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 2023

1 hour

Additional Materials: Multiple Choice Answer Sheet

3398084060

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 **16** printed 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 does **not** cause a systematic error?

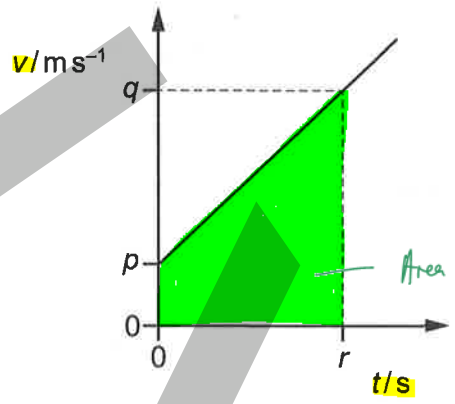
A a bent needle on an analogue voltmeter Syst. error

B a metre rule that is worn down at both ends

C the varying reaction time of a person using a stop-watch Random.

D the zero error on a micrometer Syst. error

2 The diagram shows how the velocity v of a car travelling in a straight line changes with time t.



Area = $s = \frac{1}{2}(p+q)(r)$

Which expression gives the displacement of the car between time $t = 0$ and $t = r$?

A $\frac{1}{2}qr$

B $\frac{1}{2}(q-p)r$

C $\frac{1}{2}(q-p)r + qr$

D $\frac{1}{2}(p+q)r$

3 An arrow flies through the air and arrives with kinetic energy E at a target. The arrow is stopped in a time t by an average force F.

The process is repeated for the same arrow with different values of E.

What is the relationship between E, F and t?

A $Ft \propto \sqrt{E}$ B $Ft \propto E$ C $Ft \propto \frac{1}{\sqrt{E}}$ D $Ft \propto \frac{1}{E}$

(i) $I = Ft = \Delta p = p_f - p_i = 0 - p = -p$

(ii) $E = \frac{p^2}{2m}$ $\therefore$ $p = \sqrt{2mE}$

$\therefore$ $|Ft| = |-\sqrt{2mE}|$

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4 Two bodies approach each other with speeds u_1 and u_2 and collide head-on.



The collision is elastic. The speeds after collision are v_1 and v_2.

Which equation must be correct?

A $u_1 - u_2 = v_2 - v_1$

B $u_1 - u_2 = v_2 + v_1$

C $u_1 + u_2 = v_2 - v_1$

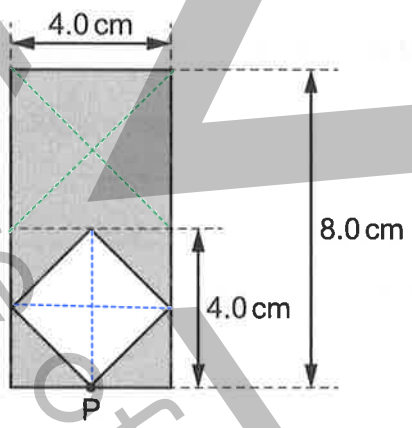
D $u_1 + u_2 = v_2 + v_1$

$v_2 - v_1 = -(u_2 - u_1)$

$v_2 \quad v_1 \quad -u_2 \quad u_1$

$\therefore v_2 - v_1 = u_2 + u_1$

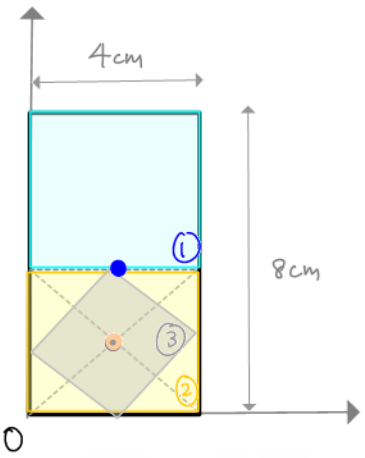
5 A uniform sheet of metal of height 8.0 cm and width 4.0 cm has a square hole cut in it.



Point P is the mid-point of the bottom of the sheet.

What is the distance from point P of the centre of gravity of the sheet of metal?

A 4.0 cm B 4.7 cm C 5.3 cm D 6.0 cm



Finding centroid :

	① + ② − ③				
	cm^2				
A_1	16	x_1	2	y_1	6
A_2	16	x_2	2	y_2	2
A_3	8	x_3	2	y_3	2

$\therefore x_c = \frac{A_1x_1 + A_2x_2 - A_3x_3}{A_1 + A_2 - A_3} = 2$

$y_c = \frac{A_1y_1 + A_2y_2 - A_3y_3}{A_1 + A_2 - A_3} = 4.666$

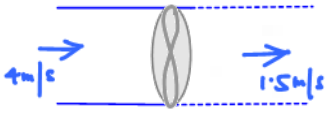
coordinates of c.g of metal

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6 A small wind turbine contains a generator that is used to generate electricity. Every second, 9.7 kg of air arrives at its blades with a speed of 4.0 m s^{-1} and leaves the blades with a speed of 1.5 m s^{-1}.

The efficiency of the generator is 60%.



① $\eta = \frac{P_{out}}{P_{in}}$

② $P_{in} = \frac{\Delta KE}{\Delta t}$

What could be the output potential difference (p.d.) and current of the turbine?

		p.d. / V	current / A
18W	A	12	1.5
39.6	B	12	3.3
14.4	C	24	0.60
67.2	D	24	2.8

$P_{out} = \eta \cdot P_{in} = \eta \cdot \frac{\Delta KE}{\Delta t} = \eta \cdot \frac{\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}{\Delta t}$

$= \eta \cdot \frac{1}{2} \cdot \frac{m}{\Delta t}\left(v_f^2 - v_i^2\right) = -40.0125\ W$

0.6 9.7 1.5 4

7 It takes one year for the Earth to complete one orbit around the Sun.

What is the angular displacement of the Earth in half a year?

θ?

A 1 rad B 2 rad C π rad D 2π rad

8 Which physical quantity has the same meaning as gravitational force exerted per unit mass?

A gravitational constant

B gravitational field strength

C gravitational potential

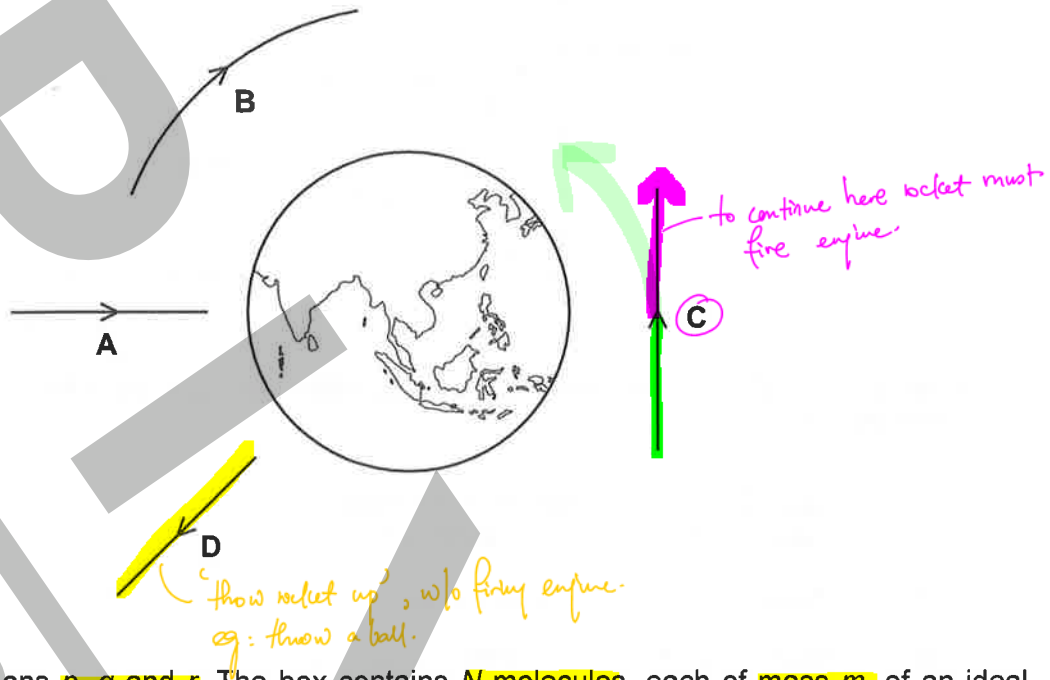
D gravitational potential energy

$g = \frac{F_G}{m}$

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9 The lines on the diagram show parts of four paths of a spacecraft moving near the Earth above any influence of the atmosphere.

Which path is **not** possible unless the spacecraft fires its rockets as it follows the path?



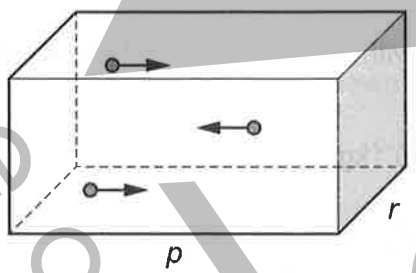
10 A box has dimensions p, q and r. The box contains N molecules, each of mass m, of an ideal gas.

In a simple model, all the molecules are moving at speed v perpendicular to the shaded wall.

$\langle F \rangle = N \cdot \frac{\Delta p}{\Delta t} = N \cdot \frac{p_f - p_i}{\Delta t}$

$= N \cdot \frac{m(v_f - v_i)}{\Delta t}$ ← Δt: dist / speed.

$= \frac{N m (0 - v)}{\frac{p}{v}}$



$\therefore \langle F \rangle = -\frac{Nmv^2}{p}$ (force on molecules)

$\therefore F_{\text{on wall}} = \frac{Nmv^2}{p}$ (N3L)

What is the average force exerted on the shaded wall of the box by N molecules?

(A) $\frac{mNv^2}{p}$ B $\frac{mNv^2}{2p}$ C $\frac{mNv^2}{3p}$ D $\frac{mNv^2}{pqr}$

11 An ideal gas has an internal energy U at 0 °C. The gas is heated to 273 °C.

What is the internal energy of the gas at 273 °C?

A $\sqrt{2}U$ (B) $2U$ C $4U$ D $273U$

① $U \propto T$ ② $K = °C + 273$

② $\frac{U_1}{T_1} = \frac{U_2}{T_2}$ ($U_1 = U$, $T_1 = 273$, $T_2 = 2(273)$, $U_2 = ?$)

$\therefore U_2 = 2U$

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P const

12 Thermal energy is supplied at the same rate to equal masses of two different solids, P and Q. The graphs show how the temperatures of the solids change with time. Each line finishes when the solid it represents has completely changed into liquid.

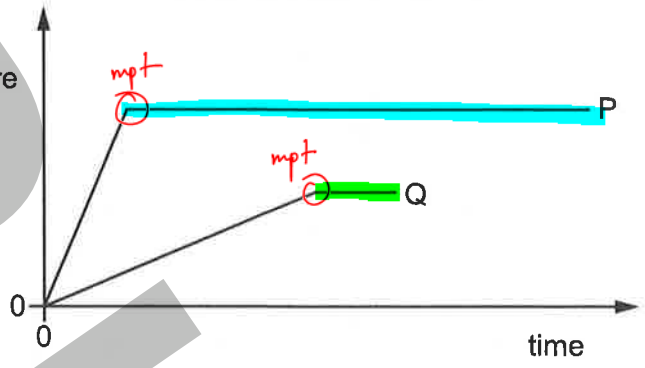
① $Q = mc\theta$

$Pt = mc\theta$

$\therefore \theta = \frac{P}{mc} \cdot t$ (P: const, mc: const, gradient)

slope_P > slope_Q

$\therefore c_P < c_Q$



② $Q = mL$

$Pt = mL$ (const)

$\therefore L \propto t$

$t_P > t_Q$

$\therefore L_P > L_Q$

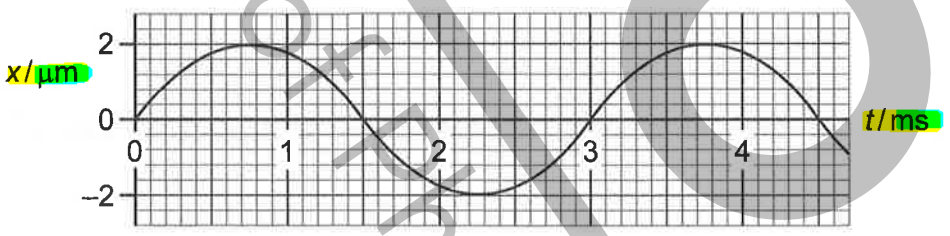
How do the values for the specific heat capacities and specific latent heats of fusion compare with each other?

	specific heat capacity of P	specific latent heat of fusion of P
A	larger than Q	larger than Q
B	larger than Q	smaller than Q
C	smaller than Q	larger than Q
D	smaller than Q	smaller than Q

13 The graph shows the variation with time t of the displacement x of an air molecule at a point in a sound wave.

The molar mass of air is 2.9×10^{-2} kg.

mass of 1 mol of air



What is the maximum kinetic energy of the air molecule?

A 1.1×10^{-32} J **B** 4.2×10^{-31} J **C** 8.5×10^{-31} J **D** 2.1×10^{-28} J

$x = x_0 \sin(\omega t) = 2\times10^{-6} \sin\left(\frac{2\pi}{3\times10^{-3}} t\right)$

$v = \frac{dx}{dt} = \frac{4\pi\times10^{-6}}{3\times10^{-3}} \cos\left(\frac{2\pi}{3\times10^{-3}} \cdot t\right)$

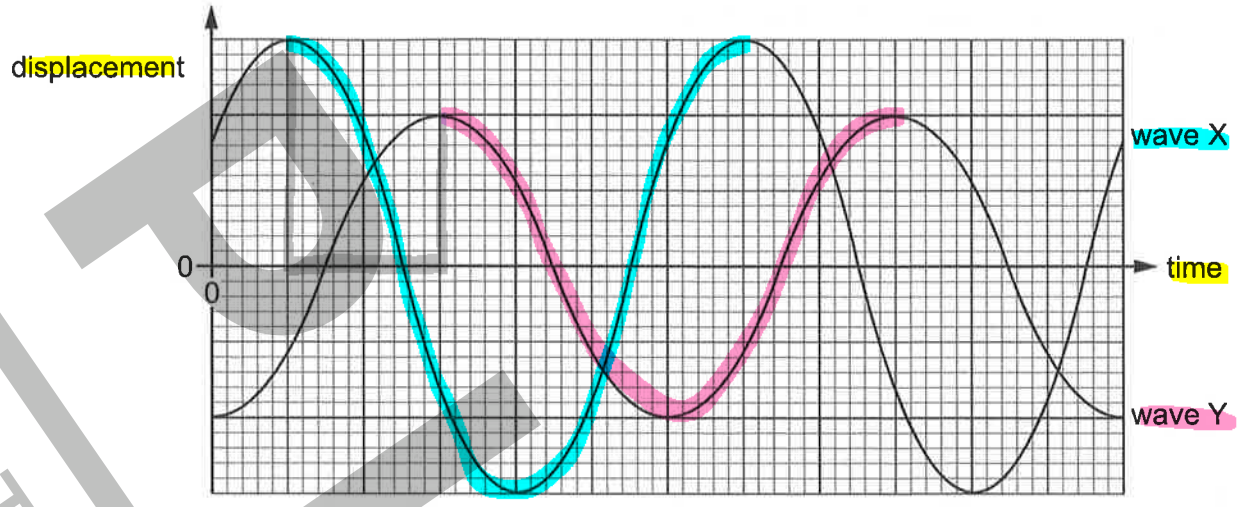
v_0

$KE_{max} = \frac{1}{2} m v_0^2 = \frac{1}{2} \cdot \frac{2.9\times10^{-2}}{6.02\times10^{23}} \cdot \left(\frac{4\pi}{3}\cdot10^{-3}\right)^2 = 4.226\times10^{-31}$ J

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14 The variation with time of the displacement of two transverse waves X and Y is shown.



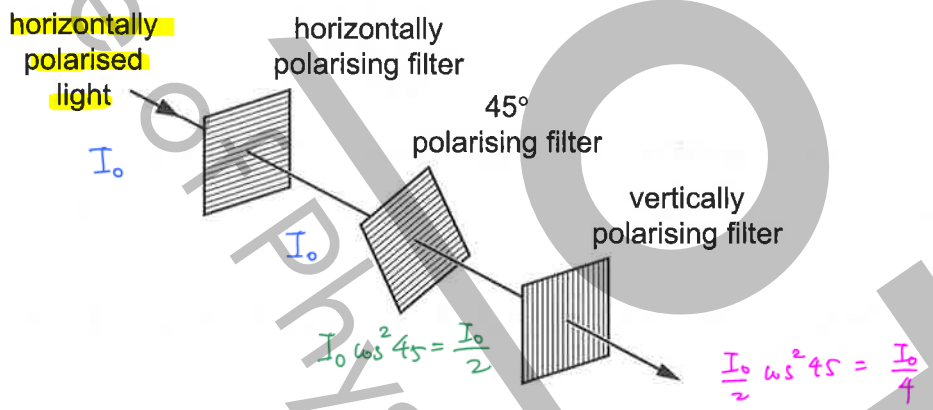
What is the phase difference between the waves and what is the ratio of their intensities?

	phase difference / °	ratio of intensities
A	60	1.50
B	60	2.25
C	120	1.50
(D)	120	2.25

10 units
(1) $\frac{\Delta t}{T} = \frac{\Delta\phi}{2\pi}$
30 units
$\Delta\phi = \frac{2\pi}{3} = 120^\circ$

(2) $\frac{I_x}{I_y} = \left(\frac{A_x}{A_y}\right)^2 = \left(\frac{15}{10}\right)^2 = 2.25$

15 Three ideal polarising filters are arranged in the order shown.



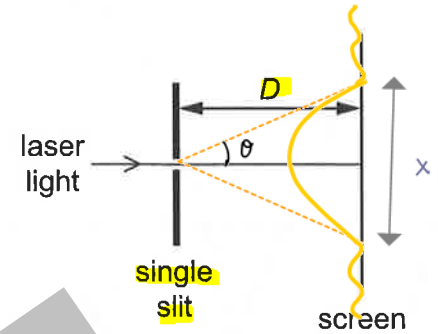
Horizontally polarised light of intensity I_0 is incident on the first filter.

What is the intensity of the light that emerges from the third filter?

A 0 **(B)** $0.25\,I_0$ **C** $0.50\,I_0$ **D** $0.71\,I_0$

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16 Laser light of frequency f passes through a single slit. The resulting diffraction pattern is observed on a screen. The width of the central maximum is x. The distance D between the single slit and the screen is much greater than the slit width.



$a\sin\theta = n\lambda$, $\lambda = \frac{c}{f}$

By small θ approx, $\sin\theta \approx \tan\theta \approx \frac{\frac{x}{2}}{D}$

$\therefore \frac{ax}{2D} = \frac{c}{f}$

Hence $a = \frac{2Dc}{xf}$

What is the correct expression for the slit width?

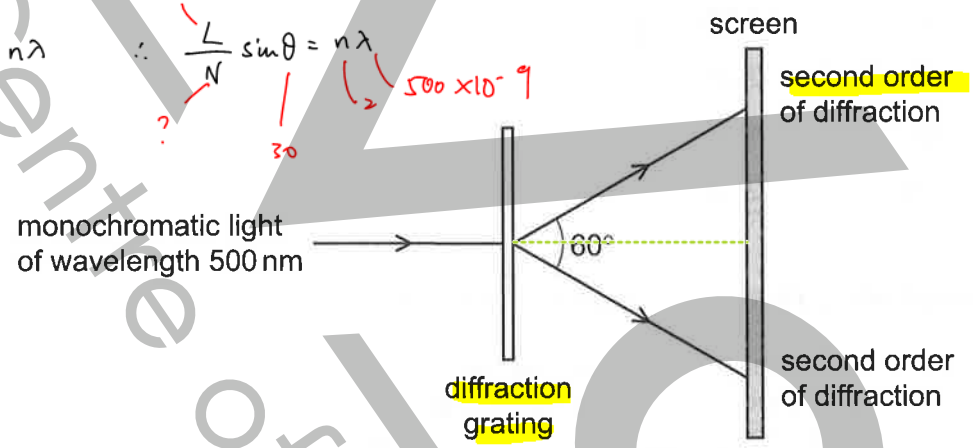
A $\frac{cx}{2Df}$ **B** $\frac{cx}{Df}$ **C** $\frac{cD}{fx}$ **D** $\frac{2cD}{fx}$

17 Monochromatic light of wavelength 500 nm is directed perpendicularly onto a diffraction grating. The second-order diffraction lines are observed at 60° to each other.

$d\sin\theta = n\lambda$, $\frac{L}{N}$

$\therefore \frac{L}{N}\sin\theta = n\lambda$ ($\times 10^{-3}$)

500×10^{-9}, 2, 30, ?

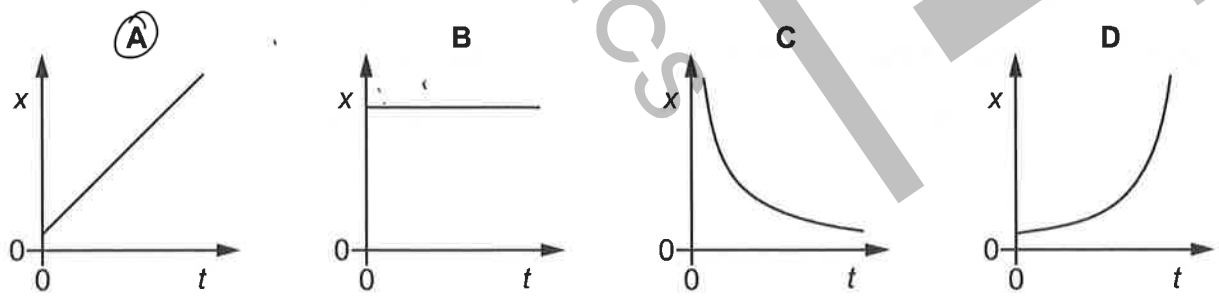


What is the number of diffraction lines per millimetre of the grating?

A 500 **B** 866 **C** 1000 **D** 500 000

18 During a double-slit experiment with light, the distance D from the slit to the screen is increased at a constant rate.

Which graph shows how the fringe width x varies with time t?



$w = \frac{\lambda D}{d} = \frac{\lambda}{d} \cdot \frac{D}{t}$

const, const

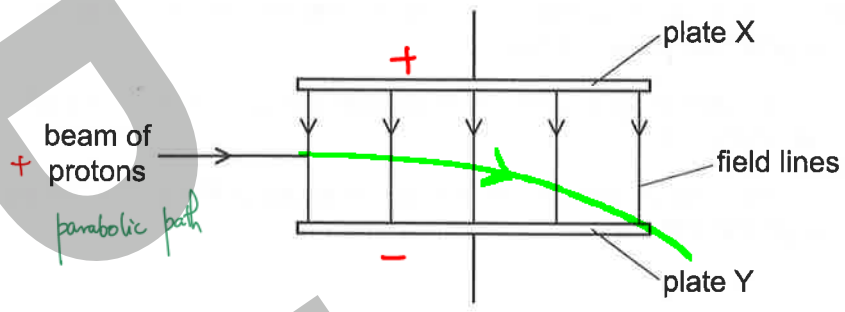
$\therefore w = kt$

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19 A beam of protons moves at constant velocity towards a uniform electric field between plates X and Y.

It enters the field normal to the field lines, as shown.



What is the path of the protons in the region of the field?

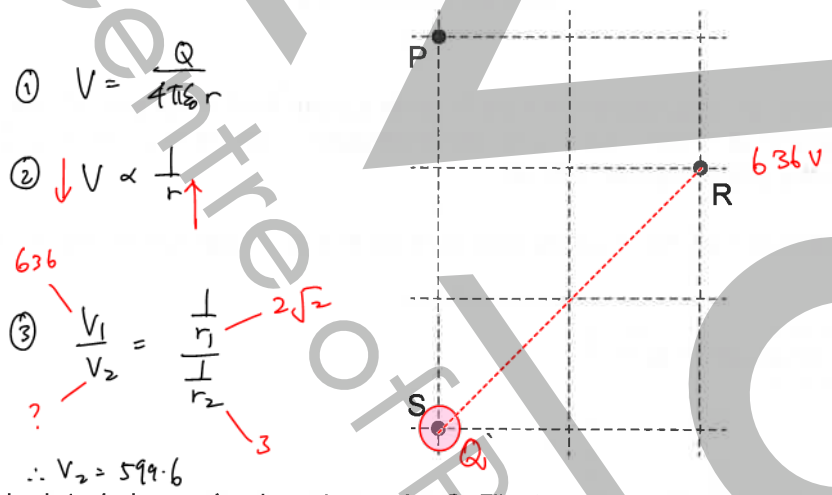
A circular curved path towards plate X

B circular curved path towards plate Y

C non-circular curved path towards plate X

D non-circular curved path towards plate Y

20 The relative positions of three points in free space, P, R and S, are shown on a grid of squares.



An isolated charge is placed at point S. The electric potential at point R is 636 V.

What is the electric potential at point P?

A 565 V **B** 600 V **C** 674 V **D** 734 V

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$\mathcal{E} = \frac{W}{q} = \frac{E_{other \to Elect}}{q}$

21 Which statement about electromotive force (e.m.f.) or potential difference (p.d.) is correct?

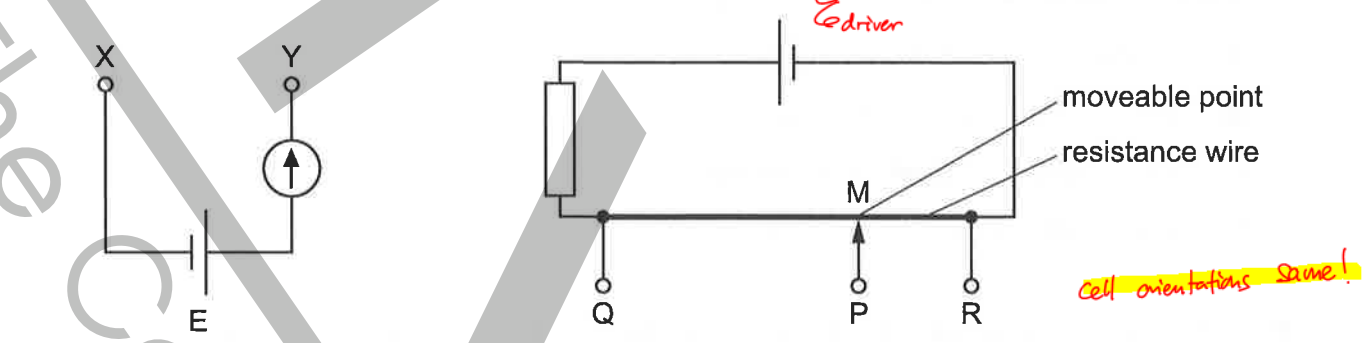
A The e.m.f. of a cell is the energy dissipated in its internal resistance per unit of charge passing through it.

B The e.m.f. of a cell is equal to the energy converted into electrical energy from other forms per unit of charge which passes through it.

C The p.d. across a resistor is the total energy dissipated in it over a period of time per unit current passing through it.

D The p.d. across the internal resistance of a cell is equal to the energy needed to move a unit of charge through the cell.

22 A cell E and a galvanometer are to be connected into a potentiometer circuit by terminals X and Y.



circuit of cell to be connected

potentiometer circuit

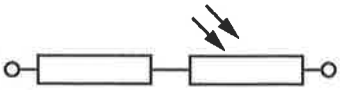
The potentiometer is a length of resistance wire with ends connected to Q and R. Point P is connected to a moveable point M on the wire. The electromotive force (e.m.f.) of cell E is less than the e.m.f. of the cell in the potentiometer circuit.

Which connections allow the e.m.f. of cell E to be balanced by the potential difference across part of the resistance wire?

	connection to X	connection to Y
A	Q	P
B	R	Q
C	Q	R
D	R	P

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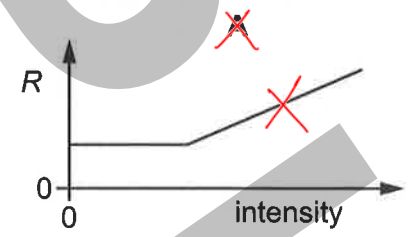
23 A resistor of fixed resistance and a light-dependent resistor (LDR) are connected in series.



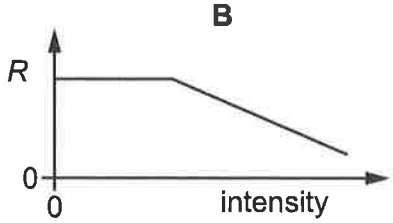
$I \uparrow, R_{LDR} \downarrow, R_{eff} \downarrow$

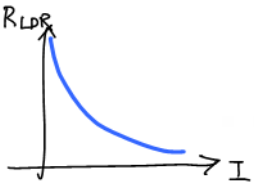
The combined resistance of the two resistors is R.

Which graph could represent the variation of R with the intensity of light incident on the LDR?

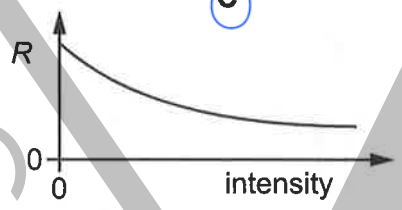


B

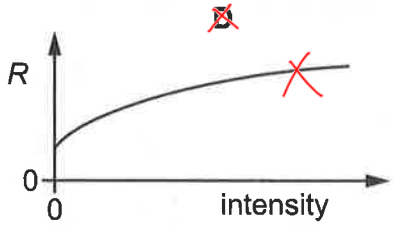




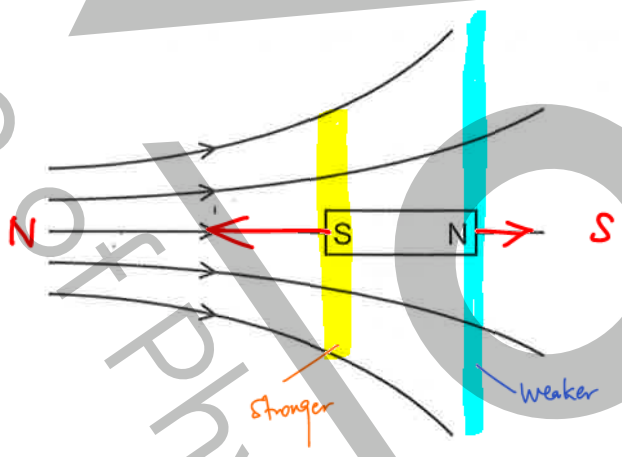
C



D



24 A small bar magnet is placed on a smooth surface. An external magnetic field is applied, and the bar magnet is held in the position as shown from above.



The bar magnet is released so that it is free to move.

What is the initial motion of the magnet?

A It moves to the left.

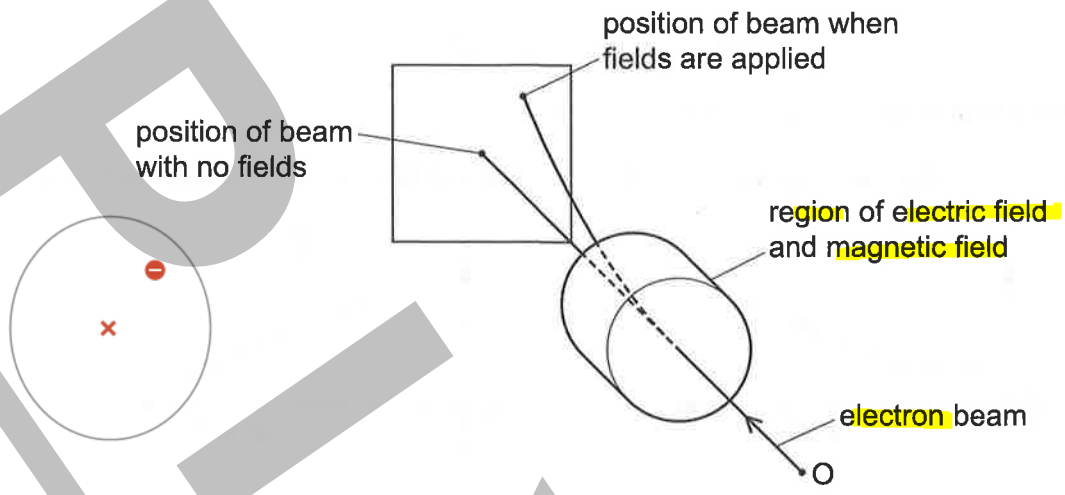
B It moves to the right.

C It rotates clockwise.

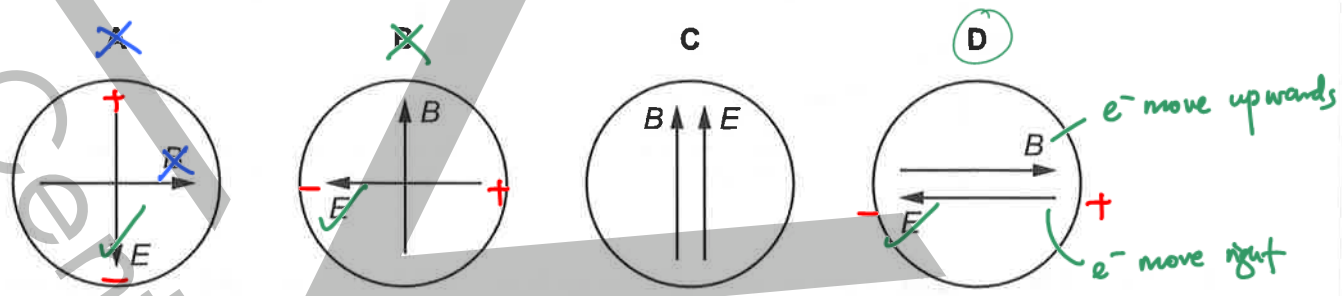
D It rotates anticlockwise.

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25 An electron beam passes through a region in which both a uniform electric field E and uniform magnetic field B can be applied.



Which pair of fields causes the beam to move upwards and to the right as viewed from O?



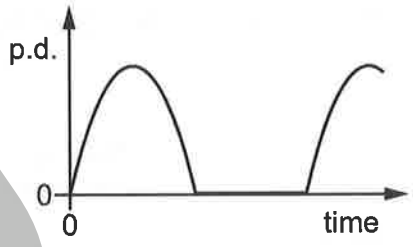
26 What are units of magnetic flux and magnetic flux density?

	magnetic flux ϕ	magnetic flux density B
A	tesla	weber
B	tesla metre^2	weber
C	tesla metre^2	tesla
D	weber metre^{-2}	tesla

$\phi = BA$

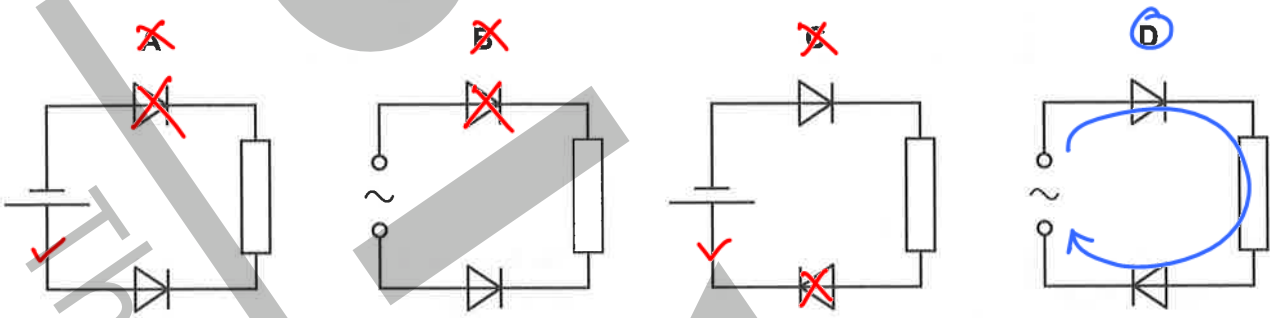
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27 The p.d. across a load resistor varies as shown.

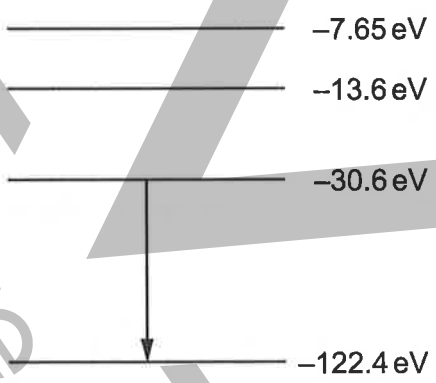


Half-wave rectified.

Which circuit results in this variation?



28 Some of the energy levels of an atom are shown.



An electron undergoes the transition shown and a photon is emitted.

What is the wavelength of the emitted photon?

(A) 1.35×10^{-8} m

B 4.06×10^{-8} m

C 1.02×10^{-7} m

D 3.06×10^{-7} m

$E = \frac{hc}{\lambda}$ (1.989×10^{-25}) ?

$(122.4 - 30.6)(1.6 \times 10^{-19})$

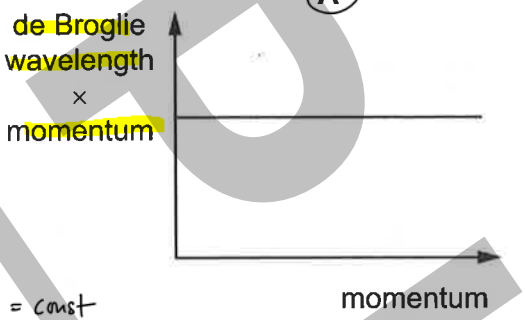
$\lambda = 1.354 \times 10^{-8}$

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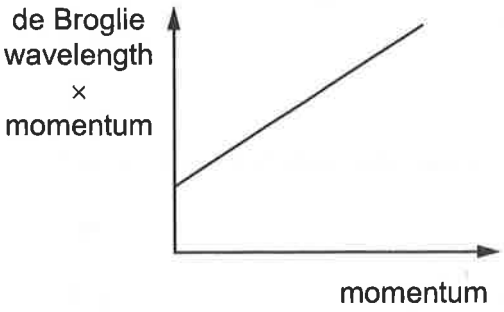
29 The momentum of a charged particle increases as it is accelerated by an electric field.

Which graph shows how the product of the particle's de Broglie wavelength and its momentum varies as its momentum increases?

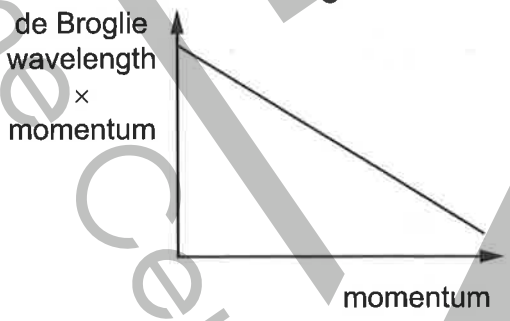
A



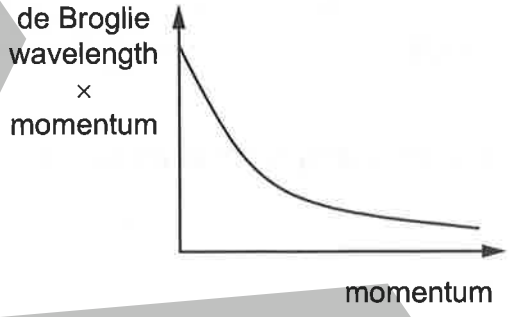
B



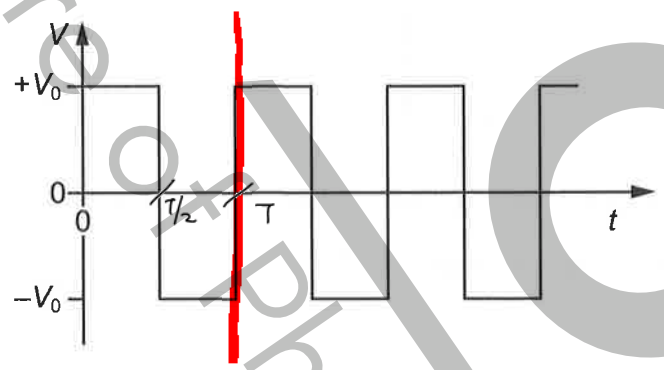
C



D



30 The diagram shows the variation with time t of an alternating voltage V.



The peak value of the alternating voltage is V_0.

What is the root-mean-square (r.m.s.) value of the alternating voltage?

A $\sqrt{V_0}$ **B** $\sqrt{2}\,V_0$ **C** V_0 **D** $2V_0$

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