MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Advanced Level
Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice

October/November 2021

1 hour

Additional Materials: Multiple Choice Answer Sheet

2940277874

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE ON ANY BARCODES.

There are **thirty** 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 rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

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This document consists of **14** printed pages and **2** blank pages.

Singapore Examinations and Assessment Board

Cambridge Assessment International Education

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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	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$
	$(1/(36\pi)) \times 10^{-9}\,\text{F m}^{-1}$
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 constant	$u = 1.66 \times 10^{-27}\,\text{kg}$
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	$g = 9.81\,\text{m s}^{-2}$

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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	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{(x_0^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

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1 What is the best estimate of the weight of a smartphone?

A 1.5 cN B 1.5 dN C 150 cN D 150 dN

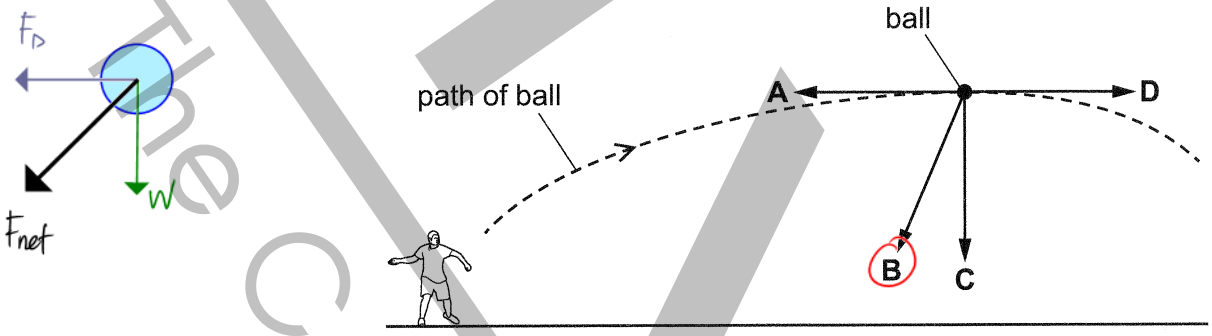
2 The SI unit of magnetic flux density is the tesla, T.

What are the SI base units of the tesla?

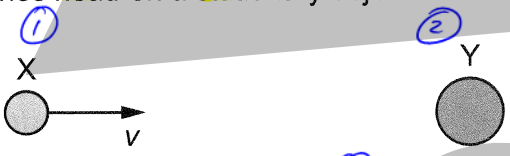
A $kg\,s^{-2}\,A^{-1}$ B $kg\,m\,s^{-2}\,A^{-1}$ C $kg\,s^{2}\,A$ D $kg\,m^{2}\,s^{-2}\,A^{-1}$

3 The diagram shows a ball which has been thrown and is being acted on by air resistance.

Which labelled arrow shows the direction of the resultant force on the ball when it is at the position shown?



4 A moving object X approaches head-on a stationary object Y with velocity v, as shown.

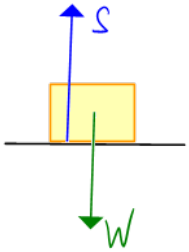


The two objects collide elastically. After the collision, Y moves to the right with speed 0.67 v.

What is the speed of X after the collision?

A 0 B 0.33 v C 0.67 v D v

5 A brick rests on the floor. The forces on the brick are its weight W and a support force S from the floor.



Which forces form a Newton's third law pair with W and with S?

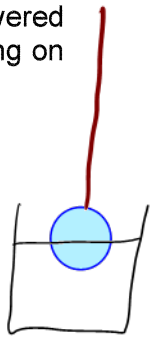
	force paired with W	force paired with S
A	the force the brick exerts on the Earth	the force the brick exerts on the floor
B	the force the Earth exerts on the brick	the force the floor exerts on the brick
C	the force the floor exerts on the brick	the force the brick exerts on the floor
D	the force the floor exerts on the brick	the force the Earth exerts on the brick

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Initial reading = mg
Final reading = $mg - U = mg - \rho_f V_{disp} g = 0.75mg$

5

6 A hollow ball of mass 100 g is suspended from a newton meter. The ball is then gently lowered into a bowl of water so that only half of the ball is above the surface of the water. The reading on the newton meter is now 0.75 of the initial value.



The density of water is 1.0 g cm^{-3}.

$\therefore V_{disp} = \frac{V_{ball}}{2} = \frac{0.25m}{\rho_f} = \frac{0.25(100)}{1}$

$\therefore V_{ball} = 50 cm^3$ #

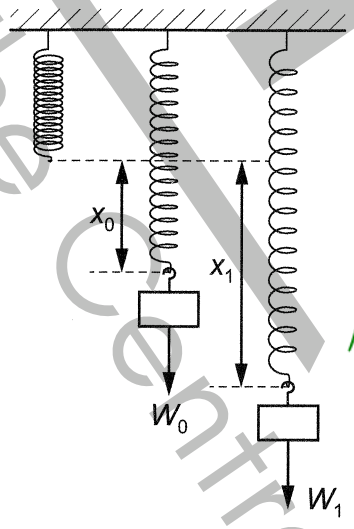
What is the volume of the ball?

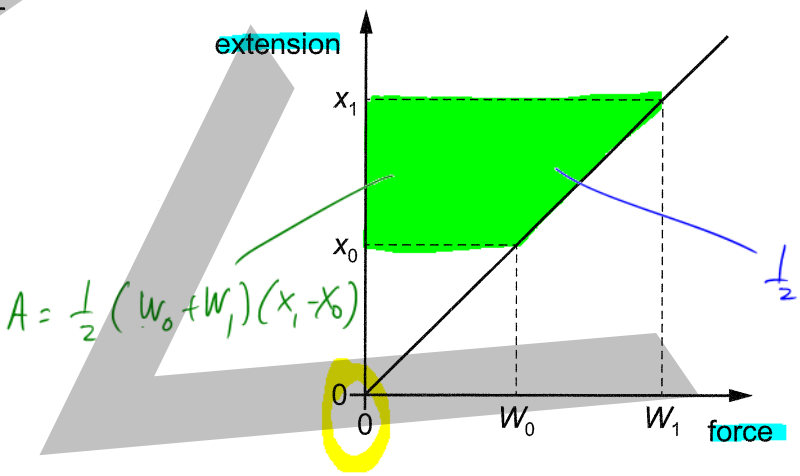
A 25 cm^3 **B** 50 cm^3 **C** 75 cm^3 **D** 150 cm^3

7 An object of weight W_0 is suspended from a spring so that the spring extends by x_0.

The object is replaced with a second object of weight W_1. The total extension is now x_1, as shown.

The extension–force graph for the spring is shown.





$A = \frac{1}{2}(W_0 + W_1)(x_1 - x_0)$

$\frac{1}{2}W_1 x_1 - \frac{1}{2}W_0 x_0$

How much extra elastic potential energy is stored in the spring when its extension increases from x_0 to x_1?

A $(W_1 - W_0)(x_1 - x_0)$

B $\frac{1}{2}W_1(x_1 - x_0)$

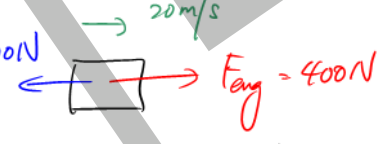
C $\frac{1}{2}(W_1 - W_0)(x_1 - x_0)$

D $\frac{1}{2}(W_1 x_1 - W_0 x_0)$

8 A small car of mass 800 kg travels at a constant speed of 20 m s^{-1} along a level road against resistive forces of 400 N. The efficiency of the car in converting the energy of the fuel into work done against the resistive forces is 16%.

One kilogram of fuel has an energy value of 48 MJ.

How much fuel does the car use to travel one kilometre?



$WD = F_{eng} \cdot d = (400)(1000) = 0.4 MJ$

A 52 g **B** 85 g **C** 220 g **D** 260 g

$\eta = \frac{W_{out}}{W_{in}} \quad \therefore W_{in} = \frac{W_{out}}{\eta} = \frac{0.4}{0.16} = 2.5 MJ$

48 MJ → 1 kg

$2.5 MJ = \frac{1}{48} \times 2.5 = 0.052 kg = 52 g$.

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9 An electron travels in a vacuum with speed v perpendicular to a magnetic field of flux density B. The electron moves in a circular orbit of radius r given by

circular motion.

$$r = \frac{mv}{Be}$$

where m is the mass of the electron and e is its charge.

Which statement about the angular velocity of the electron is correct?

$\omega = \frac{v}{r} = \frac{v}{\frac{mv}{Be}} = \frac{Be}{m}$

A It increases as B is increased.

B It increases as v is increased.

C It decreases as B is increased.

D It decreases as v is increased.

10 Near the surface of a planet, the gravitational field strength is uniform. The gravitational potential difference between two points that are 10 m apart vertically is 6.0 J kg^{-1}.

How much work is done in raising a mass of 2.0 kg vertically through 2.5 m?

$W.D = mgh = m\left(\frac{\Delta\phi}{\Delta d}\right)h$

$= (2)\left(\frac{6}{10}\right)(2.5)$

$= 3\,J$

A 1.5 J **B** 3.0 J **C** 12 J **D** 15 J

11 A satellite is in geostationary orbit above the Earth at a height of 36 000 km. The radius of the Earth is 6400 km.

$T = 24\,hrs$

$6.4 \times 10^6\,m$

$3.6 \times 10^7\,m$

What is the speed of the satellite?

$v = r\omega = r\left(\frac{2\pi}{T}\right) = \left(3.6\times10^7 + 6.4\times10^6\right)\left(\frac{2\pi}{24\times3600}\right)$

$= 3083.4\,m/s$

A 490 m s^{-1} **B** 2200 m s^{-1} **C** 2600 m s^{-1} **D** 3100 m s^{-1}

12 A school laboratory has dimensions 10 m × 3.0 m × 4.0 m. The laboratory contains 5000 moles of air, with a molar mass of 29 g, at an atmospheric pressure of 1.0 × 10^5 Pa.

What is the root-mean-square (r.m.s.) speed of the gas molecules in the air?

A 16 m s^{-1} **B** 290 m s^{-1} **C** 500 m s^{-1} **D** 2.5 × 10^5 m s^{-1}

$pV = \frac{1}{3}Nm\langle c^2\rangle = \frac{1}{3}\cdot N\cdot\frac{M}{N}\cdot\langle c^2\rangle$

m: mass of 1 particle; $\frac{M_{gas}}{N}$

$\therefore c_{rms} = \sqrt{\frac{3pV}{M_{gas}}} = \sqrt{\frac{3(1\times10^5)(10)(3)(4)}{\left(\frac{29}{1000}\right)(5000)}} = 498.2\,m/s$

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13 Thermal energy is supplied to 5.00 kg of water at 30.0 °C. All of this water becomes steam at 100 °C. There is no heat loss to the surroundings.

Specific heat capacity of water = 4190 J kg^{-1} K^{-1}.

Specific latent heat of vaporisation of water = 2260 kJ kg^{-1}.

How much thermal energy is supplied to the water?

A 1.48×10^6 J

B 3.73×10^6 J

C 1.13×10^7 J

D 1.28×10^7 J

$Q = mc\theta + ml_v$

$= 5(4190)(100-30) + (5)(2260,000)$

$= 1.276 \times 10^7$ J

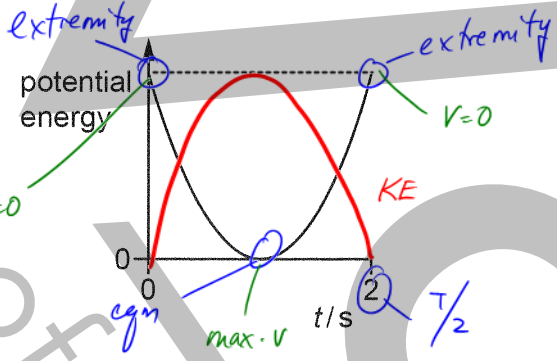
14 A canister of an ideal gas, at rest on the Earth's surface, has an internal energy of 3.0 kJ. The canister is then thrown upwards to a point X where the potential energy of the gas has increased by 0.5 kJ and its kinetic energy is 1.0 kJ. There is no heat transfer or work done on the ideal gas.

What is the internal energy of the gas when it is at point X?

$\Delta U = Q_{to} + W_{on} = 0 = \Delta KE$

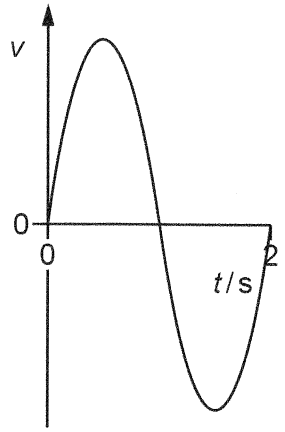
A 2.5 kJ **B** 3.0 kJ **C** 4.0 kJ **D** 4.5 kJ

15 A particle oscillates with simple harmonic motion. The graph shows the variation, with time t, of the potential energy of the particle from t = 0 to t = 2 s.

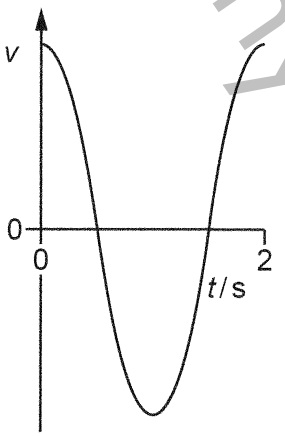


Which graph could represent the variation, with time t, of the velocity v of the particle from t = 0 to t = 2 s?

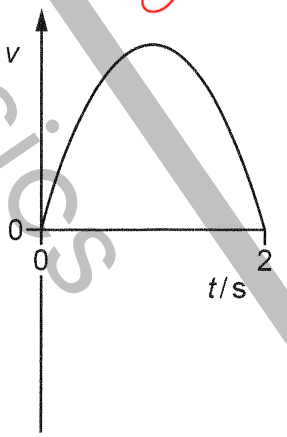
A



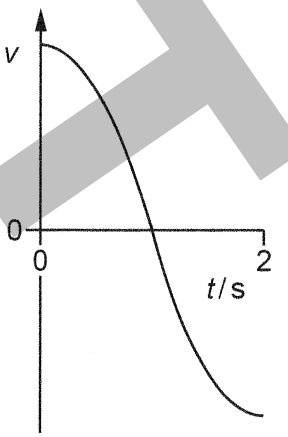
B



C



D

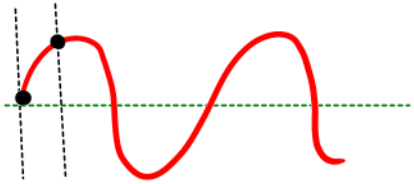


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$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda} = \frac{1.5\times10^{-6}}{\frac{3\times10^{8}}{5\times10^{14}}} = \frac{1.5\times10^{-6}}{1} \cdot \frac{5\times10^{14}}{3\times10^{8}} = 5\pi - 4\pi$

$= \pi$

$\frac{c}{f}$



16 A beam of laser light of frequency 5.0×10^{14} Hz is travelling through a vacuum.

What is the phase difference between points on the wave that are 1.5 μm apart?

A 0.5 rad **B** 0.5π rad **C** 1.0 rad **D** 1.0π rad

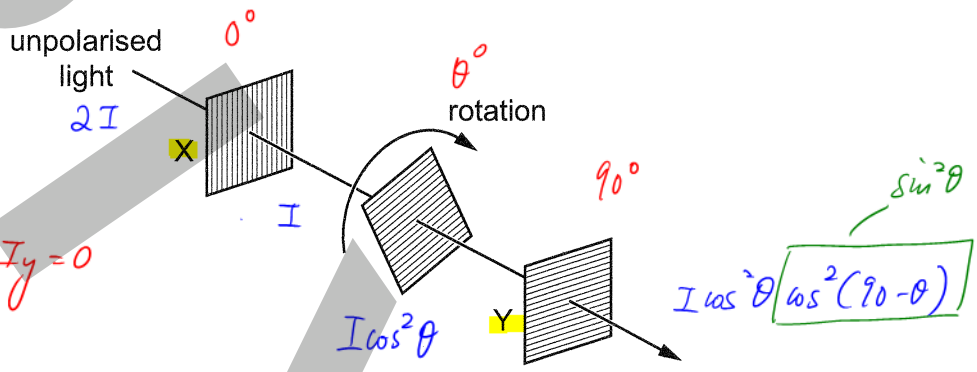
17 Two perfectly polarising filters, X and Y, are arranged in parallel and in line, with their planes of polarisation at 90°. A third filter is placed in parallel between them such that its plane of polarisation is at 45° to the other planes. Unpolarised light is directed at filter X. The middle filter is rotated through 90° in the vertical plane, keeping it parallel to the other filters.

$\sin 2\theta = 2\sin\theta\cos\theta$

$\therefore (\sin\theta\cos\theta)^2 = \frac{1}{4}\sin^2 2\theta$

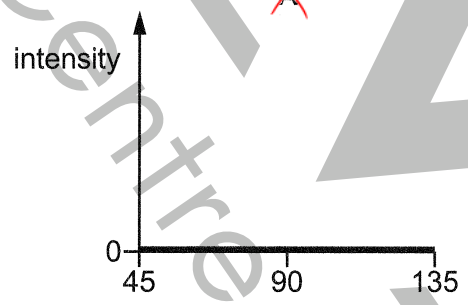
$\therefore I_y = I \cdot \frac{1}{4}\sin^2 2\theta$

if $\theta = 45$, $\sin 2(45) = 0$, $I_y = 0$

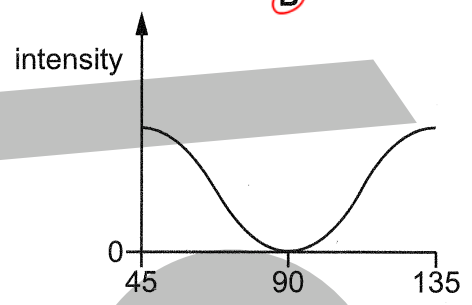


How does the intensity of the light emerging from filter Y vary with the angle of the middle filter?

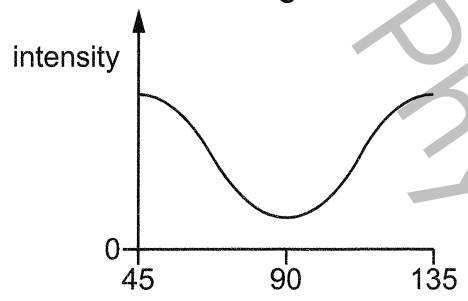
A



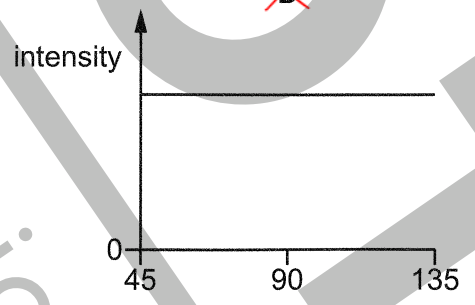
B



C



D



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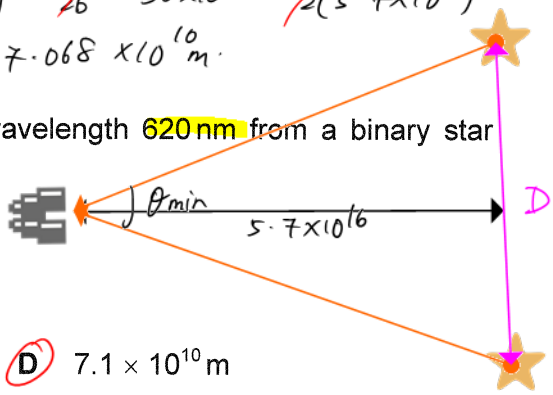
$\theta_{min} = \frac{\lambda}{b}$, $\tan\left(\frac{\theta_{min}}{2}\right) = \frac{D/2}{5.7\times10^{16}}$ $\therefore \tan\left(\frac{\lambda}{2b}\right) = \frac{\lambda}{2b} = \frac{620\times10^{-9}}{50\times10^{-2}} = \frac{D}{2(5.7\times10^{16})}$

$\therefore D = 7.068\times10^{10}$ m.

18 A telescope with an aperture of 50 cm receives light of wavelength 620 nm from a binary star system which can just be resolved by the telescope.

The two stars are 5.7×10^{16} m from the telescope.

How far apart are the two stars?



A 2.0×10^{7} m **B** 7.1×10^{8} m **C** 2.0×10^{9} m **D** 7.1×10^{10} m

19 Electric fields are often represented by diagrams of field lines.

What is an electric field line?

A a line along which electric potential is constant

B a line along which the electric force on a small positive test charge is constant

C a line along which the magnitude of the electric potential gradient is constant

D a line indicating the direction of the electric force on a small positive test charge

20 Two point charges, Q_1 and Q_2, exert a force of 2.0 N on each other.

Q_1 is replaced by Q_3, which has twice the charge of Q_1, and the distance between the charges is doubled.

What is the force on Q_2 due to Q_3?

$F_{old} = \frac{Q_1 Q_2}{4\pi\varepsilon_0 d^2} = 2N$, $F_{new} = \frac{(2Q_1)(Q_2)}{4\pi\varepsilon_0 (2d)^2} = 1N$

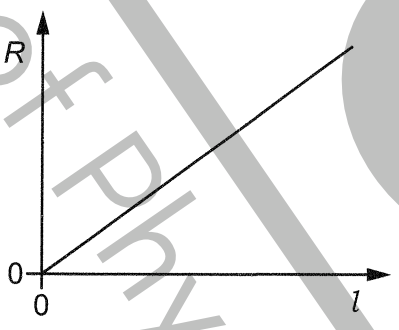
A 0.25 N **B** 0.50 N **C** 1.0 N **D** 2.0 N

21 The resistance R of a length l of a uniform, cylindrical wire is measured for different values of l. The graph of R against l has a gradient G.

$\frac{R}{l} = G$

$\therefore R = lG$

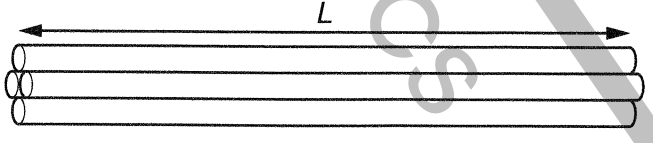
if $l = L$, then $R = LG$



Four lengths of this wire are assembled into a composite wire as shown.

$R_{eff} = \left[\frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R}\right]^{-1}$

$= \frac{R}{4} = \frac{LG}{4}$



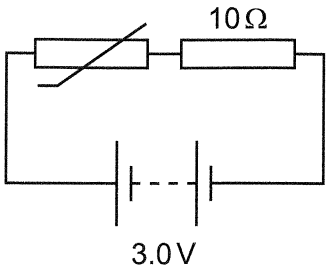
4 in //

What is the resistance of the composite wire between the two ends?

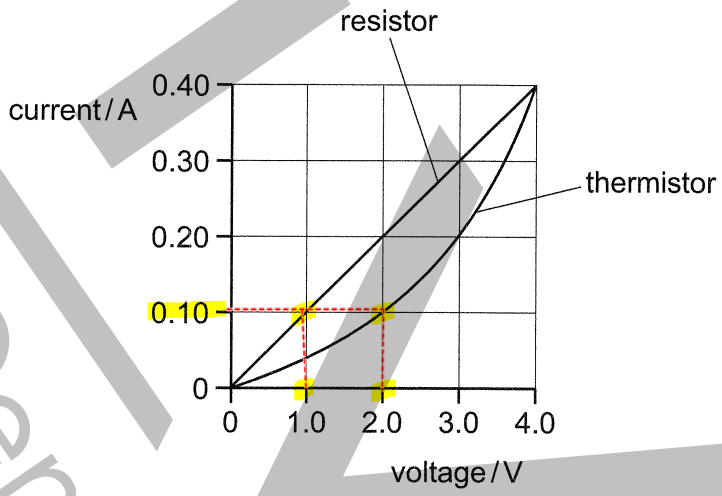
A $\frac{GL}{16}$ **B** $\frac{GL}{4}$ **C** $4GL$ **D** $16GL$

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22 A 10Ω resistor and a thermistor are connected in series to a battery of electromotive force (e.m.f.) 3.0 V and negligible internal resistance.



The graph shows the current–voltage characteristics of the resistor and of the thermistor.

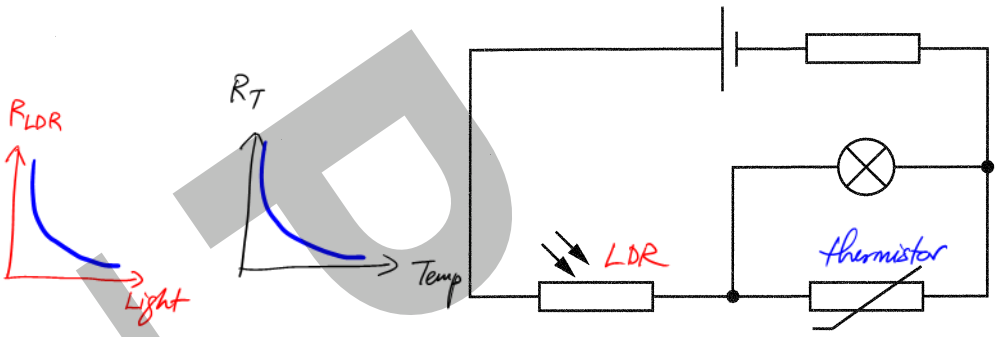


What is the current in the circuit?

A 0.10 A **B** 0.20 A **C** 0.30 A **D** 0.40 A

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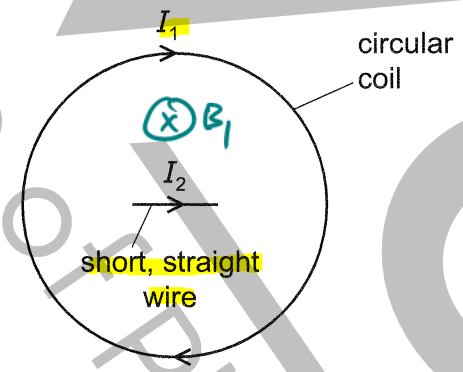
23 A filament lamp is connected into an electrical circuit with a negative temperature coefficient (NTC) thermistor and a light-dependent resistor (LDR).



Which pair of changes must cause the filament lamp to glow more brightly?

	light intensity incident on LDR	thermistor temperature
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

24 A vertical circular coil carries a current I_1 in a clockwise direction. At the centre of the coil is a short, straight horizontal wire which carries a current I_2, as shown.



What is the direction of the magnetic force on the short, straight wire due to the circular coil?

A upwards

B downwards

C into the page

D out of the page

PAPER 1 QUESTION
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25 What is a unit for magnetic flux?

A tesla metre^{-2}

B tesla metre^{-1}

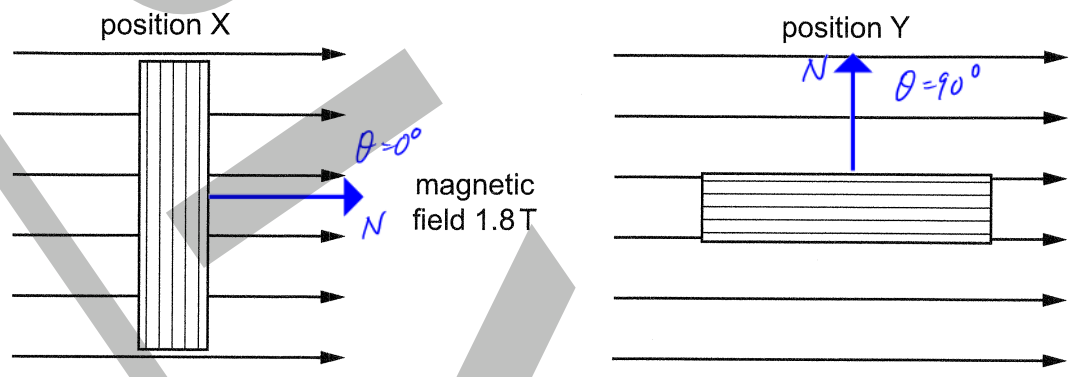
C tesla metre

D tesla metre^2

$\phi = BA$

T, m^2

26 A circular coil of diameter 0.020 m has 3000 turns. It is rotated in a magnetic field of 1.8 T from position X to position Y in 0.060 s.



What is the average electromotive force (e.m.f.) induced in the coil during the rotation?

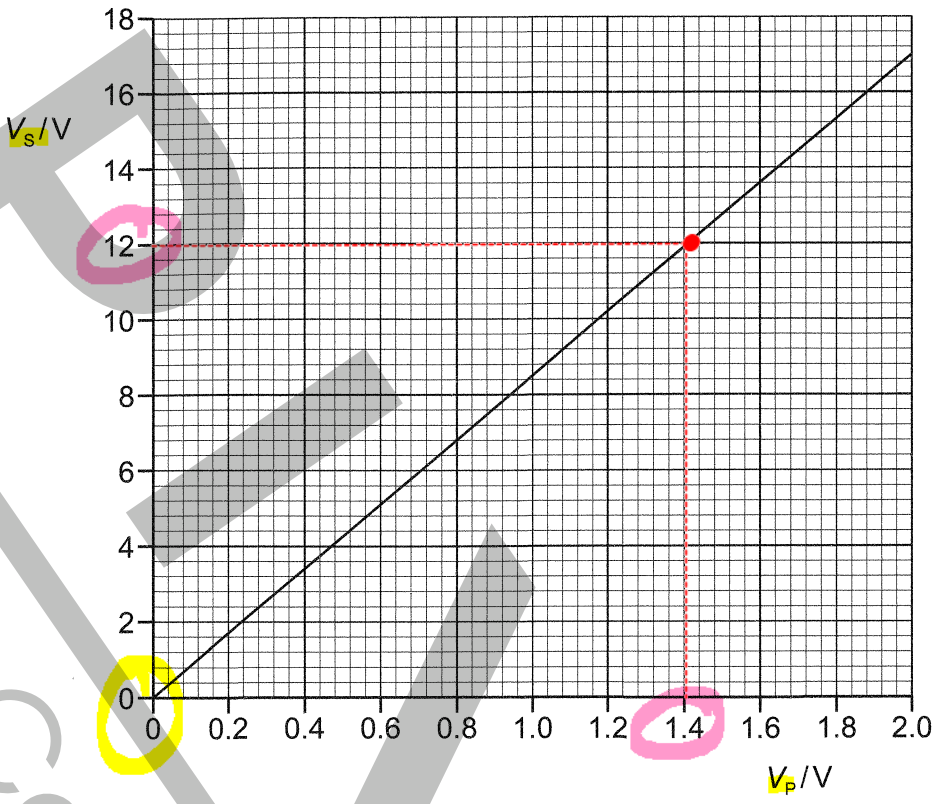
A 28 V **B** 36 V **C** 113 V **D** 1800 V

r = 0.01 m

$$|E| = \left|\frac{\Delta BAN\cos\theta}{\Delta t}\right| = \left|BAN\left(\frac{\cos\theta_f - \cos\theta_i}{\Delta t}\right)\right| = \left|(1.8)(\pi)(0.01)^2(3000)\left[\frac{\cos 90 - \cos 0}{0.06}\right]\right| = 28.27\,V$$

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27 The variation with the primary voltage V_P of the secondary voltage V_S for an ideal transformer is shown.



$\frac{V_S}{V_P} = \frac{I_P}{I_S}$

$\therefore I_S = I_P \cdot \frac{V_P}{V_S}$

$= \frac{(0.32)(1.4)}{12}$

$= 0.0373$

$\simeq 38\text{mA}$.

The primary current is 0.32 A. $I_P = 0.32$

What is the secondary current?

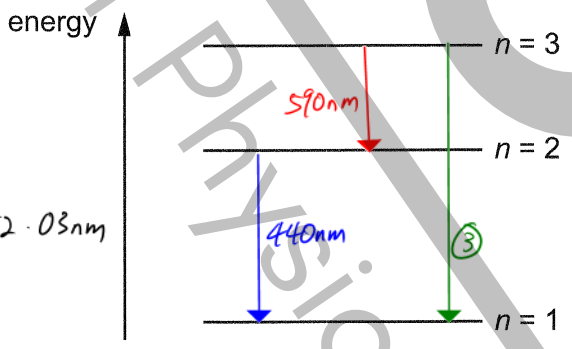
A 19 mA **B** 38 mA **C** 2.7 A **D** 5.4 A

28 A discharge lamp contains excited atoms which emit electromagnetic radiation at several wavelengths. The diagram shows the three lowest energy levels of one of these atoms, labelled n = 1, 2 and 3.

$E = \frac{hc}{\lambda}$

$\frac{1}{\lambda_1} + \frac{1}{\lambda_2} = \frac{1}{\lambda_3}$

$\frac{1}{440} + \frac{1}{590} = \frac{1}{\lambda_3}$ and $\lambda_3 = 252.03\text{nm}$



Electron transitions between these energy levels can produce three different wavelengths of radiation. The transition from n = 2 to n = 1 produces radiation of wavelength 440 nm. Radiation of wavelength 590 nm is also emitted.

What is the wavelength of the radiation emitted by the third transition?

A 150 nm **B** 250 nm **C** 1030 nm **D** 1730 nm

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29 Two beams of monochromatic light have the same frequency. One beam has a greater intensity than the other beam.

How can the greater intensity of one beam be explained in terms of the particulate nature of light?

A Each photon in the beam has more energy.

B Each photon in the beam has a greater speed.

C The amplitude of oscillation is greater.

D There are more photons passing through unit cross-sectional area of the beam per unit time.

$I = \frac{P}{A} = \frac{E}{tA} = \frac{nhf}{tA}$ — const.

$E = hf$

30 The radioactive isotope caesium-137 decays to barium-137 by emitting a β^- particle.

The masses of the nuclei and of the β^- particle are given in the table.

$^{0}_{-1}e$

nucleus or particle	mass / u
caesium-137	136.90709
barium-137	136.90583
β^- particle	5.49×10^{-4}

How much energy is released during the decay of one nucleus of caesium-137?

A 2.4×10^{-14} J

B 1.1×10^{-13} J

C 1.9×10^{-13} J

D 2.7×10^{-13} J

$^{137}Cs \longrightarrow {}^{137}Ba + {}^{0}_{-1}e$

$M_{LHS} = 136.90709\,u$

$M_{RHS} = 136.90583 + 5.49\times10^{-4}$

$= 136.906379\,u$

Mass Defect, $\Delta m = 7.11\times10^{-4}\,u$

$1\,u \Rightarrow 933.75\,MeV$

$\therefore 7.11\times10^{-4}\,u = 0.6638925\,MeV$

$= 1.06222\times10^{-13}\,J$ #

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