Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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**PHYSICS** **9702/23**

Paper 2 AS Level Structured Questions **October/November 2024**

**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.




[Turn over

**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 small aircraft is flying horizontally at a speed of $42\,m\,s^{-1}$ at a height of 63 m above horizontal ground, as shown in Fig. 1.1.

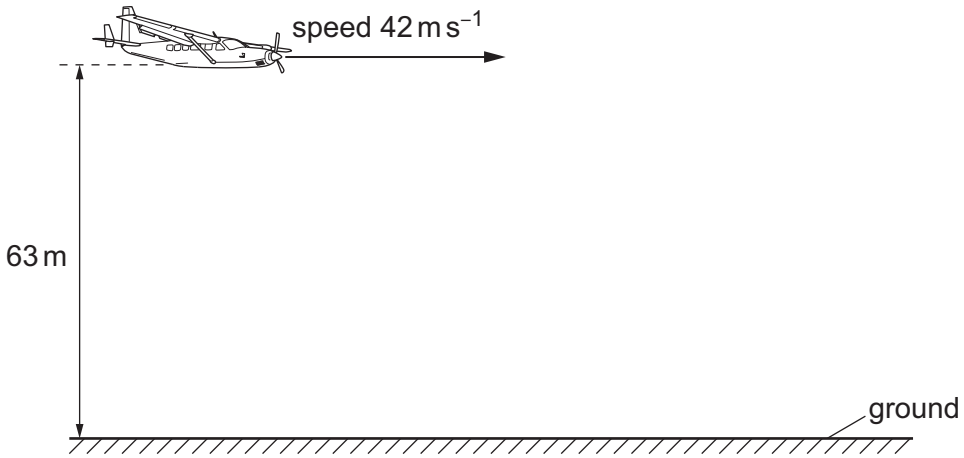


**Fig. 1.1**

The aircraft drops a small parcel. The parcel is released from the aircraft at the instant shown in Fig. 1.1. Air resistance is negligible.

**(i)** On Fig. 1.1, draw a line to show the path of the parcel as it falls from the aircraft to the ground. [1]

**(ii)** Calculate the time taken from the instant of release to the instant the parcel reaches the ground.

time = ..... s [2]

**(iii)** Calculate the vertical component of the velocity of the parcel immediately before it reaches the ground.

vertical component of velocity = ..... $m\,s^{-1}$ [1]

**(iv)** Determine the speed at which the parcel reaches the ground.

speed = ..... $m\,s^{-1}$ [2]

[Total: 7]

**2** **(a)** State the principle of conservation of momentum.

.....

.....

..... [2]

**(b)** A ball X has mass 240 g and moves in a straight line on a horizontal frictionless surface with an initial speed of 16 m s$^{-1}$. The ball collides with a stationary ball Y that has mass 480 g. After the collision, ball X is stationary, as shown in Fig. 2.1.

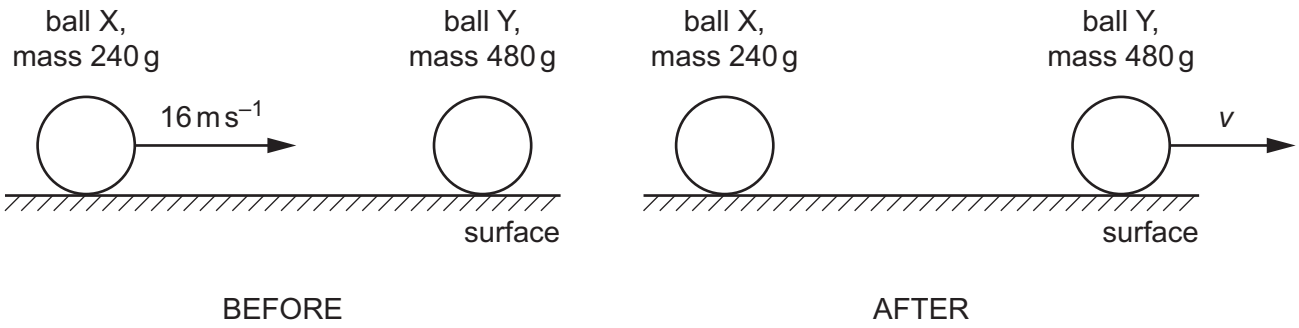


**Fig. 2.1**

**(i)** Show that the speed $v$ of ball Y after the collision is 8.0 m s$^{-1}$.

[1]

**(ii)** Calculate the change in the total kinetic energy $\Delta E_K$ of the balls due to the collision.

$\Delta E_K$ = ..... J [3]

**(c)** The collision in **(b)** lasts for a time of 2.0 ms. Assume that the contact force between the balls is constant during this time.

**(i)** Determine the magnitude and direction of the force exerted on ball X by ball Y during the collision.

magnitude = ..... N

direction .....

[3]

**(ii)** Compare the magnitude and direction of the force exerted on ball Y by ball X during the collision with the answers in **(c)(i)**. No further calculations are required.

.....

.....

..... [2]

[Total: 11]

**3** **(a)** State the principle of moments.

.....

.....

..... [1]

**(b)** A rigid uniform beam rests on a pivot at its centre, as shown in Fig. 3.1.

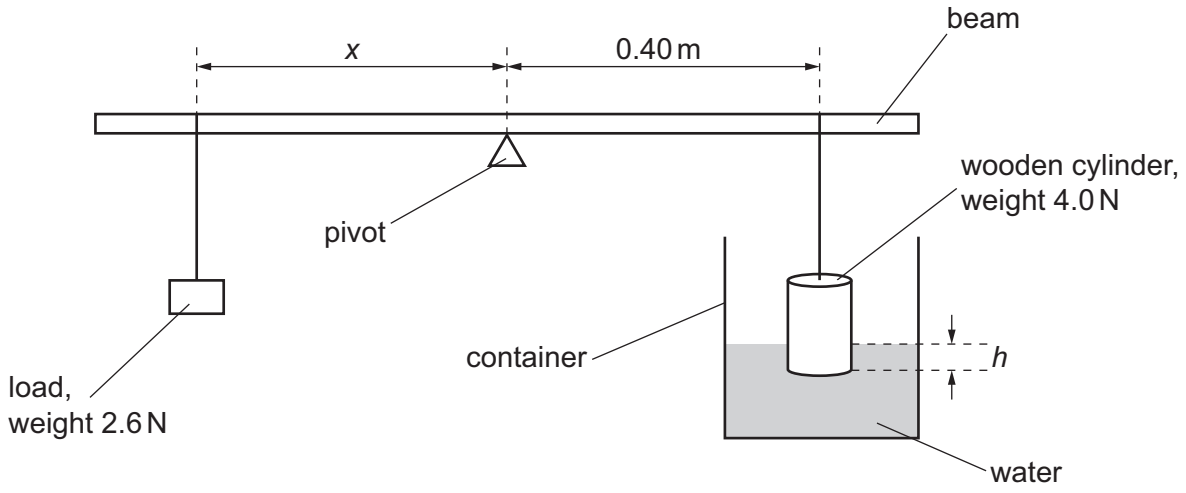


**Fig. 3.1** (not to scale)

A load of weight 2.6 N is suspended from the beam at distance *x* from the pivot.

A wooden cylinder of weight 4.0 N is suspended from the beam at a distance of 0.40 m from the pivot on the opposite side of the pivot to the load. The cylinder rests in a container of water. The lower part of the cylinder is immersed in the water to depth *h*.

Initially, *h* is equal to 0.10 m and *x* is equal to 0.40 m. The system is in equilibrium.

**(i)** Use the principle of moments to show that the upthrust *U* exerted by the water on the cylinder is 1.4 N.

[2]

**(ii)** The density of the water is $1.0 \times 10^3\,\text{kg m}^{-3}$.

Calculate the area $A$ of the circular cross-section of the cylinder.

$A$ = ..... $\text{m}^2$ [3]

**(c)** More water is gradually added to the container in **(b)**, so that depth $h$ in Fig. 3.1 gradually increases. The length $x$ is continuously adjusted so that the system remains in equilibrium.

On Fig. 3.2, sketch the variation of $x$ with $h$. Use the space below for any working.

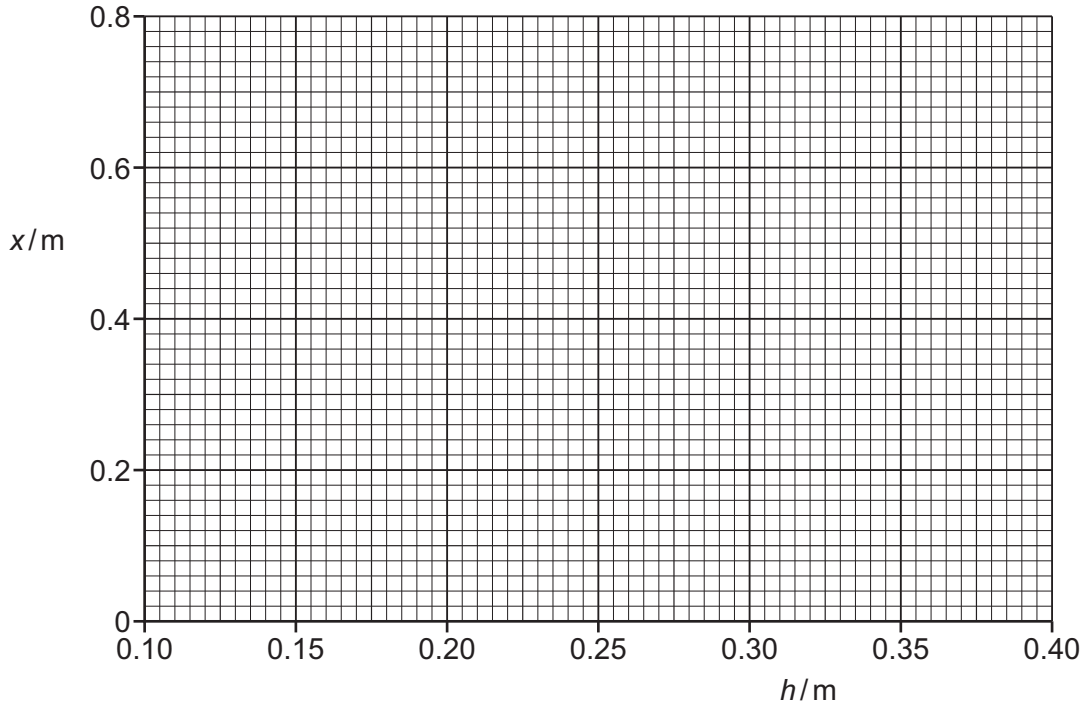


**Fig. 3.2**

[3]

[Total: 9]

**4** **(a)** Define:

**(i)** stress

.....

..... [1]

**(ii)** strain.

.....

..... [1]

**(b)** Two wires X and Y, with equal unstretched lengths of 0.84 m, are suspended from fixed points that are at the same horizontal level. The lower ends of the wires are attached to a beam of negligible mass. The beam is horizontal and in equilibrium, as shown in Fig. 4.1.

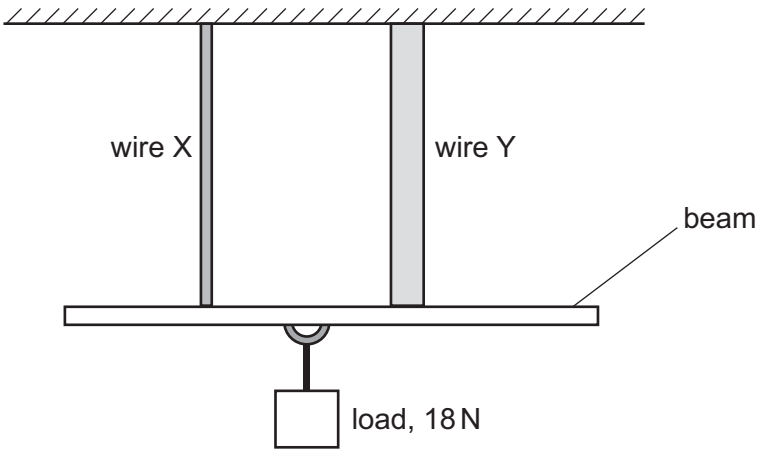


**Fig. 4.1**

Wire X is made from a metal that has a Young modulus of $1.9 \times 10^9$ Pa.
Wire Y is made from a different metal.

A load of weight 18 N is suspended from the beam at a point that is equidistant from the two wires. This load causes both wires to extend by 0.47 mm.

**(i)** Determine the cross-sectional area of wire X.

cross-sectional area = ..... $m^2$ [3]

**(ii)** Wire Y has a greater diameter than wire X.

Explain, without calculation, whether the Young modulus of the metal from which wire Y is made is less than, the same as or greater than $1.9 \times 10^9$ Pa.

.....

.....

.....

..... [2]

[Total: 7]

**5** **(a)** A stationary wave is formed on a string XY that has a length of 0.48 m. Fig. 5.1 shows the string at one instant in time.

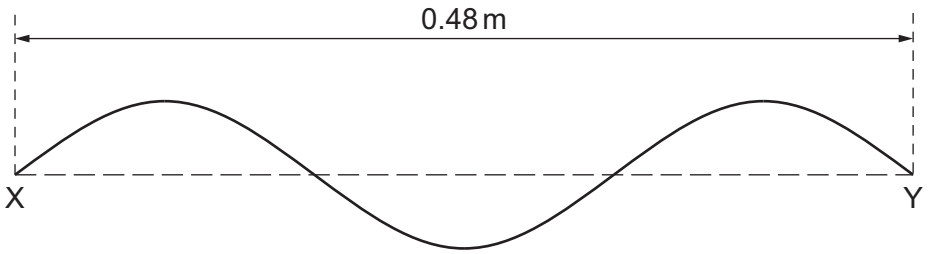


**Fig. 5.1**

The speed of the wave on the string is 1400 m s$^{-1}$.

**(i)** On Fig. 5.1, draw a cross (×) at **one** position that is a node and another cross at **one** position that is an antinode. Label the node N and the antinode A. [1]

**(ii)** Show that the wavelength of the wave produced is 0.32 m. Explain your reasoning.

[1]

**(iii)** Calculate the frequency of the wave.

frequency = ..... Hz [2]

**(b)** A source of sound waves of frequency 780 Hz is on a rotating platform. The speed of the source is 39 m s$^{-1}$.

The sound is detected by an observer that is a large distance from the rotating platform, as shown in Fig. 5.2.

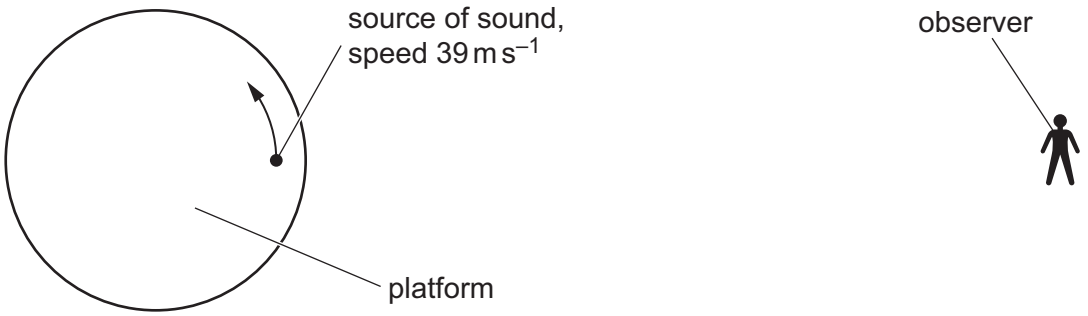


**Fig. 5.2** (not to scale)

**(i)** The speed of sound in air is 320 m s$^{-1}$.

Calculate the maximum frequency of the sound detected by the observer.

maximum frequency = ..... Hz [2]

**(ii)** At time $t$ = 0, the observer detects the sound emitted by the source when it was in the position shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with $t$ of the frequency $f$ of the sound detected by the observer for one complete rotation of the platform. Calculations are not required.

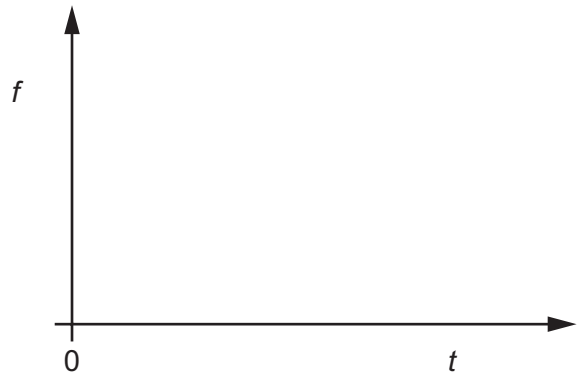


**Fig. 5.3**

[2]

[Total: 8]

**6** **(a)** Define resistance.

.....

..... [1]

**(b)** A cylindrical metal wire of length 2.4 m and cross-sectional area $8.0 \times 10^{-6}\,m^2$ has a resistance of 0.33 Ω. There is a current in the wire of 4.7 A.

**(i)** Determine the resistivity of the metal from which the wire is made.

resistivity = ..... Ω m [2]

**(ii)** Calculate the charge that passes through the wire in a time of 5.0 minutes.

charge = ..... C [2]

**(iii)** The free electrons (charge carriers) in the wire have an average drift speed of $0.16\,mm\,s^{-1}$.

Determine the number density of charge carriers in the metal.

number density = ..... $m^{-3}$ [2]

**(c)** The wire in **(b)** may be considered to be a fixed resistor. It is connected in series with a thermistor to a battery that has negligible internal resistance.

**(i)** Use circuit symbols to complete Fig. 6.1 to show the circuit diagram of this arrangement.

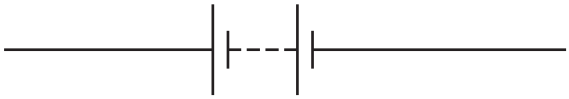

**Fig. 6.1**

[1]

**(ii)** Explain, without calculation, how the power dissipated in the wire changes as the temperature of the thermistor is increased.

.....

.....

.....

..... [2]

[Total: 10]

**7** **(a)** Complete Table 7.1 to show the charges, in terms of the elementary charge *e*, on each of the flavours of quark and antiquark shown.

**Table 7.1**

| flavour | charge / *e* | |
|---|---|---|
| | quark | antiquark |
| up | | |
| down | | |
| strange | | |

[3]

**(b)** **(i)** State the name of the class (group) of fundamental particles to which baryons and mesons belong.

..... [1]

**(ii)** Compare baryons and mesons in terms of their constituent particles.

.....

.....

..... [2]

**(c)** Describe $\beta^+$ decay in terms of the fundamental particles involved.

.....

.....

.....

..... [2]

[Total: 8]