

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2016

1 hour 15 minutes

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

* 5 3 4 0 2 2 1 4 6 2 *



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 **20** printed pages.



Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass 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 the order of magnitude of the Young modulus for a metal such as copper?

A 10^{-11} Pa **B** 10^{-4} Pa **C** 10^4 Pa **D** 10^{11} Pa

- 2 The force F between two point charges q_1 and q_2 , a distance r apart, is given by the equation

$$F = \frac{kq_1q_2}{r^2}$$

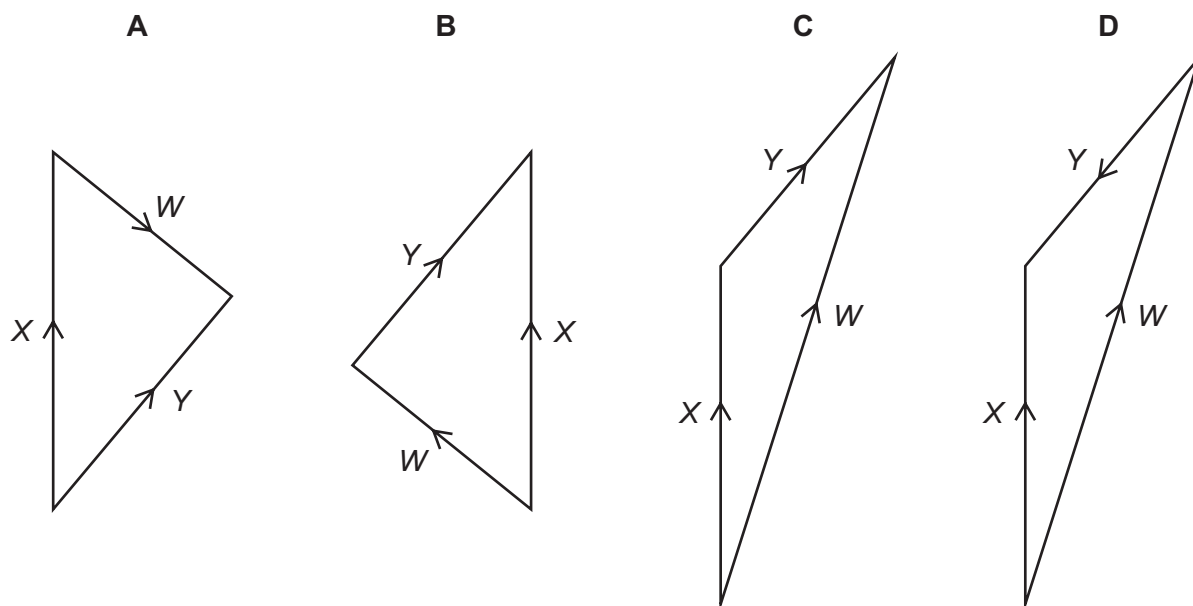
where k is a constant.

What are the SI base units of k ?

A $\text{kg m}^3 \text{s}^{-4} \text{A}^2$ **B** $\text{kg m}^3 \text{s}^{-4} \text{A}^{-2}$ **C** $\text{kg m}^3 \text{A}^2$ **D** $\text{kg m}^3 \text{A}^{-2}$

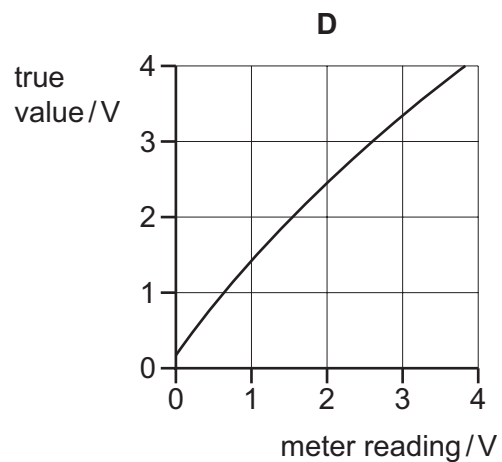
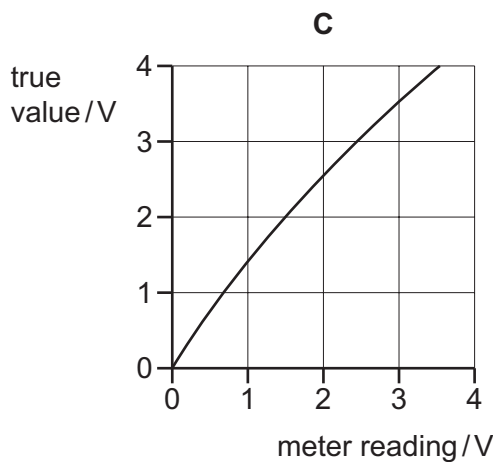
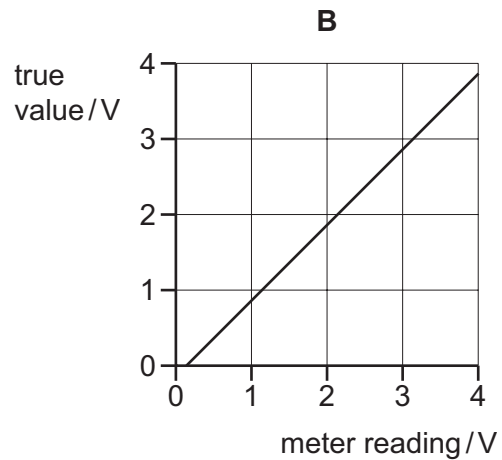
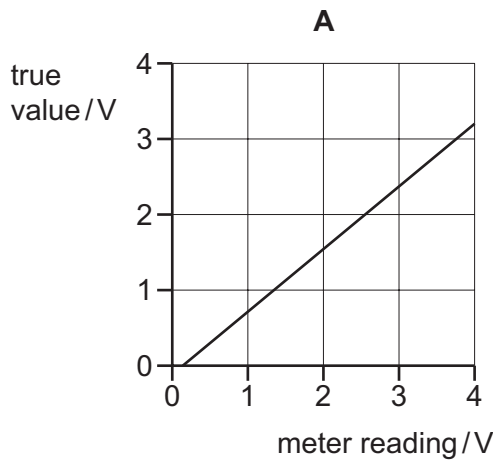
- 3 An aeroplane can fly at a velocity X when moving through still air. When flying in wind the aeroplane's velocity relative to the ground is Y .

Which vector diagram shows the magnitude and direction of the wind velocity W ?

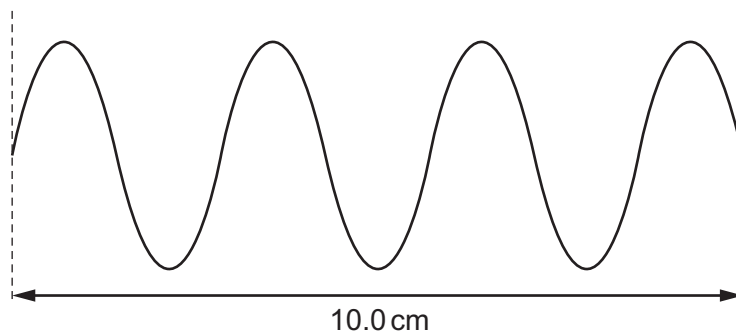


- 4 A voltmeter gives readings that are larger than the true values and has a systematic error that varies with voltage.

Which graph shows the calibration curve for the voltmeter?



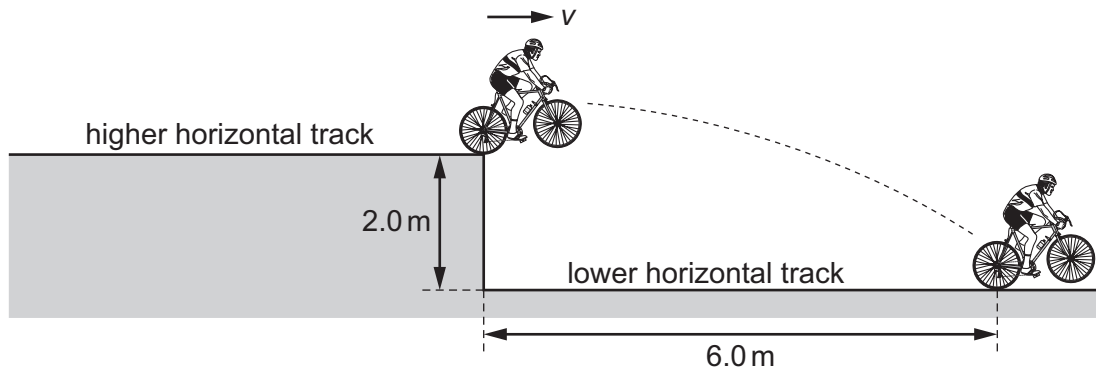
- 5 A student uses a cathode-ray oscilloscope (c.r.o.) to measure the period of a signal. She sets the time-base of the c.r.o. to 5 ms cm^{-1} and observes the trace illustrated below. The trace has a length of 10.0 cm .



What is the period of the signal?

- A** $7.1 \times 10^{-6} \text{ s}$ **B** $1.4 \times 10^{-5} \text{ s}$ **C** $7.1 \times 10^{-3} \text{ s}$ **D** $1.4 \times 10^{-2} \text{ s}$

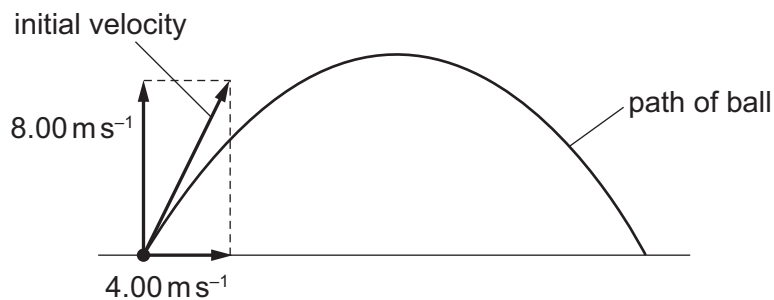
- 6 A cyclist pedals along a raised horizontal track. At the end of the track, he travels horizontally into the air and onto a track that is vertically 2.0 m lower.



The cyclist travels a horizontal distance of 6.0 m in the air. Air resistance is negligible.

What is the horizontal velocity v of the cyclist at the end of the higher track?

- A** 6.3 ms^{-1} **B** 9.4 ms^{-1} **C** 9.9 ms^{-1} **D** 15 ms^{-1}
- 7 An astronaut on the Moon, where there is no air resistance, throws a ball. The ball's initial velocity has a vertical component of 8.00 ms^{-1} and a horizontal component of 4.00 ms^{-1} , as shown.

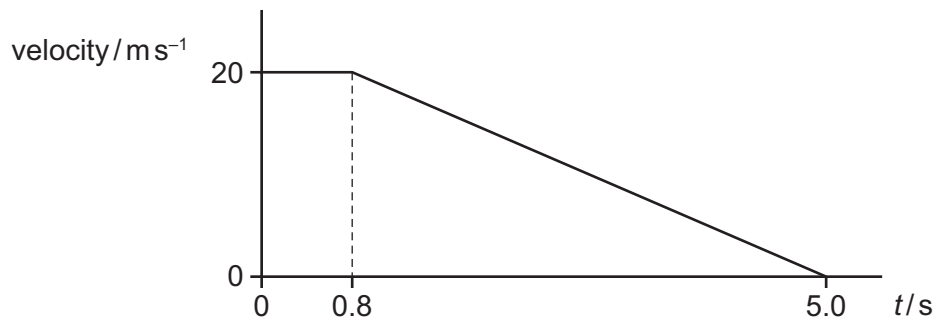


The acceleration of free fall on the Moon is 1.62 ms^{-2} .

What will be the speed of the ball 9.00 s after being thrown?

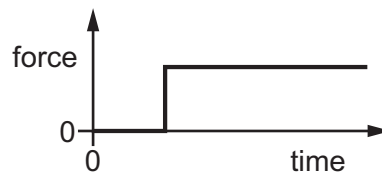
- A** 6.6 ms^{-1} **B** 7.7 ms^{-1} **C** 10.6 ms^{-1} **D** 14.6 ms^{-1}

- 8 A car is travelling at constant velocity. At time $t = 0$, the driver of the car sees an obstacle in the road and then brakes to a halt. The graph shows the variation with t of the velocity of the car.

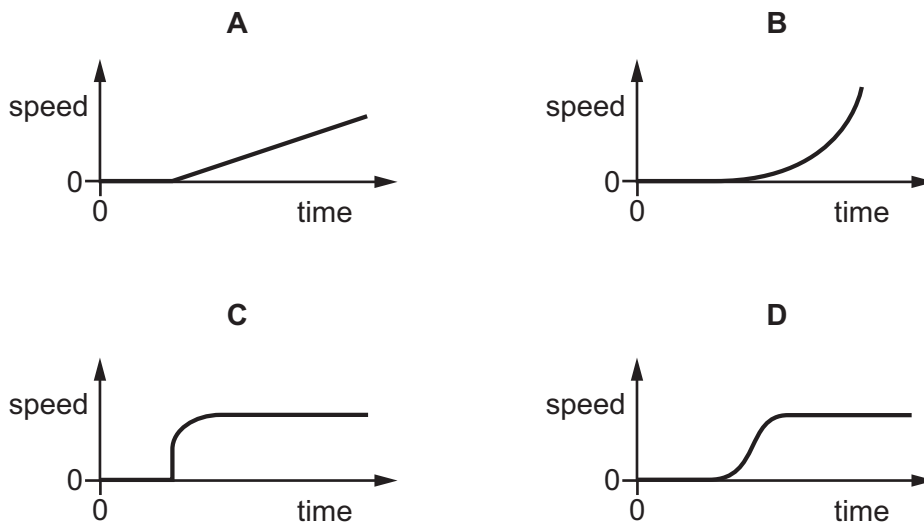


How far does the car travel in the 5.0 s after the driver sees the obstacle?

- A 16 m B 42 m C 58 m D 84 m
- 9 A car is stationary at traffic lights. When the traffic lights change to green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.

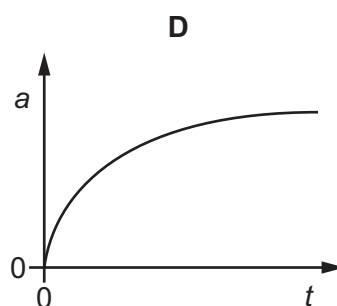
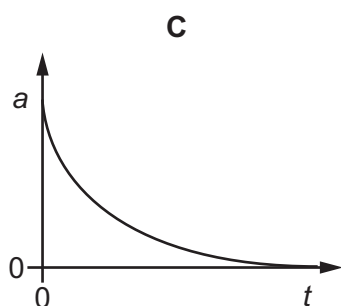
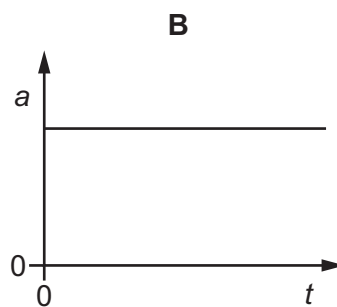
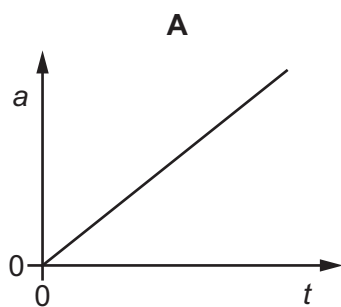


Which graph shows the variation with time of the speed of the car?



- 10 A beach-ball falls vertically from a high hotel window. Air resistance is **not** negligible.

Which graph shows the variation with time t of the acceleration a of the ball?



- 11 A car has mass m . A person needs to push the car with force F in order to give the car acceleration a . The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

Which expression gives the constant resistive force opposing the motion of the car?

A ma

B $2ma$

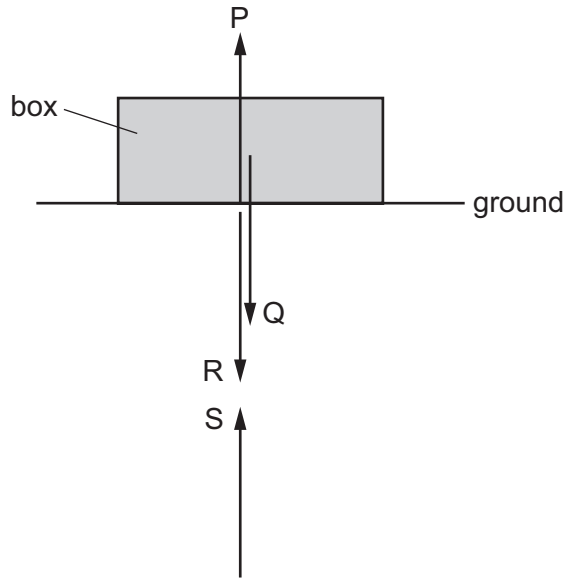
C $3ma$

D $4ma$

- 12 A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.

Forces P and Q act on the box. Forces R and S act on the Earth.

For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

- A** P is the equal and opposite force to Q and both are forces of contact.
B Q is the equal and opposite force to P and both are gravitational forces.
C R is the equal and opposite force to S and both are forces of contact.
D S is the equal and opposite force to Q and both are gravitational forces.
- 13 Two spheres travel along the same line with velocities u_1 and u_2 . They collide and after collision their velocities are v_1 and v_2 .



Which collision is **not** elastic?

	u_1/ms^{-1}	u_2/ms^{-1}	v_1/ms^{-1}	v_2/ms^{-1}
A	2	-5	-5	-2
B	3	-3	0	6
C	3	-2	1	6
D	5	2	3	6

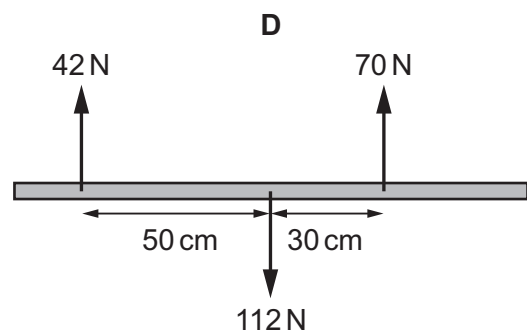
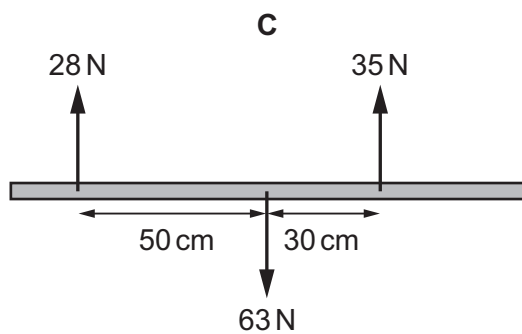
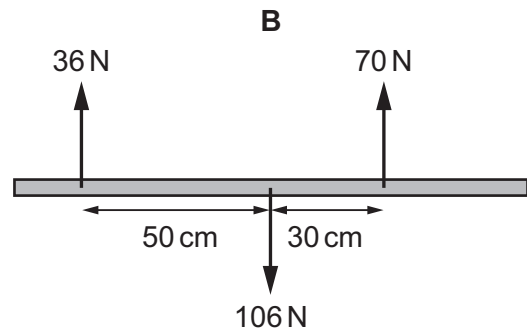
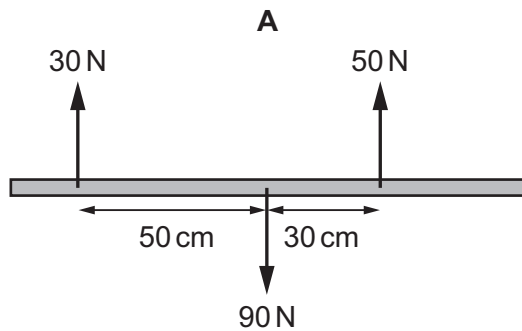
- 14** A submarine has circular windows of diameter 0.30 m. The windows can experience a maximum external pressure of 660 kPa before they crack.

What is the minimum external force needed to crack the windows?

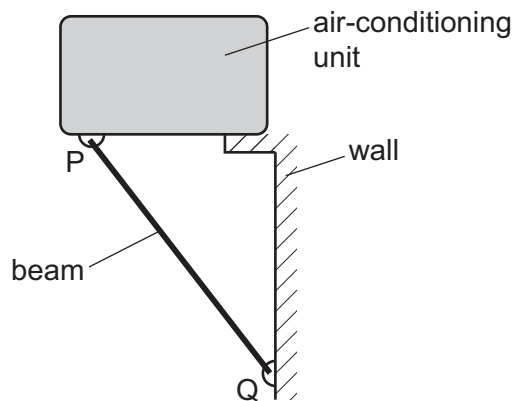
- A** 47 000 N **B** 190 000 N **C** 310 000 N **D** 620 000 N

- 15** Four beams of the same length each have three forces acting on them.

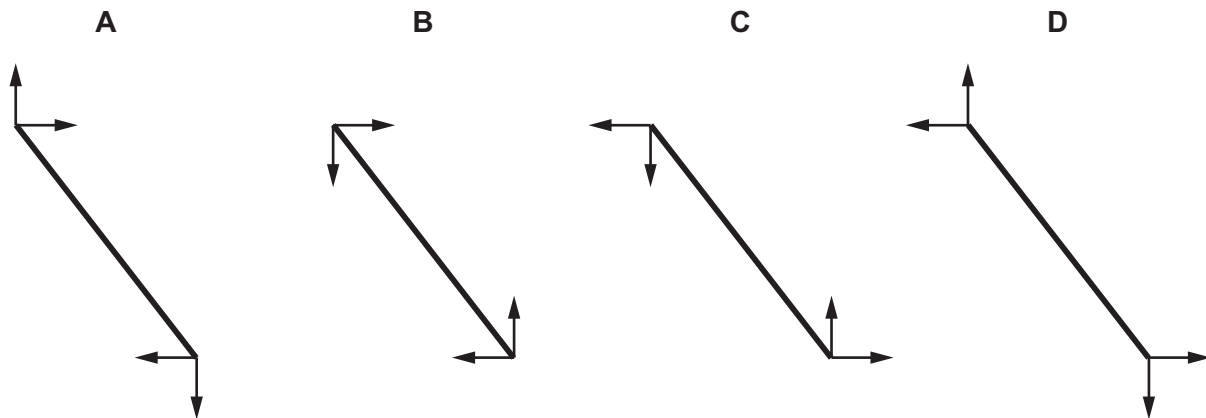
Which beam has both zero resultant force and zero resultant torque acting?



- 16 An air-conditioning unit is supported by a rigid beam PQ, as shown.



Which diagram shows the directions of the horizontal and vertical forces acting on the ends of the beam?



- 17 A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

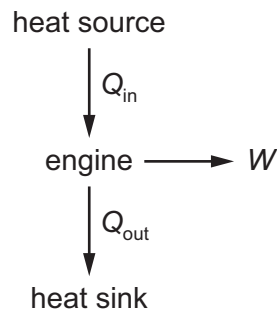
In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^5 \text{ kg s}^{-1}$. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

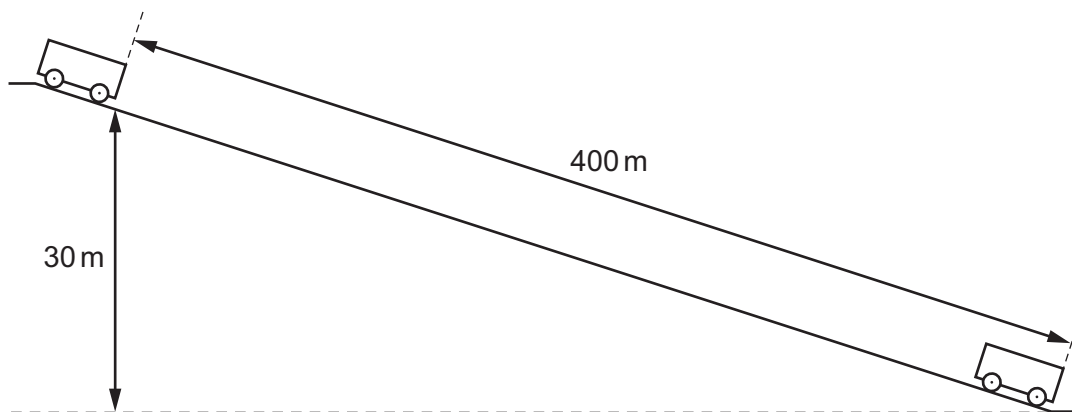
- A 5.6% B 43% C 57% D 68%

- 18 An engine transforms thermal energy into mechanical work. The engine takes in thermal energy Q_{in} from a heat source and gives out thermal energy Q_{out} to a heat sink, producing useful work W .



What is the efficiency of this engine?

- A $\frac{W}{Q_{\text{in}} + Q_{\text{out}}}$ B $\frac{W}{Q_{\text{in}} - Q_{\text{out}}}$ C $\frac{W}{Q_{\text{in}}}$ D $\frac{W}{Q_{\text{out}}}$
- 19 A truck of mass 500 kg moves from rest at the top of a section of track 400 m long and 30 m high, as shown. The frictional force acting on the truck is 250 N throughout its journey.

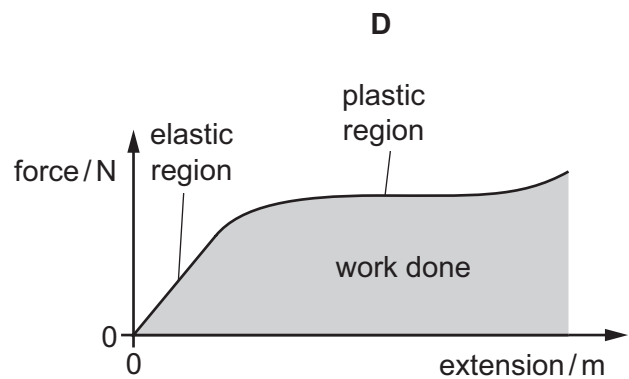
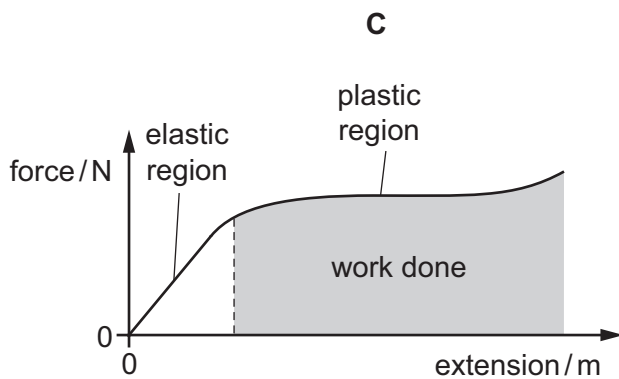
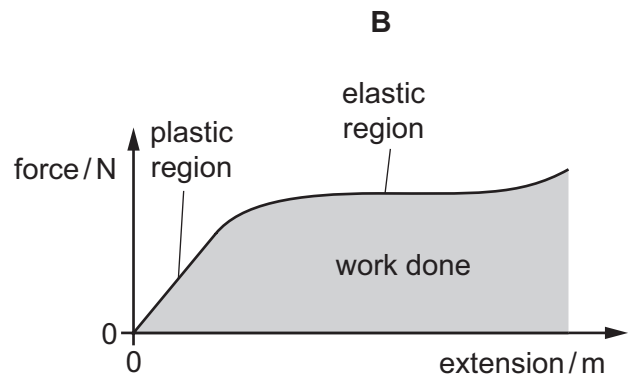
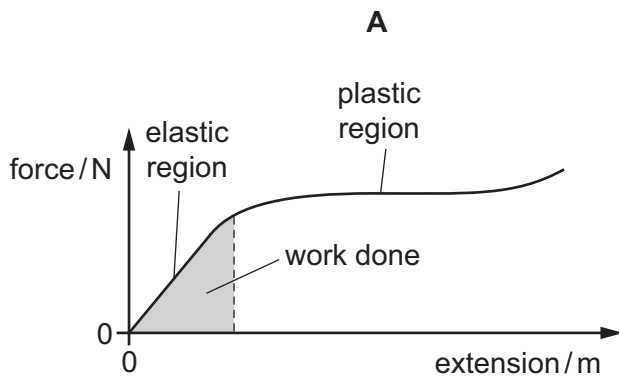


What is the final speed of the truck?

- A 14 m s^{-1} B 24 m s^{-1} C 31 m s^{-1} D 190 m s^{-1}
- 20 Which condition must apply for the work done by an expanding gas to be $p\Delta V$, where p is the pressure of the gas and ΔV is its change in volume?
- A No thermal energy must be supplied to the gas.
 B The expansion must be at a constant rate.
 C The pressure must be constant.
 D The temperature of the gas must be constant.

- 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 copper wire hangs vertically from a fixed point. A load is attached to the lower end of the wire producing an extension x . The wire obeys Hooke's law.

Which single change gives an extension $2x$?

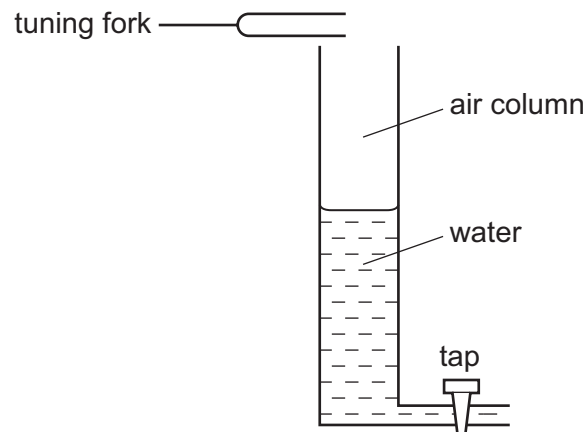
- A** Halve the cross-sectional area of the wire.
- B** Halve the diameter of the wire.
- C** Halve the length of the wire.
- D** Halve the load on the wire.

23 The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^2 m
A	gamma ray	X-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	X-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	X-ray
D	X-ray	infra-red	ultraviolet	microwave	radio wave

24 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.

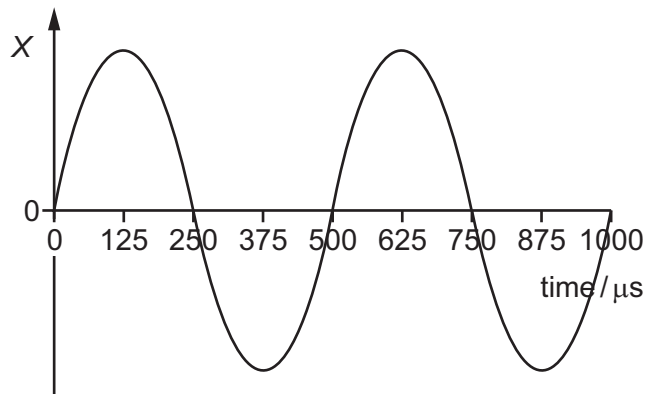


The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

What is the wavelength of the sound wave?

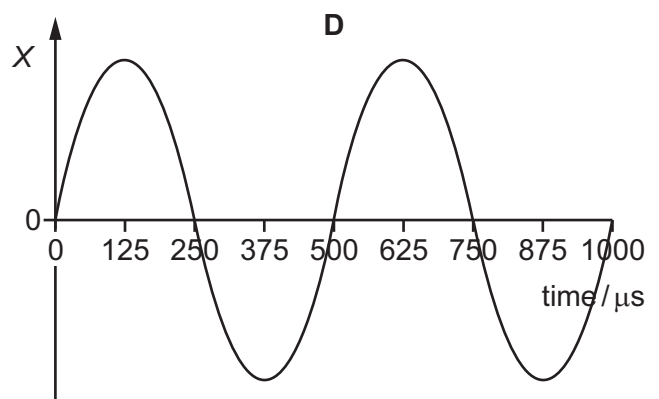
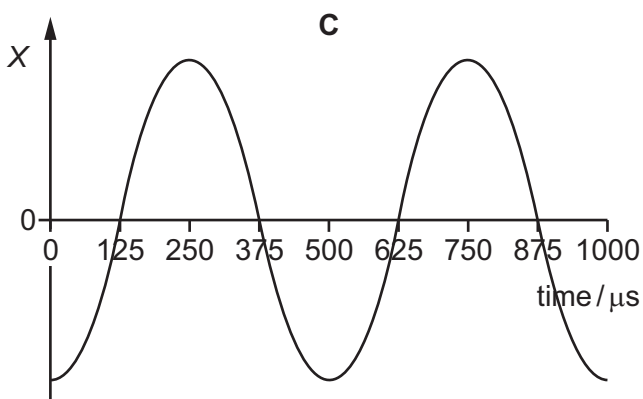
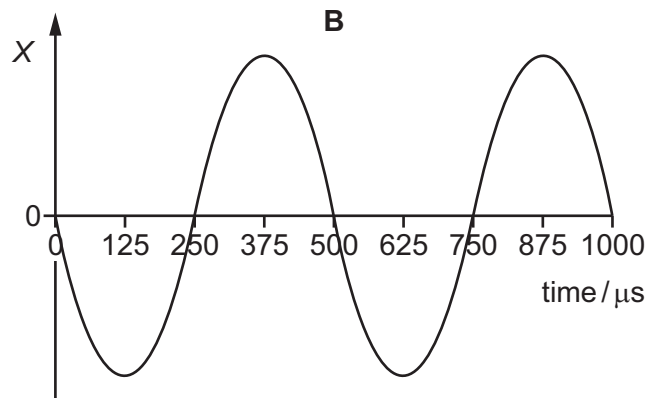
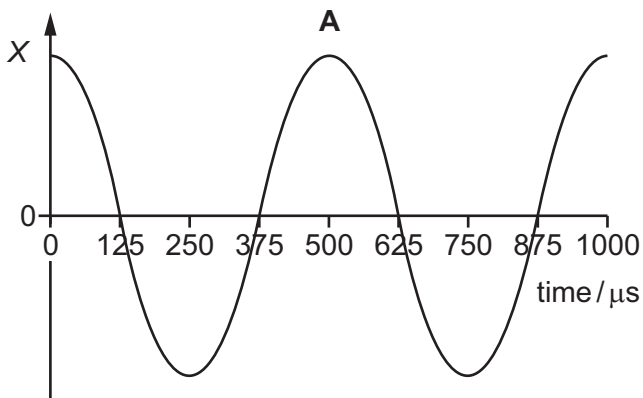
- A** 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

- 25 The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.



The velocity of sound in the gas is 330 m s^{-1} . All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.165 m further away from the source of the sound?



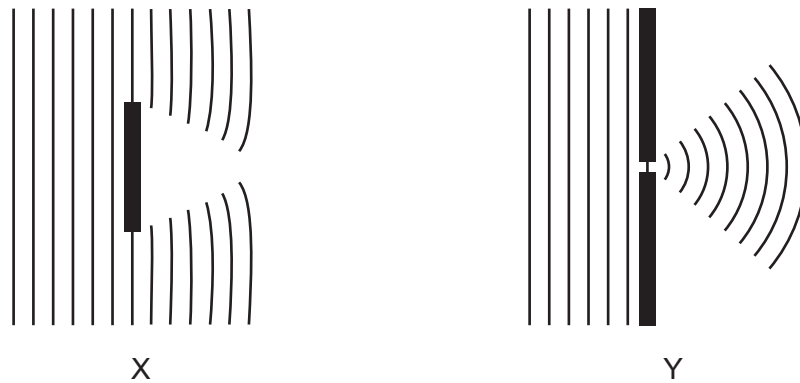
- 26 The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m s^{-1} . The ambulance is travelling with a constant velocity of 25 m s^{-1} towards an observer.



Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

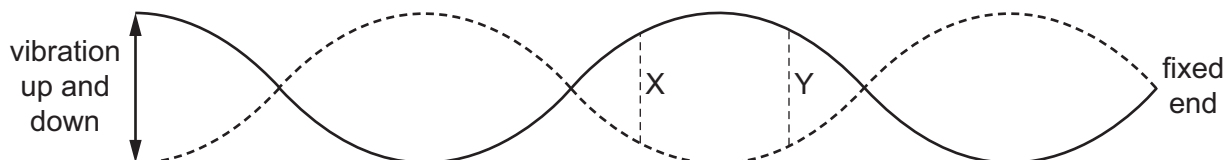
- A** 49 Hz **B** 84 Hz **C** 91 Hz **D** 98 Hz
- 27 Diagrams X and Y show the passage of water waves around an obstacle and through a gap.

The thick lines are barriers to the waves and each thin line represents a wavefront.



Which statement is correct?

- A** Diagrams X and Y both illustrate diffraction.
B Diagrams X and Y both illustrate interference.
C Only diagram X illustrates interference.
D Only diagram Y illustrates diffraction.
- 28 The diagram shows a long rope fixed at one end. The other end is moved up and down, setting up a stationary wave.

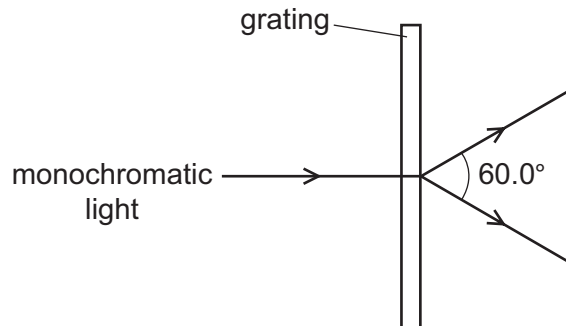


What is the phase difference between the oscillations at X and at Y?

- A** 0 **B** 45° **C** 90° **D** 135°

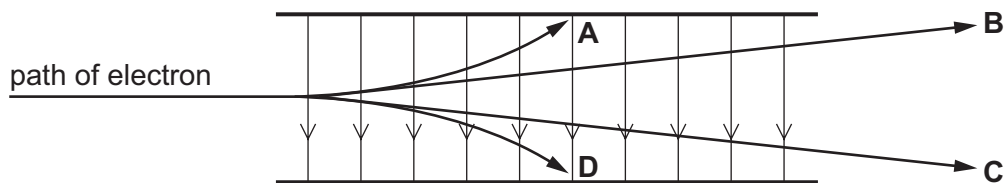
- 29** A diffraction grating is used to measure the wavelength of monochromatic light.

The spacing of the slits in the grating is $1.15 \times 10^{-6} \text{ m}$. The angle between the first order diffraction maxima is 60.0° , as shown in the diagram.



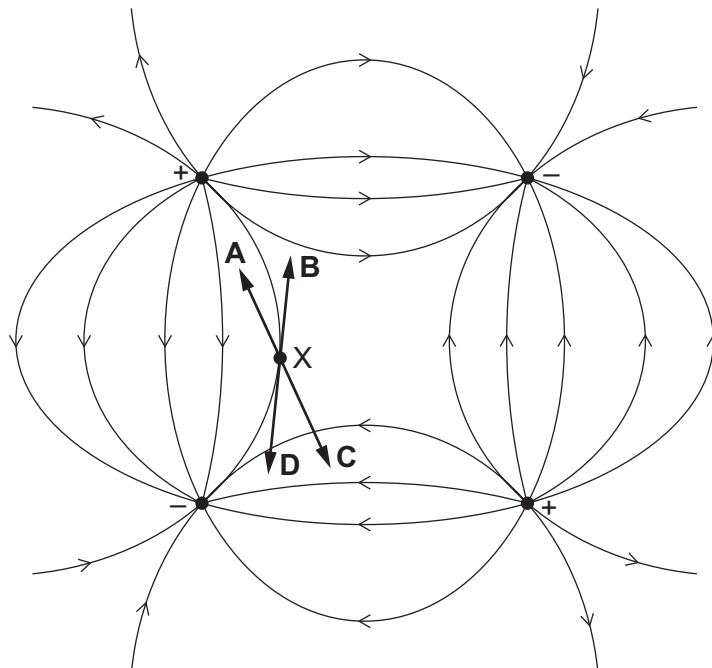
What is the wavelength of the light?

- A** 288 nm **B** 498 nm **C** 575 nm **D** 996 nm
- 30** Which path shows a possible movement of an electron in the electric field shown?

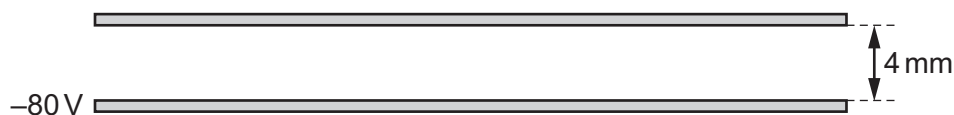


- 31** The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

In which direction does the force act on an electron at point X?



- 32 Two large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of -80 V .



Which potential should be applied to the upper plate to create an electric field of strength $60\,000\text{ V m}^{-1}$ upwards in the space between the plates?

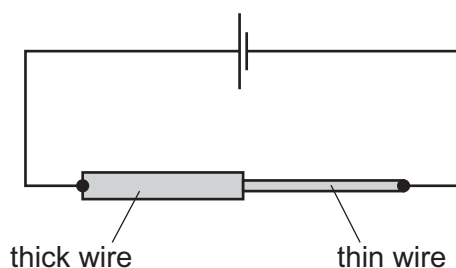
- A** -320 V **B** -160 V **C** $+160\text{ V}$ **D** $+320\text{ V}$

- 33 An electric kettle is marked 3.10 kW . It is used with an electrical supply of 240 V .

What is the electric current in the kettle and what is the kettle's electrical resistance when working?

	current / A	resistance / Ω
A	0.0129	18 600
B	0.0770	3100
C	12.9	18.6
D	12.9	3100

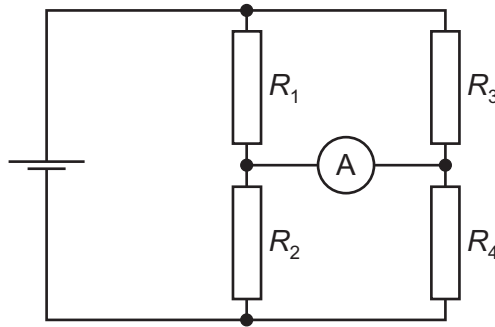
- 34 A thick copper wire is connected to a thin copper wire in series with a cell, as shown.



What is significantly **less** in the thick wire than in the thin wire?

- A** the charge passing a point per unit time
B the drift speed of the electrons
C the number density of the free electrons
D the number of free electrons passing a point per unit time
- 35 What is a typical value for the order of magnitude of the resistivity of copper?
- A** $10^{-13}\text{ }\Omega\text{ m}$ **B** $10^{-8}\text{ }\Omega\text{ m}$ **C** $10^{-3}\text{ }\Omega\text{ m}$ **D** $10^2\text{ }\Omega\text{ m}$

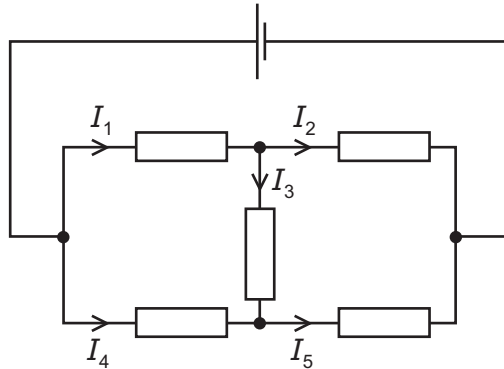
- 36 In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1 , R_2 , R_3 and R_4 .

Which equation is correct?

- A** $R_1 - R_3 = R_2 - R_4$
 - B** $R_1 \times R_3 = R_2 \times R_4$
 - C** $R_1 - R_4 = R_2 - R_3$
 - D** $R_1 \times R_4 = R_2 \times R_3$
- 37 The diagram shows currents I_1 , I_2 , I_3 , I_4 and I_5 in different branches of a circuit.



Which equation is correct?

- A** $I_1 = I_2 + I_3$
- B** $I_2 = I_1 + I_3$
- C** $I_3 = I_4 + I_5$
- D** $I_4 = I_5 + I_3$

38 What is a proton?

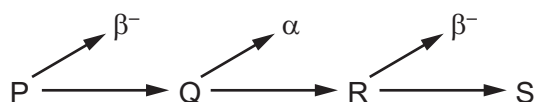
- A a hadron
- B a particle consisting of two down quarks and one up quark
- C a positive fundamental particle
- D a positive lepton

39 What are the correct descriptions of a γ -ray and a β^- particle?

	γ -ray	β^- particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	helium-4 nucleus

40 In a radioactive decay series, three successive decays each result in a particle being emitted.

The first decay results in the emission of a β^- particle. The second decay results in the emission of an α particle. The third decay results in the emission of another β^- particle.



Nuclides P and S are compared.

Which statement is correct?

- A P and S are identical in all respects.
- B P and S are isotopes of the same element.
- C S is a different element of lower atomic number.
- D S is a different element of reduced mass.

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PHYSICS

9702/12

Paper 1 Multiple Choice

October/November 2016

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 Concrete has a density of 2400 kg m^{-3} .

Which mass of concrete fills a rectangular space of dimensions $8.0 \text{ cm} \times 90 \text{ cm} \times 110 \text{ cm}$?

- A** 79 kg **B** 190 kg **C** 790 kg **D** 1900 kg

- 2 The speed v of sound in a gas is given by the equation

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

where P is the pressure of the gas, ρ is its density and γ is a constant.

What are the SI base units of γ ?

- A** $\text{m}^{-1} \text{s}$ **B** $\text{m}^3 \text{s}^{-3}$ **C** $\text{m}^{-4} \text{s}^{-4}$ **D** no units

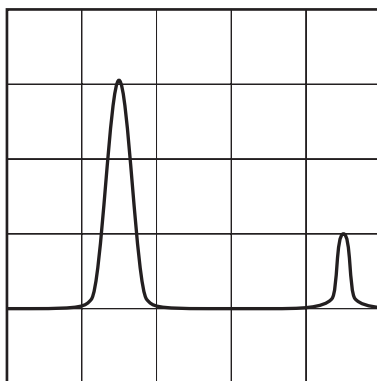
- 3 The motion of an object moving from rest with a constant acceleration a may be represented by the equation shown.

$$v^2 = 2as$$

Which row describes the quantities represented by the symbols v and s ?

	v	s
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

- 4 A cathode-ray oscilloscope (c.r.o.) displays a waveform as shown.



The time interval between two adjacent peaks of the waveform is 0.006 s.

What is the time-base setting of the c.r.o.?

- A $2\ \mu\text{s}/\text{division}$
 - B $20\ \mu\text{s}/\text{division}$
 - C $2\ \text{ms}/\text{division}$
 - D $3\ \text{ms}/\text{division}$
- 5 A value for the acceleration of free fall on Earth is given as $(10 \pm 2)\text{ms}^{-2}$.
- Which statement is correct?
- A The value is accurate but not precise.
 - B The value is both precise and accurate.
 - C The value is neither precise nor accurate.
 - D The value is precise but not accurate.
- 6 An experiment to determine atmospheric pressure P uses the equation $P = \rho gh$ where

$$\rho = (13\,600 \pm 100)\text{kg m}^{-3},$$

$$g = (9.81 \pm 0.02)\text{ms}^{-2},$$

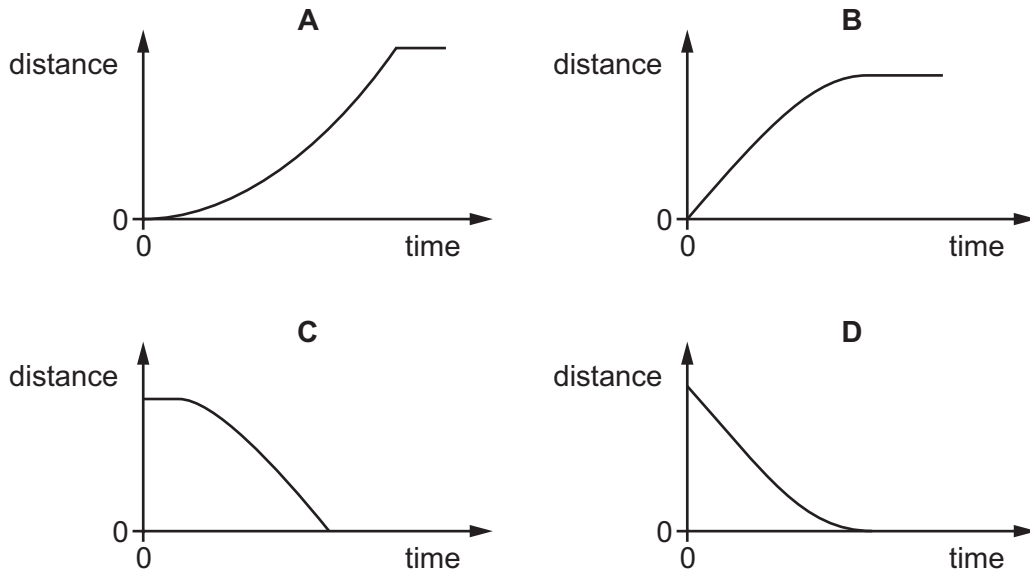
$$h = (0.762 \pm 0.005)\text{m}.$$

What is the value of P , with its uncertainty, when stated to an appropriate number of significant figures?

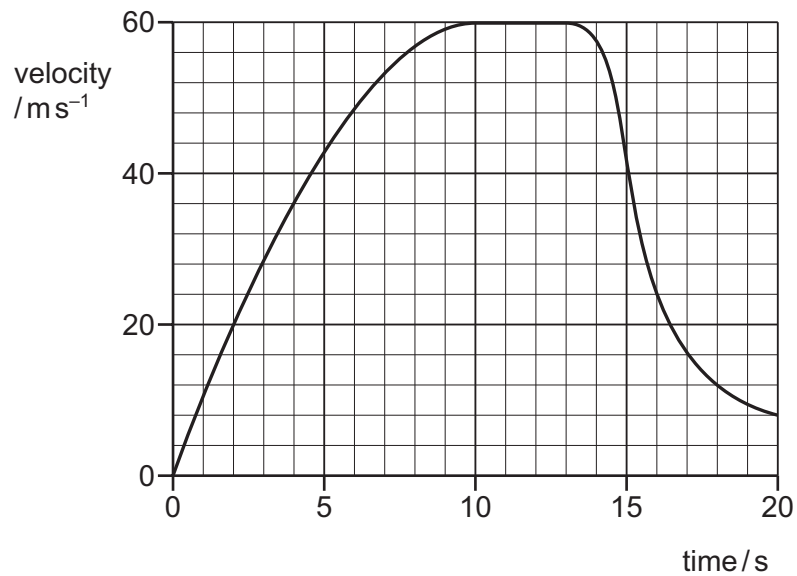
- A $(1.0166 \pm 0.0162) \times 10^5\text{Pa}$
- B $(1.017 \pm 0.016) \times 10^5\text{Pa}$
- C $(1.017 \pm 1.6\%) \times 10^5\text{Pa}$
- D $(1.02 \pm 0.02) \times 10^5\text{Pa}$

- 7 A lorry travels at a constant speed and then decelerates until it stops.

Which graph shows the variation with time of the distance travelled by the lorry?



- 8 The graph shows the vertical velocity of a parachutist during the first 20 s of her jump.

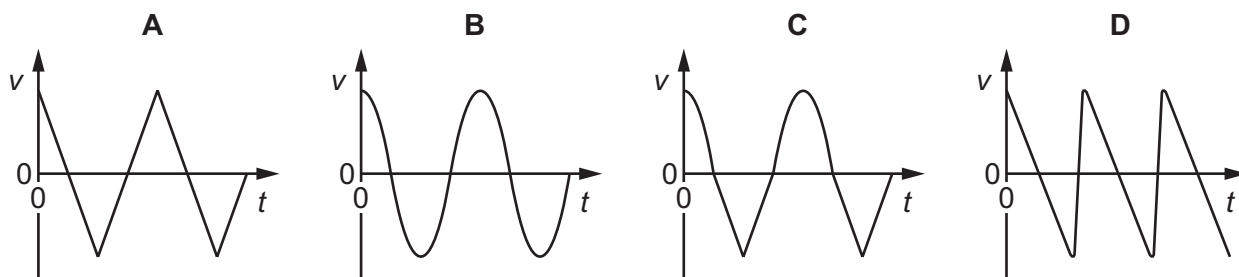


Approximately how far does she fall **before** opening the parachute?

- A** 390 m **B** 570 m **C** 710 m **D** 770 m

- 9 A girl is jumping on a trampoline.

Which graph shows the variation of the girl's velocity v with time t ?

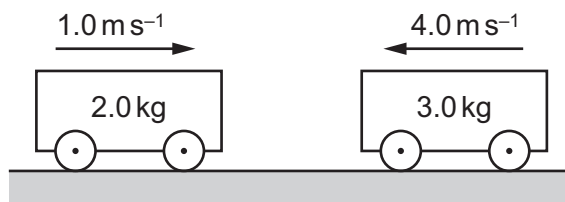


- 10 In order that a train can stop safely, it will always pass a signal showing a yellow light before it reaches a signal showing a red light. Drivers apply the brake at the yellow light and this results in a uniform deceleration to stop exactly at the red light.

The distance between the red and yellow lights is x .

If the speed of the train is increased by 20%, without changing the deceleration of the train, what must be the minimum distance between the lights?

- A 1.20 x B 1.25 x C 1.44 x D 1.56 x
- 11 Two frictionless trolleys are moving towards each other along the same horizontal straight line. Their masses and velocities are shown.



The trolleys collide and stick together.

What is the velocity of the trolleys after the collision?

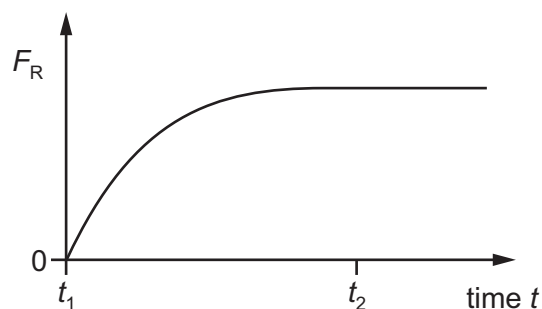
- A 2.0 m s^{-1} to the left
 B 2.0 m s^{-1} to the right
 C 2.8 m s^{-1} to the left
 D 2.8 m s^{-1} to the right
- 12 A bullet of mass 8.0 g travels at a speed of 300 m s^{-1} . The bullet hits a target and stops after a time of $100 \mu\text{s}$.

What is the average force exerted by the target on the bullet?

- A 24 N B 240 N C 2400 N D 24 000 N

- 13 A light ball is falling vertically through air.

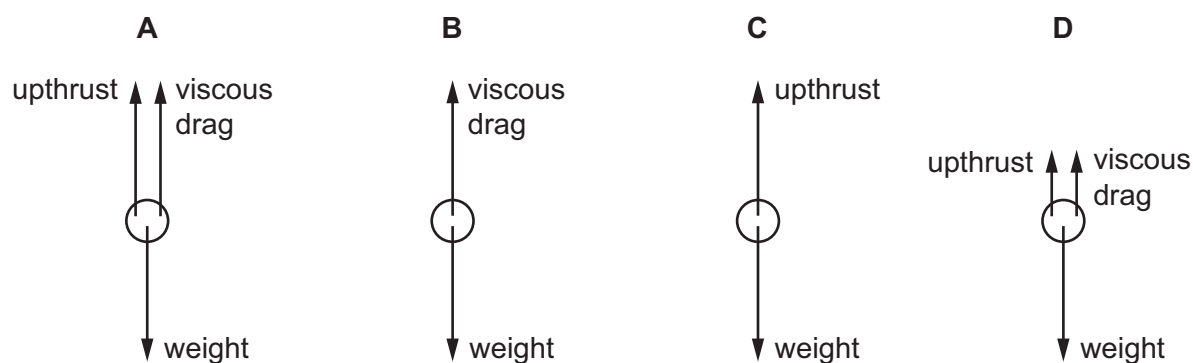
The variation with time t of the resistive force F_R acting on the ball is shown.



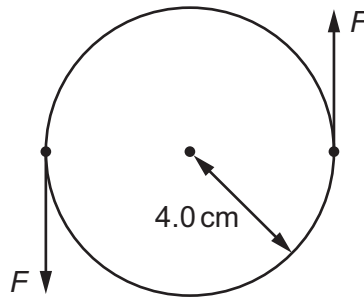
At which times are the speed of the ball zero, the speed at a maximum and the acceleration zero?

	zero speed	maximum speed	zero acceleration
A	t_1	t_2	t_1
B	t_1	t_2	t_2
C	t_2	t_1	t_1
D	t_2	t_1	t_2

- 14 Which diagram best shows the forces acting on a ball falling at a constant velocity through a liquid?

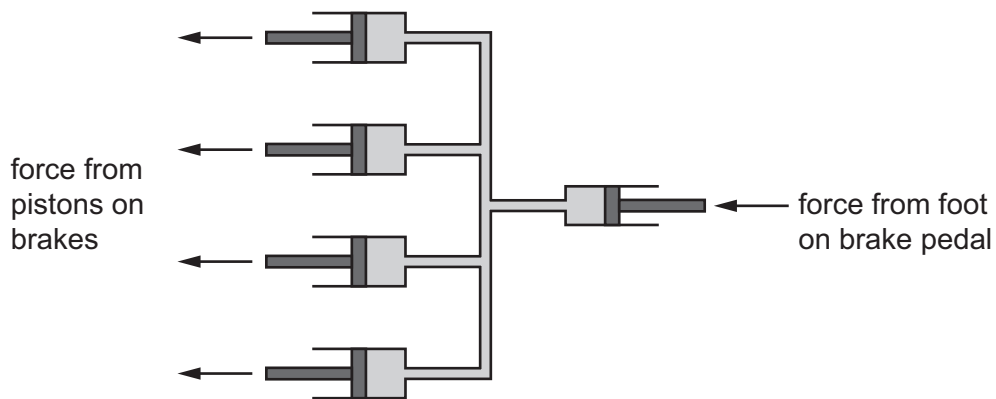


- 15 A minimum torque of 20 N m must be applied to the lid of a jar for it to open. The radius of the lid is 4.0 cm.



What is the minimum force F that must act on each side of the lid in order to open it?

- A 2.5 N B 5.0 N C 250 N D 500 N
- 16 The diagram shows the brake system of a car.



The pipes are filled with incompressible liquid. When a force is applied to the brake pedal, the pressure in the liquid increases and applies a force to each of the four wheels.

The area of the piston connected to the brake pedal is 8 cm^2 .

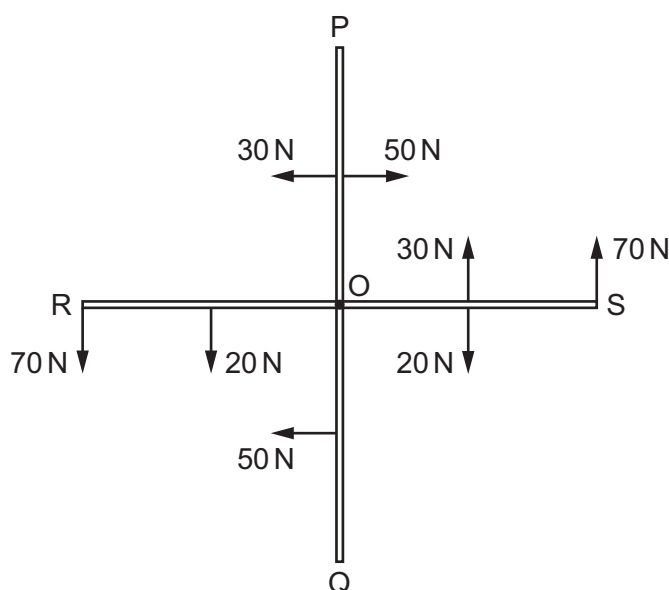
The area of each piston connected to the brakes is 12 cm^2 .

A force of 800 N is applied by the foot to the brake pedal.

What is the force applied to each brake?

- A 300 N B 530 N C 1200 N D 4800 N

- 17 A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.00 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the magnitude of the resultant moment on the structure about O?

- A 45 Nm B 90 Nm C 120 Nm D 190 Nm
- 18 On the surface of a planet, 30 J of work is done against gravity to raise a mass of 1.0 kg through a height of 10 m.

How much work must be done to raise a mass of 4.0 kg through a height of 5.0 m on this planet?

- A 15 J B 60 J C 120 J D 200 J
- 19 The speed of a car increases from 10 m s^{-1} to 15 m s^{-1} and its kinetic energy increases by E_1 .

Later, the speed of the car increases from 15 m s^{-1} to 25 m s^{-1} and its kinetic energy increases by E_2 .

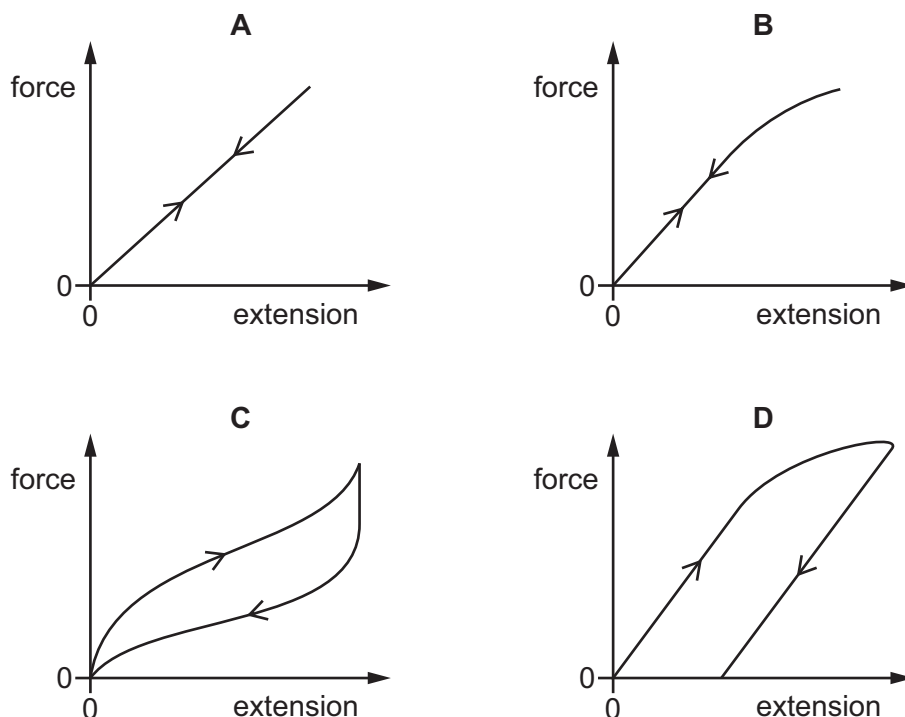
What is the ratio $\frac{E_2}{E_1}$?

- A 1.6 B 2.6 C 3.2 D 4.0
- 20 A car travels at a constant speed of 25 m s^{-1} up a slope. The wheels driven by the engine exert a forward force of 3000 N. There is a drag force due to air resistance and friction of 2100 N. The weight of the car has a component down the slope of 900 N.

What is the rate at which thermal energy is dissipated?

- A zero B $2.3 \times 10^4 \text{ W}$ C $5.3 \times 10^4 \text{ W}$ D $7.5 \times 10^4 \text{ W}$

21 Which force-extension graph shows plastic deformation of a sample of material?



22 Four solid steel rods, each of length 2.0 m and cross-sectional area 250 mm^2 , equally support an object weighing 10 kN. The weight of the object causes the rods to contract by 0.10 mm.

What is the Young modulus of steel?

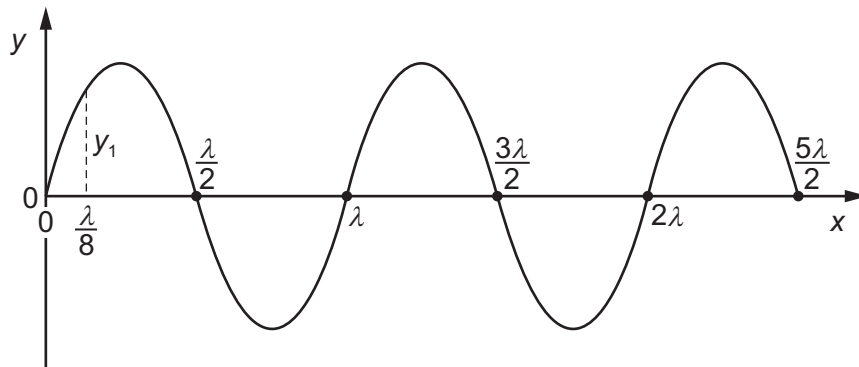
- A $2.0 \times 10^8 \text{ Nm}^{-2}$
- B $2.0 \times 10^{11} \text{ Nm}^{-2}$
- C $8.0 \times 10^8 \text{ Nm}^{-2}$
- D $8.0 \times 10^{11} \text{ Nm}^{-2}$

23 High-frequency sound waves with frequency 2.0 MHz travel with a speed of 2.0 km s^{-1} through a liquid.

What is the shortest distance between a compression and a rarefaction (expansion) in the liquid?

- A 0.5 mm
- B 1.0 mm
- C 5.0 mm
- D 10.0 mm

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



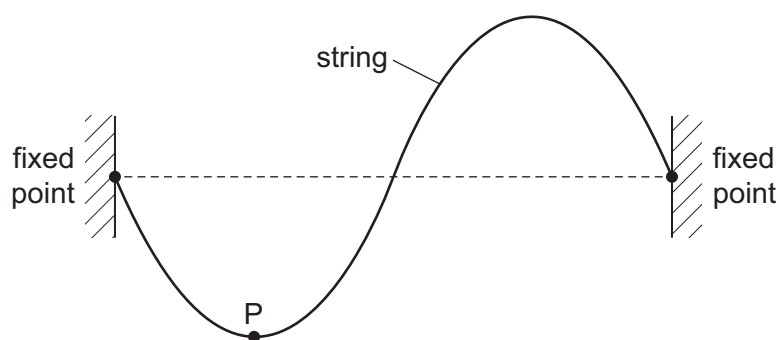
What are the next two values of x where the displacement y is again equal to y_1 ?

- A** $\frac{3\lambda}{8}$ and $\frac{5\lambda}{8}$
- B** $\frac{3\lambda}{8}$ and $\frac{9\lambda}{8}$
- C** $\frac{5\lambda}{8}$ and $\frac{9\lambda}{8}$
- D** $\frac{9\lambda}{8}$ and $\frac{17\lambda}{8}$
- 25** A man standing next to a stationary train hears sound of frequency 400 Hz emitted from the train's horn. The train then moves directly away from the man and sounds its horn when it has a speed of 50 ms^{-1} . The speed of sound is 340 ms^{-1} .

What is the difference in frequency of the sound heard by the man on the two occasions?

- A** 51 Hz **B** 69 Hz **C** 349 Hz **D** 469 Hz

- 26 A stationary wave is formed on a stretched string. The diagram illustrates the string at an instant of time when the displacement of the string is at its maximum.



The frequency of the wave is 250 Hz. Point P on the string has a vertical displacement of -1.0 mm.

What will be the vertical displacement of the point P after a time of 5 ms?

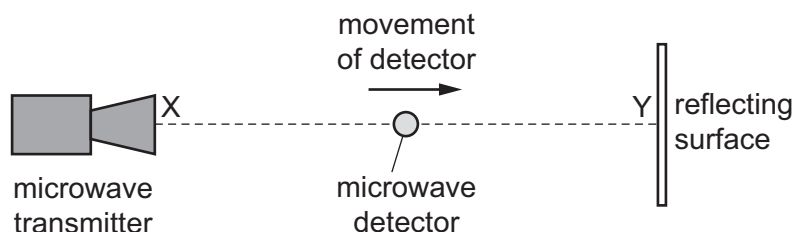
- A** -1.0 mm **B** zero **C** $+0.5$ mm **D** $+1.0$ mm
- 27 Observable interference fringes are produced using light from a double slit. The intensity of the light emerging from each slit is initially the same.
- The intensity of the light emerging from one of the slits is now reduced.
- How does this affect the interference pattern?
- A** The bright fringes and the dark fringes all become brighter.
B The bright fringes and the dark fringes all become darker.
C The bright fringes become brighter and the dark fringes become darker.
D The bright fringes become darker and the dark fringes become brighter.
- 28 Monochromatic light of wavelength 450 nm passes through two parallel slits 0.30 mm apart. Bright fringes are observed on a screen 2.0 m away.



How far apart are the bright fringes on the screen?

- A** 1.3 mm **B** 1.5 mm **C** 3.0 mm **D** 6.0 mm

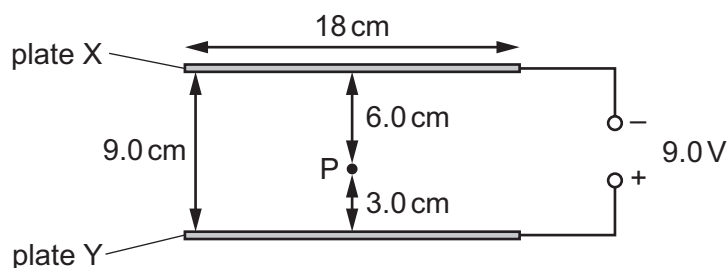
- 29 A microwave transmitter is placed at a fixed distance from a flat reflecting surface, as shown.



A microwave detector is moved steadily in a straight line from X to Y. A series of maxima and minima of intensity is obtained. The distance between adjacent maxima is 1.5 cm.

What is the frequency of the microwave radiation?

- A $1.0 \times 10^8 \text{ Hz}$
 B $2.0 \times 10^8 \text{ Hz}$
 C $1.0 \times 10^{10} \text{ Hz}$
 D $2.0 \times 10^{10} \text{ Hz}$
- 30 Two parallel circular metal plates X and Y, each of diameter 18 cm, have a separation of 9.0 cm. A potential difference of 9.0 V is applied between them.

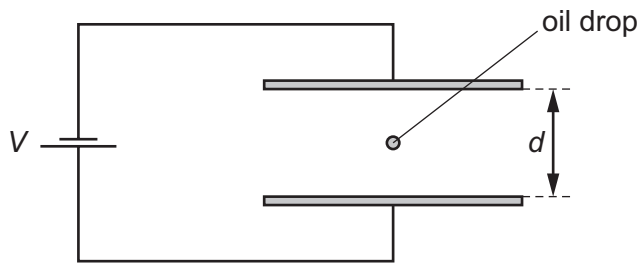


Point P is 6.0 cm from the surface of plate X and 3.0 cm from the surface of plate Y.

What is the electric field strength at P?

- A 50 NC^{-1} B 100 NC^{-1} C 150 NC^{-1} D 300 NC^{-1}

- 31 An oil drop has mass m and charge q . The drop is held stationary in an electric field between two parallel horizontal plates, distance d apart, as shown.

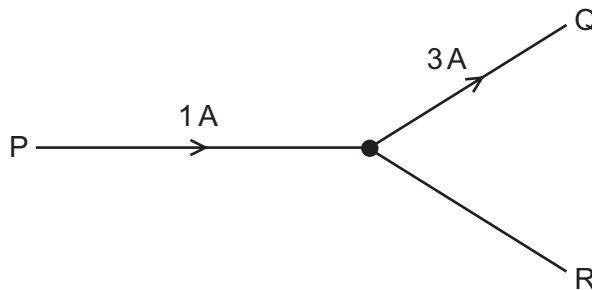


The potential difference between the plates is V and the acceleration of free fall is g .

What is the charge-to-mass ratio $\frac{q}{m}$ of the oil drop?

- A $\frac{gd}{V}$ B $\frac{V}{dg}$ C $\frac{gV}{d}$ D $\frac{d}{Vg}$

- 32 The diagram shows a junction in a circuit where three wires P, Q and R meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.



How much charge passes a given point in wire R in a time of 5 s?

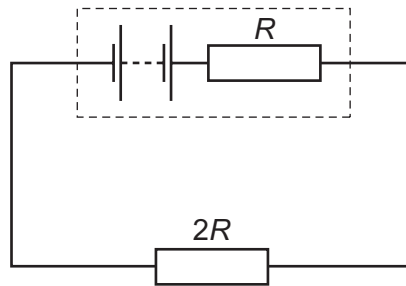
- A 0.4 C B 2 C C 10 C D 20 C

- 33 A wire carries a current of 2.0 A for 1.0 hour.

How many electrons pass a point in the wire in this time?

- A 1.2×10^{-15} B 7.2×10^3 C 1.3×10^{19} D 4.5×10^{22}

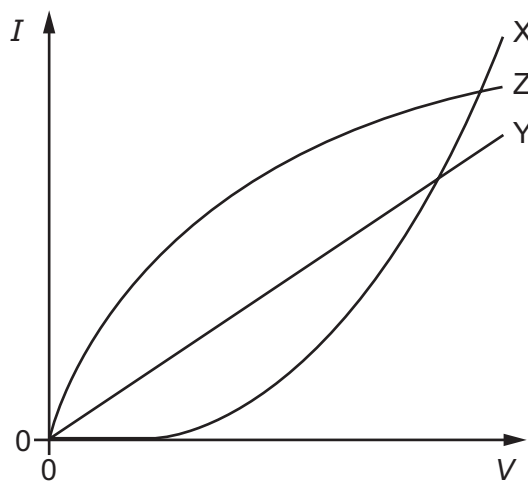
- 34 The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R .



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

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

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



Which row correctly identifies the components?

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

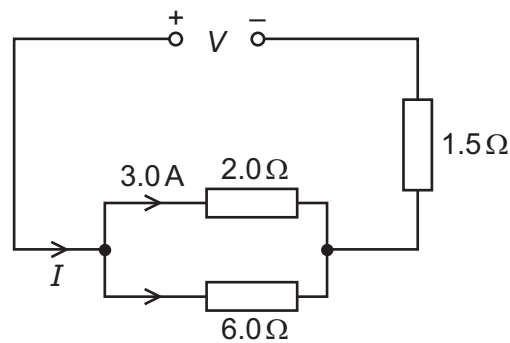
36 Four statements about either potential difference or electromotive force are listed.

- 1 It involves changing electrical energy into other forms.
- 2 It involves changing other energy forms into electrical energy.
- 3 It is the energy per unit charge to move charge around a complete circuit.
- 4 It is the work done per unit charge by the charge moving from one point to another.

Which statements apply to potential difference and which apply to electromotive force?

	potential difference	electromotive force
A	1 and 3	2 and 4
B	1 and 4	2 and 3
C	2 and 3	1 and 4
D	2 and 4	1 and 3

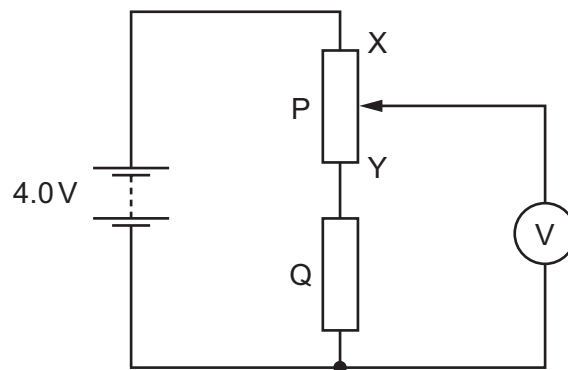
37 In the circuit shown, there is a current of 3.0 A in the 2.0Ω resistor.



What are the values of the current I delivered by the power supply and the voltage V across it?

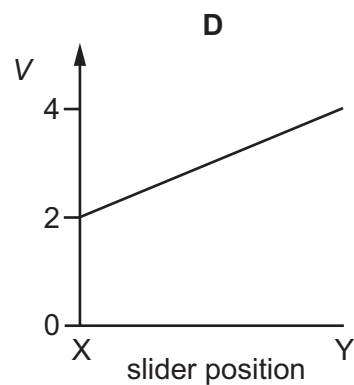
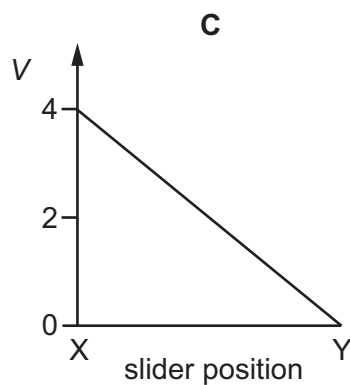
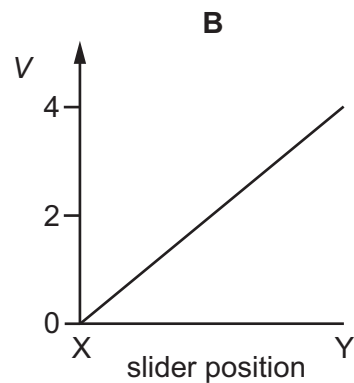
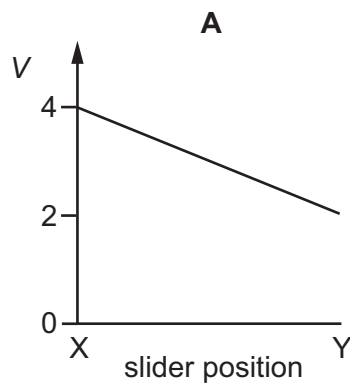
	I/A	V/V
A	3.0	10.5
B	4.0	9.0
C	4.0	12
D	12	18

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



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

Which graph is obtained?

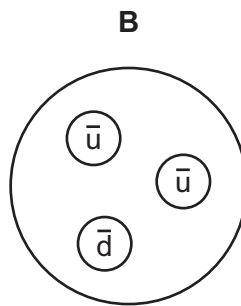
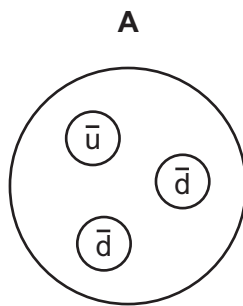


- 39 The calcium nuclide $^{42}_{20}\text{Ca}$ is formed by β^- decay.

What are the nucleon (mass) number and proton (atomic) number of the unstable nuclide that underwent β^- decay to form the calcium nuclide?

	nucleon number	proton number
A	41	19
B	41	21
C	42	19
D	42	21

- 40 Which diagram represents the structure of an antineutron?



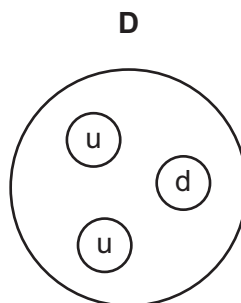
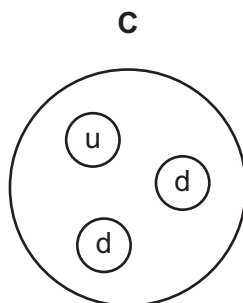
key

u up quark

d down quark

$\bar{u}$ up antiquark

$\bar{d}$ down antiquark



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PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2016

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

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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 **20** printed pages.



Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass 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 the order of magnitude of the Young modulus for a metal such as copper?

A 10^{-11} Pa **B** 10^{-4} Pa **C** 10^4 Pa **D** 10^{11} Pa

- 2 The force F between two point charges q_1 and q_2 , a distance r apart, is given by the equation

$$F = \frac{kq_1q_2}{r^2}$$

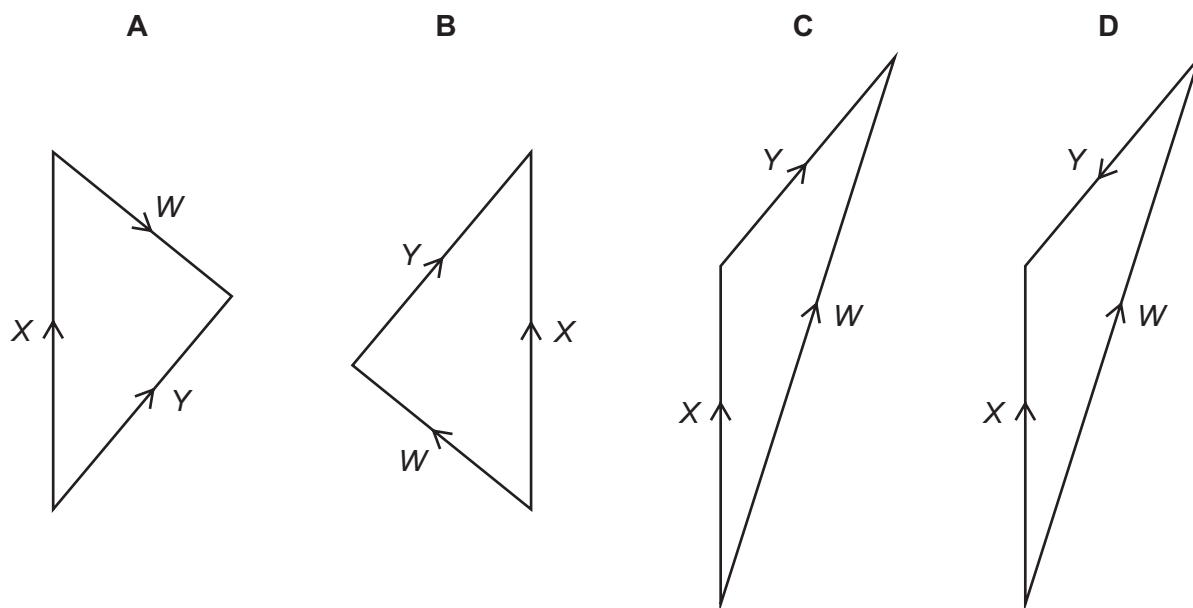
where k is a constant.

What are the SI base units of k ?

A $\text{kg m}^3 \text{s}^{-4} \text{A}^2$ **B** $\text{kg m}^3 \text{s}^{-4} \text{A}^{-2}$ **C** $\text{kg m}^3 \text{A}^2$ **D** $\text{kg m}^3 \text{A}^{-2}$

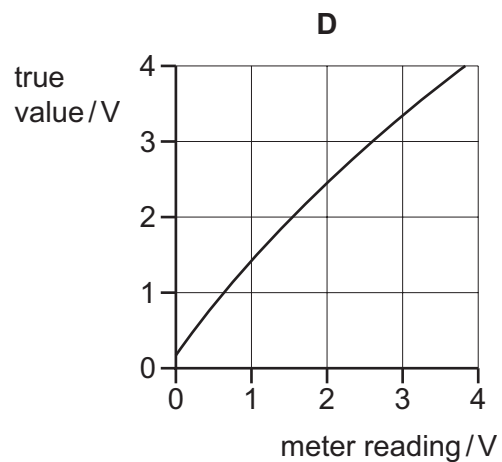
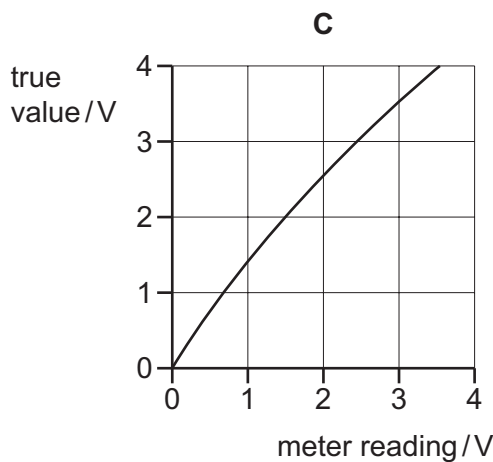
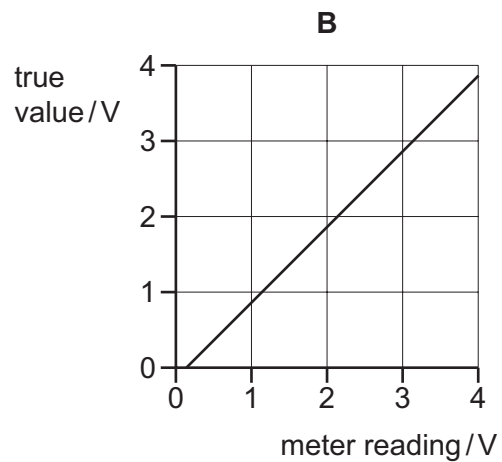
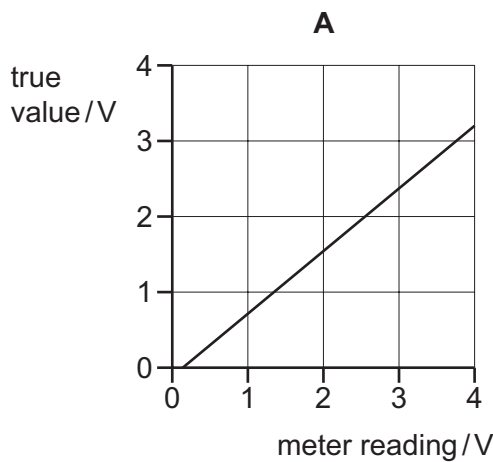
- 3 An aeroplane can fly at a velocity X when moving through still air. When flying in wind the aeroplane's velocity relative to the ground is Y .

Which vector diagram shows the magnitude and direction of the wind velocity W ?

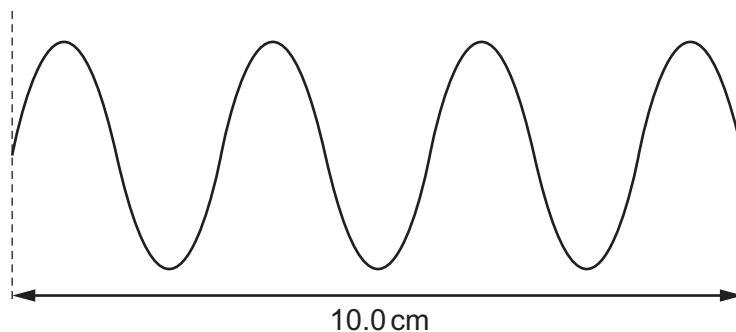


- 4 A voltmeter gives readings that are larger than the true values and has a systematic error that varies with voltage.

Which graph shows the calibration curve for the voltmeter?



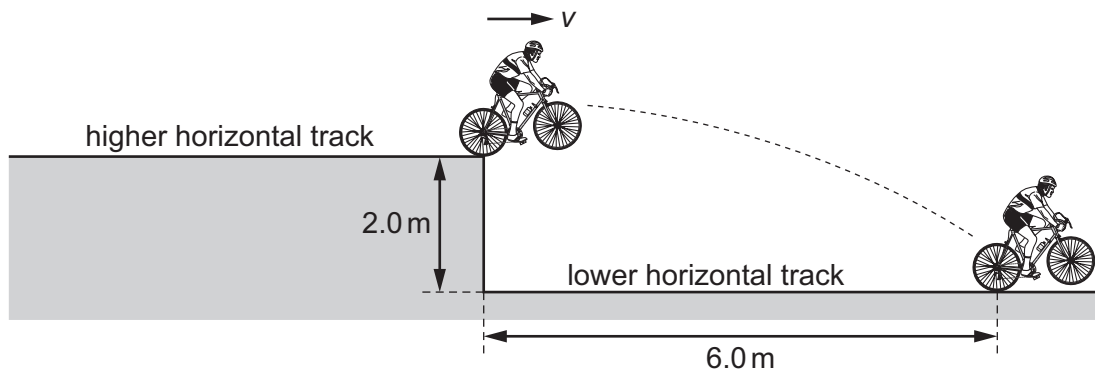
- 5 A student uses a cathode-ray oscilloscope (c.r.o.) to measure the period of a signal. She sets the time-base of the c.r.o. to 5 ms cm^{-1} and observes the trace illustrated below. The trace has a length of 10.0 cm .



What is the period of the signal?

- A** $7.1 \times 10^{-6} \text{ s}$ **B** $1.4 \times 10^{-5} \text{ s}$ **C** $7.1 \times 10^{-3} \text{ s}$ **D** $1.4 \times 10^{-2} \text{ s}$

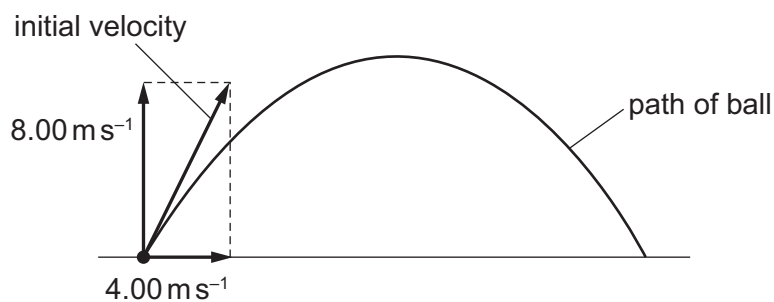
- 6 A cyclist pedals along a raised horizontal track. At the end of the track, he travels horizontally into the air and onto a track that is vertically 2.0 m lower.



The cyclist travels a horizontal distance of 6.0 m in the air. Air resistance is negligible.

What is the horizontal velocity v of the cyclist at the end of the higher track?

- A** 6.3 ms^{-1} **B** 9.4 ms^{-1} **C** 9.9 ms^{-1} **D** 15 ms^{-1}
- 7 An astronaut on the Moon, where there is no air resistance, throws a ball. The ball's initial velocity has a vertical component of 8.00 ms^{-1} and a horizontal component of 4.00 ms^{-1} , as shown.

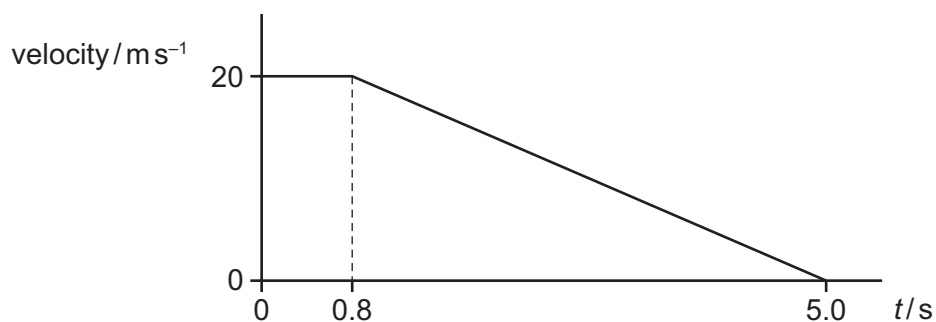


The acceleration of free fall on the Moon is 1.62 ms^{-2} .

What will be the speed of the ball 9.00 s after being thrown?

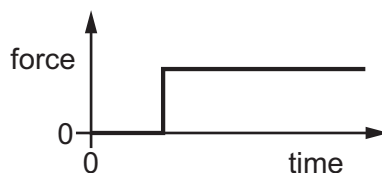
- A** 6.6 ms^{-1} **B** 7.7 ms^{-1} **C** 10.6 ms^{-1} **D** 14.6 ms^{-1}

- 8 A car is travelling at constant velocity. At time $t = 0$, the driver of the car sees an obstacle in the road and then brakes to a halt. The graph shows the variation with t of the velocity of the car.

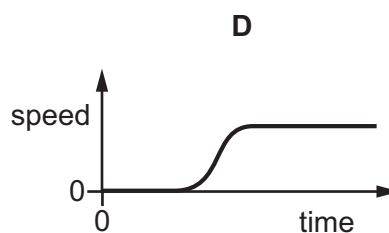
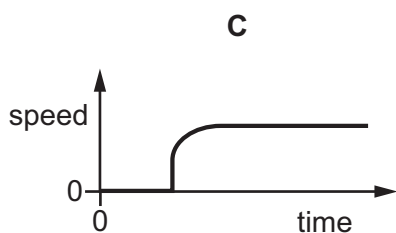
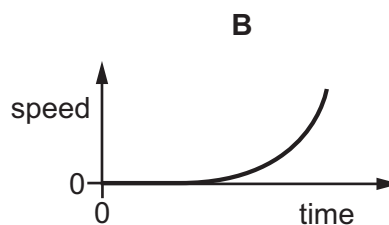
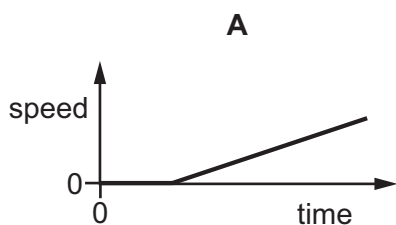


How far does the car travel in the 5.0 s after the driver sees the obstacle?

- A 16 m B 42 m C 58 m D 84 m
- 9 A car is stationary at traffic lights. When the traffic lights change to green, the driver presses down sharply on the accelerator. The resultant horizontal force acting on the car varies with time as shown.

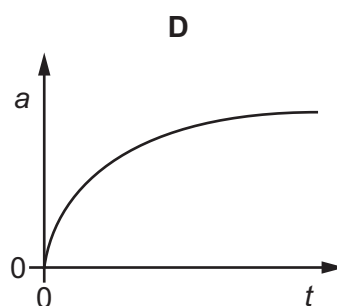
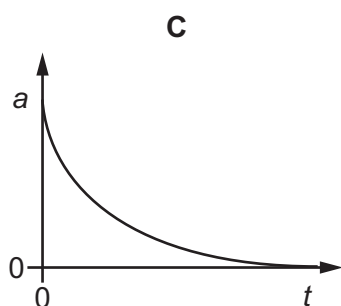
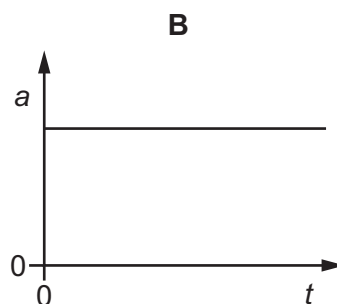
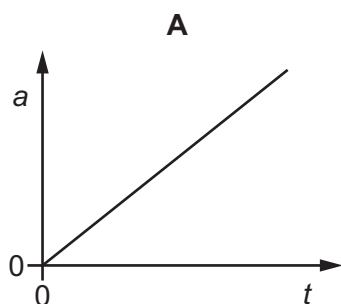


Which graph shows the variation with time of the speed of the car?



- 10 A beach-ball falls vertically from a high hotel window. Air resistance is **not** negligible.

Which graph shows the variation with time t of the acceleration a of the ball?



- 11 A car has mass m . A person needs to push the car with force F in order to give the car acceleration a . The person needs to push the car with force $2F$ in order to give the car acceleration $3a$.

Which expression gives the constant resistive force opposing the motion of the car?

A ma

B $2ma$

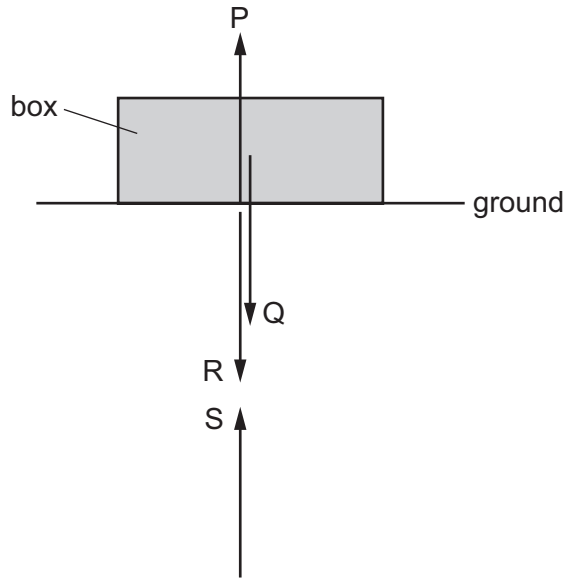
C $3ma$

D $4ma$

- 12 A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.

Forces P and Q act on the box. Forces R and S act on the Earth.

For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

- A** P is the equal and opposite force to Q and both are forces of contact.
B Q is the equal and opposite force to P and both are gravitational forces.
C R is the equal and opposite force to S and both are forces of contact.
D S is the equal and opposite force to Q and both are gravitational forces.
- 13 Two spheres travel along the same line with velocities u_1 and u_2 . They collide and after collision their velocities are v_1 and v_2 .



Which collision is **not** elastic?

	u_1/ms^{-1}	u_2/ms^{-1}	v_1/ms^{-1}	v_2/ms^{-1}
A	2	-5	-5	-2
B	3	-3	0	6
C	3	-2	1	6
D	5	2	3	6

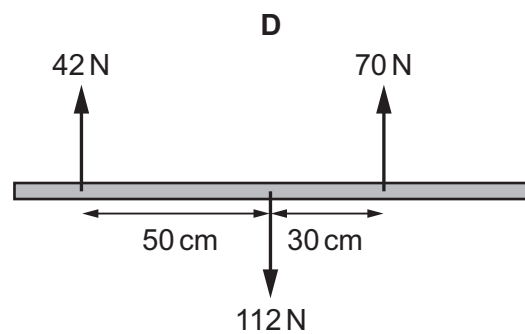
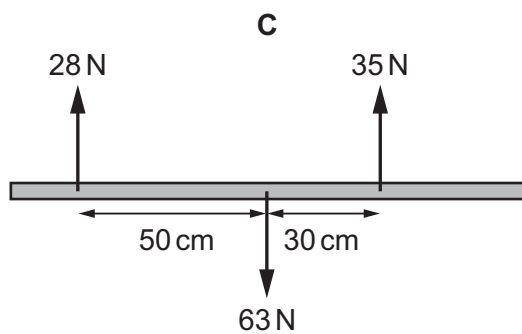
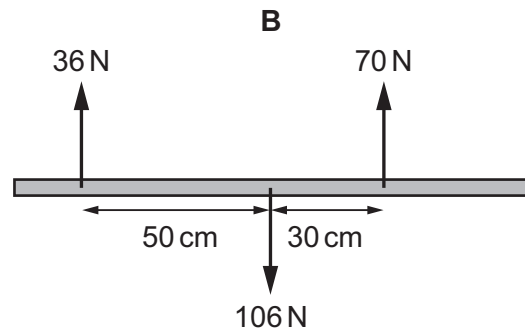
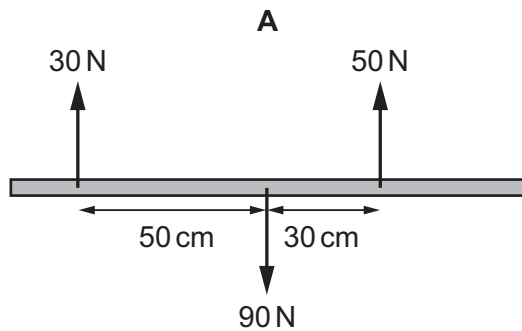
- 14** A submarine has circular windows of diameter 0.30 m. The windows can experience a maximum external pressure of 660 kPa before they crack.

What is the minimum external force needed to crack the windows?

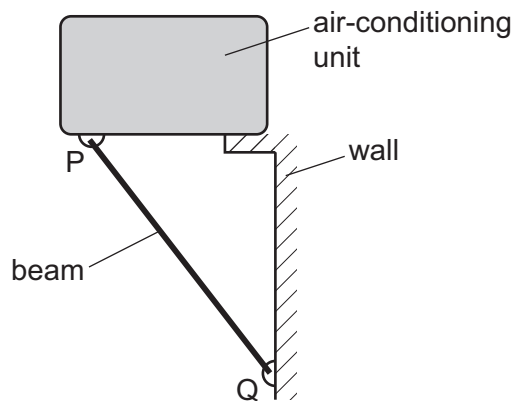
- A** 47 000 N **B** 190 000 N **C** 310 000 N **D** 620 000 N

- 15** Four beams of the same length each have three forces acting on them.

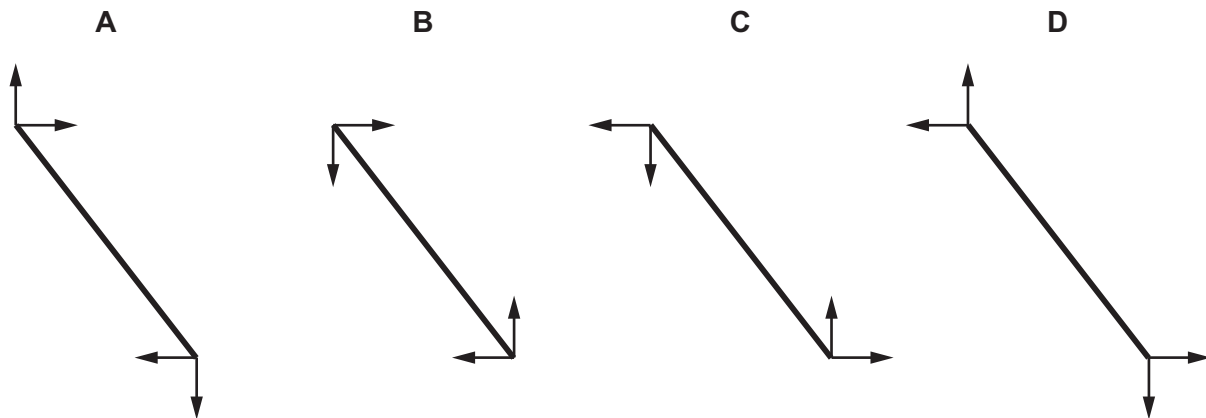
Which beam has both zero resultant force and zero resultant torque acting?



- 16 An air-conditioning unit is supported by a rigid beam PQ, as shown.



Which diagram shows the directions of the horizontal and vertical forces acting on the ends of the beam?



- 17 A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

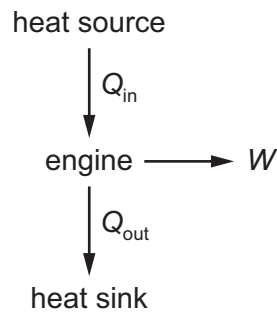
In one particular power station, the mass of water flowing per unit time is $1.5 \times 10^5 \text{ kg s}^{-1}$. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

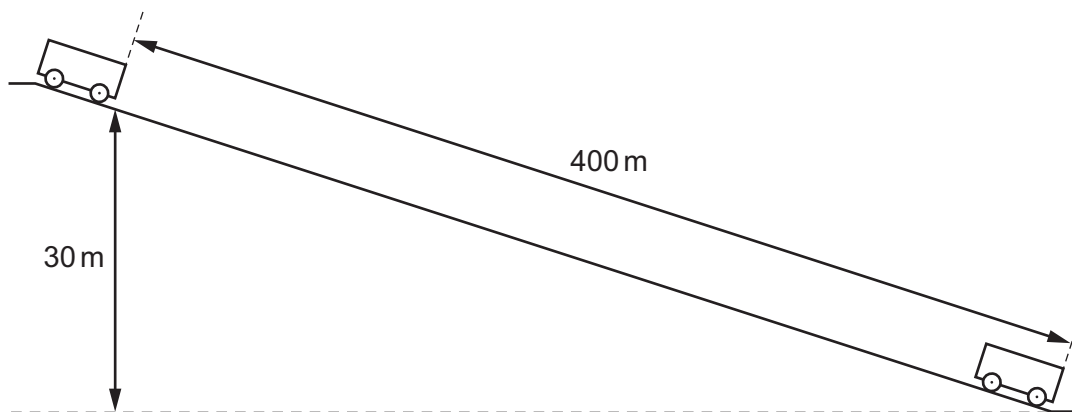
- A** 5.6% **B** 43% **C** 57% **D** 68%

- 18 An engine transforms thermal energy into mechanical work. The engine takes in thermal energy Q_{in} from a heat source and gives out thermal energy Q_{out} to a heat sink, producing useful work W .



What is the efficiency of this engine?

- A $\frac{W}{Q_{\text{in}} + Q_{\text{out}}}$ B $\frac{W}{Q_{\text{in}} - Q_{\text{out}}}$ C $\frac{W}{Q_{\text{in}}}$ D $\frac{W}{Q_{\text{out}}}$
- 19 A truck of mass 500 kg moves from rest at the top of a section of track 400 m long and 30 m high, as shown. The frictional force acting on the truck is 250 N throughout its journey.

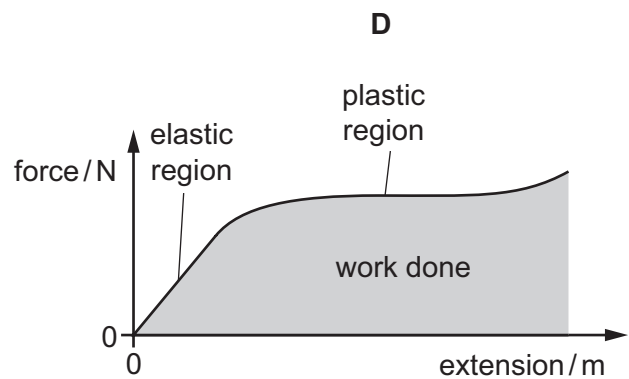
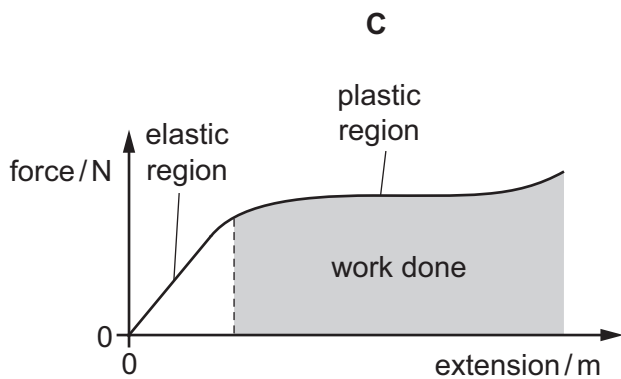
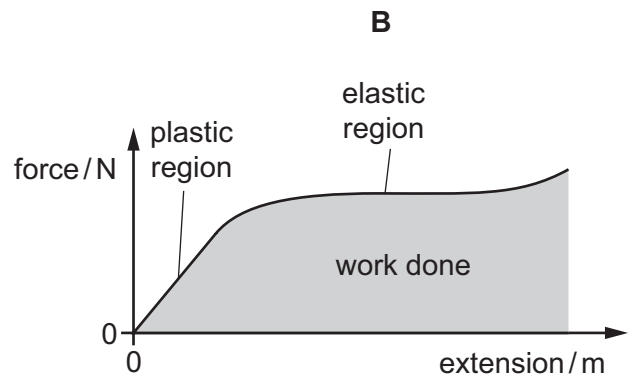
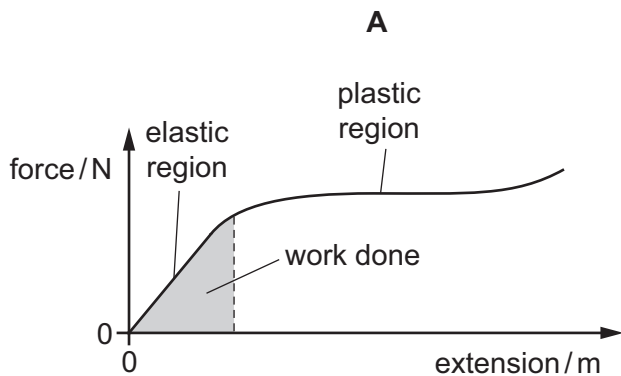


What is the final speed of the truck?

- A 14 m s^{-1} B 24 m s^{-1} C 31 m s^{-1} D 190 m s^{-1}
- 20 Which condition must apply for the work done by an expanding gas to be $p\Delta V$, where p is the pressure of the gas and ΔV is its change in volume?
- A No thermal energy must be supplied to the gas.
 B The expansion must be at a constant rate.
 C The pressure must be constant.
 D The temperature of the gas must be constant.

- 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 copper wire hangs vertically from a fixed point. A load is attached to the lower end of the wire producing an extension x . The wire obeys Hooke's law.

Which single change gives an extension $2x$?

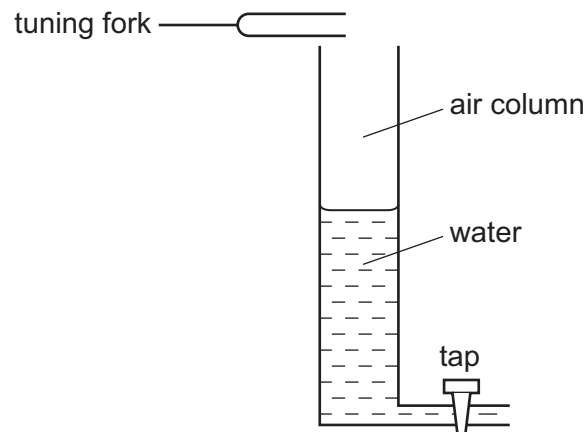
- A** Halve the cross-sectional area of the wire.
- B** Halve the diameter of the wire.
- C** Halve the length of the wire.
- D** Halve the load on the wire.

23 The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^2 m
A	gamma ray	X-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	X-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	X-ray
D	X-ray	infra-red	ultraviolet	microwave	radio wave

24 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.

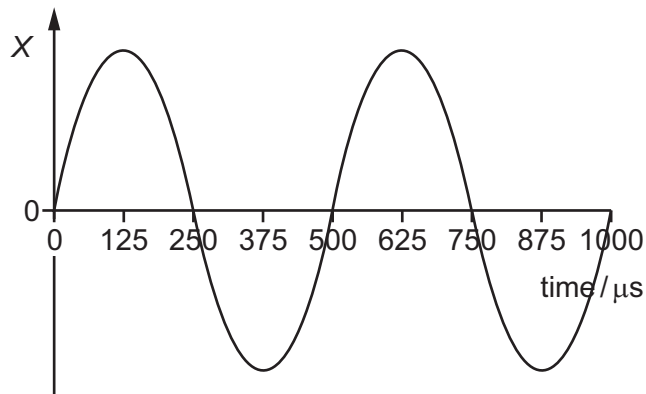


The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

What is the wavelength of the sound wave?

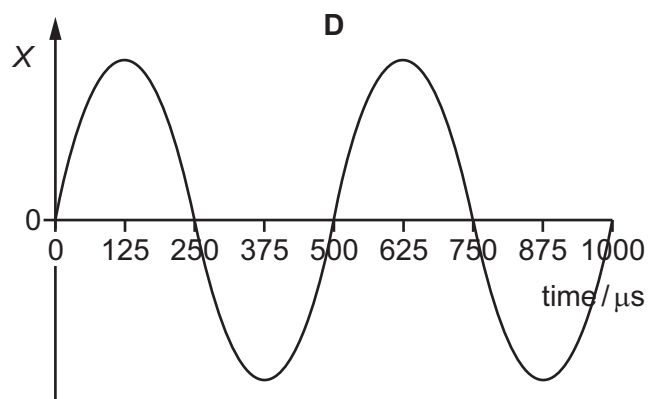
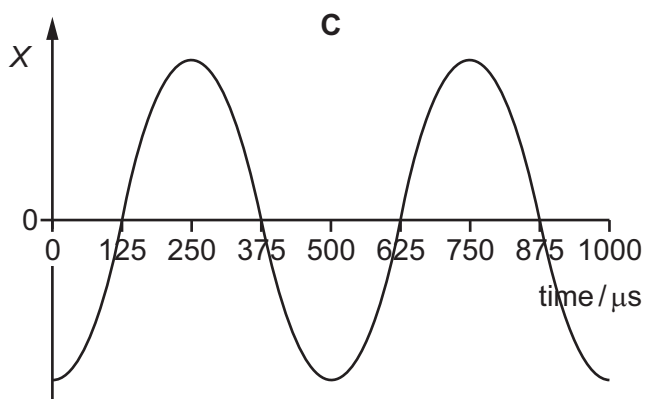
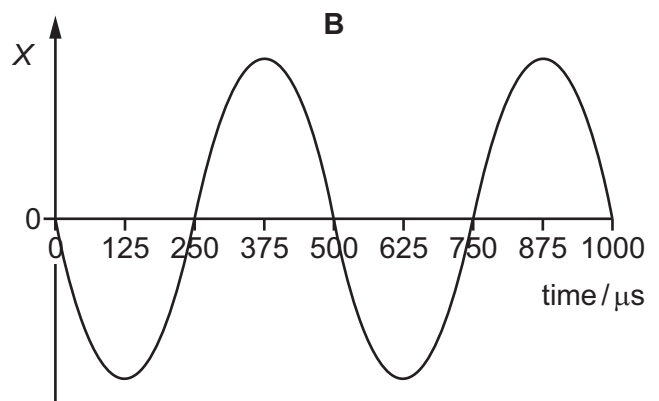
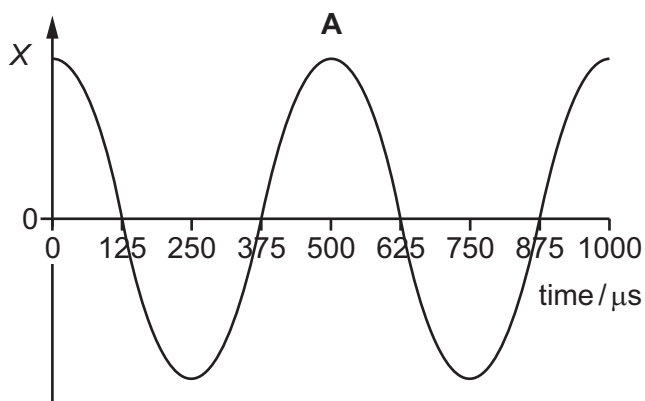
- A** 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

- 25 The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.

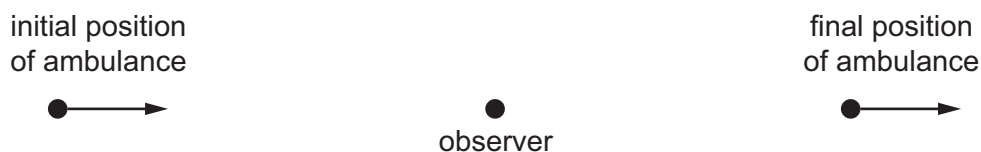


The velocity of sound in the gas is 330 m s^{-1} . All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.165 m further away from the source of the sound?



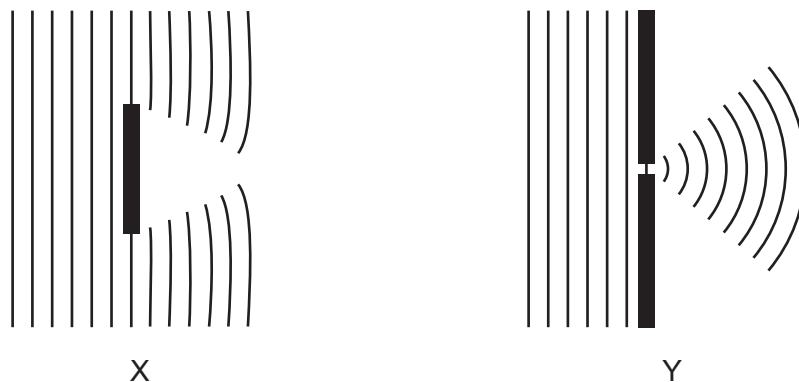
- 26 The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m s^{-1} . The ambulance is travelling with a constant velocity of 25 m s^{-1} towards an observer.



Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

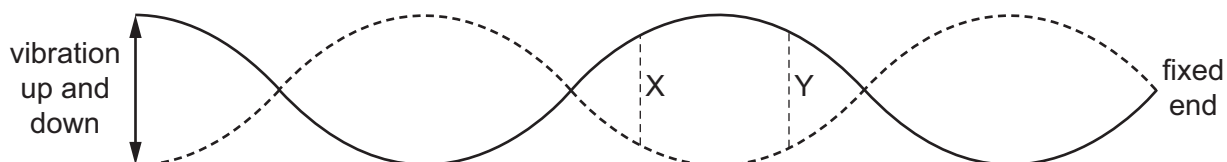
- A** 49 Hz **B** 84 Hz **C** 91 Hz **D** 98 Hz
- 27 Diagrams X and Y show the passage of water waves around an obstacle and through a gap.

The thick lines are barriers to the waves and each thin line represents a wavefront.



Which statement is correct?

- A** Diagrams X and Y both illustrate diffraction.
B Diagrams X and Y both illustrate interference.
C Only diagram X illustrates interference.
D Only diagram Y illustrates diffraction.
- 28 The diagram shows a long rope fixed at one end. The other end is moved up and down, setting up a stationary wave.

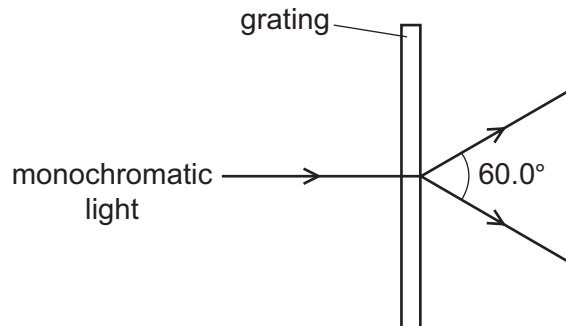


What is the phase difference between the oscillations at X and at Y?

- A** 0 **B** 45° **C** 90° **D** 135°

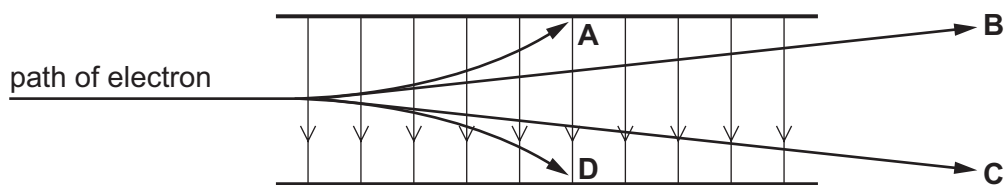
- 29** A diffraction grating is used to measure the wavelength of monochromatic light.

The spacing of the slits in the grating is $1.15 \times 10^{-6} \text{ m}$. The angle between the first order diffraction maxima is 60.0° , as shown in the diagram.



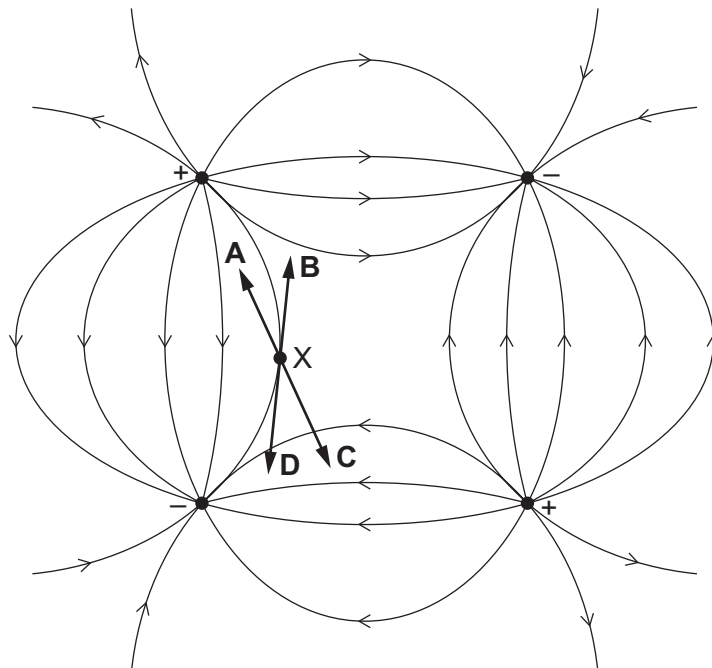
What is the wavelength of the light?

- A** 288 nm **B** 498 nm **C** 575 nm **D** 996 nm
- 30** Which path shows a possible movement of an electron in the electric field shown?

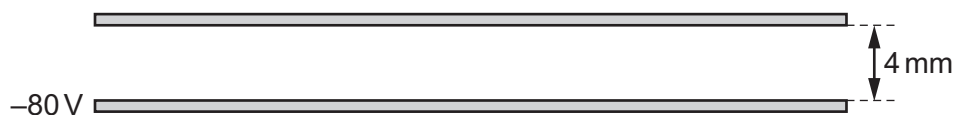


- 31** The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

In which direction does the force act on an electron at point X?



- 32 Two large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of -80 V .



Which potential should be applied to the upper plate to create an electric field of strength $60\,000\text{ V m}^{-1}$ upwards in the space between the plates?

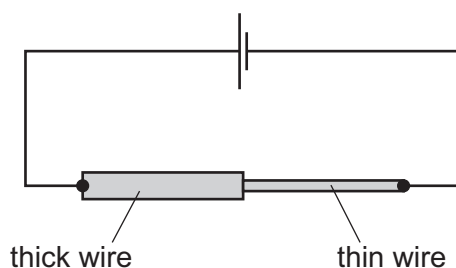
- A** -320 V **B** -160 V **C** $+160\text{ V}$ **D** $+320\text{ V}$

- 33 An electric kettle is marked 3.10 kW . It is used with an electrical supply of 240 V .

What is the electric current in the kettle and what is the kettle's electrical resistance when working?

	current / A	resistance / Ω
A	0.0129	18 600
B	0.0770	3100
C	12.9	18.6
D	12.9	3100

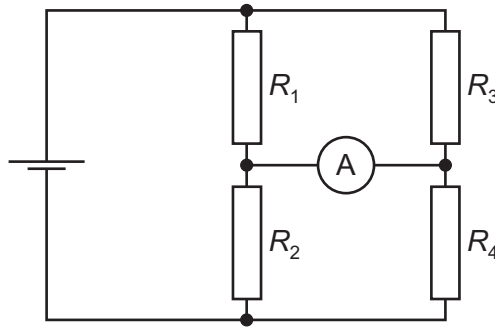
- 34 A thick copper wire is connected to a thin copper wire in series with a cell, as shown.



What is significantly **less** in the thick wire than in the thin wire?

- A** the charge passing a point per unit time
B the drift speed of the electrons
C the number density of the free electrons
D the number of free electrons passing a point per unit time
- 35 What is a typical value for the order of magnitude of the resistivity of copper?
- A** $10^{-13}\text{ }\Omega\text{ m}$ **B** $10^{-8}\text{ }\Omega\text{ m}$ **C** $10^{-3}\text{ }\Omega\text{ m}$ **D** $10^2\text{ }\Omega\text{ m}$

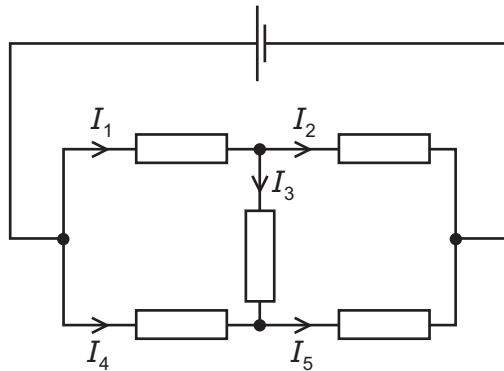
- 36 In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1 , R_2 , R_3 and R_4 .

Which equation is correct?

- A $R_1 - R_3 = R_2 - R_4$
 - B $R_1 \times R_3 = R_2 \times R_4$
 - C $R_1 - R_4 = R_2 - R_3$
 - D $R_1 \times R_4 = R_2 \times R_3$
- 37 The diagram shows currents I_1 , I_2 , I_3 , I_4 and I_5 in different branches of a circuit.



Which equation is correct?

- A $I_1 = I_2 + I_3$
- B $I_2 = I_1 + I_3$
- C $I_3 = I_4 + I_5$
- D $I_4 = I_5 + I_3$

38 What is a proton?

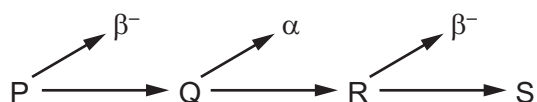
- A a hadron
- B a particle consisting of two down quarks and one up quark
- C a positive fundamental particle
- D a positive lepton

39 What are the correct descriptions of a γ -ray and a β^- particle?

	γ -ray	β^- particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	helium-4 nucleus

40 In a radioactive decay series, three successive decays each result in a particle being emitted.

The first decay results in the emission of a β^- particle. The second decay results in the emission of an α particle. The third decay results in the emission of another β^- particle.



Nuclides P and S are compared.

Which statement is correct?

- A P and S are identical in all respects.
- B P and S are isotopes of the same element.
- C S is a different element of lower atomic number.
- D S is a different element of reduced mass.

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