Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1805904974

PHYSICS **9702/22**

Paper 2 AS Level Structured Questions **October/November 2023**

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.

DC (RW/SG) 313481/2

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	ε_0	$= 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$(\frac{1}{4\pi\varepsilon_0}$	$= 8.99 \times 10^{9}\ \text{m F}^{-1})$
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	$= \dfrac{f_s v}{v \pm v_s}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R}$	$= \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

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1 **(a)** In the following list, underline **all** quantities that are SI base quantities.

charge electric current force time [1]

(b) Under certain conditions, the distance s moved in a straight line by an object in time t is given by

$$s = \frac{1}{2}at^2$$

where a is the acceleration of the object.

State **two** conditions under which the above expression applies to the motion of the object.

1 ....

2 ....
[2]

(c) The variation with time t of the velocity v of a car that is moving in a straight line is shown in Fig. 1.1.

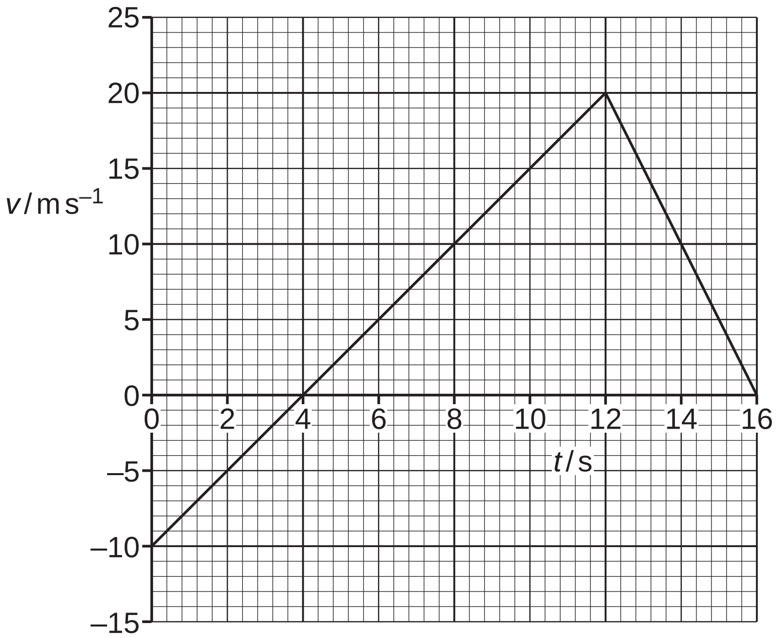


Fig. 1.1

(i) Compare, qualitatively, the acceleration of the car at time $t = 8.0\,s$ and at time $t = 14.0\,s$ in terms of:

- magnitude

....

....

- direction.

....

....
[2]

(ii) Determine the magnitude of the acceleration of the car at time $t = 4.0\,s$.

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

(iii) The car is at point X at time $t = 0$.

Determine the magnitude of the displacement of the car from X at time $t = 12.0\,s$.

displacement = ... m [2]

[Total: 9]

2 A high-altitude balloon is stationary in still air. A solid sphere is suspended from the balloon by a string, as shown in Fig. 2.1.

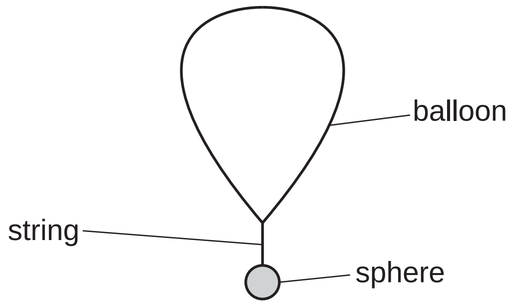


Fig. 2.1 (not to scale)

The volume of the balloon is 7.5 m^3. The total weight of the balloon, string and sphere is 65 N. The upthrust acting on the string and sphere is negligible.

(a) Calculate the density of the air surrounding the balloon.

density = ... $kg\,m^{-3}$ [2]

(b) The string breaks, releasing the sphere.

(i) State the magnitude of the acceleration of the sphere immediately after the string breaks.

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

(ii) State and explain the variation, if any, in the magnitude of the acceleration of the sphere when it is moving downwards **before** it reaches terminal (constant) velocity.

....

....

....

....

....

....

.... [3]

(c) The sphere has a mass of 4.0 kg.

Calculate the total resistive force acting on the sphere at the instant when its acceleration is $1.9\,m\,s^{-2}$.

resistive force = ... N [2]

[Total: 8]

3 A vertical rod is fixed to the horizontal surface of a table, as shown in Fig. 3.1.

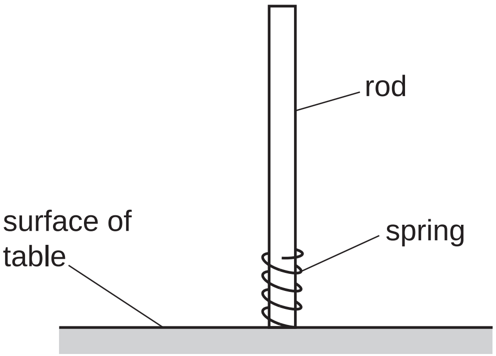


Fig. 3.1 (not to scale)

A spring of mass 7.5 g is able to slide along the full length of the rod.

The spring is first pushed against the surface of the table so that it has an initial compression of 2.1 cm. The spring is then suddenly released so that it leaves the surface of the table with a kinetic energy of 0.048 J and then moves up the rod.

Assume that the spring obeys Hooke's law and that the initial elastic potential energy of the compressed spring is equal to the kinetic energy of the spring as it leaves the surface of the table. Air resistance is negligible.

(a) By using the initial elastic potential energy of the compressed spring, calculate its spring constant.

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

(b) Calculate the speed of the spring as it leaves the surface of the table.

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

(c) The spring rises to its maximum height up the rod from the surface of the table. This causes the gravitational potential energy of the spring to increase by 0.039 J.

(i) Calculate, for this movement of the spring, the increase in height of the spring after leaving the surface of the table.

increase in height = ... m [2]

(ii) Calculate the average frictional force exerted by the rod on the spring as it rises.

average frictional force = ... N [2]

(d) The rod is replaced by another rod that exerts negligible frictional force on the moving spring. The initial compression x of the spring is now varied in order to vary the maximum increase in height Δh of the spring after leaving the surface of the table. Assume that the spring obeys Hooke's law for all compressions.

On Fig. 3.2, sketch a graph to show the variation with x of Δh. Numerical values are not required.

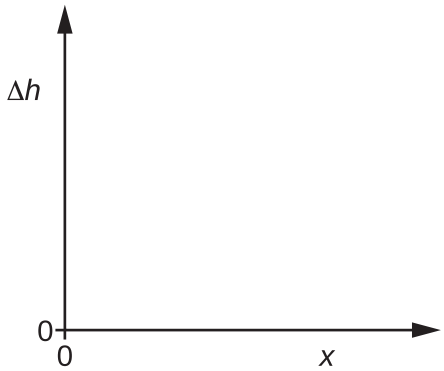
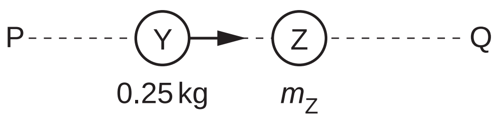


Fig. 3.2

[2]

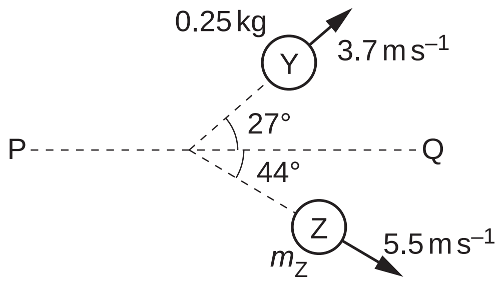
[Total: 10]

4 **(a)** A ball Y moves along a horizontal frictionless surface and collides with a ball Z, as illustrated in the views from above in Fig. 4.1 and Fig. 4.2.



BEFORE COLLISION

Fig. 4.1 (not to scale)



AFTER COLLISION

Fig. 4.2 (not to scale)

Ball Y has a mass of 0.25 kg and initially moves along a line PQ.
Ball Z has a mass m_Z and is initially stationary.

After the collision, ball Y has a final velocity of 3.7 m s^{-1} at an angle of 27° to line PQ and ball Z has a final velocity of 5.5 m s^{-1} at an angle of 44° to line PQ.

(i) Calculate the component of the final momentum of ball Y in the direction perpendicular to line PQ.

component of momentum = ... N s [2]

(ii) By considering the component of the final momentum of each ball in the direction perpendicular to line PQ, calculate m_Z.

m_Z = ... kg [1]

(iii) During the collision, the average force exerted on Y by Z is F_Y and the average force exerted on Z by Y is F_Z.

Compare the magnitudes and directions of F_Y and F_Z. Numerical values are not required.

magnitudes: ....

directions: ....
[2]

(b) Two blocks, A and B, move directly towards each other along a horizontal frictionless surface, as shown in the view from above in Fig. 4.3.

Fig. 4.3

The blocks collide perfectly elastically. Before the collision, block A has a speed of $4\,m\,s^{-1}$ and block B has a speed of $6\,m\,s^{-1}$. After the collision, block B moves back along its original path with a speed of $2\,m\,s^{-1}$.

Calculate the speed of block A after the collision.

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

[Total: 6]

5 **(a)** A beam of vertically polarised light is incident normally on a polarising filter, as shown in Fig. 5.1.

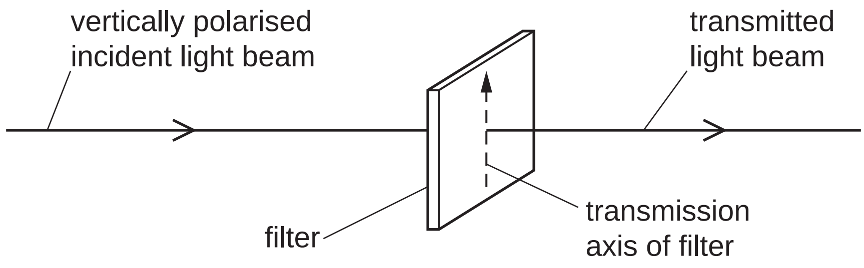


Fig. 5.1

(i) The transmission axis of the filter is initially vertical. The filter is then rotated through an angle of 360° while the plane of the filter remains perpendicular to the beam.

On Fig. 5.2, sketch a graph to show the variation of the intensity of the light in the transmitted beam with the angle through which the transmission axis is rotated.

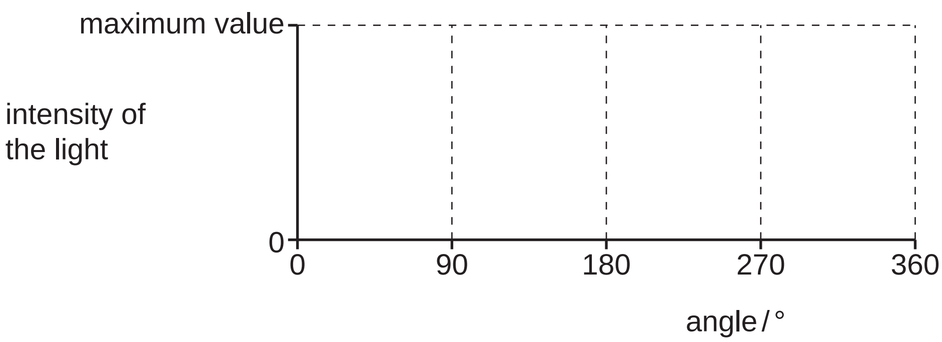


Fig. 5.2

[2]

(ii) The intensity of the light in the incident beam is $7.6\,\mathrm{W\,m^{-2}}$. When the transmission axis of the filter is at angle θ to the vertical, the light intensity of the transmitted beam is $4.2\,\mathrm{W\,m^{-2}}$.

Calculate angle θ.

θ = ...° [2]

(b) State what is meant by the diffraction of a wave.

....

....

.... [2]

(c) A beam of light of wavelength 4.3×10^{-7} m is incident normally on a diffraction grating in air, as shown in Fig. 5.3.

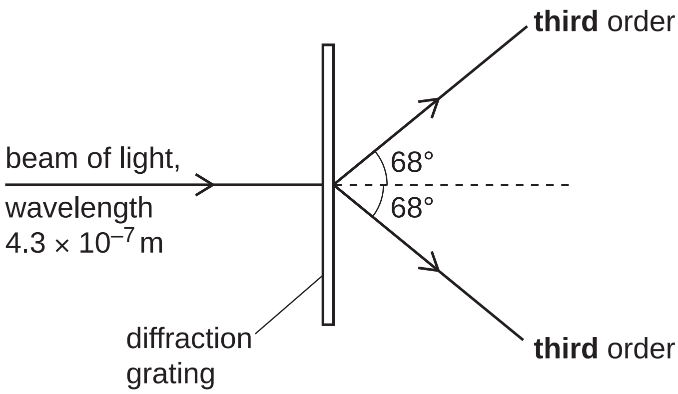


Fig. 5.3 (not to scale)

The **third**-order diffraction maximum of the light is at an angle of 68° to the direction of the incident light beam.

(i) Calculate the line spacing d of the diffraction grating.

d = ... m [2]

(ii) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 68°.

wavelength = ... m [2]

[Total: 10]

6 **(a)** A metal wire has a resistance per unit length of 0.92 Ω m^{-1}. The wire has a uniform cross-sectional area of 5.3×10^{-7} m^2.

Calculate the resistivity of the metal of the wire.

resistivity = ... Ω m [2]

(b) A battery of electromotive force (e.m.f.) *E* and negligible internal resistance is connected in series with a fixed resistor and a light-dependent resistor (LDR), as shown in Fig. 6.1.

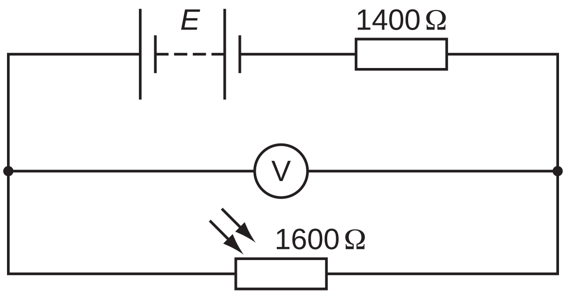


Fig. 6.1

The resistance of the fixed resistor is 1400 Ω. The intensity of the light illuminating the LDR causes it to have a resistance of 1600 Ω. A voltmeter connected across the LDR reads 6.4 V.

(i) Show that the current in the LDR is 4.0×10^{-3} A.

[1]

(ii) Calculate the number of free electrons passing through the LDR in a time of 3.2 minutes.

number of free electrons = ... [2]

(iii) Calculate the e.m.f. E.

E = ... V [2]

(iv) Determine the ratio

$$\frac{\text{power dissipated in LDR}}{\text{power dissipated in fixed resistor}}.$$

ratio = ... [2]

(c) The environmental conditions change causing a decrease in the resistance of the LDR in **(b)**. The temperature of the environment does not change.

State whether there is a decrease, increase or no change to:

(i) the intensity of the light illuminating the LDR

.... [1]

(ii) the current in the battery

.... [1]

(iii) the reading of the voltmeter.

.... [1]

[Total: 12]

7 **(a)** In the following list, underline **all** the particles that are **not** fundamental.

antineutrino baryon nucleon positron [1]

(b) A nucleus of thorium-230 ($^{230}_{90}Th$) decays in stages, by emitting α-particles and β^- particles, to form a nucleus of lead-206 ($^{206}_{82}Pb$).

Determine the total number of α-particles and the total number of β^- particles that are emitted during the sequence of decays that form the nucleus of lead-206 from the nucleus of thorium-230.

number of α-particles = ...

number of β^- particles = ...
[2]

(c) A meson has a charge of –1*e*, where *e* is the elementary charge. The quark composition of the meson includes a charm antiquark.

State and explain a possible flavour (type) of the other quark in the meson.

....

.... [2]

[Total: 5]