



Cambridge International AS & A Level

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2021

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

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

INSTRUCTIONS

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

INFORMATION

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

This document has **20** pages. Any blank pages are indicated.



Data

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

Formulae

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

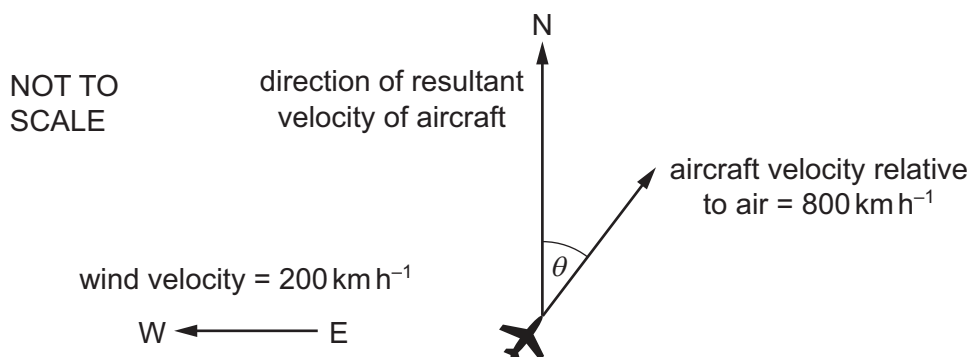
- 1 What is essential when recording a measurement of a physical quantity?
- A** the measurement has an SI unit
B the measurement has a unit and a number
C the measurement has a unit given as a base unit
D the measurement is from an analogue scale
- 2 The mobility μ of electrons travelling through a metal conductor can be calculated using the equation

$$\mu = \left(\frac{e}{m} \right) \tau$$

where e is the charge on an electron and m is its mass. The average time between the collisions of an electron with the atoms in the metal is τ .

What are the SI base units of μ ?

- A** A kg^{-1} **B** $\text{A s}^2 \text{kg}^{-1}$ **C** A s kg^{-1} **D** $\text{A s}^{-2} \text{kg}^{-1}$
- 3 An aircraft heads in a direction at an angle θ east of north with a horizontal velocity relative to the air of 800 km h^{-1} . The wind blows with a horizontal velocity of 200 km h^{-1} from east to west, as shown.



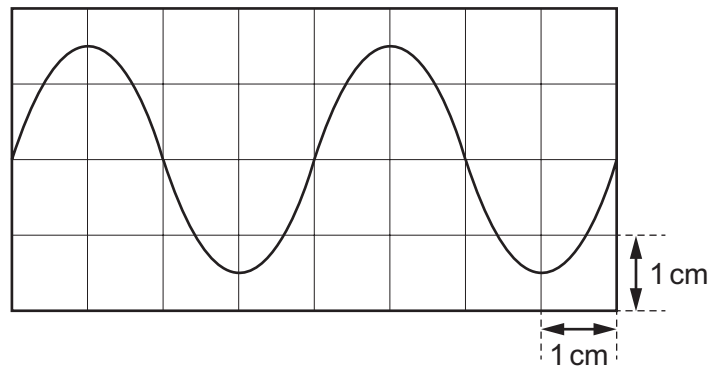
The resultant velocity of the aircraft is in a direction due north.

What is angle θ and what is the magnitude of the resultant velocity?

	$\theta / ^\circ$	resultant velocity / km h^{-1}
A	14	770
B	14	820
C	76	770
D	76	820

- 4 A cathode-ray oscilloscope (CRO) is used to display a sound wave of frequency 2000 Hz.

The display of the CRO is shown.



What is the time-base setting on the CRO?

- A** $125 \mu\text{s cm}^{-1}$ **B** $250 \mu\text{s cm}^{-1}$ **C** $500 \mu\text{s cm}^{-1}$ **D** $1000 \mu\text{s cm}^{-1}$

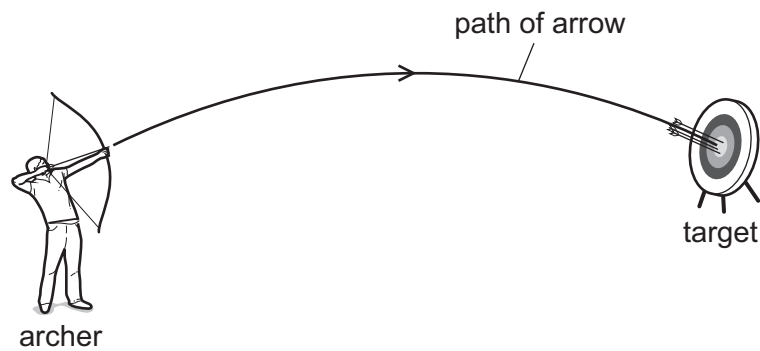
- 5 Four possible sources of error in a series of measurements are listed.

- 1 an analogue meter whose scale is read from different angles
- 2 a meter which always measures 5% too high
- 3 a meter with a needle that is not frictionless, so the needle sometimes sticks slightly
- 4 a meter with a zero error

Which errors are random and which are systematic?

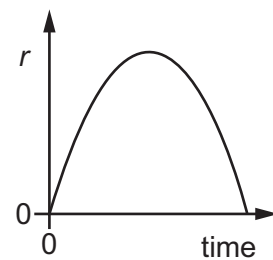
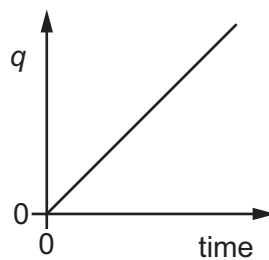
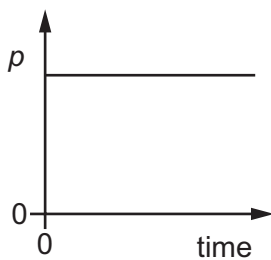
	random error	systematic error
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

- 6 An archer shoots an arrow at a target. The diagram shows the path of the arrow.



Air resistance is negligible.

The graphs show how three different quantities p , q and r vary with time.



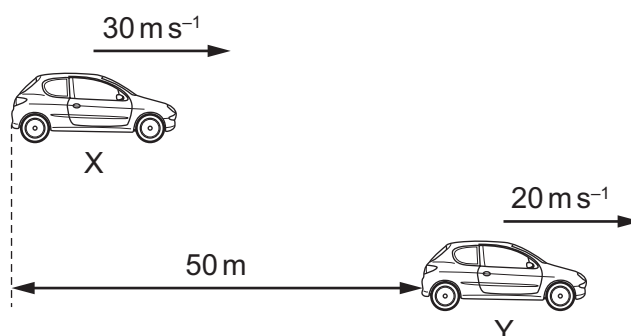
Which quantity could be the horizontal component of displacement and which quantity could be the vertical component of displacement of the arrow?

	horizontal component of displacement	vertical component of displacement
A	p	q
B	q	r
C	r	p
D	r	q

- 7 Two cars X and Y are positioned as shown at time $t = 0$.

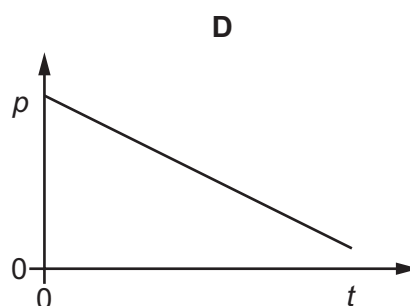
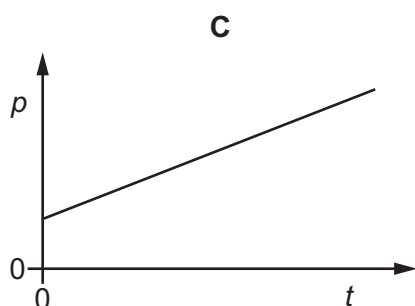
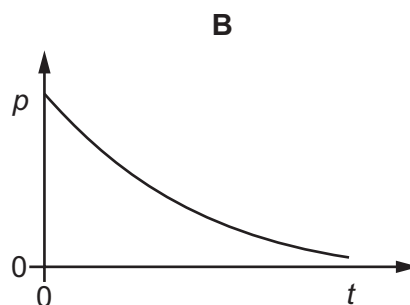
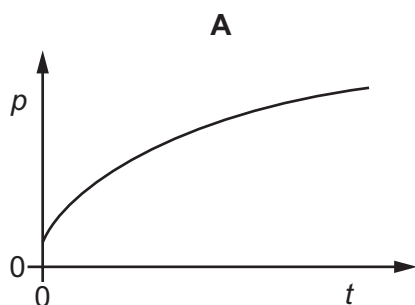
They are travelling in the same direction.

X is 50 m behind Y and has a constant velocity of 30 m s^{-1} . Y has a constant velocity of 20 m s^{-1} .



What is the value of t when X is level with Y?

- A** 1.0 s **B** 1.7 s **C** 2.5 s **D** 5.0 s
- 8 A constant resultant force acts on an object in the direction of the object's velocity.
Which graph could show the variation with time t of the momentum p of the object?



- 9 Which statement **must** be true for an object in a gravitational field?
- A** If the object has mass then the field causes it to accelerate.
B If the object has mass then the field causes it to have weight.
C If the object has weight then the field causes it to accelerate.
D If the object has weight then the field causes it to have mass.

- 10 A ball of mass 0.16 kg is travelling horizontally at a speed of 20 ms^{-1} .

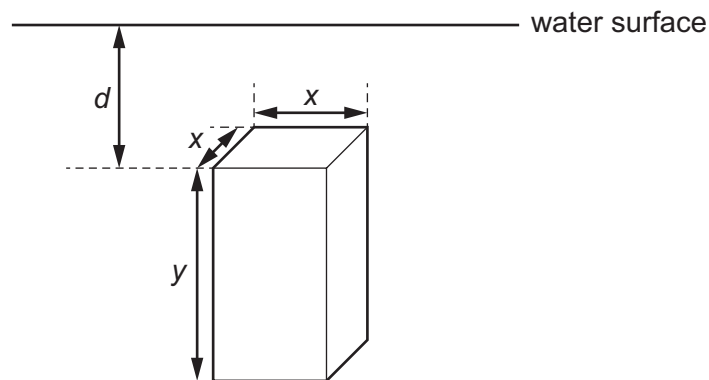
It collides with a wall and rebounds with a speed of 15 ms^{-1} along its original path. The ball is in contact with the wall for a time of 1.0 ms .

What is the average force exerted by the wall on the ball?

- A 800 N B 2400 N C 3200 N D 5600 N

- 11 A uniform solid block is fully submerged in a tank of water.

The dimensions of the block are x and y , as shown.



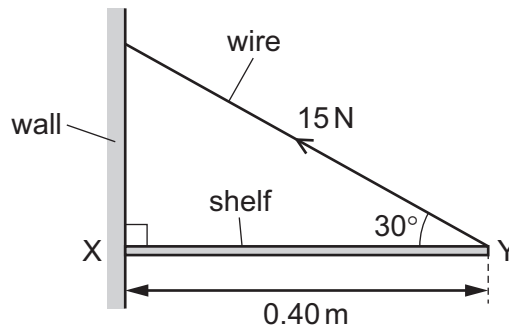
The block is held vertically in the position shown. The density of the block is the same as the density of the water.

If the block is always held at the same depth d below the surface of the water, which single change would **increase** the magnitude of the upthrust force on the block?

- A decrease the density of the block
B hold the block horizontally
C increase dimension y
D increase the density of the block

- 12** A shelf XY is 0.40 m long and is attached to a wall at end X.

It is kept horizontal by a wire attached to Y and to the wall, as shown.



The tension force in the wire is 15 N at an angle of 30° to the horizontal.

What is the moment of this force about point X?

- A** 3.0 N m **B** 5.2 N m **C** 6.9 N m **D** 12 N m
- 13** A statement about the principle of moments with some words omitted is shown.

'For an object in a state of rotational equilibrium, the sum of the clockwise moments about any point is equal to the sum of the anticlockwise moments about '

Which words correctly complete the statement?

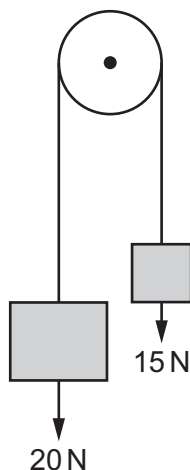
- A** any point
B the centre of gravity of the object
C the pivot
D the same point
- 14** A bird dives to a depth of 1.50 m below the surface of a lake. Atmospheric pressure is 101 kPa. The density of water is 1000 kg m^{-3} .

What is the pressure at this depth?

- A** 14.7 kPa **B** 86.3 kPa **C** 103 kPa **D** 116 kPa
- 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 A pulley of radius 0.40 m supports weights of 20 N and 15 N by means of a thin string, as shown.



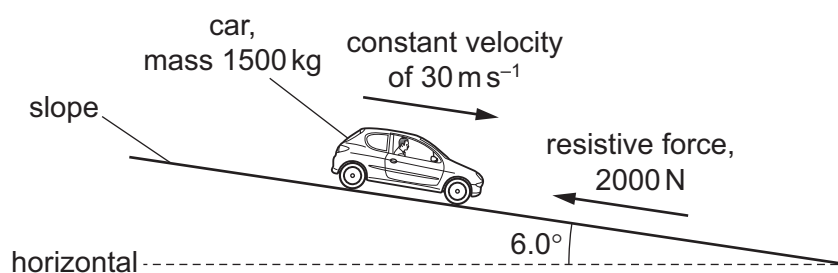
The weights are moved by slowly rotating the pulley clockwise through an angle of 60° .

What is the increase in the total gravitational potential energy of the weights?

- A** 0.33 J **B** 2.0 J **C** 2.1 J **D** 15 J
- 17 A car of mass 1500 kg accelerates from an initial speed of 15 ms^{-1} . This acceleration causes the car to gain $3.0 \times 10^5 \text{ J}$ of kinetic energy.

What is the change in the speed of the car?

- A** 5.4 ms^{-1} **B** 10 ms^{-1} **C** 20 ms^{-1} **D** 25 ms^{-1}
- 18 A car of mass 1500 kg travels at a constant velocity of 30 ms^{-1} down a slope. The slope is at an angle of 6.0° to the horizontal, as shown.



The magnitude of the total resistive force acting on the car is 2000 N.

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

- A** 14 kW **B** 60 kW **C** 110 kW **D** 380 kW

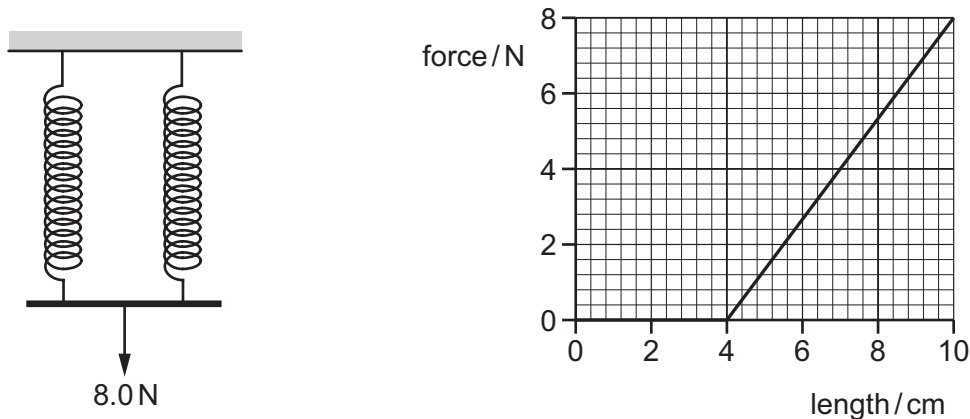
- 19 A metal wire, of cross-sectional area A and unstretched length l , is subjected to stress σ . As a result it has strain ε .

Which expression gives the Young modulus of the metal?

- A $\frac{\varepsilon}{\sigma}$ B $\frac{\varepsilon A}{\sigma l}$ C $\frac{\sigma}{\varepsilon}$ D $\frac{\sigma l}{\varepsilon A}$

- 20 Two identical springs are connected in parallel.

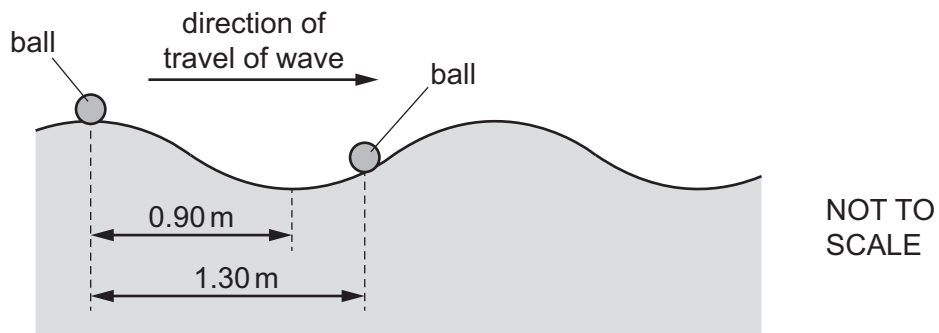
A weight of 8.0 N is hung from the combination, as shown.



The graph shows the variation with length of the force applied to **one** of the springs.

What is the strain energy in **one** of the springs?

- A 0.060 J B 0.12 J C 0.14 J D 0.24 J
- 21 Two balls float on the surface of the sea. The balls are separated by a distance of 1.30 m.
- A wave travels on the surface of the sea so that the balls move vertically up and down.



The distance between a crest and an adjacent trough of the wave is 0.90 m.

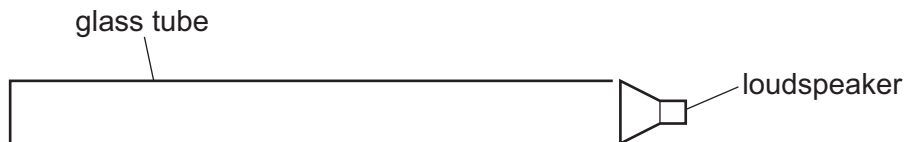
What is the phase difference between the two balls?

- A 55° B 110° C 160° D 260°

22 Which statement about transverse or longitudinal waves is **not** correct?

- A Longitudinal waves can be used to demonstrate diffraction.
- B Longitudinal waves can travel in a vacuum.
- C Transverse waves can form stationary waves.
- D Transverse waves can transfer energy.

23 A glass tube is closed at one end and has a loudspeaker at the other end.



A stationary wave is formed with a node at the closed end of the tube when the sound has frequency f_0 . There are no other nodes.

The frequency of the sound is then slowly increased.

What is the frequency of the sound that produces the next stationary wave?

- A $1.25f_0$
- B $1.50f_0$
- C $2.00f_0$
- D $3.00f_0$

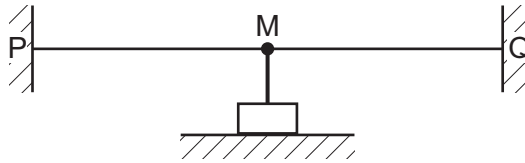
24 With which waves can the Doppler effect be observed?

- A all waves including sound and light
- B light waves only
- C sound and light waves only
- D sound waves only

25 Which radiation could consist of waves of wavelength 0.5 nm?

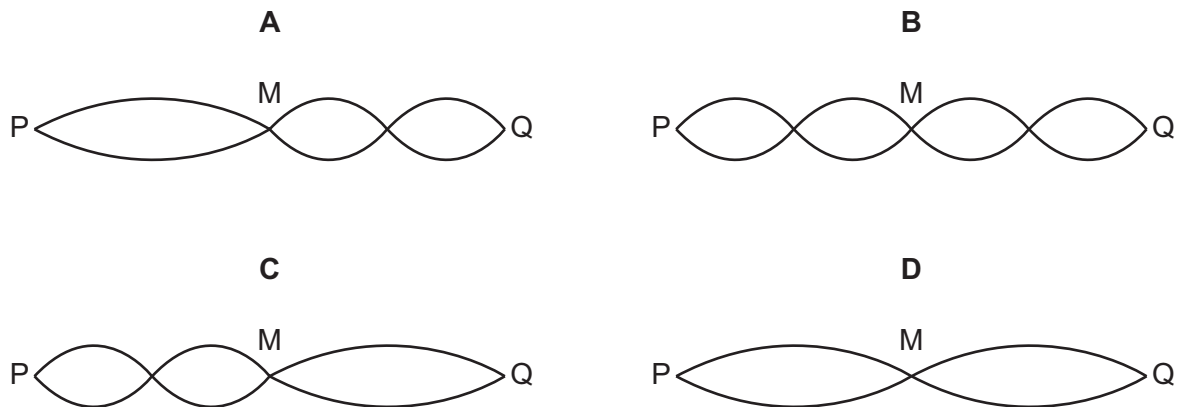
- A γ -rays
- B ultraviolet
- C visible light
- D X-rays

- 26** A string is fixed between point P and an oscillator M. Another string is fixed between M and point Q. M is midway between P and Q.



The frequency of the oscillator is adjusted until a stationary wave is formed on both strings. The speed of the wave between P and M is twice the speed of the wave between M and Q.

Which diagram could represent the stationary wave pattern?

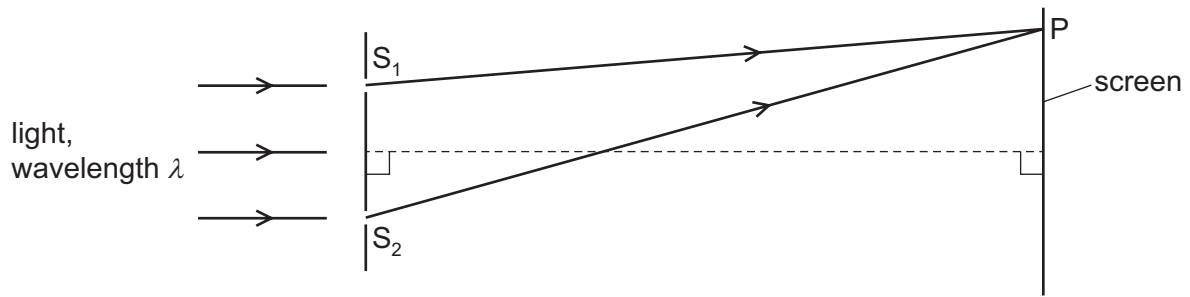


- 27** A water wave in a ripple tank is diffracted as it passes through a gap in a barrier.

Which two factors affect the angle of diffraction of the wave?

- A** the amplitude and frequency of the incident wave
- B** the amplitude of the incident wave and the width of the gap
- C** the wavelength and amplitude of the incident wave
- D** the wavelength of the incident wave and the width of the gap

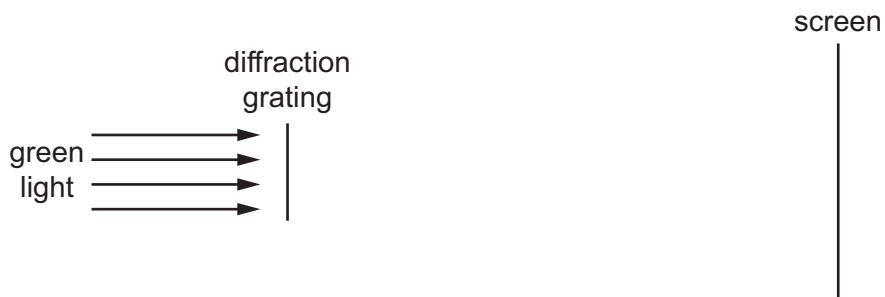
- 28 Light of wavelength λ is incident normally on two narrow slits S_1 and S_2 , a small distance apart. Bright and dark fringes are observed on a screen a long distance away from the slits.



The n th **dark** fringe from the central bright fringe is observed at point P on the screen.

Which equation is correct for all positive values of n ?

- A $S_2P - S_1P = \frac{n\lambda}{2}$
- B $S_2P - S_1P = n\lambda$
- C $S_2P - S_1P = (n - \frac{1}{2})\lambda$
- D $S_2P - S_1P = (n + \frac{1}{2})\lambda$
- 29 Green light is incident normally on a diffraction grating and forms a diffraction pattern on a distant screen.



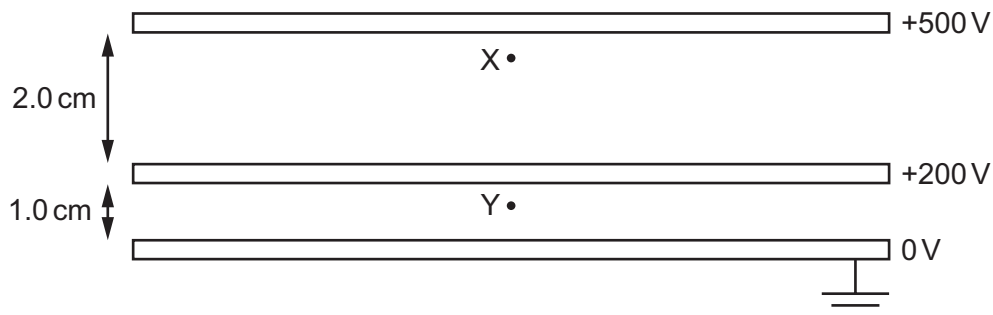
Which change, on its own, would **decrease** the separation of the diffraction maxima on the screen?

- A Increase the distance between the screen and the diffraction grating.
- B Replace the diffraction grating with a grating that has a smaller separation between the slits.
- C Replace the diffraction grating with a grating that has fewer slits per unit length.
- D Replace the green light with red light.

30 What is meant by electric field strength?

- A force per unit charge acting on a small mass
- B force per unit charge acting on a small positive charge
- C force per unit mass acting on a small mass
- D force per unit mass acting on a small positive charge

31 Three parallel metal plates of the same area are fixed with a separation of 2.0 cm between the top plate and the middle plate, and 1.0 cm between the middle plate and the bottom plate. The top plate is held at a potential of +500 V, the middle plate at +200 V and the bottom plate is earthed, as shown.



What is the value of the ratio $\frac{\text{magnitude of force on an electron at X}}{\text{magnitude of force on an electron at Y}}$?

- A 0.75
- B 1.00
- C 1.25
- D 1.50

32 The current I in a wire is given by the equation

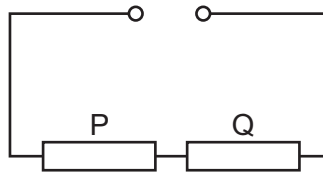
$$I = nAvq$$

where n is the number density of the free electrons, A is the cross-sectional area of the wire, v is the average drift velocity of the free electrons and q is the charge of an electron.

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

- A charge = current $\times$ time
- B distance = speed $\times$ time
- C number = number density $\times$ area
- D volume = length $\times$ area

- 33 A circuit contains two resistors, P and Q, and a power supply of negligible internal resistance, as shown.

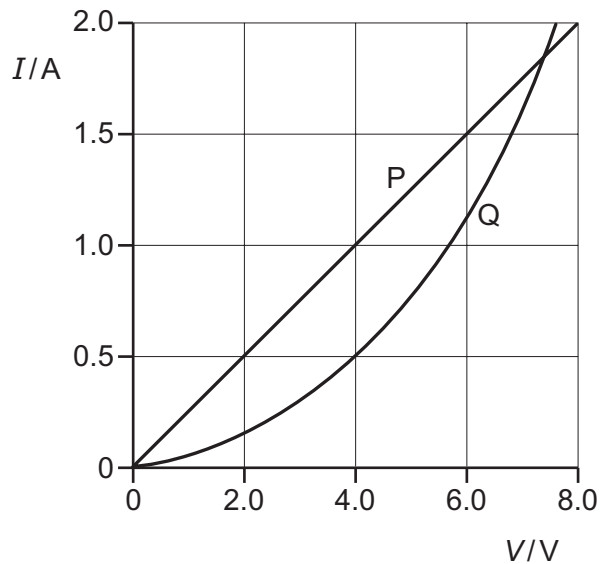


The current in resistor P is 2.0 A and the power dissipated by resistor P is 18 W .

Resistor Q dissipates 240 J of energy when a charge of 40 C passes through it.

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

- A** 3.0 V **B** 6.0 V **C** 9.0 V **D** 15 V
- 34 The I – V characteristics of two electrical components P and Q are shown.



Which statement is correct?

- A** For a current of 0.5 A , the power dissipated in Q is double that in P.
- B** For a current of 1.9 A , the resistance of Q is approximately half that of P.
- C** The resistance of Q increases as the current in it increases.
- D** P is a fixed resistor and Q is a filament lamp.

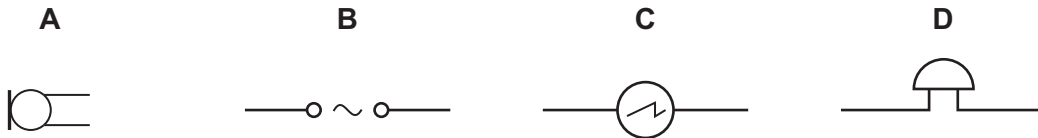
- 35 Two copper wires S and T, of equal length, are connected in parallel. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

A potential difference is applied across the ends of this parallel arrangement.

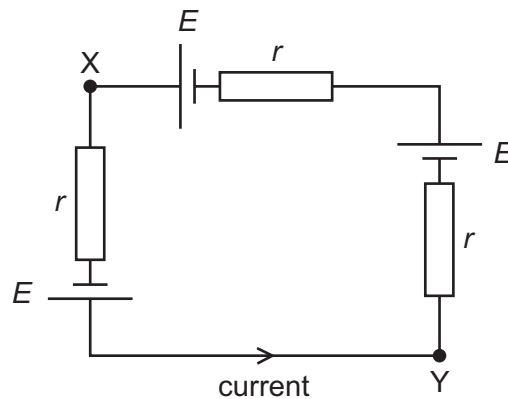
What is the value of the ratio $\frac{\text{current in S}}{\text{current in T}}$?

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

- 36 What is the circuit symbol for an oscilloscope?



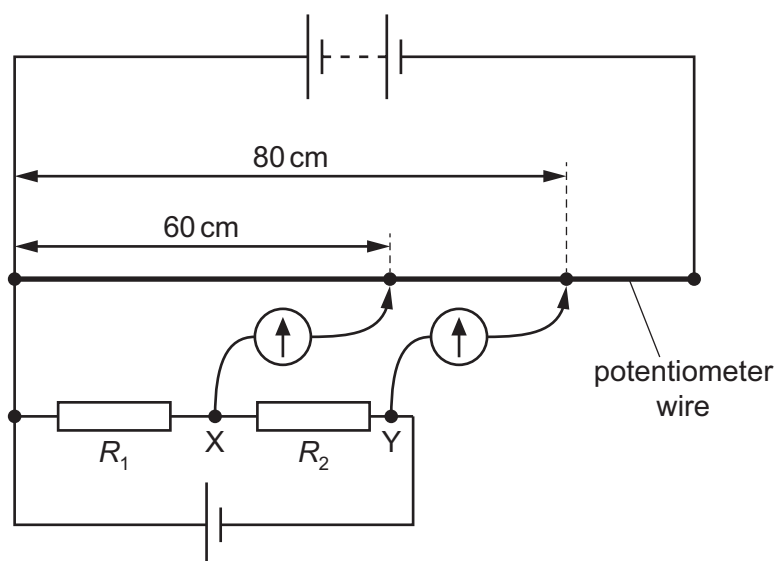
- 37 Three identical cells, each of electromotive force (e.m.f.) E and internal resistance r , are connected as shown.



What is the potential difference between points X and Y?

- A 0 B E C $2E$ D $3E$

- 38 Potential differences across two resistors of resistances R_1 and R_2 are compared using a potentiometer wire (uniform resistance wire) in the electrical circuit shown.



One terminal of a galvanometer is connected to point X. The galvanometer reads zero when its other terminal is connected to a point that is a distance of 60 cm from one end of the potentiometer wire.

One terminal of a second galvanometer is connected to point Y. This galvanometer reads zero when its other terminal is connected to a point that is a distance of 80 cm from the same end of the potentiometer wire.

What is the ratio $\frac{R_2}{R_1}$?

- A $\frac{1}{3}$ B $\frac{3}{4}$ C $\frac{3}{1}$ D $\frac{4}{3}$

- 39 A uranium-238 nucleus, ${}^{238}_{92}\text{U}$, undergoes a series of nuclear decays to form uranium-234, ${}^{234}_{92}\text{U}$.

Which series of decays could give this result?

- A emission of four β^- particles
 B emission of four γ -rays
 C emission of one α -particle and two β^- particles
 D emission of two α -particles and eight β^- particles

- 40 Which combination of up (u) and down (d) quarks forms a proton?

- A u u u B u u d C u d d D d d d

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

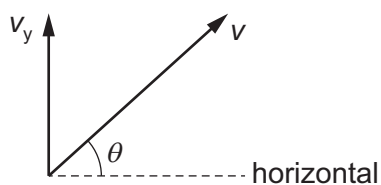
- 1 Which row shows what all physical quantities must have?

	magnitude	direction	unit
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✓
D	✗	✗	✓

- 2 What is an alternative way of expressing an energy of 43 dJ?

- A** $4.3 \times 10^3 \text{ mJ}$
B $4.3 \times 10^3 \text{ MJ}$
C $4.3 \times 10^{-3} \text{ mJ}$
D $4.3 \times 10^{-3} \text{ MJ}$

- 3 A tennis ball is hit so that it leaves the racket with velocity v at an angle θ to the horizontal.

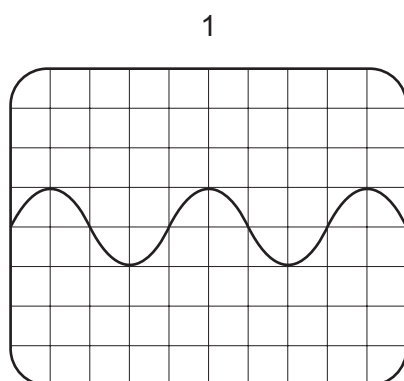


The vertical component of the velocity is v_y .

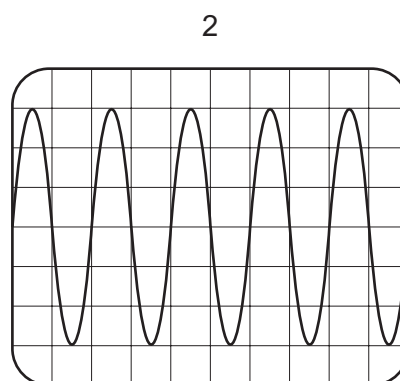
What is the magnitude of the horizontal component of v ?

- A** $v \sin \theta$ **B** $v_y \cos \theta$ **C** $v_y \sin \theta$ **D** $(v^2 - v_y^2)^{\frac{1}{2}}$

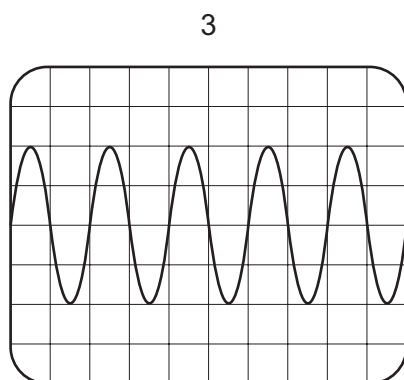
- 4 Four cathode-ray oscilloscope (CRO) screens each display a waveform. The screen and the time-base setting of each CRO is shown.



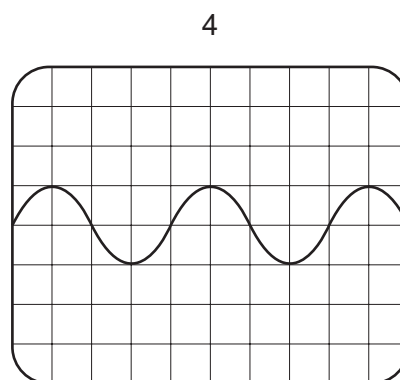
time-base setting: 0.02 s/div



time-base setting: 0.04 s/div



time-base setting: 0.01 s/div



time-base setting: 0.08 s/div

Which screens show waveforms of the same frequency?

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

- 5 A student measures the time T for one complete oscillation of a pendulum of length l .
Her results are shown in the table.

l/m	T/s
0.420 ± 0.001	1.3 ± 0.1

She uses the formula

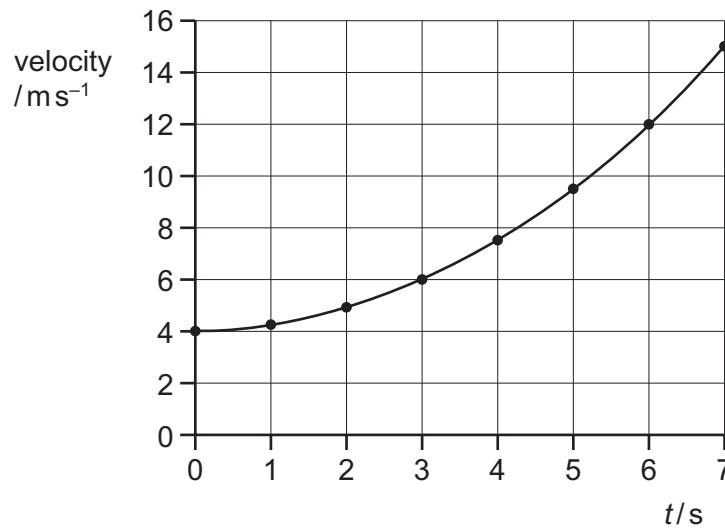
$$T = 2\pi \sqrt{\frac{l}{g}}$$

to calculate the acceleration of free fall g .

What is the best estimate of the percentage uncertainty in the value of g ?

- A** 0.02% **B** 4% **C** 8% **D** 16%

- 6 The graph shows the variation with time t of the velocity of a vehicle moving in a straight line.



The vehicle, moving at 4.0 ms^{-1} , begins to accelerate at time $t = 0$.

What is the vehicle's acceleration at time $t = 3.0 \text{ s}$?

- A** 0.67 ms^{-2} **B** 1.0 ms^{-2} **C** 1.3 ms^{-2} **D** 2.0 ms^{-2}

- 7 A stone is projected vertically upwards from the ground at an initial speed of 15 ms^{-1} . Air resistance is negligible.

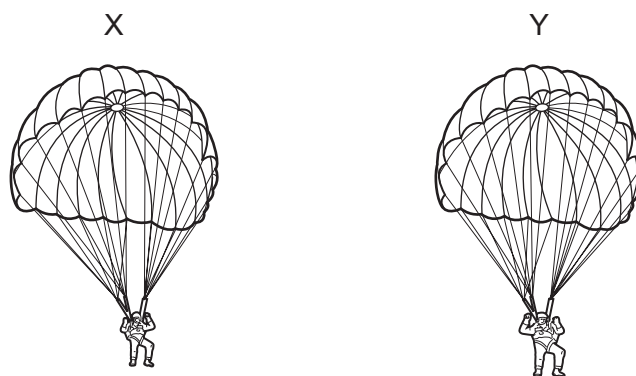
What is the maximum height reached by the stone?

- A** 0.76 m **B** 11 m **C** 23 m **D** 110 m

- 8 What is meant by the mass of an object?

- A** the property of the object that resists a change in motion
B the pull of the Earth on the object
C the total number of atoms in the object
D the weight of the object

- 9 The diagram shows two parachutists, X and Y, moving vertically downwards.



The total mass of parachutist Y and his parachute is twice the total mass of parachutist X and his parachute. At this moment, the air resistance on parachute Y is twice the air resistance on parachute X. Neither parachutist has reached his constant (terminal) velocity.

Which statement describes the acceleration of Y compared with the acceleration of X?

- A The acceleration of Y is half the acceleration of X.
 - B The acceleration of Y is the same as the acceleration of X.
 - C The acceleration of Y is more than the acceleration of X, but less than twice the value.
 - D The acceleration of Y is twice the acceleration of X.
- 10 The table shows four different collisions between two blocks, each of mass 0.50 kg.

Which collision is perfectly elastic?

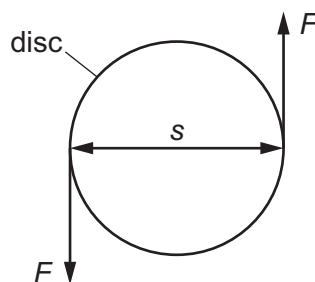
	before collision	after collision
A	$4.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg 0.0 m s^{-1} 0.50 kg	$2.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg 0.50 kg
B	$2.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg $\leftarrow 2.0 \text{ m s}^{-1}$ 0.50 kg	0.0 m s^{-1} 0.50 kg 0.50 kg
C	$2.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg $\leftarrow 1.0 \text{ m s}^{-1}$ 0.50 kg	$\leftarrow 2.0 \text{ m s}^{-1}$ 0.50 kg $3.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg
D	$4.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg $1.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg	$1.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg $4.0 \text{ m s}^{-1} \rightarrow$ 0.50 kg

- 11 A cylindrical block of wood has cross-sectional area A and weight W . It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

What is the upthrust on the block?

- A $(p_b - p_t)$
- B $(p_b - p_t)A$
- C $(p_b - p_t)A - W$
- D $(p_b - p_t)A + W$

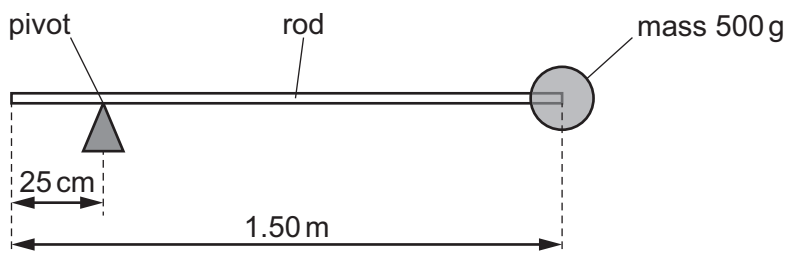
- 12 Two forces, each of magnitude F , act on a disc of diameter s , as shown.



What is the torque exerted on the disc?

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

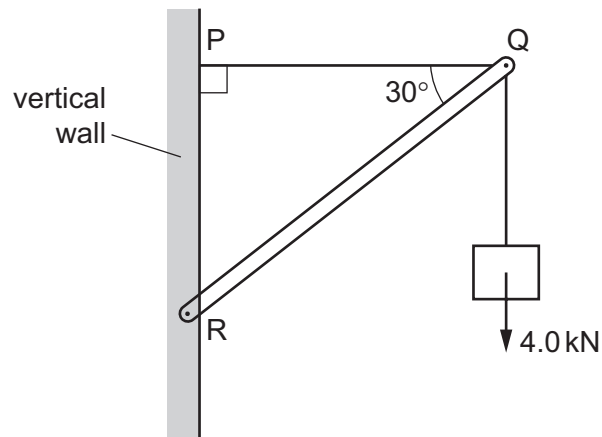
- 13 A mass of 500 g is attached at one end of a rod of length 1.50 m. The rod is pivoted at a distance of 25 cm from the other end. The rod is horizontal.



What is the moment about the pivot due to the mass?

- A 0.63 Nm
- B 1.2 Nm
- C 6.1 Nm
- D 7.4 Nm

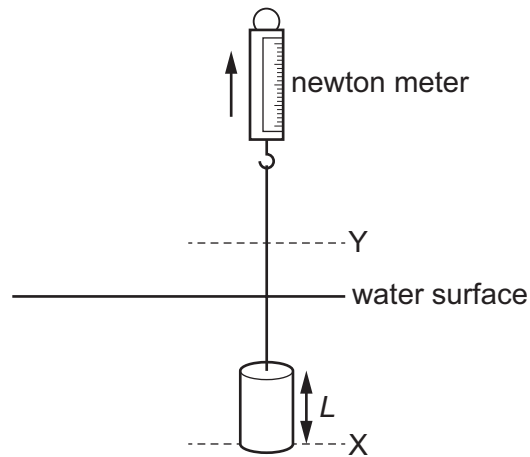
- 14 A beam QR is held in position by a wire PQ. The structure is used to form a crane supporting a stationary load of 4.0 kN, as shown.



What is the force exerted by the beam QR on point Q?

- A** 4.0 kN **B** 4.6 kN **C** 6.9 kN **D** 8.0 kN

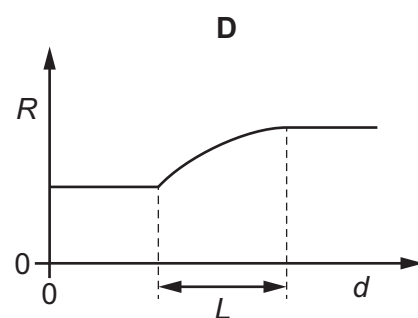
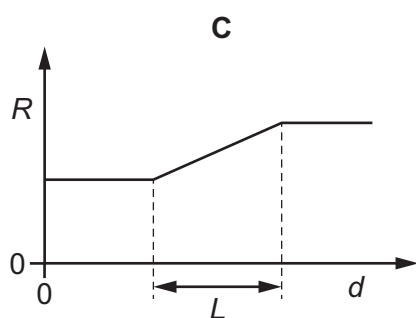
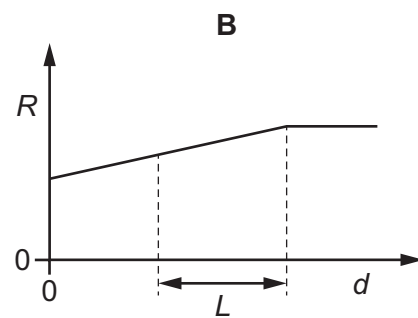
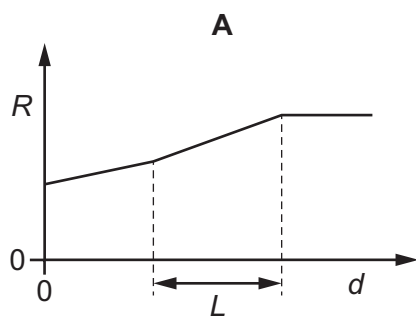
- 15 A metal cylinder, totally immersed in water, is hung from a newton meter.



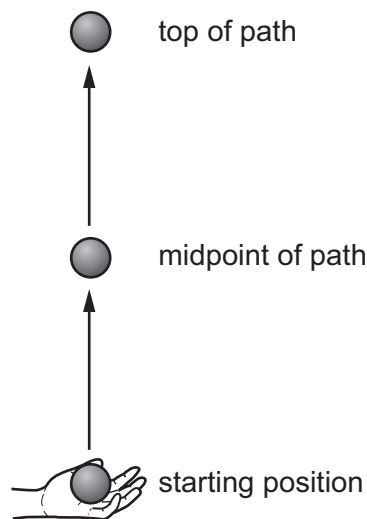
The cylinder, of height L , is slowly raised vertically by lifting the newton meter.

As the base of the cylinder moves from line X in the water to line Y above the surface of the water, the reading R on the newton meter is recorded. The velocity of the cylinder is constant.

Which graph best shows the variation of R with the distance d of the base of the cylinder from line X ?



- 16 A ball is thrown vertically upwards into the air. It rises to the top of its path before beginning to fall vertically downwards.



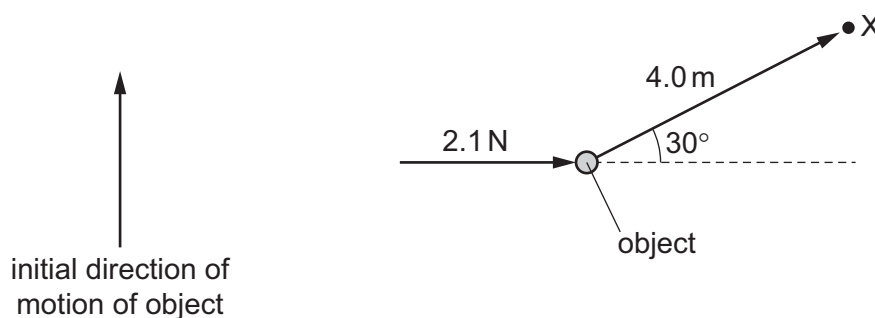
Assume that the gravitational potential energy of the ball is zero at its starting position.

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

- A As it rises, its kinetic energy is transferred to gravitational potential energy.
- B At the midpoint of its path, its gravitational potential energy is equal to its initial kinetic energy.
- C At the top of its path, its kinetic energy is zero.
- D At the top of its path, its total energy is less than its initial total energy.

- 17 An object slides with constant velocity across a horizontal sheet of ice. Friction is negligible.

A constant horizontal force of 2.1 N is then applied to the object as shown.



A short time after applying the force, the object reaches point X at a displacement of 4.0 m from its position when the force was first applied.

What is the work done by the force on the object as it travels to point X?

- A 4.2 J
- B 4.8 J
- C 7.3 J
- D 8.4 J

- 18 The energy conversions inside a power station burning fossil fuel can be simplified as shown.

chemical energy $W \rightarrow$ thermal energy $X \rightarrow$ electrical energy Y

Which expression gives the efficiency of the power station?

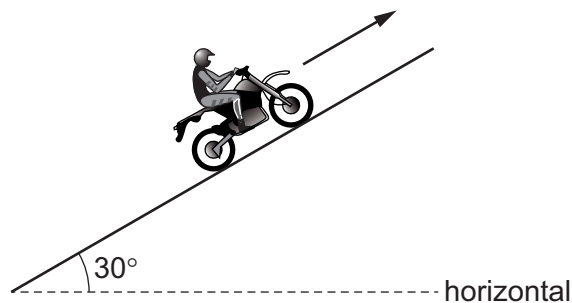
- A $\frac{Y}{W}$ B $\frac{Y}{(W + X)}$ C $\frac{Y}{X}$ D $\frac{Y}{(W + X + Y)}$

- 19 Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.

Which statement is correct?

- A Car X has half the kinetic energy of car Y.
 B Car X has one quarter of the kinetic energy of car Y.
 C Car X has twice the kinetic energy of car Y.
 D The two cars have the same kinetic energy.

- 20 The total weight of a motorbike and rider is 1800 N. The motorbike travels in a straight line at constant speed up a hill at an angle of 30° to the horizontal.

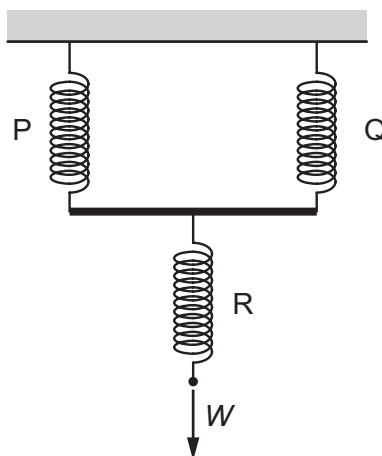


The useful output power of the motorbike is 36 000 W. The total resistive force due to air resistance and friction on the motorbike and rider is 2400 N.

What is the speed of the motorbike?

- A 8.6 ms^{-1} B 11 ms^{-1} C 15 ms^{-1} D 24 ms^{-1}

21 Three springs are arranged vertically as shown.

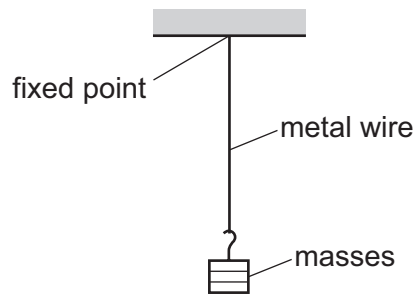


Springs P and Q are identical and each has spring constant k . Spring R has spring constant $3k$.

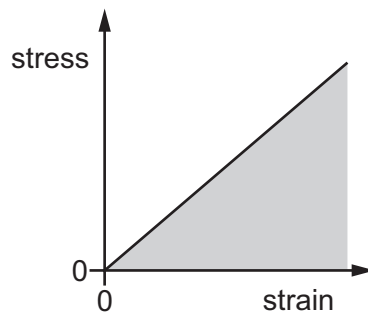
What is the increase in the overall length of the arrangement when a force W is applied as shown?

- A $\frac{5W}{6k}$ B $\frac{4W}{3k}$ C $\frac{7}{2}kW$ D $4kW$

- 22 A length of metal wire is attached to a fixed point and hangs vertically. Masses are then suspended from the wire. Assume that the cross-sectional area of the wire remains constant.



A stress–strain graph for the wire is plotted, as shown.



What is represented by the shaded area under the graph?

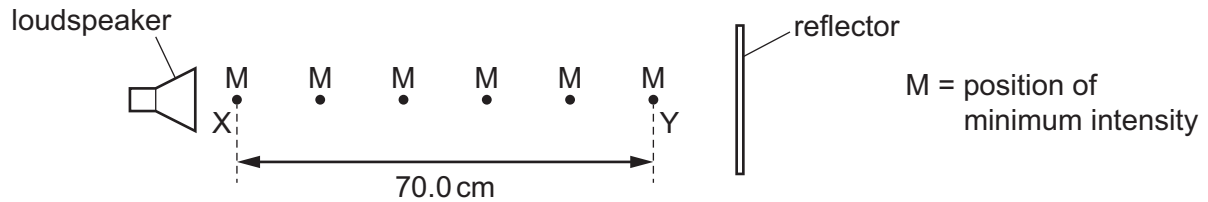
- A** strain energy in the wire
- B** $\frac{\text{strain energy in the wire}}{\text{cross-sectional area of the wire}}$
- C** $\frac{\text{strain energy in the wire}}{\text{original length of the wire}}$
- D** $\frac{\text{strain energy in the wire}}{\text{original volume of the wire}}$
- 23 The table contains descriptions and examples of waves.

Which row is correct?

	description of wave	example
A	oscillations are parallel to the direction of energy transfer	gamma-rays
B	oscillations are parallel to the direction of energy transfer	ultraviolet waves
C	oscillations are perpendicular to the direction of energy transfer	sound waves
D	oscillations are perpendicular to the direction of energy transfer	X-rays

- 24** A sound wave from a loudspeaker is reflected back along its original path by a reflector.

A microphone is initially at point X where the sound intensity is a minimum, as shown.



The microphone is moved towards the reflector and passes through four more intensity minima until reaching a fifth minimum at point Y. The distance XY is 70.0 cm.

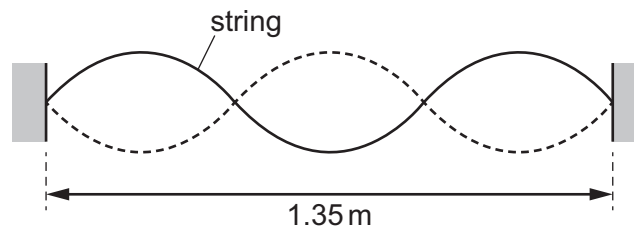
What is the wavelength of the sound?

- A** 11.7 cm **B** 14.0 cm **C** 23.3 cm **D** 28.0 cm
- 25** A train travels in a straight line at a constant speed of 30 ms^{-1} . The train's horn continuously emits sound of frequency 2400 Hz.
- A stationary observer stands next to the train track. The train approaches the stationary observer, passes him and then moves away.
- The speed of sound is 340 ms^{-1} .
- What is the maximum difference in the frequencies of the sound heard by the stationary observer?
- A** 190 Hz **B** 230 Hz **C** 430 Hz **D** 460 Hz
- 26** Electromagnetic waves of frequency 30 THz are in a vacuum.

In which region of the electromagnetic spectrum are the waves?

- A** infrared
- B** microwave
- C** ultraviolet
- D** visible light

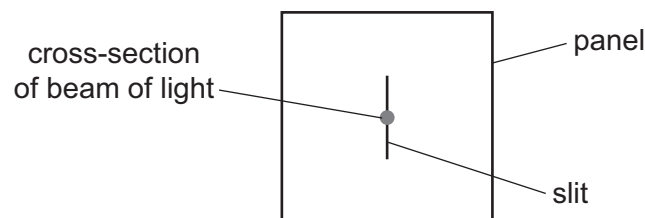
- 27** A stationary wave is produced on a string that is stretched between two fixed points that are a distance of 1.35 m apart, as shown.



The speed of the waves on the string is 450 m s^{-1} .

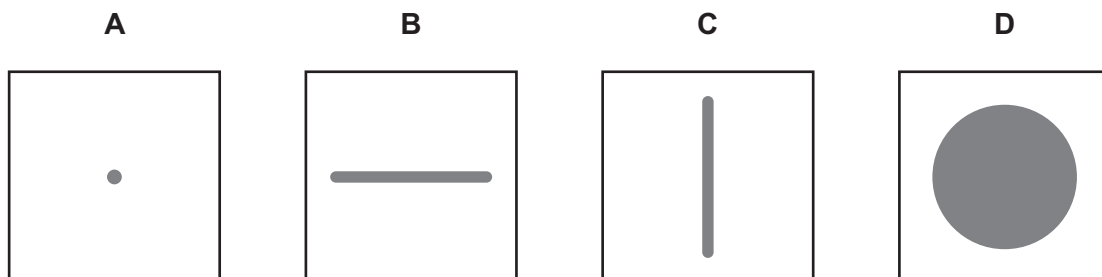
What is the frequency of oscillation of the stationary wave?

- A** 333 Hz **B** 405 Hz **C** 500 Hz **D** 1000 Hz
- 28** A beam of laser light is directed towards a narrow slit.



After emerging from the other side of the slit, the diffracted light then falls on a screen.

What is the pattern of light seen on the screen?

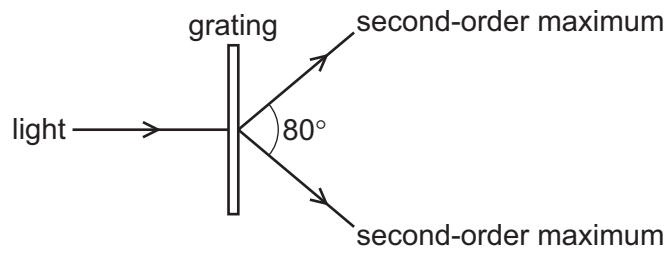


- 29** Two waves, each with a constant amplitude, interfere and produce an interference pattern. The pattern has minima at fixed points where the displacement is zero at all times.

Which statement describes the two waves?

- A** They must be coherent and of the same amplitude.
B They must be coherent but not necessarily of the same amplitude.
C They must be of the same amplitude but not necessarily coherent.
D They must not be coherent or of the same amplitude.

- 30 Light of wavelength $5.5 \times 10^{-7} \text{ m}$ is incident normally on a diffraction grating.

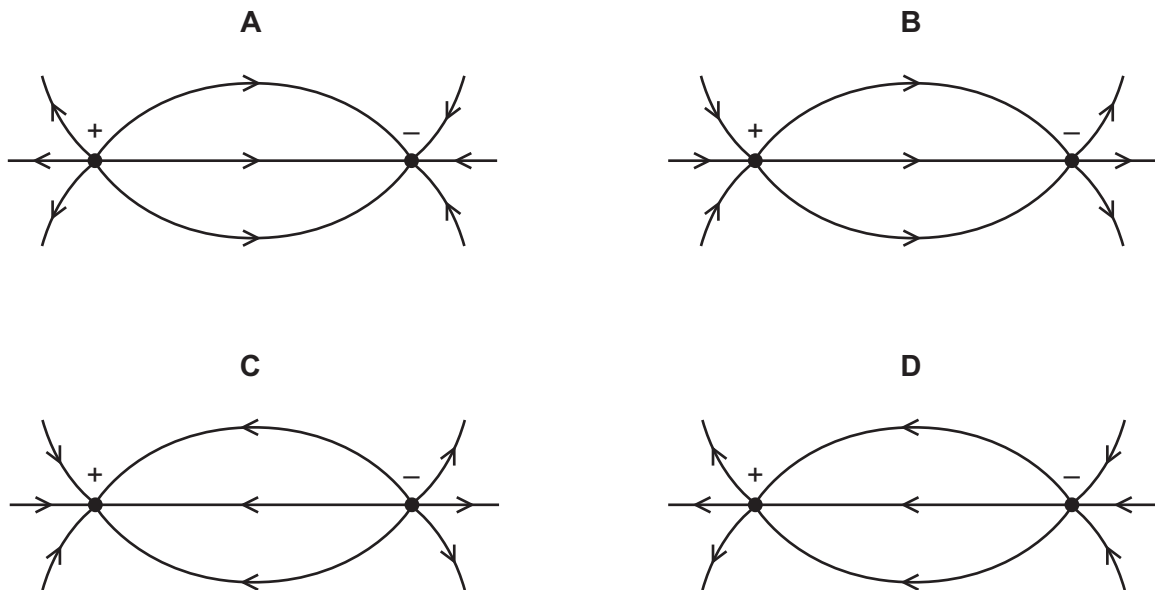


The angle between the second-order diffraction maxima is 80° , as shown.

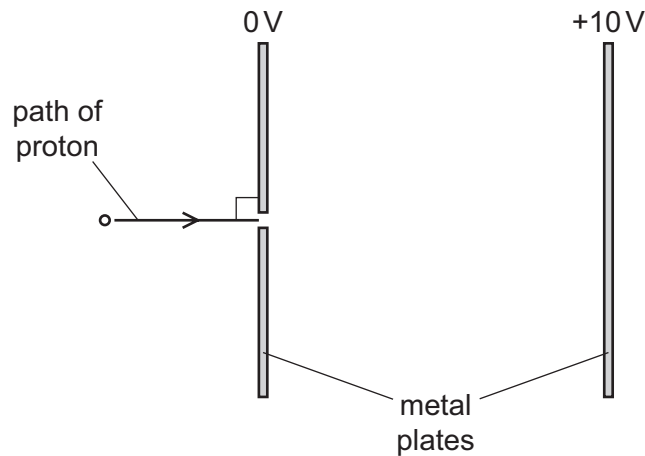
What is the number of lines per metre of the diffraction grating?

- A** 5.8×10^5 lines per metre
B 9.0×10^5 lines per metre
C 1.2×10^6 lines per metre
D 2.3×10^6 lines per metre
- 31 Four diagrams representing the electric field between two oppositely charged point charges are shown.

Which diagram correctly shows the electric field lines?



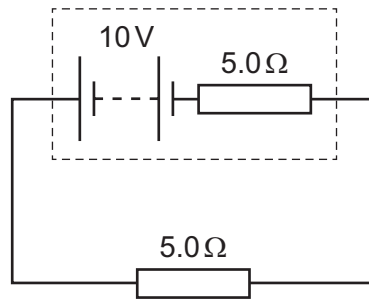
- 32** A proton enters the uniform electric field between two parallel vertical metal plates in a vacuum. One plate is at a potential of 0 V and the other plate is at a potential of +10 V, as shown.



What is the initial change in the motion of the proton caused by the electric field, immediately after the proton enters the field?

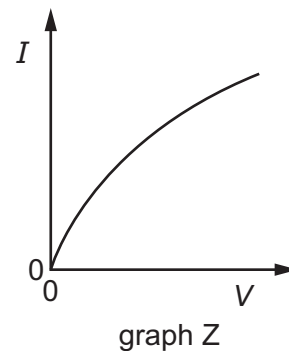
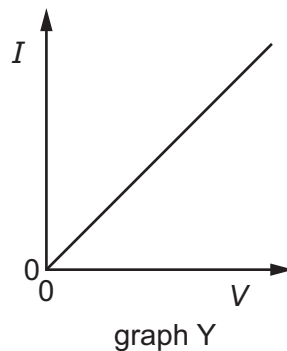
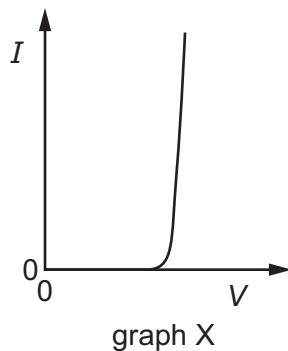
- A** It begins to move downwards.
 - B** It begins to move upwards.
 - C** Its speed decreases.
 - D** Its speed increases.
- 33** What is a description of the coulomb?
- A** the electric charge of one electron
 - B** the electric charge transferred by a current of one ampere in one second
 - C** the kinetic energy gained by an electron accelerated through a potential difference of one volt
 - D** the kinetic energy of an electron moving at a speed of one metre per second

- 34** A battery of electromotive force (e.m.f.) 10 V and internal resistance $5.0\ \Omega$ is connected to a $5.0\ \Omega$ load resistor.



Which change occurs when the $5.0\ \Omega$ load resistor is replaced with a $50\ \Omega$ load resistor?

- A** The current in the circuit increases.
 - B** The potential difference across the load resistor increases.
 - C** The power dissipated in the internal resistance of the battery increases.
 - D** The total power dissipated in the circuit increases.
- 35** The graphs show the variation with potential difference V of the current I for three circuit components.



The components are a metal wire at constant temperature, a semiconductor diode and a filament lamp.

Which row correctly identifies these graphs?

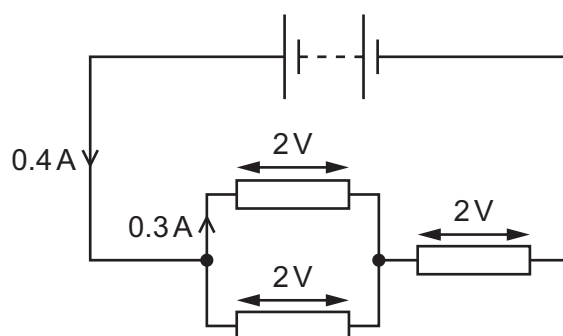
	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

- 36** The electromotive force (e.m.f.) of a cell is 6.0 V . It has negligible internal resistance and is connected across a resistor. The potential difference (p.d.) across the resistor is also 6.0 V .

The e.m.f. and the p.d. have the same numerical value but represent different processes.

Which statement about the different processes is correct?

- A** The e.m.f. is the energy transferred from chemical energy to electrical energy in the cell and the p.d. is the energy transferred from electrical energy to thermal energy in the resistor.
- B** The p.d. is the energy transferred from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred from electrical energy to thermal energy in the resistor.
- C** The e.m.f. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the p.d. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.
- D** The p.d. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.
- 37** A battery of negligible internal resistance is connected to three resistors, as shown.



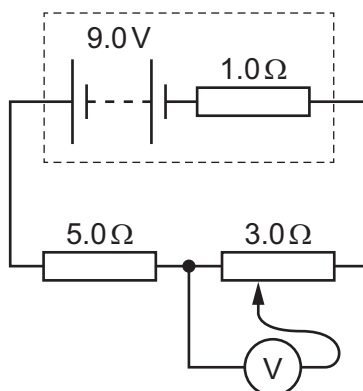
The potential difference across each resistor is 2 V .

The current from the battery is 0.4 A and the current through one of the resistors connected in parallel is 0.3 A .

What is the current through the other resistor connected in parallel and what is the electromotive force (e.m.f.) of the battery?

	current / A	e.m.f. / V
A	0.1	4
B	0.3	4
C	0.1	6
D	0.3	6

- 38 A battery of electromotive force (e.m.f.) 9.0 V and internal resistance $1.0\ \Omega$ is connected to a fixed resistor of resistance $5.0\ \Omega$ and a potentiometer of maximum resistance $3.0\ \Omega$, as shown.



The sliding contact of the potentiometer is moved over its full range of movement.

What is the maximum value of the potential difference that is measured by the voltmeter?

- A** 3.0 V **B** 3.4 V **C** 4.5 V **D** 5.4 V
- 39 An unstable nucleus decays by emitting a β^+ particle.
- Which statement is correct?
- A** An antineutrino is also emitted.
- B** A neutron changes into a proton.
- C** Mass–energy is conserved.
- D** The nucleon number is not conserved.
- 40 Which statement is **not** correct?
- A** An antineutrino is a fundamental particle.
- B** An electron is made up of a quark and an antiquark.
- C** A neutrino is a lepton.
- D** A neutron is composed of three quarks.

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Cambridge International AS & A Level

PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2021

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

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

INSTRUCTIONS

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

INFORMATION

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

This document has **20** pages. Any blank pages are indicated.



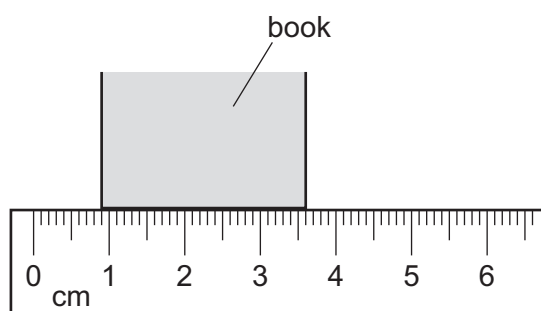
Data

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

Formulae

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

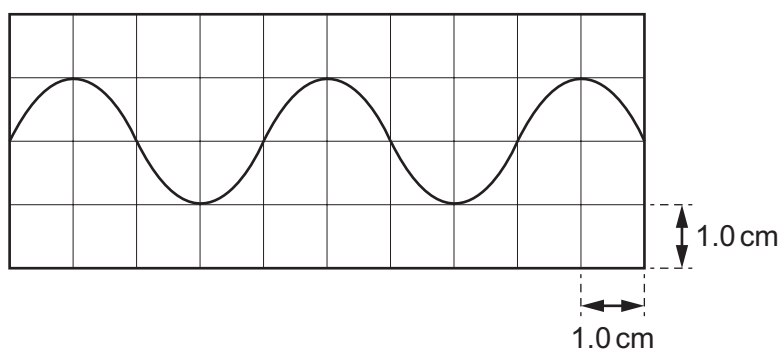
- 1 A paperback book contains 210 sheets of paper (pages). Its thickness is measured with a ruler, as shown.



What is the average thickness of one sheet of the paper in the book?

- A** 0.013 mm **B** 0.017 mm **C** 0.13 mm **D** 0.17 mm
- 2 What is the unit of resistance when expressed in SI base units?
- A** $\text{kg}^{-1} \text{m}^{-2} \text{sA}^2$
B $\text{kg}^{-1} \text{m}^{-2} \text{s}^3 \text{A}^2$
C $\text{kgm}^2 \text{s}^{-1} \text{A}^{-2}$
D $\text{kgm}^2 \text{s}^{-3} \text{A}^{-2}$
- 3 Which list consists only of scalar quantities?
- A** acceleration, displacement, force, weight
B density, energy, frequency, velocity
C distance, pressure, temperature, time
D momentum, power, volume, wavelength

- 4 The output of a signal generator is connected to a cathode-ray oscilloscope (CRO). A trace is shown on the screen.



The time-base of the CRO is set at 2.00 ms cm^{-1} .

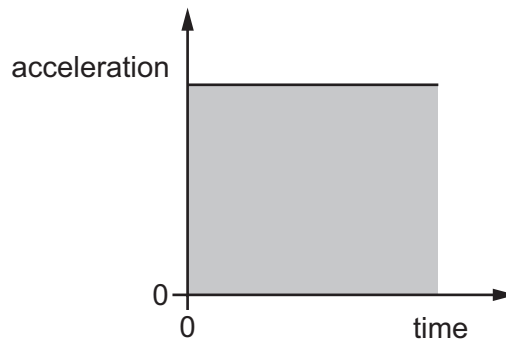
What is the frequency of the signal?

- A** 50 Hz **B** 125 Hz **C** 250 Hz **D** 500 Hz
- 5 After measuring the width of a shelf to be 305 mm, it is found that the graduations on the ruler used are 1.0% further apart than they should be.

Which type of measurement error is this and what is the true width of the shelf?

	type of error	true width / mm
A	random	302
B	random	308
C	systematic	302
D	systematic	308

- 6 The graph shows the variation with time of the acceleration of a car.

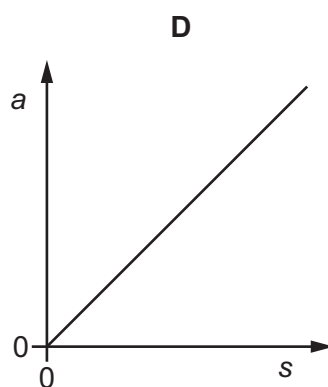
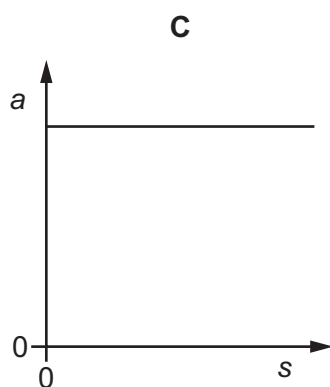
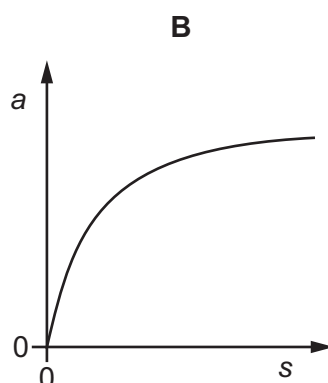
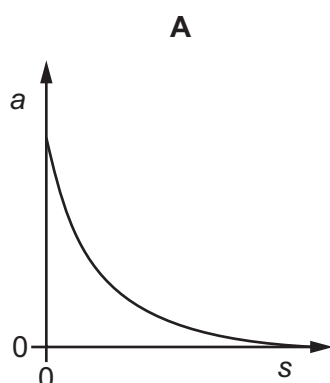


What **must** the shaded area under the graph represent?

- A the average velocity of the car
 - B the change in velocity of the car
 - C the final velocity of the car
 - D the initial velocity of the car
- 7 A stone is thrown horizontally off a cliff and then lands in the sea. Air resistance is negligible.
- Which statement about the stone's motion is **not** correct?
- A The final displacement of the stone depends upon its initial horizontal velocity.
 - B The stone travels with a constant horizontal component of velocity until it hits the water.
 - C The stone travels with an increasing vertical component of velocity.
 - D The time taken for the stone to hit the surface of the water depends on its initial horizontal velocity.
- 8 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 110 000 N

- 9 A skydiver leaves a stationary balloon and falls vertically through a long distance.

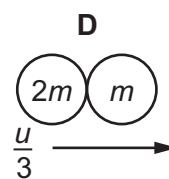
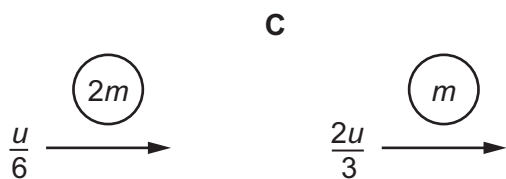
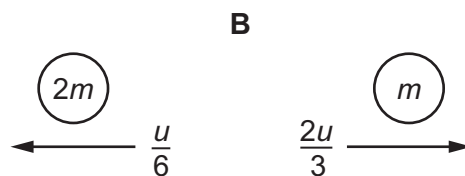
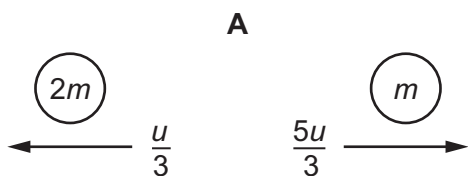
Which graph best represents the variation of the acceleration a of the skydiver with the distance s travelled as she falls through the air?



- 10 The diagram shows two spheres approaching each other head-on. Each sphere has speed u . One sphere has mass $2m$ and the other has mass m .



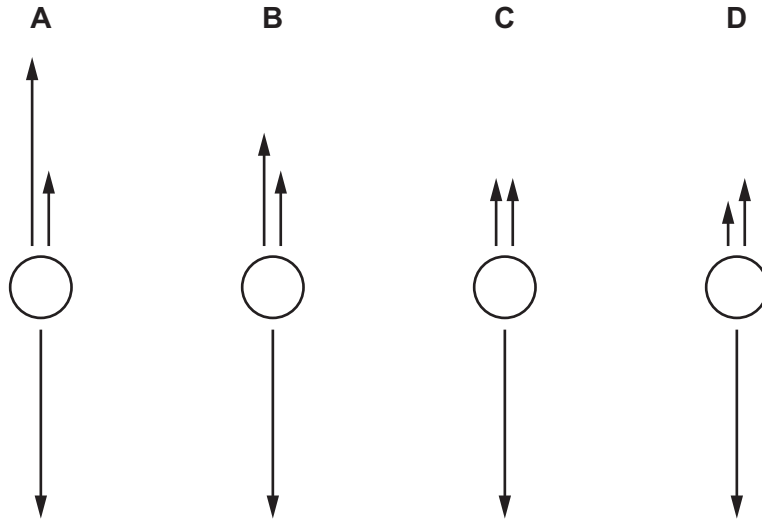
Which diagram shows the result of a perfectly elastic collision?



the spheres stick together

- 11 A spherical object falls through water at a constant speed. Three forces act on the object.

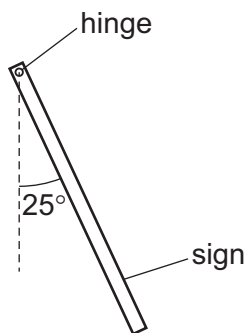
Which diagram, showing these three forces to scale, is correct?



- 12 Two forces act as a couple.

Which statement about the two forces must **not** be correct?

- A They act along the same straight line.
 - B They act in opposite directions.
 - C They are the same type of force.
 - D They have the same magnitude.
- 13 A sign outside a shop is suspended from a rusty horizontal hinge at its top end. The sign hangs in equilibrium at an angle of 25° to the vertical, as shown.

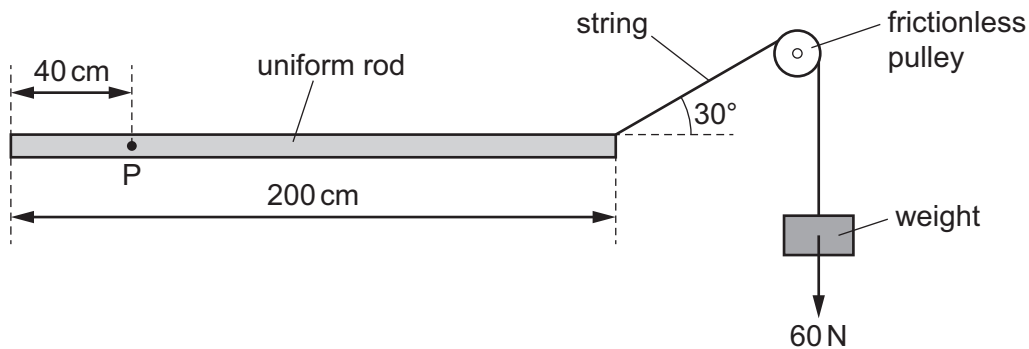


The sign is a square of side length 52 cm and uniform thickness. It has a mass of 36 kg.

What is the moment of the weight of the sign about the hinge?

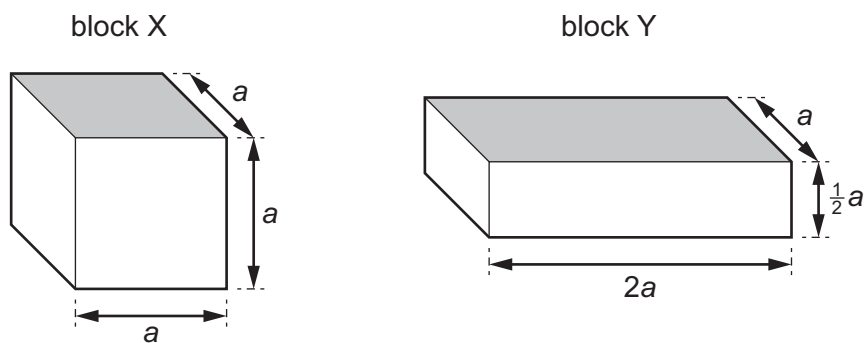
- A 39 Nm
- B 78 Nm
- C 83 Nm
- D 92 Nm

- 14 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
- 15 The diagram shows two blocks X and Y.



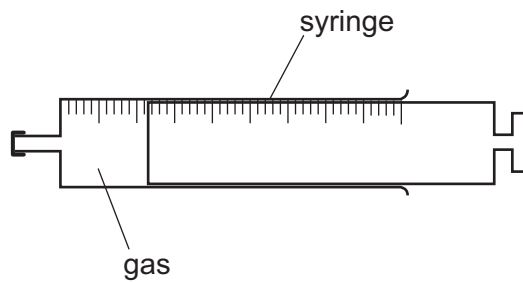
Block X has sides of length a . When block X is placed in a liquid of density ρ with the shaded face level with the liquid surface, it experiences an upthrust U .

Block Y has horizontal sides of length a and $2a$ and height $\frac{1}{2}a$. Block Y is placed in a liquid of density 2ρ , also with the shaded face level with the liquid surface.

What is the upthrust on block Y?

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

- 16 A gas is contained inside a syringe, as shown.



The initial volume of the gas is 2.00 cm^3 .

Atmospheric pressure is 101 kPa .

What is the work done by the gas on the atmosphere when the gas is heated and expands to a volume of 6.00 cm^3 ?

- A** $404 \mu\text{J}$ **B** 404 mJ **C** 404 J **D** 404 kJ
- 17 A mechanical device does useful work at rate X and wastes energy at rate Y .

Which expression gives the efficiency of this device?

- A** $\frac{X}{Y}$ **B** $\frac{(X - Y)}{Y}$ **C** $\frac{X}{(X + Y)}$ **D** $\frac{(X - Y)}{(X + Y)}$

- 18 Car P has kinetic energy 240 kJ .

Car Q has half the mass and twice the speed of car P.

What is the kinetic energy of car Q?

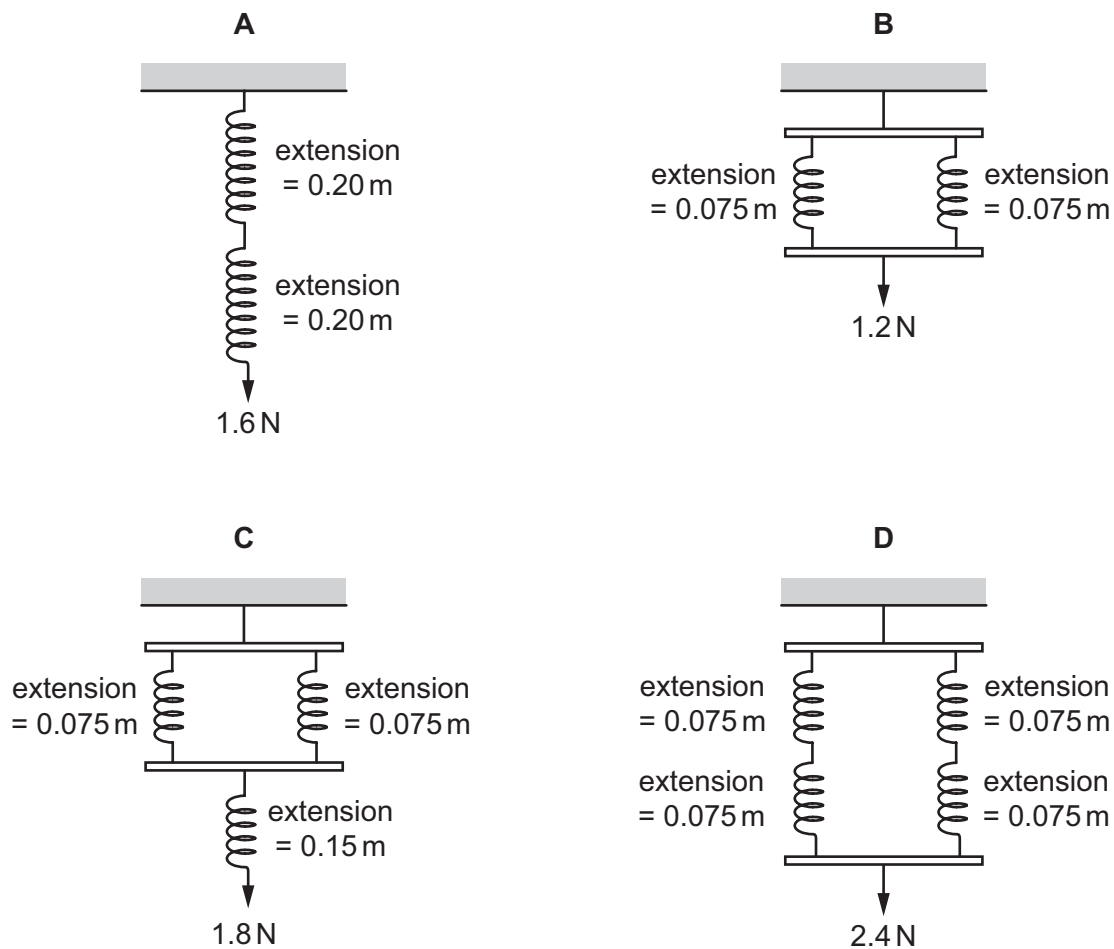
- A** 120 kJ **B** 240 kJ **C** 480 kJ **D** 960 kJ
- 19 A water pump is driven by an engine. The pump raises a volume of 0.50 m^3 of water in 1.0 minute from a depth of 30 m . The pump has an efficiency of 70% .

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

What is the useful output power from the engine?

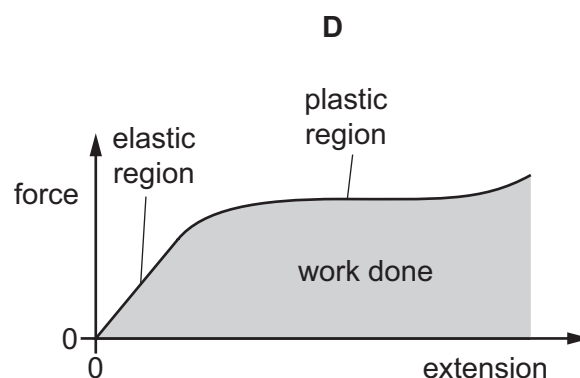
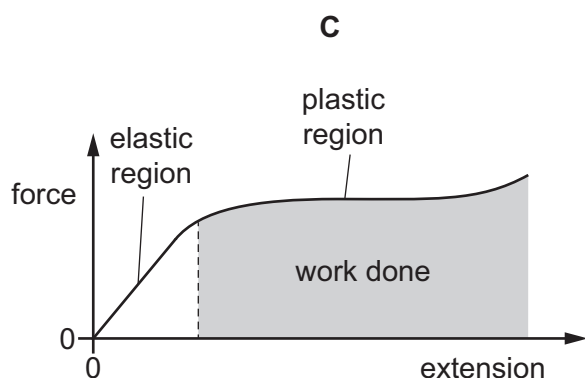
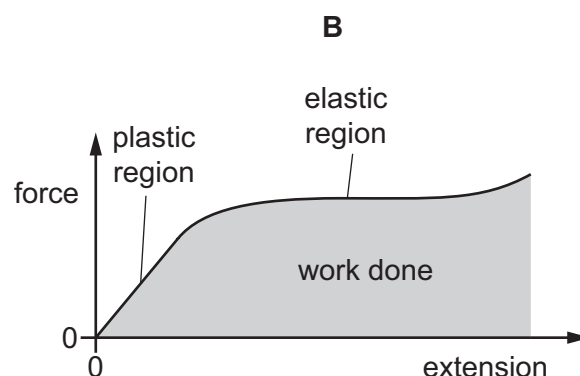
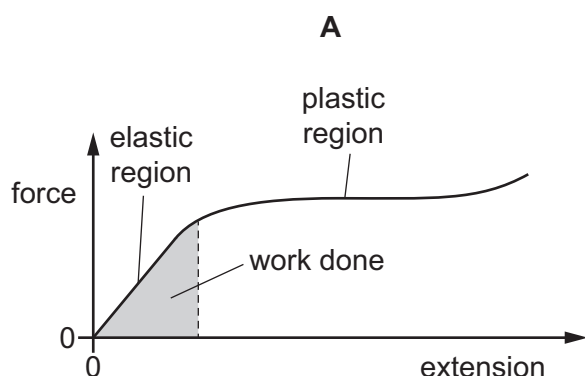
- A** 2.5 kW **B** 3.5 kW **C** 150 kW **D** 210 kW

20 Which spring combination has an overall spring constant of 8.0 N m^{-1} ?



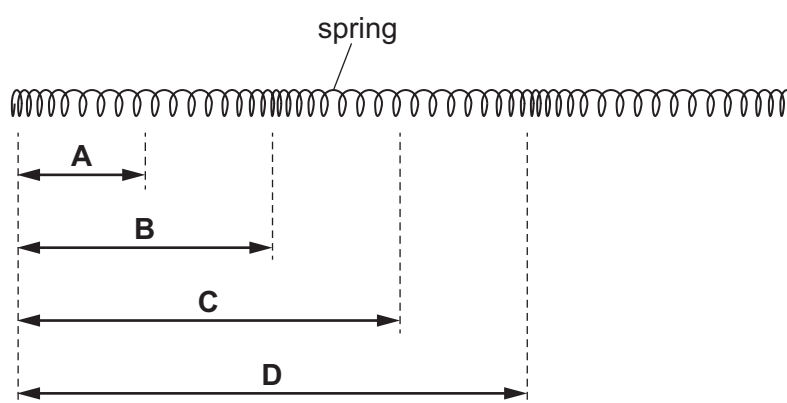
21 A metal wire is stretched to breaking point and the force–extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?



22 A longitudinal wave travels through a long spring. The spring is shown at one instant.

What is the wavelength of the wave?



23 Which statement about waves is correct?

- A Both longitudinal and transverse waves can travel through a vacuum.
- B Both longitudinal and transverse waves transfer matter.
- C Longitudinal progressive waves consist of alternate nodes and antinodes.
- D The particles of a transverse wave vibrate perpendicular to the direction of energy propagation.

24 A stationary sound wave is formed in a pipe that is closed at one end and open at the other end. The wave has two antinodes. One of these antinodes is at the open end of the pipe.

The length of the pipe is 0.600 m. The speed of sound in the air column in the pipe is 340 m s^{-1} .

What is the frequency of the sound wave?

- A 425 Hz B 850 Hz C 1130 Hz D 2270 Hz

25 A train travels at constant speed along a straight track. The train's horn emits sound of frequency 500 Hz.

A person standing by the side of the track hears sound of frequency 450 Hz.

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

What is the speed of the train and in which direction is it travelling relative to the person?

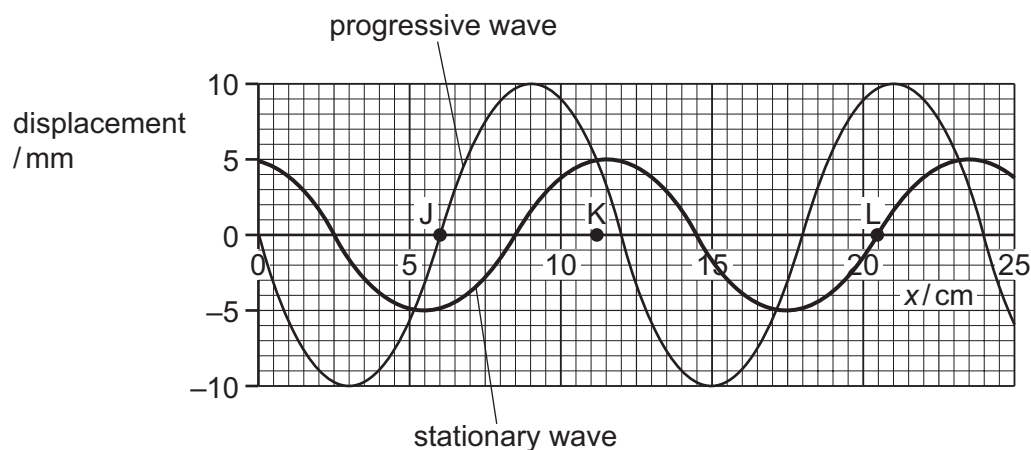
	speed / m s^{-1}	direction
A	34	away from the person
B	34	towards the person
C	38	away from the person
D	38	towards the person

26 A smooth surface has bumps on the surface that are smaller than the wavelength of visible light.

What is the approximate maximum size of the largest bumps on the surface?

- A 20 nm B 350 nm C 720 nm D $5.0 \mu\text{m}$

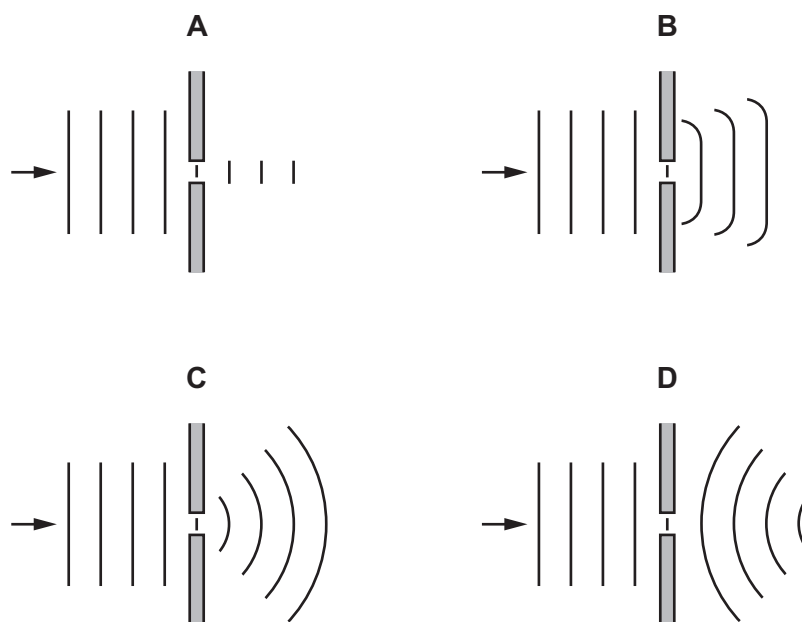
- 27 Two progressive waves travel in opposite directions and form a stationary wave. The graph shows the variation with distance x of the displacement of the stationary wave and of one of the two progressive waves at the same instant in time.



What are the approximate displacements of the **other** progressive wave at the positions J, K and L?

	displacement / mm		
	J	K	L
A	-5	0	-10
B	-5	+5	0
C	0	+5	+10
D	+5	-5	0

- 28 Which diagram shows the diffraction of water waves in a ripple tank?

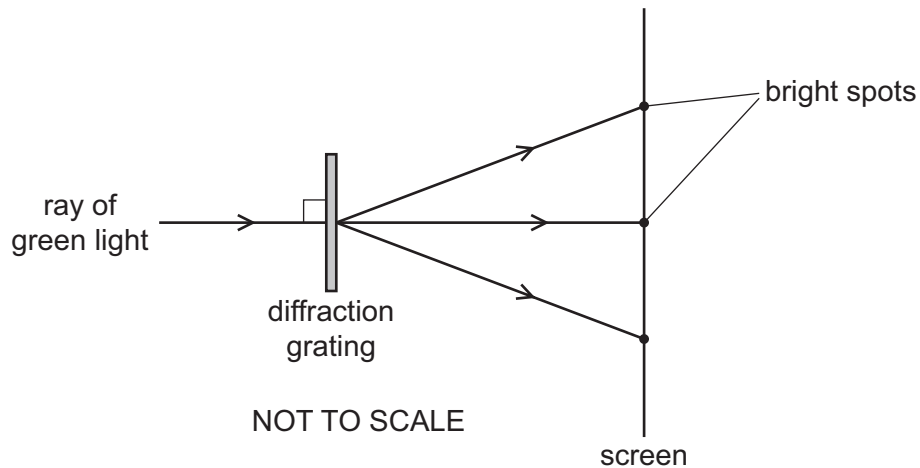


- 29 Interference fringes are produced on a screen by double-slit interference using light of wavelength 600 nm. The fringe separation is 4.0 mm and the separation of the slits is 0.60 mm.

What is the distance between the double slit and the screen?

- A 0.25 m B 0.40 m C 2.5 m D 4.0 m

- 30 A ray of green light is incident normally on a diffraction grating. Several bright spots are produced on a screen on the other side of the grating, as shown.

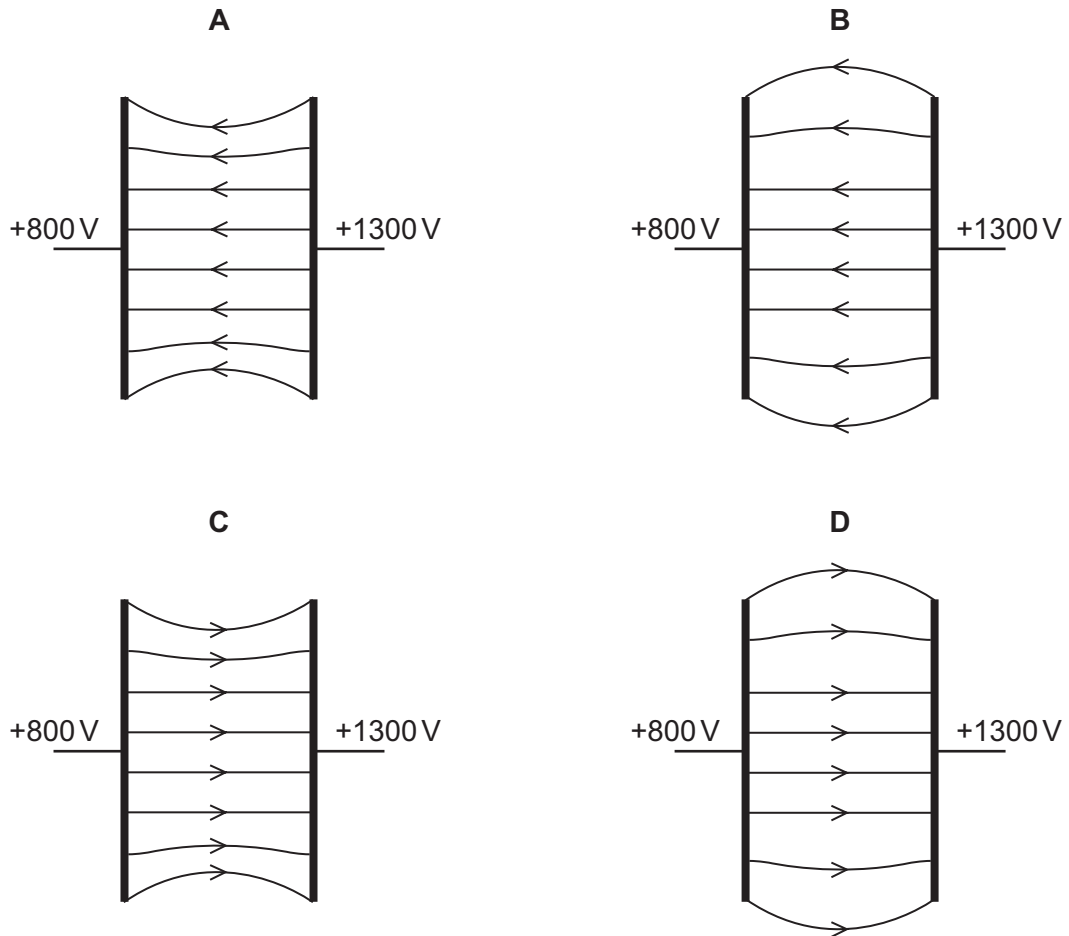


Which pair of changes could result in bright spots at exactly the same angles as previously?

- A Use blue light and increase the distance between the grating and the screen.
B Use blue light and increase the number of lines per unit length in the grating.
C Use red light and increase the distance between the grating and the screen.
D Use red light and increase the number of lines per unit length in the grating.

- 31 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?

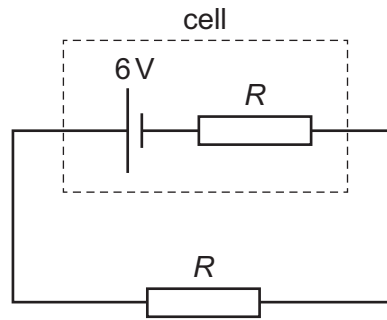


- 32 An electron is in a uniform electric field of field strength 1500 V m^{-1} .

What is the acceleration of the electron due to the electric field?

- A $8.5 \times 10^{-9} \text{ m s}^{-2}$
 - B $1.6 \times 10^{-5} \text{ m s}^{-2}$
 - C $1.4 \times 10^{11} \text{ m s}^{-2}$
 - D $2.6 \times 10^{14} \text{ m s}^{-2}$
- 33 A lightning strike transfers 1×10^{20} electrons past a point in a time of $30 \mu\text{s}$.
- What is the average current during the lightning strike?
- A 0.5 mA
 - B 0.5 A
 - C 500 A
 - D 500 kA

- 34 A cell has an electromotive force (e.m.f.) of 6V and internal resistance R . An external resistor, also of resistance R , is connected across this cell, as shown.



Power P is dissipated by the external resistor.

The cell is replaced by a different cell that has an e.m.f. of 6V and negligible internal resistance.

What is the new power that is dissipated in the external resistor?

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

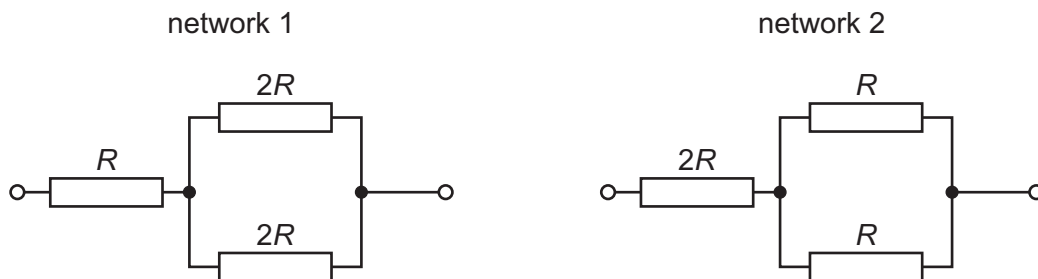
- 35 A wire of uniform cross-section has resistance R .

A second wire is made of the same material but is twice as long and has twice the diameter of the first wire.

What is the resistance of the second wire?

- A $\frac{R}{8}$ B $\frac{R}{2}$ C R D $8R$

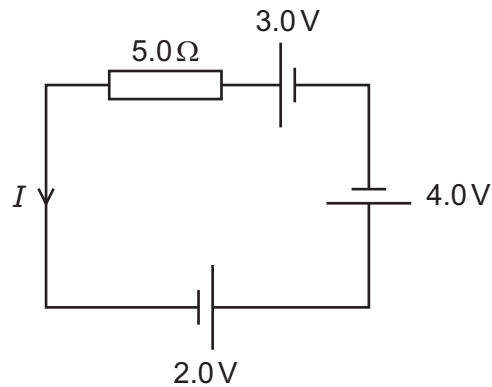
- 36 The diagram shows two resistor networks.



What is the ratio $\frac{\text{total resistance of network 1}}{\text{total resistance of network 2}}$?

- A $\frac{4}{5}$ B $\frac{5}{4}$ C $\frac{1}{2}$ D $\frac{2}{1}$

- 37 The circuit shown contains three cells of electromotive forces 3.0 V, 2.0 V and 4.0 V, in series with a resistor of resistance $5.0\ \Omega$. The cells have negligible internal resistance.



What is the current I in the circuit?

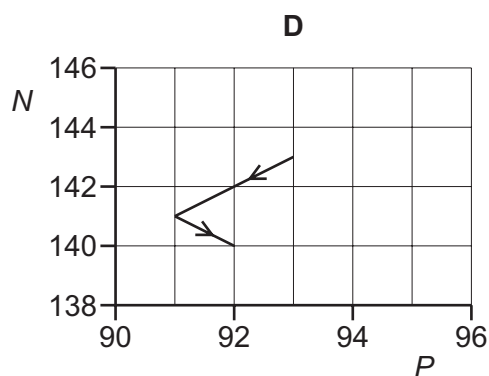
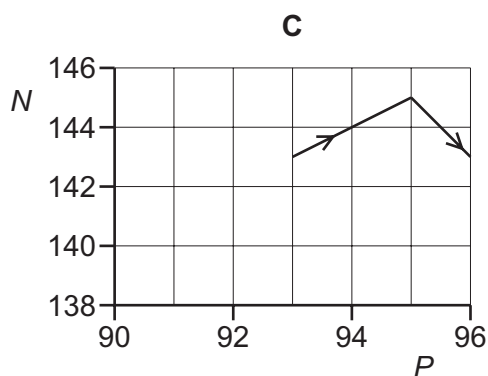
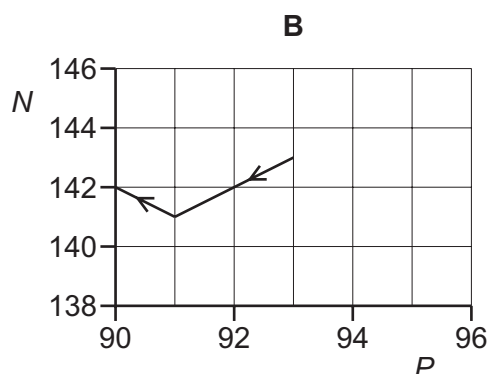
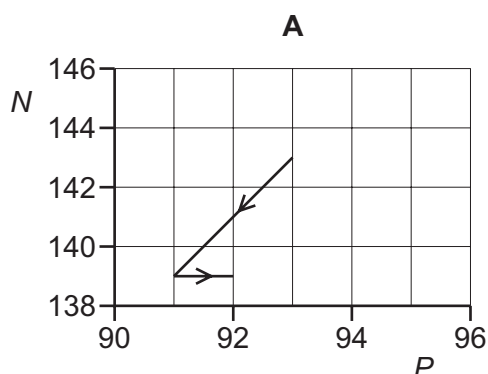
- A** 0.20 A **B** 0.60 A **C** 1.0 A **D** 1.8 A
- 38 When α -particles are fired at a thin metal foil, most of the particles pass straight through but a few are deflected by a large angle.

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 double thickness foil
C using a foil made of a metal with fewer protons in its nuclei
D using a source emitting more α -particles per unit time

- 39** A nucleus of neptunium-236 contains 93 protons and 143 neutrons. This nucleus decays with the emission of an α -particle. The nucleus formed then emits a β^- particle.

Which diagram shows the changes in the number P of protons and the number N of neutrons in these nuclei?



- 40** Which combination of quarks could **not** be the quark composition of the hadron shown?

p = proton

n = neutron

Σ^- = sigma particle of charge $-e$

Σ^+ = sigma particle of charge $+e$

u = up quark

d = down quark

s = strange quark

	hadron	quark composition
A	Σ^-	dds
B	Σ^+	uds
C	p	uud
D	n	udd

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