Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
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	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
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 student uses the volume of a metal coin in order to determine the density of the metal.

What is **not** needed in order to determine an estimate of the volume of the coin?

A estimate of the diameter

B estimate of the mass

C estimate of the thickness

D use of the formula for the volume of a cylinder

2 The speed v of waves on a stretched wire is given by the equation

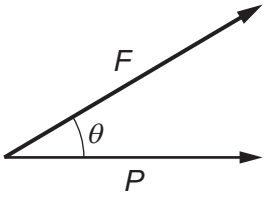
$$v = T^p \mu^q$$

where T is the tension in the wire and μ is the mass per unit length of the wire.

What are the values of p and q?

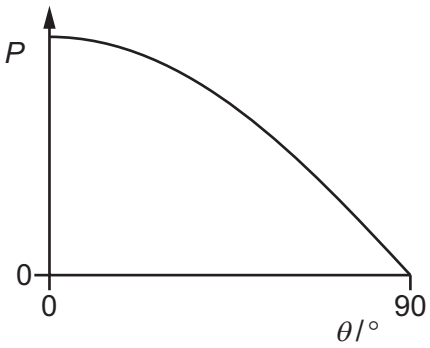
	p	q
A	$-\frac{1}{2}$	$-\frac{1}{2}$
B	$-\frac{1}{2}$	$\frac{1}{2}$
C	$\frac{1}{2}$	$-\frac{1}{2}$
D	$\frac{1}{2}$	$\frac{1}{2}$

3 The diagram shows a force *F*. *P* is the horizontal component of *F*, at an angle θ to *F*.

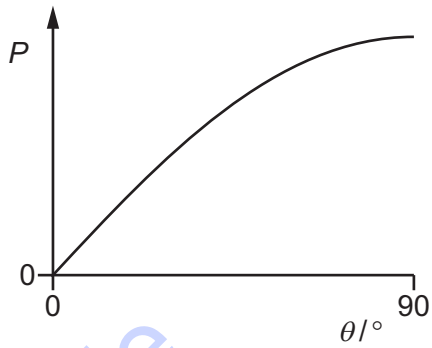


Which graph best shows the variation with θ of the magnitude of *P*?

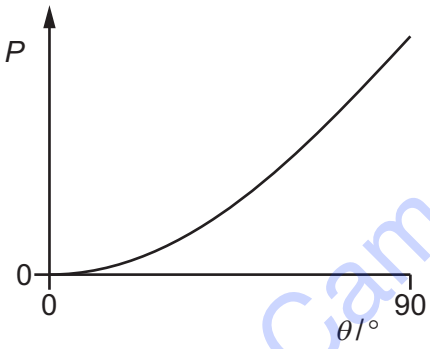
A



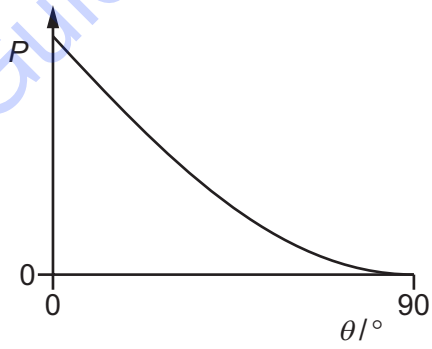
B



C



D



4 A student wishes to measure a distance of about 10 cm to a precision of 0.01 cm.

Which measuring instrument should be used?

A metre rule

B micrometer

C tape measure

D vernier calipers

5 A steel ball is dropped and falls through a vertical height h. The time t taken to fall is measured using light gates.

The results are given in the table.

h	$(4.05 \pm 0.01)\,\text{m}$
t	$(0.91 \pm 0.02)\,\text{s}$

The acceleration of free fall g is calculated using the equation shown.

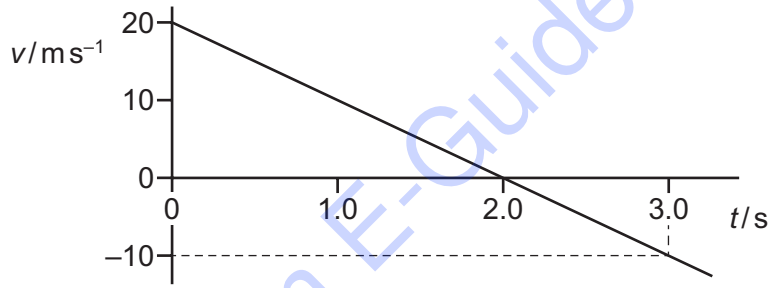
$$h = \tfrac{1}{2}gt^2$$

What is the percentage uncertainty in the value of g?

A 2.4% **B** 4.6% **C** 5.1% **D** 9.3%

6 A stone is thrown vertically upwards from a point X at time $t = 0$.

The variation with time t of the velocity v of the stone is shown.



What is the displacement of the stone from point X at time $t = 3.0\,\text{s}$?

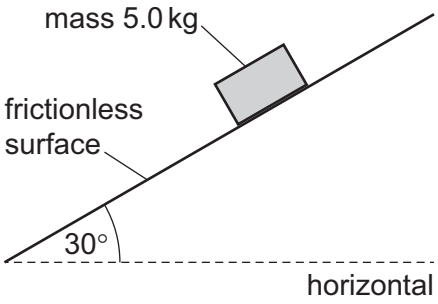
A 15 m above X

B 15 m below X

C 25 m above X

D 25 m below X

7 A mass of 5.0 kg is released from rest on a frictionless surface inclined at 30° to the horizontal. Air resistance is negligible.



How far does the mass travel in a time of 0.80 s?

A 1.6 m **B** 2.0 m **C** 2.7 m **D** 3.1 m

8 What is **not** a statement of one of Newton's laws of motion?

A If body X exerts a force on body Y, body Y exerts an equal and opposite force on body X.

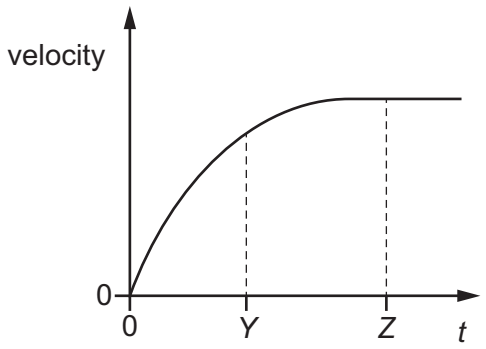
B If no resultant force acts on a body it has constant velocity.

C The rate of change of momentum of a body is proportional to the resultant force acting on it and takes place in the direction of the force.

D The total momentum of a system of interacting bodies is constant if there is no external force.

9 An object falls from a tall building.

The graph shows how the velocity of the object changes with time *t*.



The acceleration of free fall is *g*.

What describes the acceleration of the object at times $t = Y$ and $t = Z$?

	acceleration at $t = Y$	acceleration at $t = Z$
A	decreasing	*g*
B	decreasing	0
C	constant	*g*
D	constant	0

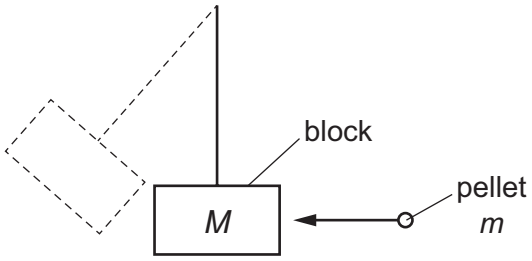
10 Two balls, one of mass 2*m* and one of mass *m*, collide.

The diagrams show the initial and final velocities of the balls.

Which collision is **not** elastic?

	before collision	after collision
A	2*m* 4.0 m s^{-1} → *m* 1.0 m s^{-1} →	2*m* 2.0 m s^{-1} → *m* 5.0 m s^{-1} →
B	2*m* 6.0 m s^{-1} → *m* 3.0 m s^{-1} →	2*m* 4.0 m s^{-1} → *m* 7.0 m s^{-1} →
C	2*m* 8.0 m s^{-1} → *m* 2.0 m s^{-1} →	2*m* 5.0 m s^{-1} → *m* 8.0 m s^{-1} →
D	2*m* 10.0 m s^{-1} → *m* 4.0 m s^{-1} →	2*m* 6.0 m s^{-1} → *m* 12.0 m s^{-1} →

11 The diagram shows a 'ballistic pendulum'.



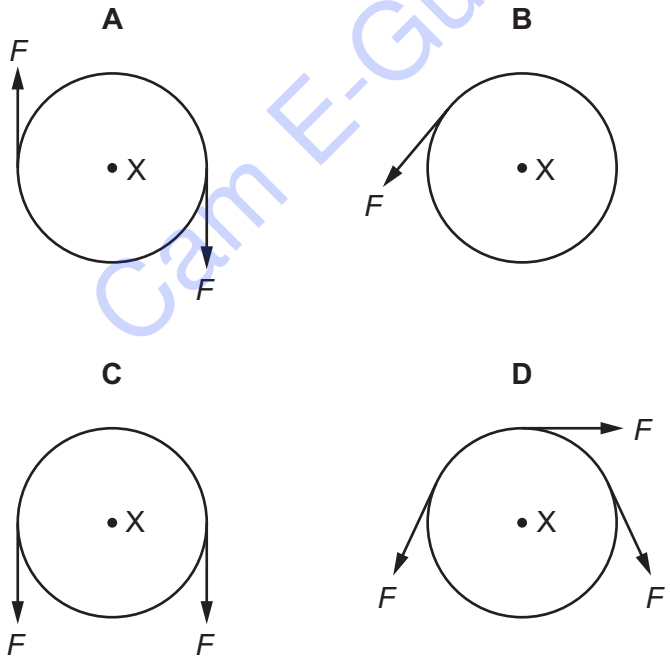
A pellet of mass m travelling at a speed u hits a stationary block of mass M. The pellet becomes embedded in the block and causes the block to move at a speed v immediately after the impact.

When a pellet of mass $2m$, travelling at a speed $2u$, hits a block of mass $2M$, what is the speed of the block immediately after the impact? (Neglect the small increase in the mass of the block as the pellet's mass is added during the collision.)

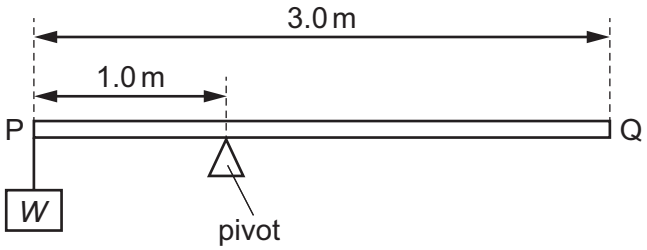
A v **B** $v\sqrt{2}$ **C** $2v$ **D** $4v$

12 A rigid circular disc of radius r has its centre at X. A number of forces of equal magnitude F act at the edge of the disc. All the forces are in the plane of the disc.

Which arrangement of forces provides a total moment of magnitude $2Fr$ about X?



13 The diagram shows a uniform beam PQ. The length of the beam is 3.0 m and its weight is 50 N. The beam is supported on a pivot 1.0 m from end P. A load of weight *W* is hung from end P. The beam is in equilibrium.



What is the value of *W*?

A 25 N **B** 50 N **C** 75 N **D** 100 N

14 In a high-wire circus act, a man of mass 85 kg is standing at rest at the midpoint of the wire.

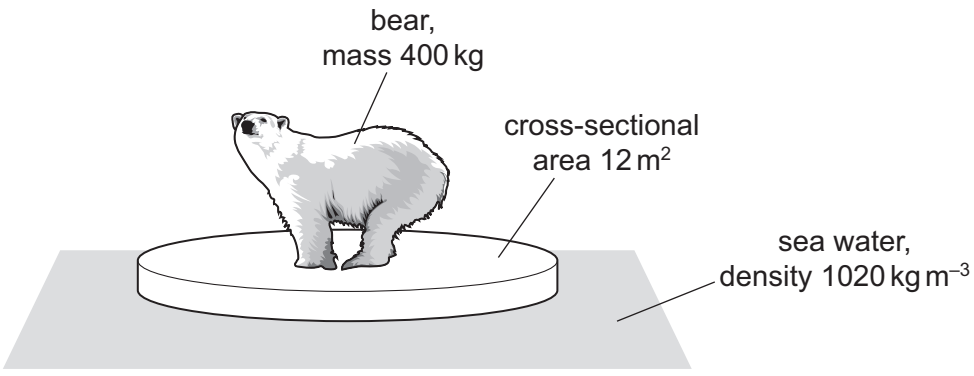
The wire on either side of the man is at an angle of 20° to the horizontal.

What is the tension *T* in the wire?

A 0.44 kN **B** 0.89 kN **C** 1.2 kN **D** 2.4 kN

15 A cylindrical block of ice of cross-sectional area 12 m^2 is floating, partially submerged, in the sea.

The density of the sea water is 1020 kg m^{-3}. A polar bear of mass 400 kg steps onto the block of ice.



The block of ice sinks a vertical distance *d*.

What is the value of *d*?

A 3.3 mm **B** 3.3 cm **C** 0.32 m **D** 3.1 m

16 A ball is thrown vertically upwards. Air resistance is negligible.

Which statement is correct?

A By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.

B By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.

C The kinetic energy of the ball is greatest at the greatest height attained.

D The potential energy of the ball increases at a constant rate during its ascent.

17 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

18 The change in gravitational potential energy ΔE of an object of mass m when moving through height Δh near the surface of the Earth is given by the equation shown.

$$\Delta E = mg\Delta h$$

Which equation is needed as part of the derivation of this expression?

A kinetic energy = $\frac{1}{2} \times$ mass $\times$ (speed)^2

B moment = force $\times$ distance

C weight = mass $\times$ acceleration of free fall

D work done = power $\times$ time

19 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

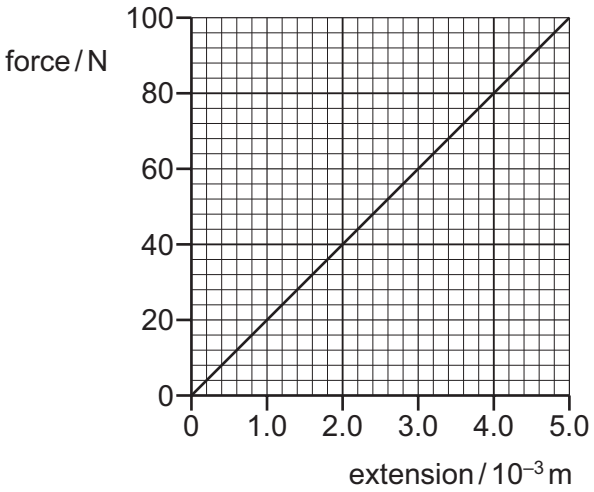
20 A mass of 60.0 g is suspended from a spring and the distance from the bottom of the spring to the floor is measured to be 16.4 cm.

The mass is replaced with a 100.0 g mass and the distance from the bottom of the spring to the floor is now measured to be 12.6 cm. The spring obeys Hooke's law.

What is the spring constant of the spring?

A 1.05 N m^{-1} **B** 1.35 N m^{-1} **C** 10.3 N m^{-1} **D** 103 N m^{-1}

21 The graph shows the force–extension graph for a wire.



The wire is already extended by a force of 60 N.

How much work is done to increase the extension of the wire by 2.0 mm?

A 0.040 J **B** 0.090 J **C** 0.16 J **D** 0.25 J

22 The speed v of waves in deep water is given by the equation

$$v^2 = \frac{g\lambda}{2\pi}$$

where λ is the wavelength of the waves and g is the acceleration of free fall.

A student measures the wavelength λ and the frequency f of a number of these waves.

Which graph should he plot to give a straight line through the origin?

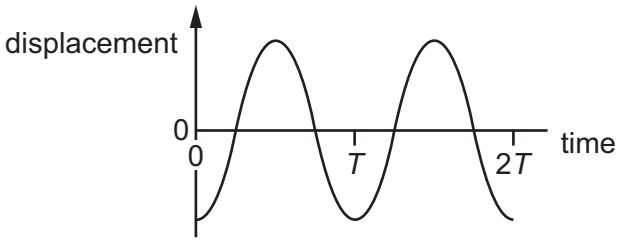
A f^2 against λ

B f against λ^2

C f against $\frac{1}{\lambda}$

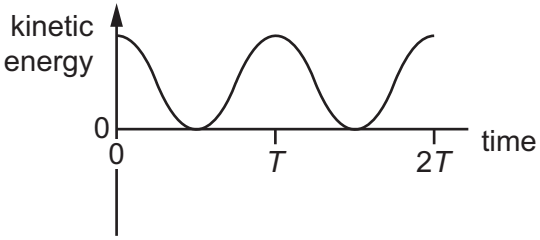
D f^2 against $\frac{1}{\lambda}$

23 When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.

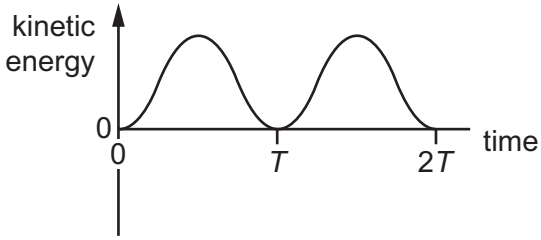


Which graph shows how the kinetic energy of the air particle varies with time?

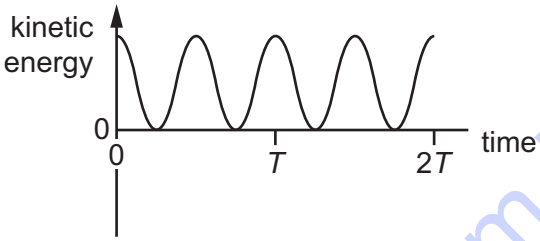
A



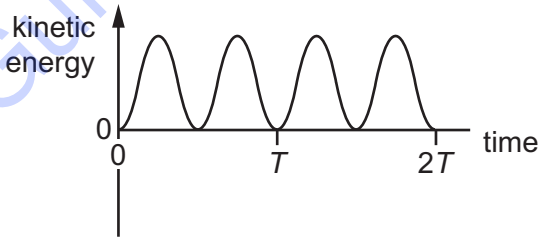
B



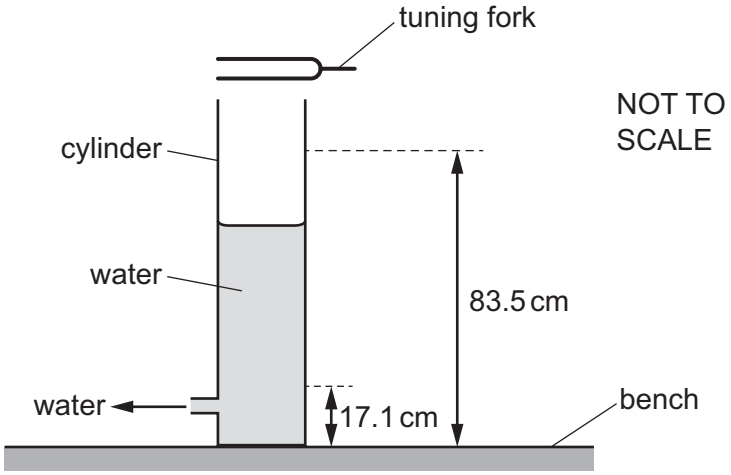
C



D



24 A vibrating tuning fork is held above a glass cylinder filled to the top with water. The water level is steadily lowered. A loud sound is first heard when the water level is 83.5 cm above the bench. The next loud sound is heard when the water level is 17.1 cm above the bench.

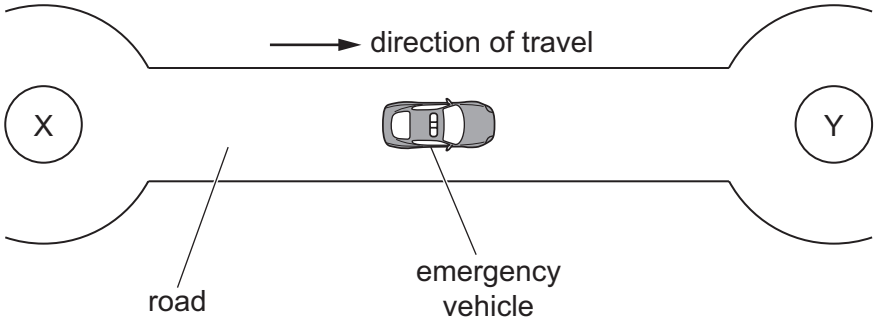


The speed of sound in air is 340 m s^{-1}.

What is the frequency of the tuning fork?

A 128 Hz **B** 256 Hz **C** 384 Hz **D** 512 Hz

25 An emergency vehicle sounds its siren as it accelerates along a straight road between two points X and Y, as shown in the diagram.



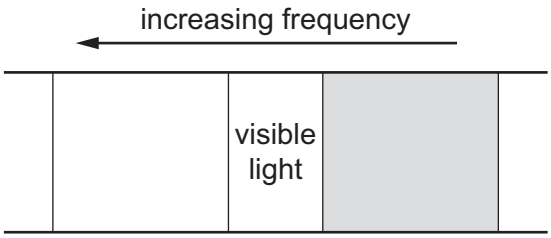
The frequency of the sound emitted by the siren is 750 Hz.

A person stands at X and another person stands at Y.

What describes the sounds heard by the people at X and at Y as the vehicle accelerates?

	sound heard by person at X	sound heard by person at Y
A	higher than 750 Hz, increasing in frequency	lower than 750 Hz, decreasing in frequency
B	higher than 750 Hz, decreasing in frequency	lower than 750 Hz, increasing in frequency
C	lower than 750 Hz, decreasing in frequency	higher than 750 Hz, increasing in frequency
D	lower than 750 Hz, increasing in frequency	higher than 750 Hz, decreasing in frequency

26 Part of the electromagnetic spectrum is shown.



What is the name of the shaded region and what is the order of magnitude of a wavelength of a wave from this region?

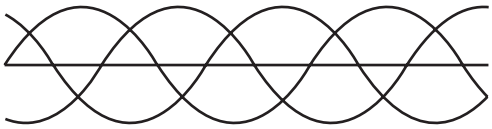
	name	wavelength / m
A	infrared	10^{-5}
B	infrared	10^{-8}
C	ultraviolet	10^{-5}
D	ultraviolet	10^{-8}

27 The three waves shown in each diagram have the same amplitude and frequency but different phase.

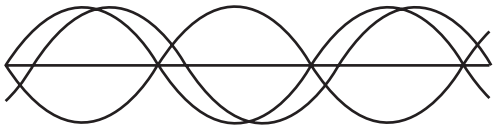
They are added together to give a resultant wave.

In which case is the resultant wave zero at this instant?

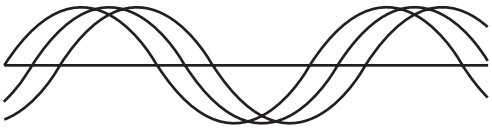
A



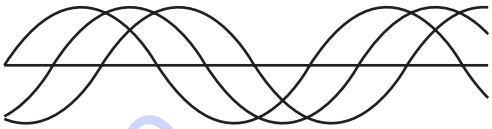
B



C



D



28 A transmitting mast sends out microwaves of wavelength 1.5 cm and radio waves of wavelength 1.5 km.

NOT TO SCALE

A receiving aerial behind a mountain can detect the radio waves but not the microwaves.

What is the reason for this?

A The radio waves are coherent but the microwaves are not.

B The radio waves are diffracted around the mountain but the microwaves are not.

C The radio waves are reflected by the mountain but the microwaves are not.

D The radio waves travel at the speed of light but the microwaves do not.

29 An experiment is carried out to demonstrate double-slit interference using light of wavelength 500 nm. The distance between bright fringes in the interference pattern is 5 mm.

What are possible values for the distance between the slits and the screen, and the slit separation?

	slit–screen distance	slit separation
A	50 cm	0.5 mm
B	50 cm	5 mm
C	5 m	0.5 mm
D	5 m	5 mm

30 Light of a single frequency is incident on a diffraction grating. Seven bright spots are observed on a screen.

Which change will result in an increase in the number of bright spots observed?

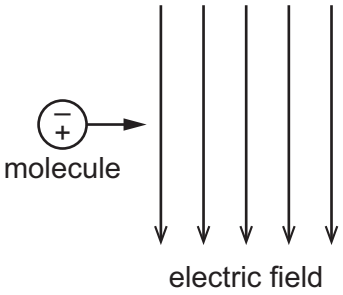
A Increase the distance between the grating and the screen.

B Increase the frequency of the incident light.

C Increase the intensity of the incident light.

D Increase the number of lines per metre in the grating.

31 A molecule behaves as an electric 'dipole' consisting of two equal point charges of opposite sign, separated by a fixed distance. The molecule moves with constant horizontal velocity as it enters a vertical uniform electric field, as shown.

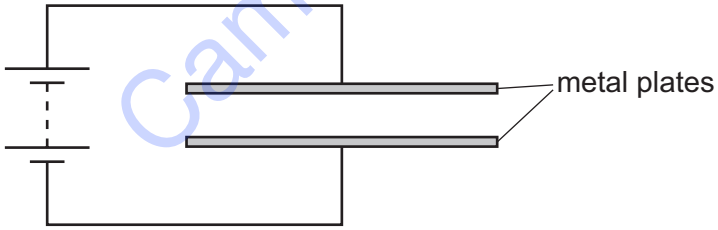


The positive and negative charges of the molecule enter the field at the same time.

What describes the effect of the electric field on the velocity of the molecule?

	horizontal component of velocity	vertical component of velocity
A	constant	increases
B	constant	zero
C	increases	increases
D	increases	zero

32 Two parallel metal plates are connected to a battery of negligible internal resistance.



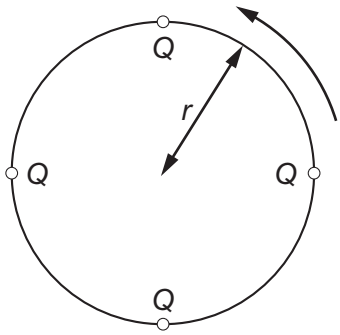
One of the plates is slowly moved towards the other.

Which row is correct?

	electric field strength between the plates	potential difference between the plates
A	decreases	constant
B	increases	constant
C	decreases	increases
D	increases	increases

33 Four point charges, each of charge Q, are placed on the edge of an insulating disc of radius r.

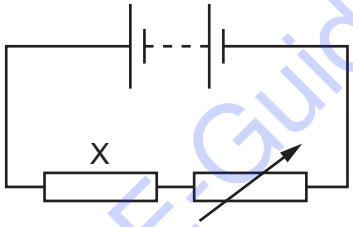
The disc rotates at a rate of n revolutions per unit time.



What is the equivalent electric current at the edge of the disc?

A $4Qn$ **B** $\frac{4Q}{n}$ **C** $8\pi rQn$ **D** $\frac{2Qn}{\pi r}$

34 In the circuit shown, a fixed resistor X is connected in series with a battery and a variable resistor.



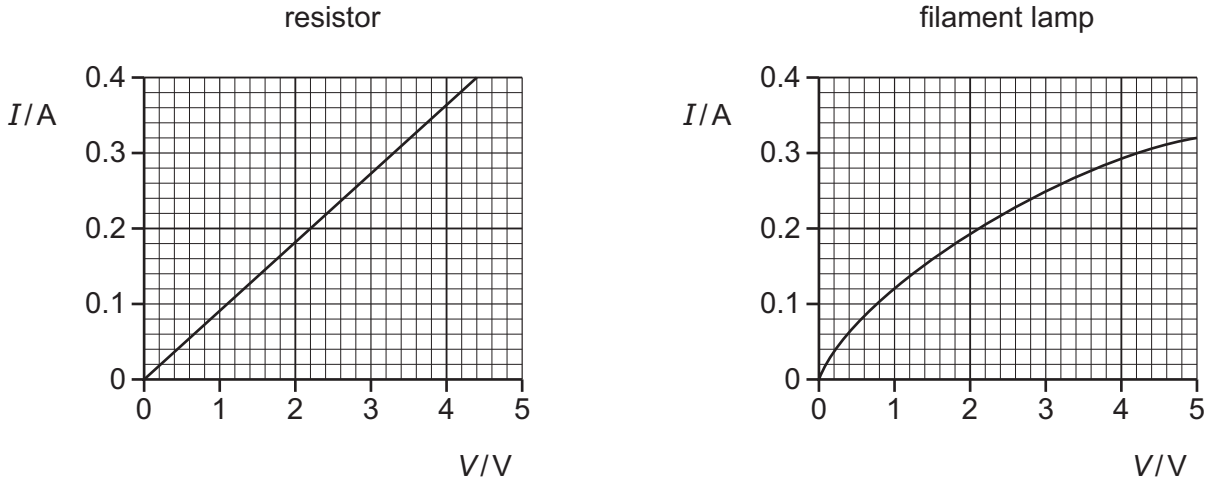
The power dissipated in resistor X is 7.2 W when a current of 3.0 A passes through it.

The variable resistor is adjusted so that the power dissipated in X increases by 50%.

What is the new current in the circuit?

A 2.4 A **B** 3.7 A **C** 4.5 A **D** 14 A

35 A resistor and a filament lamp are connected in series with a power supply. The I–V characteristics of the resistor and of the lamp are shown below.

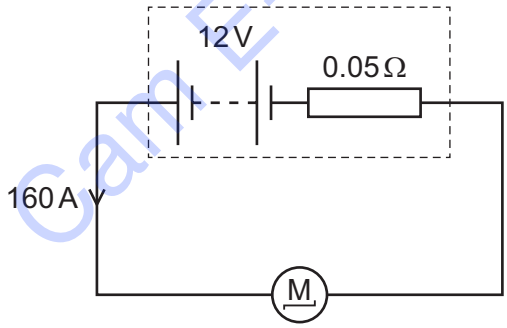


The potential difference (p.d.) across the resistor is 3.3 V.

What is the resistance of the lamp?

A 0.071 Ω **B** 4.2 Ω **C** 11 Ω **D** 14 Ω

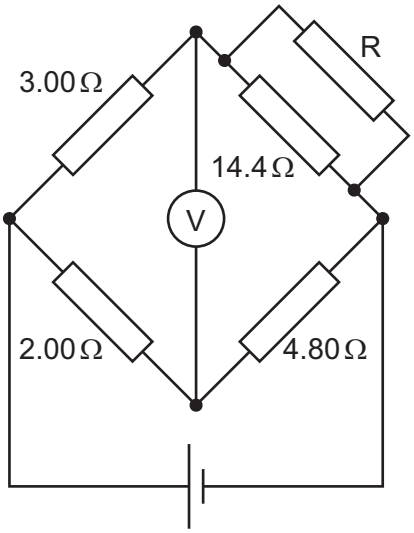
36 A car battery has an electromotive force (e.m.f.) of 12 V and an internal resistance of 0.05 Ω. The battery is connected to the starter motor of a car. The current in the motor is 160 A.



What is the terminal p.d. across the battery?

A 0 V **B** 4 V **C** 8 V **D** 12 V

37 A cell of negligible internal resistance is connected to a network of resistors and a voltmeter, as shown.

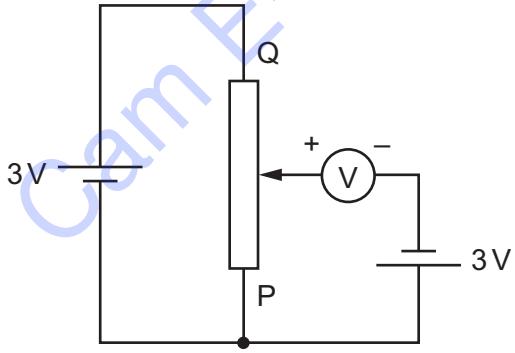


The reading on the voltmeter is zero.

What is the resistance of resistor R?

A 1.20 Ω **B** 1.80 Ω **C** 7.20 Ω **D** 14.4 Ω

38 A voltmeter is connected into a circuit with the polarity shown in the diagram.



The sliding contact is moved to end P of the potentiometer and then to end Q.

What are the two readings of the voltmeter?

	sliding contact at end P	sliding contact at end Q
A	0 V	3 V
B	0 V	6 V
C	3 V	3 V
D	3 V	6 V

39 What is a conclusion from the alpha-particle scattering experiment?

A Protons and electrons have equal but opposite charges.

B Protons have a much larger mass than electrons.

C The nucleus contains most of the mass of the atom.

D The nucleus of an atom contains protons and neutrons.

40 Which particle is a hadron?

A electron

B neutrino

C positron

D proton