



Cambridge International AS & A Level

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PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 2025

1 hour 15 minutes

You must answer on the question paper.

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.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.



Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
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	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$





1 (a) Define acceleration.

.....
 [1]

(b) A rocket is launched vertically from the surface of the Earth.

Fig. 1.1 shows the variation of the velocity of the rocket with time for the first 20 s after its launch.

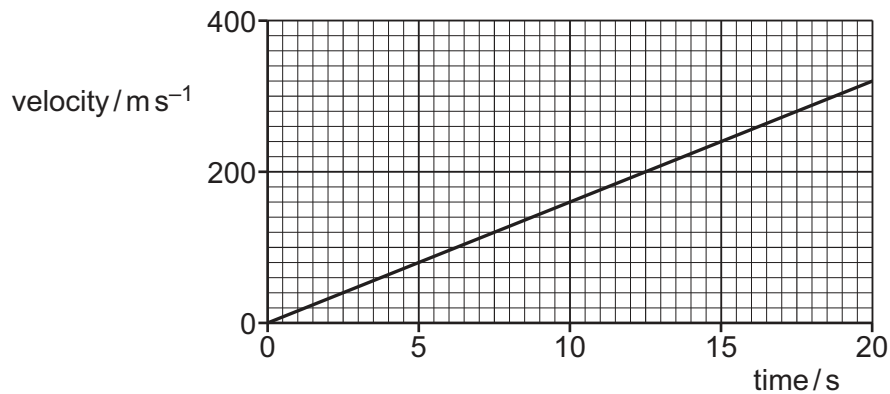


Fig. 1.1

(i) Determine the acceleration of the rocket.

acceleration = ... m s^{-2} [1]

(ii) Show that the height of the rocket above the surface of the Earth at a time of 20 s after launch is 3.2 km.

[2]



- (c) The mass of the rocket in (b) is $2.9 \times 10^6 \text{ kg}$. Assume that this mass remains constant.

For this rocket, from launch to its height at a time of 20 s after launch:

- (i) calculate the gain in gravitational potential energy ΔE_p

$$\Delta E_p = \dots\dots\dots \text{ J [2]}$$

- (ii) calculate the gain in kinetic energy ΔE_k

$$\Delta E_k = \dots\dots\dots \text{ J [2]}$$

- (iii) determine the average power output of the rocket engines. Assume that resistive forces are negligible.

$$\text{power} = \dots\dots\dots \text{ W [2]}$$

[Total: 10]



2 (a) (i) Define pressure.

.....
 [1]

(ii) Explain how hydrostatic pressure results in an upthrust force acting on a solid object immersed in a liquid.

.....

 [2]

(b) A small steel ball of radius r and mass m falls vertically at terminal speed v through oil.

The viscous drag force D that acts on the ball is given by

$$D = 6\pi\eta rv$$

where η is a property of the oil called its viscosity.

(i) On Fig. 2.1, draw labelled arrows from the ball to show the directions of the **three** forces that act on the ball as it falls.



Fig. 2.1

[3]





(ii) Determine the SI base units of η .

base units [2]

(c) The oil in (b) has a density of 920 kg m^{-3} and a viscosity of 4.7 in SI units.

The steel ball has a mass of $2.4 \times 10^{-3} \text{ kg}$ and a radius of $4.2 \times 10^{-3} \text{ m}$.

(i) Show that the upthrust force acting on the ball is $2.8 \times 10^{-3} \text{ N}$.

[1]

(ii) Determine the terminal speed v of the ball.

$v = \dots \text{ m s}^{-1}$ [3]

[Total: 12]



- 3 A wire has length L and cross-sectional area A . The wire is made from a metal that has Young modulus E and resistivity ρ .

(a) Define the Young modulus of a material.

.....
 [1]

- (b) (i) State an expression, in terms of some or all of L , A , E and ρ , for the resistance R_0 of the wire.

$R_0 =$ [1]

- (ii) Show that the spring constant k_0 of the wire is given by

$$k_0 = \frac{EA}{L}.$$

[2]

- (c) The wire is stretched, within the limit of proportionality, by a tensile force F . Assume that any changes in the cross-sectional area of the wire are negligible.

- (i) On Fig. 3.1, sketch the variation with F of the resistance R of the wire.



Fig. 3.1

[1]



- (ii) On Fig. 3.2, sketch the variation with F of the spring constant k of the wire.



Fig. 3.2

[1]

- (d) Copper has a resistivity of $1.8 \times 10^{-8} \Omega \text{ m}$ and a Young modulus of $1.3 \times 10^{11} \text{ Pa}$.

A copper wire of diameter 1.6 mm has a resistance of 0.034Ω .

- (i) Show that the length of the wire is 3.8 m.

[1]

- (ii) Use the equation in (b)(ii) to determine the spring constant of the wire.

spring constant = ... N m^{-1} [2]

[Total: 9]



- 4 (a) State what is meant by diffraction of a wave.

.....

.....

..... [2]

- (b) A beam of vertically polarised light of wavelength 540 nm is incident normally on a diffraction grating, as shown in Fig. 4.1.

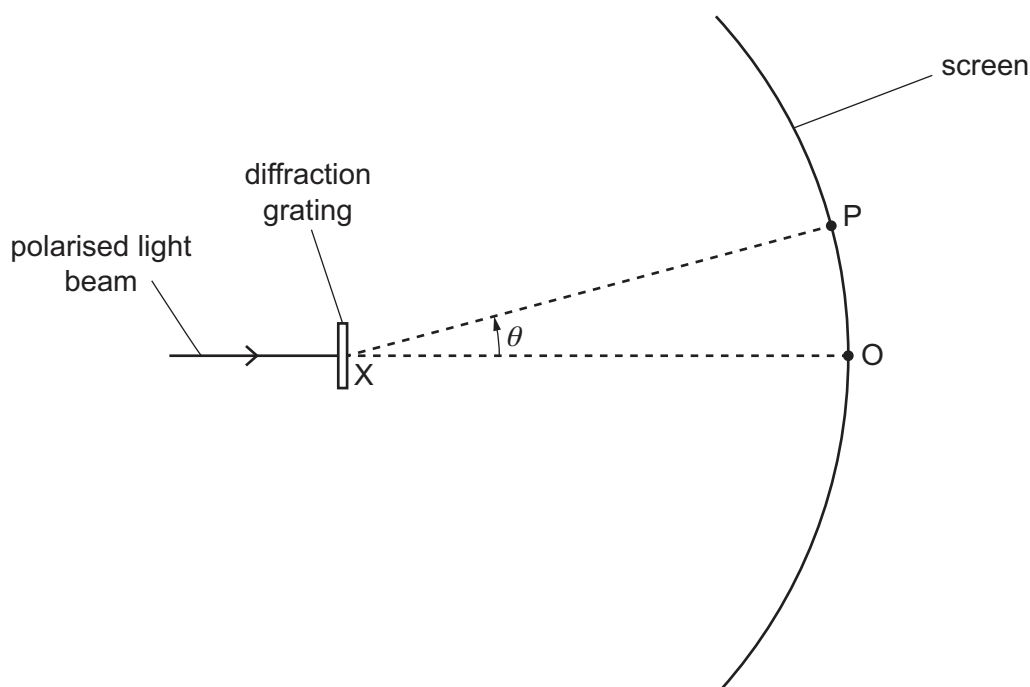


Fig. 4.1 (not to scale)

The diffraction grating has a line spacing of $5.0 \times 10^{-6}\text{ m}$.

The light transmitted by the diffraction grating illuminates a circular screen. The diffraction grating is at the centre X of the circle.

The central bright fringe is formed at point O on the screen and has intensity I_0 .

P is a point on the screen where the line XP is at a variable angle θ to the line XO. The intensity I of light on the screen at P varies with θ .

- (i) Show that the angle θ at which the first-order bright fringe is formed is 6.2° .

[2]



- (ii) Determine the value of θ at which the second-order bright fringe is formed.

$$\theta = \dots\dots\dots^\circ \quad [1]$$

- (iii) On Fig. 4.2, sketch the variation of the intensity I with θ for values of θ from -15° to $+15^\circ$.

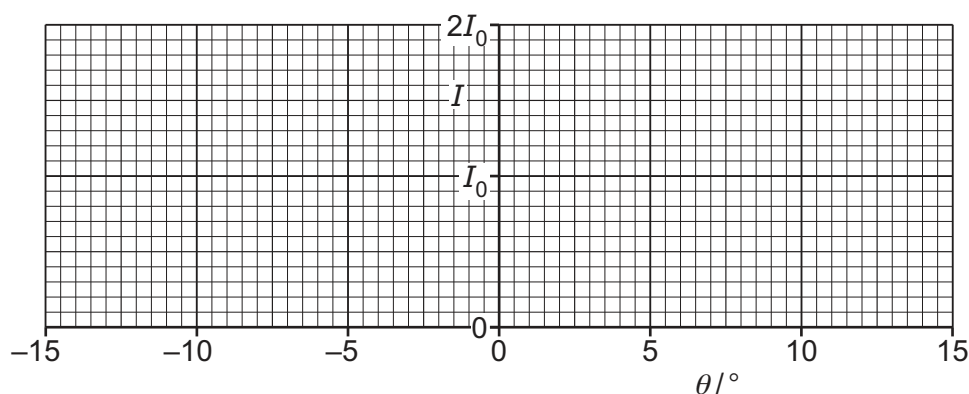


Fig. 4.2

[3]

- (c) A polarising filter is placed in the path of the light beam that is incident on the diffraction grating in Fig. 4.1. The transmission axis of the filter is at 45° to the vertical.

Suggest how the variation of intensity with θ for the light on the screen compares with the answer in (b)(iii).

.....

 [2]

[Total: 10]



5 (a) State Kirchhoff's first law.

.....
 [1]

(b) Fig. 5.1 shows a circuit containing a thermistor T that has a negative temperature coefficient.

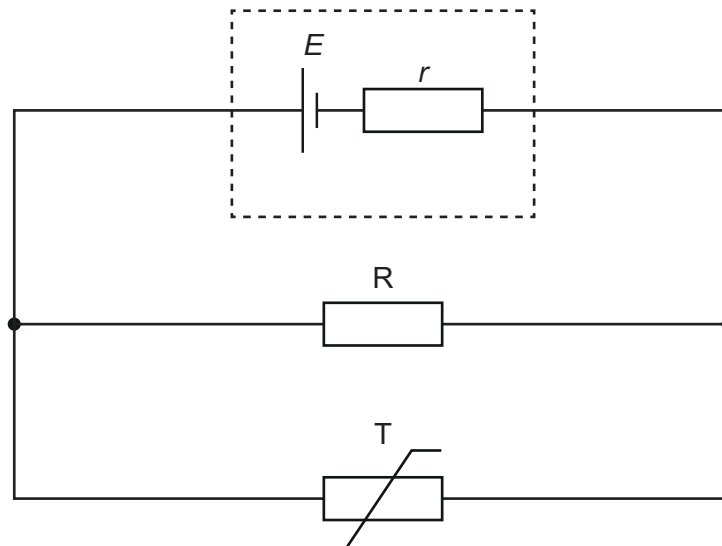


Fig. 5.1

(i) The thermistor has resistance R_0 at a temperature of 0°C .

On Fig. 5.2, sketch a possible variation of the resistance of the thermistor with temperature between 0°C and 100°C .

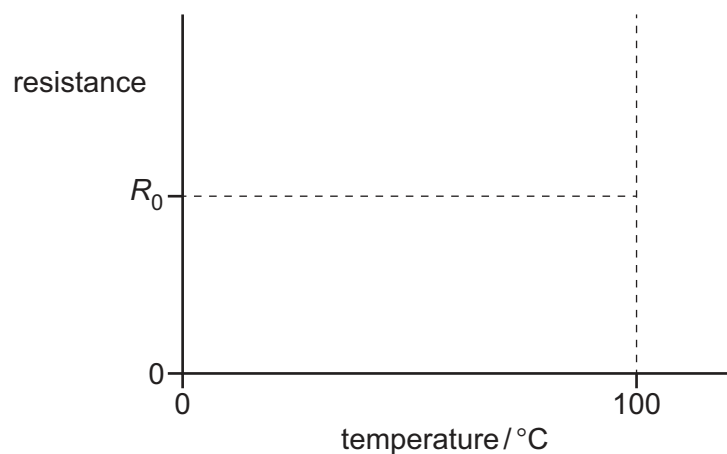


Fig. 5.2

[2]



- (ii) With reference to the current in the cell, explain why the current in **resistor R** decreases with increasing temperature of the thermistor.

.....

.....

.....

.....

..... [3]

- (c) The electromotive force (e.m.f.) E of the cell in Fig. 5.1 is 1.50 V. The internal resistance r of the cell is $0.12\ \Omega$.

Resistor R has a resistance of $6.00\ \Omega$.

At a particular temperature of the thermistor, the current in R is 0.200 A.

For this temperature of the thermistor, determine:

- (i) the current in the cell

current = ... A [2]

- (ii) the resistance of the thermistor.

resistance = ... Ω [2]

[Total: 10]



6 The nuclide ${}^3_1\text{H}$ is an isotope of hydrogen that is called tritium.

(a) (i) Determine the numbers of protons, neutrons and electrons in a neutral atom of tritium.

number of protons = ...

number of neutrons = ...

number of electrons = ...

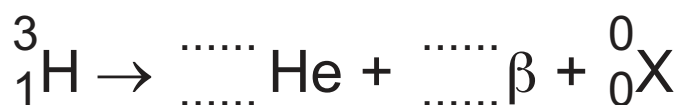
[2]

(ii) Draw a labelled diagram to represent a simple model of the arrangement of the protons, neutrons and electrons in a tritium atom.

[2]

(b) Tritium is radioactive and undergoes β^- decay to form an isotope of helium (He). Gamma radiation is not emitted during this decay.

(i) Complete the equation to represent the radioactive decay of tritium.



[2]

(ii) State the name of particle X.

..... [1]





(c) Determine the quark composition of a tritium nucleus.

.....

..... [2]

[Total: 9]





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