

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	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\text{m F}^{-1})$
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	$V = \frac{Q}{4\pi\varepsilon_0 r}$
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 Which quantity is a physical quantity?

A atomic number

B efficiency

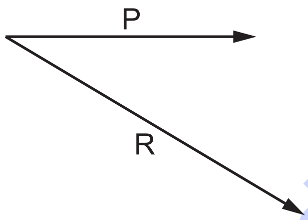
C number density of charge carriers

D strain

2 Which time interval is the shortest?

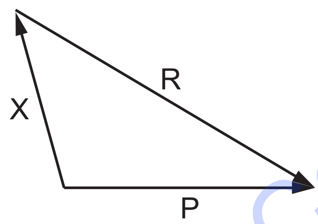
A 0.05 ms **B** 50 ns **C** 500 000 ps **D** 0.5 μs

3 P and R are coplanar vectors.

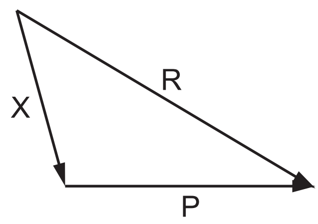


If X = P – R, which diagram best represents vector X?

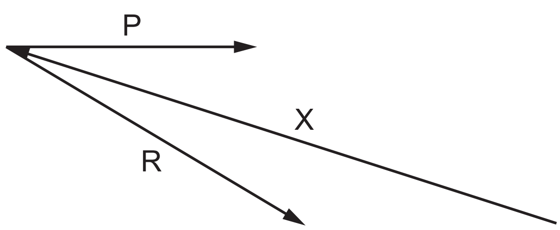
A



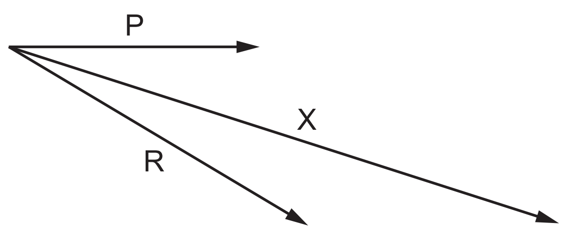
B



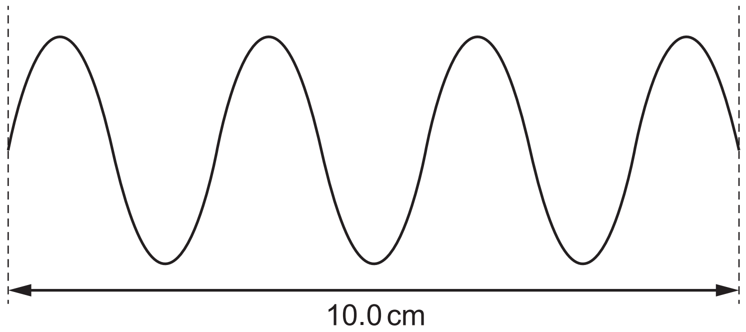
C



D



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



What is the period of the signal?

A 7.1×10^{-6} s **B** 1.4×10^{-5} s **C** 7.1×10^{-3} s **D** 1.4×10^{-2} s

5 The diameter of a spherical golf ball is measured with calipers and found to be (4.11 ± 0.01) cm.

The volume of a sphere is $V = \frac{1}{6}\pi d^3$, where d is the diameter of the sphere.

What is the volume of the golf ball?

A (36.35 ± 0.01) cm^3

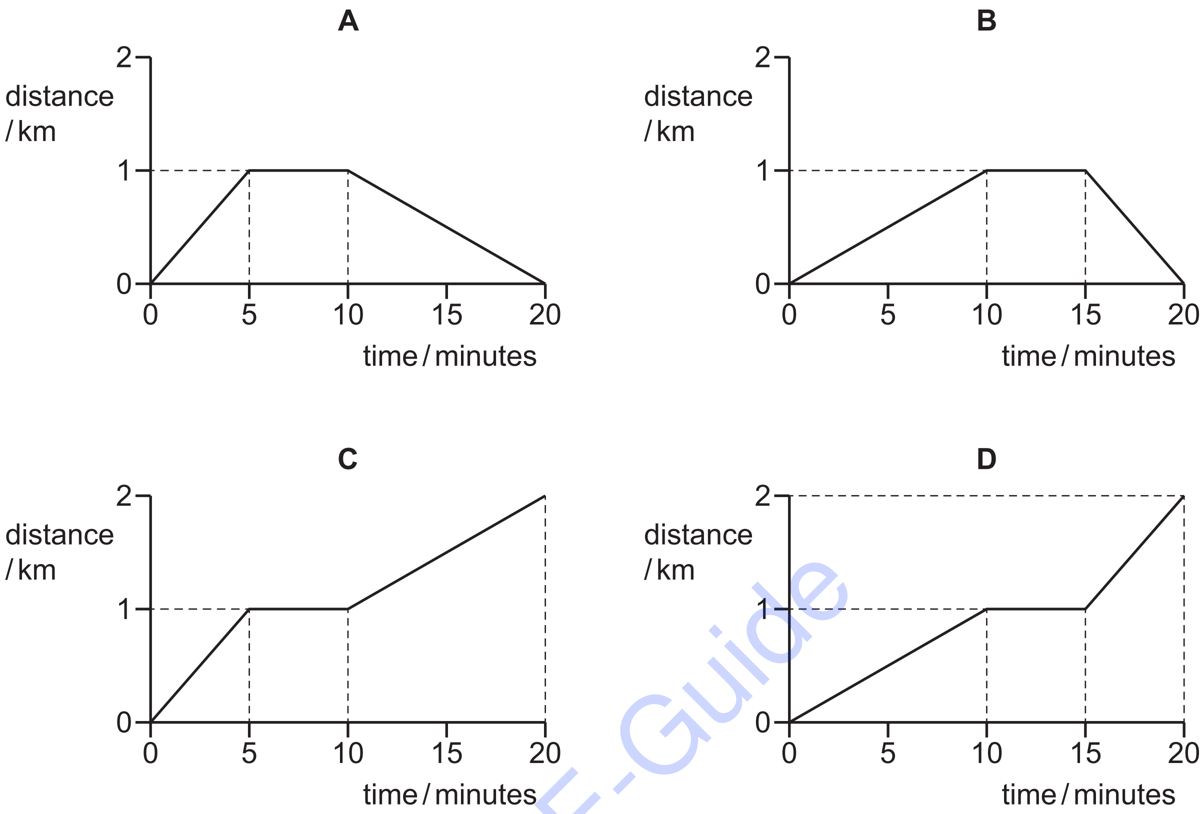
B (36.35 ± 0.03) cm^3

C (36.35 ± 0.09) cm^3

D (36.4 ± 0.3) cm^3

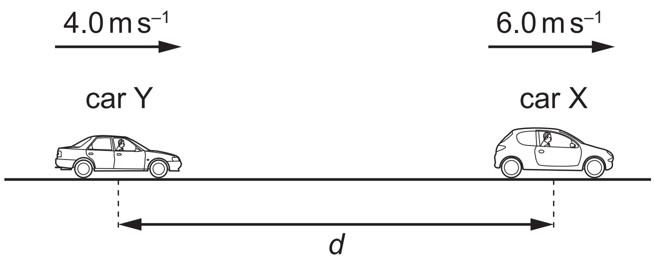
6 A student cycles uphill from home to a shop, taking 10 minutes. The student then spends 5 minutes in the shop, before cycling home downhill at twice the initial speed.

Which graph could show the variation with time of the distance travelled by the cyclist?



7 Two cars X and Y are travelling along the same straight road. Car X is travelling at a constant speed of $6.0\,m\,s^{-1}$. Car Y has a constant acceleration of $0.50\,m\,s^{-2}$.

At the instant shown, car X is a distance *d* ahead of car Y. Car Y is travelling at a speed of $4.0\,m\,s^{-1}$.

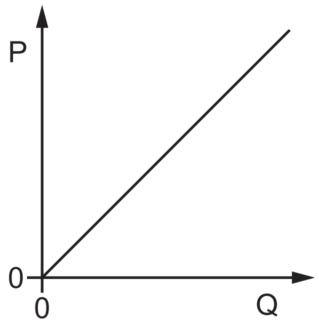


Car Y is level with car X after a time of 20 seconds.

What is the distance *d*?

A 40 m **B** 60 m **C** 180 m **D** 300 m

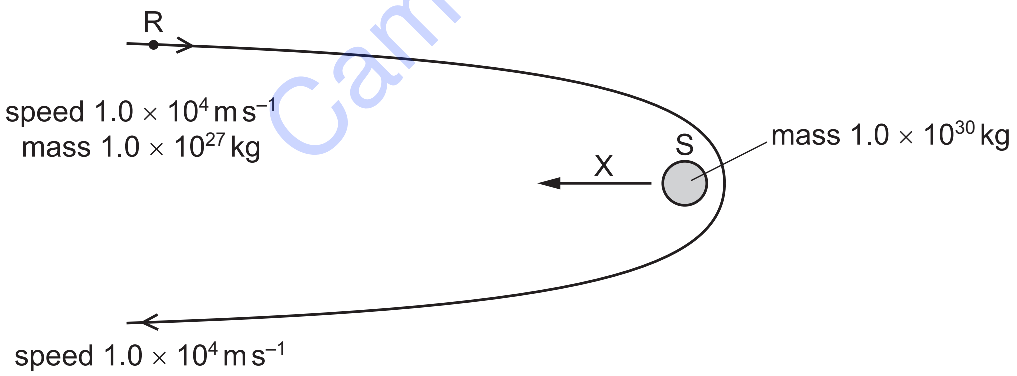
8 The graph shows how quantity P varies with quantity Q for an object falling in air for a long time in a uniform gravitational field.



What could be the identities of P and Q?

	P	Q
A	force of air resistance	acceleration
B	kinetic energy	time
C	potential energy	height
D	work done against air resistance	speed

9 A rock R of mass 1.0×10^{27} kg is a large distance from a star S and is travelling at a speed of $1.0 \times 10^4\,m\,s^{-1}$. The star has mass 1.0×10^{30} kg. The rock travels around the star on the path shown so that it reverses its direction of motion and, when finally again a large distance from the star, has the same speed as initially.



Which statement is correct?

A The change in the momentum of S is in the direction of arrow X.

B The change in the velocity of S is approximately $20\,m\,s^{-1}$.

C The magnitude of the change of momentum of R is 10^3 times greater than the magnitude of the change of momentum of S.

D The momentum of R does not change.

10 The diagram shows the masses and velocities of two trolleys that are about to collide.

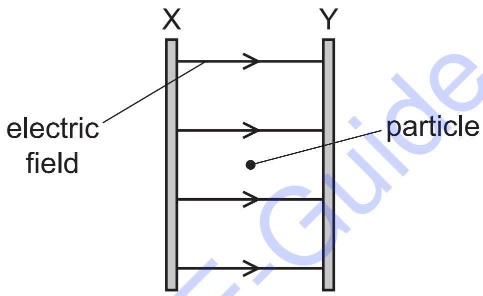
After the impact they move off together.

What is the kinetic energy lost in the collision?

A 4 J **B** 6 J **C** 12 J **D** 14 J

11 A particle is situated at rest between two metal plates X and Y.

A potential difference (p.d.) is then applied across the plates and produces the electric field shown.



The particle moves towards plate X when the p.d. is applied.

What could be the particle?

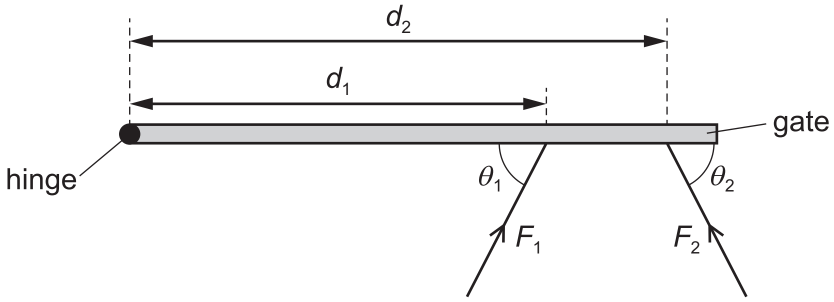
A alpha-particle

B electron

C neutron

D proton

12 Two people push a vertical gate to open it. The forces exerted by the people on the gate are shown.



One person is distance d_1 from the gate's hinge and pushes with horizontal force F_1 at angle θ_1 to the gate.

The other person is at distance d_2 from the hinge and pushes with horizontal force F_2 at an angle θ_2 to the gate.

What is the total moment about the hinge due to forces F_1 and F_2?

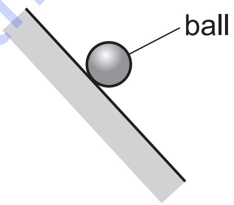
A $(d_1 \times F_1 \cos\theta_1) + (d_2 \times F_2 \cos\theta_2)$

B $(d_1 \times F_1 \sin\theta_1) + (d_2 \times F_2 \sin\theta_2)$

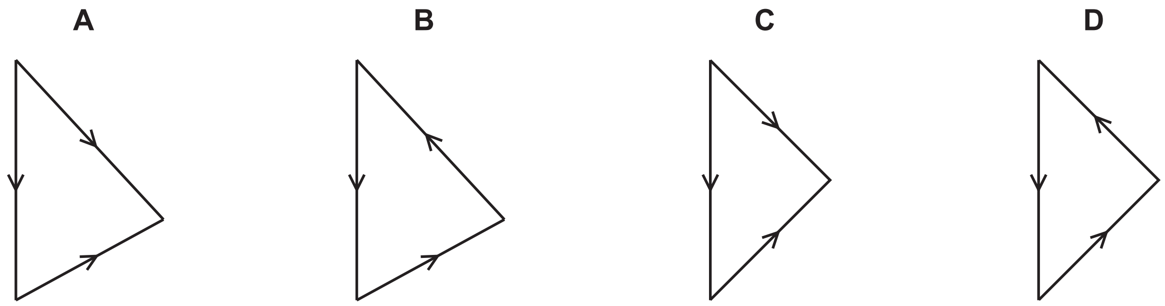
C $(d_1 \times F_1 \cos\theta_1) - (d_2 \times F_2 \cos\theta_2)$

D $(d_1 \times F_1 \sin\theta_1) - (d_2 \times F_2 \sin\theta_2)$

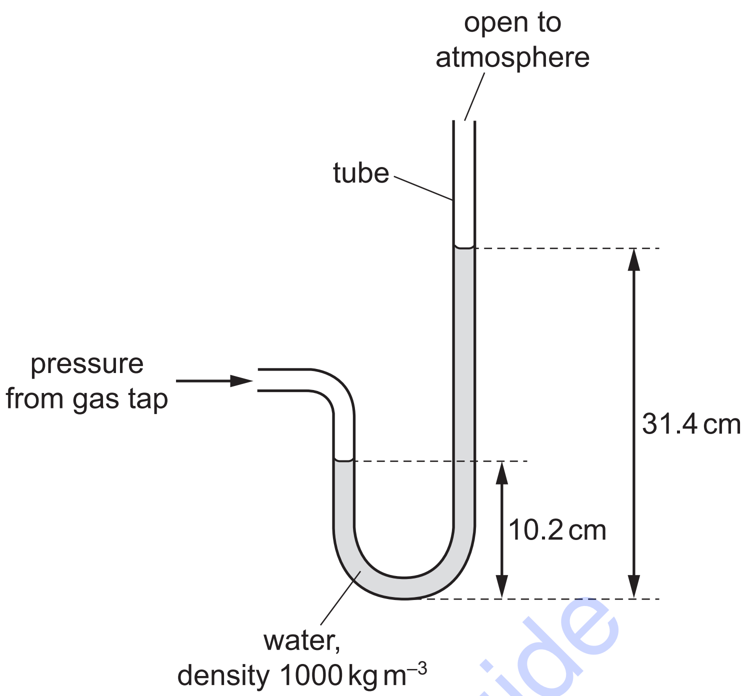
13 A ball is rolling down a slope at a constant speed. The three forces acting on the ball are its weight, the contact force normal to the slope and friction.



Which diagram could represent these three forces?



14 One end of a U-shaped tube is attached to a gas tap, with its other end open to the atmosphere. It contains water of density 1000 kg m^{-3} and the heights of both sides of the water column are shown.

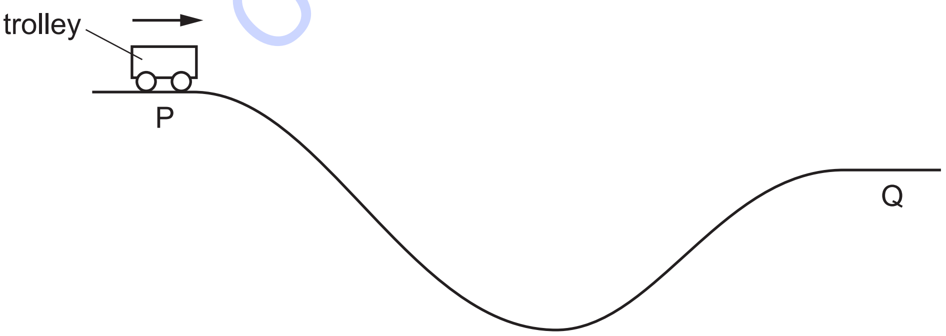


The atmospheric pressure is 101 kPa.

What is the pressure of the gas from the gas tap?

A 99 kPa **B** 100 kPa **C** 102 kPa **D** 103 kPa

15 A trolley runs from P to Q along a track. At Q its potential energy is 50 kJ less than at P.



At P, the kinetic energy of the trolley is 5 kJ. Between P and Q, the trolley does 10 kJ of work against friction.

What is the kinetic energy of the trolley at Q?

A 35 kJ **B** 45 kJ **C** 55 kJ **D** 65 kJ

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

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

The electrical power generated is 100 MW.

What is the efficiency of the power station?

A 5.6% **B** 43% **C** 57% **D** 77%

17 Which amount of energy is **not** 2400 J?

A the decrease in gravitational potential energy of a mass of 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 mass of 12 kg moving at a speed of $20\,\text{m}\,\text{s}^{-1}$

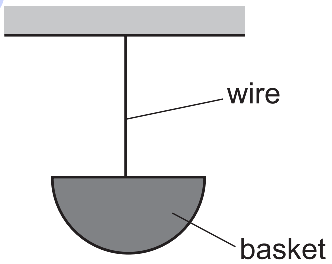
D the work done by a gas expanding against a constant external pressure of 120 kPa when its volume increases by $0.020\,\text{m}^3$

18 A train of mass 300 000 kg is accelerating at $0.80\,\text{m}\,\text{s}^{-2}$. At one instant, the speed of the train is $5.0\,\text{m}\,\text{s}^{-1}$ and the resistive force to its motion is 15 kN.

At this instant, what is the rate of increase of kinetic energy of the train?

A 0.075 MW **B** 1.2 MW **C** 1.3 MW **D** 3.8 MW

19 A wire of circular cross-section, which obeys Hooke's law, is used to suspend a basket as shown.



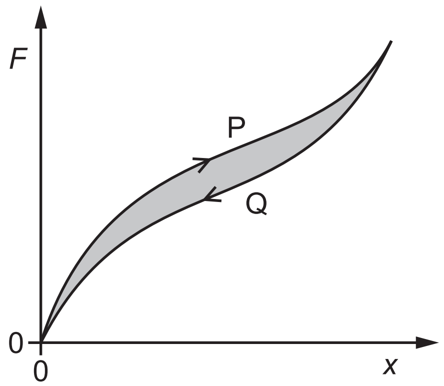
The Young modulus for the material of the wire is 2.5×10^{11} Pa.

When a weight of 34 N is added to the basket, the strain in the wire increases by 6.0×10^{-5}.

What is the radius of the wire?

A 7.2×10^{-7} m **B** 2.3×10^{-6} m **C** 8.5×10^{-4} m **D** 1.7×10^{-3} m

20 An unstretched rubber cord is stretched by a force. The force F is plotted against the extension x. F is slowly increased from zero, causing the cord to extend along path P. F is then reduced back to zero along path Q.



What is represented by the shaded area?

A the elastic energy stored in the rubber cord

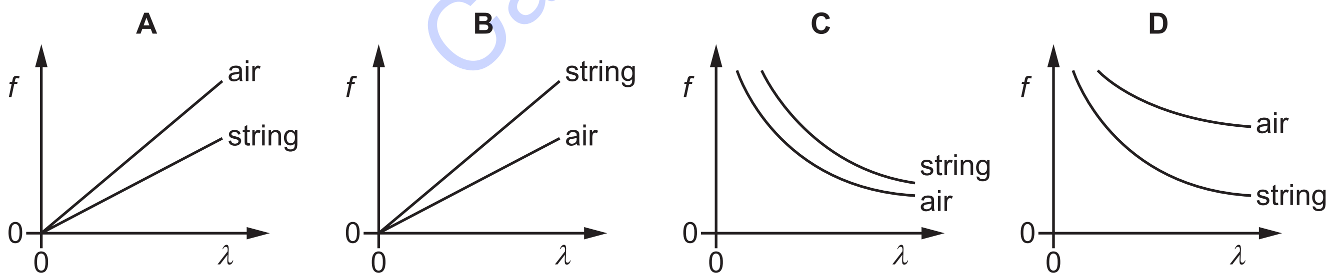
B the energy that causes plastic deformation

C the energy dissipated as heat

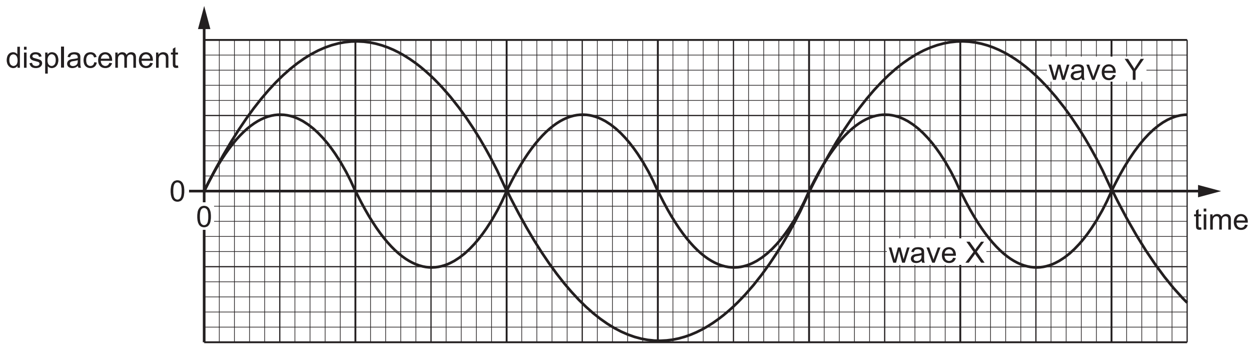
D the work done to extend the rubber cord

21 A guitar string vibrates to create a sound. The speed of the wave in the guitar string is always $440\,m\,s^{-1}$. The vibrating string creates a sound wave that moves in the air with a speed of $330\,m\,s^{-1}$.

Which graph shows the variation of frequency f with the wavelength λ for the waves in the string and in the air?



22 The graph shows the variation with time of displacement for two different waves X and Y.

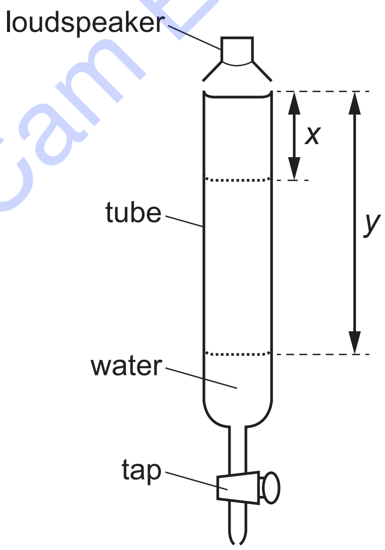


Wave X has frequency *f* and amplitude *A*.

What is the frequency and what is the amplitude of wave Y?

	frequency	amplitude
A	$\frac{1}{2}f$	$\frac{1}{2}A$
B	$\frac{1}{2}f$	$2A$
C	$2f$	$\frac{1}{2}A$
D	$2f$	$2A$

23 A loudspeaker emits a sound wave into a tube initially full of water.



A tap at the bottom of the tube is opened so that water slowly leaves the tube. For some lengths of the air column in the tube, the sound heard is much louder.

The first loud sound is heard when the air column in the tube has length x.

The next time that a loud sound is heard is when the air column in the tube has length y.

What is the wavelength of the sound wave from the loudspeaker?

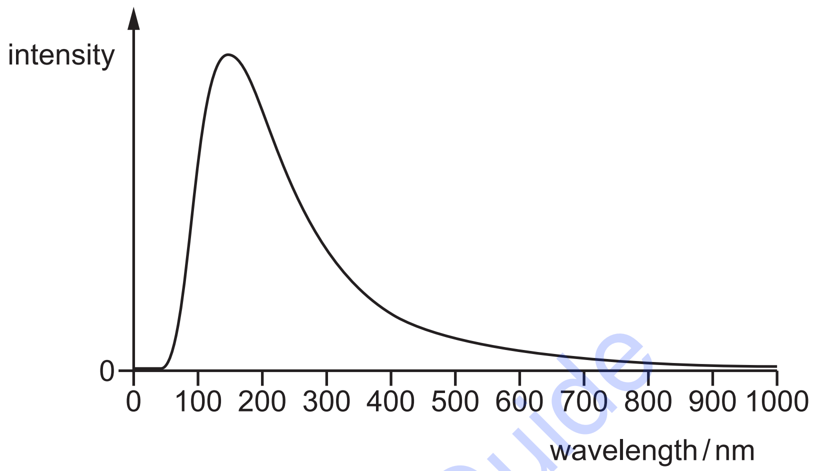
A $2x$ **B** $4y$ **C** $2(y - x)$ **D** $4(y - x)$

24 A source of sound of frequency 1000 Hz directly approaches a stationary observer. The observer measures the frequency of the received sound to be 1500 Hz. The speed of sound in still air is 330 m s^{-1}.

What is the speed of the source of sound?

A 110 m s^{-1} **B** 165 m s^{-1} **C** 220 m s^{-1} **D** 330 m s^{-1}

25 The graph shows how the intensity of electromagnetic radiation emitted from a distant star varies with wavelength.



In which region of the electromagnetic spectrum is the radiation of greatest intensity?

A infrared

B visible light

C ultraviolet

D X-ray

26 Which statement concerning a stationary wave is correct?

A All the particles between two adjacent 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.

27 Which waves would best demonstrate diffraction through a doorway?

A sound waves

B ultraviolet waves

C visible light waves

D X-rays

28 Two loudspeakers are placed near to each other and facing in the same direction.

A microphone connected to an oscilloscope is moved along a line some distance away from the loudspeakers, as shown.

Which statement about the waves emitted by the loudspeakers is **not** a necessary condition for the microphone to detect a fixed point along the line where there is no sound?

A The waves must be emitted in phase.

B The waves must be emitted with a similar amplitude.

C The waves must have the same frequency.

D The waves must have the same wavelength.

29 A parallel beam of white light passes through a diffraction grating. Orange light of wavelength 600 nm in the fourth-order diffraction maximum coincides with blue light in the fifth-order diffraction maximum.

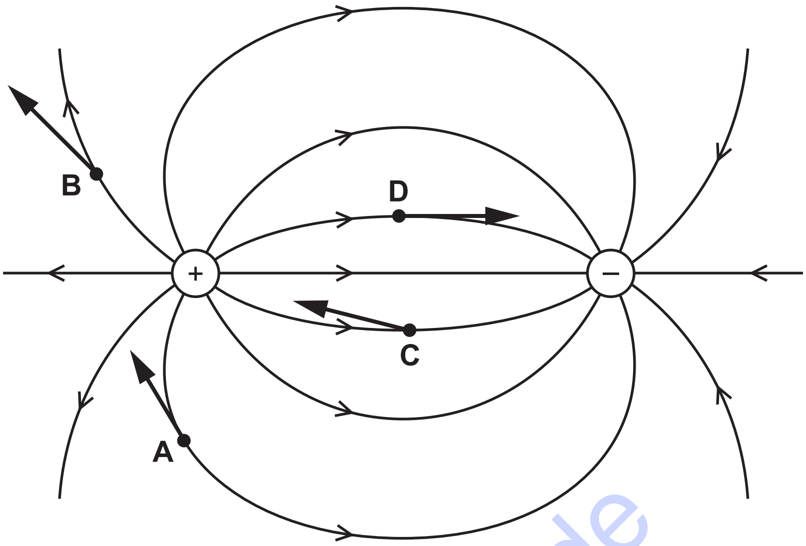
What is the wavelength of the blue light?

A 450 nm **B** 480 nm **C** 500 nm **D** 750 nm

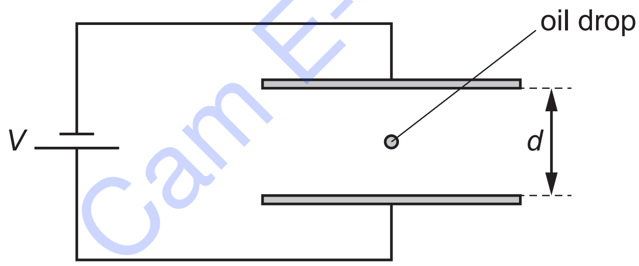
30 The diagram shows the electric field near a positively charged sphere and a negatively charged sphere.

Four electrons **A**, **B**, **C** and **D** are shown at different positions in the field.

On which electron is the direction of the force on the electron shown correctly?



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



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

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

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

32 Free electrons flow along a copper wire X of radius 5.0×10^{-5} m with an average drift speed of 2.8×10^{-2} m s^{-1}. The current in the wire is 3.0 A.

There is a current of 2.0 A in a copper wire Y of radius 1.0×10^{-4} m.

What is the average drift speed of the free electrons in copper wire Y?

A 4.7×10^{-3} m s^{-1}

B 9.3×10^{-3} m s^{-1}

C 1.1×10^{-2} m s^{-1}

D 1.9×10^{-2} m s^{-1}

33 What is the definition of potential difference?

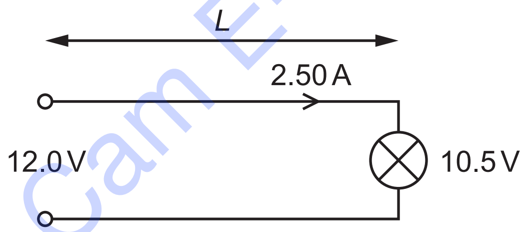
A power per unit current

B product of current and resistance

C product of electric field strength and distance

D work done per unit charge

34 A cable of length *L* consisting of two wires is used to connect a 12.0 V power supply of negligible internal resistance to a lamp, as shown.



The potential difference across the lamp is 10.5 V. The current in the wire is 2.50 A.

Each wire is made of metal of resistivity 1.70×10^{-8} Ω m and has a cross-sectional area of 6.00×10^{-7} m^2.

What is the length *L* of the cable?

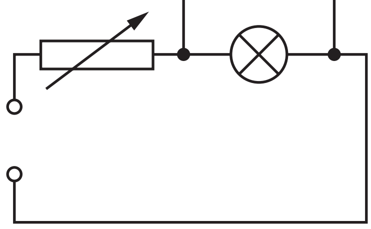
A 10.6 m **B** 21.2 m **C** 29.4 m **D** 58.8 m

35 In the circuits shown, the power supply has an electromotive force (e.m.f.) greater than the normal operating voltage of the lamp. The internal resistance of the power supply is negligible.

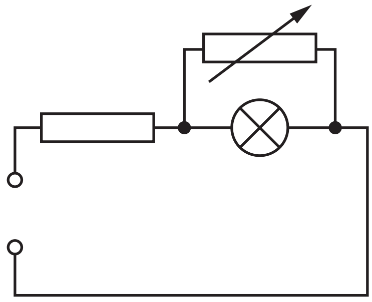
The resistance of the variable resistor is adjusted from zero to its maximum value.

In which circuit could the voltage across the lamp change from zero to its normal operating voltage and **not** exceed its normal operating voltage?

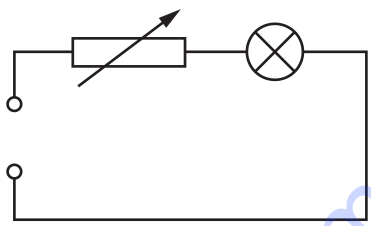
A



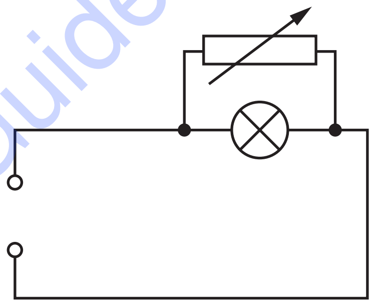
B



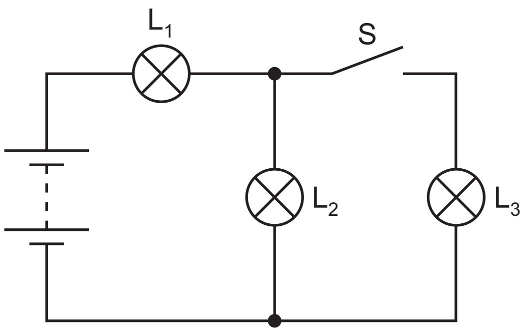
C



D



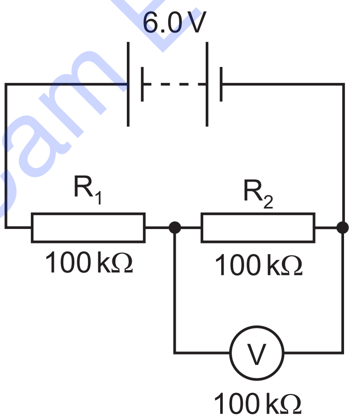
36 Three identical lamps L_1, L_2 and L_3 are connected to a battery with negligible internal resistance, as shown.



What happens to the brightness of lamps L_1 and L_2 when the switch S is closed?

	lamp L_1	lamp L_2
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

37 In the circuit shown, the 6.0 V battery has negligible internal resistance. Resistors R_1 and R_2 and the voltmeter each have a resistance of 100 kΩ.



What is the current in the resistor R_2?

A 20 μA **B** 30 μA **C** 40 μA **D** 60 μA

38 Which statement about two nuclei that are isotopes of the same element is correct?

A The nuclei each have the same acceleration when in the same uniform electric field.

B The nuclei each have the same number of neutrons.

C The nuclei each have the same number of nucleons.

D Uncharged atoms containing the nuclei each have the same number of electrons.