm at the shallow end to 30.0 cm at the end with the plug.



The density of the water is 1000 kg m^{-3} .

What is the pressure of the water acting on the plug?

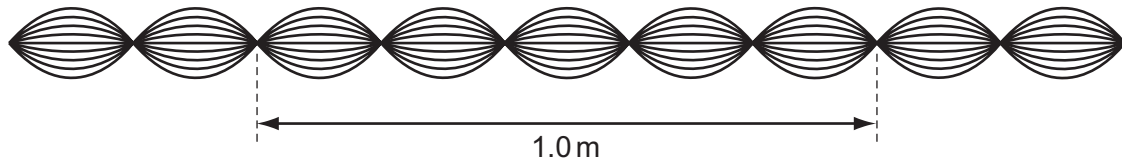
- A** 1960 Pa **B** 2450 Pa **C** 2940 Pa **D** 4900 Pa
- 23 Which properties best describe modelling clay?
- A** brittle and ductile
B ductile and elastic
C elastic and plastic
D plastic and ductile
- 24 A steel spring has a spring constant of 150 N m^{-1} . When a 25 N weight is hung from the spring, it has a stretched length of 55 cm.

What was the original length of the spring?

- A** 0.38 m **B** 0.49 m **C** 0.61 m **D** 0.72 m

Space for working

25 The diagram shows a sketch of a wave pattern, over a short period of time.



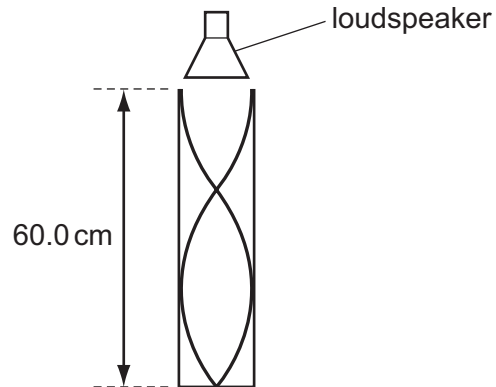
Which description of this wave is correct?

- A The wave is longitudinal, has a wavelength of 20 cm and is stationary.
 - B The wave is transverse, has a wavelength of 20 cm and is stationary.
 - C The wave is transverse, has a wavelength of 40 cm and is progressive.
 - D The wave is transverse, has a wavelength of 40 cm and is stationary.
- 26 Which statement about a light wave and a sound wave is correct?
- A Both can be polarised.
 - B Both can travel through free space.
 - C Both have a frequency inversely proportional to their wavelength.
 - D Both have an intensity proportional to their amplitude.

Space for working

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

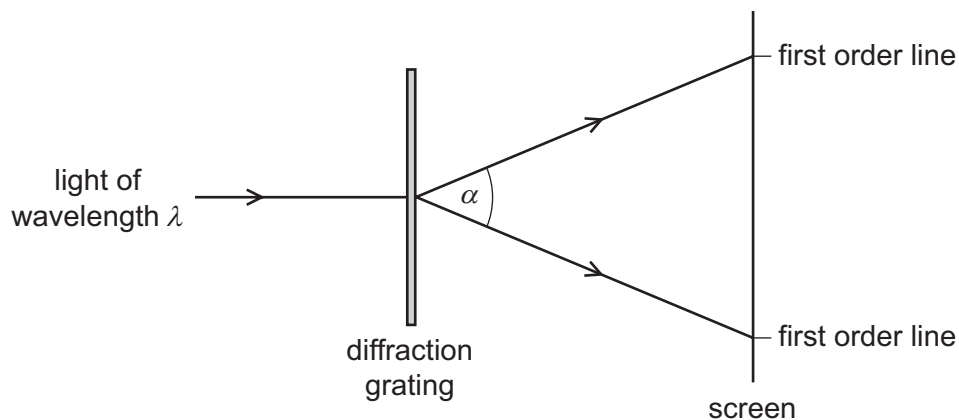
A stationary wave is formed with two nodes and two antinodes as shown.



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

What is the frequency of the sound?

- A** 413 Hz **B** 550 Hz **C** 830 Hz **D** 1650 Hz
- 28 Light of wavelength λ passes through a diffraction grating with slit spacing d . A series of lines is observed on a screen.

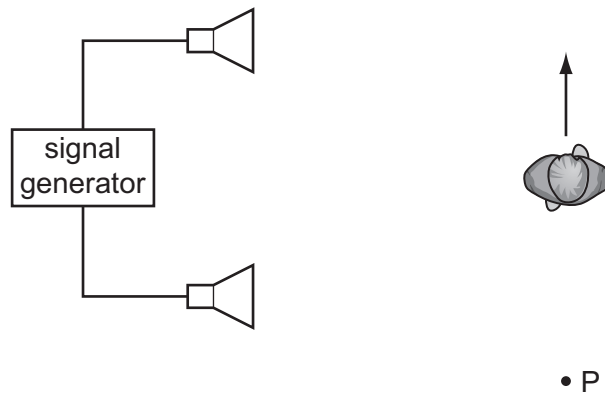


What is the angle α between the two first order lines?

- A** $\sin^{-1}\left(\frac{\lambda}{2d}\right)$ **B** $\sin^{-1}\left(\frac{\lambda}{d}\right)$ **C** $2\sin^{-1}\left(\frac{\lambda}{2d}\right)$ **D** $2\sin^{-1}\left(\frac{\lambda}{d}\right)$

Space for working

29 A student connects two loudspeakers to a signal generator.



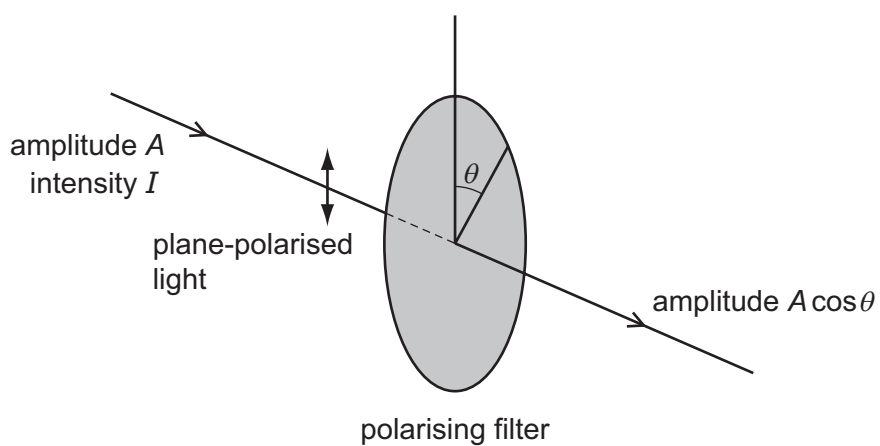
As the student walks from P to Q, he notices that the loudness of the sound rises and falls repeatedly.

What causes the loudness of the sound to vary?

- A** diffraction of the sound waves
- B** interference of the sound waves
- C** polarisation of the sound waves
- D** reflection of the sound waves

Space for working

- 30 When plane-polarised light of amplitude A is passed through a polarising filter as shown, the amplitude of the light emerging is $A \cos \theta$.



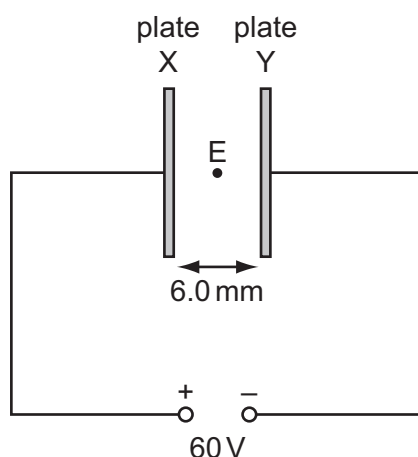
The intensity of the initial beam is I .

What is the intensity of the emerging light when θ is 60.0° ?

- A** $0.250 I$ **B** $0.500 I$ **C** $0.750 I$ **D** $0.866 I$

Space for working

- 31 Two vertical conducting plates X and Y are positioned so that they are separated by a distance of 6.0 mm in air. A 60 V d.c. supply is connected as shown.



What is the electric field strength at E, a point midway between the plates?

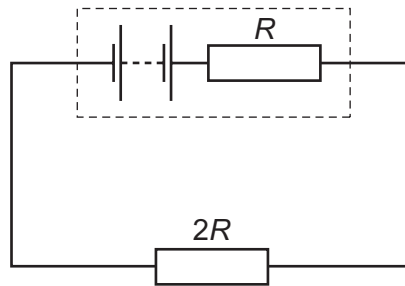
- A $1.0 \times 10^4 \text{ V m}^{-1}$ towards X
 B $1.0 \times 10^4 \text{ V m}^{-1}$ towards Y
 C $2.0 \times 10^4 \text{ V m}^{-1}$ towards X
 D $2.0 \times 10^4 \text{ V m}^{-1}$ towards Y
- 32 Two parallel metal plates have a potential difference between them of 12 V. The distance between the plates is 1.0 mm.

What are the electric field strength between the plates and the work done on a charge of $+3.9 \mu\text{C}$ to move the charge from the negative plate to the positive plate?

	electric field strength / N C^{-1}	work done / J
A	12	4.7×10^{-5}
B	12	47
C	12 000	4.7×10^{-5}
D	12 000	47

Space for working

- 33 The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R .



What is the ratio $\frac{\text{power in external resistor}}{\text{power in internal resistance}}$?

- A** $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4
- 34 Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

- A** Both lamps light at less than their normal brightness.
B Both lamps light normally.
C Only the 60 W lamp lights.
D The 10 V lamp blows.

Space for working

- 35 The wire of a heating element has resistance R . The wire breaks and is replaced by a different wire.

Data for the original wire and the replacement wire are shown in the table.

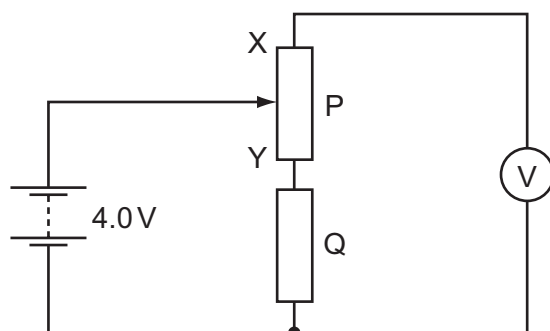
	length	diameter	resistivity of metal
original wire	l	d	ρ
replacement wire	l	$2d$	2ρ

What is the resistance of the replacement wire?

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

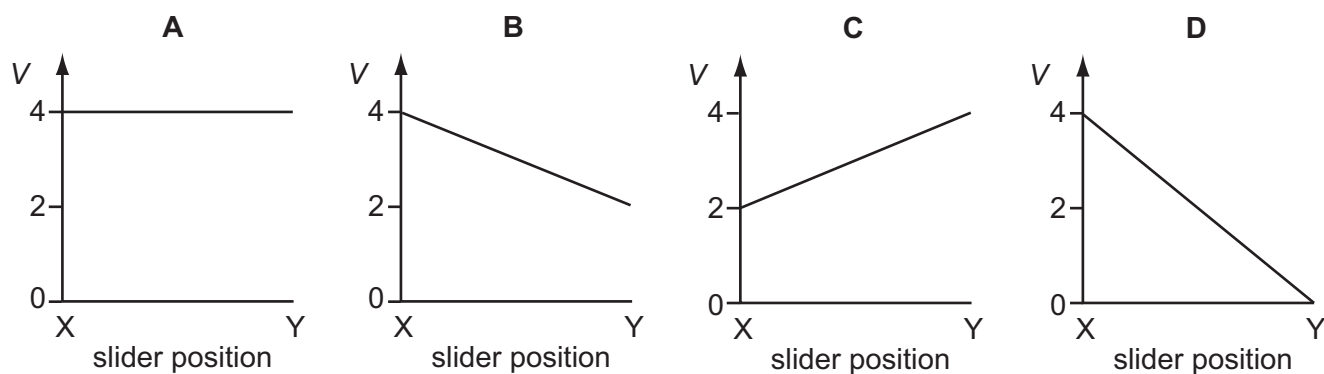
Space for working

- 36 In the circuit below, P is a potentiometer of total resistance 10Ω and Q is a fixed resistor of resistance 10Ω . The battery has an electromotive force (e.m.f.) of 4.0V and negligible internal resistance. The voltmeter has a very high resistance.



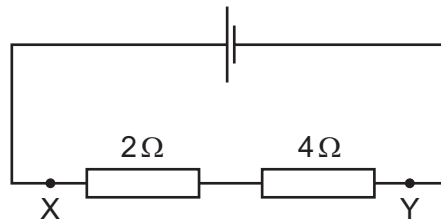
The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading V is plotted against slider position.

Which graph would be obtained?

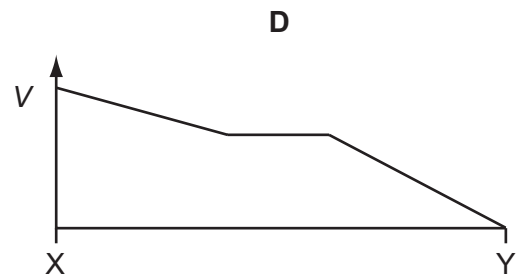
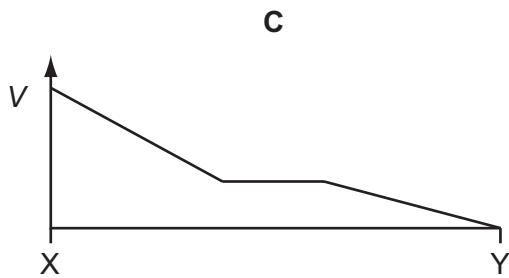
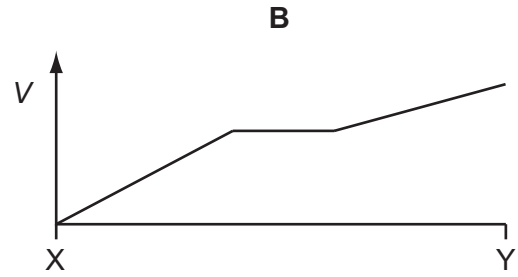
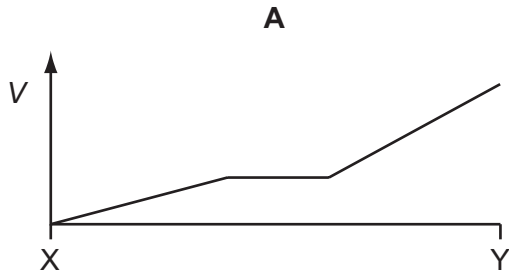


Space for working

37 A 2Ω resistor and a 4Ω resistor are connected to a cell.



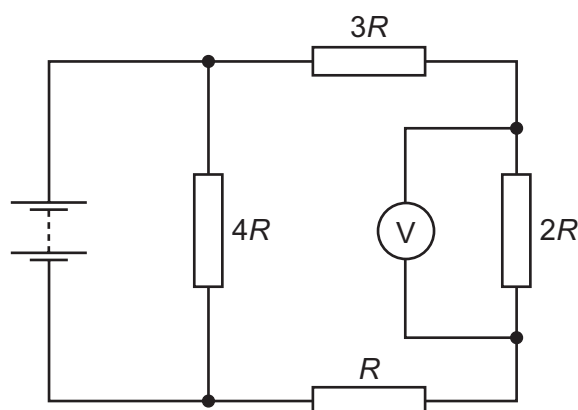
Which graph shows how the potential V varies with distance between X and Y?



Space for working

- 38 Four resistors of resistance R , $2R$, $3R$ and $4R$ are connected to form a network.

A battery of negligible internal resistance and a voltmeter are connected to the resistor network as shown.



The voltmeter reading is 2 V .

What is the electromotive force (e.m.f.) of the battery?

- A 2 V B 4 V C 6 V D 10 V
- 39 When α -particles are fired at a thin metal foil, most of the particles pass straight through but a few are deflected by a large angle.

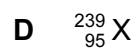
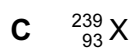
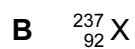
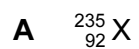
Which change would increase the **proportion** of α -particles deflected by a large angle?

- A using α -particles with greater kinetic energy
 B using a foil made of a metal with fewer protons in its nuclei
 C using a double thickness foil
 D using an alpha source with a higher activity

Space for working

40 Plutonium-239 ($^{239}_{94}\text{Pu}$) decays by emitting α -radiation.

Which nuclide is formed from one of these decay reactions? (The product nuclides are represented by X.)



Space for working

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$$p = \rho gh$$

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.,

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{(x_0^2 - x^2)}$$

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,

$$W = \frac{1}{2}QV$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

alternating current/voltage,

$$x = x_0 \sin \omega t$$

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

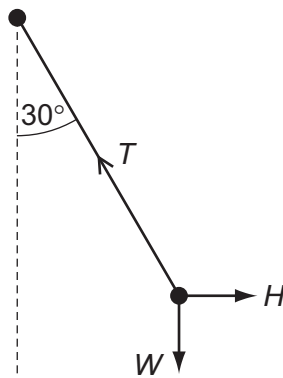
decay constant,

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

- 1 Which row shows an SI base quantity with its correct unit?

	SI base quantity	unit
A	charge	coulomb
B	current	ampere
C	potential difference	volt
D	temperature	degree Celsius

- 2 A pendulum bob is held stationary by a horizontal force H . The three forces acting on the bob are shown in the diagram.



The tension in the string of the pendulum is T . The weight of the pendulum bob is W .

Which statement is correct?

- A** $H = T \cos 30^\circ$
- B** $T = H \sin 30^\circ$
- C** $W = T \cos 30^\circ$
- D** $W = T \sin 30^\circ$

Space for working

- 3 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. It is given by the equation

$$C_d = \frac{2F}{\rho v^n A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n ?

- A 1 B 2 C 3 D 4

- 4 A signal that repeats periodically is displayed on the screen of a cathode-ray oscilloscope.



The screen has 1 cm squares and the time base is set at 2.00 ms cm^{-1} .

What is the frequency of this periodic signal?

- A 50 Hz B 100 Hz C 125 Hz D 200 Hz

Space for working

- 5 A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The micrometer reading is $5.00 \text{ mm} \pm 0.01 \text{ mm}$.

What will be the percentage uncertainty in a calculation of the volume of the sphere, using these values?

- A 0.2% B 0.4% C 0.6% D 1.2%

- 6 One object moves directly from P to R.



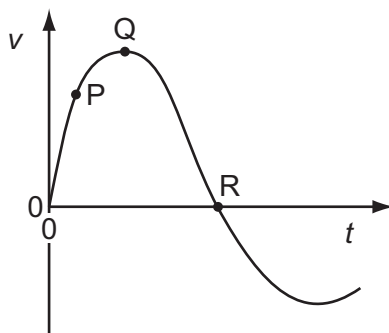
In a shorter time, a second object moves from P to Q to R.

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.

Space for working

- 7 The graph shows how velocity v varies with time t for a bungee jumper.



At which point is the bungee jumper momentarily at rest and at which point does she have zero acceleration?

	jumper at rest	jumper with zero acceleration
A	Q	P
B	Q	R
C	R	Q
D	R	R

- 8 An aeroplane travels at an average speed of 600 km h^{-1} on an outward flight and at 400 km h^{-1} on the return flight over the same distance.

What is the average speed of the whole flight?

- A** 111 ms^{-1} **B** 167 ms^{-1} **C** 480 km h^{-1} **D** 500 km h^{-1}

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

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

Space for working

- 10** An astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

What is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

- A** $1.2mg$ **B** mg **C** $0.8mg$ **D** 0

- 11** A beam of α -particles collides with a lead sheet. Each α -particle in the beam has a mass of $6.6 \times 10^{-27} \text{ kg}$ and a speed of $1.5 \times 10^7 \text{ m s}^{-1}$.

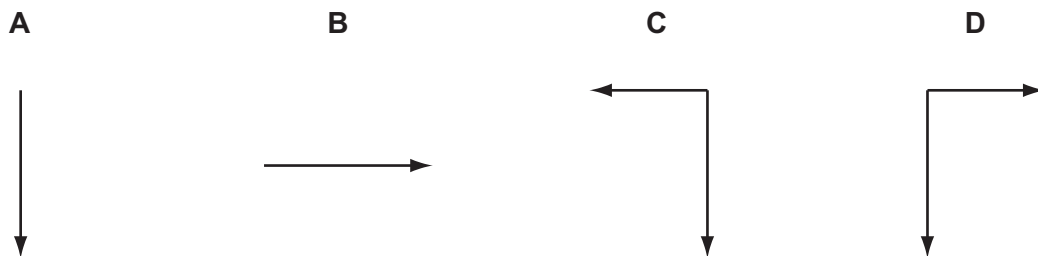
5.0×10^4 α -particles per second collide with an area of 1.0 cm^2 of lead. Almost all of the α -particles are absorbed by the lead so that they have zero speed after collision.

What is an estimate of the average pressure exerted on the lead by the α -particles?

- A** $5.0 \times 10^{-15} \text{ Pa}$
B $5.0 \times 10^{-13} \text{ Pa}$
C $5.0 \times 10^{-11} \text{ Pa}$
D $5.0 \times 10^{-9} \text{ Pa}$

- 12** An object in air is thrown upwards and towards the left.

Which diagram shows the force(s) acting on the body when it is at its highest point?



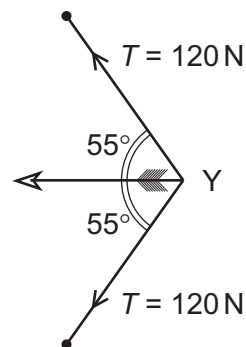
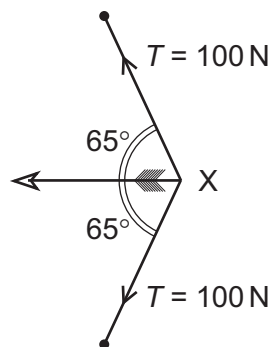
Space for working

- 13** A particle is in a uniform field. The particle experiences a force in the opposite direction to the field.

Which field is the particle in, and on which property of the particle is the field acting?

	field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

- 14** An archer draws his bowstring back to position X. The bowstring and arrow are shown. The tension T in the string is also shown. Then he draws the bowstring back further to position Y.



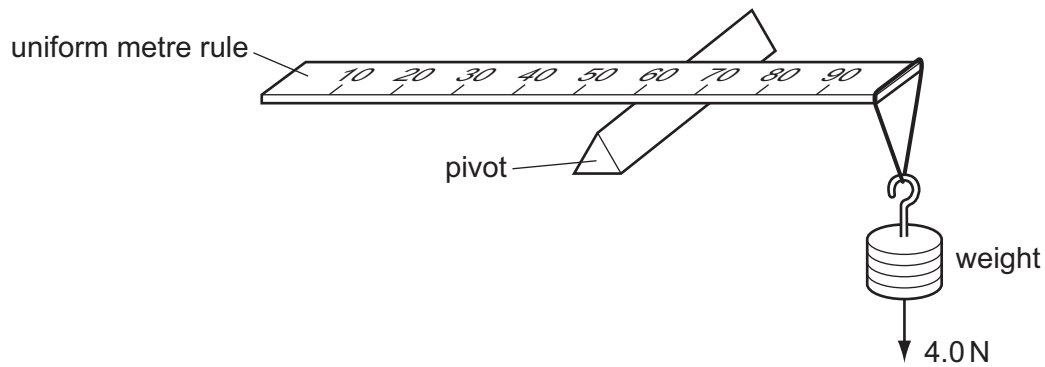
The resultant force on the arrow is greater when the arrow is released from position Y.

What is the increase in force?

- A** 15 N **B** 27 N **C** 40 N **D** 53 N

Space for working

- 15** A uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N weight is suspended from one end, causing the rule to rotate about the pivot.

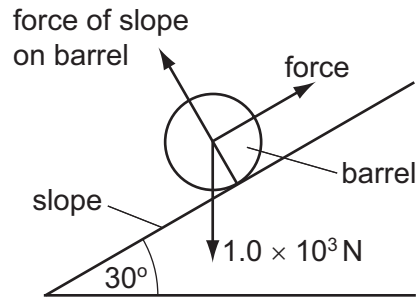


At the instant when the rule is horizontal, what is the resultant turning moment about the pivot?

- A** zero **B** 1.4 Nm **C** 1.6 Nm **D** 1.8 Nm
- 16** What is the internal energy of a system?
- A** the amount of heat supplied to the system
- B** the random energy of the atoms of the system
- C** the total kinetic energy of the system
- D** the total potential energy of the system

Space for working

- 17 The diagram shows a barrel of weight $1.0 \times 10^3 \text{ N}$ on a frictionless slope inclined at 30° to the horizontal.



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

What is the work done in moving the barrel a distance of 5.0 m up the slope?

- A** $2.5 \times 10^3 \text{ J}$ **B** $4.3 \times 10^3 \text{ J}$ **C** $5.0 \times 10^3 \text{ J}$ **D** $1.0 \times 10^4 \text{ J}$
- 18 A car travelling on a level road at a steady 20 m s^{-1} against a constant resistive force develops a power of 40 kW.

What is the magnitude of the resistive force?

- A** 200 N **B** 800 N **C** 2000 N **D** 4000 N
- 19 A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

The overall efficiency of the turbine and generator system is 90%.

What is the output power of the power station? (The density of water is 1000 kg m^{-3} .)

- A** 0.15 MW **B** 1.5 MW **C** 1.7 MW **D** 90 MW

Space for working

20 Below are four short paragraphs describing the molecules in a beaker of water at 50°C.

Which paragraph correctly describes the molecules?

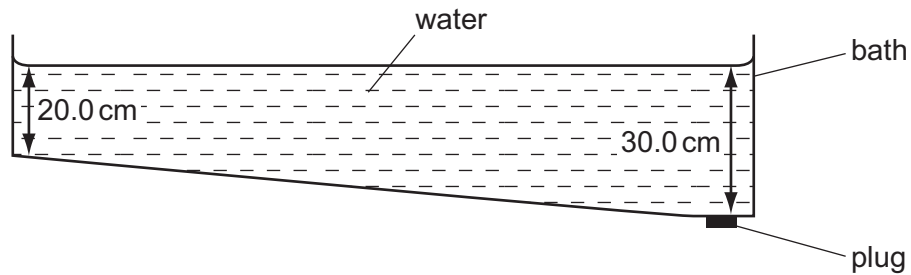
- A** The molecules all travel at the same speed. This speed is not large enough for any of the molecules to leave the surface of the water. There are attractive forces between the molecules.
- B** The molecules have a range of speeds. Some molecules travel sufficiently fast to leave the surface of the water. There are no forces between the molecules.
- C** The molecules have a range of speeds. The fastest molecules are unable to leave the surface of the water. There are attractive forces between the molecules.
- D** The molecules have a range of speeds. Some molecules travel sufficiently fast to leave the surface of the water. There are attractive forces between the molecules.

21 Which two substances are normally both crystalline?

- A** copper and diamond
- B** copper and glass
- C** diamond and glass
- D** diamond and rubber

Space for working

- 22 Water in a bath varies in depth from 20.0 cm at the shallow end to 30.0 cm at the end with the plug.



The density of the water is 1000 kg m^{-3} .

What is the pressure of the water acting on the plug?

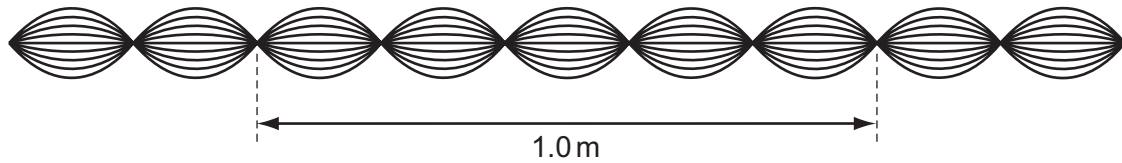
- A** 1960 Pa **B** 2450 Pa **C** 2940 Pa **D** 4900 Pa
- 23 Which properties best describe modelling clay?
- A** brittle and ductile
B ductile and elastic
C elastic and plastic
D plastic and ductile
- 24 A steel spring has a spring constant of 150 N m^{-1} . When a 25 N weight is hung from the spring, it has a stretched length of 55 cm.

What was the original length of the spring?

- A** 0.38 m **B** 0.49 m **C** 0.61 m **D** 0.72 m

Space for working

25 The diagram shows a sketch of a wave pattern, over a short period of time.



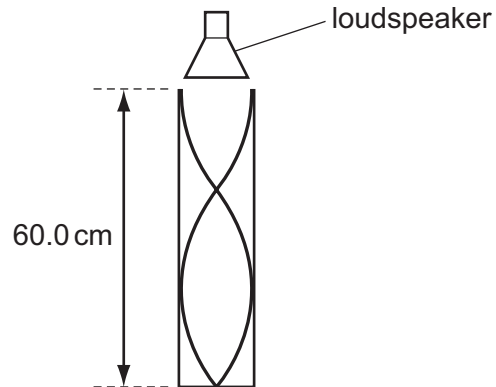
Which description of this wave is correct?

- A The wave is longitudinal, has a wavelength of 20 cm and is stationary.
 - B The wave is transverse, has a wavelength of 20 cm and is stationary.
 - C The wave is transverse, has a wavelength of 40 cm and is progressive.
 - D The wave is transverse, has a wavelength of 40 cm and is stationary.
- 26 Which statement about a light wave and a sound wave is correct?
- A Both can be polarised.
 - B Both can travel through free space.
 - C Both have a frequency inversely proportional to their wavelength.
 - D Both have an intensity proportional to their amplitude.

Space for working

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

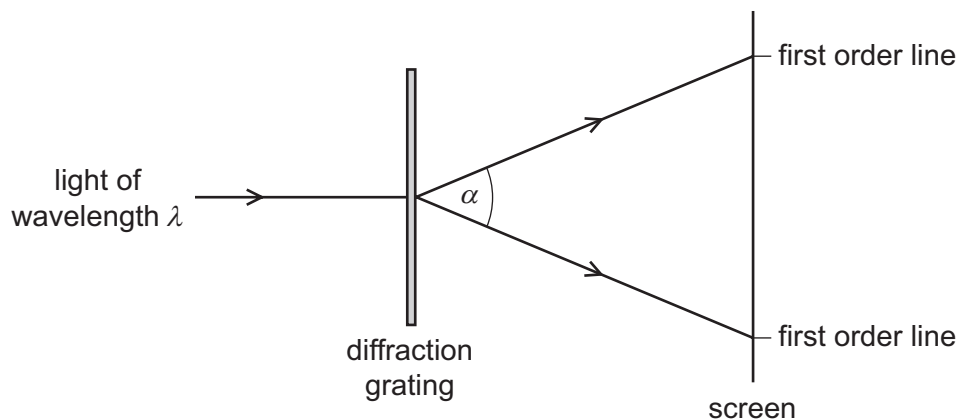
A stationary wave is formed with two nodes and two antinodes as shown.



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

What is the frequency of the sound?

- A** 413 Hz **B** 550 Hz **C** 830 Hz **D** 1650 Hz
- 28 Light of wavelength λ passes through a diffraction grating with slit spacing d . A series of lines is observed on a screen.

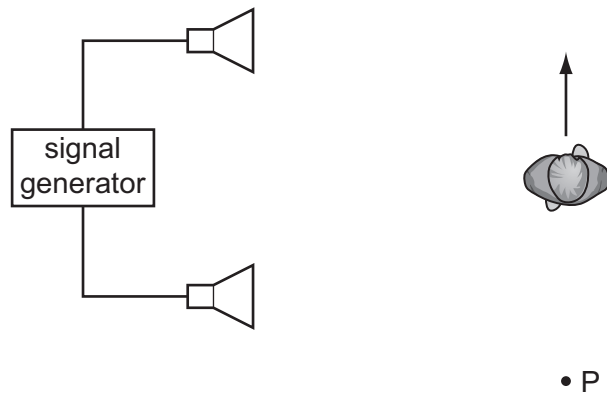


What is the angle α between the two first order lines?

- A** $\sin^{-1}\left(\frac{\lambda}{2d}\right)$ **B** $\sin^{-1}\left(\frac{\lambda}{d}\right)$ **C** $2\sin^{-1}\left(\frac{\lambda}{2d}\right)$ **D** $2\sin^{-1}\left(\frac{\lambda}{d}\right)$

Space for working

29 A student connects two loudspeakers to a signal generator.



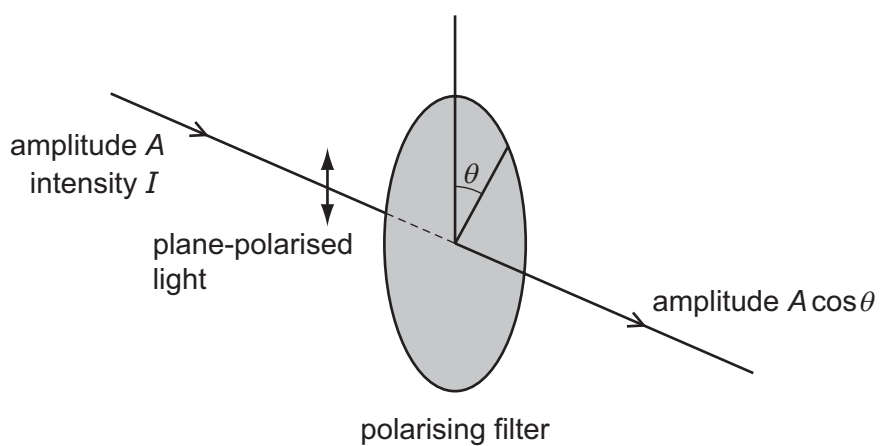
As the student walks from P to Q, he notices that the loudness of the sound rises and falls repeatedly.

What causes the loudness of the sound to vary?

- A diffraction of the sound waves
- B interference of the sound waves
- C polarisation of the sound waves
- D reflection of the sound waves

Space for working

- 30 When plane-polarised light of amplitude A is passed through a polarising filter as shown, the amplitude of the light emerging is $A \cos \theta$.



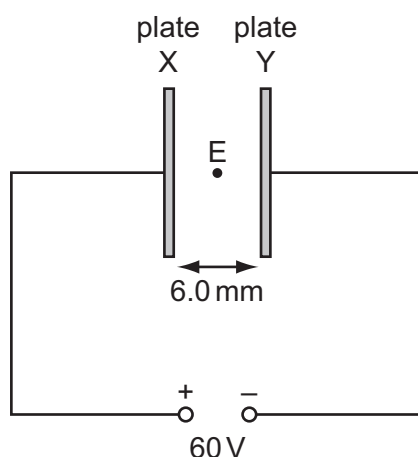
The intensity of the initial beam is I .

What is the intensity of the emerging light when θ is 60.0° ?

- A** $0.250 I$ **B** $0.500 I$ **C** $0.750 I$ **D** $0.866 I$

Space for working

- 31 Two vertical conducting plates X and Y are positioned so that they are separated by a distance of 6.0 mm in air. A 60 V d.c. supply is connected as shown.



What is the electric field strength at E, a point midway between the plates?

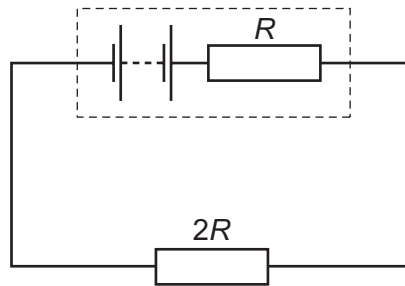
- A** $1.0 \times 10^4 \text{ V m}^{-1}$ towards X
B $1.0 \times 10^4 \text{ V m}^{-1}$ towards Y
C $2.0 \times 10^4 \text{ V m}^{-1}$ towards X
D $2.0 \times 10^4 \text{ V m}^{-1}$ towards Y
- 32 Two parallel metal plates have a potential difference between them of 12 V. The distance between the plates is 1.0 mm.

What are the electric field strength between the plates and the work done on a charge of $+3.9 \mu\text{C}$ to move the charge from the negative plate to the positive plate?

	electric field strength / N C^{-1}	work done / J
A	12	4.7×10^{-5}
B	12	47
C	12 000	4.7×10^{-5}
D	12 000	47

Space for working

- 33 The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R .



What is the ratio $\frac{\text{power in external resistor}}{\text{power in internal resistance}}$?

- A** $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4
- 34 Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

- A** Both lamps light at less than their normal brightness.
B Both lamps light normally.
C Only the 60 W lamp lights.
D The 10 V lamp blows.

Space for working

- 35 The wire of a heating element has resistance R . The wire breaks and is replaced by a different wire.

Data for the original wire and the replacement wire are shown in the table.

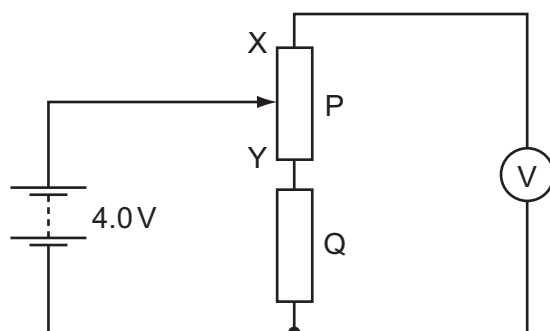
	length	diameter	resistivity of metal
original wire	l	d	ρ
replacement wire	l	$2d$	2ρ

What is the resistance of the replacement wire?

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

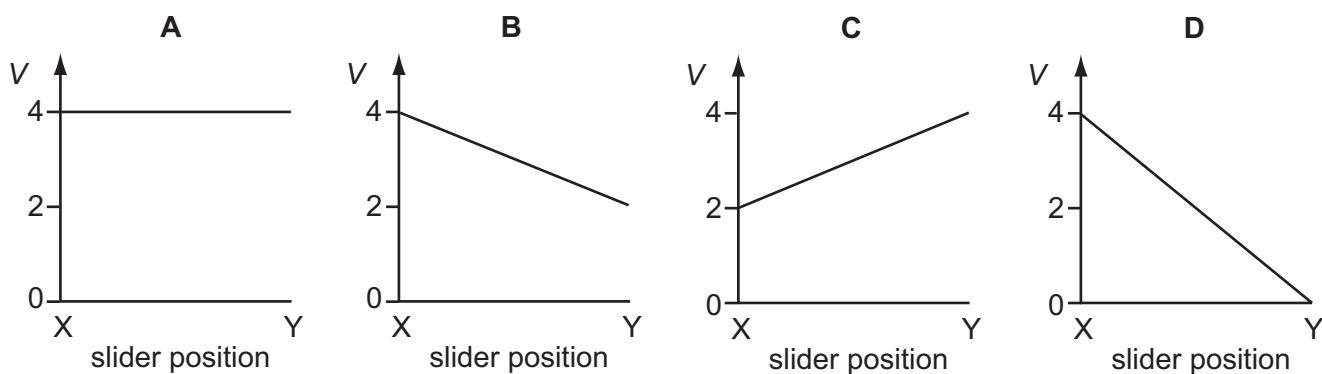
Space for working

- 36 In the circuit below, P is a potentiometer of total resistance 10Ω and Q is a fixed resistor of resistance 10Ω . The battery has an electromotive force (e.m.f.) of 4.0V and negligible internal resistance. The voltmeter has a very high resistance.



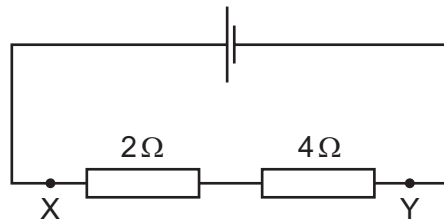
The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading V is plotted against slider position.

Which graph would be obtained?

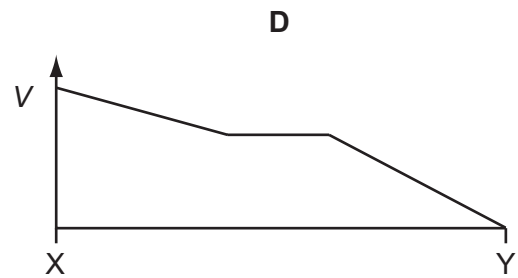
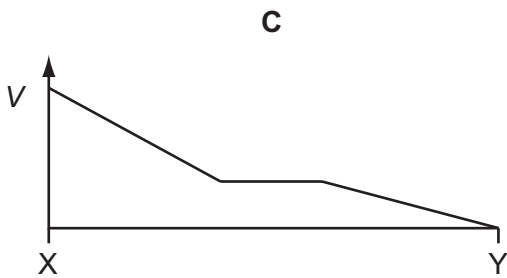
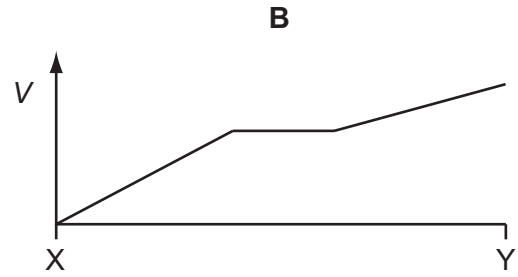
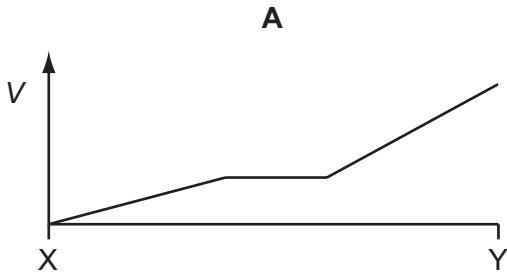


Space for working

37 A 2Ω resistor and a 4Ω resistor are connected to a cell.



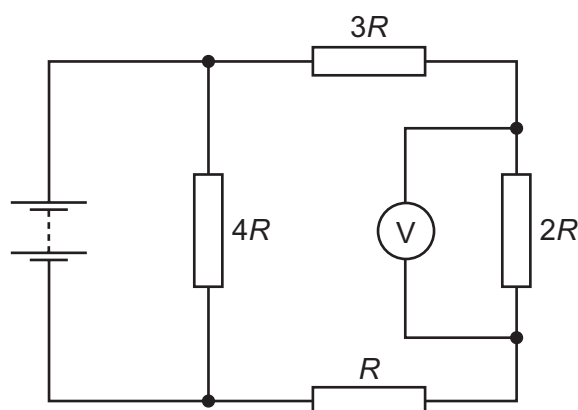
Which graph shows how the potential V varies with distance between X and Y?



Space for working

- 38 Four resistors of resistance R , $2R$, $3R$ and $4R$ are connected to form a network.

A battery of negligible internal resistance and a voltmeter are connected to the resistor network as shown.



The voltmeter reading is 2 V .

What is the electromotive force (e.m.f.) of the battery?

- A 2 V B 4 V C 6 V D 10 V
- 39 When α -particles are fired at a thin metal foil, most of the particles pass straight through but a few are deflected by a large angle.

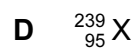
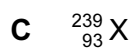
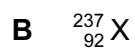
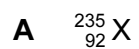
Which change would increase the **proportion** of α -particles deflected by a large angle?

- A using α -particles with greater kinetic energy
 B using a foil made of a metal with fewer protons in its nuclei
 C using a double thickness foil
 D using an alpha source with a higher activity

Space for working

40 Plutonium-239 ($^{239}_{94}\text{Pu}$) decays by emitting α -radiation.

Which nuclide is formed from one of these decay reactions? (The product nuclides are represented by X.)



Space for working



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2013

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)



READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO NOT WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any working should be done in this booklet.

Electronic calculators may be used.

This document consists of **23** printed pages and **1** blank page.



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 constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
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.,

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{(x_0^2 - x^2)}$$

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,

$$W = \frac{1}{2}QV$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

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 Which estimate is realistic?

- A The kinetic energy of a bus travelling on an expressway is 30 000 J.
- B The power of a domestic light is 300 W.
- C The temperature of a hot oven is 300 K.
- D The volume of air in a car tyre is 0.03 m^3 .

2 Which unit is equivalent to the coulomb?

- A ampere per second
- B joule per volt
- C watt per ampere
- D watt per volt

3 Two forces of equal magnitude are represented by two coplanar vectors. One is directed eastwards and the other is directed northwards.

What is the direction of a single force that will balance these two forces?

- A towards the north-east
- B towards the north-west
- C towards the south-east
- D towards the south-west

Space for working

- 4 The spring constant k of a coiled wire spring is given by the equation

$$k = \frac{Gr^4}{4nR^3}$$

where r is the radius of the wire, n is the number of turns of wire and R is the radius of each of the turns of wire. The quantity G depends on the material from which the wire is made.

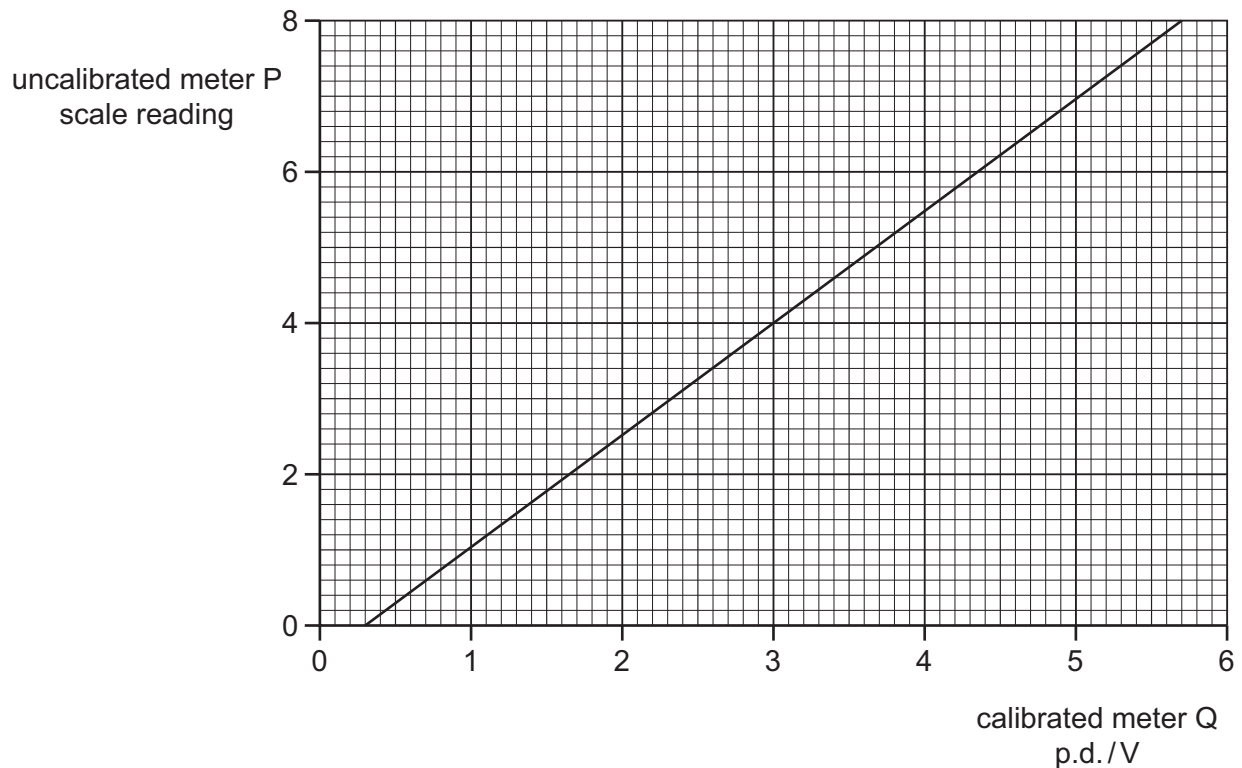
What is a suitable unit for G ?

- A** Nm^{-2} **B** Nm^{-1} **C** Nm **D** Nm^2

Space for working

- 5 An uncalibrated analogue voltmeter P is connected in parallel with another voltmeter Q which is known to be accurately calibrated. For a range of values of potential difference (p.d.), readings are taken from the two meters.

The diagram shows the calibration graph obtained.



The graph shows that meter P has a zero error. This meter is now adjusted to remove this zero error. When the meter is recalibrated, the gradient of the calibration graph is found to be unchanged.

What is the new scale reading on meter P when it is used to measure a p.d. of 5.0 V?

- A** 6.6 **B** 6.7 **C** 7.2 **D** 7.4

Space for working

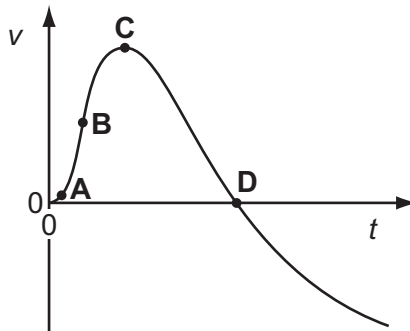
- 6 A student wishes to determine the density ρ of lead. She measures the mass and diameter of a small sphere of lead:

$$\text{mass} = (0.506 \pm 0.005) \text{ g}$$

$$\text{diameter} = (2.20 \pm 0.02) \text{ mm}.$$

What is the best estimate of the percentage uncertainty in her value of ρ ?

- A** 1.9% **B** 2.0% **C** 2.8% **D** 3.7%
- 7 The graph shows how the velocity v of a firework rocket changes with time t .
At which point on the graph does the rocket have the greatest acceleration?



- 8 On a particular railway, a train driver applies the brake of the train at a yellow signal, a distance of 1.0 km from a red signal, where the train stops.

The maximum deceleration of the train is 0.20 m s^{-2} .

Assuming uniform deceleration, what is the maximum safe speed of the train at the yellow signal?

- A** 14 m s^{-1} **B** 20 m s^{-1} **C** 40 m s^{-1} **D** 400 m s^{-1}

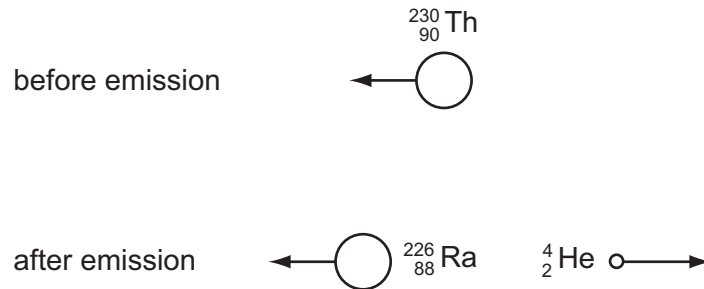
Space for working

- 9 A person, travelling on a motorway a total distance of 200 km, travels the first 90 km at an average speed of 80 km h^{-1} .

Which average speed must be obtained for the rest of the journey if the person is to reach the destination in a total time of 2 hours 0 minutes?

- A 110 km h^{-1} B 120 km h^{-1} C 122 km h^{-1} D 126 km h^{-1}

- 10 A moving thorium nucleus ${}_{90}^{230}\text{Th}$ spontaneously emits an α -particle. The nucleus formed is a radium nucleus ${}_{88}^{226}\text{Ra}$, as shown.



Which statement is correct?

- A The kinetic energy of the α -particle equals the kinetic energy of the radium nucleus.
 B The momentum of the α -particle equals the momentum of the radium nucleus.
 C The total momentum before the emission equals the total momentum after the emission.
 D The velocity of the α -particle equals the velocity of the radium nucleus.

Space for working

- 11** An isolated system consists of two bodies on which no external forces act. The two bodies collide with each other and stick together on impact.

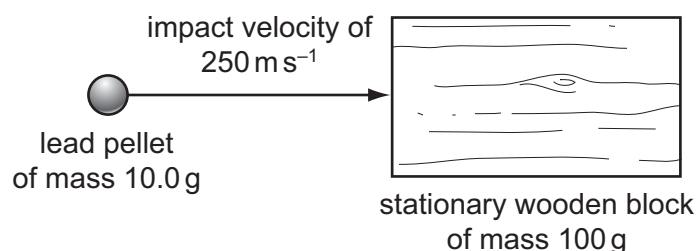
Which row correctly compares the total kinetic energy and the total momentum of the bodies before and after the collision?

	total kinetic energy before and after the collision	total momentum before and after the collision
A	different	different
B	different	the same
C	the same	different
D	the same	the same

- 12** A mass accelerates uniformly when the resultant force acting on it

- A** is zero.
- B** is constant but not zero.
- C** increases uniformly with respect to time.
- D** is proportional to the displacement from a fixed point.

- 13** A lead pellet of mass 10.0 g is shot horizontally into a stationary wooden block of mass 100 g. The pellet hits the block with an impact velocity of 250 m s^{-1} . It embeds itself in the block and it does not emerge.



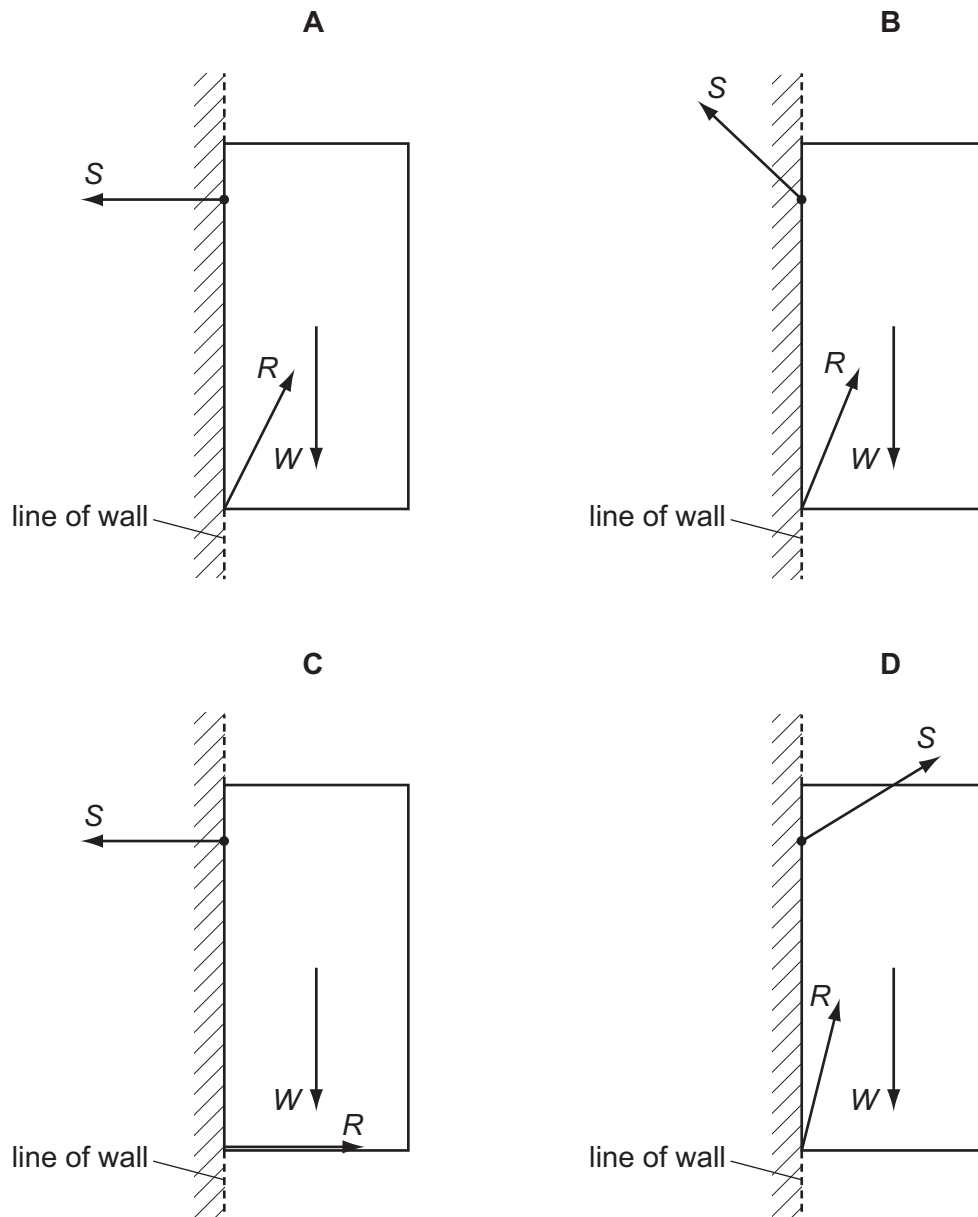
What will be the speed of the block immediately after the pellet is embedded?

- A** 23 m s^{-1} **B** 25 m s^{-1} **C** 75 m s^{-1} **D** 79 m s^{-1}

Space for working

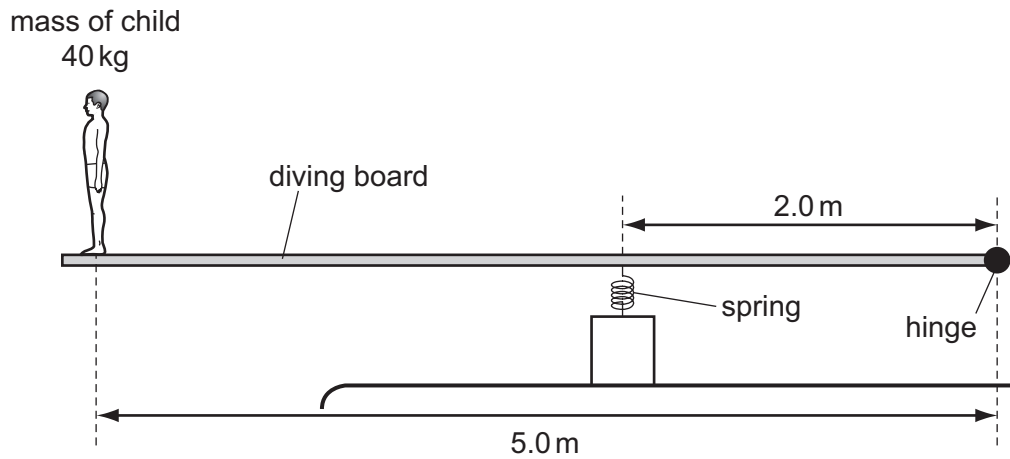
14 A cupboard is attached to a wall by a screw.

Which force diagram shows the cupboard in equilibrium, with the weight W of the cupboard, the force S that the screw exerts on the cupboard and the force R that the wall exerts on the cupboard?



Space for working

- 15 A diving board of length 5.0 m is hinged at one end and supported 2.0 m from this end by a spring of spring constant 10 kN m^{-1} . A child of mass 40 kg stands at the far end of the board.



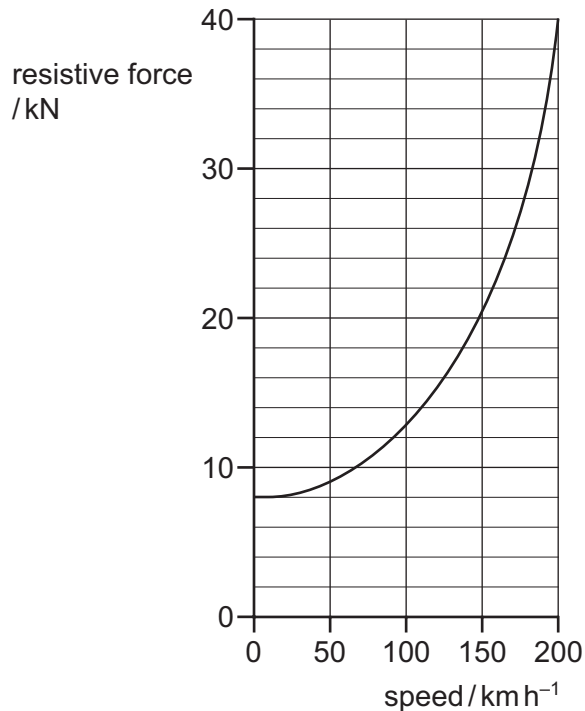
What is the extra compression of the spring caused by the child standing on the end of the board?

- A 1.0 cm B 1.6 cm C 9.8 cm D 16 cm

Space for working

- 16 The graph shows how the total resistive force acting on a train varies with its speed.

Part of this force is due to wheel friction, which is constant. The rest is due to wind resistance.



What is the ratio $\frac{\text{wind resistance}}{\text{wheel friction}}$ at a speed of 200 km h⁻¹?

- A** 4 **B** 5 **C** 8 **D** 10

- 17 The pump of a water pumping system uses 2.0 kW of electrical power when raising water. The pumping system lifts 16 kg of water per second through a vertical height of 7.0 m.

What is the efficiency of the pumping system?

- A** 1.8% **B** 5.6% **C** 22% **D** 55%

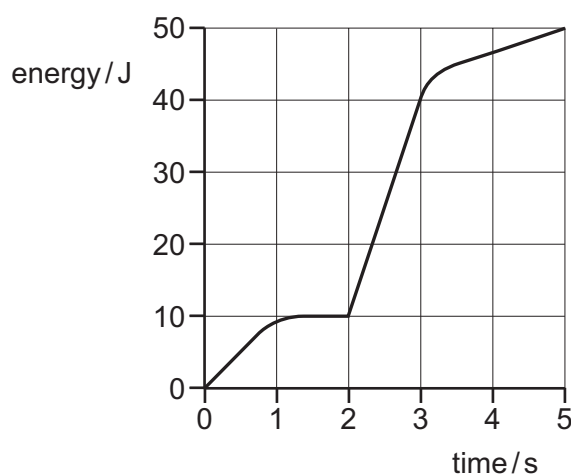
- 18 A body travelling with a speed of 20 m s⁻¹ has kinetic energy E_k .

If the speed of the body is increased to 80 m s⁻¹, what is its new kinetic energy?

- A** $4E_k$ **B** $8E_k$ **C** $12E_k$ **D** $16E_k$

Space for working

- 19 An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph.



What is the maximum electrical power generated at any instant during these first 5 seconds?

- A** 10 W **B** 13 W **C** 30 W **D** 50 W
- 20 Gold has a density of 19.3 g cm^{-3} .

The volume occupied by a single atom of gold may be considered to be a cube with sides of length $2.6 \times 10^{-8} \text{ cm}$.

What is the mass of a gold atom?

- A** $3.4 \times 10^{-25} \text{ g}$
B $3.4 \times 10^{-22} \text{ g}$
C $1.3 \times 10^{-17} \text{ g}$
D $1.3 \times 10^{-14} \text{ g}$

Space for working

- 21** In an experiment to demonstrate Brownian motion, a transparent container is filled with smoke particles suspended in air.

What can be seen when the contents of the container are strongly illuminated and viewed through a microscope?

- A** molecules in random motion
- B** molecules vibrating regularly
- C** smoke particles in random motion
- D** smoke particles vibrating regularly

- 22** A lift is supported by two steel cables each of length 20 m.

Each of the cables consists of 100 parallel steel wires, each wire of cross-sectional area $3.2 \times 10^{-6} \text{ m}^2$. The Young modulus of steel is $2.1 \times 10^{11} \text{ N m}^{-2}$.

Which distance does the lift move downward when a man of mass 70 kg steps into it?

- A** 0.010 mm **B** 0.020 mm **C** 0.10 mm **D** 0.20 mm

- 23** What is equal to the Young modulus of a material that is extended elastically within the limit of proportionality?

- A** area under the force-extension graph
- B** area under the stress-strain graph
- C** gradient of the force-extension graph
- D** gradient of the stress-strain graph

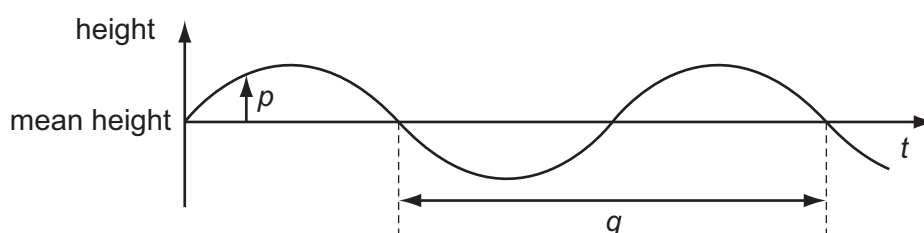
Space for working

- 24 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m.

Which type of wave are they most likely to be?

- A radio waves
- B microwaves
- C infra-red waves
- D ultraviolet waves

- 25 The graph shows how the height of the water surface at a point in a harbour varies with time t as waves pass the point.



What are p and q ?

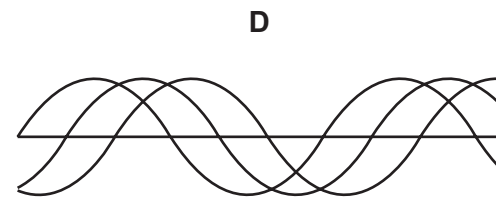
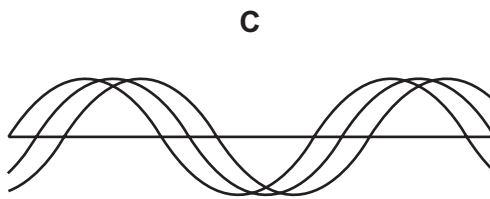
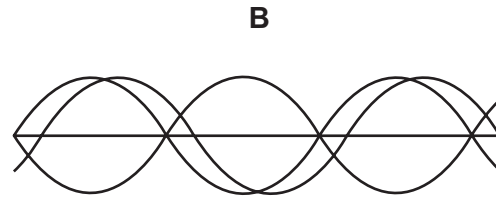
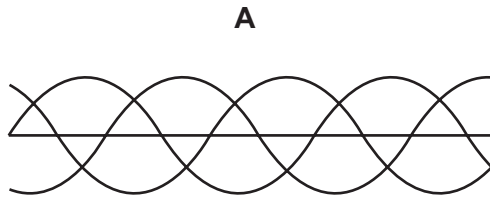
	p	q
A	displacement	period
B	displacement	wavelength
C	amplitude	period
D	amplitude	wavelength

Space for working

- 26** The three waves shown in each diagram have the same amplitude and frequency but differ in phase.

They are added together to give a resultant wave.

In which case is the resultant wave zero?



- 27** A stationary sound wave has a series of nodes. The distance between the first and the sixth node is 30.0 cm.

What is the wavelength of the sound wave?

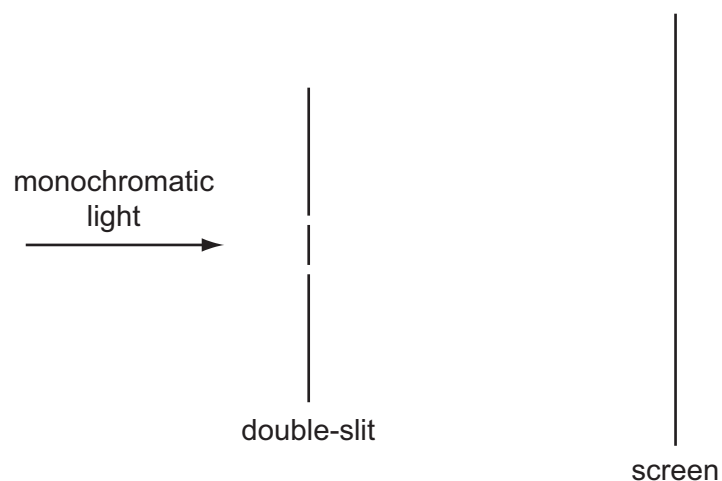
- A** 5.0 cm **B** 6.0 cm **C** 10.0 cm **D** 12.0 cm

- 28** What is meant by diffraction?

- A** Addition of two coherent waves to produce a stationary wave pattern.
B Bending of waves round an obstacle.
C Change of direction when waves cross the boundary between one medium and another.
D Splitting of white light into colours.

Space for working

- 29 A student sets up apparatus to observe the double-slit interference of monochromatic light, as shown.



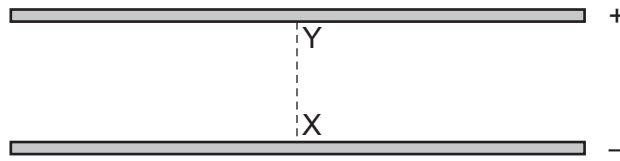
Interference fringes are formed on the screen.

Which change would increase the distance between adjacent fringes?

- A Decrease the distance between the two slits.
- B Decrease the width of each slit.
- C Move the screen closer to the double-slit.
- D Use light of a higher frequency.

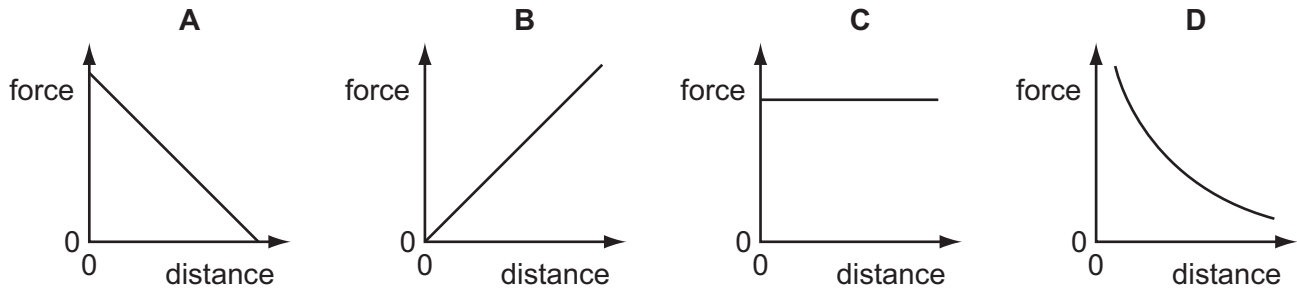
Space for working

- 30 Two charged parallel metal plates produce an electric field.



A charged particle moves from X to Y.

Which graph shows the variation of the force on the particle with distance from X along the line XY?



- 31 A small charge q is placed in the electric field of a large charge Q .

Both charges experience a force F .

What is the electric field strength of the charge Q at the position of the charge q ?

- A $\frac{F}{Qq}$ B $\frac{F}{Q}$ C FqQ D $\frac{F}{q}$

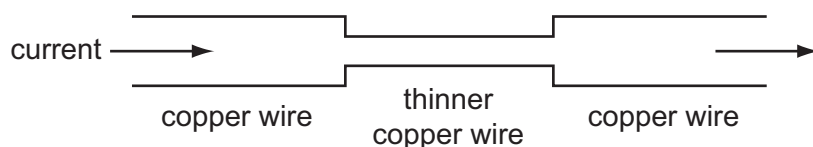
- 32 The current in a component is reduced uniformly from 100 mA to 20 mA over a period of 8.0 s.

What is the charge that flows during this time?

- A 160 mC B 320 mC C 480 mC D 640 mC

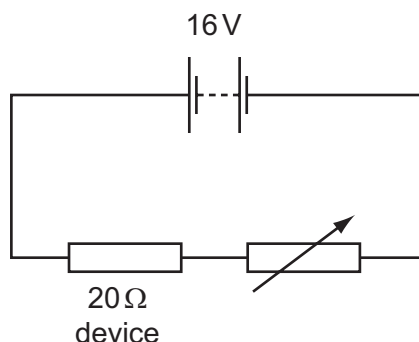
Space for working

- 33 An electric current is passed from a thick copper wire through a section of thinner copper wire before entering a second thick copper wire as shown.



Which statement about the current and the speed of electrons in the wires is correct?

- A The current and the speed of the electrons in the thinner wire are both less than in the thicker copper wires.
 - B The current and the speed of the electrons is the same in all the wires.
 - C The current is the same in all the wires but the speed of the electrons in the thinner wire is greater than in the thicker wires.
 - D The current is the same in all the wires but the speed of the electrons in the thinner wire is less than in the thicker wire.
- 34 An electrical device of fixed resistance 20Ω is connected in series with a variable resistor and a battery of electromotive force (e.m.f.) 16 V and negligible internal resistance.



What is the resistance of the variable resistor when the power dissipated in the electrical device is 4.0 W ?

- A 16Ω
- B 36Ω
- C 44Ω
- D 60Ω

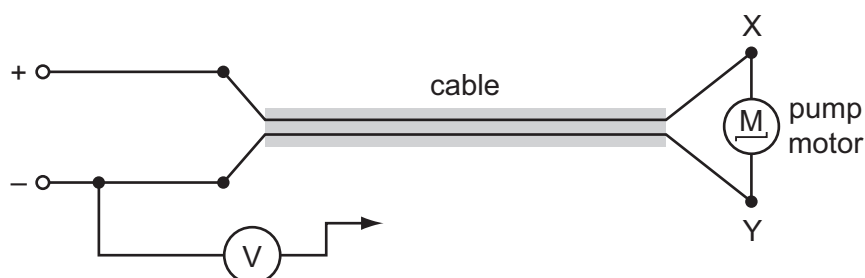
Space for working

- 35 A copper wire is cylindrical and has resistance R .

What will be the resistance of a copper wire of twice the length and twice the radius?

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

- 36 The diagram shows the electric motor for a garden pump connected to a 24 V power supply by an insulated two-core cable.



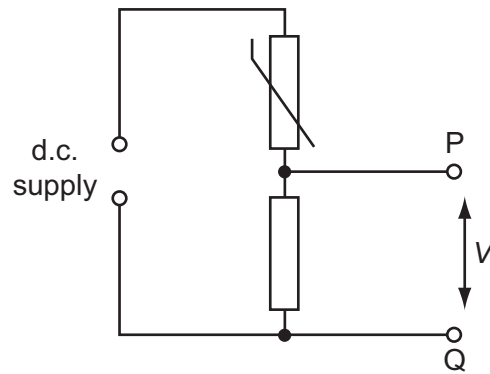
The motor does not work so, to find the fault, the negative terminal of a voltmeter is connected to the negative terminal of the power supply and its other end is connected in turn to terminals X and Y at the motor.

Which row represents two readings and a correct conclusion?

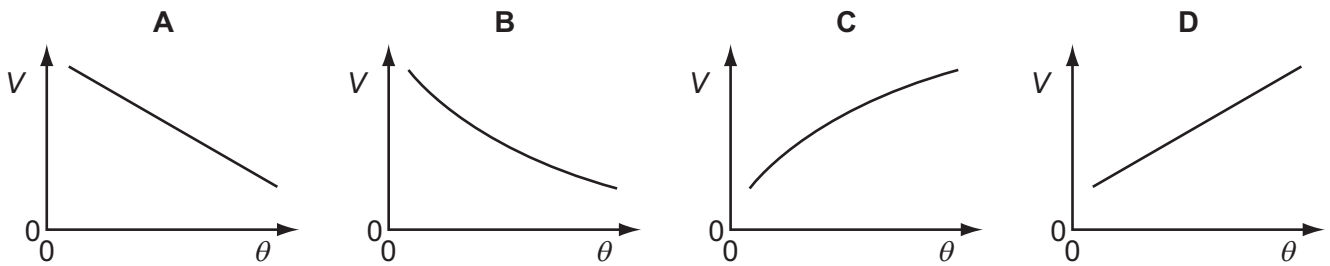
	voltmeter reading when connected to X/V	voltmeter reading when connected to Y/V	conclusion
A	24	0	break in positive wire of cable
B	24	12	break in negative wire of cable
C	24	24	break in connection within the motor
D	24	24	break in negative wire of cable

Space for working

37 In the circuit shown, the resistance of the thermistor decreases as temperature increases.

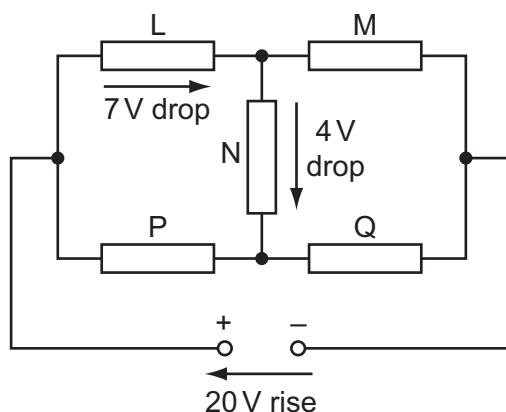


Which graph shows the variation with Celsius temperature θ of potential difference V between points P and Q?



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- 38 A 20 V d.c. supply is connected to a circuit consisting of five resistors L, M, N, P and Q.

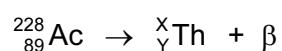


There is a potential drop of 7 V across L and a further 4 V potential drop across N.

What are the potential drops across M, P and Q?

	potential drop across M/V	potential drop across P/V	potential drop across Q/V
A	9	7	13
B	13	7	13
C	13	11	9
D	17	3	17

- 39 A nucleus of the nuclide ${}^{228}_{89}\text{Ac}$ decays by emitting a beta particle. The nuclear equation below represents this decay.



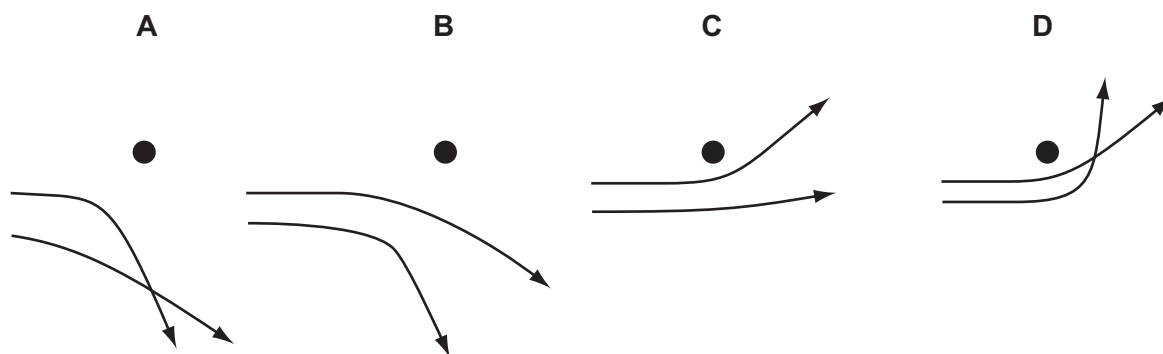
Which pair of values of X and Y is correct?

	X	Y
A	224	87
B	224	89
C	228	88
D	228	90

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40 Two α -particles with equal energies are deflected by a large nucleus.

Which diagram best represents their paths?



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