

Cambridge International AS & A Level

	CANDIDATE NAME				
* 8 5 1 4 5 5 6 8 4	CENTRE NUMBER		CANDIDATE NUMBER		
	PHYSICS		9702/21		
	Paper 2 AS Level Structured Questions		May/June 2024		
			1 hour 15 minutes		
	You must answer on the question paper.				
4	No additional materials are needed.				
	 INSTRUCTIONS Answer all questions. Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs. Write your name, centre number and candidate number in the boxes at the top of the page. Write your answer to each question in the space provided. Do not use an erasable pen or correction fluid. Do not write on any bar codes. You may use a calculator. You should show all your working and use appropriate units. 				
		No.			

This document has 20 pages. Any blank pages are indicated.

Data

acceleration of free fall	g	=	$9.81 \mathrm{ms^{-2}}$
speed of light in free space	С	=	$3.00 \times 10^8 \mathrm{ms^{-1}}$
elementary charge	е	=	$1.60 \times 10^{-19} \mathrm{C}$
unified atomic mass unit	1 u	=	$1.66 \times 10^{-27} \text{kg}$
rest mass of proton	m _p	=	$1.67 \times 10^{-27} \text{kg}$
rest mass of electron	m _e	=	$9.11 \times 10^{-31} \text{kg}$
Avogadro constant	N _A	=	$6.02 \times 10^{23} \text{mol}^{-1}$
molar gas constant	R	=	8.31 J K ⁻¹ mol ⁻¹
Boltzmann constant	k	=	$1.38 \times 10^{-23} \mathrm{J}\mathrm{K}^{-1}$
gravitational constant	G	=	$6.67 \times 10^{-11} \mathrm{N}\mathrm{m}^2\mathrm{kg}^{-2}$
permittivity of free space	ε	₹	$8.85 \times 10^{-12} \mathrm{F m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0})$	=	$8.99 \times 10^9 \mathrm{mF^{-1}})$
Planck constant	h	=	$6.63 \times 10^{-34} \mathrm{Js}$
Stefan–Boltzmann constant	σ	SINE C	$5.67 \times 10^{-8} \mathrm{W m^{-2} K^{-4}}$
Formulae			
uniformly accelerated motion	S	=	$ut + \frac{1}{2}at^2$
	V^2	-	u^2 + 2as
hydrostatic pressure	Δρ	Ē	ρg∆h
upthrust	F	=	ho gV
Doppler effect for sound waves	f _o	=	$\frac{f_{\rm s}V}{V\pm V_{\rm s}}$
electric current	Ι	=	Anvq
resistors in series	R	=	$R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \dots$

3



1 The drag force $F_{\rm D}$ acting on an object falling through air is given by

$$F_{\rm D} = \frac{1}{2} \, C \rho A v^2$$

where A is the cross-sectional area of the object,

- v is the velocity of the object in the air,
- $\rho\,$ is the density of the air and
- C is a constant called the drag coefficient.
- (a) Use SI base units to show that the drag coefficient has no units.



Assume that the upthrust on the sphere is negligible.

On Fig. 1.1, draw and label arrows to show the directions of the **two** forces acting on the sphere. [2]

(c) The mass of the sphere is 49g.

Calculate the drag force $F_{\rm D}$ acting on the sphere.

*F*_D = N [2]

(d) The sphere is falling in air at a terminal velocity of 25 in SI base units. The density of the air is 1.2 in SI base units. The diameter of the sphere is 0.060 in SI base units.

Use your answer in (c) to calculate the drag coefficient C for the sphere.



2 (a) Define velocity.

.....[1]

(b) A student throws a ball over a vertical wall of height *h*, as shown in Fig. 2.1.



The ball leaves the hand of the student at a height of 1.2 m above the horizontal ground. The ball has an initial velocity of 22 m s^{-1} at an angle of 40° to the horizontal. The wall is a horizontal distance of 36 m from where the student releases the ball.

Air resistance is negligible.

(i) Determine the time taken for the ball to reach the wall.

D	230	*		
	time taken = .		 s [2	2]

- 7
- (ii) Calculate the vertical component *u* of the initial velocity of the ball.

 $u = \dots m s^{-1}$ [1]

(iii) The ball just goes over the wall.Calculate the height *h* of the wall.



8

3 (a) State the principle of conservation of momentum.

(b) An object of mass 2m is travelling at a speed of 5.0 m s^{-1} in a straight line. It collides with an object of mass 3m which is initially stationary, as shown in Fig. 3.1.



Fig. 3.1

After the collision, the object of mass 2m moves with velocity v at an angle of 30° to its original direction of motion.

The object of mass 3*m* moves with velocity *w* also at an angle of 30°, as shown in Fig. 3.2.



By considering the conservation of momentum in two dimensions, calculate the magnitudes of v and w.

	$v = \dots m s^{-1}$
	$w = \dots m s^{-1}$ [4]
(c)	An object of mass 4.2 kg is travelling in a straight line at a speed of 6.0 m s^{-1} . The object is brought to rest in a distance of 0.050 m by a constant force.
	Calculate the magnitude of this force.
	force = N [3]
	[Total: 9]

4 (a) Define strain.

.....[1]

(b) A copper wire of length 4.0 m has a uniform cross-sectional area of $4.5 \times 10^{-7} \text{ m}^2$.

A tensile force of 18N is applied to the wire. This causes the wire to extend by 1.4 mm up to its limit of proportionality.

(i) Calculate the Young modulus of the wire.



(ii) On Fig. 4.1, draw a line to show how the stress varies with the strain for the wire up to its limit of proportionality.



(c) A second copper wire has the same length as the wire in (b) but a larger diameter. Both wires are subjected to a tensile force of 18 N.

By placing a tick (\checkmark) in each row, complete Table 4.1 to compare the stress and strain of the two wires.

Table 4.1

	greater in second wire	less in second wire	the same in both wires
stress			
strain			

[2]

[2]

[Total: 8]

5 A stretched string PQ has length 1.2m. One end of the string is attached to a vibration generator and the other end is attached to a wall, as shown in Fig. 5.1.





The vibration generator is switched on and a stationary wave is formed on the string. The string is shown at one instant of time in Fig. 5.2.



wavelength = m [1]

(c) Fig. 5.3 shows the stationary wave at time t = 0 when all points on the wave are at their maximum displacements.



Fig. 5.3

The period of the wave is 0.16 s.

On Fig. 5.3, sketch the shape of the stationary wave at time t = 0.24 s. [2]

(d) Points R and T on the string are a horizontal distance of 0.30 m apart and in the positions shown in Fig. 5.4.



State the phase difference between the oscillations of points R and T.

phase difference =° [1]

(e) Calculate the speed of the progressive waves on the stretched string.

speed = ms^{-1} [2]

[Total: 8]

6 (a) State Kirchhoff's first law.

-[1]
- (b) A cell with internal resistance r is connected to two resistors of resistances R_1 and R_2 as shown in Fig. 6.1.



The potential differences (p.d.s) across R_1 and R_2 are V_1 and V_2 respectively. The terminal p.d. across the cell is V. The current in the circuit is I.

Use Kirchhoff's laws to show that the total resistance R_{T} of the external circuit is given by

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 $R_{\rm T} = R_1 + R_2$.

(c) The electromotive force (e.m.f.) of the cell in Fig. 6.1 is 1.50 V.

The values of R_1 and R_2 are 10Ω and 15Ω respectively. The terminal p.d. of the cell is 1.35V. Calculate the internal resistance *r* of the cell.

r =Ω [3]

(d) A resistor of resistance R_3 is added to the circuit in Fig. 6.1, so that the circuit is as shown in Fig. 6.2.



- 7 Nuclei of an isotope of copper (Cu) each have 29 protons and 37 neutrons. This isotope is a β^- emitter.
 - (a) State the nuclide notation in the form ${}^{A}_{7}X$ for this nucleus of copper.

- [1]
- (b) The energy spectrum of the β^- radiation emitted by a sample of this isotope is shown in Fig. 7.1.



(iii) The copper isotope decays to an isotope of zinc (Zn).

Give the radioactive decay equation for this decay. Include the nucleon and proton numbers of **all** the particles involved.

[3]

[Total: 8]









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