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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6377769973778

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.

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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_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	ε_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	σ	=	$5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
hydrostatic pressure	Δp	=	$\rho g \Delta h$
upthrust	F	=	$\rho g V$
Doppler effect for sound waves	f_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.

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..... [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.

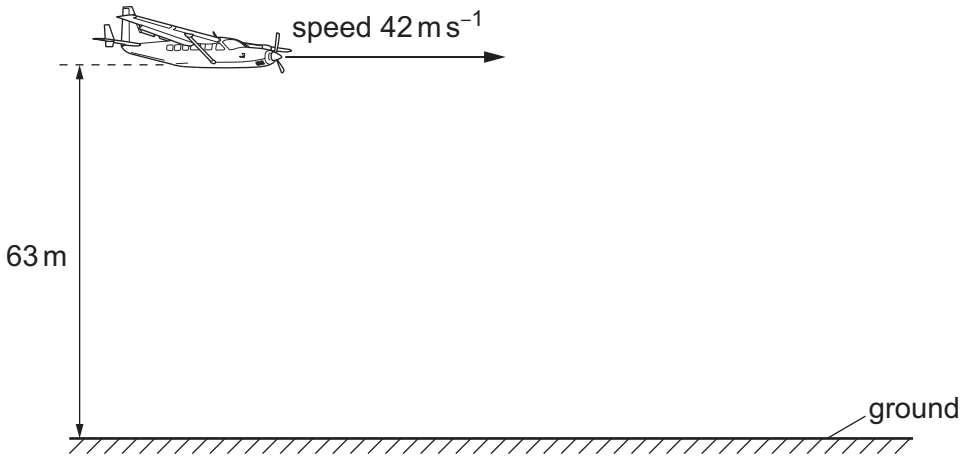

Fig. 1.1

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]

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(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]

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

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..... [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.

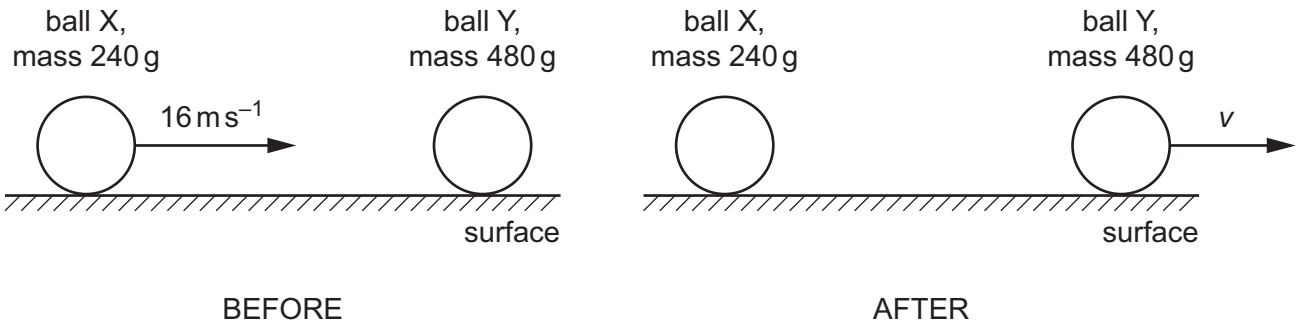

Fig. 2.1

(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 ΔE_K of the balls due to the collision.

ΔE_K = ... J [3]

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(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]

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

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..... [1]

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

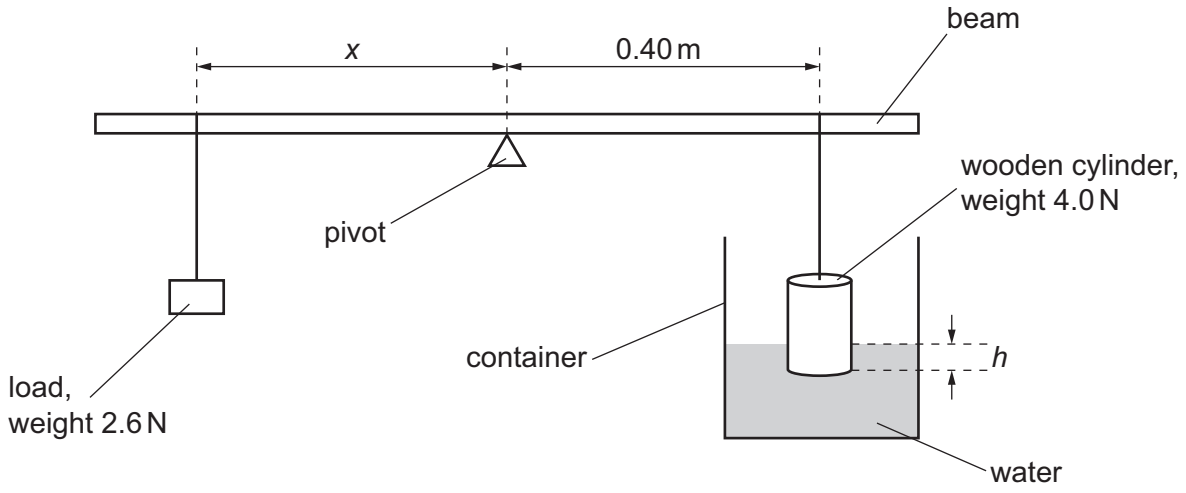

Fig. 3.1 (not to scale)

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]

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(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 = ... 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.

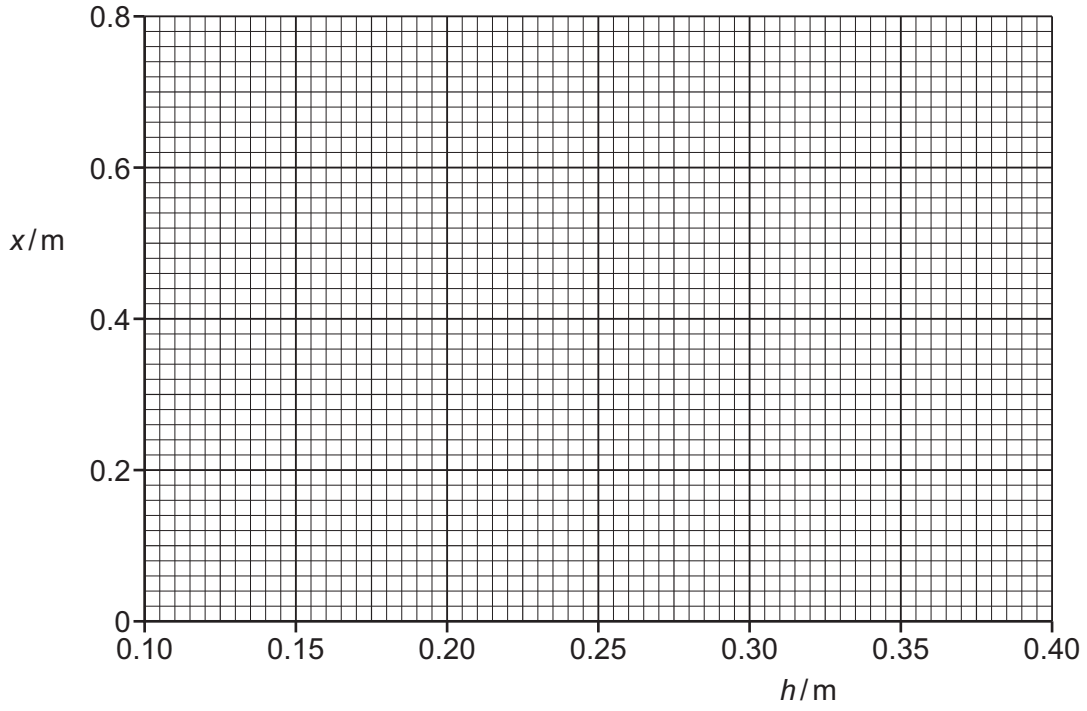

Fig. 3.2

[3]

[Total: 9]

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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.

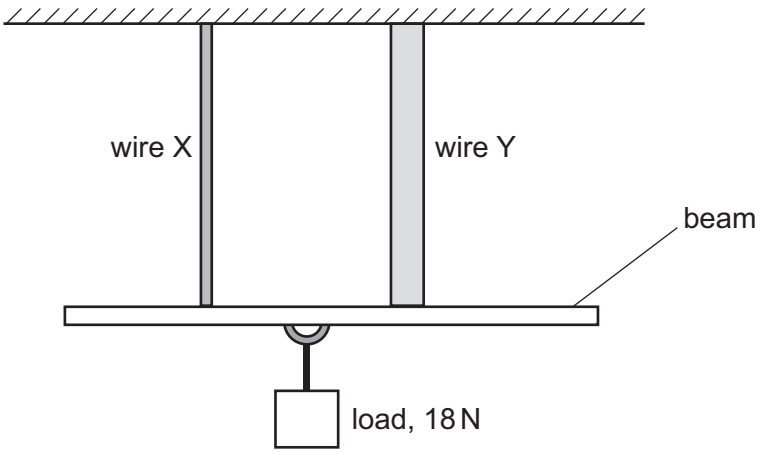

Fig. 4.1

Wire X is made from a metal that has a Young modulus of 1.9×10^9 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.

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(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 1.9×10^9 Pa.

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..... [2]

[Total: 7]

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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.

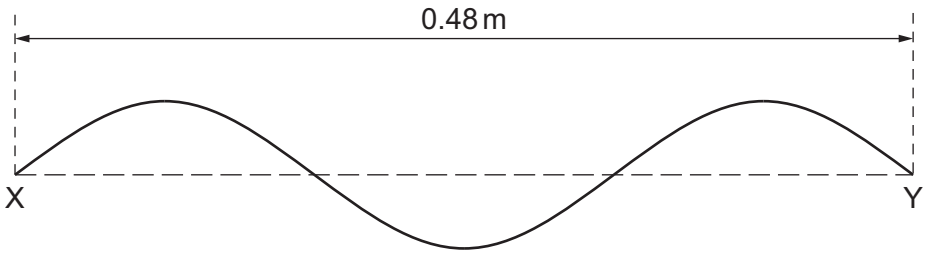

Fig. 5.1

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]

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(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.

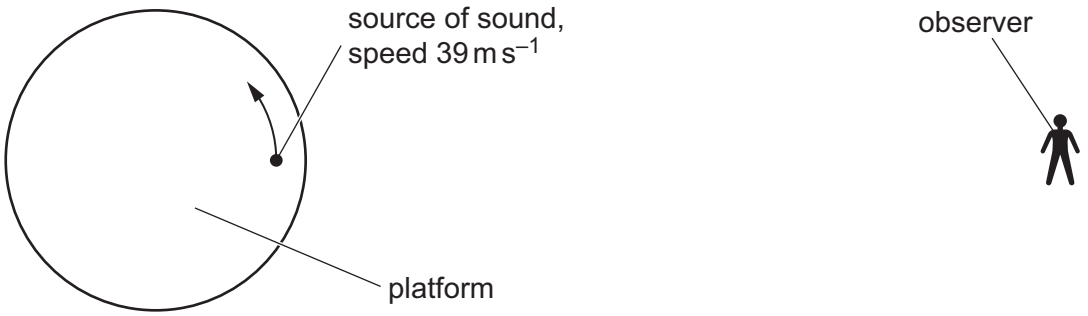

Fig. 5.2 (not to scale)

(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.

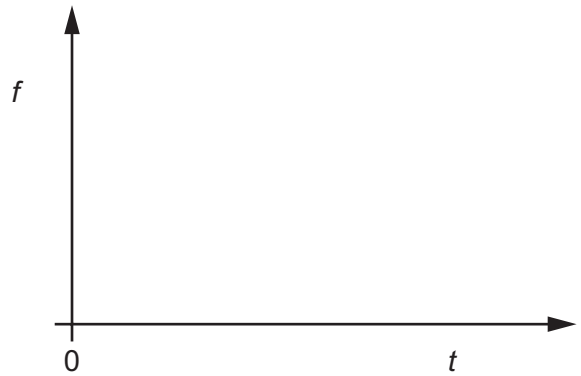

Fig. 5.3

[2]

[Total: 8]

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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]

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(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.

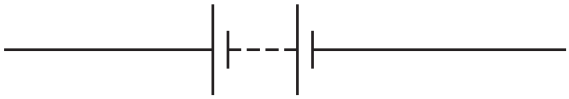

Fig. 6.1

[1]

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

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..... [2]

[Total: 10]

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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 β^+ decay in terms of the fundamental particles involved.

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.....

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..... [2]

[Total: 8]

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