



Cambridge International AS & A Level

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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.

**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	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$



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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.

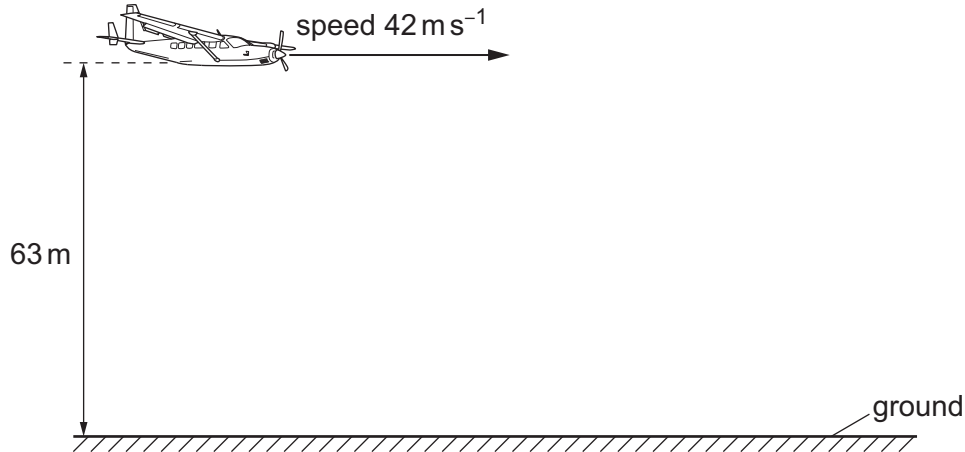


Fig. 1.1

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 = ms^{-1} [1]

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

speed = ms^{-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.

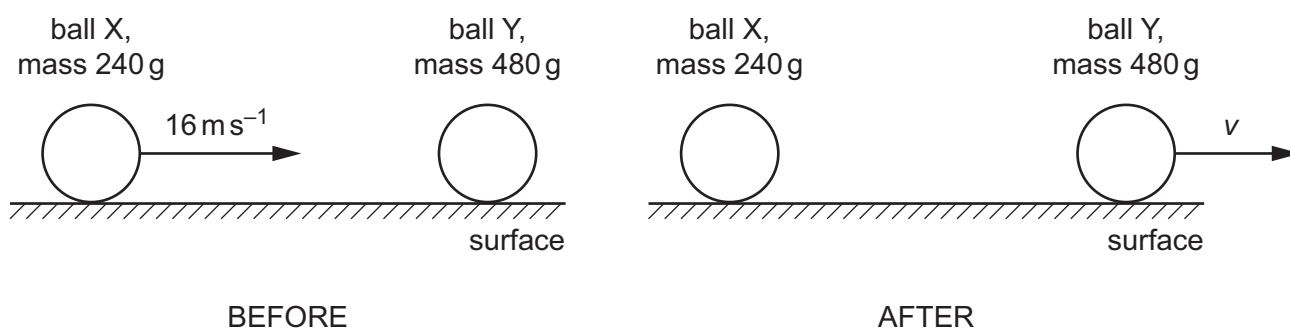


Fig. 2.1

- (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 ΔE_K of the balls due to the collision.

$\Delta E_K = \dots\dots\dots \text{ J [3]}$





(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.

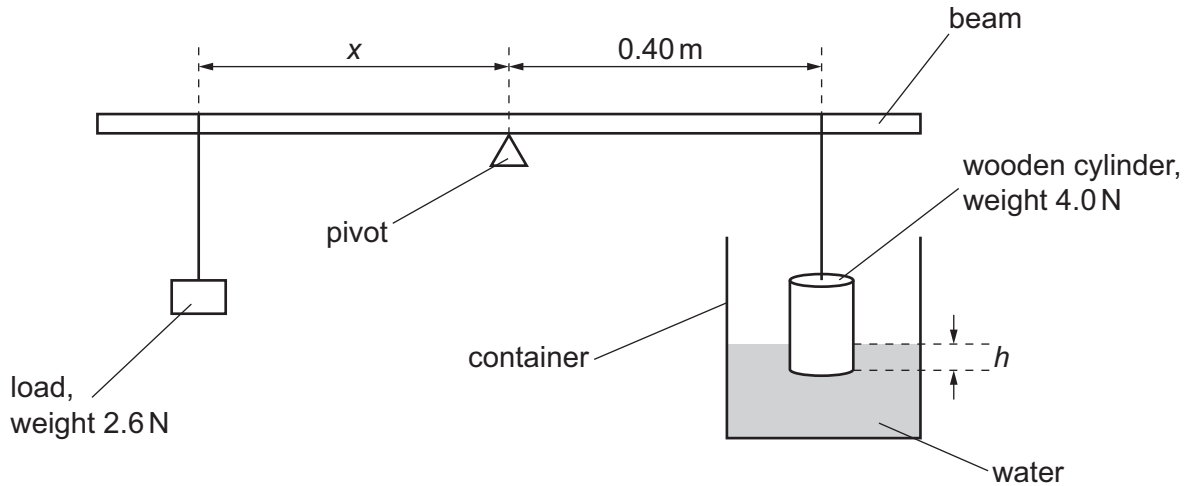


Fig. 3.1 (not to scale)

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.

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

- (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.

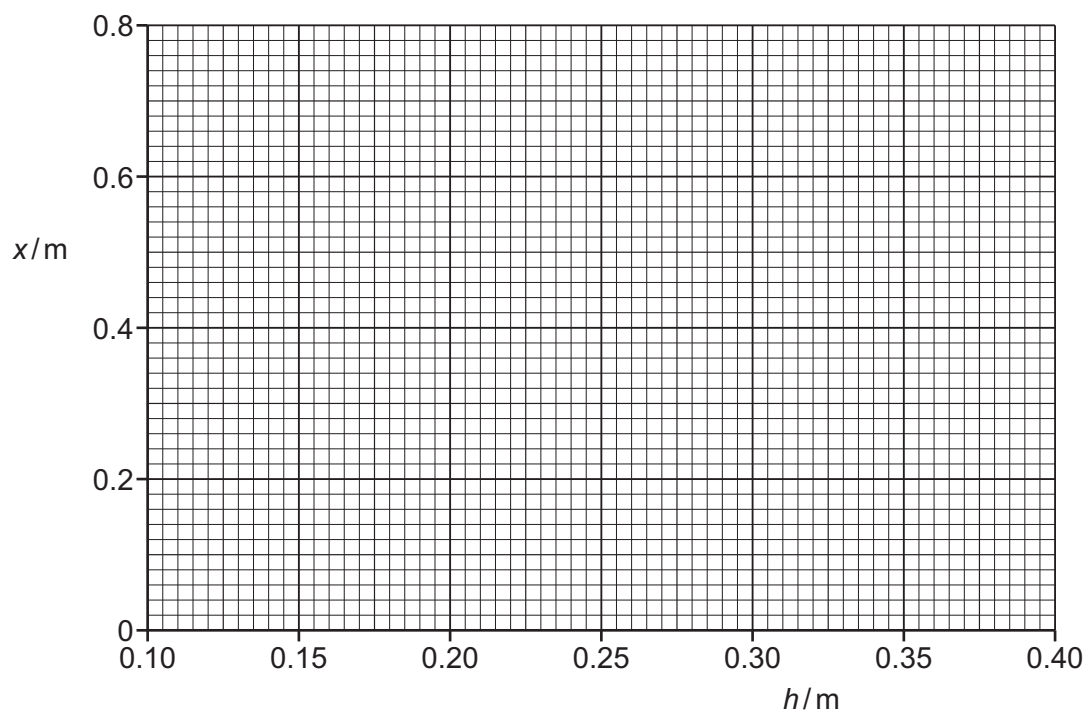


Fig. 3.2

[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.

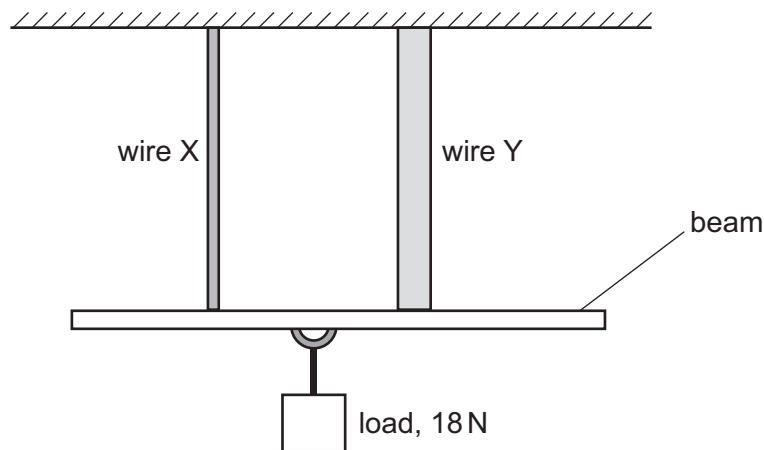


Fig. 4.1

Wire X is made from a metal that has a Young modulus of 1.9×10^9 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 = m² [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.

.....
.....
.....
..... [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.

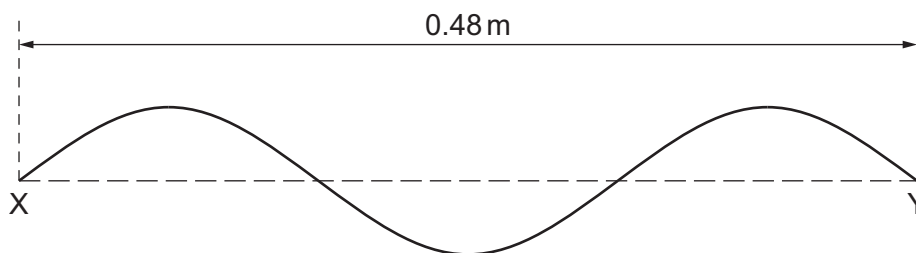


Fig. 5.1

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.

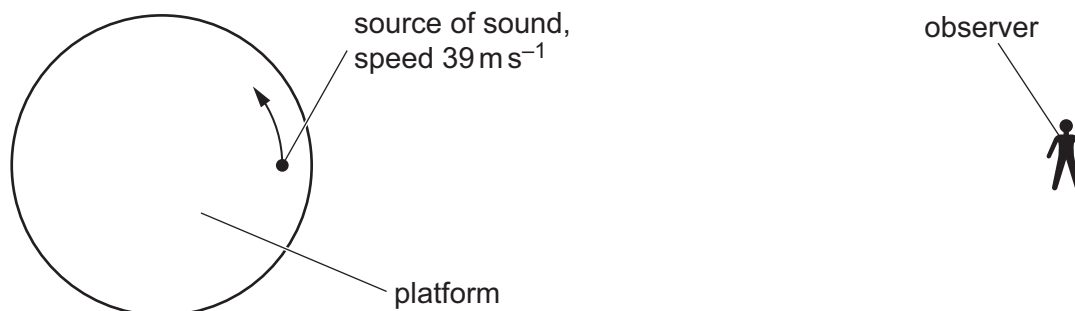


Fig. 5.2 (not to scale)

- (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 $8.0 \times 10^{-6} \text{ m}^2$ has a resistance of 0.33Ω . 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 = $\Omega \text{ m}$ [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.

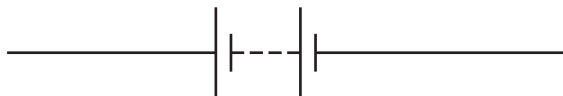


Fig. 6.1

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

.....

 [2]

[Total: 8]

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