



Cambridge International AS & A Level

PHYSICS

9702/11

Paper 1 Multiple Choice

May/June 2020

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. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **20** pages. Blank pages are indicated.



Data

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

Formulae

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

- 1 What is a reasonable estimate of the kinetic energy of a car travelling at a speed of 30 m s^{-1} ?
A 10^2 J **B** 10^4 J **C** 10^6 J **D** 10^8 J
- 2 The frequency f of vibration of a mass m supported by a spring with spring constant k is given by the equation

$$f = Cm^p k^q$$

where C is a constant with no units.

What are the values of p and q ?

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

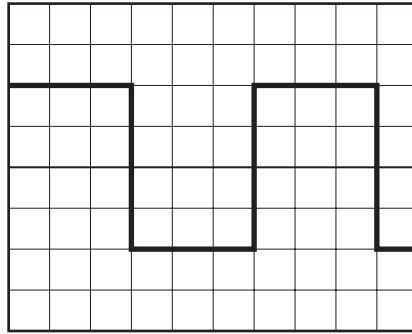
- 3 The power produced by a force moving an object is given by the equation shown.

$$\text{power} = \frac{\text{work}}{\text{time}} = \frac{\text{force} \times \text{displacement}}{\text{time}}$$

Which quantities are scalars and which are vectors?

	scalars	vectors
A	displacement, time	force, power
B	power, work	displacement, force
C	power, force	displacement, work
D	work, time	power, displacement

- 4 A cathode-ray oscilloscope displays a square wave, as shown.



The time-base setting is 0.20 ms per division.

What is the frequency of the square wave?

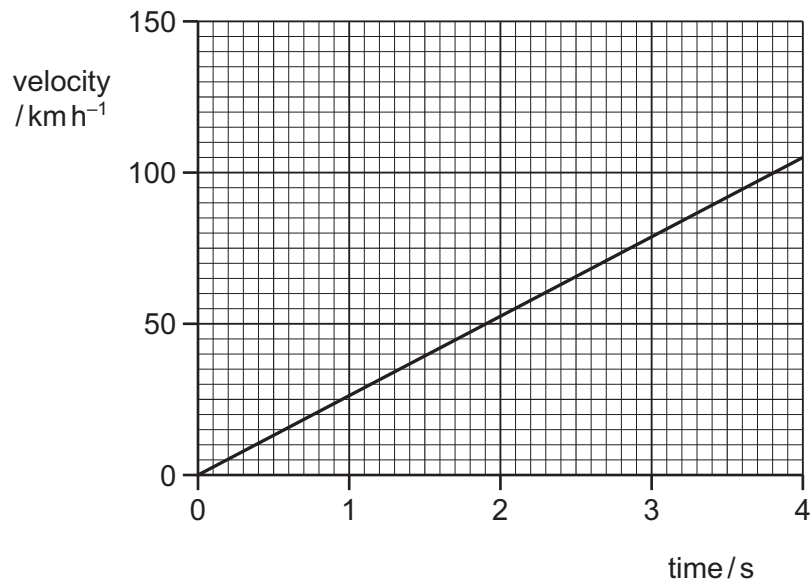
- A** 0.83 Hz **B** 830 Hz **C** 1300 Hz **D** 1700 Hz

- 5 A measurement is taken correctly but with a ruler at a significantly higher temperature than that at which the ruler was calibrated. The higher temperature causes the ruler to expand.

What describes the effect on the measurement caused by the higher temperature and how the measurement may be improved?

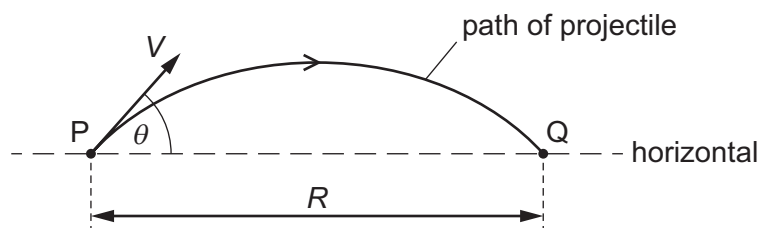
- A** The measurement will be subject to a random error. The measurement can be made more accurate by taking the average of several repeated measurements.
- B** The measurement will be subject to a random error. The measurement can be made more precise by taking the average of several repeated measurements.
- C** The measurement will be subject to a systematic error. The measurement can be made more accurate by taking the average of several repeated measurements.
- D** The measurement will be subject to a systematic error. The measurement can be made more precise by taking the average of several repeated measurements.

- 6 The velocity of an electric car changes as shown.



What is the acceleration of the car?

- A** 210 ms^{-2} **B** 58 ms^{-2} **C** 26 ms^{-2} **D** 7.3 ms^{-2}
- 7 A projectile is fired from point P with velocity V at an angle θ to the horizontal. It lands at point Q, a horizontal distance R from P, after time T .



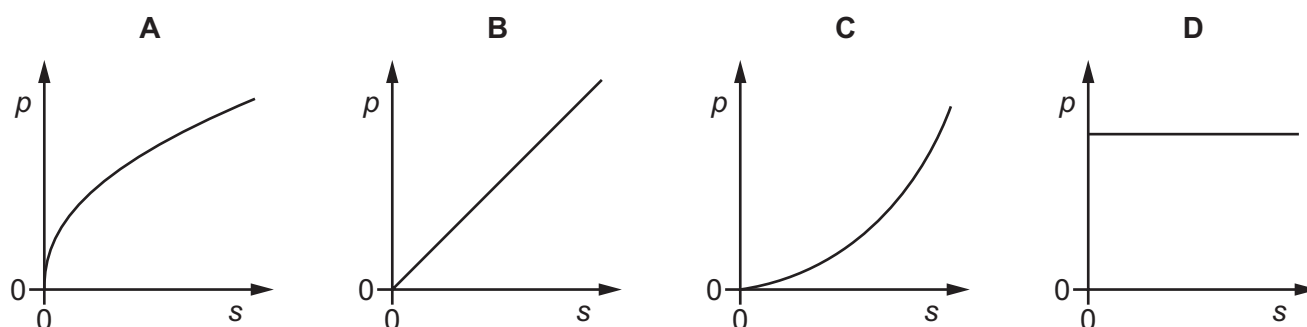
The acceleration of free fall is g . Air resistance is negligible.

Which equation is correct?

- A** $R = VT \cos \theta$
B $R = VT \sin \theta$
C $R = VT \cos \theta - \frac{1}{2} g T^2$
D $R = VT \sin \theta - \frac{1}{2} g T^2$

- 8 A car accelerates from rest in a straight line with constant acceleration.

Which graph best represents the variation of the momentum p of the car with the distance s travelled by the car?



- 9 The resultant force F on a raindrop of mass m falling with velocity v is given by the equation

$$F = mg - kv^2$$

where k is a constant and g is the acceleration of free fall.

What is the velocity of the raindrop when it reaches a constant (terminal) velocity?

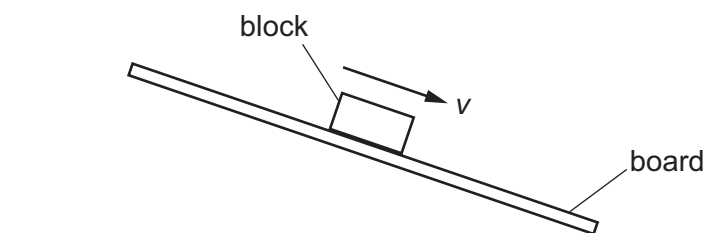
- A $\sqrt{\frac{k}{mg}}$ B $\frac{k}{mg}$ C $\sqrt{\frac{mg}{k}}$ D $\frac{mg}{k}$

- 10 A stationary toy gun fires a bullet.

Which statement about the bullet and the gun, immediately after firing, is **not** correct?

- A The force exerted on the bullet by the gun has the same magnitude as the force exerted on the gun by the bullet.
 B The force exerted on the bullet by the gun is in the opposite direction to the force exerted on the gun by the bullet.
 C The gun and the bullet have the same magnitude of momentum.
 D The kinetic energy of the gun must equal the kinetic energy of the bullet.

- 11 A wooden block rests on the rough surface of a board. One end of the board is then raised until the block slides down the board at constant velocity v .



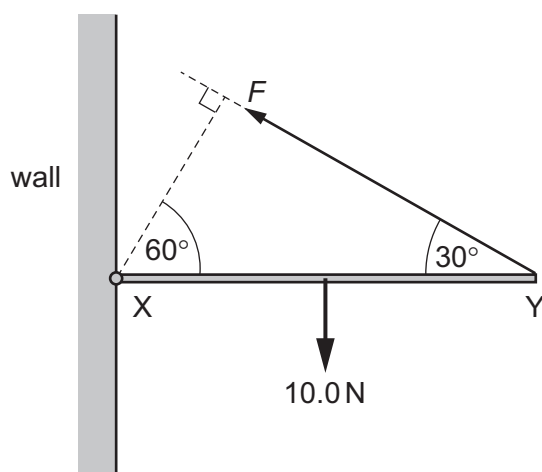
What describes the forces acting on the block when it is sliding with constant velocity?

	frictional force on block	resultant force on block
A	down the board	down the board
B	down the board	zero
C	up the board	down the board
D	up the board	zero

- 12 Which statement best describes a couple?

- A** a pair of forces of equal magnitude acting in opposite directions which produce rotational motion but not translational motion
- B** a pair of forces of equal magnitude acting in opposite directions which produce translational motion but not rotational motion
- C** a pair of forces of equal magnitude acting in the same direction which produce rotational motion but not translational motion
- D** a pair of forces of equal magnitude acting in the same direction which produce translational motion but not rotational motion

- 13** A uniform rod XY of weight 10.0 N is freely hinged to a wall at X. It is held horizontal by a force F acting from Y at an angle of 30° to the horizontal, as shown.



What is the value of F ?

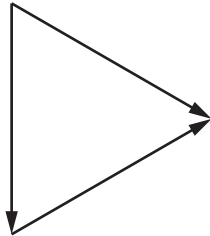
- A** 5.0 N **B** 8.7 N **C** 10.0 N **D** 20.0 N

- 14** Four combinations of vectors are shown, each representing all the forces acting on an object. The forces all act in the same plane.

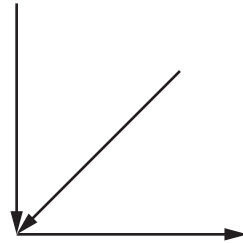
The object is in equilibrium.

Which combination of vectors could represent the forces acting on the object?

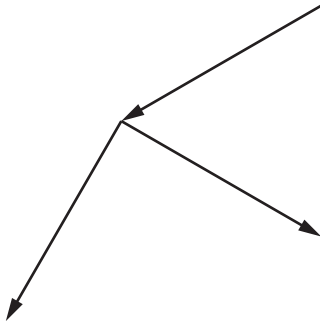
A



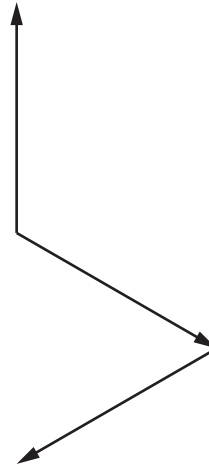
B



C



D



- 15** A rectangular metal bar exerts a pressure of 15 200 Pa on the horizontal surface on which it rests.

The height of the metal bar is 80 cm.

What is the density of the metal?

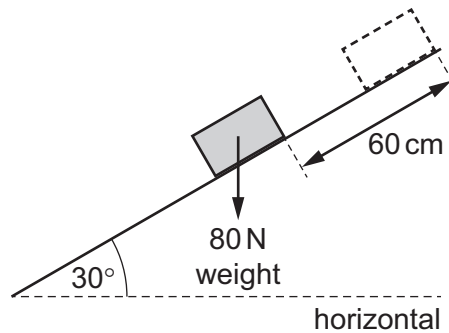
- A** 190 kg m⁻³
- B** 1900 kg m⁻³
- C** 19 000 kg m⁻³
- D** 190 000 kg m⁻³

- 16** A mass attached to the lower end of a spring bounces up and down.

At which points in the path of the mass do the gravitational potential energy of the mass (GPE), the elastic potential energy in the spring (EPE) and the kinetic energy of the mass (KE) have their highest values?

	GPE	EPE	KE
A	bottom	middle	top
B	bottom	top	middle
C	top	bottom	middle
D	top	bottom	top

- 17** A block of weight 80 N is pushed a distance of 60 cm up a slope inclined at 30° to the horizontal. There is a frictional force of 25 N between the block and the surface of the slope.

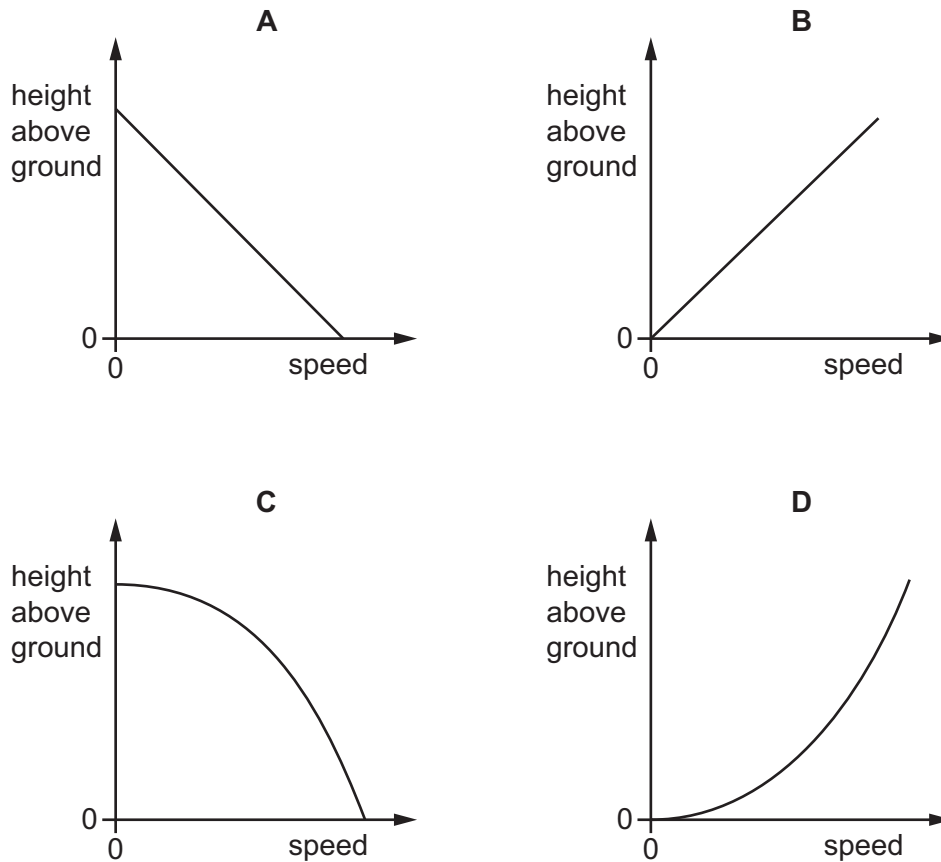


What is the work W_g done against the gravitational force and the work W_f done against the frictional force?

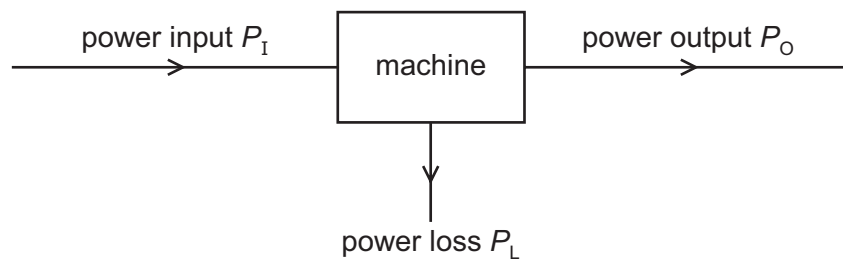
	W_g / J	W_f / J
A	24	7.5
B	24	15
C	48	7.5
D	48	15

- 18 A ball is dropped from rest and falls towards the ground. Air resistance is negligible.

Which graph shows the variation with speed of the height of the ball above the ground?



- 19 Power is transferred through a machine as shown.



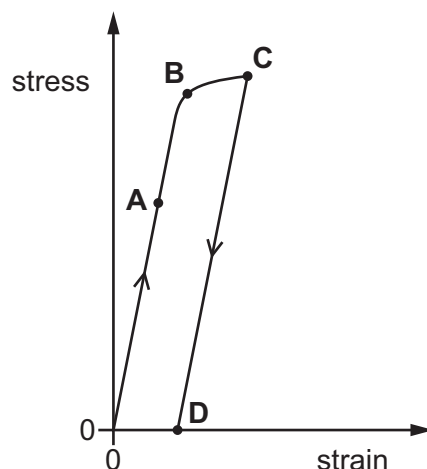
What is the efficiency of the machine?

- A** $\frac{P_I}{P_O + P_L}$
 B $\frac{P_L}{P_I}$
 C $\frac{P_L}{P_O}$
 D $\frac{P_O}{P_I}$

- 20 A tensile force is used to extend a sample of a material. The force is then removed.

The variation with strain of the applied stress is shown on the graph.

Which point on the graph could represent the elastic limit for the material?



- 21 A tensile force is applied to an unstretched rubber band, causing it to stretch. The tensile force is then removed.

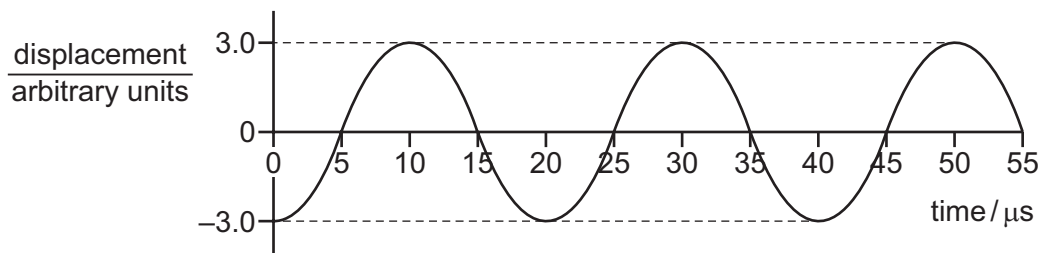
Which statement about the rubber band **must** be correct?

- A If the rubber band stretches elastically and plastically, all the work done by the force is converted to thermal energy in the rubber.
 - B If the rubber band stretches elastically, it obeys Hooke's law.
 - C If the rubber band stretches elastically, the gradient of the force–extension graph represents the work done by the force.
 - D If the rubber band stretches plastically, the rubber band will be longer after the force is removed than it was before the force is applied.
- 22 A sound wave reduces in intensity but maintains a constant frequency as it travels through air.

Which statement is correct?

- A The maximum displacement of the particles changes between one particle and the next particle.
- B The phase difference between adjacent particles is zero.
- C The wavelength is the distance between two particles that have a phase difference of 180° .
- D Two particles that have a phase difference of 360° have the same maximum displacement.

- 23 The graph shows the variation with time of the displacement of an electromagnetic wave at a point.



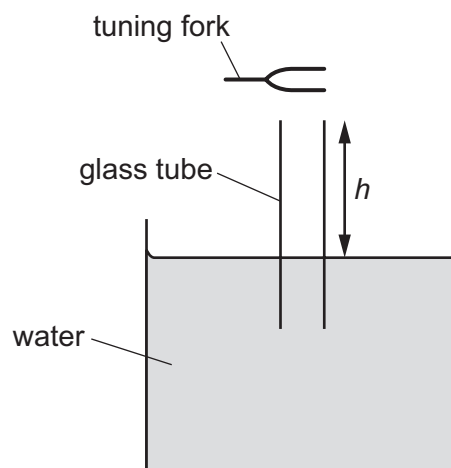
The wave is travelling in a vacuum.

What is the amplitude and what is the wavelength of the wave?

	amplitude / arbitrary units	wavelength / m
A	3.0	6000
B	6.0	6000
C	3.0	7500
D	6.0	7500

- 24 A long glass tube is almost completely immersed in a large tank of water. A tuning fork is struck and held just above the open end of the tube as it is slowly raised.

A louder sound is first heard when the height h of the end of the tube above the water is 18.8 cm. A louder sound is next heard when h is 56.4 cm. The speed of sound in air is 330 m s^{-1} .

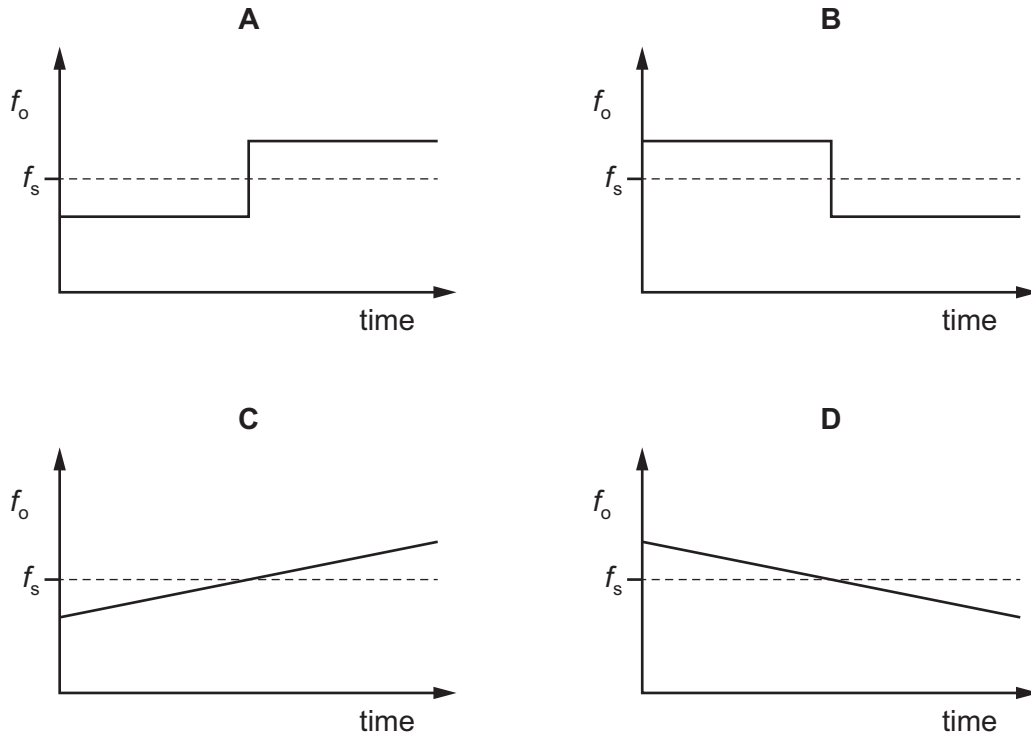


What is the frequency of the sound produced by the tuning fork?

- A** 220 Hz **B** 440 Hz **C** 660 Hz **D** 880 Hz

- 25** A source emitting sound of a single frequency f_s travels at constant speed directly towards an observer. The source then passes the observer and continues to move directly away from the observer. The velocity of the source remains constant.

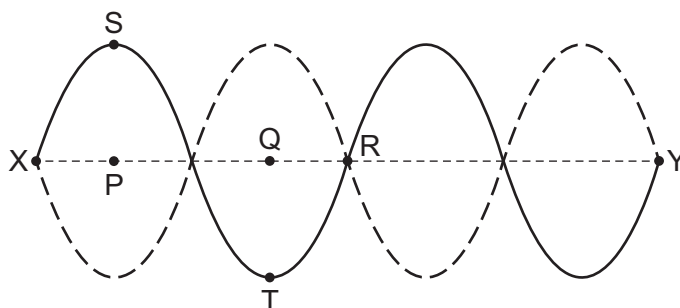
Which graph represents the variation with time of the frequency f_o of the sound heard by the observer?



- 26** What are the names of the electromagnetic waves that have wavelengths in a vacuum of 100 pm and of $100\text{ }\mu\text{m}$?

	wavelength 100 pm	wavelength $100\text{ }\mu\text{m}$
A	γ -rays	infrared
B	γ -rays	red light
C	X-rays	infrared
D	X-rays	red light

- 27 The diagram shows a string stretched between fixed points X and Y. There is a stationary wave on the string.



The solid curve shows the string at a position of maximum displacement. The dashed curve shows the other position of maximum displacement. The straight central dashed line shows the mean position of the string. Point S on the string is directly above point P. Point T on the string is directly below point Q.

Which statement is correct?

- A A short time later, point R on the string will be displaced.
 - B Points S and T on the string move in opposite directions.
 - C The distance between P and Q is one wavelength.
 - D Two points on the string that are equal distances from point R vibrate in phase.
- 28 Which statement **must** be true for diffraction to occur when a wave passes through a gap?
- A The wave is able to travel in a vacuum.
 - B The wave is progressive.
 - C The wave has a large amplitude.
 - D The wave has a long wavelength.
- 29 Light of a single wavelength is incident normally on two slits that are 0.20 mm apart. Interference fringes are observed on a screen that is 5.4 m away from the slits. The distance between successive bright fringes is 12 mm.

What is the wavelength of the light?

- A 440 nm
- B 540 nm
- C 650 nm
- D 900 nm

- 30 A diffraction grating and a screen are used to determine the single wavelength λ of the light from a source.

What is an essential feature of this experiment?

- A A curved screen must be used.
- B The diffraction angle θ must be measured for at least two interference maxima.
- C The light waves incident on the grating must be coherent.
- D The third order intensity maximum must be produced.

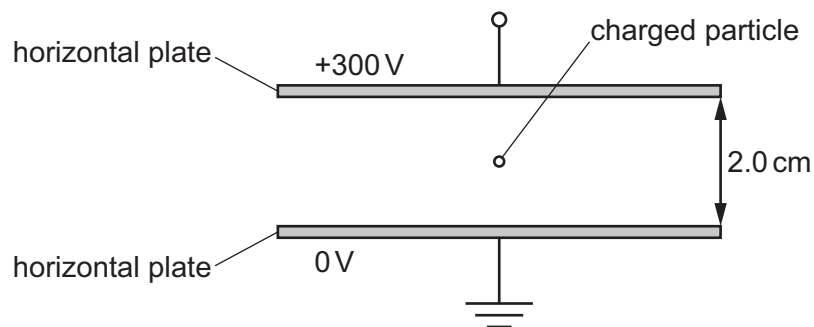
- 31 A small charge q is placed in the electric field of a large charge Q .

Both charges experience a force F .

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

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

- 32 A charged particle is in a vacuum between two horizontal metal plates as shown.

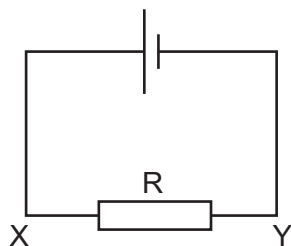


The acceleration of the particle is $7.15 \times 10^{11} \text{ ms}^{-2}$ downwards. The particle has a mass of $3.34 \times 10^{-27} \text{ kg}$.

What is the charge on the particle?

- A $+1.6 \times 10^{-19} \text{ C}$
- B $-1.6 \times 10^{-19} \text{ C}$
- C $+1.6 \times 10^{-17} \text{ C}$
- D $-1.6 \times 10^{-17} \text{ C}$

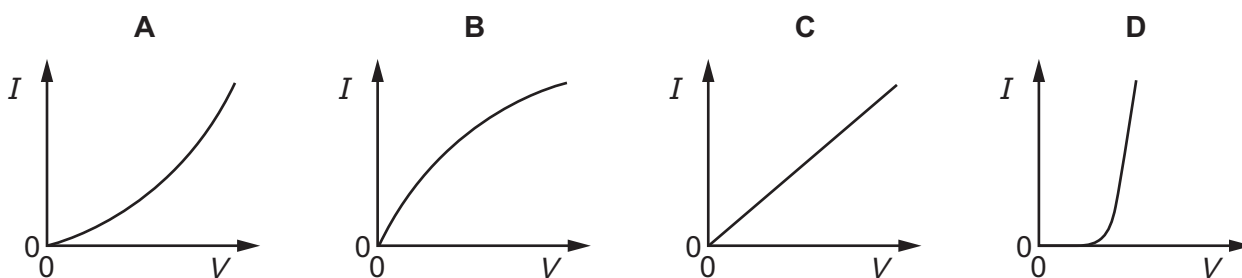
- 33 The current in the circuit shown is 3.2 mA.



What are the direction of flow and the rate of flow of electrons through the resistor R?

	direction of flow	rate of flow / s^{-1}
A	X to Y	2.0×10^{16}
B	X to Y	5.1×10^{-22}
C	Y to X	2.0×10^{16}
D	Y to X	5.1×10^{-22}

- 34 Which graph best represents the way the current I through a filament lamp varies with the potential difference V across it?



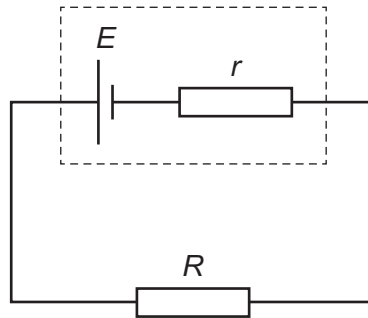
- 35 A cylindrical metal wire X has resistance R . The same volume of the same metal is made into a cylindrical wire Y of double the length.

What is the resistance of wire Y?

- A** R **B** $2R$ **C** $4R$ **D** $8R$

- 36** A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a resistor of resistance R .

A maximum power P can be dissipated by the resistor without overheating.



What is the maximum value of E if the resistor does not overheat?

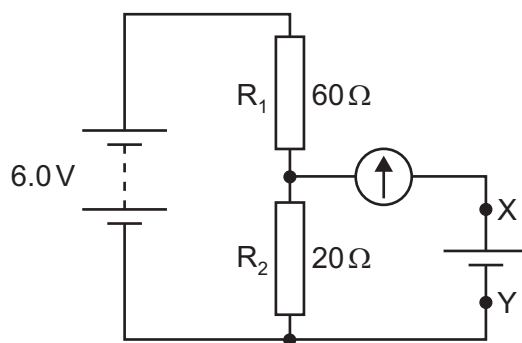
- A** $R\sqrt{\frac{P}{(R-r)}}$ **B** $R\sqrt{\frac{P}{(R+r)}}$ **C** $(R-r)\sqrt{\frac{P}{R}}$ **D** $(R+r)\sqrt{\frac{P}{R}}$
- 37** Three identical resistors can be connected together in four different ways.

The resistances of two of these combinations are $4.0\ \Omega$ and $9.0\ \Omega$.

What is the resistance of each individual resistor?

- A** $3.0\ \Omega$ **B** $6.0\ \Omega$ **C** $12\ \Omega$ **D** $18\ \Omega$

- 38 In the circuit shown, a battery of negligible internal resistance is connected in series with a pair of fixed resistors R_1 and R_2 .



The circuit is to be used to test whether the electromotive force (e.m.f.) of a particular cell is 1.5 V. The cell is connected between terminals X and Y in parallel with R_2 and in series with a galvanometer.

Which statement about the test is correct?

- A Any non-zero reading on the galvanometer means the cell has an e.m.f. of 1.5 V.
 - B The battery does not need to have an e.m.f. of 6.0 V.
 - C The cell may be connected either way round between X and Y.
 - D The galvanometer does not need a scale calibrated in amperes.
- 39 An element has two isotopic forms.
- What are the nuclear arrangements of these two isotopes?
- A They have different nucleon numbers and different proton numbers.
 - B They have different nucleon numbers but the same proton number.
 - C They have the same nucleon number and the same proton number.
 - D They have the same nucleon number but different proton numbers.
- 40 A hadron has a charge $+e$, where e is the elementary charge.

Which combination of up (u) and down (d) quarks could form this hadron?

- A ddd
- B udd
- C uud
- D uuu

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9702/12

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capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate of the mass of a raindrop?

- A 10^1 kg B 10^{-1} kg C 10^{-3} kg D 10^{-5} kg

2 Which quantity is a scalar?

- A acceleration
B force
C kinetic energy
D momentum

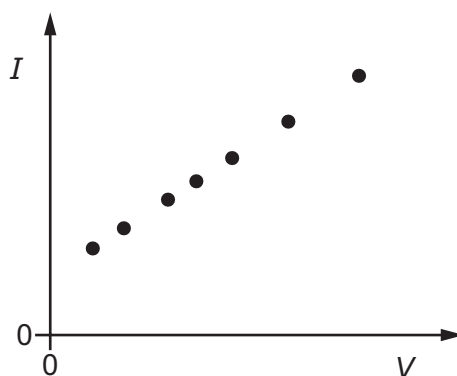
3 A galvanometer of resistance 5Ω is to be used in a null method.

In order to protect the galvanometer from damage due to an excessive initial current, resistors of resistance 0.5Ω and $1\text{ k}\Omega$ are available.

Which arrangement would provide this protection?

- A the 0.5Ω resistor in series with the galvanometer
B the 0.5Ω resistor in parallel with the galvanometer and this combination placed in series with the $1\text{ k}\Omega$ resistor
C the $1\text{ k}\Omega$ resistor in parallel with the galvanometer
D the $1\text{ k}\Omega$ resistor in parallel with the galvanometer and this combination placed in series with the 0.5Ω resistor

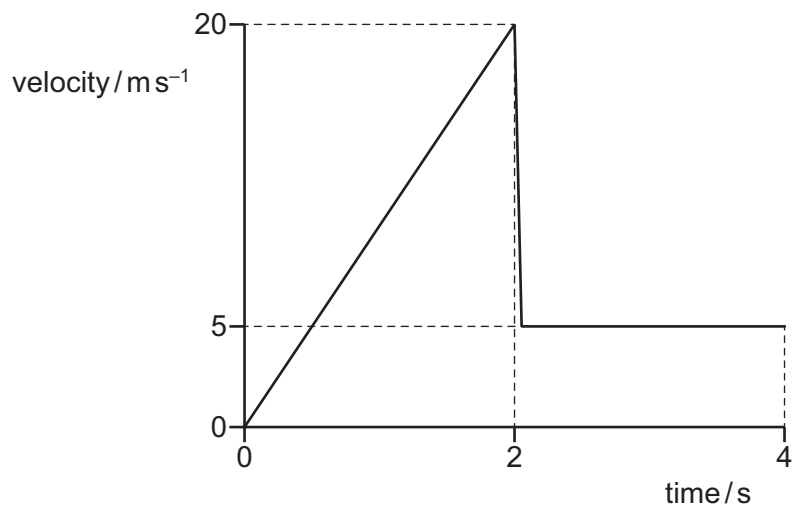
4 Readings are made of the current I for different voltages V across a fixed resistor. The results are plotted on a graph to show the variation of I with V .



What is the best description of the errors in the readings?

- A both systematic and random
B neither systematic nor random
C random only
D systematic only

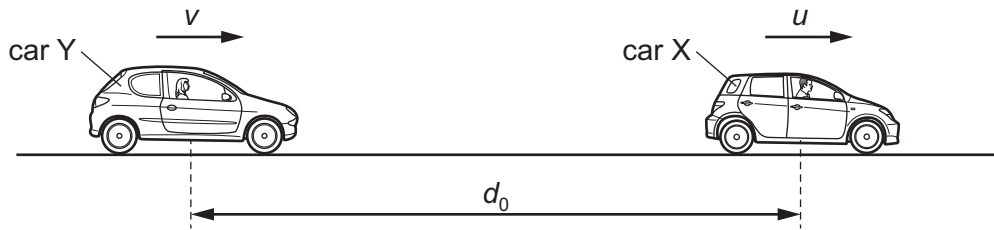
- 5 A stone is dropped from a height of 20 m above water. The graph shows the variation with time of the velocity of the stone.



Which statement describes the approximate position of the stone four seconds after it is dropped?

- A** It is at a distance of 10 m above the surface of the water.
- B** It is at a distance of 10 m below the surface of the water.
- C** It is at a distance of 20 m below the surface of the water.
- D** It is at a distance of 30 m below the surface of the water.

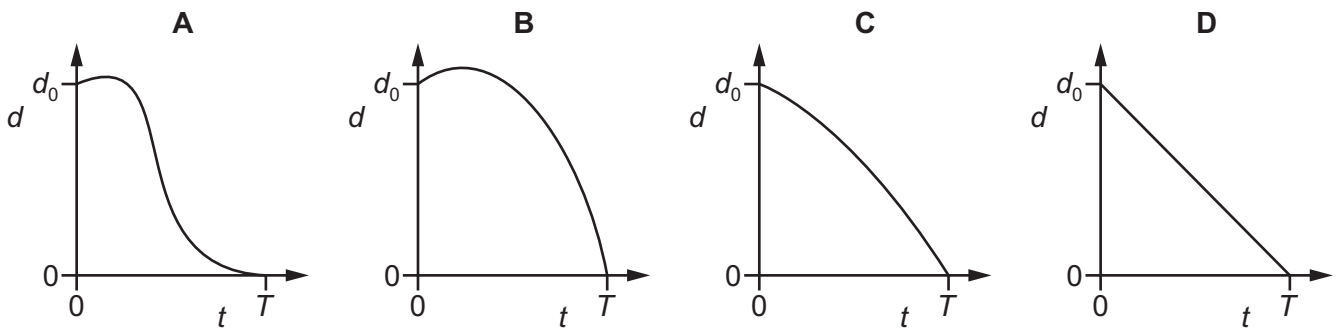
- 6 A car X is travelling at a constant speed u along a straight road. At time $t = 0$ a second car Y is a distance d_0 behind car X and travelling at a speed v in the same direction. Speed v is less than speed u .



At time $t = 0$ car Y begins to accelerate with a constant acceleration.

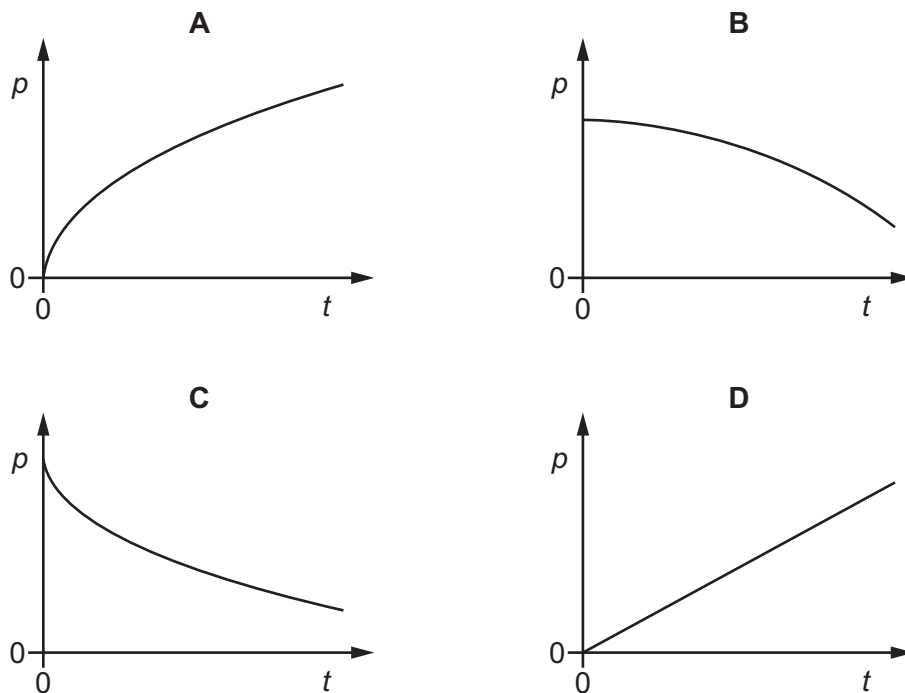
Car Y overtakes car X at time $t = T$.

Which graph could best show the variation with time t of the distance d between the cars?



- 7 The resultant force acting on an object is slowly increased.

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



- 8 An astronaut has a weight of 660 N when she is standing on the Earth's surface.

The acceleration of free fall on the surface of Mars is 3.71 m s^{-2} .

What would be the weight of the astronaut if she stood on the surface of Mars?

- A** 67.3 N **B** 178 N **C** 250 N **D** 660 N

- 9 A mass m_1 travelling with speed u_1 collides with a mass m_2 travelling with speed u_2 in the same direction. After the collision, mass m_1 has speed v_1 and mass m_2 has speed v_2 in the same direction. The collision is perfectly elastic.



before the collision

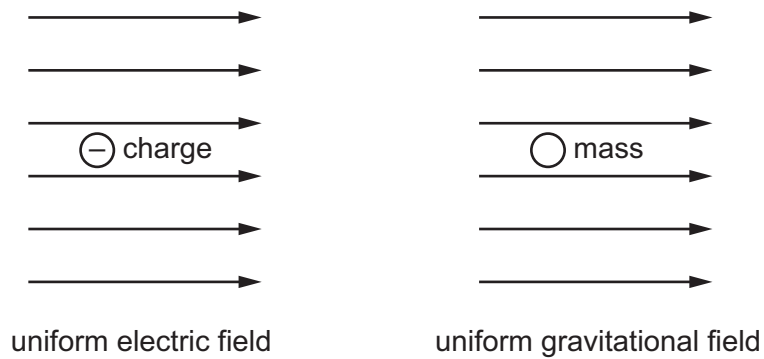


after the collision

Which equation is **not** correct?

- A** $m_1 u_1^2 - m_1 v_1^2 = m_2 v_2^2 - m_2 u_2^2$
B $v_2 + u_2 = v_1 + u_1$
C $m_1(u_1 - v_1) = m_2(v_2 - u_2)$
D $m_1(u_1 - v_1)^2 = m_2(u_2 - v_2)^2$

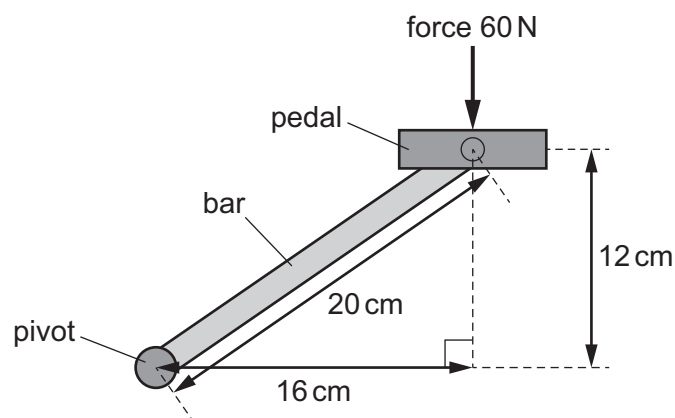
- 10 The diagrams show a negative electric charge situated in a uniform electric field and a mass situated in a uniform gravitational field.



Which row shows the directions of the forces acting on the charge and on the mass?

	charge	mass
A		
B		
C		
D		

- 11 A bicycle pedal is connected to a pivot by a metal bar, as shown.

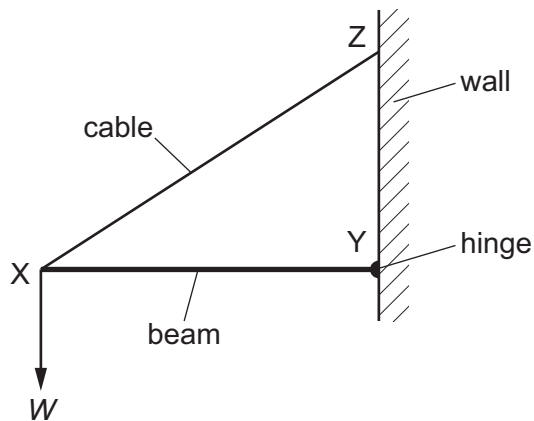


The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

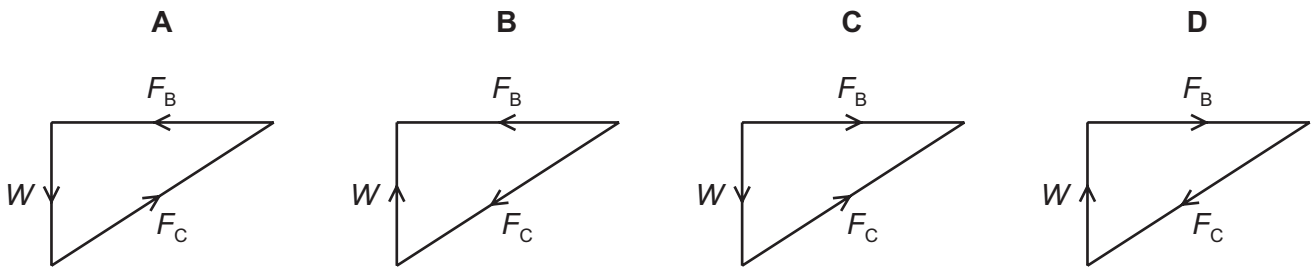
- A 7.2 Nm B 9.6 Nm C 12 Nm D 1200 Nm

- 12 A thin horizontal beam XY is freely hinged at point Y to a vertical wall. The beam is held stationary by a cable XZ which is attached to the wall at point Z.

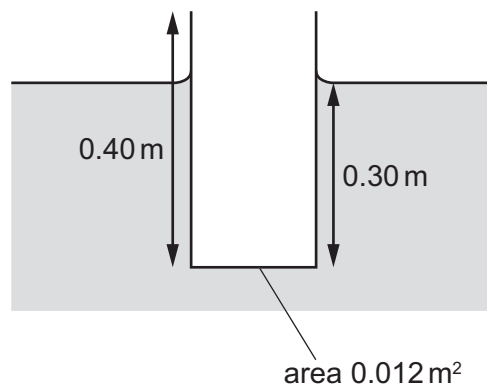


The beam supports a weight W at point X. The forces in the cable and the beam are F_C and F_B respectively.

Which vector triangle represents the forces acting on point X?



- 13 A pipe, open at one end, floats in a liquid as shown.



The cross-sectional area of the pipe is 0.012 m^2 . The weight of the pipe is 32 N .

What is the density of the liquid?

- A 680 kg m^{-3} B 910 kg m^{-3} C 6700 kg m^{-3} D 8900 kg m^{-3}

- 14 During an interval of time, fuel supplies energy X to a car.

Some of this energy is converted into kinetic energy as the car accelerates.

The rest of the energy Y is lost as thermal energy.

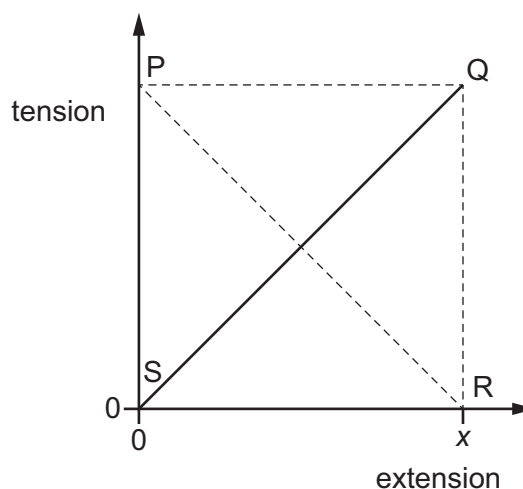
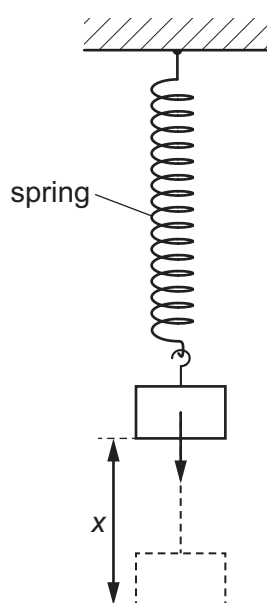
What is the efficiency of the car?

- A $\frac{X}{X-Y}$ B $\frac{Y}{X-Y}$ C $\frac{X-Y}{X}$ D $\frac{X-Y}{Y}$

- 15 In which situation is work done on an object?

- A The object slides with a constant velocity along a horizontal frictionless surface in a vacuum.
 B A person holds the object at arm's length and at a fixed height above the ground.
 C A person pushes the object up a frictionless ramp.
 D The stationary object floats partially submerged in water.

- 16 A spring is attached at one end to a fixed point. A mass is then hung from the other end of the spring. The spring has extension x when the system is in equilibrium.



The variation of the tension in the spring with its extension is shown on the graph.

Which statement is correct?

- A Area SPR represents the energy stored in the spring which cannot be recovered.
 B Area SPQR represents the energy stored in the spring which can be recovered.
 C Area SPQ represents the loss of gravitational potential energy of the mass due to the extension of the spring.
 D Area SQR represents the elastic potential energy stored in the spring.

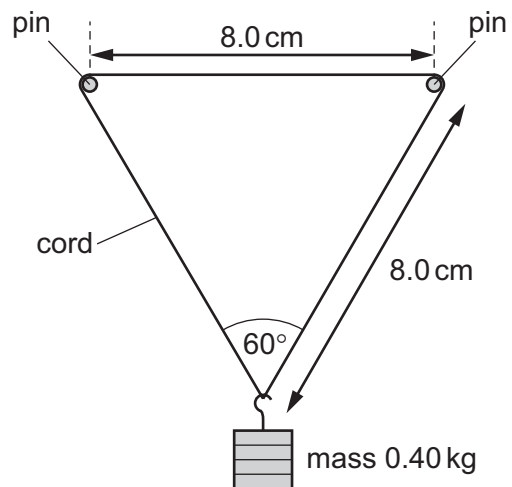
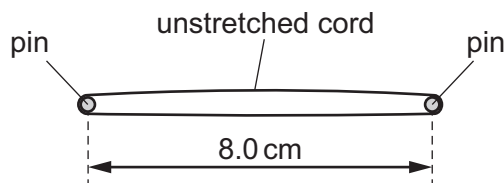
- 17** An escalator in an underground station has 25 people standing on it and is moving with a speed of 4.3 m s^{-1} . The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40° .

What is the minimum power required to lift these people?

- A** 5.4 kW **B** 6.4 kW **C** 53 kW **D** 63 kW

- 18** An elastic cord of unstretched total length 16.0 cm and cross-sectional area $2.0 \times 10^{-6} \text{ m}^2$ is held horizontally by two smooth pins a distance 8.0 cm apart.

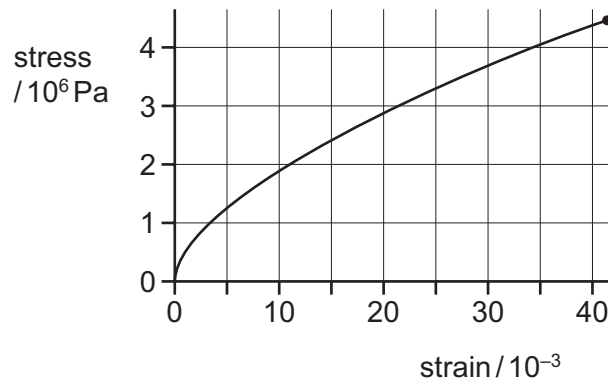
The cord obeys Hooke's law. A load of mass 0.40 kg is suspended centrally on the cord. The angle between the two sides of the cord supporting the load is 60° .



What is the Young modulus of the cord material?

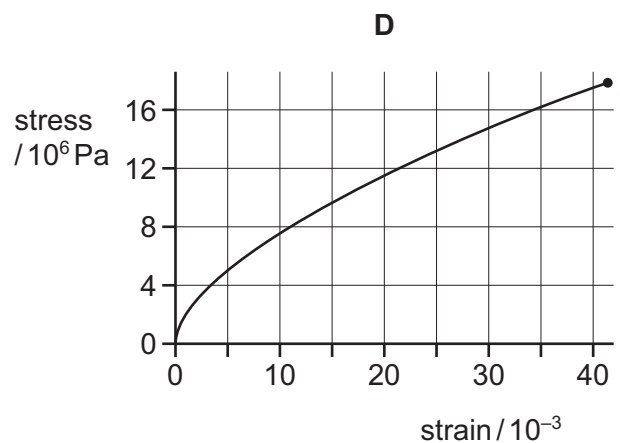
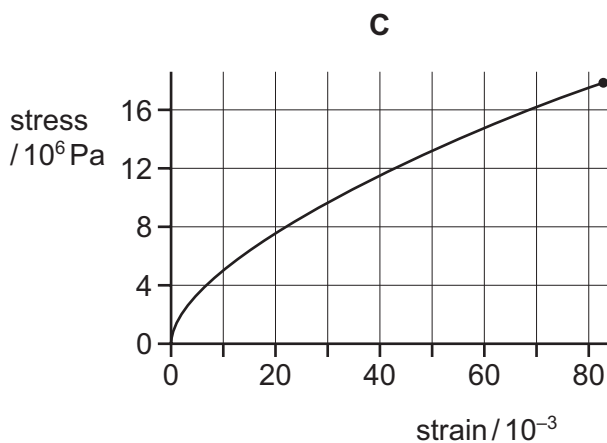
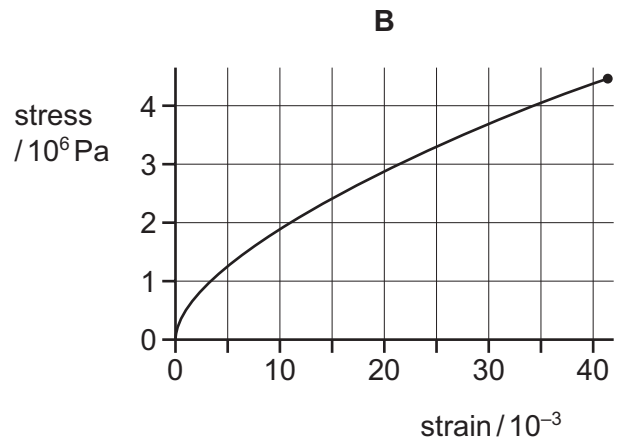
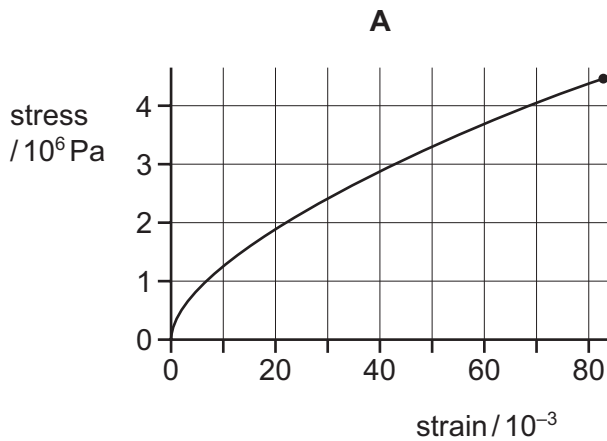
- A** $5.7 \times 10^5 \text{ Pa}$ **B** $1.1 \times 10^6 \text{ Pa}$ **C** $2.3 \times 10^6 \text{ Pa}$ **D** $3.9 \times 10^6 \text{ Pa}$

- 19 A student is investigating the mechanical properties of a metal. He applies different loads to a long thin wire up to its breaking point, and measures the extension of the wire for each load. He then plots a graph of stress against strain.

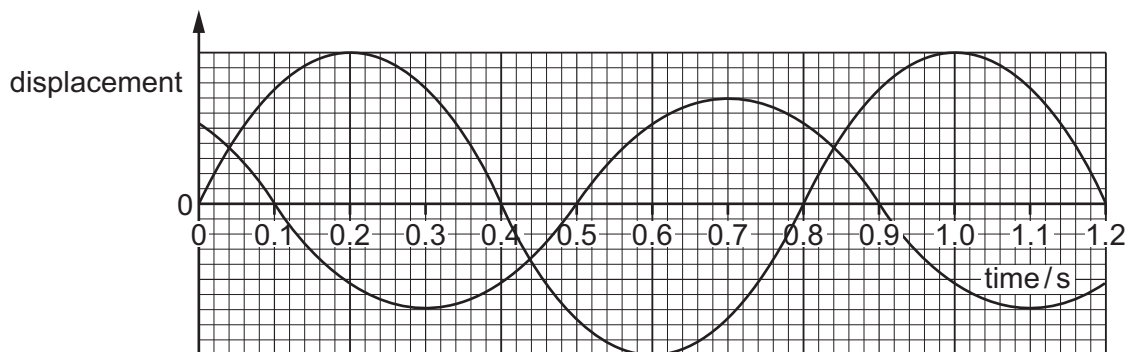


The student repeats the experiment with a wire made from the same metal, with twice the original length and half the diameter.

Which graph is obtained?



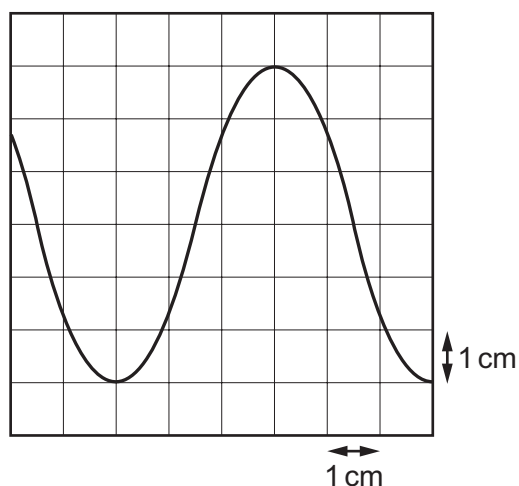
- 20 Which statement describes what is meant by the plastic deformation of a material?
- A It always obeys Hooke's law.
 - B It does not return to its original length when the extending force is removed.
 - C It never obeys Hooke's law.
 - D It returns to its original length when the extending force is removed.
- 21 A transverse wave is moving along a rope. Two points X and Y on the rope are a quarter of a wavelength apart from each other.
- Which statement is **not** possible for the two points X and Y at any instant?
- A They are both stationary.
 - B They are displaced in opposite directions from their equilibrium position.
 - C They are moving in opposite directions.
 - D They both have displacements of the same magnitude from their equilibrium positions.
- 22 Two progressive waves meet at a fixed point P. The variation with time of the displacement of each wave at point P is shown in the graph.



What is the phase difference between the two waves at point P?

- A 45°
- B 90°
- C 135°
- D 180°

- 23 A microphone connected to the Y-plates of a cathode-ray oscilloscope (CRO) is placed in front of a loudspeaker. The trace on the screen of the CRO is shown.

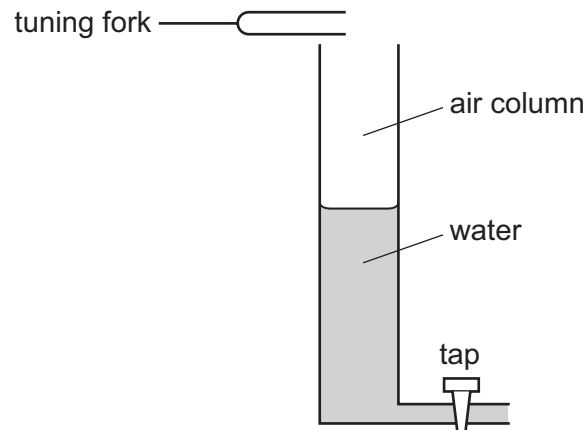


The time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 0.2 mV cm^{-1} .

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the CRO?

	frequency / Hz	amplitude / mV
A	330	0.6
B	330	1.2
C	670	0.6
D	670	1.2

- 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** A stationary person measures the speed and wavelength of the sound from a horn on a stationary vehicle. The person then repeats the measurements when the vehicle is approaching at a constant speed.

Which row describes the measured wavelength and the measured speed of the sound wave from the moving vehicle when compared with the sound wave from the stationary vehicle?

	wavelength of the sound wave	speed of the sound wave
A	longer	greater
B	shorter	greater
C	longer	same
D	shorter	same

26 The table shows the wavelengths of five electromagnetic waves.

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

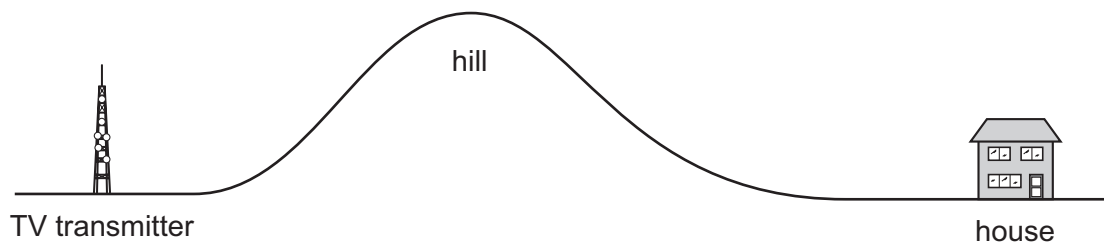
	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^2 m
A	gamma-ray	X-ray	infrared	microwave	radio wave
B	radio wave	microwave	infrared	X-ray	gamma-ray
C	radio wave	microwave	ultraviolet	infrared	X-ray
D	X-ray	infrared	ultraviolet	microwave	radio wave

27 Two progressive waves meet at a point.

Which condition must be met for superposition of the waves to occur?

- A** The waves must be coherent.
- B** The waves must be of the same type.
- C** The waves must be travelling in opposite directions.
- D** The waves must meet in phase.

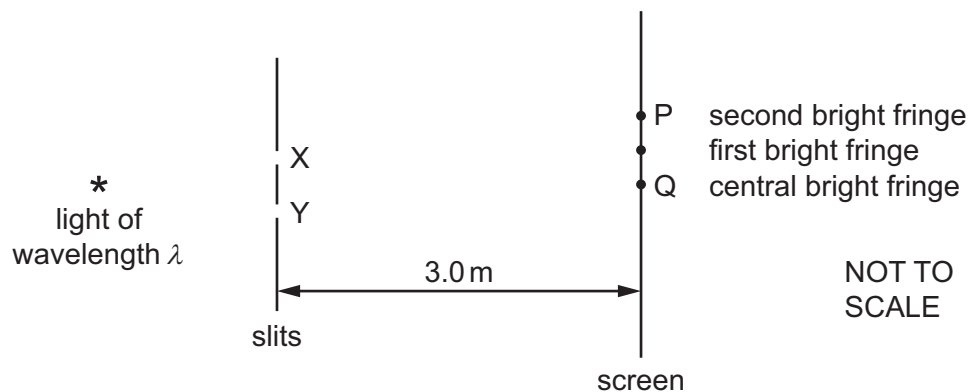
28 A hill separates a television (TV) transmitter from a house. The transmitter cannot be seen from the house. However, the house has good TV reception.



By which wave effect at the hill could the TV signal reach the house?

- A** coherence
- B** diffraction
- C** interference
- D** reflection

- 29 The diagram shows an arrangement for demonstrating two-source interference using coherent light of a single wavelength λ .

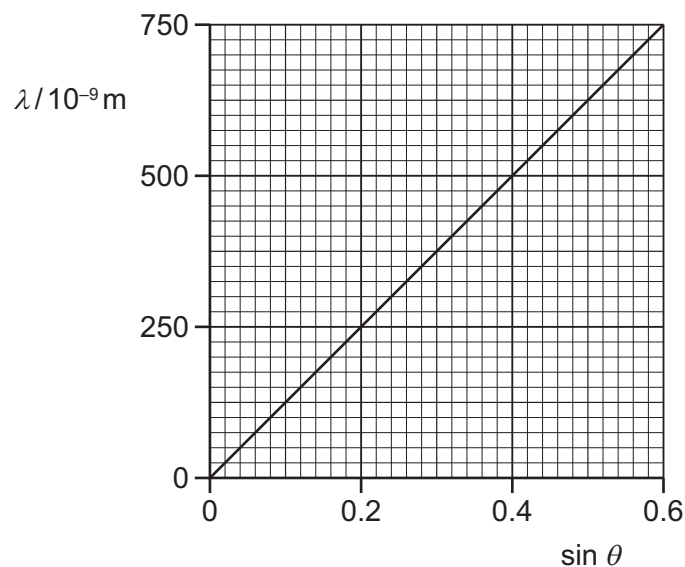


An interference pattern is observed on a screen 3.0 m away from the slits X and Y, which have a separation of 1.0 mm.

The central bright fringe is at Q, and the **second** bright fringe from the centre is at P.

What is the distance between Q and P?

- A $6.0 \times 10^3 \lambda$
 B $3.0 \times 10^3 \lambda$
 C $6.7 \times 10^{-4} \lambda$
 D $3.3 \times 10^{-4} \lambda$
- 30 Light of wavelength λ is incident normally on a diffraction grating. The angle between the **second**-order maximum and the normal to the grating is θ . The variation with $\sin \theta$ of λ is shown on the graph.

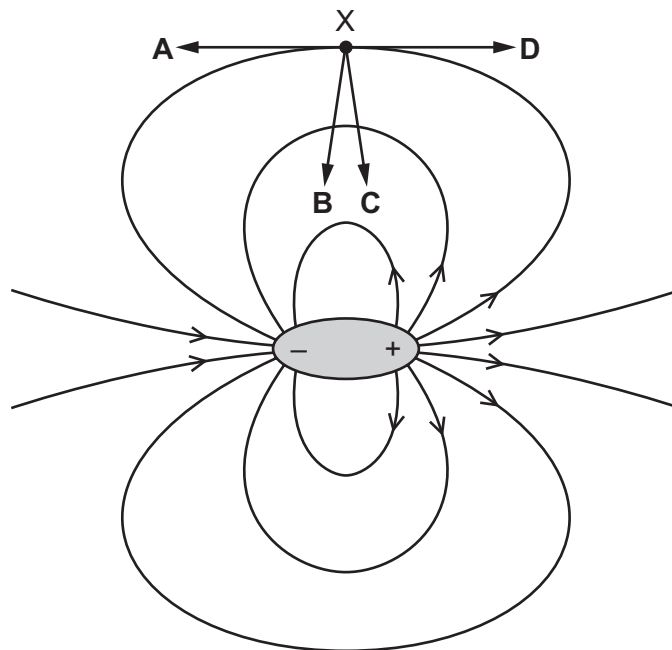


How many lines per millimetre are on the diffraction grating?

- A 400 mm^{-1} B 625 mm^{-1} C 800 mm^{-1} D 1250 mm^{-1}

- 31 A dipole is a pair of charges of equal magnitude, one negative and one positive. The electric field of a dipole is shown below.

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



- 32 A charged oil droplet of mass m is falling, initially freely, in a vacuum between two horizontal metal plates that are separated by a distance x .

A potential difference (p.d.) V is then applied across the plates. This results in the oil droplet continuing to accelerate downwards but with a reduced acceleration a .

The polarity of the applied p.d. is then reversed so that the direction of the electric force on the droplet is reversed. This results in the downwards acceleration of the oil droplet increasing to $3a$.

What is the magnitude of the charge on the oil droplet?

- A $\frac{max}{V}$ B $2\frac{max}{V}$ C $3\frac{max}{V}$ D $4\frac{max}{V}$
- 33 The number density of free electrons in copper is $8.0 \times 10^{28} \text{ m}^{-3}$.

A copper wire has diameter 0.42 mm.

What is the average drift speed of the free electrons in the wire when the current in the wire is 0.57 A?

- A $8.0 \times 10^{-11} \text{ m s}^{-1}$
 B $3.2 \times 10^{-10} \text{ m s}^{-1}$
 C $8.0 \times 10^{-5} \text{ m s}^{-1}$
 D $3.2 \times 10^{-4} \text{ m s}^{-1}$

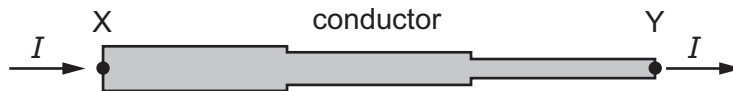
- 34** An electric kettle is rated at 2.0 kW, which describes the power supplied to the heating coil in the kettle.

The coil has a resistance of 5.0 k Ω .

What is the current in the coil?

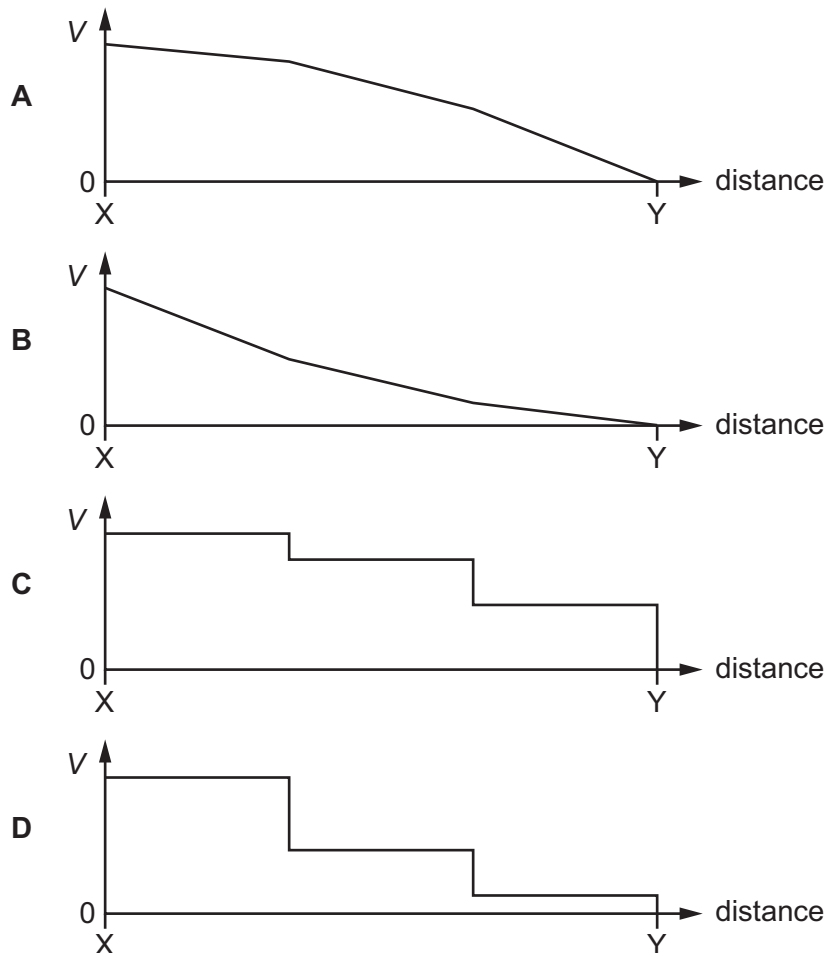
- A** 0.40 A **B** 0.63 A **C** 1.6 A **D** 2.5 A

- 35** A conductor consists of three wires connected in series. The wires are all made of the same metal but have different cross-sectional areas. There is a current I in the conductor.

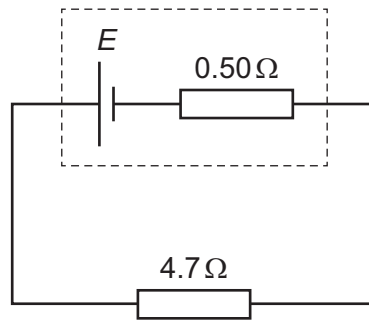


Point Y on the conductor is at zero potential.

Which graph best shows the variation of potential V with distance along the conductor?



- 36** A cell of electromotive force (e.m.f.) E and internal resistance $0.50\,\Omega$ is connected to a resistor of resistance $4.7\,\Omega$.



The maximum power that can be dissipated by the resistor without overheating is $0.50\,\text{W}$.

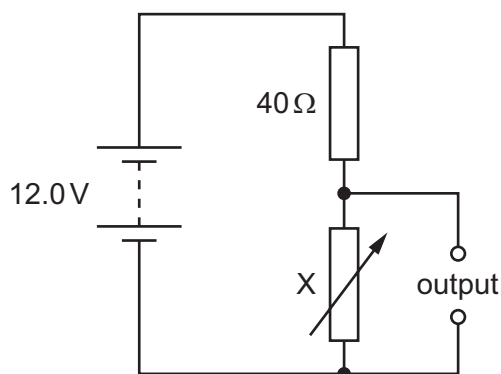
What is the maximum value of E for the resistor **not** to overheat?

- A** $1.4\,\text{V}$ **B** $1.5\,\text{V}$ **C** $1.7\,\text{V}$ **D** $2.9\,\text{V}$
- 37** Kirchhoff's first and second laws link to the conservation of physical quantities.

Which quantities do they link to?

	first law	second law
A	charge	energy
B	charge	momentum
C	energy	charge
D	energy	momentum

- 38** In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0Ω to 500Ω . The electromotive force (e.m.f.) of the battery is 12.0V . It has negligible internal resistance.



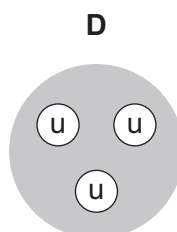
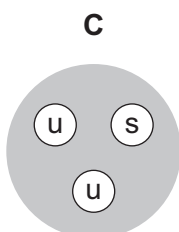
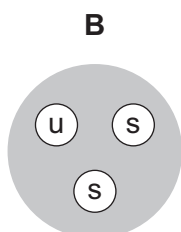
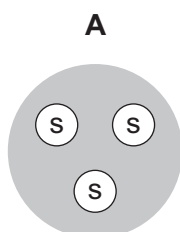
What is the maximum range of values of potential difference across the output?

- A** 1.3V to 11.1V
B 1.3V to 12.0V
C 1.5V to 11.1V
D 1.5V to 12.0V
- 39** An unstable nucleus goes through successive decays to become a final, stable nucleus. The initial nucleus and the final nucleus are isotopes of each other.
- How many α and β^- particles could have been emitted during the decay sequence?

	particle	
	α	β^-
A	1	0
B	1	2
C	2	0
D	2	1

- 40** A hadron has a charge of $-e$ and is composed of three quarks.

What could be the quark composition of the hadron?



key

u = up quark
s = strange quark

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Cambridge International AS & A Level

PHYSICS

9702/13

Paper 1 Multiple Choice

May/June 2020

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. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **24** pages. 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 man is running a race in a straight line.

What is an approximate value of his kinetic energy?

- A 10 J B 100 J C 1000 J D 10 000 J

- 2 A sample of gas has a mass of $4.8 \mu\text{g}$ and occupies a volume of 1.2 dm^3 .

What is the density of the sample of gas?

- A $4.0 \times 10^{-3} \text{ kg m}^{-3}$
 B $4.0 \times 10^{-5} \text{ kg m}^{-3}$
 C $4.0 \times 10^{-6} \text{ kg m}^{-3}$
 D $4.0 \times 10^{-8} \text{ kg m}^{-3}$

- 3 Which characteristics are possessed by a vector quantity but **not** by a scalar quantity?

- A direction only
 B magnitude and direction
 C magnitude and unit
 D unit only

- 4 A circuit is set up in order to determine the resistance of a 12 V, 1.2 W lamp when operating normally. An analogue ammeter and an analogue voltmeter are used.

Which ranges for the meters would be most suitable?

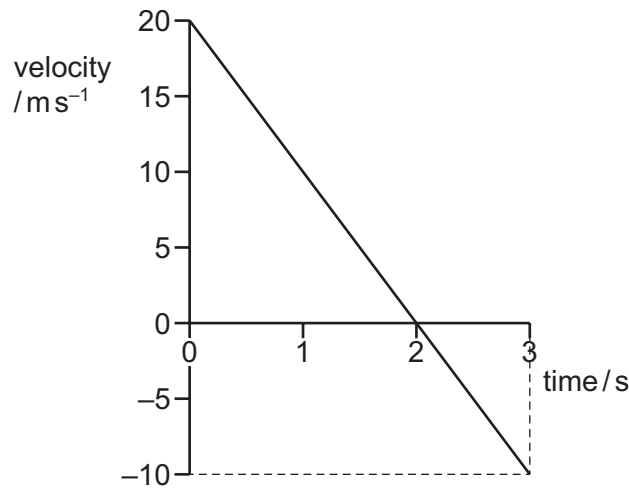
	ammeter range / A	voltmeter range / V
A	0–0.5	0–20
B	0–0.5	0–100
C	0–10	0–20
D	0–10	0–100

- 5 Two liquid-in-glass thermometers in a well-mixed liquid are individually observed by 10 different students. All agree that one thermometer reads 21°C and the other thermometer reads 23°C .

What is a possible explanation for the difference?

- A The liquid is not all at the same temperature.
 B The readings are not precise.
 C There is a random error affecting the readings.
 D There is a systematic error affecting the readings.

- 6 The graph shows how the velocity of a ball varies with time from the moment it is hit vertically upwards from the ground.



What is the displacement of the ball from the ground after a time of 3.0 s?

- A** 15 m **B** 25 m **C** 30 m **D** 45 m

- 7 Two students each throw a ball horizontally from the top of a tower. The two balls are released at the same time.

The first student throws her ball with a speed of 20 m s^{-1} and the second student throws his ball with a speed of 10 m s^{-1} .

Assume air resistance is negligible and that the balls land on horizontal ground.

Which row describes the horizontal distances travelled and the landing times of the two balls on the ground?

	horizontal distances	landing times
A	same	same
B	same	different
C	different	same
D	different	different

- 8 A ball of mass m travels vertically downwards and then hits a horizontal floor at speed u .
It rebounds vertically upwards with speed v .

The collision lasts a time Δt .

What is the average resultant force exerted on the ball during the collision?

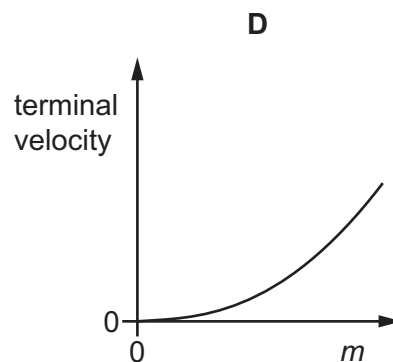
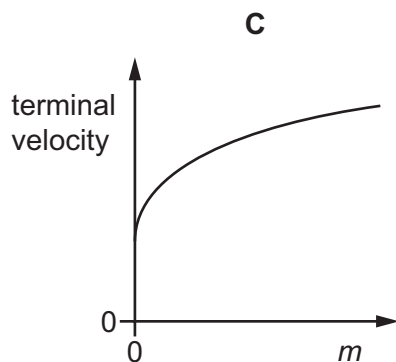
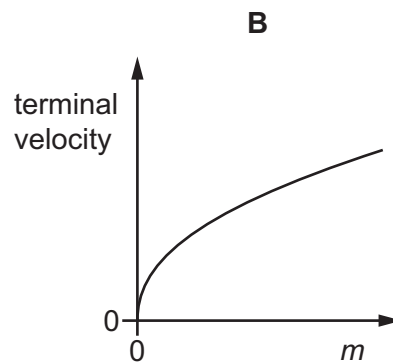
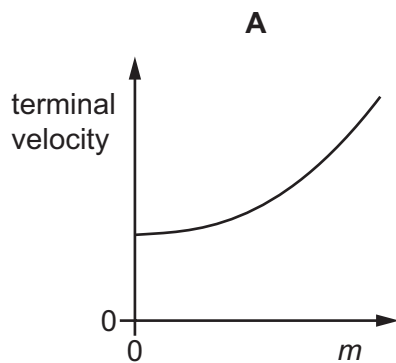
- A $\frac{mv - mu}{\Delta t}$ downwards
B $\frac{mv - mu}{\Delta t}$ upwards
C $\frac{mv + mu}{\Delta t}$ downwards
D $\frac{mv + mu}{\Delta t}$ upwards
- 9 The resultant force F on a raindrop of mass m falling vertically with velocity v is given by the equation

$$F = mg - kv^2$$

where k is a constant and g is the acceleration of free fall.

The falling raindrop eventually reaches a constant (terminal) velocity.

Which graph shows the variation of the terminal velocity of the raindrop with mass m ?



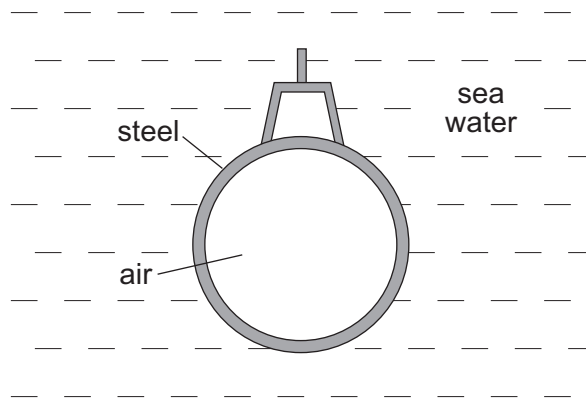
- 10 A ball of mass m , moving at a velocity v , collides with a stationary ball of mass $2m$.

The two balls stick together.

Which fraction of the initial kinetic energy is lost on impact?

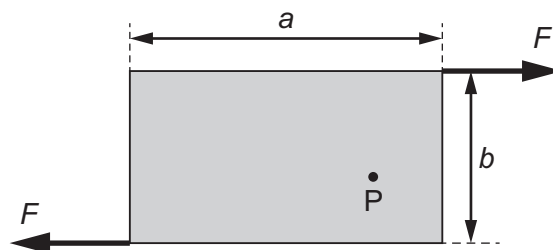
- A $\frac{1}{9}$ B $\frac{1}{3}$ C $\frac{2}{3}$ D $\frac{8}{9}$

- 11 A submarine is in equilibrium in a fully submerged position.



What causes the upthrust on the submarine?

- A The air in the submarine is less dense than sea water.
 B There is a difference in water pressure acting on the top and on the bottom of the submarine.
 C The sea water exerts a greater upward force on the submarine than the weight of the steel.
 D The submarine displaces its own volume of sea water.
- 12 Two forces, each of magnitude F , act along the edges of a rectangular metal plate, as shown.

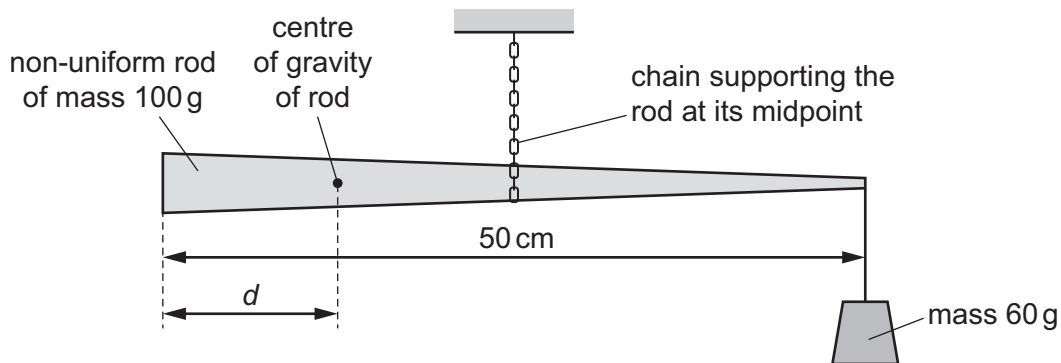


The plate has length a and width b .

What is the torque about point P?

- A Fa B Fb C $2Fa$ D $2Fb$

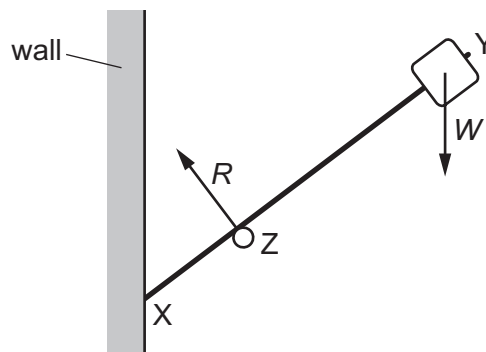
- 13 A non-uniform rod has a mass of 100 g and a length of 50 cm. It is supported by a chain at its midpoint. The rod is held in equilibrium by having a mass of 60 g suspended from its right-hand end, as shown.



The centre of gravity of the rod is a distance d from its left-hand end.

What is the value of d ?

- A 10 cm B 15 cm C 25 cm D 40 cm
- 14 A light rigid rod XY has an object of weight W fixed at one end. The rod is in equilibrium, resting on a support at Z and a vertical wall at X. The support exerts a force R on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces R and W .



What is the direction of the force on the rod at X?



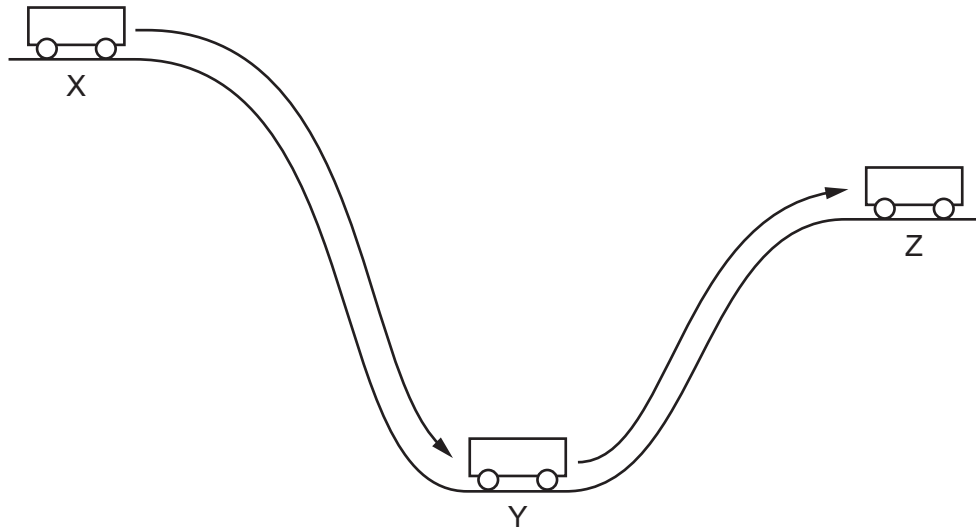
- 15 Liquid Q has twice the density of liquid R.

At depth x in liquid R, the pressure due to the liquid is 4 kPa.

At which depth in liquid Q is the pressure due to the liquid 7 kPa?

- A $\frac{2x}{7}$ B $\frac{7x}{8}$ C $\frac{8x}{7}$ D $\frac{7x}{2}$

- 16 A trolley starts from rest at X. It rolls down to Y and eventually comes to rest at Z.



Which row is a possible summary of the energy changes during this process?

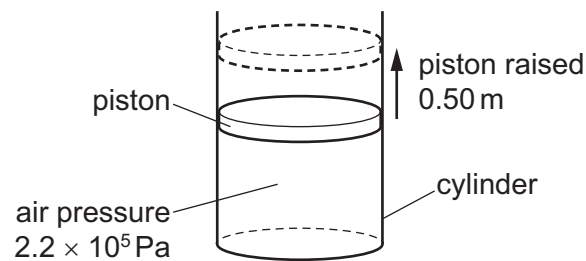
	X to Y	Y to Z
A	PE → KE	KE → PE
B	PE → KE	KE → PE + heat
C	PE → KE + heat	KE → PE
D	PE → KE + heat	KE → PE + heat

key

PE = potential energy

KE = kinetic energy

- 17 A cylinder is heated, causing the air inside to expand at a constant pressure of $2.2 \times 10^5 \text{ Pa}$.

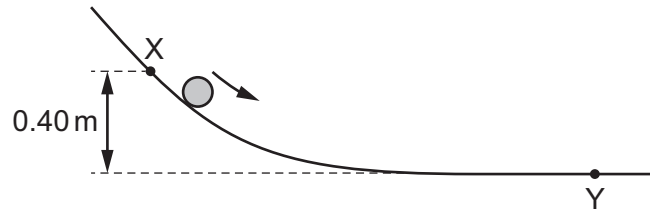


The expansion of the air causes the piston to rise through a vertical distance of 0.50 m, doing 11 kJ of work. Frictional forces are negligible.

What is the cross-sectional area of the piston?

- A** $1.0 \times 10^{-4} \text{ m}^2$
- B** $2.5 \times 10^{-2} \text{ m}^2$
- C** $5.0 \times 10^{-2} \text{ m}^2$
- D** $1.0 \times 10^{-1} \text{ m}^2$

- 18 A ball slides down a curved track, as shown.

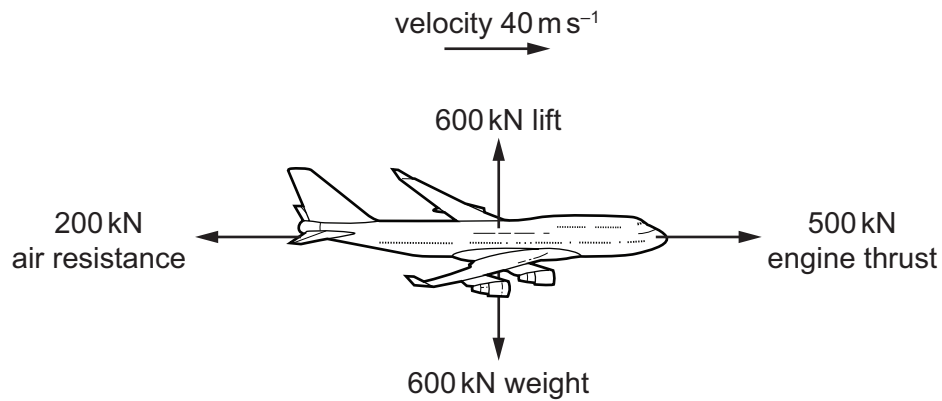


Point X is at a height of 0.40 m above point Y. The speed of the ball at point X is 2.5 m s^{-1} .

Frictional forces are negligible.

What is the speed of the ball at point Y?

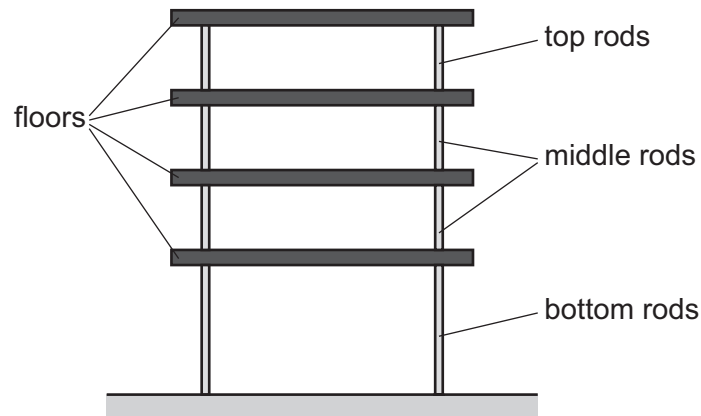
- A 2.8 m s^{-1} B 3.2 m s^{-1} C 3.8 m s^{-1} D 14 m s^{-1}
- 19 The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is 40 m s^{-1} .



At which rate is its kinetic energy increasing?

- A 2.4 MW B 8.0 MW C 12 MW D 20 MW

- 20 The diagram shows a simplified model of a building with four identical heavy floors.

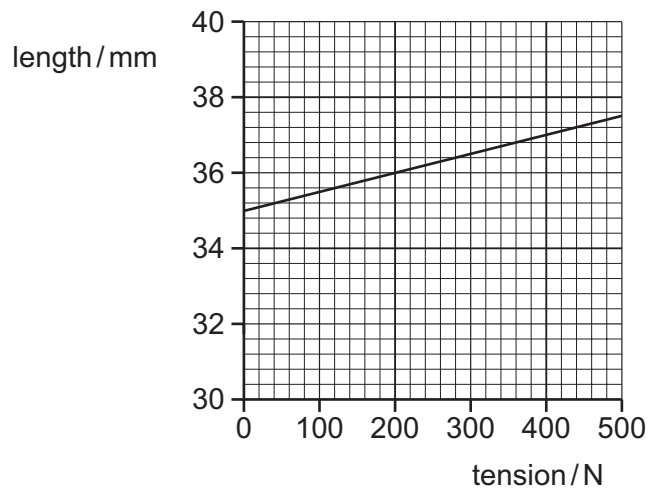


The spacing of the bottom floor from the ground is twice that of the spacing between the floors. Between each floor are equal numbers of vertical steel supporting rods of negligible mass compared with the floors. The rods are of different diameters so that the stress in each rod is the same.

What is the ratio $\frac{\text{diameter of bottom rods}}{\text{diameter of top rods}}$?

- A** 2 **B** 4 **C** 8 **D** 16
- 21 The Achilles tendon in a rabbit's leg is stretched when the rabbit jumps.

The graph shows the variation with tension of the length of the tendon.



What is the strain energy in the tendon when the tension is 400 N?

- A** 0.40 J **B** 0.80 J **C** 2.4 J **D** 7.4 J

- 22** A wave of amplitude A has an intensity I .

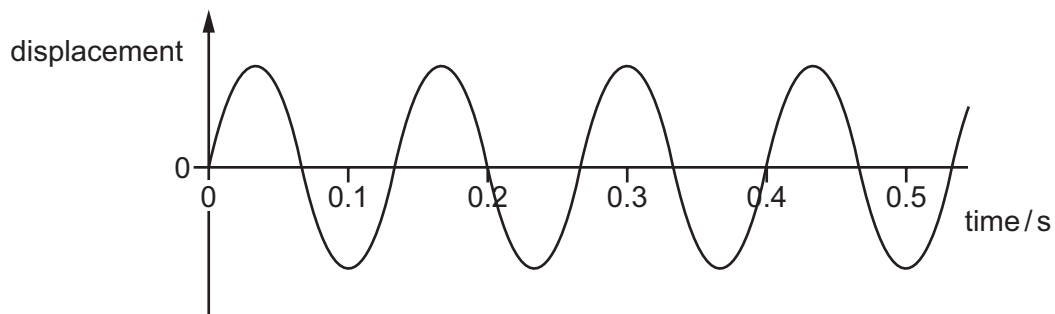
After passing through a certain medium, the wave has a new intensity of $\frac{I}{4}$.

What is the new amplitude of the wave?

- A** $2A$ **B** $\frac{A}{2}$ **C** $\frac{A}{4}$ **D** $\frac{A}{16}$

- 23** A wave travels along a coiled spring.

The graph shows the variation with time of the displacement of a point on the spring.

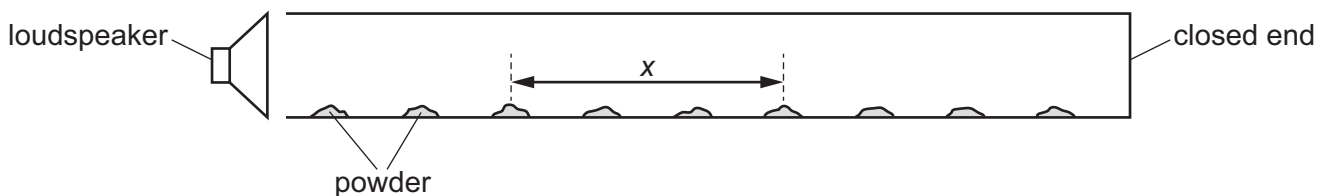


What is the frequency of the wave?

- A** 0.13 Hz **B** 0.20 Hz **C** 5.0 Hz **D** 7.5 Hz

- 24** A loudspeaker is set up at the open end of a closed tube containing powder.

When the loudspeaker produces sound of frequency 1200 Hz, a stationary wave is produced in the tube. The powder gathers at the nodes of the stationary wave as shown.



The speed of sound in the air is 336 m s^{-1} .

What is the value of distance x ?

- A** 28 cm **B** 42 cm **C** 84 cm **D** 112 cm

- 25** A stationary source S emits a sound wave of frequency f .

The source now moves away from a stationary observer.

Which statement is correct?

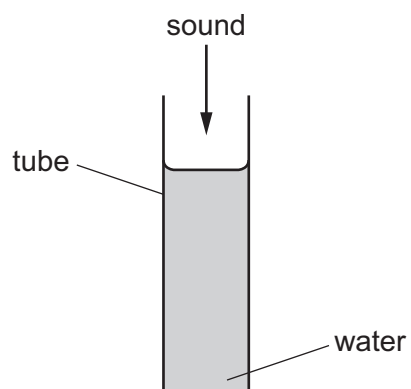
- A** The frequency of the source S and the observed frequency are now both higher than f .
- B** The frequency of the source S and the observed frequency are now both lower than f .
- C** The frequency of the source S is now lower than f .
- D** The observed frequency is now lower than f .

- 26** The table lists possible wavelengths of four different electromagnetic waves.

Which row is correct?

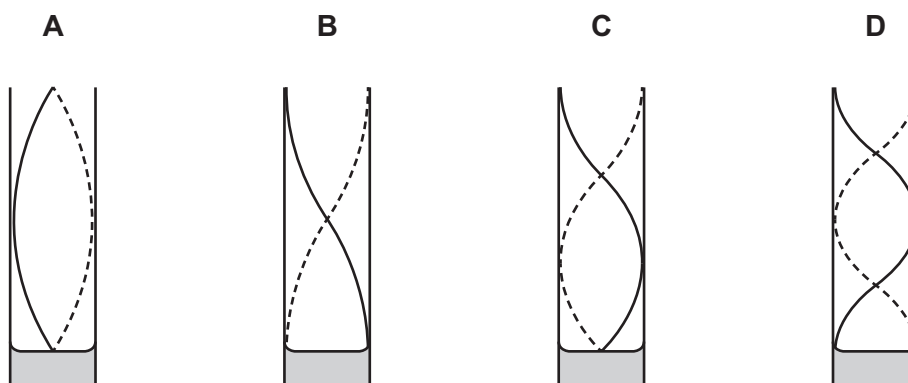
	type of wave	approximate wavelength / m
A	infrared	10^{-5}
B	radio	10^{-3}
C	ultraviolet	10^{-12}
D	X-rays	10^{-7}

- 27** A vertical tube is partially filled with water. A sound wave moves down the tube and is reflected by the surface of the water. The frequency of the sound wave is gradually increased from zero until a much louder sound is heard.



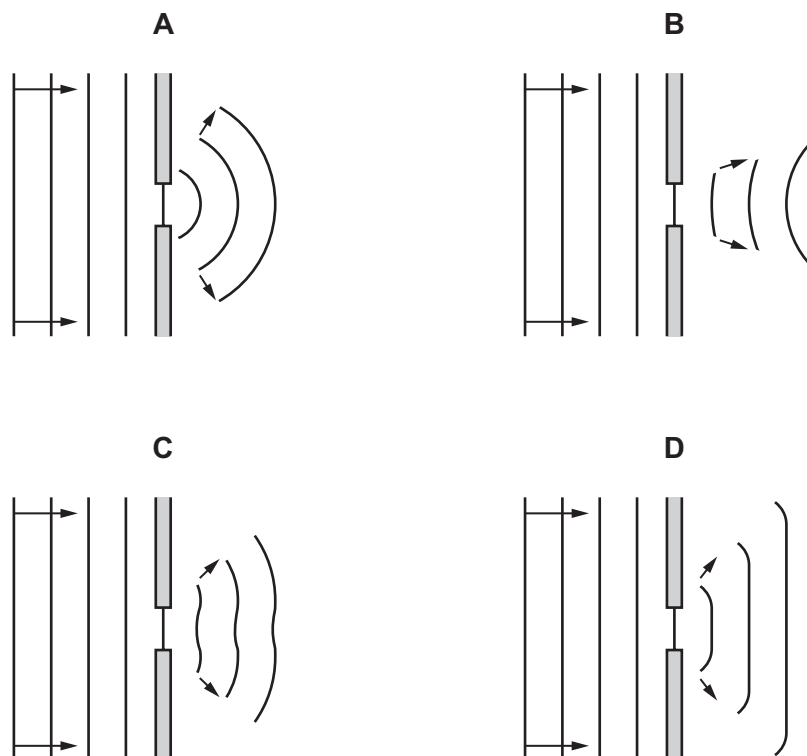
Water is then removed from the tube until a second louder sound is heard.

Which diagram shows the new pattern of the stationary wave that is formed?



28 Water waves in a ripple tank are made to pass through a small gap as shown.

Which diagram shows the waves after they have passed through the gap?



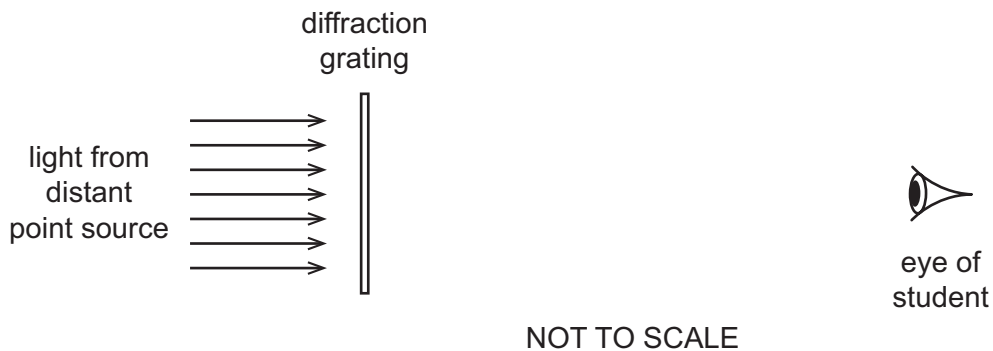
29 A double-slit interference experiment is set up using green light.

A pattern of interference fringes is formed on a screen.

Which single change will increase the separation of the fringes?

- A** increase the width of each slit
- B** move the screen nearer to the double slit
- C** use slits that are further apart
- D** use red light instead of green light

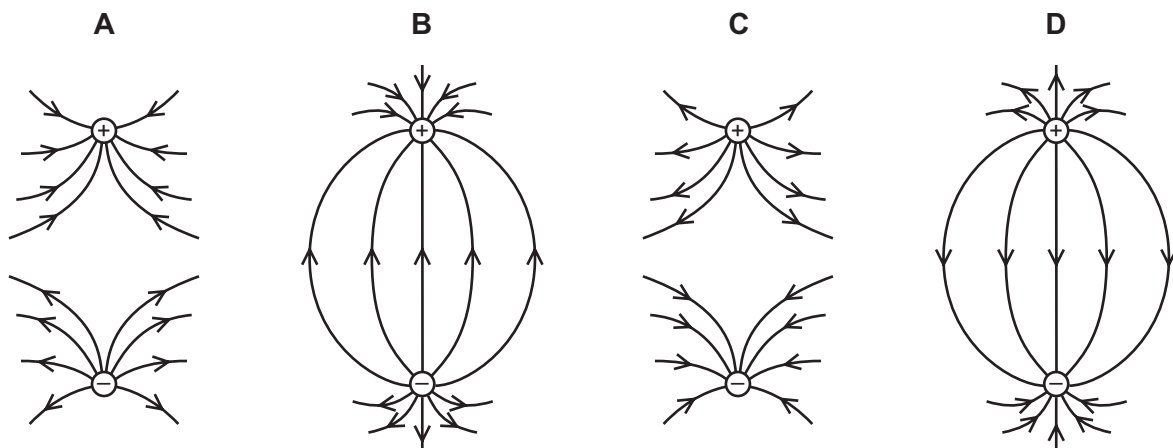
- 30 Light of a single wavelength from a distant point source falls normally onto a diffraction grating positioned with its lines vertical.



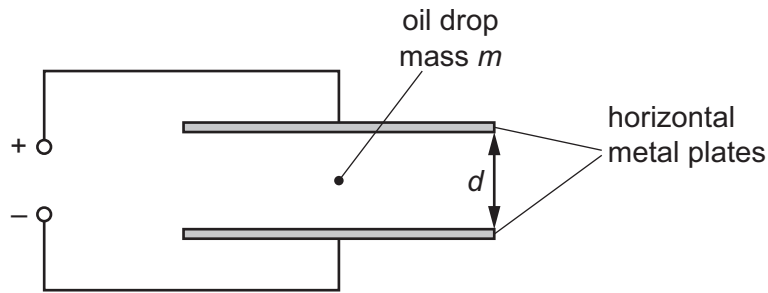
The plane of the diffraction grating is at right angles to the incident light. A student looks at the grating from a position near to the grating.

What could the student see?

- A a central point source with a series of point source images on either side
 - B a central vertical line with a series of spectra on either side
 - C a series of fine vertical lines
 - D a single point source
- 31 Which diagram best represents the electric field between two point charges of equal magnitude and opposite sign?



- 32 A negatively charged oil drop of mass m is between two horizontal parallel metal plates a distance d apart.



When the potential difference (p.d.) between the plates is V_1 the oil drop rises at a constant speed. When the p.d. is decreased to a value V_2 the oil drop falls at the same constant speed.

Air resistance acts on the drop when it is moving. The upthrust on the drop is negligible.

The acceleration of free fall is g .

What is the charge on the oil drop?

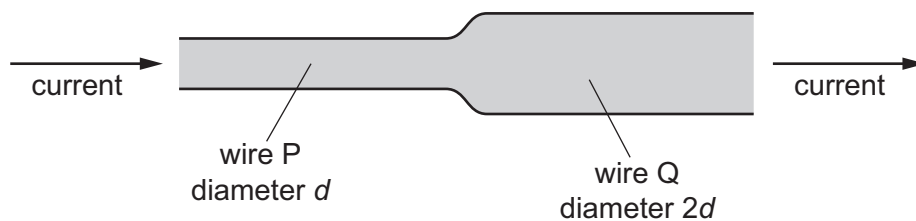
- A $\frac{mdg}{V_1 - V_2}$ B $\frac{mdg}{V_1 + V_2}$ C $\frac{2mdg}{V_1 - V_2}$ D $\frac{2mdg}{V_1 + V_2}$

- 33 The unit of electric charge is the coulomb.

What is meant by 1 coulomb?

- A the charge passing a point in 1 second when a current produces 1 joule of work
 B the charge passing a point in 1 second when a current produces 1 watt of power
 C the charge passing a point in 1 second when there is a current of 1 ampere
 D the charge passing a point in 1 second when there is 1 ohm of resistance

- 34 Two copper wires are joined together and carry a current, as shown.

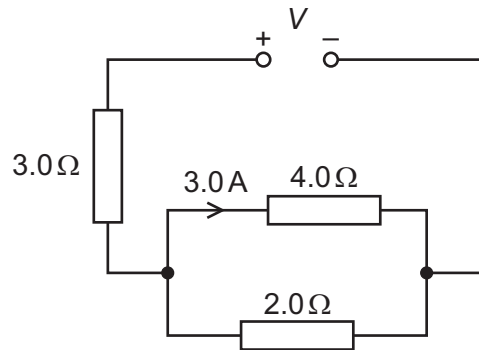


Wire P has diameter d and wire Q has diameter $2d$.

What is the ratio $\frac{\text{average drift speed of the free electrons in wire P}}{\text{average drift speed of the free electrons in wire Q}}$?

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

- 35 A power supply of electromotive force (e.m.f.) V and negligible internal resistance is connected in the circuit shown. There is a current of 3.0 A in the $4.0\ \Omega$ resistor.



What is the value of V ?

- A 15 V B 29 V C 39 V D 51 V
- 36 The wire of a heating element has resistance R . The wire breaks and is replaced by a different wire.

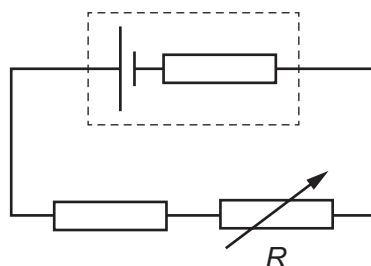
Data for the original wire and for the replacement wire are shown in the table.

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

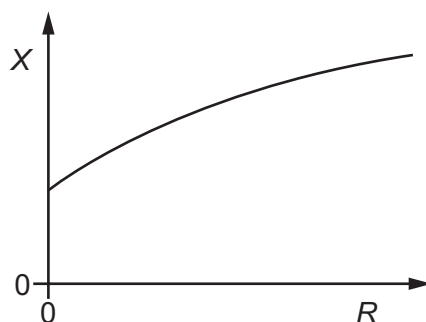
What is the resistance of the replacement wire?

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

- 37 A fixed resistor and a variable resistor are connected in series with a cell that has an internal resistance, as shown.



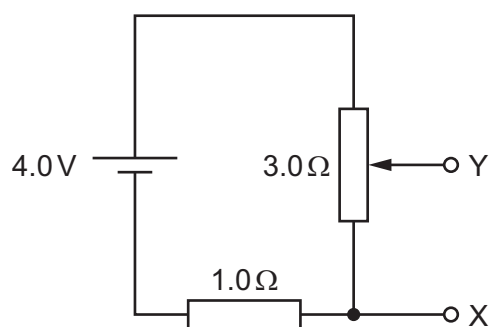
The graph shows the variation of a quantity X with the resistance R of the variable resistor as R is increased from zero to its maximum value.



What could X represent?

- A the current in the circuit
- B the electromotive force of the cell
- C the potential difference across the internal resistance
- D the terminal potential difference across the cell

- 38 A cell of electromotive force (e.m.f.) 4.0 V and negligible internal resistance is connected to a fixed resistor of resistance $1.0\ \Omega$ and a potentiometer of maximum resistance $3.0\ \Omega$, as shown.



Which range of potential differences can be obtained between the terminals X and Y?

- A 0 V to 3.0 V
 - B 0 V to 4.0 V
 - C 1.0 V to 3.0 V
 - D 1.0 V to 4.0 V
- 39 Radiation from a radioactive source has a range of a few millimetres in air and can be deflected by an electric field.

Which type of radiation is being emitted?

- A α -radiation
 - B β^- radiation
 - C β^+ radiation
 - D γ -rays
- 40 Which equation describes the process of β^+ decay?

key:

u = up quark

d = down quark

ν = (electron) neutrino

$\bar{\nu}$ = (electron) antineutrino

- A $ddu \rightarrow uud + \beta^+ + \nu$
- B $ddu \rightarrow uud + \beta^+ + \bar{\nu}$
- C $uud \rightarrow ddu + \beta^+ + \nu$
- D $uud \rightarrow ddu + \beta^+ + \bar{\nu}$

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