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Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

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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.

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**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 u | = | $1.66 \times 10^{-27}\ \text{kg}$ |
| rest mass of proton | $m_\text{p}$ | = | $1.67 \times 10^{-27}\ \text{kg}$ |
| rest mass of electron | $m_\text{e}$ | = | $9.11 \times 10^{-31}\ \text{kg}$ |
| Avogadro constant | $N_\text{A}$ | = | $6.02 \times 10^{23}\ \text{mol}^{-1}$ |
| 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 | $\varepsilon_0$ | = | $8.85 \times 10^{-12}\ \text{F m}^{-1}$ |
| | $\left(\frac{1}{4\pi\varepsilon_0}\right.$ | = | $\left.8.99 \times 10^{9}\ \text{m F}^{-1}\right)$ |
| 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 | $f_\text{o}$ | = | $\frac{f_\text{s} v}{v \pm v_\text{s}}$ |
| electric current | $I$ | = | $Anvq$ |
| resistors in series | $R$ | = | $R_1 + R_2 + \ldots$ |
| resistors in parallel | $\frac{1}{R}$ | = | $\frac{1}{R_1} + \frac{1}{R_2} + \ldots$ |

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**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.

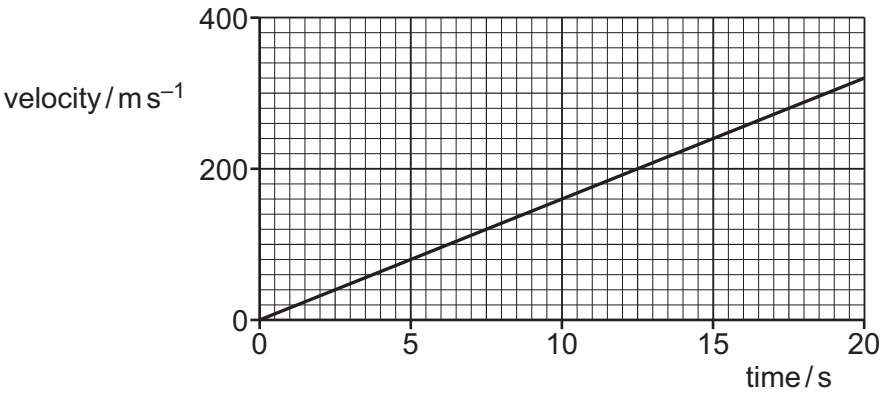



**Fig. 1.1**

**(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]

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**(c)** The mass of the rocket in **(b)** is $2.9 \times 10^6$ 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 $\Delta E_P$

$\Delta E_P$ = ..... J [2]

**(ii)** calculate the gain in kinetic energy $\Delta E_K$

$\Delta E_K$ = ..... J [2]

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

power = ..... W [2]

[Total: 10]

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**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 $\eta$ 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]

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**(ii)** Determine the SI base units of $\eta$.

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 $2.4 \times 10^{-3}$ kg and a radius of $4.2 \times 10^{-3}$ m.

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

[1]

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

$v$ = ..... m s$^{-1}$ [3]

[Total: 12]

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**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 $\rho$.

**(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 $\rho$, 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]

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**(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 $0.034\,\Omega$.

**(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 = ..... $\text{N m}^{-1}$ [2]

[Total: 9]

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

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.....

..... [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.

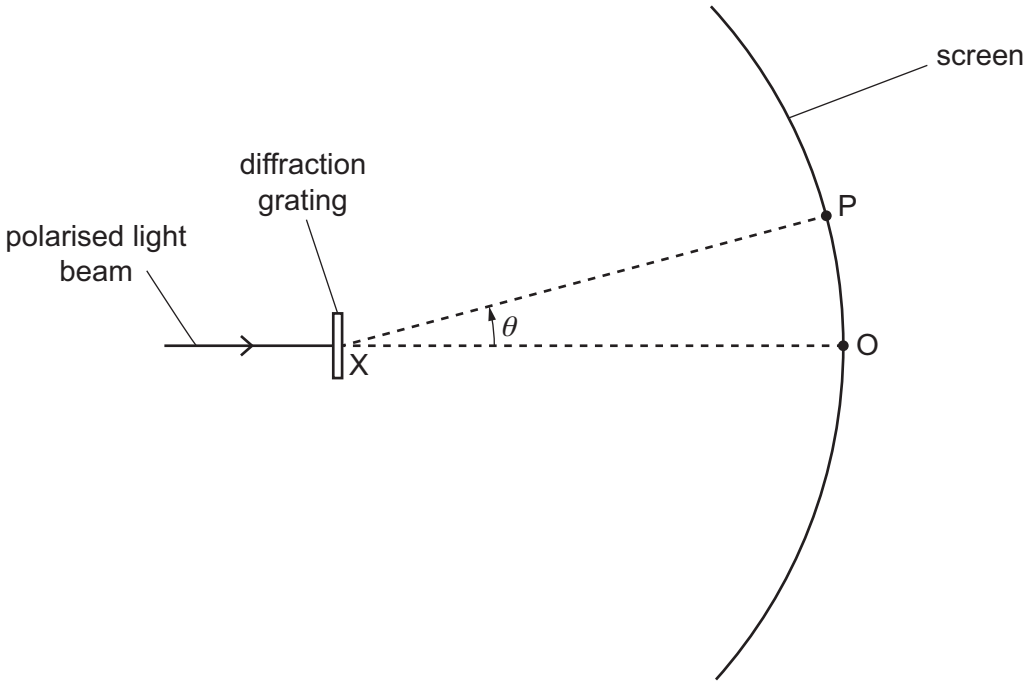



**Fig. 4.1** (not to scale)

The diffraction grating has a line spacing of $5.0 \times 10^{-6}$ 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 $\theta$ to the line XO. The intensity $I$ of light on the screen at P varies with $\theta$.

**(i)** Show that the angle $\theta$ at which the first-order bright fringe is formed is 6.2°.

[2]

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**(ii)** Determine the value of $\theta$ at which the second-order bright fringe is formed.

$\theta$ = .....° [1]

**(iii)** On Fig. 4.2, sketch the variation of the intensity $I$ with $\theta$ for values of $\theta$ from –15° to +15°.

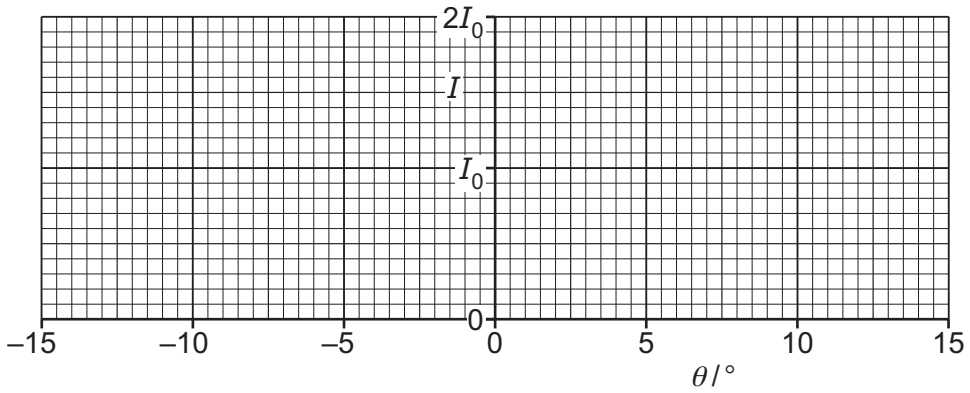



**Fig. 4.2**

[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 $\theta$ for the light on the screen compares with the answer in **(b)(iii)**.

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..... [2]

[Total: 10]

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**5** **(a)** State Kirchhoff's first law.

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..... [1]

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

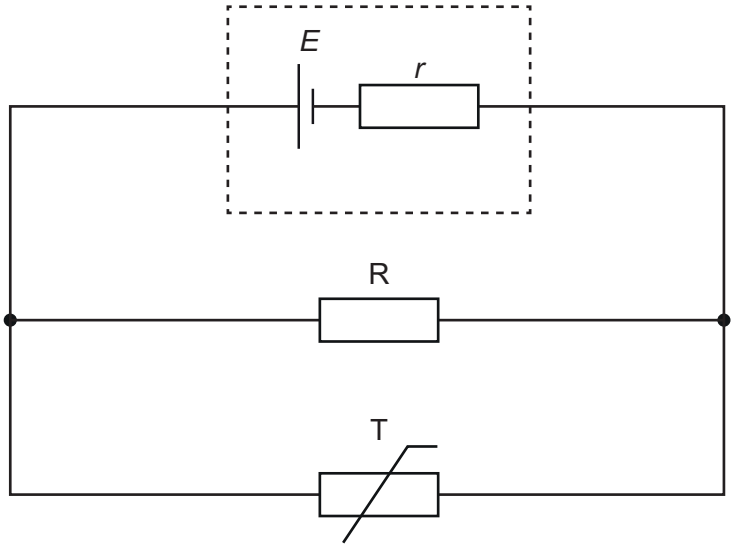



**Fig. 5.1**

**(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.

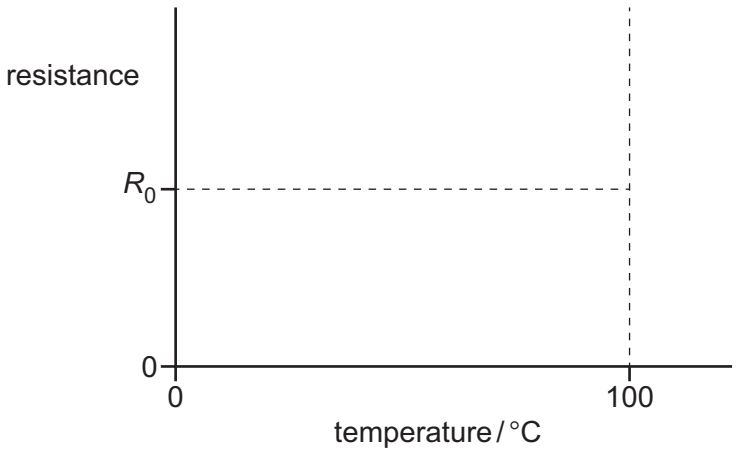



**Fig. 5.2**

[2]

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**(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 Ω.

Resistor R has a resistance of 6.00 Ω.

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]

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**6** The nuclide $^{3}_{1}H$ 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 $\beta^-$ 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.

$$^{3}_{1}H \rightarrow {}^{.....}_{.....}He + {}^{.....}_{.....}\beta + {}^{0}_{0}X$$

[2]

**(ii)** State the name of particle X.

..... [1]

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

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..... [2]

[Total: 9]

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