

PHYSICS

9702/11

Paper 1 Multiple Choice

May/June 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 **18** printed pages and **2** blank pages.



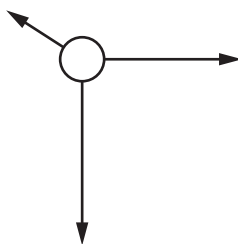
Data

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

Formulae

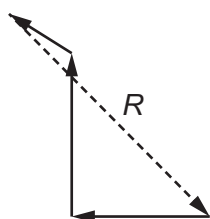
uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2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

- 1 Three wires each exert a horizontal force on a vertical pole, as shown.

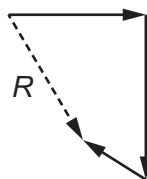


Which vector diagram shows the resultant force R acting on the pole?

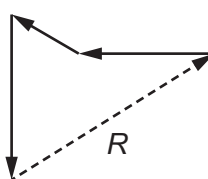
A



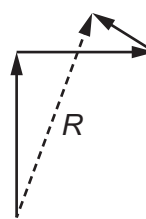
B



C



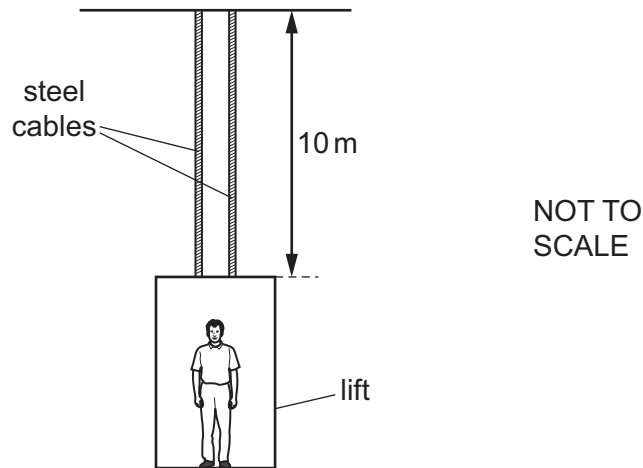
D



- 2 Which pair of quantities do **not** have the same SI base units?

- A electromotive force and electric potential difference
- B pressure and stress
- C spring constant and moment of a force
- D torque and work

- 3 A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.

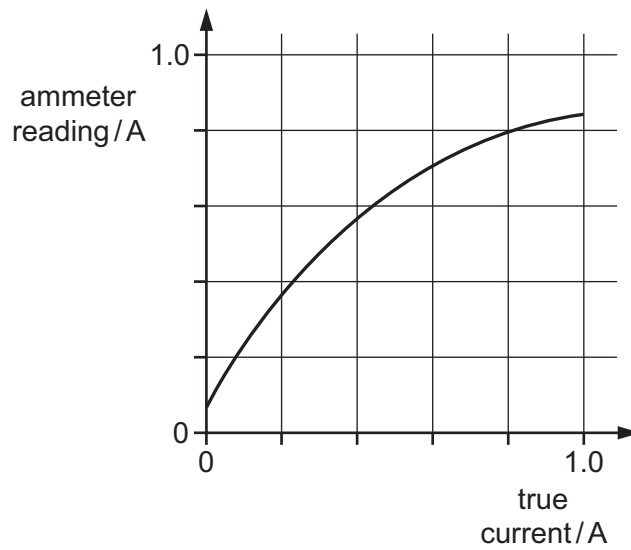


The cables extend by 1 mm when a man of mass 80 kg steps into the lift.

What is the best estimate of the value of the Young modulus of the steel?

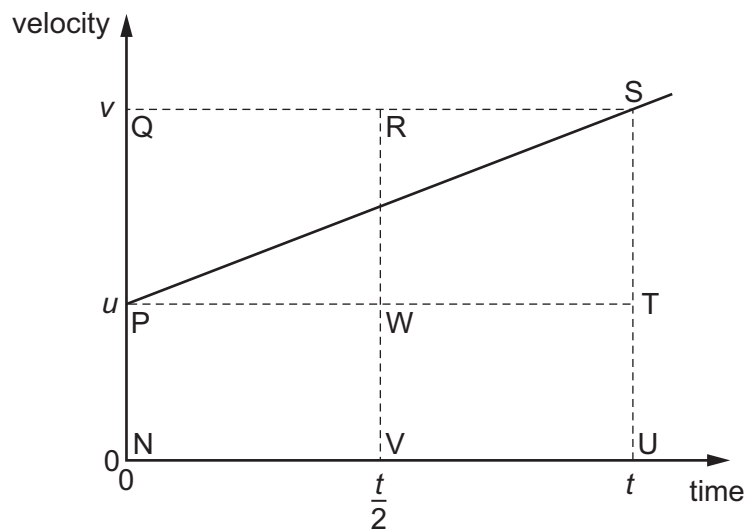
- A $2 \times 10^{10} \text{ N m}^{-2}$
 - B $4 \times 10^{10} \text{ N m}^{-2}$
 - C $2 \times 10^{11} \text{ N m}^{-2}$
 - D $4 \times 10^{11} \text{ N m}^{-2}$
- 4 When performing an experiment, a student should minimise the uncertainty of any measurement.
- In which case is the student reducing the systematic error in a measurement?
- A adjusting a voltmeter needle pointer to the zero position before using it to measure a potential difference
 - B measuring the diameter of a wire at several points and orientations
 - C measuring the mass of 100 paperclips to determine the mass of one paperclip
 - D timing 20 oscillations of a mass on a spring to determine the period of one oscillation

- 5 A calibration graph is produced for a faulty ammeter.



Which ammeter reading will be nearest to the true current?

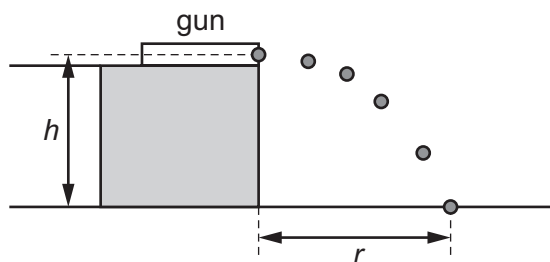
- A** 0.2 A **B** 0.4 A **C** 0.6 A **D** 0.8 A
- 6 A car accelerates uniformly from velocity u to velocity v in time t .



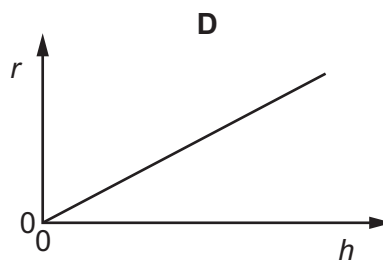
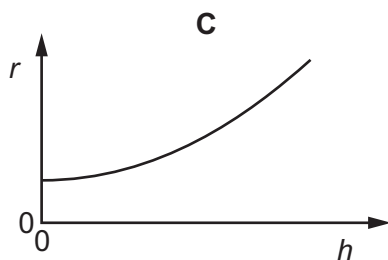
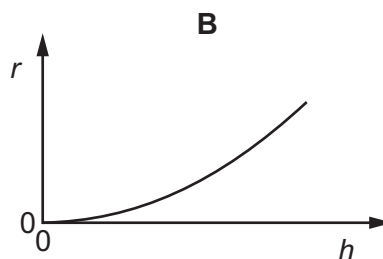
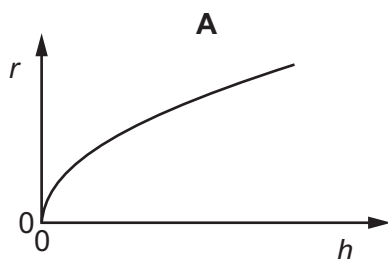
On the graph, which area equals the distance travelled by the car in time t ?

- A** $\text{NPTU} + \text{PQST}$
B $\text{NPWV} + \text{VRSU}$
C $\text{NPWV} + \text{WRST}$
D $\text{PST} + \text{PQS}$

- 7 A student uses a spring gun to launch a steel ball with a constant horizontal velocity. He varies the height h of the gun and measures the horizontal displacement r of the ball when it hits the ground.



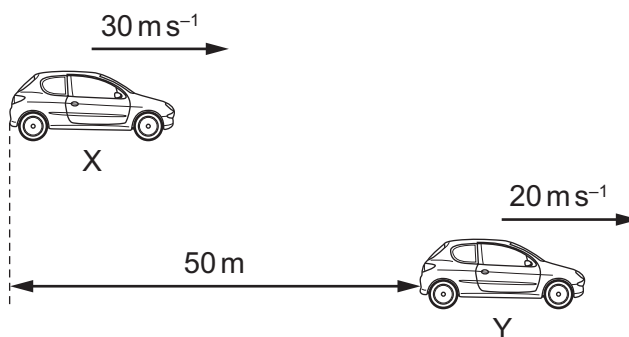
Which graph shows the variation with height h of the horizontal displacement r ?



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

They are travelling in the same direction.

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



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

- A** 1.0 s **B** 1.7 s **C** 2.5 s **D** 5.0 s

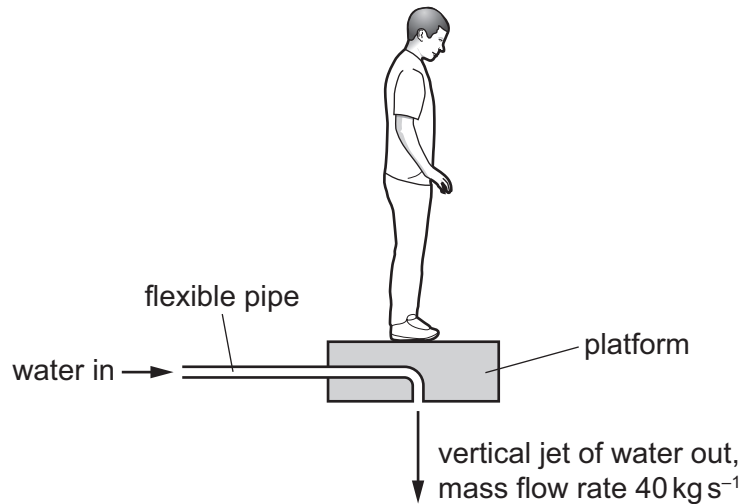
- 9 Which statement about a perfectly elastic collision between two bodies in an isolated system is correct?
- A Both total kinetic energy and total momentum are conserved.
 - B Total kinetic energy is conserved, but total momentum is not conserved.
 - C Total momentum is conserved, but total kinetic energy is not conserved.
 - D Neither total kinetic energy nor total momentum is conserved.
- 10 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before they collide. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below.



The collision is perfectly elastic. Which equation must be correct?

- A $u_1 - u_2 = v_2 + v_1$
- B $u_1 - u_2 = v_2 - v_1$
- C $u_1 + u_2 = v_2 + v_1$
- D $u_1 + u_2 = v_2 - v_1$

- 11 The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



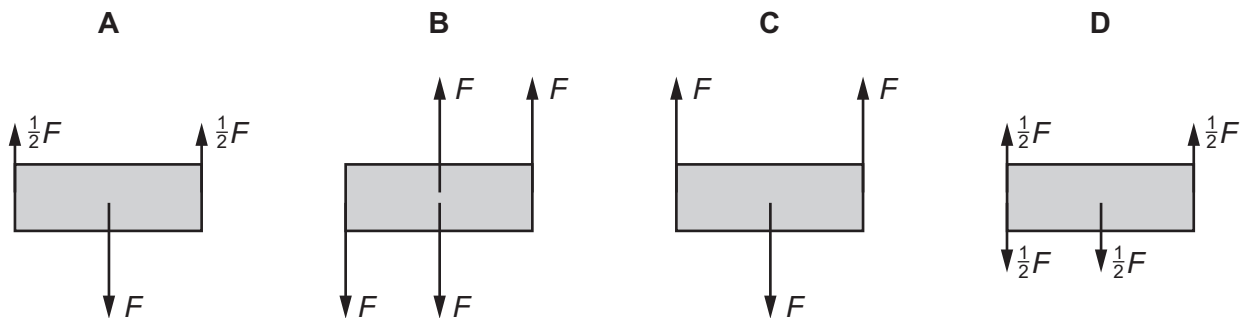
The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg . The mass of water that is discharged vertically downwards from the platform each second is 40 kg .

What is the speed of the water leaving the platform?

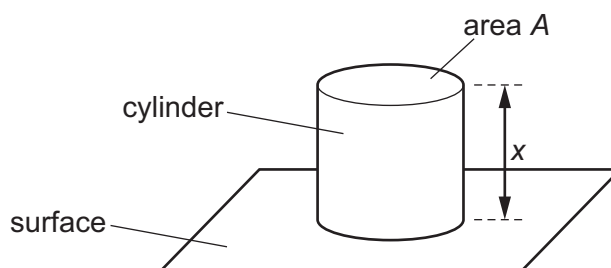
- A 2.4 ms^{-1} B 6.9 ms^{-1} C 24 ms^{-1} D 47 ms^{-1}

- 12 Forces are applied to a rigid body. The forces all act in the same plane.

In which diagram is the body in equilibrium?



- 13 A solid metal cylinder stands on a horizontal surface, as shown.

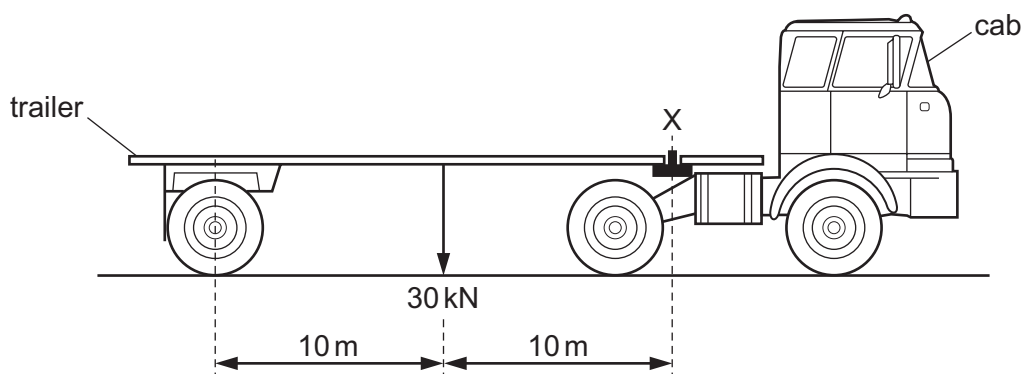


The cylinder has length x and cross-sectional area A . The cylinder exerts a pressure p on the surface. The acceleration of free fall is g .

Which expression gives the density of the metal of the cylinder?

- A $\frac{gx}{p}$ B $\frac{p}{gx}$ C $\frac{gx}{pA}$ D $\frac{pA}{gx}$

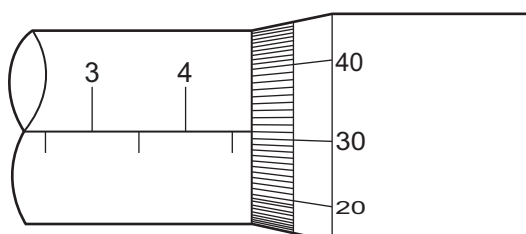
- 14 A trailer of weight 30 kN is attached to a cab at X, as shown in the diagram.



What is the upward force exerted at X by the cab on the trailer?

- A 3 kN B 15 kN C 30 kN D 60 kN

- 15 The diameter of a solid metal sphere is measured using a micrometer screw gauge. The diagram shows an enlargement of the shaft of the micrometer screw gauge when taking the measurement.



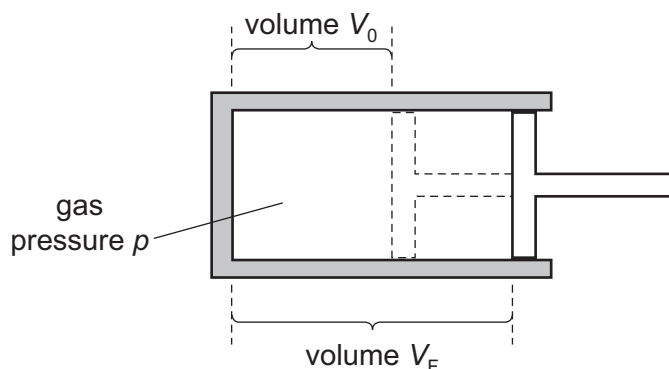
The mass of the sphere is 0.450 g.

What is the density of the metal used to make the sphere?

- A 965 kg m^{-3} B 1340 kg m^{-3} C 7720 kg m^{-3} D $10\,700 \text{ kg m}^{-3}$

- 16 Some gas in a cylinder is supplied with thermal energy q .

The gas does useful work in expanding at constant pressure p from volume V_0 to volume V_F , as shown.



Which expression gives the efficiency of this change?

- A $\frac{pV_0}{q}$ B $\frac{V_F}{V_0q}$ C $\frac{p(V_F - V_0)}{q}$ D $\frac{(V_F - V_0)}{V_0q}$

- 17 The power P required to move an object through a medium at constant speed depends on the speed v and the resistive force F acting on the object.

The resistive force F also depends on the speed v .

Which row shows a possible relationship between speed v , resistive force F and power P ?

	resistive force F	power P
A	proportional to v	constant
B	proportional to v	proportional to v
C	proportional to v^2	proportional to v^2
D	proportional to v^2	proportional to v^3

- 18 Which amount of energy is **not** 2400 J?

- A the decrease in gravitational potential energy of a body of mass 60 kg when it moves vertically downwards through 40 m near the Earth's surface
- B the energy transferred in 15 s by a machine of power 160 W
- C the kinetic energy of a body of mass 12 kg moving at a speed of 20 m s^{-1}
- D the work done by a gas expanding against a constant external pressure of 120 kPa when its volume increases by 0.020 m^3

- 19** A hammer with 10 J of kinetic energy hits a nail and pushes it 5.0 mm into a plank.

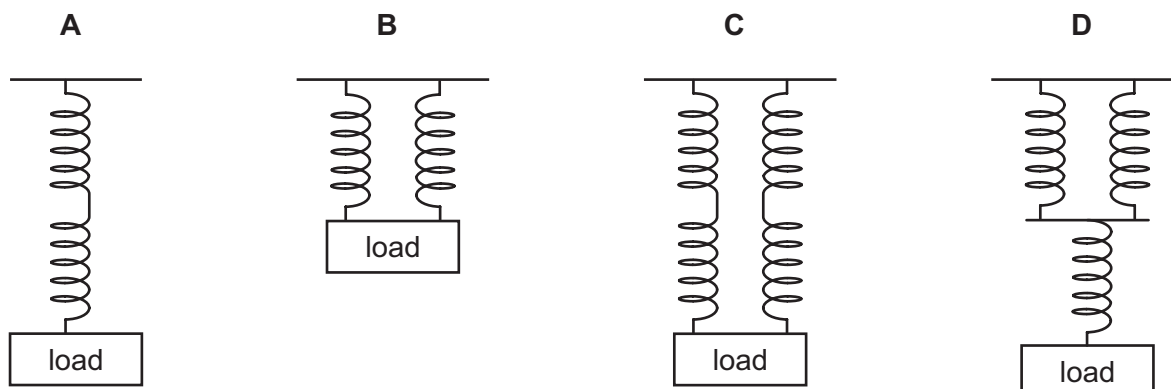
Both the hammer and nail come to rest after the collision.

What is the approximate average force that acts on the nail while it moves through 5.0 mm?

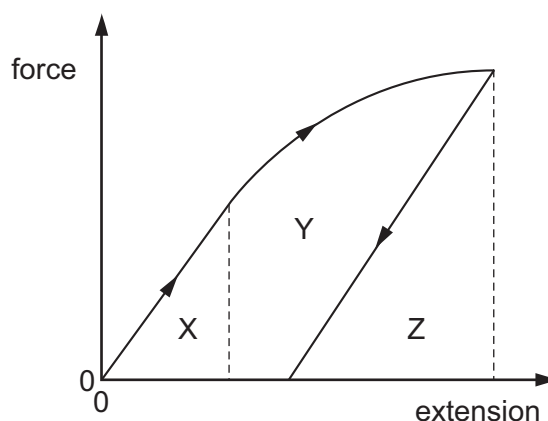
- A** 0.050 N **B** 2.0 N **C** 50 N **D** 2000 N

- 20** A number of identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



- 21** A sample of material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below.



Which area represents the net work done on the sample?

- A** X **B** X + Y **C** Y + Z **D** Z

- 22** Two sound waves have frequencies of 250 Hz and 300 Hz. The speed of sound is 340 m s^{-1} .

What is the difference between the wavelengths of the two waves?

- A** 0.23 m **B** 1.1 m **C** 1.4 m **D** 6.8 m

- 23 Which electromagnetic waves have the wavelengths of 10^{-2} m, 10^{-5} m, 10^{-10} m and 10^{-13} m?

	10^{-2} m	10^{-5} m	10^{-10} m	10^{-13} m
A	infra-red	microwaves	visible light	X-rays
B	microwaves	infra-red	X-rays	gamma rays
C	microwaves	visible light	ultraviolet	gamma rays
D	radio waves	microwaves	ultraviolet	X-rays

- 24 Which statement concerning a stationary wave is correct?

- A** All the particles between two successive nodes oscillate in phase.
- B** The amplitude of the stationary wave is equal to the amplitude of one of the waves creating it.
- C** The wavelength of the stationary wave is equal to the separation of two adjacent nodes.
- D** There is no displacement of a particle at an antinode at any time.

- 25 Continuous water waves are diffracted through a gap in a barrier in a ripple tank.

Which change will cause the diffraction of the waves to increase?

- A** increasing the frequency of the waves
- B** increasing the width of the gap
- C** reducing the wavelength of the waves
- D** reducing the width of the gap

- 26 A parallel beam of light of wavelength 450 nm is incident normally on a diffraction grating which has 300 lines/mm.

What is the total number of intensity maxima observed?

- A** 7 **B** 8 **C** 14 **D** 15

- 27 Fringes of separation x are observed on a screen 1.00 m from a double slit that is illuminated by yellow light of wavelength 600 nm.

At which distance from the slits would fringes of the same separation x be observed when using blue light of wavelength 400 nm?

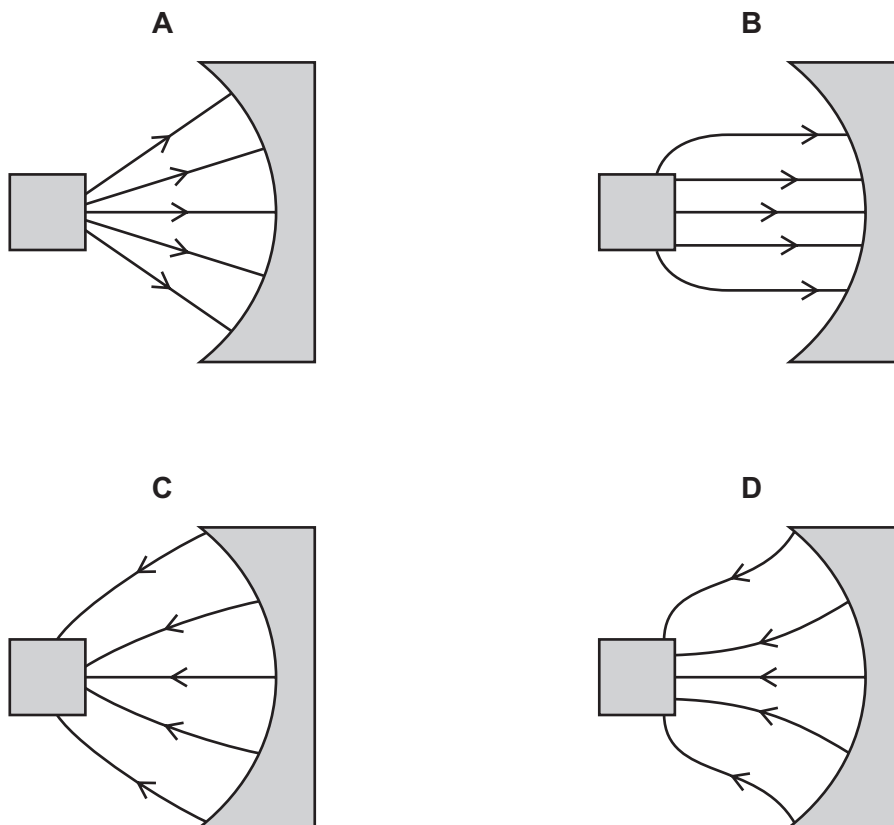
- A** 0.33 m **B** 0.67 m **C** 0.75 m **D** 1.50 m

- 28 A charged particle is moving in a uniform electric field.

For the motion of the particle due to the field, which quantity has a constant non-zero value?

- A acceleration
- B displacement
- C rate of change of acceleration
- D velocity

- 29 Which diagram could represent the electric field lines between two oppositely charged conducting surfaces?



- 30 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

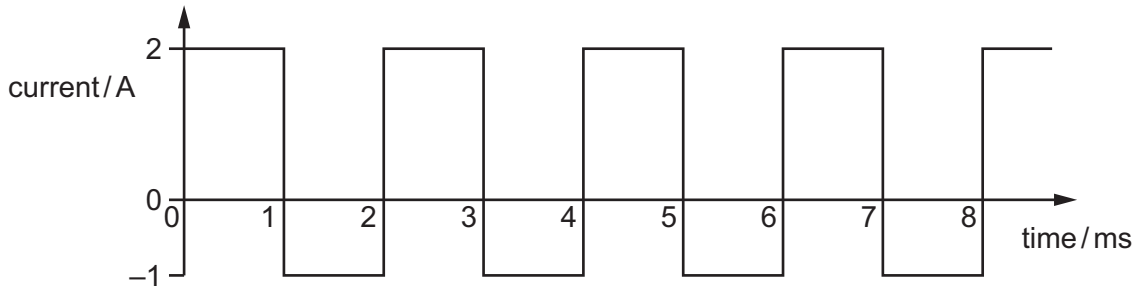
- A the current in the resistor and the potential difference across the resistor
- B the resistance of the resistor and the current in the resistor
- C the total charge passing through the resistor and the potential difference across the resistor
- D the total charge passing through the resistor and the resistance of the resistor

- 31 Two copper wires of equal length are connected in parallel. A potential difference is applied across the ends of this parallel arrangement. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

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

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

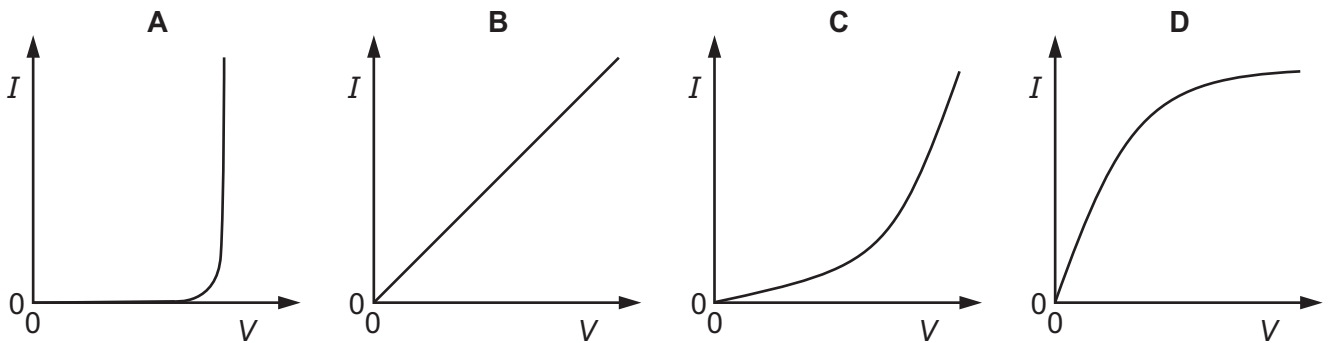
- 32 A $100\ \Omega$ resistor conducts a current with changing direction and magnitude, as shown.



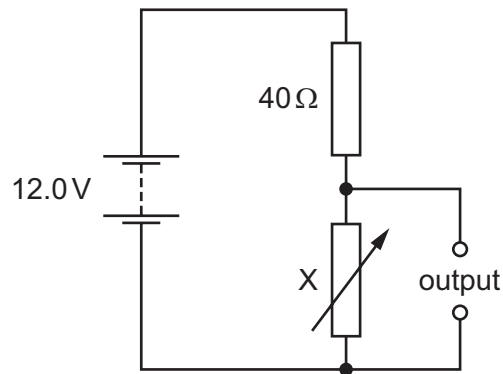
What is the mean power dissipated in the resistor?

- A 100 W B 150 W C 250 W D 400 W

- 33 Which graph shows the I – V characteristic of a filament lamp?

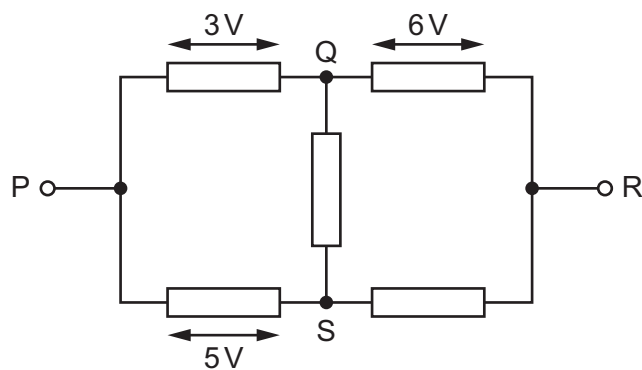


- 34 In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0Ω to 500Ω . The e.m.f. of the battery is 12.0V . It has negligible internal resistance.



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
- 35 There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3V.

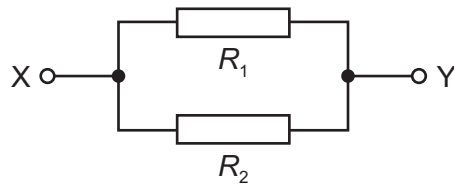
The p.d. between Q and R is 6V.

The p.d. between P and S is 5V.

Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2V	4V
B	2V	10V
C	3V	4V
D	3V	10V

- 36 Two resistors of resistances R_1 and R_2 are connected in parallel.



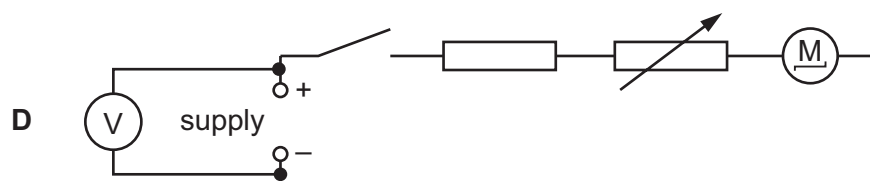
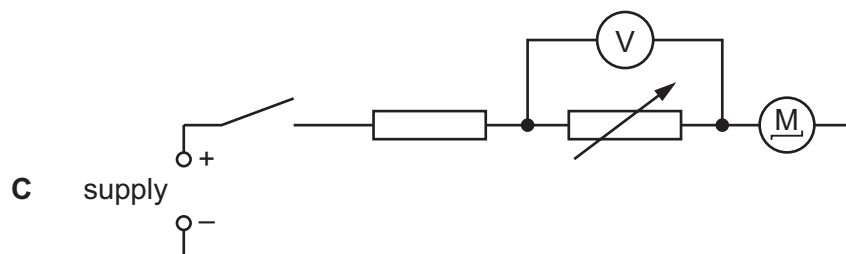
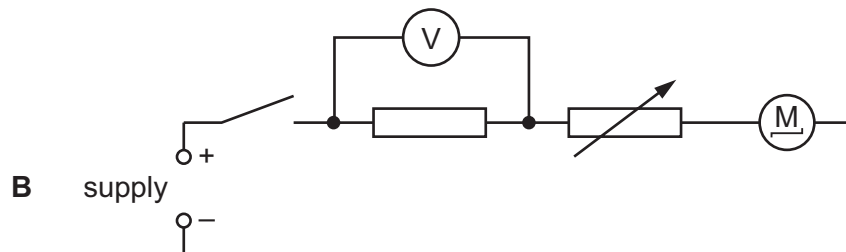
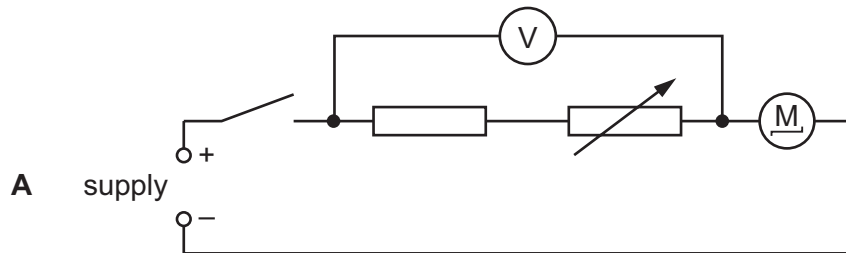
What is the combined resistance between X and Y?

- A $R_1 + R_2$ B $\frac{R_1 R_2}{R_1 + R_2}$ C $\frac{R_1 + R_2}{R_1 R_2}$ D $\frac{R_1}{R_2}$

- 37 A voltmeter is used to monitor the operation of an electric motor. The motor speed is controlled by a variable resistor. A fixed resistor is used to limit the speed.

The current in the motor is gradually changed.

In which circuit is the voltmeter reading proportional to the current in the motor?



- 38 Which statement describes β^- decay in terms of a simple quark model?
- A A down quark changes to an up quark and emits an electron and an electron antineutrino.
 - B A down quark changes to an up quark and emits a positron and an electron neutrino.
 - C An up quark changes to a down quark and emits an electron and an electron antineutrino.
 - D An up quark changes to a down quark and emits a positron and an electron neutrino.
- 39 Which word equation represents β^+ decay?
- A proton $\rightarrow$ neutron + electron + electron antineutrino
 - B proton $\rightarrow$ neutron + electron + electron neutrino
 - C proton $\rightarrow$ neutron + positron + electron antineutrino
 - D proton $\rightarrow$ neutron + positron + electron neutrino
- 40 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?
- A A tiny proportion of the alpha-particles are deflected through large angles.
 - B Slower alpha-particles are deflected through larger angles.
 - C The kinetic energies of the deflected alpha-particles are unchanged.
 - D The number of alpha-particles deflected depends on the thickness of the foil.

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

1 Which quantity with its unit is correct?

- A acceleration of a bicycle = 1.4 m s^{-1}
- B electric current in a lamp = 0.25 A s^{-1}
- C electric potential difference across a battery = 8.0 J C^{-1}
- D kinetic energy of a car = 4500 N m^{-1}

2 The luminosity L of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

r is the radius of the star,

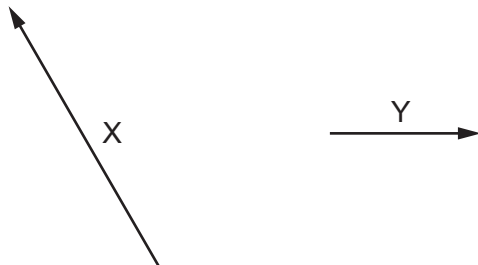
T is the temperature of the star,

σ is a constant with units $\text{W m}^{-2} \text{K}^{-4}$.

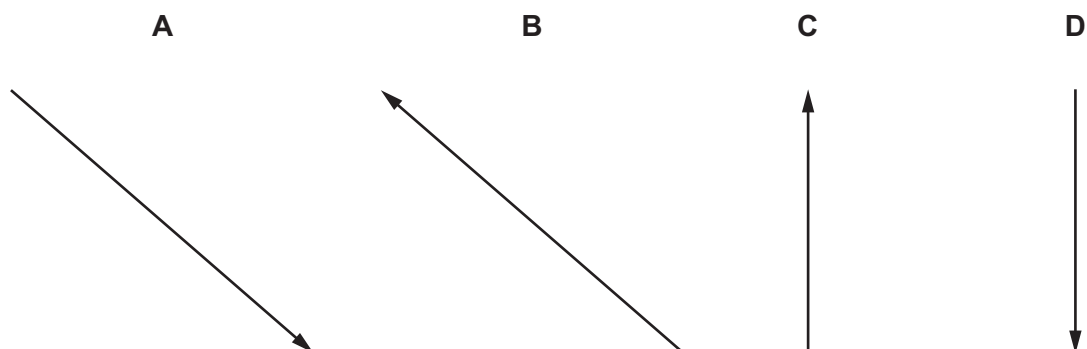
What are the SI base units of L ?

- A $\text{kg m}^2 \text{s}^{-1}$
- B $\text{kg m}^2 \text{s}^{-2}$
- C $\text{kg m}^2 \text{s}^{-3}$
- D $\text{kg m}^2 \text{s}^{-4}$

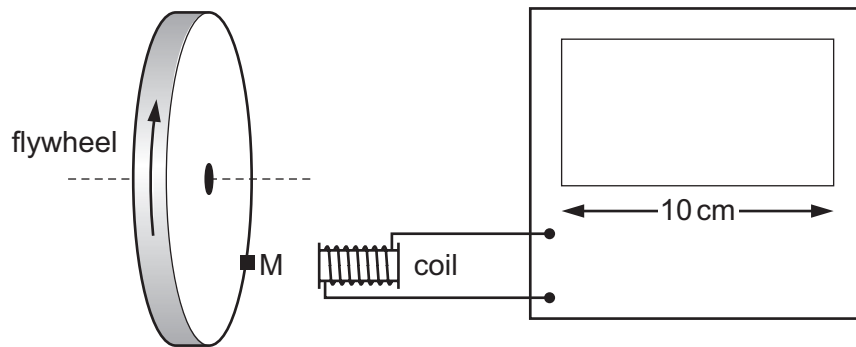
3 The diagram shows two vectors X and Y , drawn to scale.



If $X = Y - Z$, which diagram best represents the vector Z ?



- 4 The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.



The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at 3000 revolutions per minute.

Which time-base setting will display clearly separate pulses on the screen?

- A** 1 s cm^{-1} **B** 10 ms cm^{-1} **C** $100 \mu\text{s cm}^{-1}$ **D** $1 \mu\text{s cm}^{-1}$
- 5 A student determines the density ρ of steel by taking measurements from a steel wire.

$$\text{mass } m = 6.2 \pm 0.1 \text{ g}$$

$$\text{length } l = 25.0 \pm 0.1 \text{ cm}$$

$$\text{diameter } d = 2.00 \pm 0.01 \text{ mm}$$

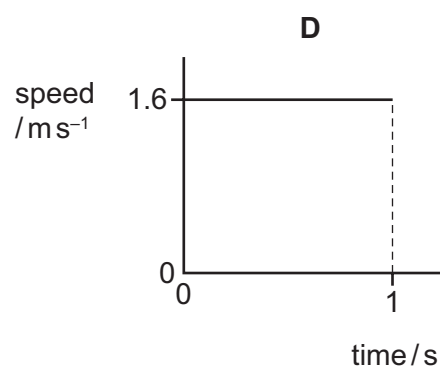
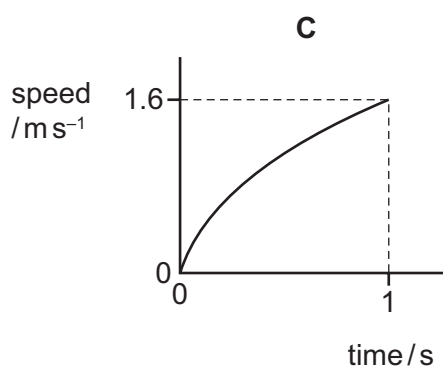
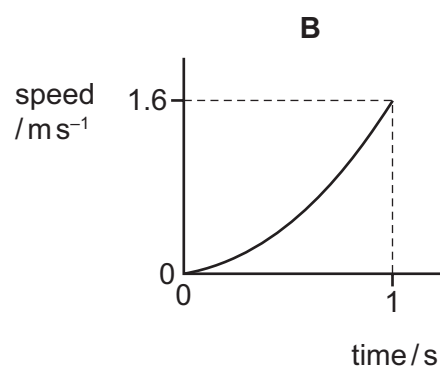
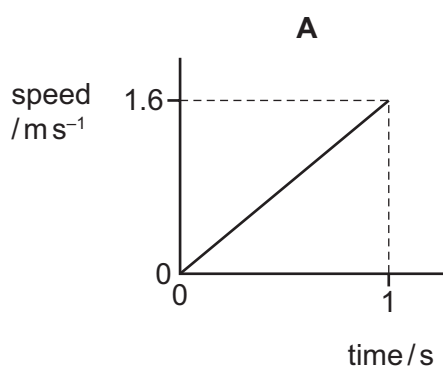
He uses the equation $\rho = \frac{4m}{\pi d^2 l}$.

What is the percentage uncertainty in his calculated value of density?

- A** 1.1% **B** 1.8% **C** 2.5% **D** 3.0%

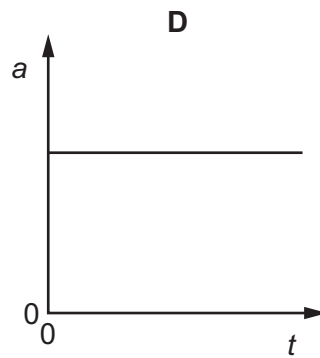
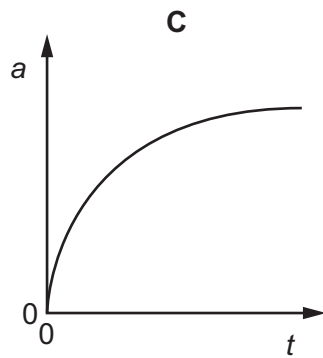
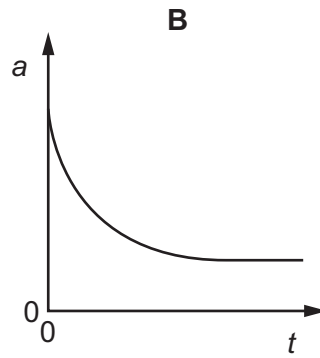
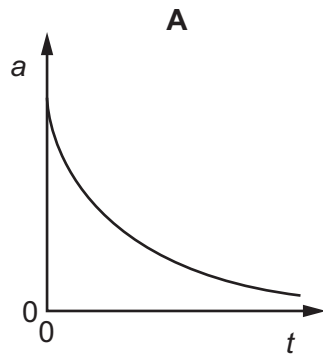
- 6 The acceleration of free fall on the Moon is 1.6 m s^{-2} . The Moon has no atmosphere. An astronaut standing on the surface of the Moon drops a feather.

Which graph shows the variation with time of the speed of the feather during the first second of its fall?

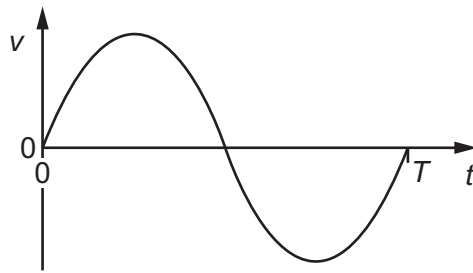


- 7 A tennis ball is released from rest at the top of a tall building.

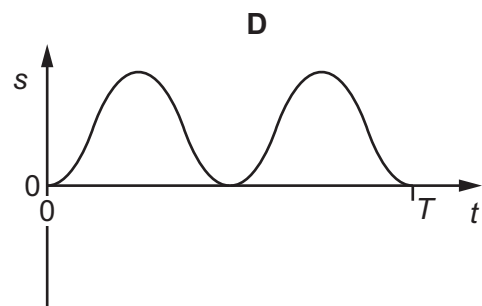
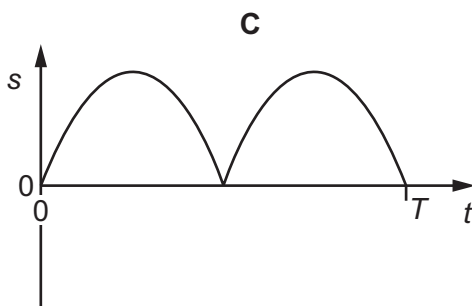
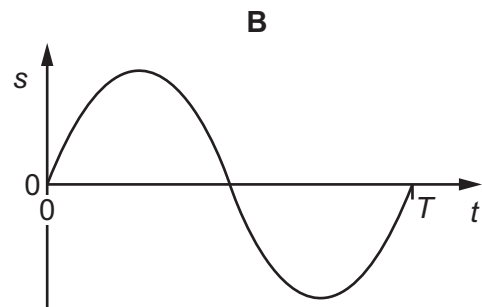
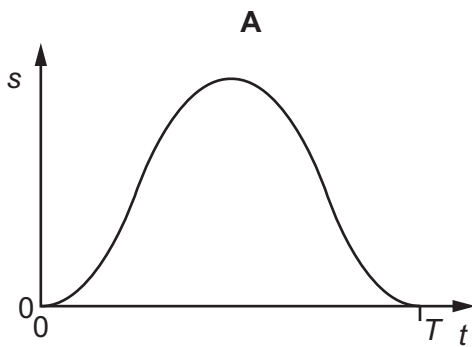
Which graph best represents the variation with time t of the acceleration a of the ball as it falls, assuming that the effect of air resistance is **not** negligible?



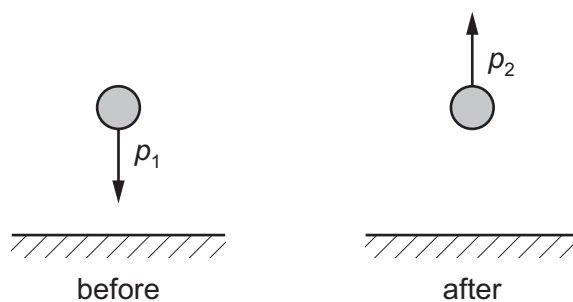
- 8 The graph shows how the velocity v of an object moving in a straight line varies with time t from $t = 0$ to $t = T$.



Which graph represents the displacement s of the object in the time $t = 0$ to $t = T$?



- 9 A ball falls vertically onto horizontal ground and rebounds, as shown.

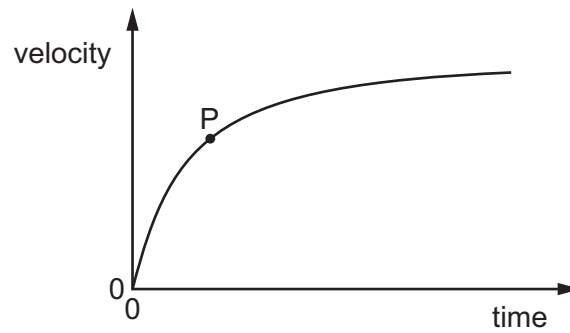


The ball has momentum p_1 downwards just before hitting the ground. After rebounding, the ball leaves the ground with momentum p_2 upwards. The ball is in contact with the ground for 0.020 s. During this time interval, an average resultant force of 25 N acts on the ball.

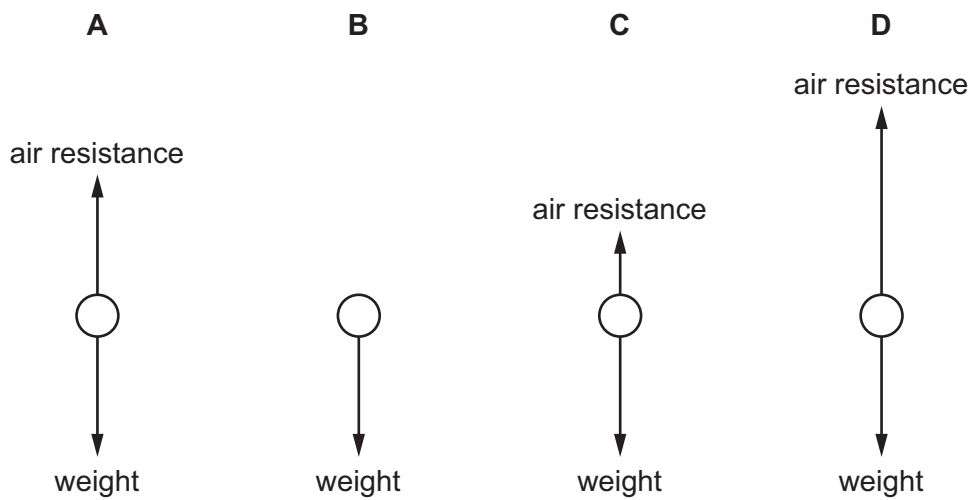
What is a possible combination of values for p_1 and p_2 ?

	$p_1/\text{kg m s}^{-1}$	$p_2/\text{kg m s}^{-1}$
A	0.15	0.65
B	0.20	0.30
C	0.30	0.20
D	0.65	0.15

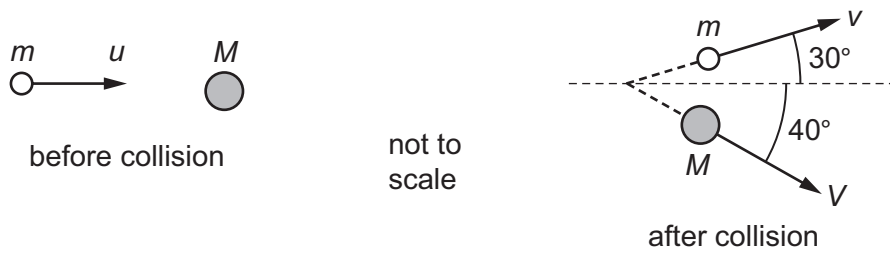
- 10 A sphere falls from rest through the air. The graph shows the variation with time of the sphere's velocity.



Which diagram shows the forces acting on the sphere when it is at the velocity corresponding to point P on the graph?



- 11 A ball of mass m travelling at velocity u collides with a stationary ball of mass M . After collision the two balls travel at velocities v and V respectively, in the directions shown.

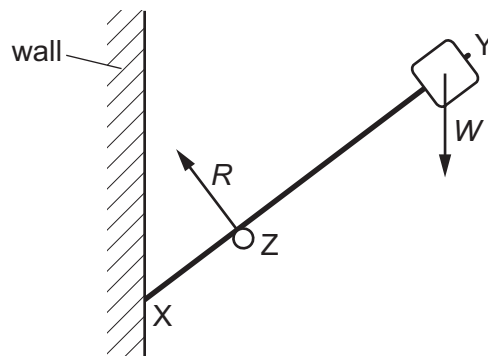


A student writes three equations relating to the collision.

Which row in the table indicates the correct and incorrect equations?

	$mu = MV + mv$	$mv \sin 30^\circ = MV \sin 40^\circ$	$mu = mv \cos 30^\circ + MV \cos 40^\circ$
A	correct	correct	correct
B	incorrect	correct	incorrect
C	correct	incorrect	incorrect
D	incorrect	correct	correct

- 12 A light rigid rod XY has an object of weight W fixed at one end. The rod is in equilibrium, resting on a roller at Z and a vertical wall at X. The roller 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?



- 13 In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of

1200 kg of oil of density 1100 kg m^{-3} ,

1500 kg of oil of density 860 kg m^{-3} ,

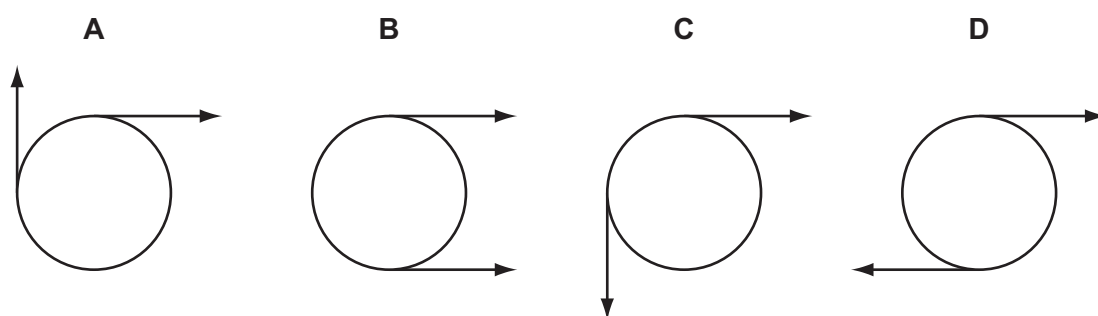
4000 kg of oil of density 910 kg m^{-3} .

What is the density of the mixture?

- A 927 kg m^{-3} B 957 kg m^{-3} C 1010 kg m^{-3} D 1080 kg m^{-3}

- 14 Two coplanar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?



- 15 The density of air on the Earth decreases almost linearly with height from 1.22 kg m^{-3} at sea level to 0.74 kg m^{-3} at an altitude of 5000 m.

Atmospheric pressure at the Earth's surface on a particular day is $100\,000 \text{ Pa}$. The value of g between the Earth's surface and an altitude of 5000 m can be considered to have a constant value of 9.7 m s^{-2} .

What will be the atmospheric pressure at an altitude of 5000 m?

- A $36\,000 \text{ Pa}$ B $48\,000 \text{ Pa}$ C $52\,000 \text{ Pa}$ D $59\,000 \text{ Pa}$

- 16 A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

- A Gravitational potential energy is converted into kinetic energy of the air.
 B Gravitational potential energy is converted into kinetic energy of the parachutist.
 C Gravitational potential energy is converted into thermal energy of the air.
 D Gravitational potential energy is converted into thermal energy of the parachutist.

- 17** A boy on a bicycle starts from rest and rolls down a hill inclined at 30° to the horizontal.

The boy and bicycle have a combined mass of 25 kg.

There is a frictional force of 30 N, which is independent of the velocity of the bicycle.

What is the kinetic energy of the boy and the bicycle after rolling 20 m down the slope?

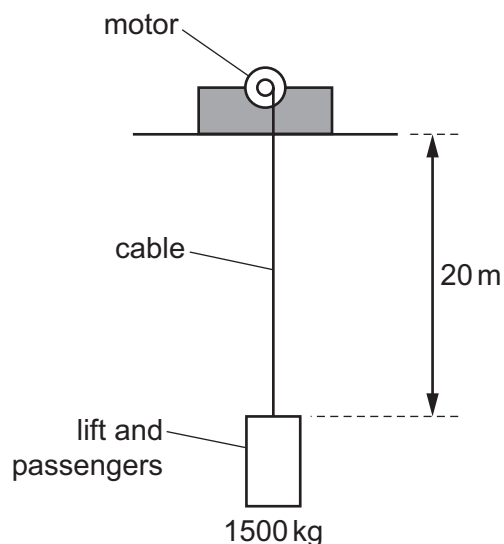
- A** 1850 J **B** 2450 J **C** 3050 J **D** 3640 J

- 18** An escalator in an underground station has 250 people standing on it and is moving with a velocity 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** 54 kW **B** 64 kW **C** 530 kW **D** 630 kW

- 19** An electric motor operating a lift has an output power of 20 kW.



The lift and passengers have a combined mass of 1500 kg. The motor raises the lift through a distance of 20 m.

How long does it take?

- A** 6 s **B** 15 s **C** 30 s **D** 60 s

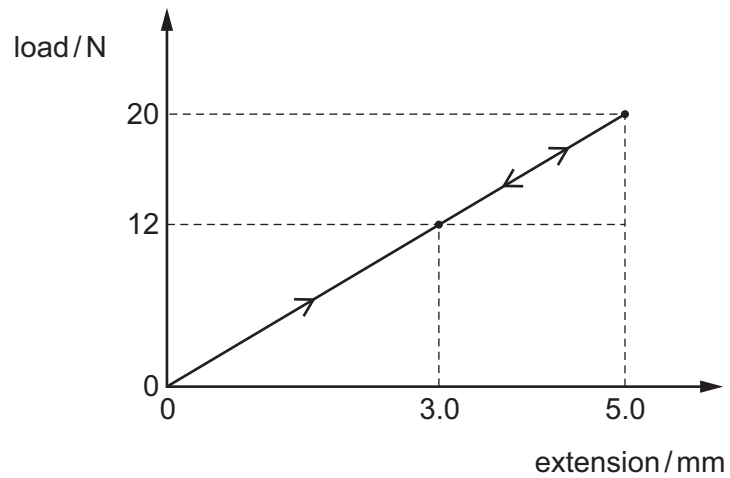
- 20** A spring balance consists of a spring of length 20.0 cm with a hook attached.

When a fish of mass 3.0 kg is suspended from the hook, the new length of the spring is 27.0 cm.

What is the spring constant of the spring?

- A** 4.2 N m^{-1} **B** 43 N m^{-1} **C** 110 N m^{-1} **D** 420 N m^{-1}

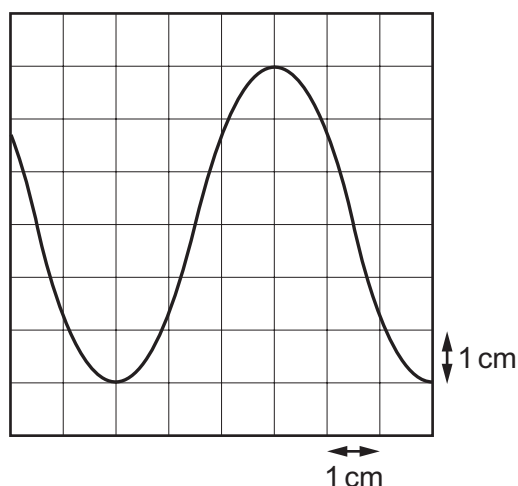
- 21 A metal wire is attached at one end to a fixed point and a load is hung from the other end so that the wire hangs vertically. The load is increased from zero to 20 N. This causes the wire to extend elastically by 5.0 mm. The load is then reduced to 12 N and the extension decreases to 3.0 mm.



How much strain energy is released during the unloading process?

- A** $0.8 \times 10^{-2} \text{ J}$ **B** $1.8 \times 10^{-2} \text{ J}$ **C** $2.4 \times 10^{-2} \text{ J}$ **D** $3.2 \times 10^{-2} \text{ J}$

- 22 A microphone connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.) is placed in front of a loudspeaker. The trace on the screen of the c.r.o. 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 c.r.o.?

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

- 23 A source of sound of frequency 1000 Hz moves away from a stationary observer at a speed of 30.0 ms^{-1} . The speed of sound is 330 ms^{-1} .

What is the frequency of the sound heard by the observer?

- A** 909 Hz **B** 917 Hz **C** 1090 Hz **D** 1100 Hz

- 24 Each of the principal radiations of the electromagnetic spectrum has a range of wavelengths.

Which wavelength is correctly linked to its radiation?

	wavelength /m	radiation
A	10^{-9}	gamma ray
B	10^{-5}	microwave
C	10^{-8}	ultraviolet
D	10^{-14}	X-ray

- 25 A stationary wave is set up on a stretched string.

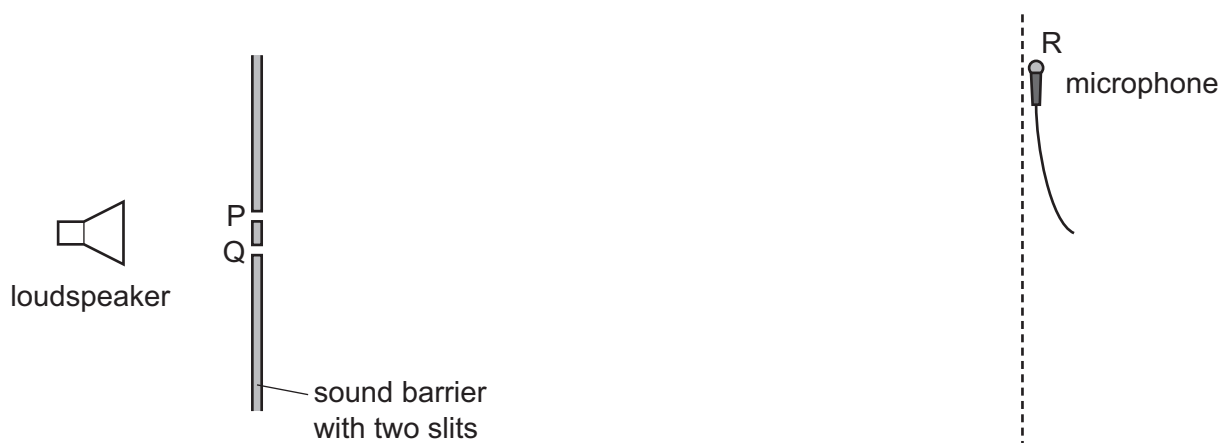
The diagram shows the string at two instants of time when it has maximum displacement.



The oscillations of point P on the string have amplitude A .

What is the distance moved by P from the position shown in the diagram after half a time period of the wave?

- A** 0 **B** A **C** $2A$ **D** $4A$
- 26 Which statement is an example of the diffraction of light?
- A** the addition of the amplitudes of two beams of light which are in phase
- B** the change in direction of a beam of light when passing from air into water
- C** the separation of a beam of white light into a spectrum of colours using a prism
- D** the spreading of a beam of light as it passes through a small hole
- 27 Sound waves of wavelength λ are emitted by a loudspeaker and pass through two slits P and Q. Two sound waves from the slits meet at R.



What is the condition for an intensity maximum (loud sound) to be detected by a microphone at R?

- A** The amplitudes of the two waves at R must be the same.
- B** The distance PQ must be smaller than the wavelength λ .
- C** The two waves from the slits must have travelled the same distance to R.
- D** The two waves must be in phase at R.

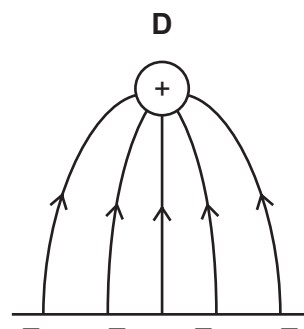
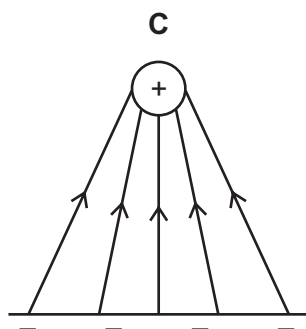
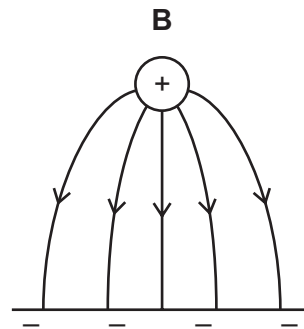
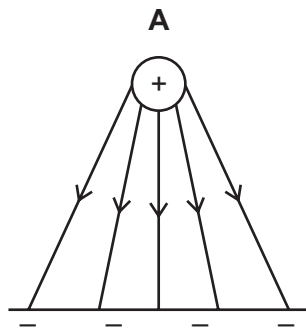
- 28** Coherent light passes through a double slit, producing bright and dark fringes on a screen placed parallel to the plane of the double slit. The intensity of the light from each of the slits is initially the same.

The intensity of the light passing through one of the slits in the double slit is now increased. The frequency of the light remains constant.

What is the effect on the appearance of the fringes on the screen?

	separation of fringes	maximum intensity of dark fringes
A	decreases	no change
B	increases	greater
C	no change	greater
D	no change	no change

- 29** Which diagram shows the pattern of the electric field between a positively charged metal sphere and a negatively charged metal plate?

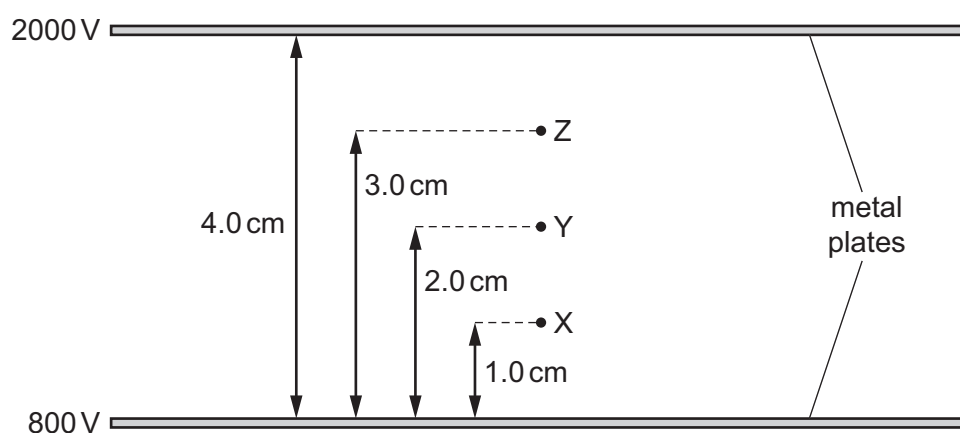


- 30 Before a thunderstorm, the hairs on your head sometimes stand on end.

A hair with mass 0.50 mg and charge 1.0 pC is supported by a force due to an electric field. Ignore any forces other than the weight of the hair and the electric force.

What is the electric field strength?

- A $4.9 \times 10^3 \text{ NC}^{-1}$
 B $4.9 \times 10^5 \text{ NC}^{-1}$
 C $4.9 \times 10^6 \text{ NC}^{-1}$
 D $4.9 \times 10^9 \text{ NC}^{-1}$
- 31 Two parallel metal plates, 4.0 cm apart, are at electric potentials of 800 V and 2000 V . Points X, Y and Z are situated in the space between the plates at distances of 1.0 cm , 2.0 cm and 3.0 cm from the lower plate.

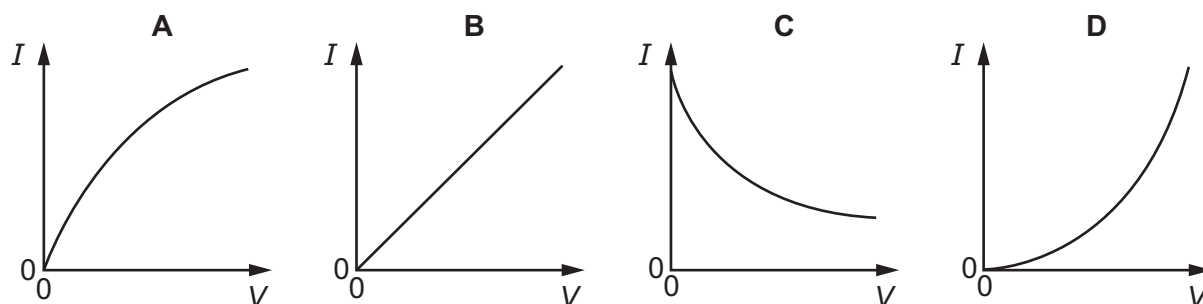


What is the electric field strength, in V m^{-1} , at X, Y and Z?

	X	Y	Z
A	300	600	900
B	1100	1400	1700
C	3.0×10^4	3.0×10^4	3.0×10^4
D	5.0×10^4	5.0×10^4	5.0×10^4

- 32 The potential difference V across a filament lamp is slowly raised from zero to its normal operating value.

Which graph represents the variation with V of the current I in the lamp?



- 33 Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

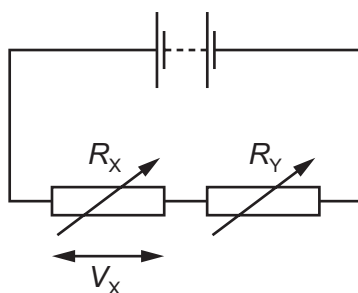
Which statement most accurately describes what happens?

- A** Both lamps light at less than their normal brightness.
B Both lamps light at their normal brightness.
C Only the 240 V lamp lights.
D The 10 V lamp blows.
- 34 Which equation is used to define resistance?
- A** $\text{energy} = (\text{current})^2 \times \text{resistance} \times \text{time}$
B $\text{potential difference} = \text{current} \times \text{resistance}$
C $\text{power} = (\text{current})^2 \times \text{resistance}$
D $\text{resistivity} = \text{resistance} \times \text{area} \div \text{length}$
- 35 The charge that a fully charged 12 V car battery can supply is 100 kC. The starter motor of the car requires a current of 200 A for an average period of 2.0 s. The battery does not recharge because of a fault.

What is the maximum number of times the starter motor of the car can be used?

- A** 21 **B** 25 **C** 42 **D** 250

- 36 A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



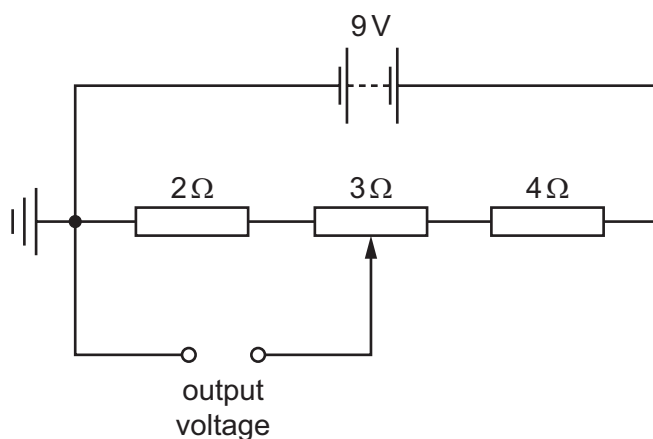
The variable resistors have resistances R_X and R_Y .
 V_X is the potential difference across resistance R_X .

R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

- 37 In the circuit shown, contact may be made at any point along the 3Ω resistor (potentiometer).



The battery has e.m.f. 9V and negligible internal resistance.

What is the maximum range of the output voltage?

- A** 0–2V **B** 0–5V **C** 2–3V **D** 2–5V

- 38 The gold nucleus $^{185}_{79}\text{Au}$ undergoes alpha decay.

What are the nucleon number and proton number of the nucleus formed by this decay?

	nucleon number	proton number
A	183	79
B	183	77
C	181	77
D	181	75

- 39 Which row gives the correct classification of protons, electrons and neutrinos?

	protons	electrons	neutrinos
A	hadrons	leptons	hadrons
B	hadrons	leptons	leptons
C	leptons	hadrons	hadrons
D	leptons	hadrons	leptons

- 40 Which equation represents β^+ decay?

- A** neutron $\rightarrow$ proton + positron + antineutrino
B neutron $\rightarrow$ proton + positron + neutrino
C proton $\rightarrow$ neutron + positron + antineutrino
D proton $\rightarrow$ neutron + positron + neutrino

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PHYSICS

9702/13

Paper 1 Multiple Choice

May/June 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 **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 Which list contains only SI base units?

- A ampere, kelvin, joule, gram
- B kilogram, newton, metre, ampere
- C metre, coulomb, second, kelvin
- D second, kelvin, ampere, kilogram

2 The stress σ needed to fracture a particular solid is given by the equation

$$\sigma = k \sqrt{\frac{\gamma E}{d}}$$

where E is the Young modulus, d is the distance between planes of atoms, and k is a constant with no units.

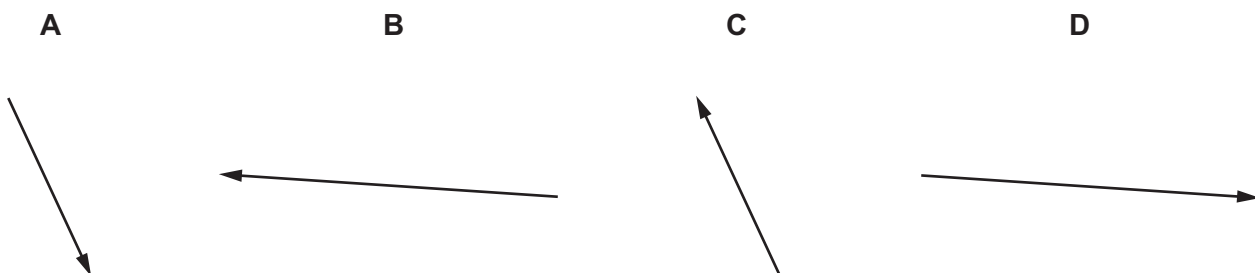
What are the SI base units of γ ?

- A kg m s^{-2}
- B kg s^{-2}
- C kg m s^{-1}
- D kg s^{-1}

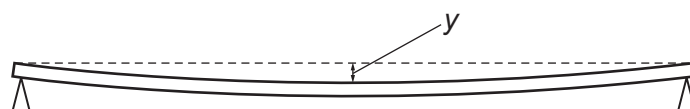
3 Vectors P and Q are drawn to scale.



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



- 4 A metre rule is supported horizontally by two pivots as shown.



The vertical displacement y at the centre of the rule is given by the equation

$$y = \frac{kML^3}{wt^3}$$

where

k is a constant,

L is the distance between the pivots,

M is the mass of the rule,

t is the thickness of the rule and

w is the width of the rule.

In an experiment, the following results are obtained:

$$L = (80.0 \pm 0.2) \text{ cm}$$

$$M = (60 \pm 1) \text{ g}$$

$$t = (6.0 \pm 0.1) \text{ mm}$$

$$w = (23.0 \pm 0.5) \text{ mm}.$$

Which measurement contributes most to the uncertainty in the calculated value of y ?

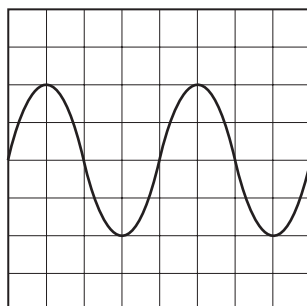
A L

B M

C t

D w

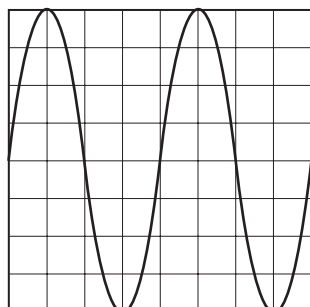
- 5 The following trace is seen on the screen of a cathode-ray oscilloscope.



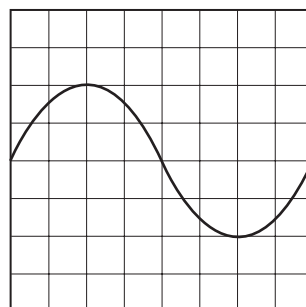
The setting of the time-base is then changed from 10ms cm^{-1} to 20ms cm^{-1} and the Y-plate sensitivity remains constant.

Which trace is now seen on the screen?

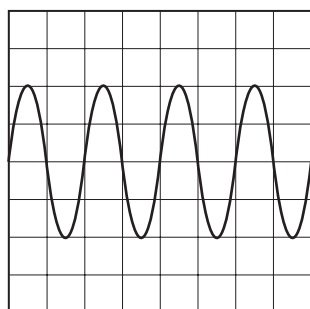
A



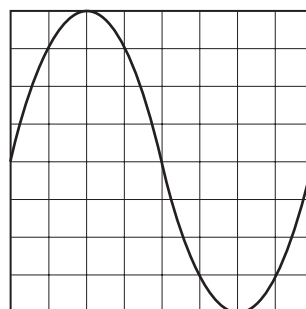
B



C

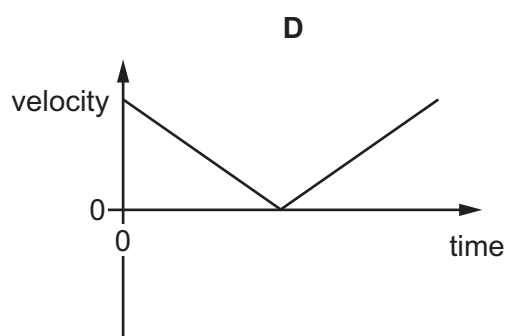
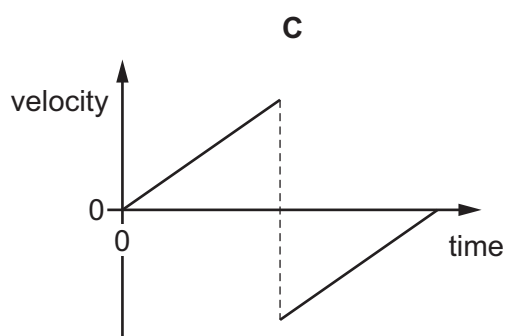
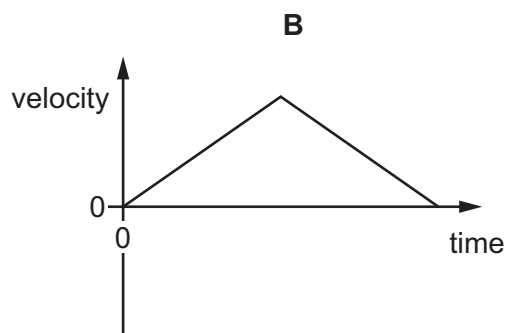
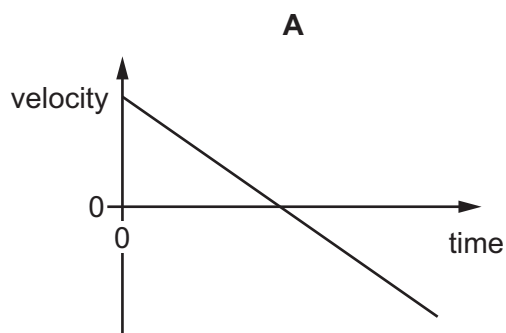


D

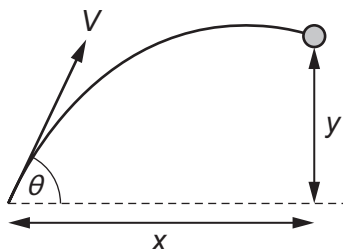


- 6 A ball rolls in a straight line up a ramp and then back down the ramp along its original path.

Which graph shows the variation with time of the ball's velocity?



- 7 A ball is thrown with velocity V at an angle θ to the horizontal.

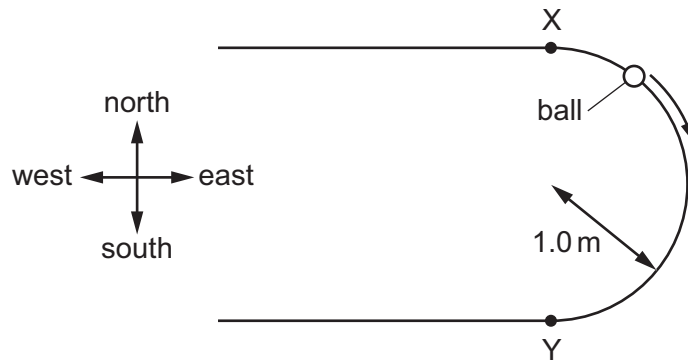


The acceleration of free fall is g . Assume that air resistance is negligible.

What are the horizontal displacement x and the vertical displacement y after time t ?

	x	y
A	$Vt \cos \theta$	$Vt \sin \theta + \frac{1}{2}gt^2$
B	$Vt \cos \theta$	$Vt \sin \theta - \frac{1}{2}gt^2$
C	$Vt \sin \theta$	$Vt \cos \theta + \frac{1}{2}gt^2$
D	$Vt \sin \theta$	$Vt \cos \theta - \frac{1}{2}gt^2$

- 8 A ball travels from point X to point Y around a semi-circular track of radius 1.0 m as shown.



What is the displacement of the ball from X to Y?

- A 2.0 m
 B 2.0 m due south
 C 3.1 m
 D 3.1 m due south
- 9 Which row in the table gives the quantities that are conserved in a perfectly elastic collision between two gas molecules?

	total momentum	total kinetic energy
A	conserved	conserved
B	conserved	not conserved
C	not conserved	conserved
D	not conserved	not conserved

- 10 Two equal masses travel towards each other on a frictionless track at speeds of 60 cm s^{-1} and 30 cm s^{-1} . They stick together on impact.



What is the speed of the masses after impact?

- A 15 cm s^{-1} B 20 cm s^{-1} C 30 cm s^{-1} D 45 cm s^{-1}

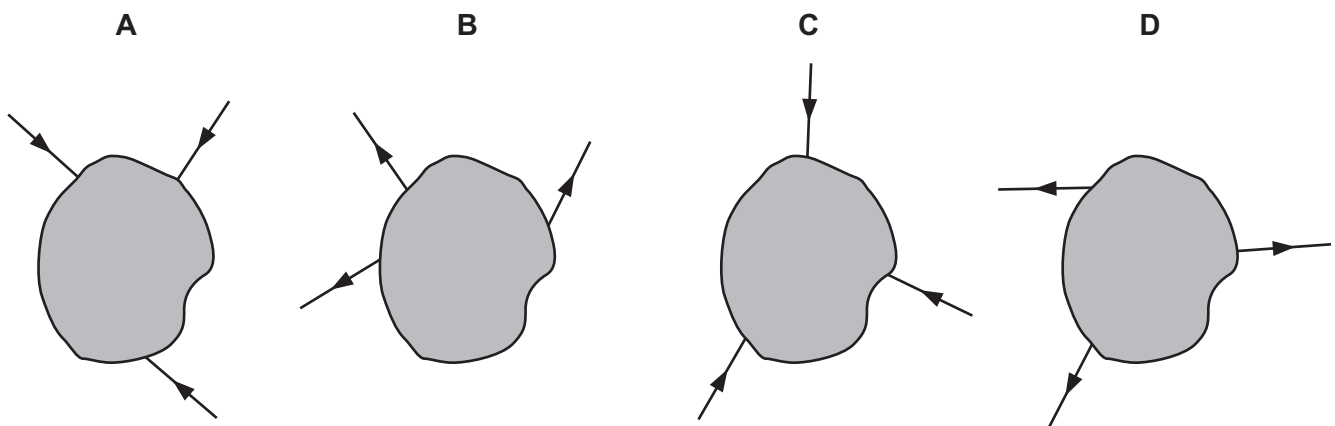
- 11 The IKAROS satellite has mass 320 kg and moves through space using a solar sail of area 20 m^2 . The average solar wind pressure is $1.0 \times 10^{-5} \text{ N m}^{-2}$.

What is the acceleration of the satellite caused by the solar wind?

- A $3.1 \times 10^{-8} \text{ m s}^{-2}$
- B $6.3 \times 10^{-7} \text{ m s}^{-2}$
- C $3.2 \times 10^{-3} \text{ m s}^{-2}$
- D $6.4 \times 10^{-2} \text{ m s}^{-2}$

- 12 Three coplanar forces act on an object in the directions shown.

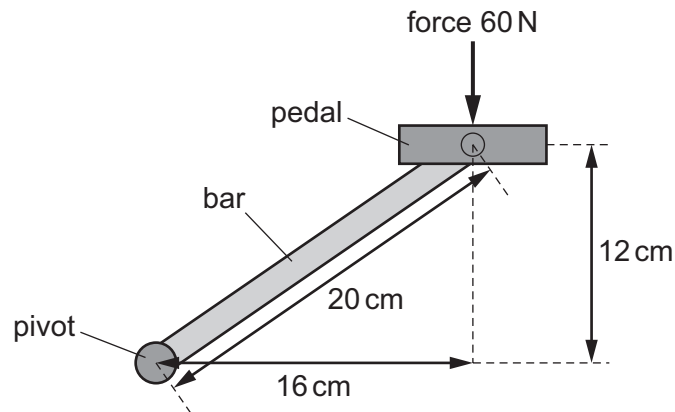
In which diagram could the object be in equilibrium?



- 13 What is the centre of gravity of an object?

- A the geometrical centre of the object
- B the point at which the weight of the object may be considered to act
- C the point on the object about which there is a zero net torque
- D the point where gravity acts on the object

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



The force on the pedal is 60 N downwards.

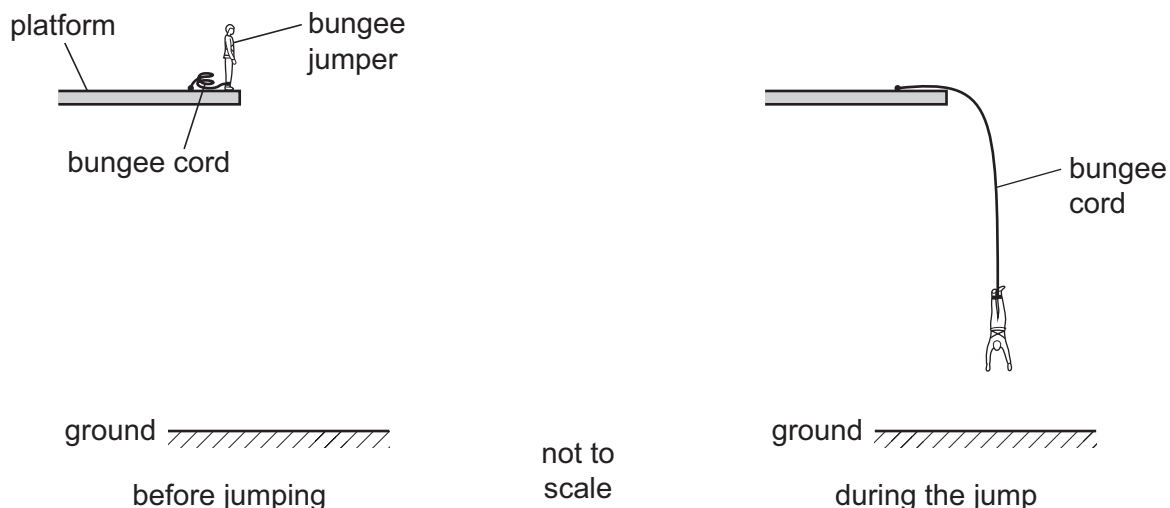
What is the moment of this force about the pivot?

- A 7.2 Nm B 9.6 Nm C 12 Nm D 1200 Nm
- 15 For a change in depth Δh in a liquid of density ρ , the change in pressure Δp is given by $\Delta p = \Delta h \rho g$ where g is the acceleration of free fall.

What is the equation, or principle of physics, used in the derivation of this formula?

- A atmospheric pressure decreases with height
- B change in gravitational potential energy = mass $\times g \Delta h$
- C $\rho = \frac{\text{mass}}{\text{volume}}$
- D the density of a fluid increases with depth

- 16** A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



When the jumper makes the jump, his initial gravitational potential energy is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

- A** on the platform before the jump
 - B** on the way down before the cord has started to extend
 - C** on the way down as he decelerates
 - D** at the bottom of the jump when he is stationary
- 17** An object of mass 0.30 kg is thrown vertically upwards from the ground with an initial velocity of 8.0 m s^{-1} . The object reaches a maximum height of 1.9 m .

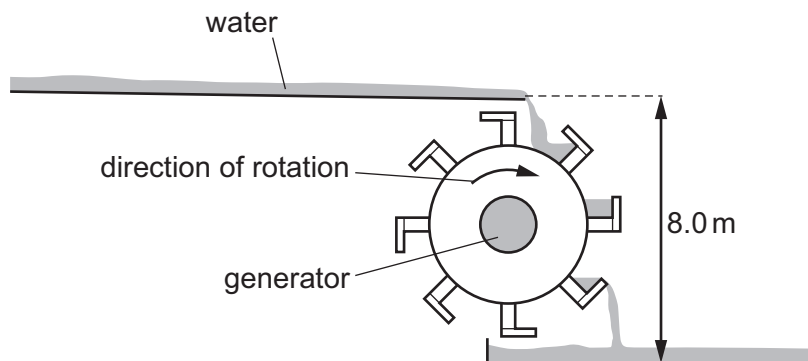
How much work is done against air resistance as the object rises to its maximum height?

- A** 4.0 J **B** 5.6 J **C** 9.6 J **D** 15 J
- 18** A racing car has an output power of 300 kW when travelling at a constant speed of 60 m s^{-1} .

What is the total resistive force acting on the car?

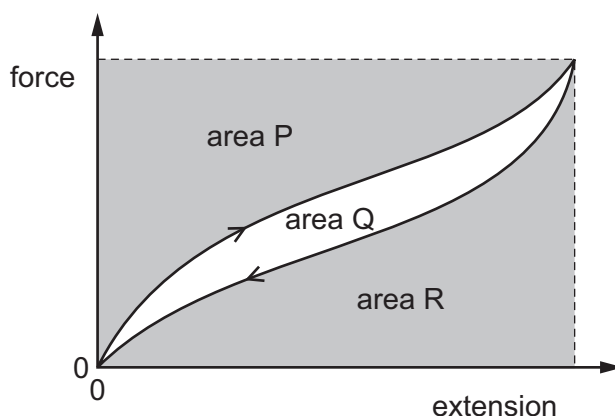
- A** 5 kN **B** 10 kN **C** 50 kN **D** 100 kN

- 19 The diagram shows the design of a water wheel which drives a generator to produce electrical power. The flow rate of the water is 200 kg s^{-1} . The generator supplies a current of 32 A at a voltage of 230 V .



Ignoring any changes in kinetic energy of the water, what is the efficiency of the system?

- A 14% B 16% C 22% D 47%
- 20 The diagram shows the force-extension graph for a sample of material. The sample is stretched and then returns to its original length.



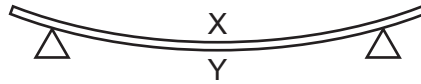
Which area represents the work done to stretch the sample?

- A $P + Q$ B P only C $Q + R$ D R only
- 21 A metal wire of cross-sectional area 0.20 mm^2 hangs vertically from a fixed point. A load of 84 N is then attached to the lower end of the wire. The wire obeys Hooke's law and increases in length by 0.30% .

What is the Young modulus of the metal of the wire?

- A $1.4 \times 10^5 \text{ Pa}$
 B $1.4 \times 10^8 \text{ Pa}$
 C $1.4 \times 10^9 \text{ Pa}$
 D $1.4 \times 10^{11} \text{ Pa}$

- 22 The diagram shows a beam supported on two pivots.

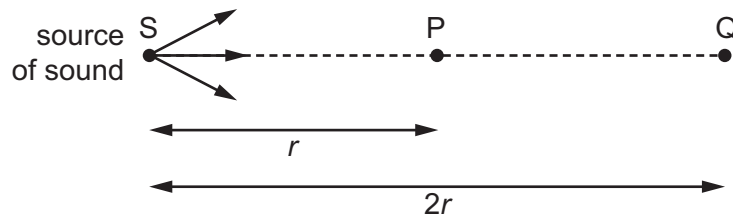


Which statement describes the state of the top surface X and of the bottom surface Y?

- A Both X and Y are in compression.
 - B Both X and Y are in tension.
 - C X is in compression and Y is in tension.
 - D X is in tension and Y is in compression.
- 23 A beam of red laser light has length 1.0 m.
- What is the order of magnitude of the number of wavelengths of the red light in 1.0 m?
- A 10^4
 - B 10^6
 - C 10^8
 - D 10^{10}
- 24 When a car travelling with constant velocity passes a stationary observer, the observer hears a change in the frequency of the sound emitted by the car.
- Which statement is correct?
- A The change in frequency is greater as the car moves away than as it approaches.
 - B The greater the speed of the car, the greater the change in observed frequency.
 - C The observed frequency is lower as the car moves towards the observer and higher as the car moves away from the observer.
 - D The volume of the sound heard by the observer does not change as the car approaches.

- 25** The intensity I of sound is inversely proportional to the square of the distance x from the source of the sound. This can be represented as

$$I \propto \frac{1}{x^2}.$$

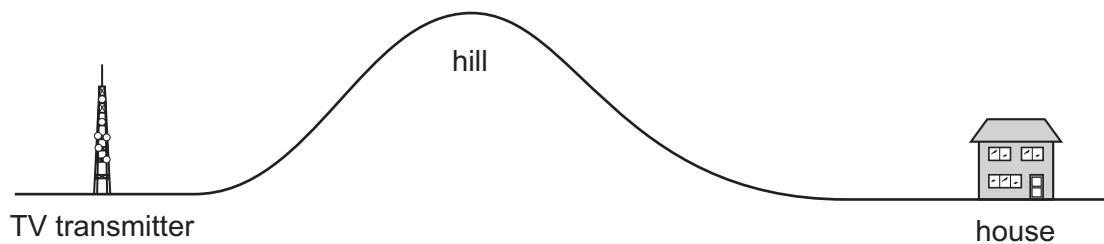


Air molecules at point P, a distance r from the source S, oscillate with amplitude $8.0 \mu\text{m}$.

Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

- A** $1.4 \mu\text{m}$ **B** $2.0 \mu\text{m}$ **C** $2.8 \mu\text{m}$ **D** $4.0 \mu\text{m}$
- 26** 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.

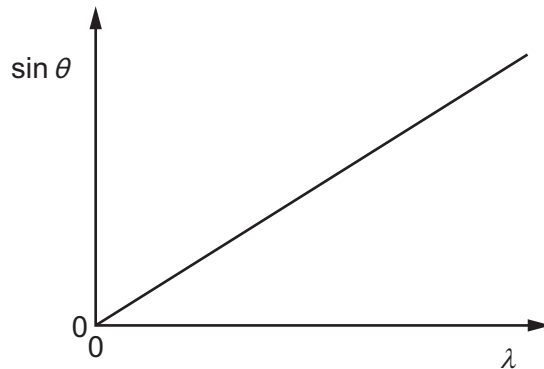


By which wave effect at the hill could the TV signal reach the house?

- A** coherence
B diffraction
C interference
D reflection

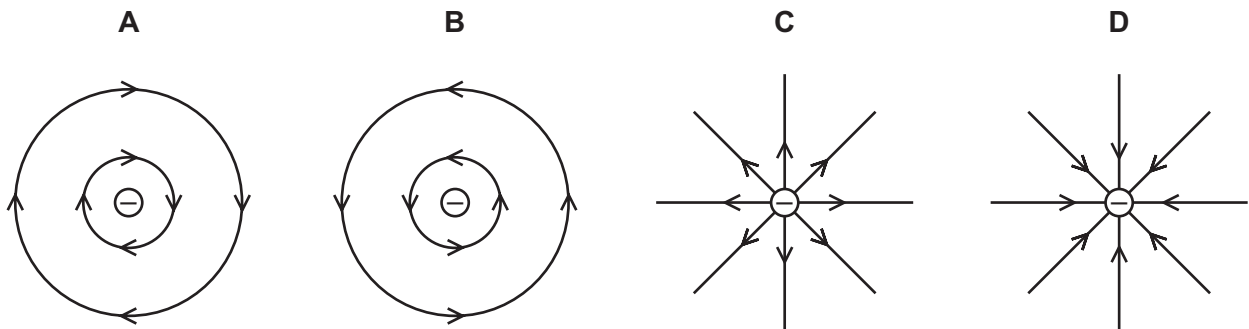
- 27 A diffraction grating with N lines per metre is used to deflect light of various wavelengths λ .

The graph shows a relation between the deflection angle θ and λ for different wavelengths in the n^{th} order interference pattern.



What is the gradient of the graph?

- A Nn B $\frac{N}{n}$ C $\frac{n}{N}$ D $\frac{1}{Nn}$
- 28 Which wave phenomenon is **not** needed to explain the pattern of observable fringes produced by a double slit experiment?
- A coherence
B diffraction
C interference
D reflection
- 29 Which diagram shows the electric field pattern of an isolated negative point charge?



- 30 An electron is in an electric field of strength $5 \times 10^4 \text{ V m}^{-1}$. The field is the only influence on the electron.

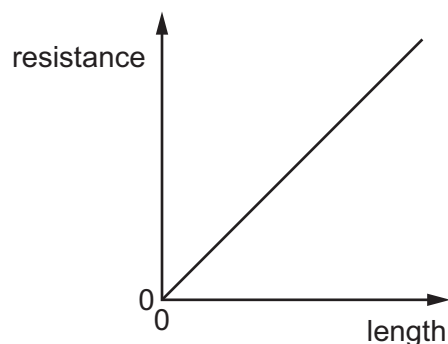
The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

- A the force on the electron
 - B the momentum of the electron
 - C the kinetic energy of the electron
 - D the speed of the electron
- 31 In an electrolyte, the electric current is carried by charged particles (ions) in solution.

What is **not** a possible value for the charge on an ion in solution?

- A $-4.8 \times 10^{-19} \text{ C}$
 - B $+1.6 \times 10^{-19} \text{ C}$
 - C $+3.2 \times 10^{-19} \text{ C}$
 - D $+4.0 \times 10^{-19} \text{ C}$
- 32 The graph shows the variation with length of the resistance of a uniform metal wire.



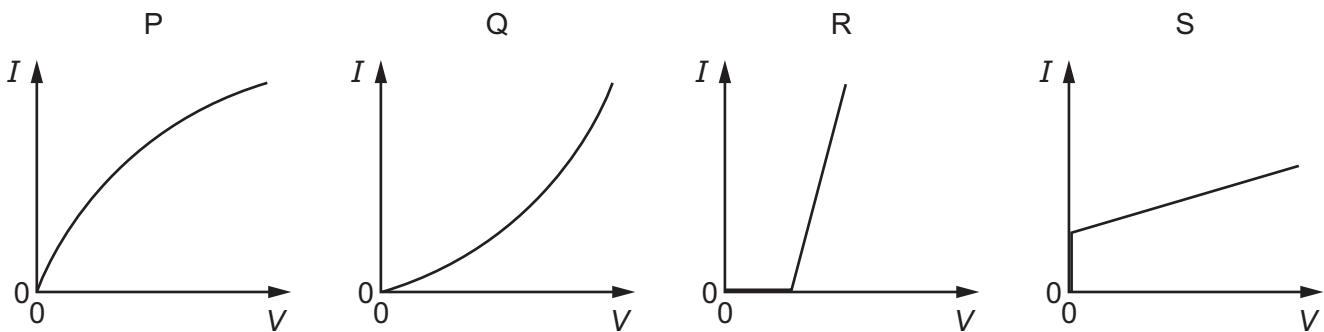
The gradient of the graph is G .

The wire has cross-sectional area A .

Which expression could be used to calculate the resistivity of the metal of the wire?

- A $G \times A$
- B $\frac{G}{A}$
- C $\frac{A}{G}$
- D $G \times A^2$

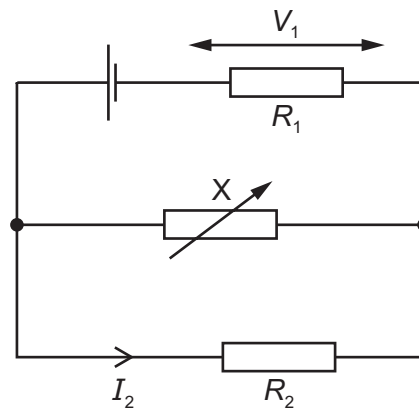
- 33 What describes the electric potential difference between two points in a wire that carries a current?
- A the force required to move a unit positive charge between the points
 - B the ratio of the energy dissipated between the points to the current
 - C the ratio of the power dissipated between the points to the current
 - D the ratio of the power dissipated between the points to the charge moved
- 34 The graphs show possible current-voltage (I - V) characteristics for a filament lamp and for a semiconductor diode.



Which row in the table best specifies the correct I - V graphs for the lamp and for the diode?

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

- 35 A circuit contains a cell, two resistors of resistances R_1 and R_2 and a variable resistor X . The cell has negligible internal resistance.



V_1 is the potential difference across the resistor of resistance R_1 .

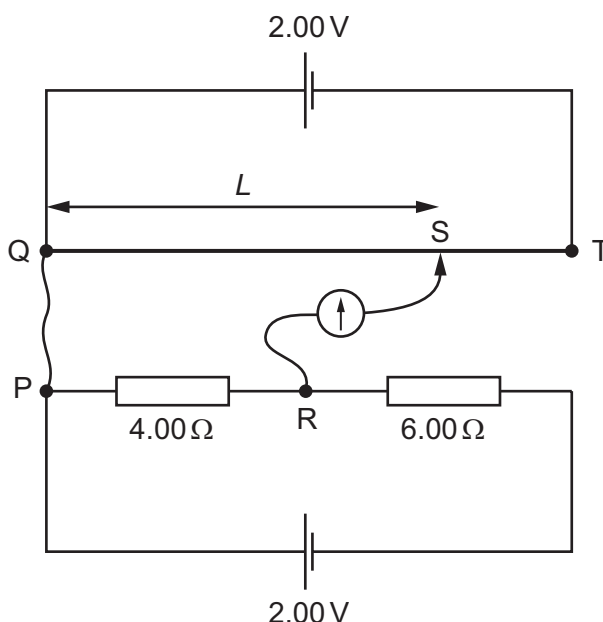
I_2 is the current through the resistor of resistance R_2 .

The resistance of X is reduced.

What is the effect on V_1 and I_2 ?

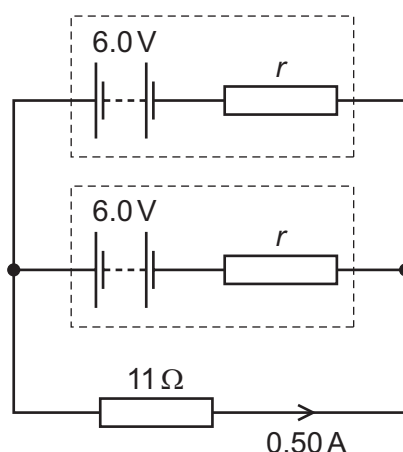
	V_1	I_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

- 36** A 100 cm potentiometer wire QT is connected in series with a 2.00 V cell. Another circuit, consisting of a 2.00 V cell in series with resistors of resistance $4.00\ \Omega$ and $6.00\ \Omega$, is set up alongside the potentiometer. Connections PQ and RS are then made so that the potential difference (p.d.) across the $4.00\ \Omega$ resistor is balanced against the p.d. across a length L of potentiometer wire. Both cells have negligible internal resistance.



What is the balance length L ?

- A** 0 cm **B** 40 cm **C** 60 cm **D** 100 cm
- 37** Two identical batteries each have e.m.f. 6.0 V and internal resistance r . The batteries are connected to an external resistor of resistance $11\ \Omega$, as shown.



The current in the external resistor is 0.50 A.

What is the internal resistance r of each battery?

- A** $1.0\ \Omega$ **B** $2.0\ \Omega$ **C** $4.0\ \Omega$ **D** $6.5\ \Omega$

- 38 A nitrogen-13 nucleus $^{13}_7\text{N}$ undergoes beta decay.

In the equations below, ν and $\bar{\nu}$ represent a neutrino and antineutrino respectively and γ represents a photon of gamma radiation.

Which equation represents this decay?

- A** $^{13}_7\text{N} \rightarrow ^{13}_6\text{C} + \beta^- + \bar{\nu} + \gamma$
B $^{13}_7\text{N} \rightarrow ^{13}_6\text{C} + \beta^- + \nu + \gamma$
C $^{13}_7\text{N} \rightarrow ^{13}_6\text{C} + \beta^+ + \bar{\nu} + \gamma$
D $^{13}_7\text{N} \rightarrow ^{13}_6\text{C} + \beta^+ + \nu + \gamma$

- 39 Radon $^{222}_{86}\text{Rn}$ is the start of a decay chain that forms bismuth $^{214}_{83}\text{Bi}$ by α and β^- emission.

For the decay of each nucleus of radon, how many α particles and β^- particles are emitted?

	α particles	β^- particles
A	1	1
B	2	1
C	1	2
D	2	2

- 40 The magnitude of the charge on the proton may be regarded as +1 unit. On this basis, the charges on the up (u) quark, down (d) quark and their antiquarks ($\bar{u}$ and $\bar{d}$) are not whole units.

Which row in the table shows the correct values for the charges on the u, d, $\bar{u}$ and $\bar{d}$ quarks?

	u	d	$\bar{u}$	$\bar{d}$
A	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$
B	$-\frac{2}{3}$	$+\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$
C	$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$
D	$-\frac{2}{3}$	$+\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$