

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2018

1 hour 15 minutes

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, 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 **21** printed pages and **3** blank 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 The radius of the Earth is approximately 6.4×10^6 m, and the radius of the Moon is approximately 1.7×10^6 m. A student wishes to build a scale model of the Solar System in the classroom, using a football of radius 0.12 m to represent the Earth.

Which object would best represent the Moon?

- A basketball
- B cherry
- C golf ball
- D tennis ball

- 2 When a beam of light is incident on a surface, it delivers energy to the surface. The intensity of the beam is defined as the energy delivered per unit area per unit time.

What is the unit of intensity, expressed in SI base units?

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

- 3 A ship is travelling with a velocity of 8.0 km h^{-1} in a direction 30° east of north.

What are the components of the ship's velocity in the east and north directions?

	component of velocity in east direction / km h^{-1}	component of velocity in north direction / km h^{-1}
A	4.0	4.0
B	4.0	6.9
C	4.6	6.9
D	6.9	4.0

- 4 A micrometer screw gauge is used to measure the diameter of a copper wire.

The reading with the wire in position is shown in diagram 1. The wire is removed and the jaws of the micrometer are closed. The new reading is shown in diagram 2.

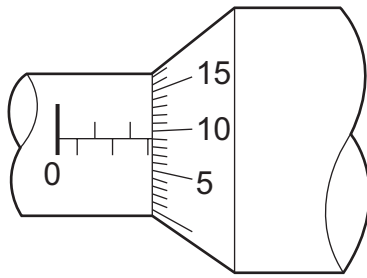


diagram 1

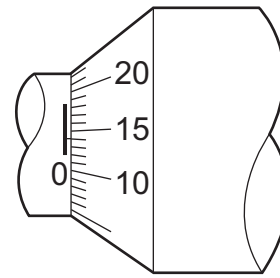


diagram 2

What is the diameter of the wire?

- A** 1.90 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

- 5 A digital meter has an accuracy of $\pm 1\%$.

The meter is used to measure the current in an electrical circuit.

The reading on the meter varies between 3.04 A and 3.08 A.

What is the value of the current, with its uncertainty?

- A** $(3.06 \pm 0.02) \text{ A}$
B $(3.06 \pm 0.04) \text{ A}$
C $(3.06 \pm 0.05) \text{ A}$
D $(3.06 \pm 0.07) \text{ A}$

- 6 A tennis ball is thrown horizontally in air from the top of a tall building.

The effect of air resistance is **not** negligible.

What happens to the horizontal and to the vertical components of the ball's velocity?

	horizontal component of velocity	vertical component of velocity
A	constant	constant
B	constant	increases at a constant rate
C	decreases to zero	increases at a constant rate
D	decreases to zero	increases to a maximum value

- 7 Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of 20 m s^{-1} .

What is the minimum force required from a person holding the hose-pipe to prevent it moving backwards?

- A** 30 N **B** 270 N **C** 1800 N **D** 108 000 N

- 8 A ball of mass m is thrown vertically into the air. When the ball has speed v , the air resistance acting on the ball is F .

What is the magnitude of the acceleration of the ball when its speed is v as it rises and as it falls?

	acceleration when ball is rising	acceleration when ball is falling
A	$g - \frac{F}{m}$	$g - \frac{F}{m}$
B	$g - \frac{F}{m}$	$g + \frac{F}{m}$
C	$g + \frac{F}{m}$	$g - \frac{F}{m}$
D	$g + \frac{F}{m}$	$g + \frac{F}{m}$

- 9 What is a statement of the principle of conservation of momentum?

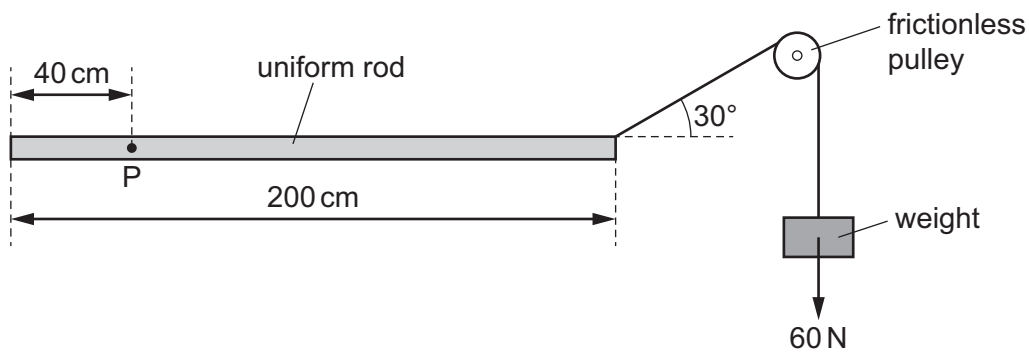
- A** A force is equal to the rate of change of momentum of the body upon which it acts.
- B** In a perfectly elastic collision, the relative momentum of the bodies before impact is equal to their relative momentum after impact.
- C** The momentum of a body is the product of the mass of the body and its velocity.
- D** The total momentum of a system of interacting bodies remains constant, providing no resultant external force acts on the system.

- 10** 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

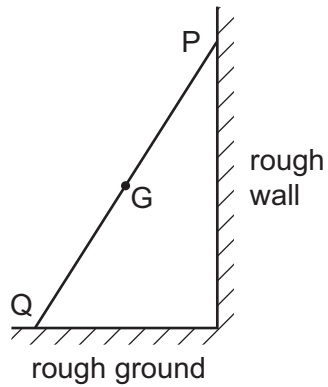
- 11** A uniform rod of length 200 cm is freely pivoted at point P. The rod is held horizontally in equilibrium by a 60 N weight that is attached to the rod by a string passing over a frictionless pulley.



What is the weight of the rod?

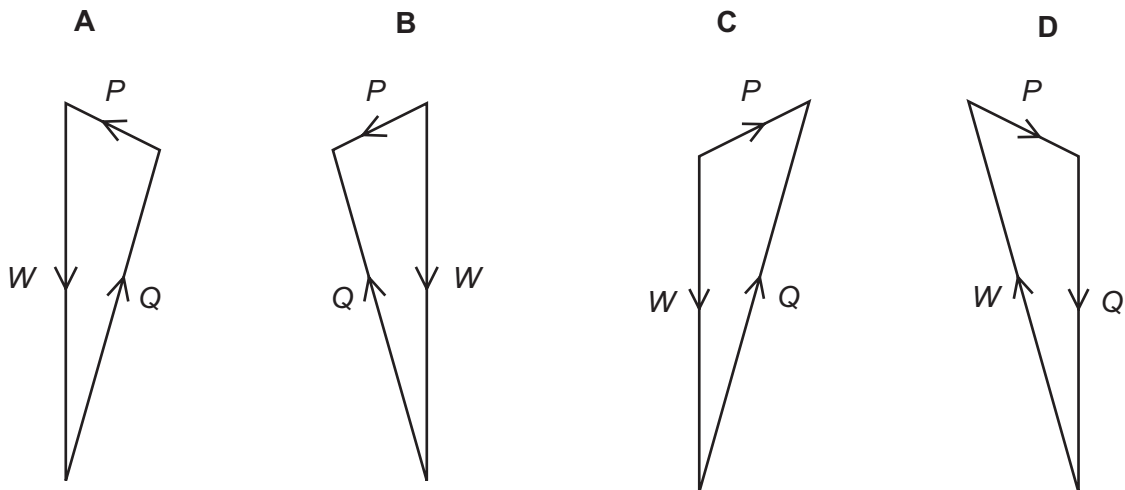
- A** 30 N **B** 60 N **C** 80 N **D** 140 N

12 A ladder rests in equilibrium on rough ground against a rough wall.

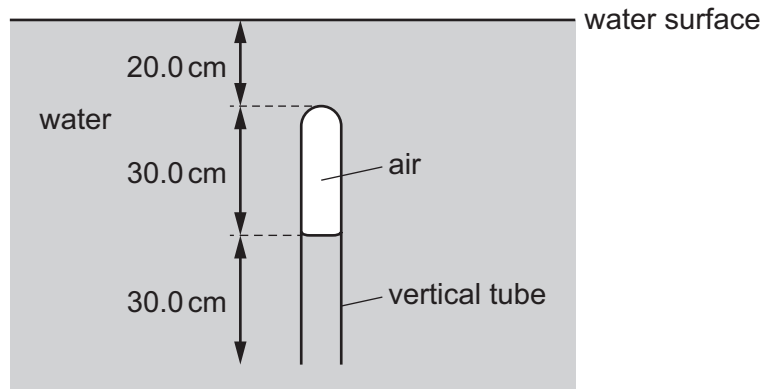


The weight W of the ladder acts through the centre of gravity G . Forces also act on the ladder at P and at Q . These forces are P and Q respectively.

Which vector triangle represents the forces on the ladder?



- 13** A vertical tube, closed at one end, is immersed in water. A column of air is trapped inside the tube.



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

What is the difference between the pressure of the air in the tube and the atmospheric pressure?

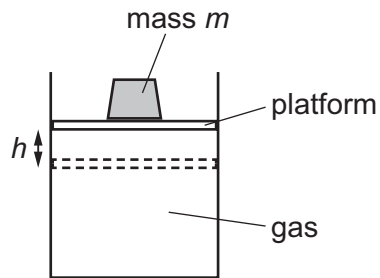
- A** 1960 Pa **B** 2940 Pa **C** 4910 Pa **D** 7850 Pa

- 14** 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

- 15 A mass m is on top of a platform that is supported by gas in a cylinder of cross-sectional area A , as shown.



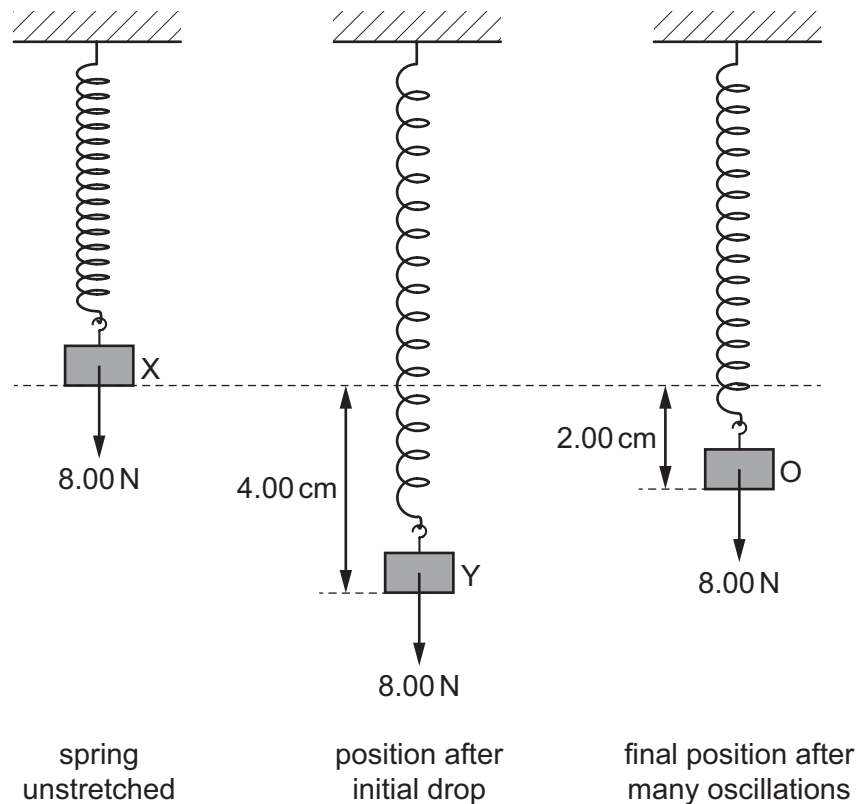
The platform has negligible mass and can move freely up and down.

The gas is heated and expands so that the mass is raised through a height h . Atmospheric pressure is p .

What is the ratio $\frac{\text{gain in gravitational potential energy of the mass}}{\text{work done by the gas}}$?

- A** $\frac{mg}{pA}$
 B $\frac{mg}{mg + pA}$
 C $\frac{pA}{mg}$
 D $\frac{mg - pA}{mg}$

- 16** An 8.00 N weight is attached to the lower end of a spring which is fixed at its upper end. The weight is initially held at rest at position X and the spring is unstretched. The weight is then released and falls to position Y, which is 4.00 cm below X. The weight oscillates and then eventually comes to rest at O, which is 2.00 cm below X.

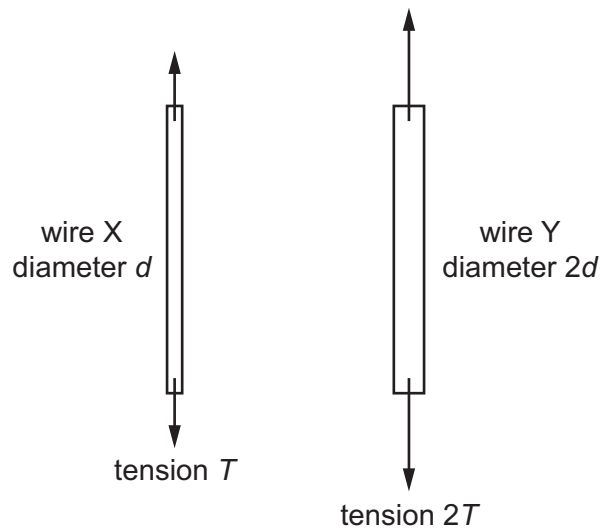


How much energy is lost from the system?

- A** 0.04 J **B** 0.08 J **C** 0.16 J **D** 0.32 J
- 17** The force resisting the motion of a car is proportional to the square of the car's speed. The magnitude of the force at a speed of 20.0 ms^{-1} is 800 N.
- What useful output power is required from the car's engine to maintain a steady speed of 40.0 ms^{-1} ?

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

- 18 Two wires X and Y are made from the same material. Wire Y has twice the diameter and experiences twice the tension of wire X. The wires obey Hooke's law and have the same original length.

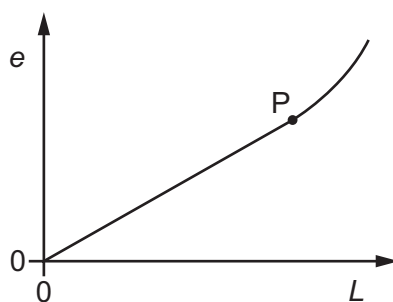


Wire X has extension e .

What is the extension of wire Y?

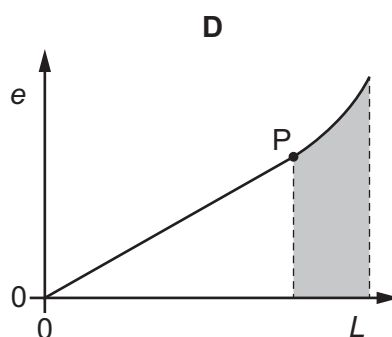
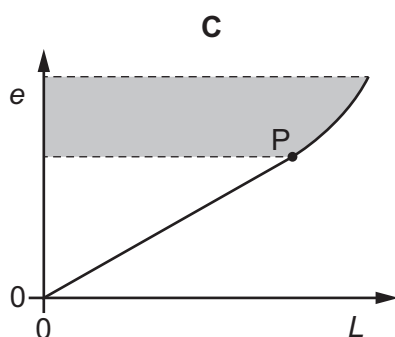
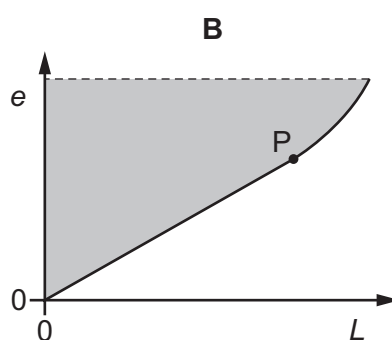
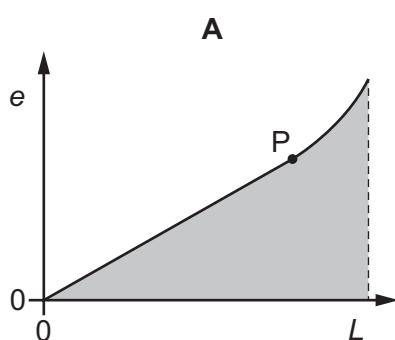
- A $\frac{e}{4}$ B $\frac{e}{2}$ C e D $2e$
- 19 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis) for a wire obeying Hooke's law?
- A elastic limit
B spring constant
C stress
D Young modulus

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

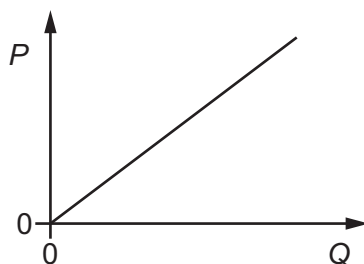


The point P is the elastic limit.

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



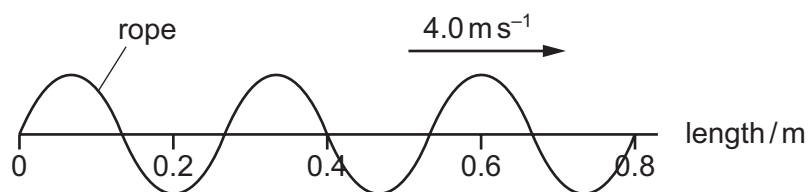
- 21 The graph shows the variation of a quantity P with a quantity Q for a sound wave travelling in air.



What could P and Q be?

	P	Q
A	amplitude	intensity
B	frequency	wavelength
C	speed	frequency
D	wavelength	period

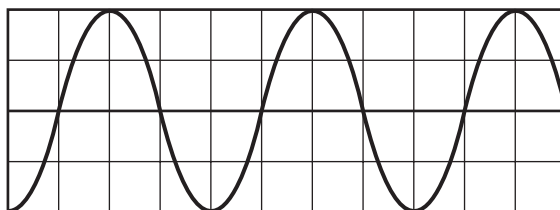
- 22 A vibration generator produces a progressive wave on a rope. The diagram shows the rope at one instant. The wave travels at a speed of 4.0 m s^{-1} .



What are the wavelength and the frequency of the wave?

	wavelength /m	frequency /Hz
A	0.13	15
B	0.13	30
C	0.27	15
D	0.27	30

- 23 The diagram shows the waveform of a signal displayed on a cathode-ray oscilloscope.



The time-base is set at 5.0 ms per division.

The Y-gain is set at 5.0 mV per division.

What are the amplitude and the frequency of the signal?

	amplitude / mV	frequency / Hz
A	10	50
B	10	100
C	20	50
D	20	100

- 24 A jet aircraft travels at a speed of $0.8v$ where v is the speed of sound. The aircraft approaches a stationary observer. The frequency of sound emitted by the aircraft is 100 Hz.

Which frequency does the observer hear?

- A** 56 Hz **B** 180 Hz **C** 400 Hz **D** 500 Hz

- 25 A telescope detects and analyses some electromagnetic radiation of wavelength 2 cm.

Which type of telescope is it?

- A** microwave telescope
B optical telescope
C radio telescope
D X-ray telescope

- 26 What may be used to produce stationary waves?

- A** blowing air over the top of an empty bottle
B making a loud sound near a mountain
C passing monochromatic light through a double slit
D passing water waves through a narrow slit

27 What is an example of the diffraction of a wave?

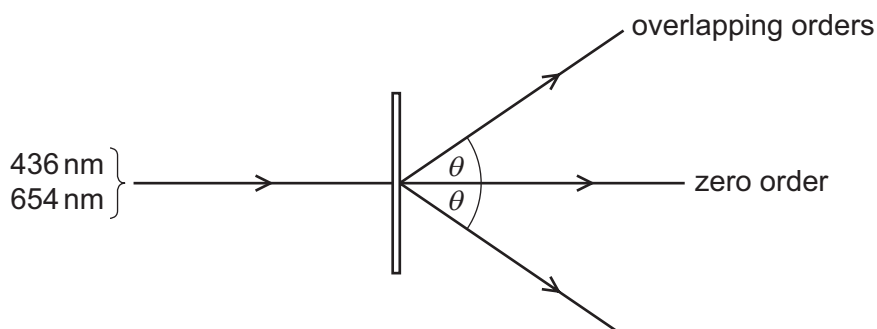
- A laser light travelling along an optic fibre
- B light waves forming images on a cinema screen
- C microwaves passing the edge of a metal plate
- D sound waves diverging as they pass through air

28 When the light from two lamps falls on a screen, no interference pattern can be obtained.

Why is this?

- A The lamps are not point sources.
- B The lamps emit light of different amplitudes.
- C The light from the lamps is not coherent.
- D The light from the lamps is white.

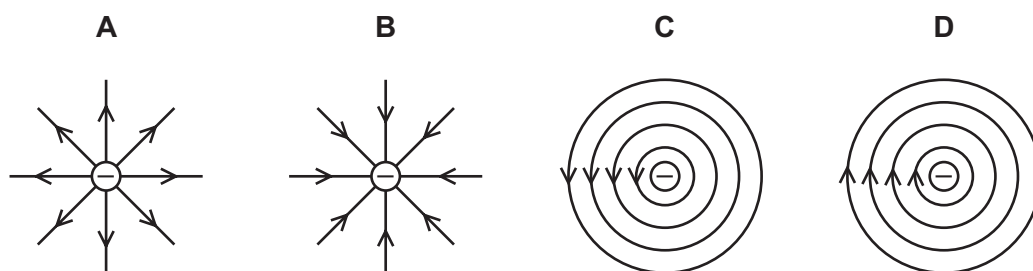
29 A beam of light consists of two wavelengths of 436 nm and 654 nm. A diffraction grating of $5.00 \times 10^5 \text{ lines m}^{-1}$ produces a diffraction pattern in which the second order of one of these wavelengths occurs at the same angle θ as the third order of the other wavelength.



What is the angle θ ?

- A 19.1°
- B 25.8°
- C 40.8°
- D 78.8°

30 Which diagram shows the electric field lines surrounding an isolated negative point charge?



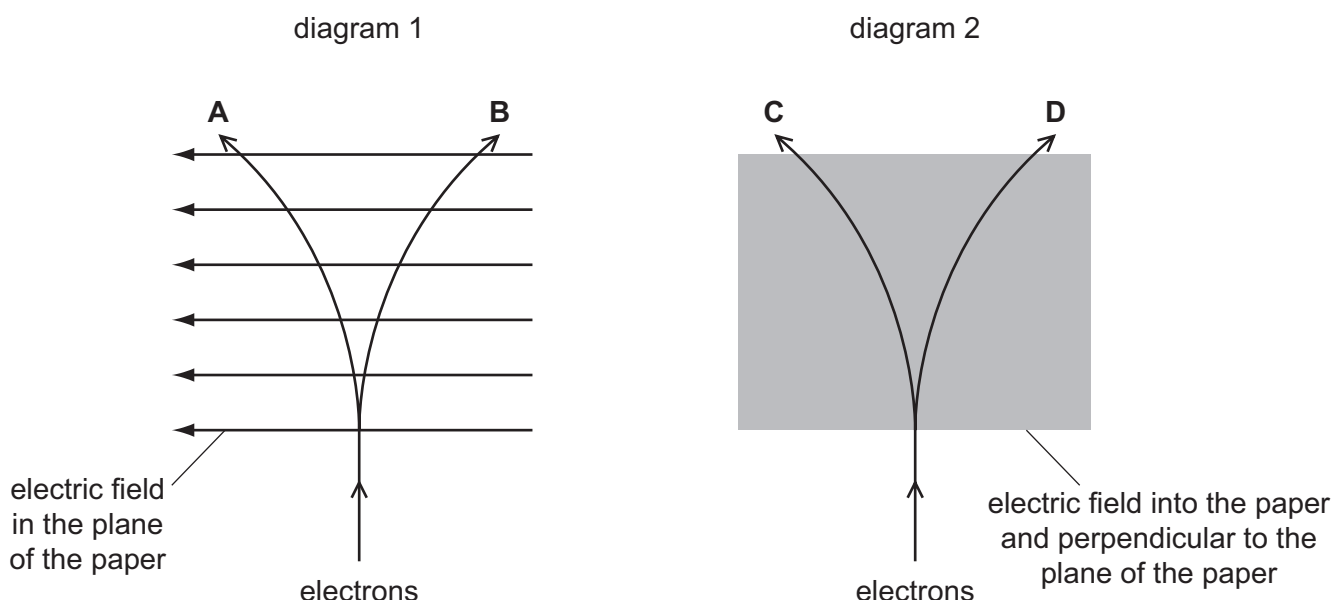
- 31 A beam of electrons is directed into an electric field and is deflected by it.

Diagram 1 represents an electric field in the plane of the paper.

Diagram 2 represents an electric field directed perpendicular to the plane of the paper.

The lines **A**, **B**, **C** and **D** represent possible paths of the electron beam. All paths are in the plane of the paper.

Which line best represents the path of the electrons inside the field?



- 32 A charged particle of charge q and mass m is initially at rest in a uniform electric field. The field is produced by parallel metal plates separated by a distance d and having a potential difference V between them.

What is an expression for the acceleration of the charged particle?

- A $\frac{md}{qV}$ B $\frac{mV}{qd}$ C $\frac{qd}{mV}$ D $\frac{qV}{md}$

- 33 When there is a current of 5.0 A in a copper wire, the average drift velocity of the free electrons is $8.0 \times 10^{-4} \text{ m s}^{-1}$.

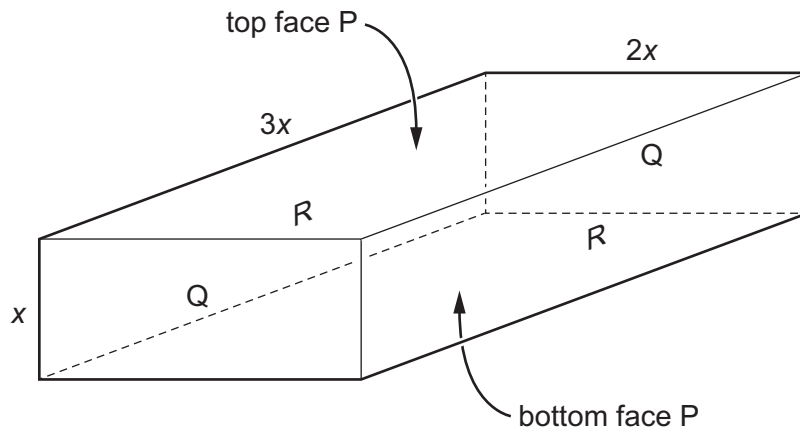
What is the average drift velocity in a different copper wire that has twice the diameter and a current of 10.0 A?

- A $4.0 \times 10^{-4} \text{ m s}^{-1}$
 B $8.0 \times 10^{-4} \text{ m s}^{-1}$
 C $1.6 \times 10^{-3} \text{ m s}^{-1}$
 D $3.2 \times 10^{-3} \text{ m s}^{-1}$

34 What is equivalent to one volt?

- A one coulomb per second
- B one joule per coulomb
- C one joule per second
- D one joule second per coulomb squared

35 The diagram shows a rectangular block with dimensions x , $2x$ and $3x$.

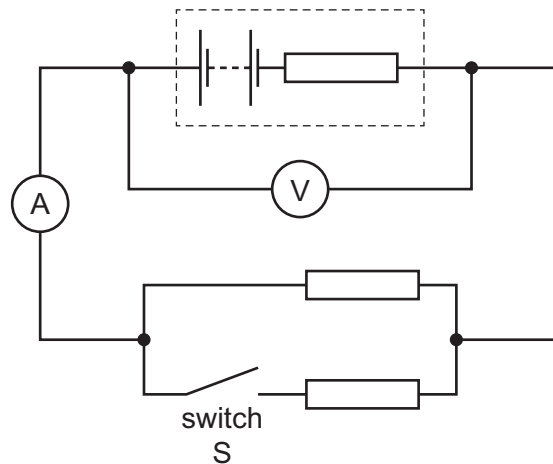


Electrical contact can be made to the block between opposite pairs of faces (for example, between the faces labelled R).

Which statement describing the electrical resistance of the block is correct?

- A It is maximum between the faces labelled P.
- B It is maximum between the faces labelled Q.
- C It is maximum between the faces labelled R.
- D It is the same, whichever pair of faces is used.

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

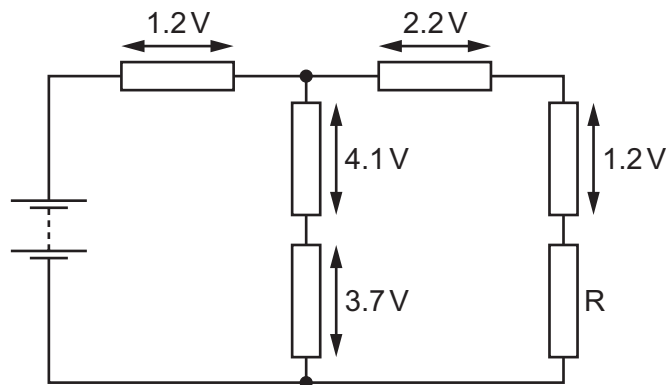


Initially switch S is open.

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

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

- 37** A battery is connected to a network of six resistors, as shown.



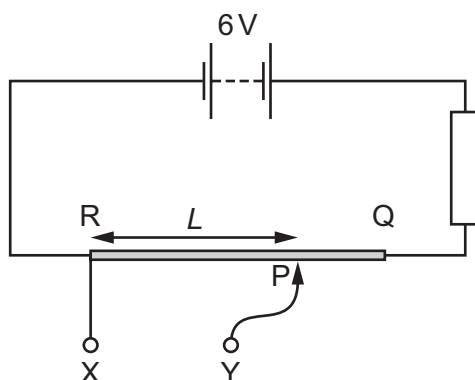
The potential differences across five of the resistors are labelled on the diagram.

What is the potential difference across resistor R?

- A** 4.4 V **B** 4.6 V **C** 6.6 V **D** 11.2 V

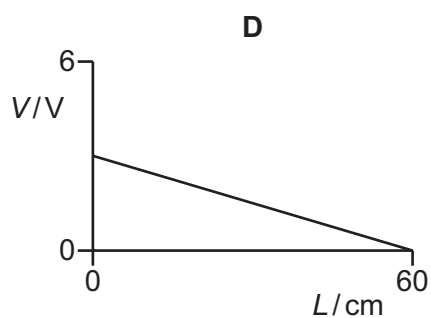
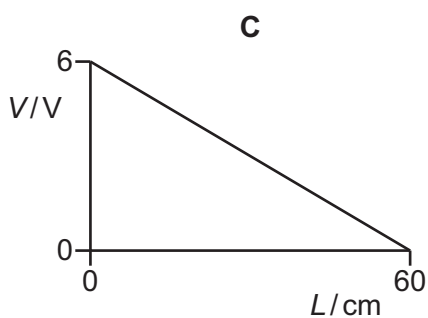
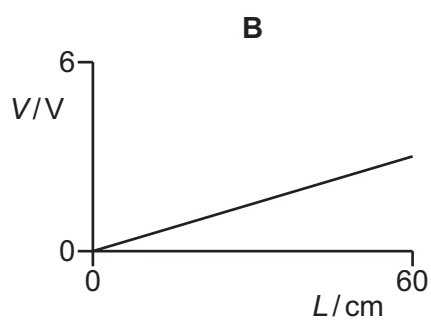
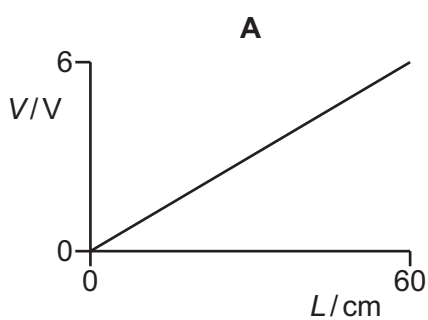
- 38 The diagram shows a battery of electromotive force (e.m.f.) 6 V, connected in series with a resistor and a uniform resistance wire RQ of length 60 cm.

The resistance of RQ is equal to the resistance of the resistor.



Terminal X is connected to fixed point R. Terminal Y is connected to point P, a connection that may be made at any position along the wire. L is the distance between R and P.

Which graph shows the variation with L of the potential difference (p.d.) V across XY?



- 39 A nucleus emits a β^- particle.

What is the change to the proton number and to the nucleon number of the nucleus?

	proton number	nucleon number
A	-1	+1
B	0	-1
C	+1	-1
D	+1	0

- 40 How many up quarks and how many down quarks are in a nucleus of the nuclide ${}^{37}_{17}\text{Cl}$?

	up quarks	down quarks
A	51	60
B	54	57
C	57	54
D	60	51

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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 A car is travelling at a speed of 20 m s^{-1} . The table contains values for the kinetic energy and the momentum of the car.

Which values are reasonable estimates?

	kinetic energy / J	momentum / kg m s^{-1}
A	3×10^5	3×10^4
B	3×10^5	5×10^6
C	2×10^7	3×10^4
D	2×10^7	5×10^6

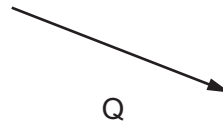
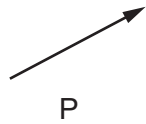
- 2 What is the unit of resistance when expressed in SI base units?

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

- 3 Which list contains both scalar and vector quantities?

- A** acceleration, momentum, velocity, weight
B area, current, force, work
C distance, kinetic energy, power, pressure
D mass, temperature, time, speed

- 4 Vectors P and Q are drawn to scale.



Which diagram represents the vector $(P + Q)$?

A



B



C



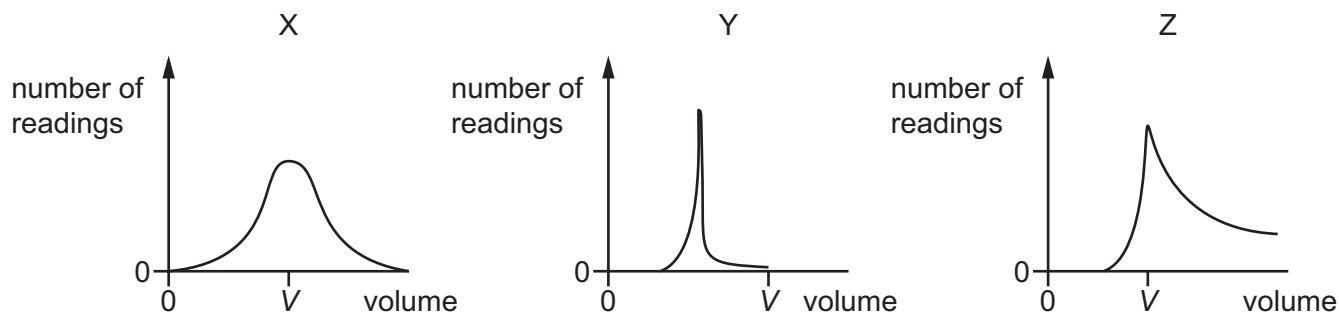
D



- 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

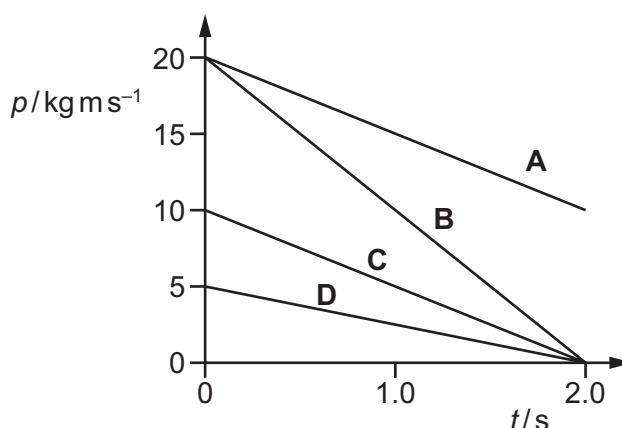
- 6 A sprinter runs a 100 m race. The sprinter has a constant acceleration from rest of 2.5 m s^{-2} until reaching a speed of 10 m s^{-1} . The speed then remains constant until the end of the race.

Which time does it take the sprinter to run the race?

- A** 8.9 s **B** 10 s **C** 12 s **D** 14 s

- 7 A resultant force of 10 N acts on a body for a time of 2.0 s.

Which graph could show the variation with time t of the momentum p of the body?



- 8 The acceleration of free fall on the surface of planet P is one tenth of that on the surface of planet Q.

On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and the weight of the same body on the surface of planet Q?

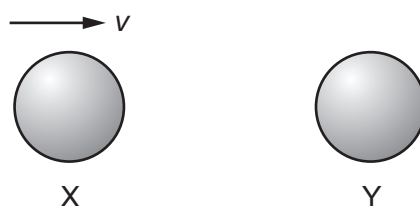
	mass on Q/kg	weight on Q/N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

- 9 Two bodies travelling along the same straight line collide in a perfectly elastic collision.

Which statement **must** be correct?

- A** The initial speed of one body will be the same as the final speed of the other body.
- B** The relative speed of approach between the two bodies equals their relative speed of separation.
- C** The total momentum is conserved but the total kinetic energy will be reduced.
- D** One of the bodies will be stationary at one instant.

- 10 The diagram shows two identical spheres X and Y.

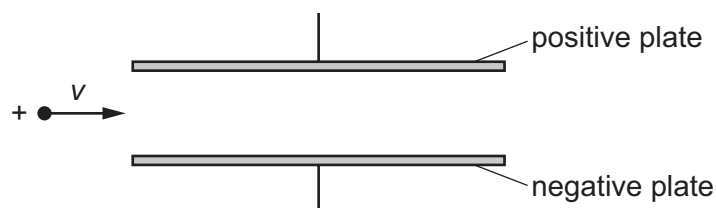


Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

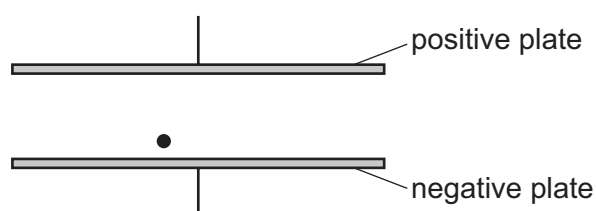
What happens?

	X	Y
A	moves with speed $\frac{1}{2}v$ to the right	moves with speed $\frac{1}{2}v$ to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}v$ to the left	moves with speed $\frac{1}{2}v$ to the right
D	stops	moves with speed v to the right

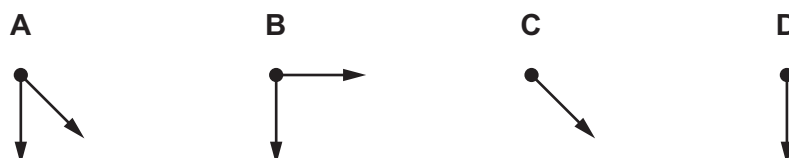
- 11 A positively-charged particle of negligible mass, moving at constant velocity v in a vacuum, enters a uniform electric field between two parallel plates, as shown.



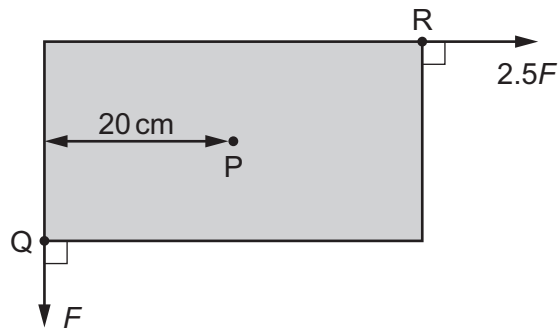
A short time later, the particle is at the position shown.



Which diagram represents the force or forces acting on the particle?



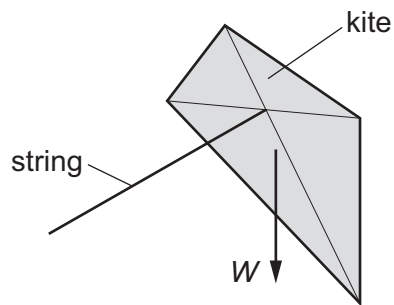
- 12 A uniform rectangular board is supported by a frictionless pivot at its centre point P.



Two forces act in the plane of the board. Force F acts at corner Q and force $2.5F$ acts at corner R. The perpendicular distance between the line of action of force F and point P is 20 cm. The board is in equilibrium.

What is the area of the board?

- A 160 cm^2 B 320 cm^2 C 640 cm^2 D 1600 cm^2
- 13 A kite is in equilibrium at the end of a string, as shown.



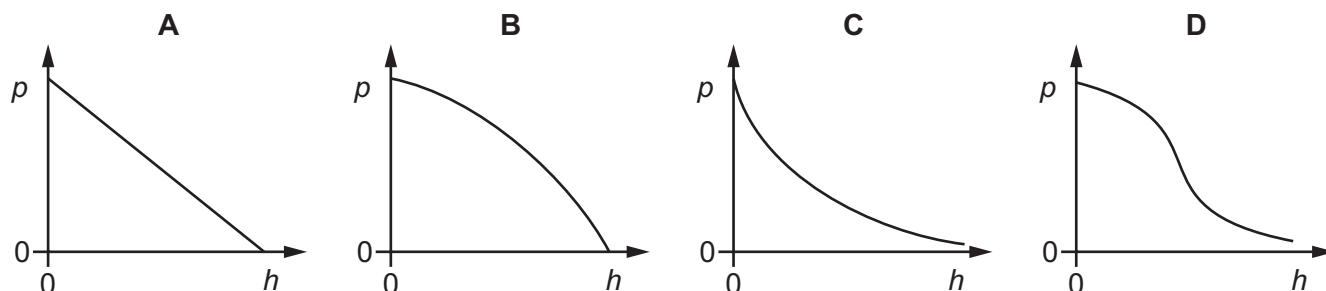
The kite has three forces acting on it: the weight W , the tension T in the string, and the force F from the wind.

Which vector diagram represents the forces acting on the kite?



- 14** The density of the air in the atmosphere decreases as the height h above the surface of the Earth increases.

Which graph best shows the variation with height h of the pressure p of the air?



- 15** A bungee jumper on a platform over a river is attached to an elastic rope that is 20 m long when unstretched. He falls towards the river and his lowest point is 30 m below the platform.

The initial gravitational potential energy of the jumper is transferred to other forms during the jump.

Which other forms of energy do the jumper and rope have when the jumper has fallen half-way and when he is at the lowest point of his jump?

	half-way	lowest point
A	kinetic energy and elastic potential energy	kinetic energy and elastic potential energy
B	kinetic energy and elastic potential energy	elastic potential energy only
C	kinetic energy only	kinetic energy and elastic potential energy
D	kinetic energy only	elastic potential energy only

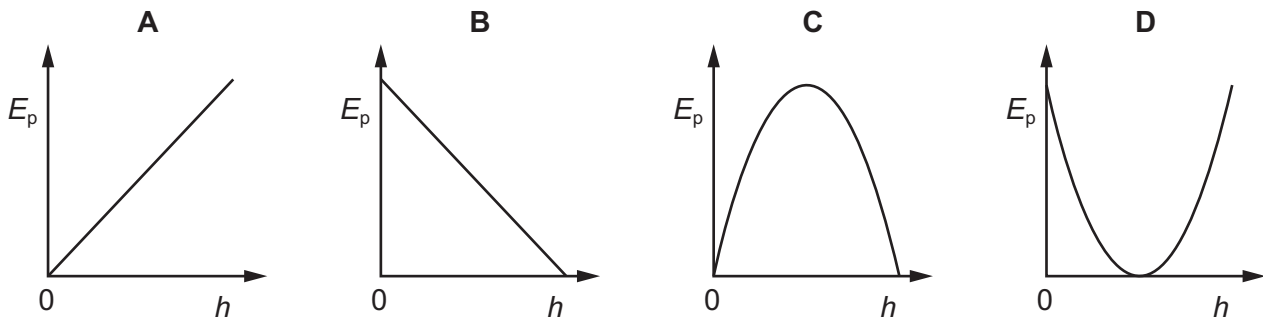
- 16** A cylinder contains a fixed mass of gas. The gas, at a constant pressure of $1.3 \times 10^5 \text{ Pa}$, expands from a volume of 900 cm^3 to a volume of 1100 cm^3 .

What is the work done by the gas during this expansion?

- A** 26 J **B** 130 J **C** 2600 J **D** 13000 J

- 17 An object is thrown into the air.

Which graph shows how the gravitational potential energy E_p of the object varies with height h above the ground?



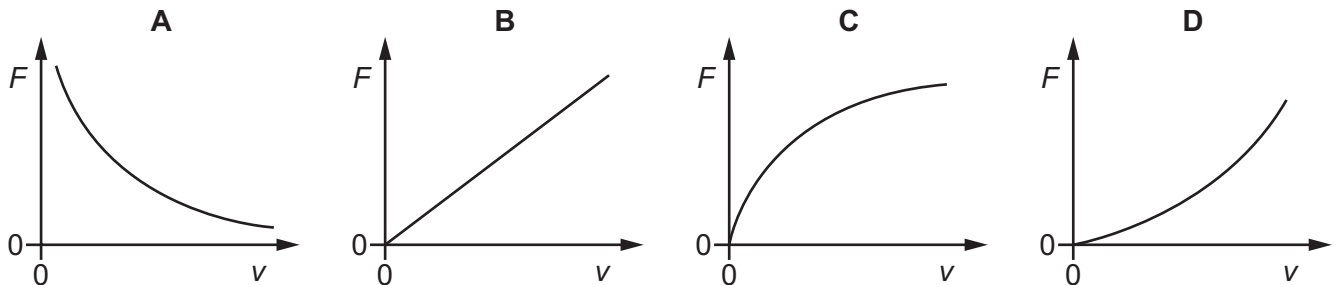
- 18 A car of mass 1800 kg accelerates along a horizontal road so that its speed increases from 20 m s^{-1} to 25 m s^{-1} in a time of 5.4 s.

What is the average useful power output of the car's engine?

- A** 4.2 kW **B** 38 kW **C** 120 kW **D** 1100 kW

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

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



- 20 A metal cylinder is able to withstand a compressive force of 4.0 kN without deforming plastically.

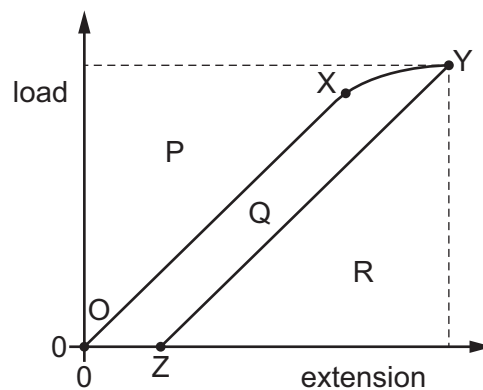


The cylinder has cross-sectional area A and would be at its elastic limit when a stress σ is applied.

What is a possible pair of values for A and σ ?

	A/m^2	σ/MPa
A	1.5×10^{-5}	50
B	1.5×10^{-5}	80
C	7.5×10^{-5}	50
D	7.5×10^{-5}	80

- 21 A wire has both elastic and plastic properties. When it is slowly loaded, its extension varies with load as shown by line OXY. The removal of the load is represented by line YZ. This creates areas P, Q and R on the graph.



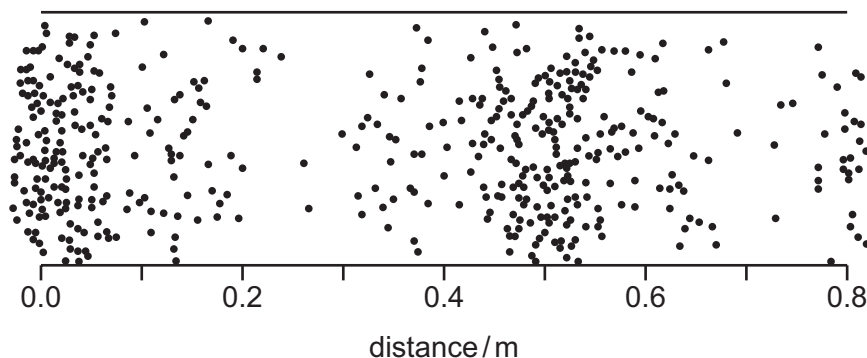
Which area represents the maximum elastic potential energy stored in the wire?

- A** P **B** Q **C** Q + R **D** R
- 22 A progressive wave on a wire has a frequency of 10 Hz. Two points on the wire, separated by a distance of 0.25 m, have a phase difference of 22.5° .

What is the maximum speed of the wave?

- A** 2.5 ms^{-1} **B** 10 ms^{-1} **C** 20 ms^{-1} **D** 40 ms^{-1}

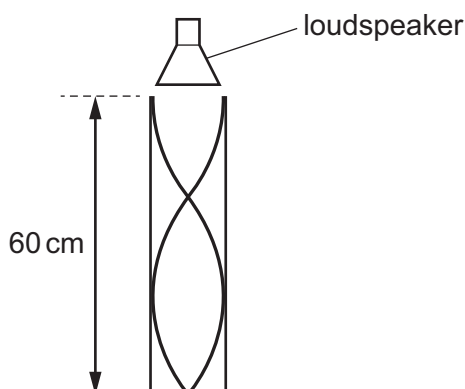
- 23 When a guitar string is plucked, it causes a longitudinal sound wave in the air, as shown.



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

What is the approximate frequency of the sound wave shown?

- A** 430 Hz **B** 680 Hz **C** 1100 Hz **D** 1400 Hz
- 24 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 the air is 340 m s^{-1} .

What is the frequency of the sound?

- A** 430 Hz **B** 570 Hz **C** 850 Hz **D** 1700 Hz
- 25 A police car has a two-tone siren emitting sound of frequencies of 700 Hz and 1000 Hz.

The police car is travelling at a speed of 40.0 m s^{-1} towards a stationary observer. The speed of sound in the air is 340 m s^{-1} .

What is the difference between the two frequencies of the sound that is heard by the observer?

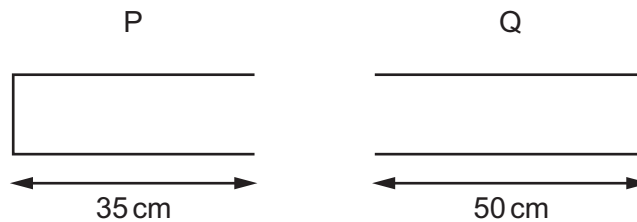
- A** 268 Hz **B** 300 Hz **C** 335 Hz **D** 340 Hz

- 26** A surveyor's device emits a pulse of light. The light is reflected from a wall 150 m away.

What is the time taken for the pulse to travel from the device to the wall and then back to the device?

- A** 0.05 ns **B** 0.10 ns **C** 0.50 μs **D** 1.0 μs

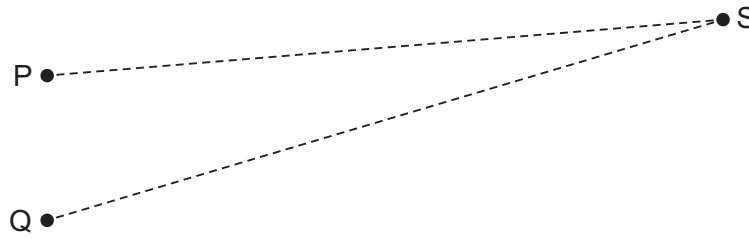
- 27** Progressive sound waves of wavelength 20 cm enter the air columns in a closed pipe P and an open pipe Q. The lengths of the pipes are shown.



In which pipe or pipes are stationary waves formed?

- A** P and Q
B P only
C Q only
D neither P nor Q
- 28** What happens when waves pass through a gap equal to their wavelength?
- A** There is diffraction and the wavelength decreases.
B There is diffraction and the wavelength stays the same.
C There is no diffraction and the wavelength decreases.
D There is no diffraction and the wavelength stays the same.

- 29 Two sources of microwaves P and Q produce coherent waves with a phase difference of 180° . The waves have the same wavelength λ .

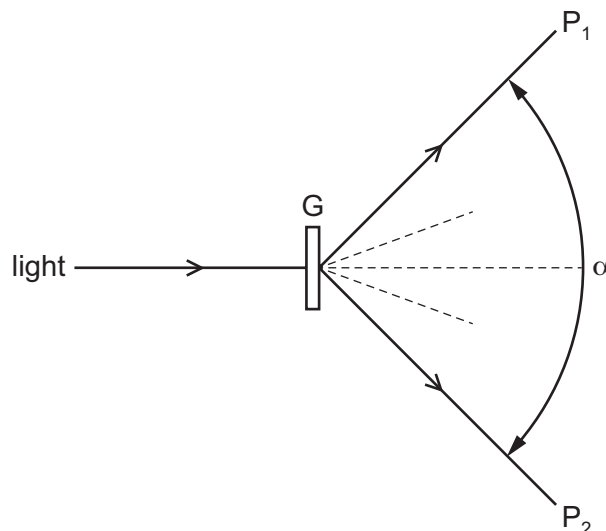


At the point S there is a minimum in the interference pattern produced by waves from the two sources. The distance $(QS - PS)$ is called the path difference.

In the expressions shown, n is an integer.

Which expression represents the path difference?

- A $n\lambda$ B $\frac{1}{2}n\lambda$ C $(n + \frac{1}{2})\lambda$ D $(2n + \frac{1}{2})\lambda$
- 30 A parallel beam of monochromatic light of wavelength λ is incident normally on a diffraction grating G. The angle between the directions of the two second-order diffracted beams at P_1 and at P_2 is α , as shown.

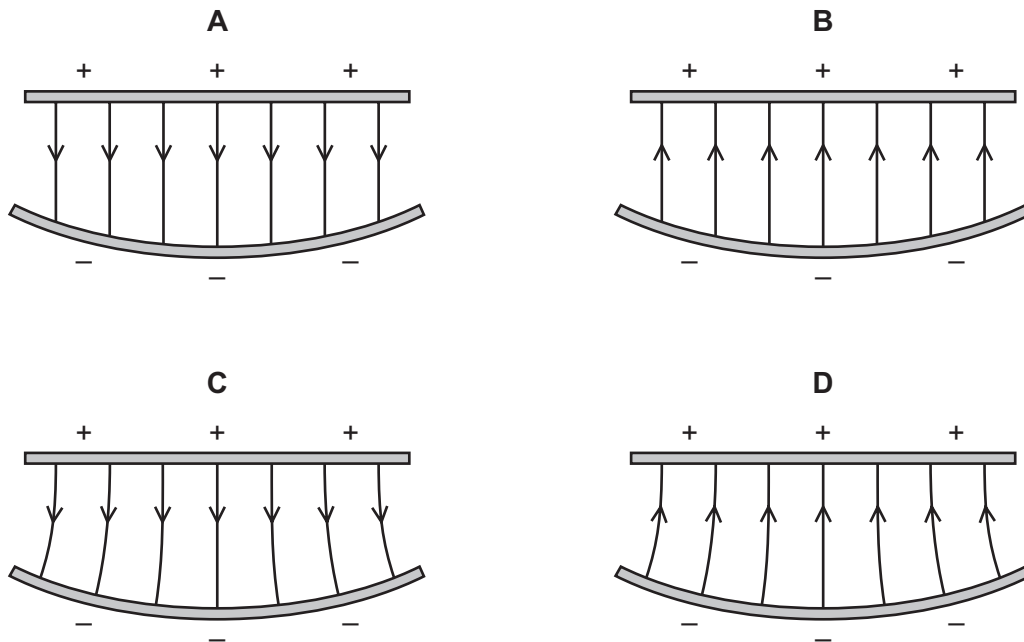


What is the spacing of the lines on the grating?

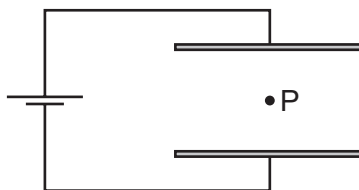
- A $\frac{2\lambda}{\sin \alpha}$ B $\frac{\lambda}{\sin \alpha}$ C $\frac{2\lambda}{\sin(\alpha/2)}$ D $\frac{\lambda}{\sin(\alpha/2)}$

- 31 A flat plate is positively charged and a curved plate is negatively charged.

Which diagram shows the electric field lines between the two plates?



- 32 Two parallel metal plates are connected to a d.c. supply, as shown.

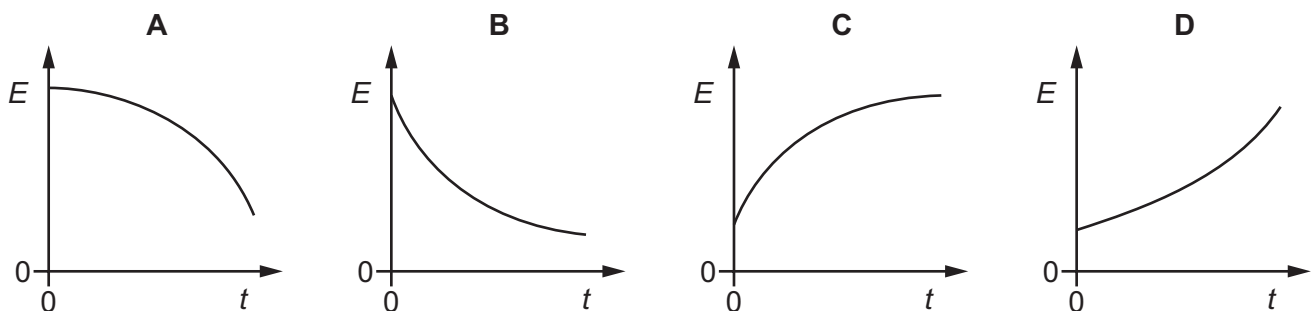


The two plates are moved towards each other at constant speed.

It may be assumed that the electric field between the plates is uniform.

Point P is mid-way between the two plates.

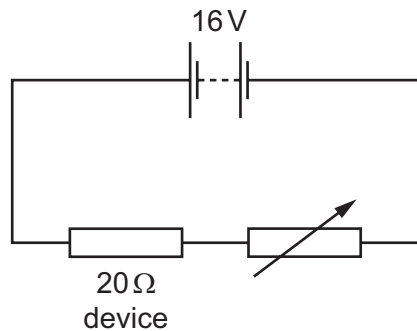
Which graph shows the variation with time t of the electric field strength E at point P?



33 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

34 An electrical device of fixed resistance $20\ \Omega$ 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 $16\ \Omega$
- B $36\ \Omega$
- C $44\ \Omega$
- D $60\ \Omega$

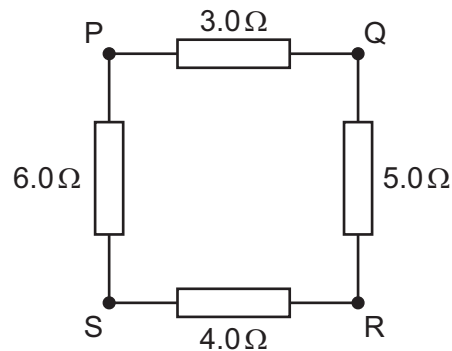
35 A wire of length L has resistance R . The cross-section of the wire is circular with radius r .

A second wire, also of circular cross-section, and of the same material, has resistance $\frac{1}{2}R$.

What could be the radius and the length of the second wire?

	radius	length
A	$\frac{r}{2}$	$\frac{L}{2}$
B	$\frac{r}{\sqrt{2}}$	$\frac{L}{2}$
C	$r\sqrt{2}$	$2L$
D	$2r$	$2L$

- 36** A battery of negligible internal resistance may be connected between any two points P, Q, R and S of the network of resistors shown.



Which connections will give the largest current and the smallest current in the battery?

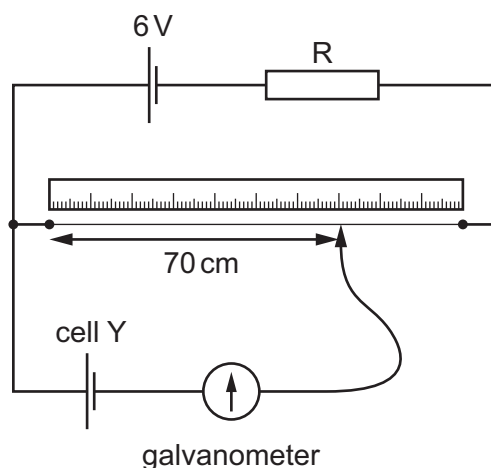
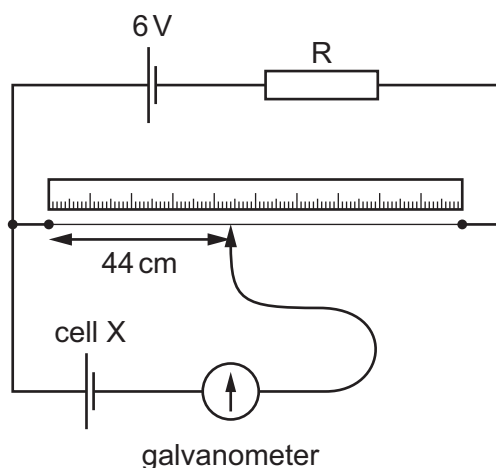
	largest current	smallest current
A	PQ	PR
B	PQ	QS
C	RS	PR
D	RS	QS

- 37** Kirchhoff's second law is a consequence of a basic principle.

What is this principle?

- A** The charge flowing in an electric circuit is conserved.
- B** The energy in an electric circuit is conserved.
- C** The sum of the electric currents entering a point in an electrical circuit is equal to the sum of the electric currents leaving that point.
- D** The sum of the potential differences in a circuit is equal to the sum of the products of the current and resistance.

- 38 Two cells are investigated using a potentiometer. At the balance point, cell X gives a reading of 44 cm and cell Y gives a reading of 70 cm.



Which statement is **not** correct?

- A A potentiometer balance point results in zero current through the galvanometer.
 - B At the balance point, the current through resistor R in both circuits is the same.
 - C The electromotive force (e.m.f.) of cell X is larger than that of cell Y.
 - D The value of the e.m.f. of each of the cells X and Y is less than 6 V.
- 39 A proton in a nucleus undergoes β^+ decay. One of the products is a neutron.
- What are the other products?
- A an electron and a neutrino
 - B an electron and an antineutrino
 - C a positron and a neutrino
 - D a positron and an antineutrino
- 40 A certain type of hadron has zero charge. It is composed of a down quark, a strange quark and one other quark.

What could be the other quark?

- A up
- B down
- C strange
- D anti-strange

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PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2018

1 hour 15 minutes

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, 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 **19** 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 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 Which statement is **not** a reasonable estimate?

- A Atmospheric pressure at sea level is about $1 \times 10^5 \text{ Pa}$.
- B Light takes $5 \times 10^2 \text{ s}$ to reach us from the Sun.
- C The frequency of ultraviolet light is $3 \times 10^{12} \text{ Hz}$.
- D The lifespan of a man is about $2 \times 10^9 \text{ s}$.

2 Three of these quantities have the same unit.

Which quantity has a different unit?

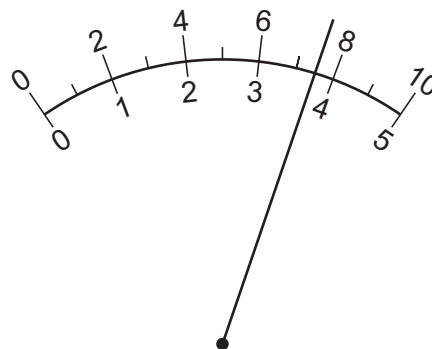
- A $\frac{\text{energy}}{\text{distance}}$
- B force
- C power $\times$ time
- D rate of change of momentum

3 Which group of quantities contains only vectors?

- A acceleration, displacement, speed
- B acceleration, work, electric field strength
- C displacement, force, velocity
- D power, electric field strength, force

4 An ammeter is calibrated so that it shows a full-scale deflection when it measures a current of 2.0 A .

The diagram shows the display of this ammeter when it is measuring a current.



Which current is the ammeter measuring?

- A 0.75 A
- B 1.5 A
- C 3.8 A
- D 7.5 A

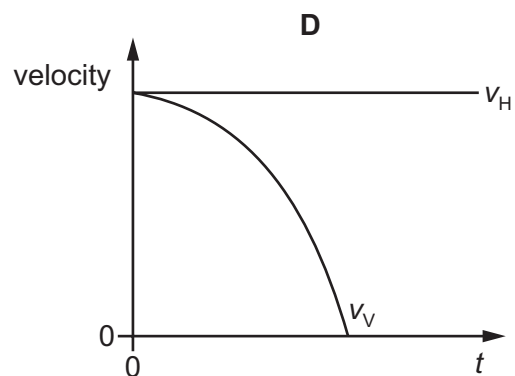
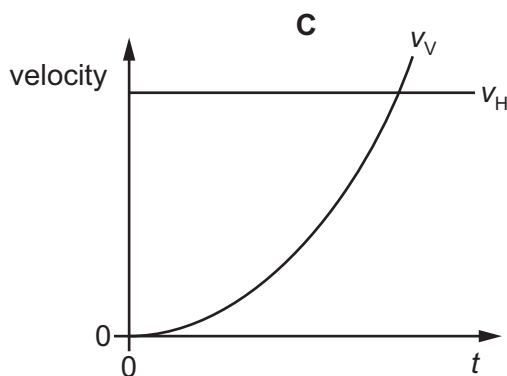
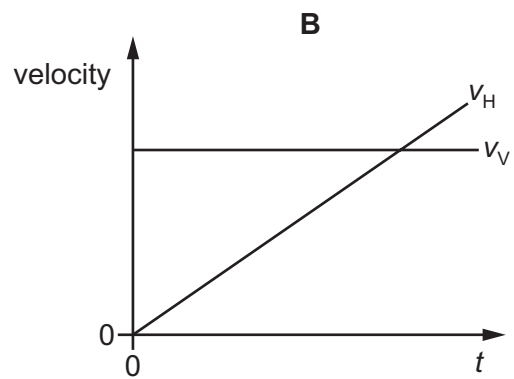
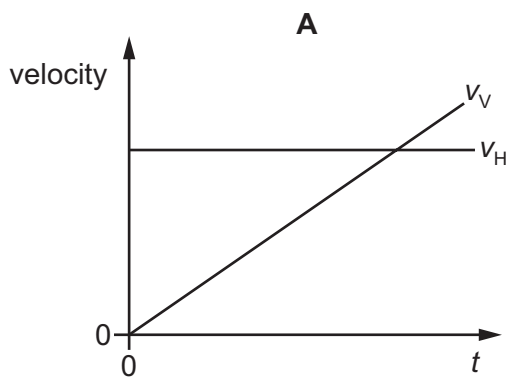
- 5 The width of a table is measured as (50.3 ± 0.1) cm. Its length is measured as (1.40 ± 0.01) m.

What is the area of the table and its absolute uncertainty?

- A $(0.7 \pm 0.1)\text{m}^2$
 B $(0.704 \pm 0.006)\text{m}^2$
 C $(0.704 \pm 0.011)\text{m}^2$
 D $(70.4 \pm 0.6)\text{m}^2$

- 6 A stone is projected horizontally at time $t = 0$ and falls. Air resistance is negligible. The stone has a horizontal component of velocity v_H and a vertical component of velocity v_V .

Which graph shows how v_H and v_V vary with time t ?



- 7 Two isolated spheres have masses 2.0 kg and 4.0 kg. The spheres collide and then move apart.

During the collision, the 2.0 kg mass has an average acceleration of 8.0 m s^{-2} .

What is the average acceleration of the 4.0 kg mass?

- A 2.0 m s^{-2} B 4.0 m s^{-2} C 8.0 m s^{-2} D 16 m s^{-2}

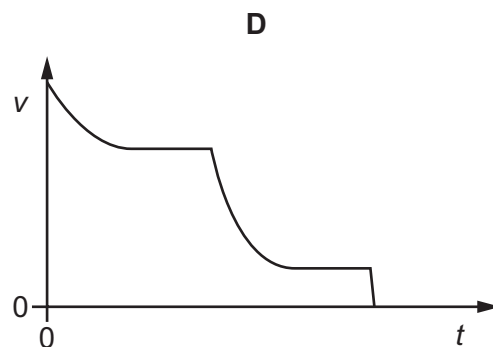
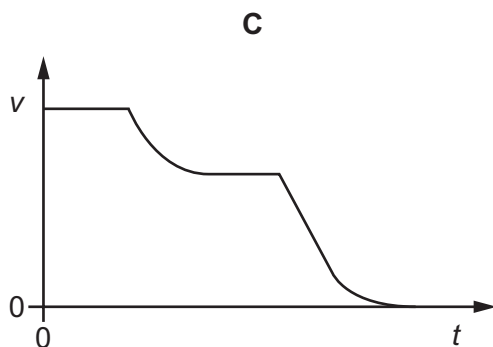
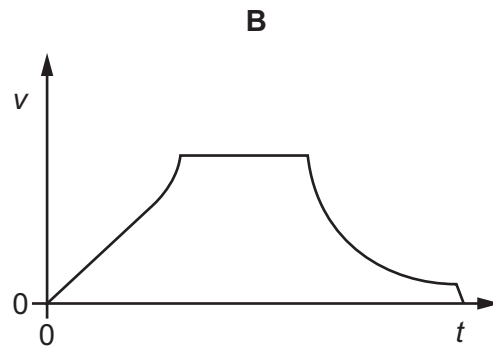
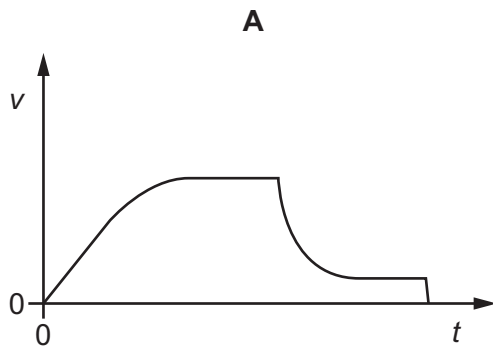
- 8 A mass is placed on a frictionless slope inclined at 30° to the horizontal. The mass is then released.

What is its acceleration down the slope?

- A 4.9 ms^{-2} B 5.7 ms^{-2} C 8.5 ms^{-2} D 9.8 ms^{-2}

- 9 A parachutist falls vertically from rest at time $t = 0$ from a hot-air balloon. She falls for some distance before opening her parachute.

Which graph best shows the variation with time t of the speed v of the parachutist?



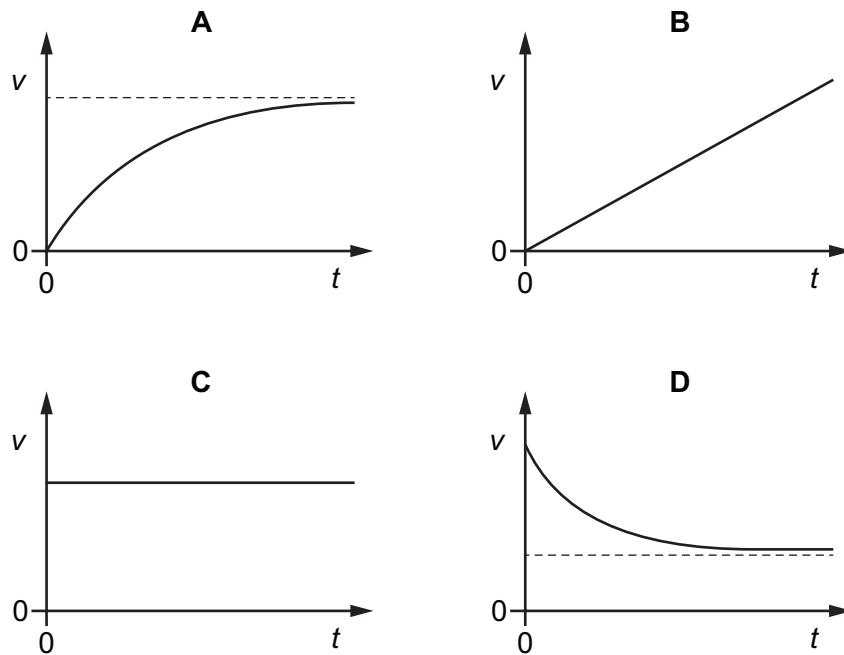
- 10 A ship of mass $8.4 \times 10^7 \text{ kg}$ is approaching a harbour with speed 16.4 ms^{-1} . By using reverse thrust it can maintain a constant total stopping force of $920\,000 \text{ N}$.

How long will it take to stop?

- A 15 seconds
B 150 seconds
C 25 minutes
D 250 minutes

- 11 A rigid, hollow sphere is immersed deep in water and released from rest. It experiences an upthrust which propels it towards the surface of the water.

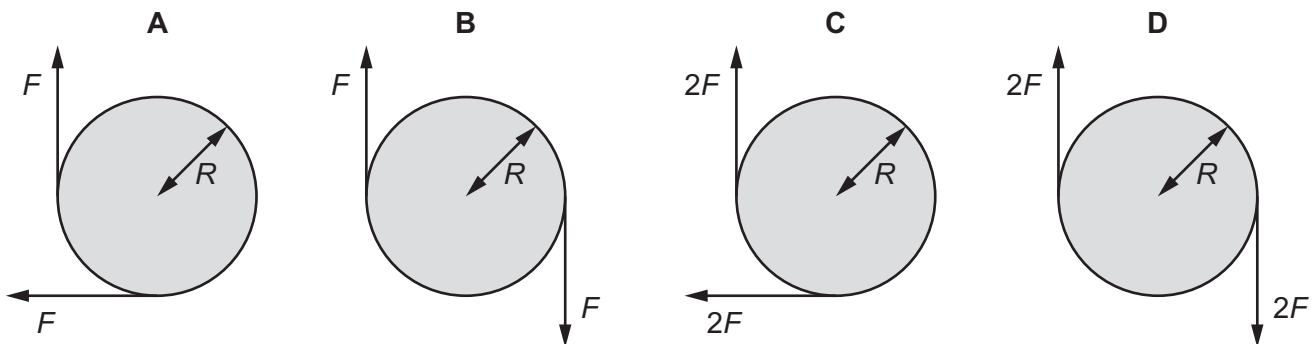
Which graph best shows the variation with time t of its upward velocity v ?



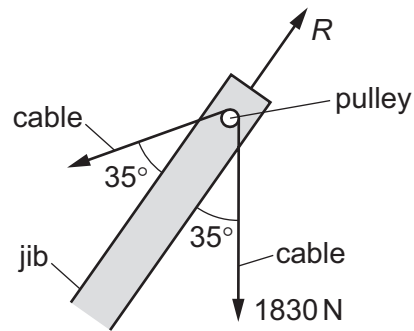
- 12 A flat metal disc has radius R .

Forces of magnitude F are applied tangentially at the edge of the disc. The forces are in the plane of the disc.

Which arrangement of forces produces only a torque of magnitude $2FR$?



- 13** The diagram shows the jib of a crane at an angle of 35° to the vertical. A cable passes over a frictionless pulley and carries a load of 1830 N.



The force R that the pulley exerts on the cable is in line with the jib. The cable and the pulley are in equilibrium.

What is the value of R ?

- A** 1000 N **B** 1500 N **C** 2100 N **D** 3000 N
- 14** What is a unit for density?
- A** Nm^{-3} **B** g mm^{-1} **C** kg cm^{-2} **D** $\mu\text{g mm}^{-3}$
- 15** Which statement about energy is **not** correct?
- A** Energy is never lost but it may be transferred between different forms.
- B** In an inelastic collision, the total energy is constant.
- C** The efficiency of a system is the ratio of the useful energy output to the total energy input.
- D** When a machine does work, friction reduces the total energy.
- 16** An electric kettle is rated as having an input power of 1.50 kW and an efficiency of 65.0%.

The kettle is switched on for 2.00 minutes.

How much energy is transferred to the water in the kettle?

- A** 0.975 kJ **B** 117 kJ **C** 180 kJ **D** 277 kJ

- 17** On a planet, a gravitational force F acts on a mass of 6.0 kg. The mass is moved by force F a distance of 30 m in the direction of the gravitational field. The work done by the field is 450 J.

What is the force F on the mass and what is the acceleration of free fall g on the planet?

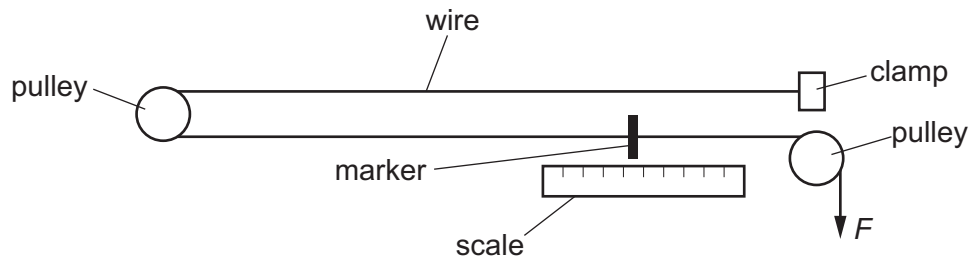
	F/N	g/ms^{-2}
A	0.067	0.011
B	0.067	0.40
C	15	2.5
D	15	90

- 18** A girl of mass 50 kg runs up a flight of 20 steps in 7.0 seconds. Each step is 25 cm high.

What is the useful average output power provided by the girl to climb the flight of steps?

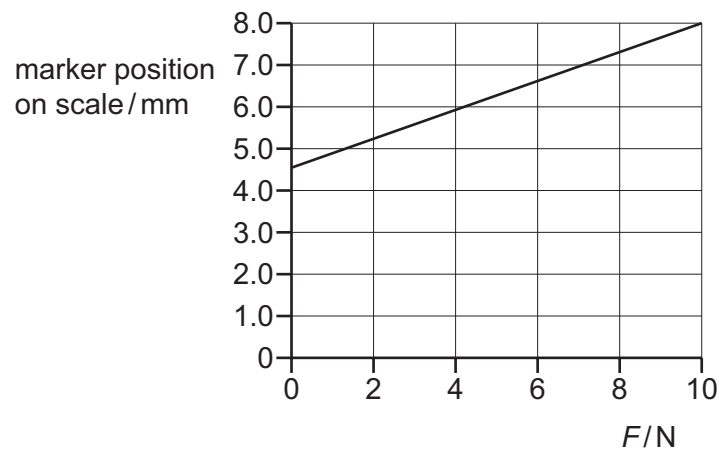
- A** 18 W **B** 36 W **C** 350 W **D** 2500 W

- 19 In an experiment to measure the Young modulus of a metal, a wire of the metal of diameter 0.25 mm is clamped, as shown.



The wire passes from a clamp, around a frictionless pulley, and then to a second frictionless pulley where loads F are applied to it. A marker is attached to the wire so that the total length of wire between the clamp and the marker is initially 3.70 m. A scale is fixed near to this marker.

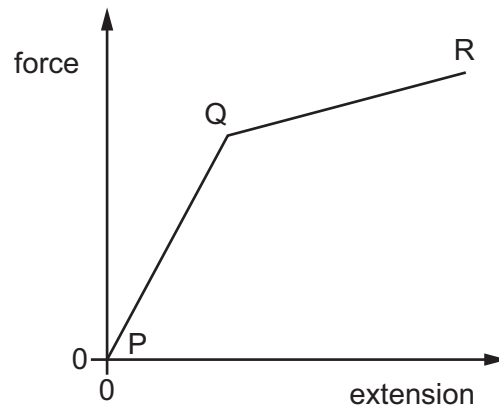
The graph shows how the reading on the scale varies with F .



What is the Young modulus of the metal?

- A $5.5 \times 10^{10} \text{ Pa}$
- B $9.4 \times 10^{10} \text{ Pa}$
- C $1.6 \times 10^{11} \text{ Pa}$
- D $2.2 \times 10^{11} \text{ Pa}$

- 20 A scientist is investigating the properties of a new material. She plots a force-extension graph for the material up to its breaking point.



Which statement **must** be correct?

- A The area under the graph from P to R is the strain energy stored in the material.
 - B The area under the graph from P to R is the work done in stretching the material.
 - C The material stretches elastically from Q to R.
 - D The material stretches plastically from P to Q.
- 21 A progressive sound wave in air has amplitude x_0 and intensity I .

The amplitude of the wave increases to $3x_0$.

What is the new intensity of the wave?

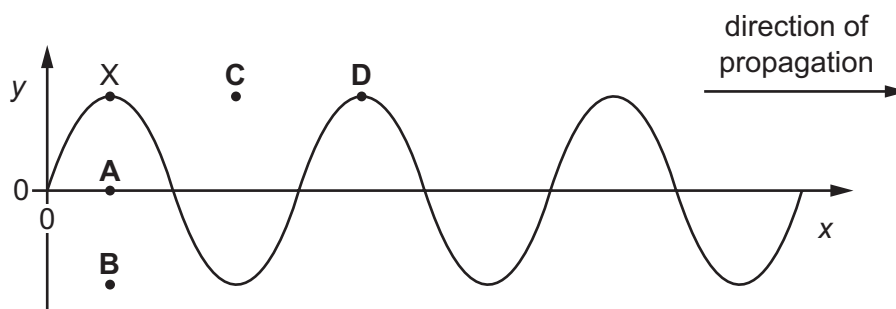
- A $\frac{I}{9}$
- B $\frac{I}{3}$
- C $3I$
- D $9I$

- 22** The variation with distance x of the displacement y of a transverse wave on a rope is shown at time $t = 0$.

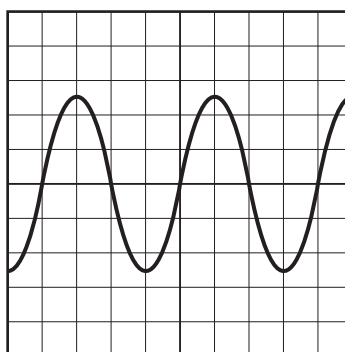
The wave has a frequency of 0.5 Hz.

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

What is the position of X at time $t = 1$ s?



- 23** A sound wave is detected by a microphone. The output from the microphone is connected to the Y-input of a cathode-ray oscilloscope (c.r.o.). The trace on the c.r.o. is shown.



The time-base is set at 0.20 ms per division.

What is the frequency of the sound wave?

- A** 1000 Hz **B** 1250 Hz **C** 2000 Hz **D** 2500 Hz
- 24** A bat flies directly towards a fixed ultrasound detector at a speed of 25.0 m s^{-1} emitting pulses of ultrasound of frequency 40.0 kHz.

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

Which frequency does the ultrasound detector record?

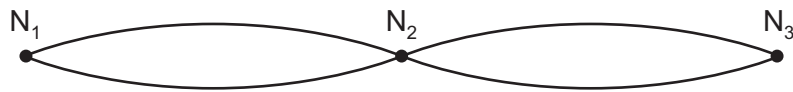
- A** 37.0 kHz **B** 37.2 kHz **C** 43.0 kHz **D** 43.3 kHz

- 25** An electromagnetic wave has a wavelength of 1.0×10^{-7} m.

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

- A** infra-red
- B** ultraviolet
- C** visible
- D** X-ray

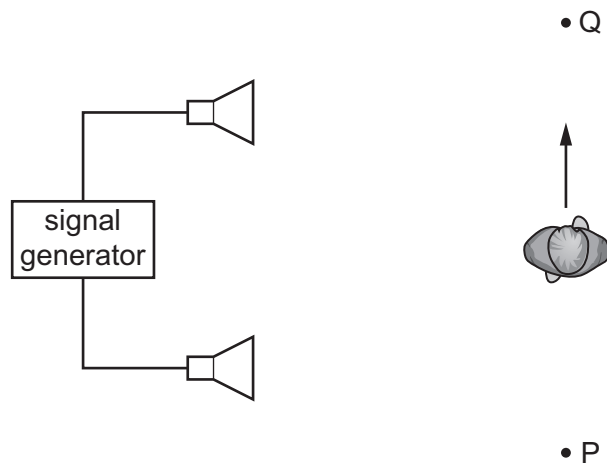
- 26** The diagram shows a stationary wave on a string. The stationary wave has three nodes N_1 , N_2 and N_3 .



Which statement is correct?

- A** All points on the string vibrate in phase.
 - B** All points on the string vibrate with the same amplitude.
 - C** Points equidistant from N_2 vibrate with the same frequency and in phase.
 - D** Points equidistant from N_2 vibrate with the same frequency and the same amplitude.
- 27** In which situation does diffraction occur?
- A** A wave bounces back from a surface.
 - B** A wave passes from one medium into another.
 - C** A wave passes through an aperture.
 - D** Waves from two identical sources are superposed.

- 28 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?

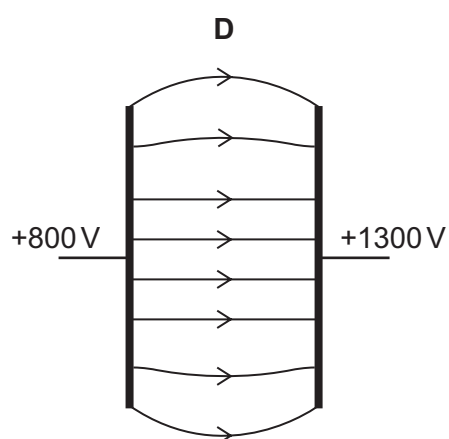
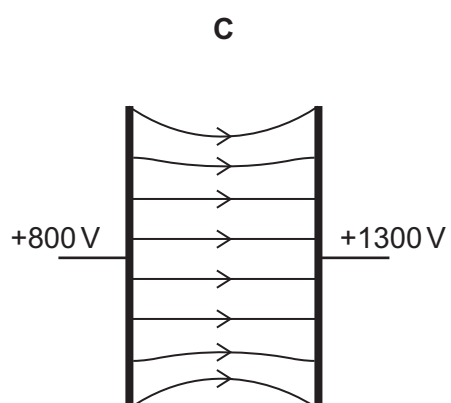
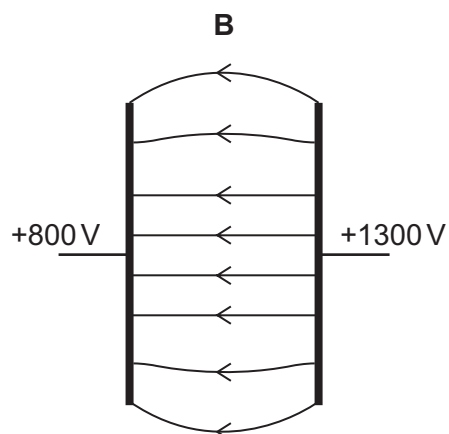
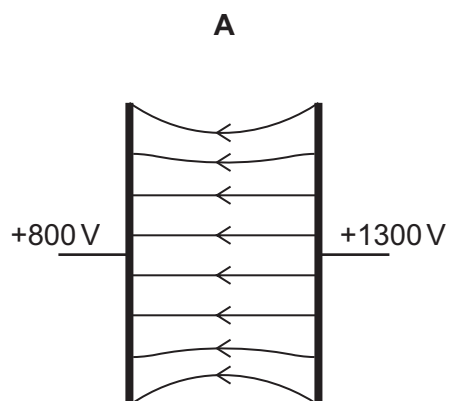
- A** diffraction of the sound waves
 - B** Doppler shift of the sound waves
 - C** interference of the sound waves
 - D** reflection of the sound waves
- 29 A parallel beam of white light is incident normally on a diffraction grating. The second-order and third-order spectra partially overlap.

Which wavelength in the third-order spectrum appears at the same angle as the wavelength of 600 nm in the second-order spectrum?

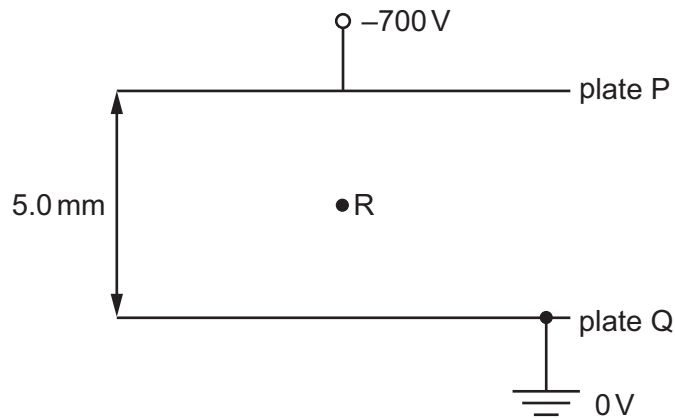
- A** 300 nm
- B** 400 nm
- C** 600 nm
- D** 900 nm

30 Two parallel metal plates are at electric potentials of +800 V and +1300 V.

Which diagram best represents the electric field between the metal plates?



- 31 The diagram shows two metal plates P and Q. There is a potential difference of 700 V between the plates. Plate Q is earthed.



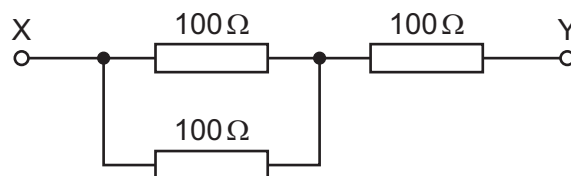
What is the magnitude and direction of the electric field at point R?

- 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 The current I in a copper wire can be calculated using the equation shown.

$$I = Anvq$$

What does the symbol v represent?

- A the average drift velocity of the charge carriers
 B the instantaneous velocity of the charge carriers
 C the voltage applied across the wire
 D the volume of the wire
- 33 Three resistors are to be connected into a circuit with the arrangement shown.



The power in any resistor must not be greater than 4.0 W.

What is the maximum voltage across XY?

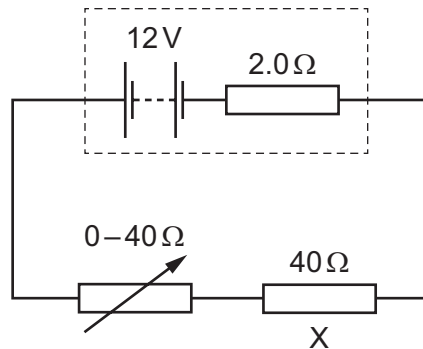
- A 24 V B 30 V C 40 V D 60 V

- 34** Gold is sometimes used to make very small connecting wires in electronic circuits.

A particular gold wire has length $2.50 \times 10^{-3} \text{ m}$ and cross-sectional area $6.25 \times 10^{-8} \text{ m}^2$. Gold has resistivity $2.30 \times 10^{-8} \Omega \text{ m}$.

What is the resistance of the wire?

- A** $3.6 \times 10^{-18} \Omega$
B $5.8 \times 10^{-13} \Omega$
C $9.2 \times 10^{-4} \Omega$
D $6.8 \times 10^{-3} \Omega$
- 35** A resistor X of resistance 40Ω and a variable resistor are connected to a battery of electromotive force (e.m.f.) 12 V and internal resistance 2.0Ω , as shown.

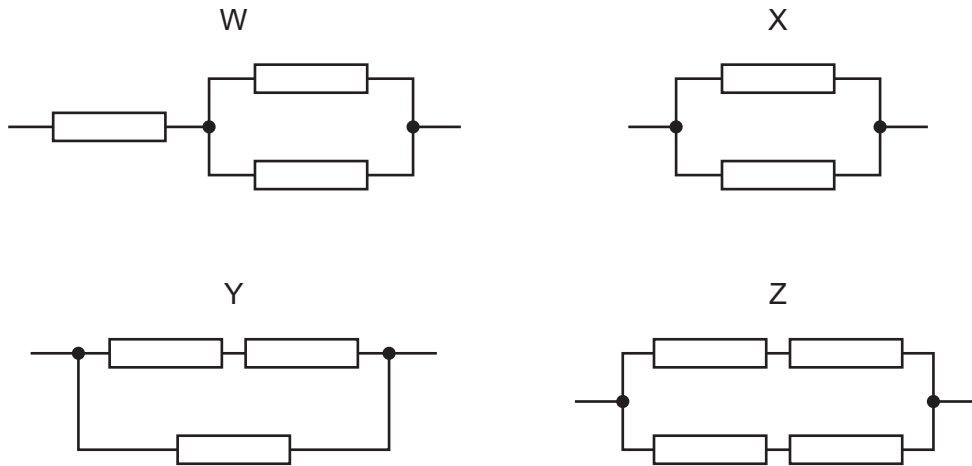


The resistance of the variable resistor is changed from 0 to 40Ω .

What is the change in power dissipated in resistor X?

- A** 2.4 W **B** 2.7 W **C** 3.6 W **D** 5.6 W

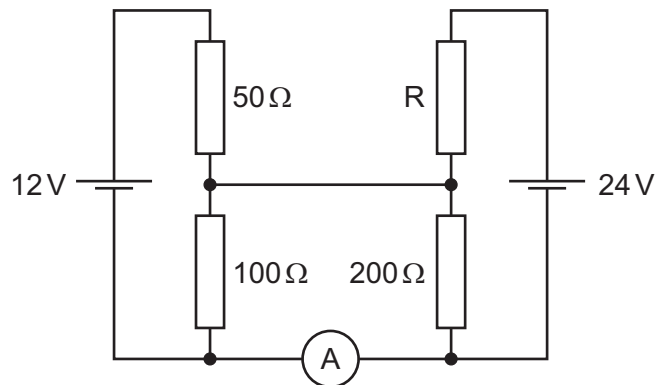
36 All the resistors shown in the resistor networks W, X, Y and Z have the same resistance.



Which list gives the networks in order of increasing total resistance?

- A $W \rightarrow Z \rightarrow Y \rightarrow X$
- B $X \rightarrow W \rightarrow Y \rightarrow Z$
- C $X \rightarrow Y \rightarrow W \rightarrow Z$
- D $X \rightarrow Y \rightarrow Z \rightarrow W$

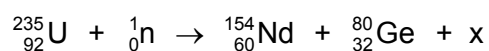
37 In the circuit shown, the ammeter reading is zero.



What is the resistance of resistor R?

- A 100Ω
- B 200Ω
- C 400Ω
- D 600Ω

- 38 A neutron collides with a nucleus of uranium-235. One possible nuclear reaction that results is represented by the equation



where x represents one or more particles.

What does x represent?

- A one neutron
 - B two electrons
 - C two neutrons
 - D two protons
- 39 A nucleus Q has the notation ${}_x^y\text{Q}$.

Which of the following is an isotope of Q?

- A ${}_{x+1}^{y-1}\text{Q}$
 - B ${}_{x-1}^y\text{Q}$
 - C ${}_{x+1}^y\text{Q}$
 - D ${}_{x+1}^{y-1}\text{Q}$
- 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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