Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

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)

6375742808

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.

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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	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$
	$\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\text{m F}^{-1}\right)$
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	$m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$
rest mass of proton	$m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$
molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
the Avogadro constant	$N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$g = 9.81\,\text{m s}^{-2}$

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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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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[Turn over

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?

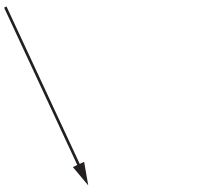
A kg m s^{-2} **B** kg s^{-2} **C** kg m s^{-1} **D** kg s^{-1}

3 Vectors P and Q are drawn to scale.



Which diagram represents the vector (P – Q)?

A



B



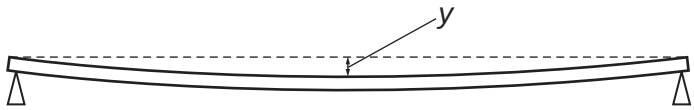
C



D



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:

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

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

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

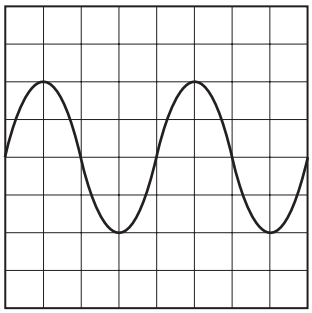
$w = (23.0 \pm 0.5)\,\text{mm}$.

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

A L **B** M **C** t **D** w

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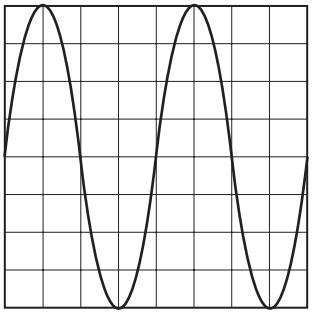
5 The following trace is seen on the screen of a cathode-ray oscilloscope.



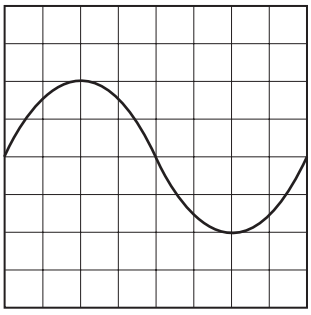
The setting of the time-base is then changed from $10\,\text{ms}\,\text{cm}^{-1}$ to $20\,\text{ms}\,\text{cm}^{-1}$ and the Y-plate sensitivity remains constant.

Which trace is now seen on the screen?

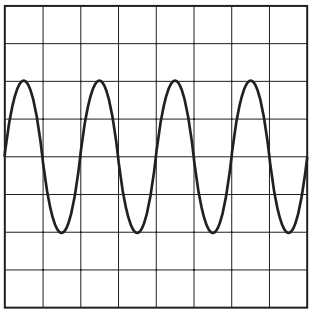
A



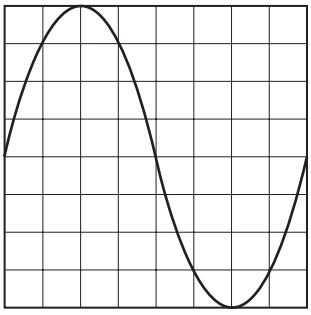
B



C



D

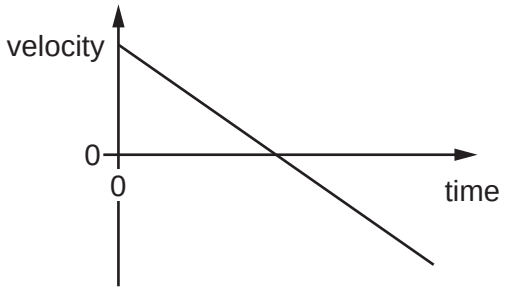


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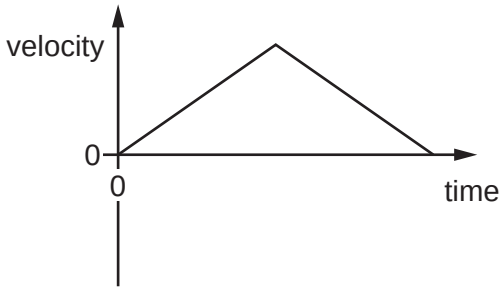
6 A ball rolls in a straight line up a ramp and then back down the ramp along its original path.

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

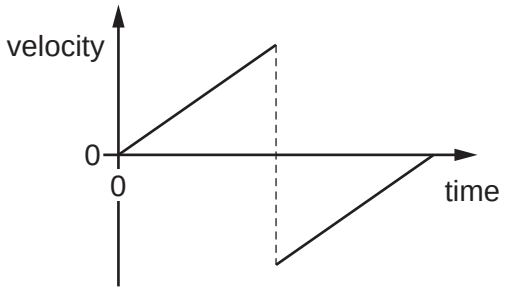
A



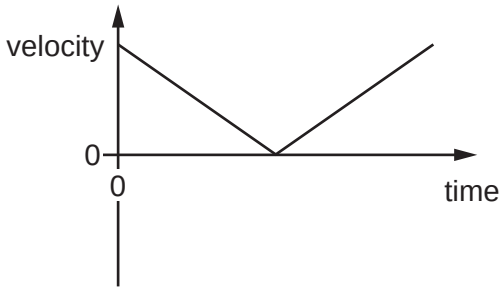
B



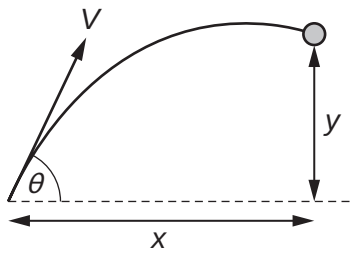
C



D



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



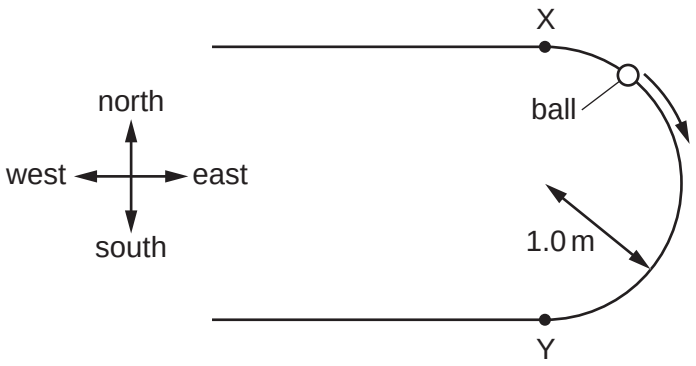
The acceleration of free fall is g. Assume that air resistance is negligible.

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	$Vt\sin\theta$	$Vt\cos\theta - \frac{1}{2}gt^2$

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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}

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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 1.0×10^{-5} N m^{-2}.

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

A 3.1×10^{-8} m s^{-2}

B 6.3×10^{-7} m s^{-2}

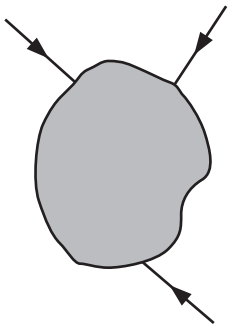
C 3.2×10^{-3} m s^{-2}

D 6.4×10^{-2} m s^{-2}

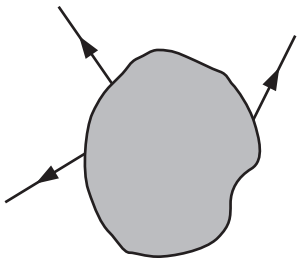
12 Three coplanar forces act on an object in the directions shown.

In which diagram could the object be in equilibrium?

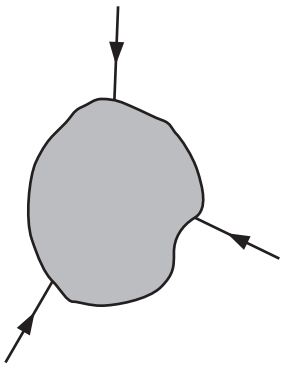
A



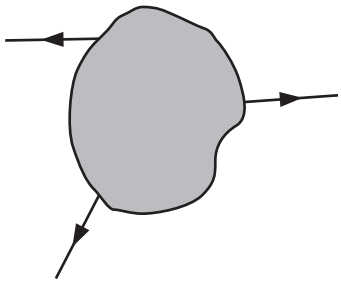
B



C



D



13 What is the centre of gravity of an object?

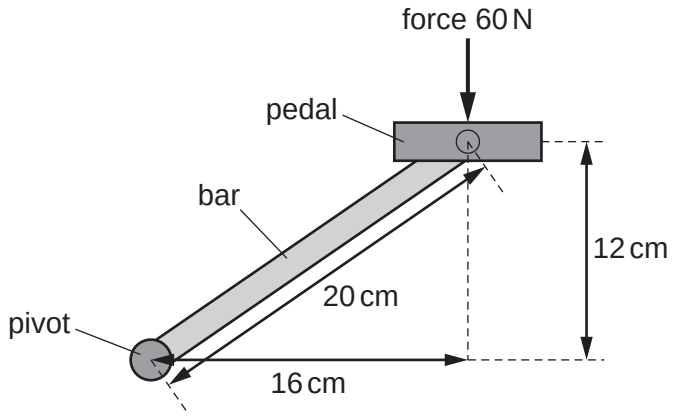
A the geometrical centre of the object

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 N m **B** 9.6 N m **C** 12 N m **D** 1200 N m

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

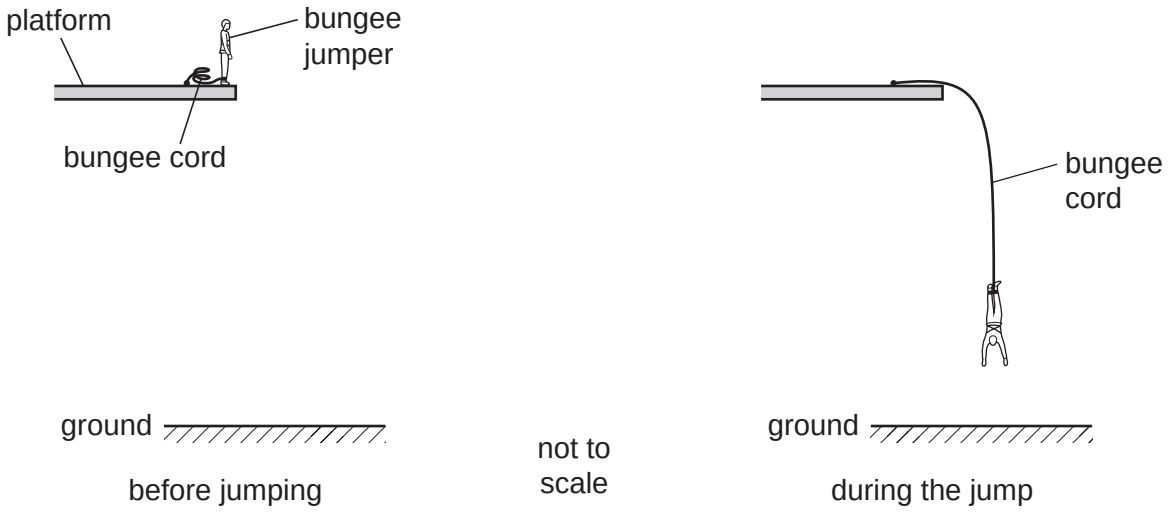
B change in gravitational potential energy = mass $\times$ $g\Delta h$

C $\rho = \dfrac{\text{mass}}{\text{volume}}$

D the density of a fluid increases with depth

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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

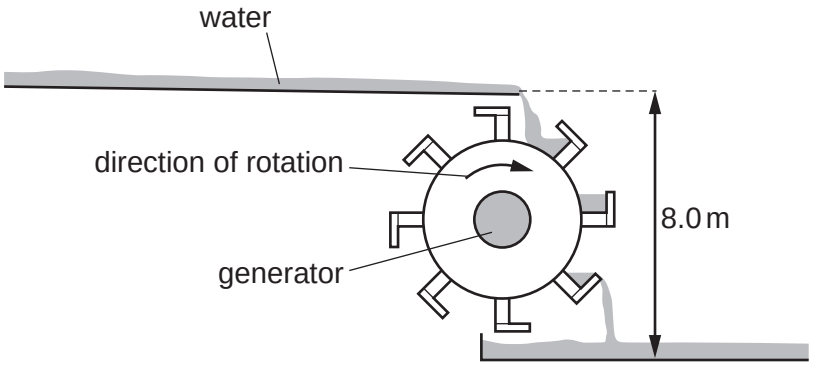
18 A racing car has an output power of 300 kW when travelling at a constant speed of $60\,m\,s^{-1}$.

What is the total resistive force acting on the car?

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

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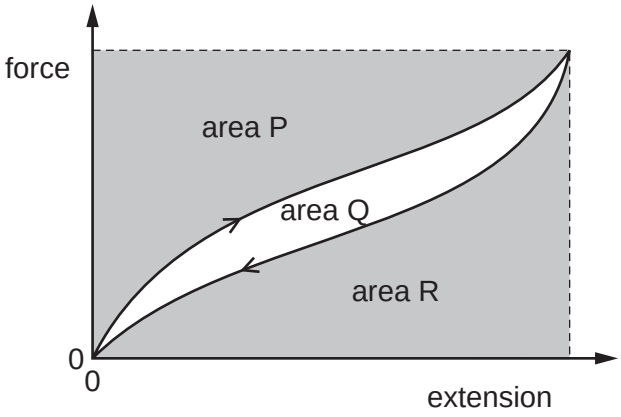
19 The diagram shows the design of a water wheel which drives a generator to produce electrical power. The flow rate of the water is $200\,kg\,s^{-1}$. The generator supplies a current of 32 A at a voltage of 230 V.



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 $1.4 \times 10^5\,Pa$

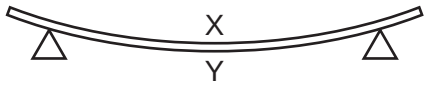
B $1.4 \times 10^8\,Pa$

C $1.4 \times 10^9\,Pa$

D $1.4 \times 10^{11}\,Pa$

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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.

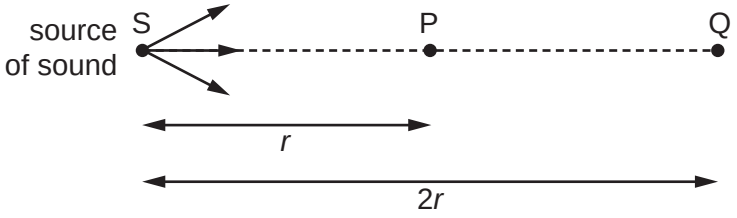
C The observed frequency is lower as the car moves towards the observer and higher as the car moves away from the observer.

D The volume of the sound heard by the observer does not change as the car approaches.

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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

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



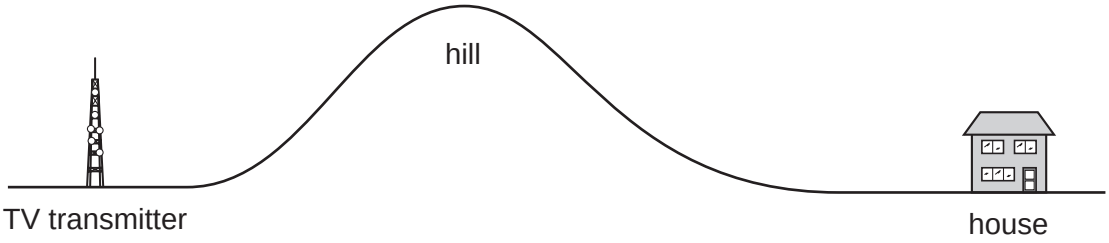
Air molecules at point P, a distance r from the source S, oscillate with amplitude 8.0 μm.

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

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

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

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

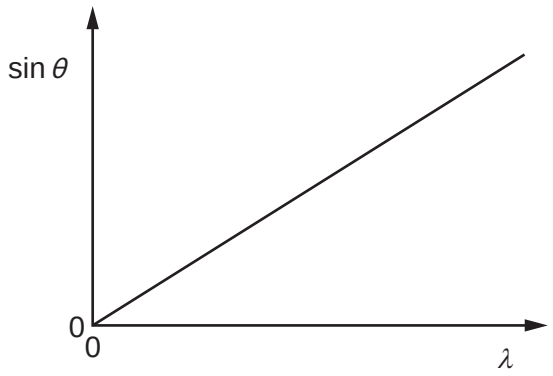
C interference

D reflection

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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

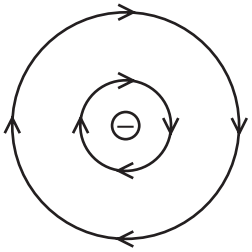
B diffraction

C interference

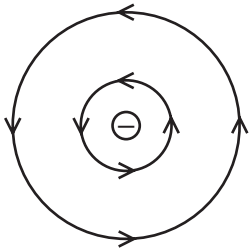
D reflection

29 Which diagram shows the electric field pattern of an isolated negative point charge?

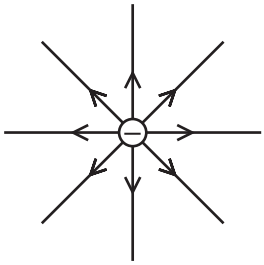
A



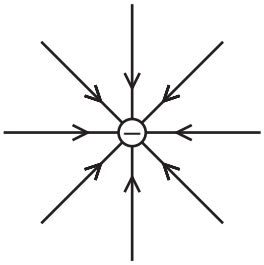
B



C



D



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?

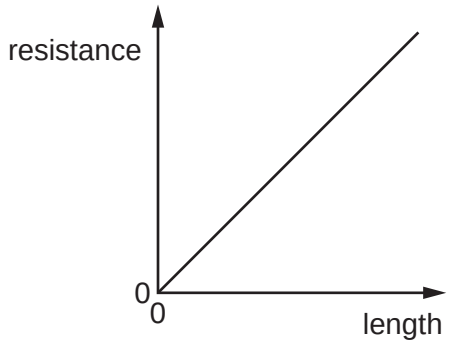
A $-4.8 \times 10^{-19}\,\text{C}$

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** $G \times A^2$

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33 What describes the electric potential difference between two points in a wire that carries a current?

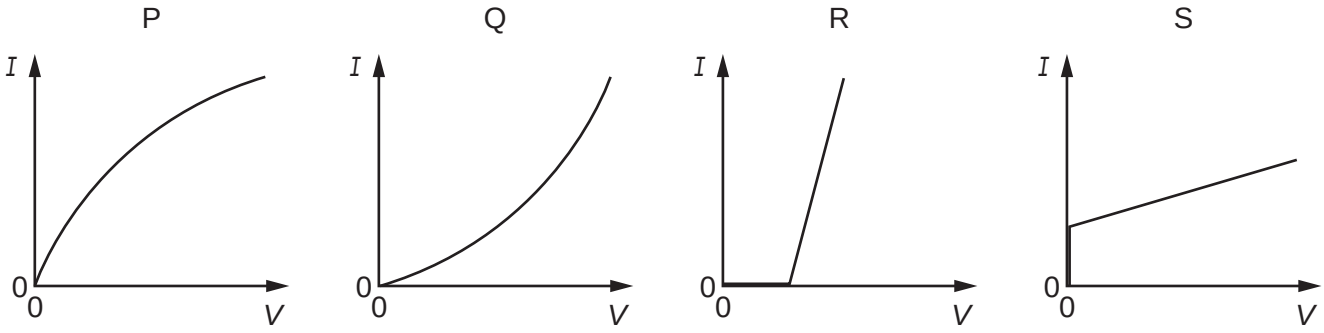
A the force required to move a unit positive charge between the points

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

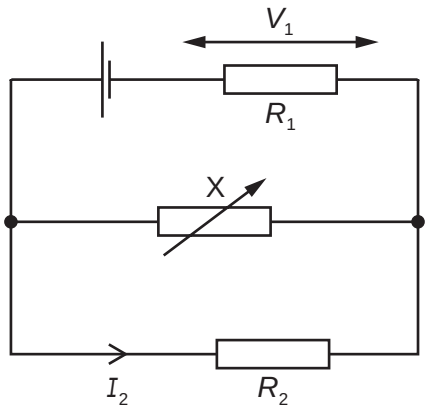
34 The graphs show possible current-voltage (I-V) characteristics for a filament lamp and for a semiconductor diode.



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.

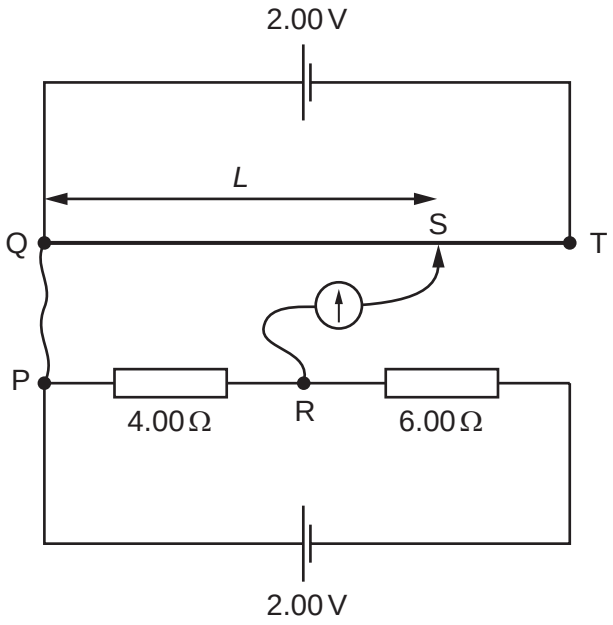
The resistance of X is reduced.

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

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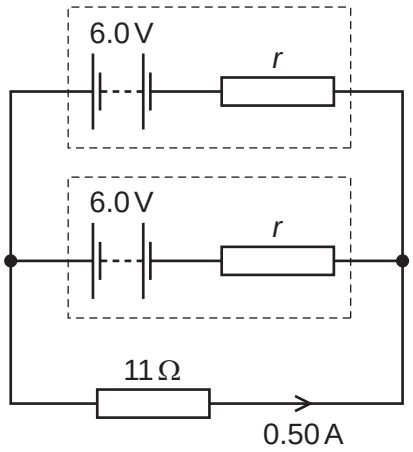
36 A 100 cm potentiometer wire QT is connected in series with a 2.00 V cell. Another circuit, consisting of a 2.00 V cell in series with resistors of resistance 4.00 Ω and 6.00 Ω, is set up alongside the potentiometer. Connections PQ and RS are then made so that the potential difference (p.d.) across the 4.00 Ω 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 Ω, as shown.



The current in the external resistor is 0.50 A.

What is the internal resistance *r* of each battery?

A 1.0 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 6.5 Ω

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38 A nitrogen-13 nucleus $^{13}_{7}\mathrm{N}$ 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 $^{13}_{7}\mathrm{N} \rightarrow {}^{13}_{6}\mathrm{C} + \beta^{-} + \bar{\nu} + \gamma$

B $^{13}_{7}\mathrm{N} \rightarrow {}^{13}_{6}\mathrm{C} + \beta^{-} + \nu + \gamma$

C $^{13}_{7}\mathrm{N} \rightarrow {}^{13}_{6}\mathrm{C} + \beta^{+} + \bar{\nu} + \gamma$

D $^{13}_{7}\mathrm{N} \rightarrow {}^{13}_{6}\mathrm{C} + \beta^{+} + \nu + \gamma$

39 Radon $^{222}_{86}\mathrm{Rn}$ is the start of a decay chain that forms bismuth $^{214}_{83}\mathrm{Bi}$ 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	$-\frac{2}{3}$	$+\frac{1}{3}$	$-\frac{2}{3}$	$+\frac{1}{3}$

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