



Cambridge International AS & A Level

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PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 2022

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 **20** pages. Any blank pages are indicated.

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	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
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) The boxes in Fig. 1.1 contain terms on the left-hand side and examples of these terms on the right-hand side.

Draw a line between each term on the left and the correct example on the right.

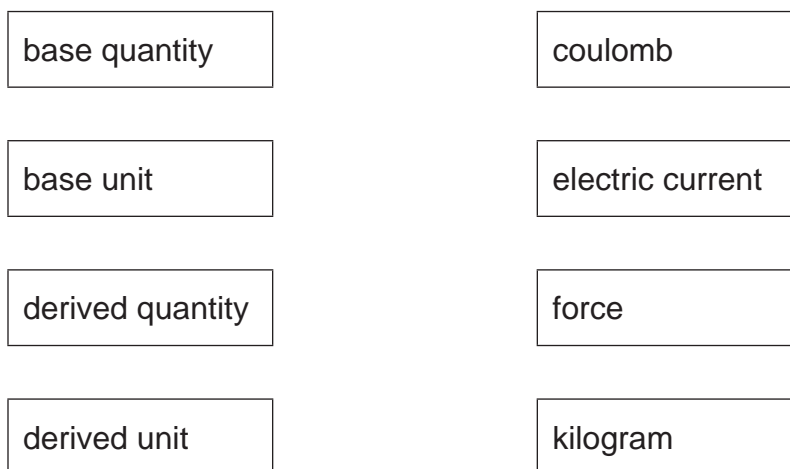


Fig. 1.1

[2]

- (b) A set of experimental measurements is described as precise and not accurate.

State what is meant by:

- (i) precise

.....
 [1]

- (ii) not accurate.

.....
 [1]

5

- (c) An object of mass m travels with speed v in a circle of radius r . The force F acting on the object is given by

$$F = \frac{mv^2}{r}.$$

The percentage uncertainties of three of the quantities are given in Table 1.1.

Table 1.1

quantity	percentage uncertainty
F	$\pm 3\%$
m	$\pm 4\%$
r	$\pm 5\%$

The value of v is determined from F , m and r .

- (i) Calculate the percentage uncertainty in v .

percentage uncertainty = % [2]

- (ii) The value of v is 15.0 m s^{-1} .

Calculate the absolute uncertainty in v .

absolute uncertainty = m s^{-1} [1]

[Total: 7]

6

- 2 A steel ball is projected horizontally from the top of a table, as shown in Fig. 2.1.

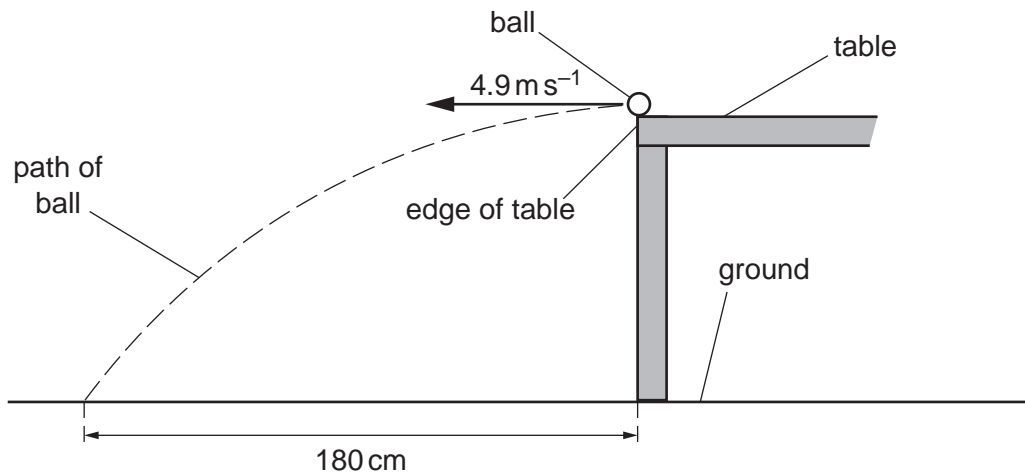


Fig. 2.1 (not to scale)

The ball is projected horizontally at a speed of 4.9 m s^{-1} . The ball lands on the ground a horizontal distance of 180 cm from the edge of the table.

Assume that air resistance is negligible.

- (a) (i) Calculate the time taken for the ball to reach the ground.

time = s [1]

- (ii) Calculate the vertical component of the velocity of the ball as it hits the ground.

velocity = m s^{-1} [2]

- (iii) Determine the magnitude and the angle to the horizontal of the velocity of the ball as it hits the ground.

magnitude of velocity = ms^{-1}

angle to the horizontal = $^{\circ}$
[3]

- (b) The ball is projected by means of a compressed spring which is attached to a fixed block as shown in Fig. 2.2.

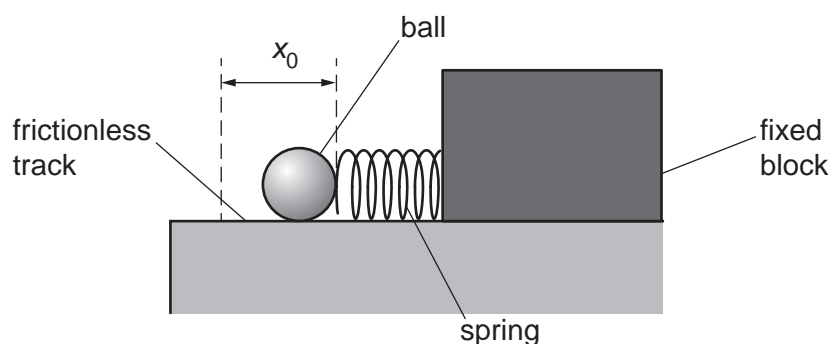


Fig. 2.2

The ball is placed on a frictionless track in front of the spring. The ball is then pulled back so that the spring has compression x_0 .

When the spring is released, the ball is projected horizontally as shown in Fig. 2.3.

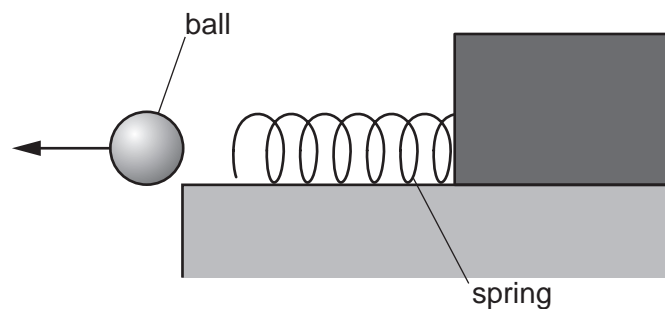


Fig. 2.3

The variation with compression x of the applied force F for the spring is shown in Fig. 2.4.

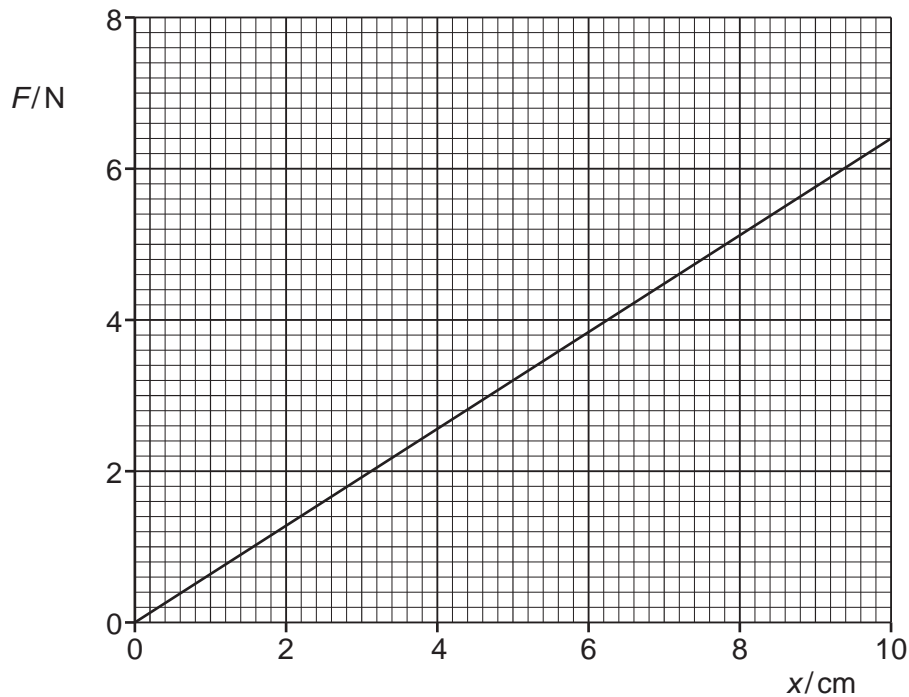


Fig. 2.4

The ball is a uniform sphere of steel of diameter 0.016 m and mass 0.017 kg.

- (i) Calculate the density of the steel.

density = kg m^{-3} [3]

- (ii) All of the elastic potential energy in the spring is converted into kinetic energy of the ball. The speed of the ball as it leaves the spring is 4.9 m s^{-1} .

Show that the maximum elastic potential energy of the spring is 0.20 J.

[2]

(iii) Use Fig. 2.4 to determine the spring constant k of the spring.

$$k = \dots\dots\dots \text{Nm}^{-1} \quad [2]$$

(iv) Use your answer in (b)(iii) and the value of energy given in (b)(ii) to determine the compression x_0 of the spring.

$$x_0 = \dots\dots\dots \text{m} \quad [2]$$

(c) The steel ball is replaced by a polystyrene ball of the same diameter but of much lower mass. The spring is given compression x_0 and is then released.

Air resistance on this ball is **not** negligible after it leaves the spring.

Explain:

(i) why this ball leaves the spring with a greater speed than that of the steel ball

.....

 [1]

(ii) why this ball takes a longer time to reach the ground than the steel ball.

.....

 [1]

[Total: 17]

3 (a) (i) Define power.

.....
..... [1]

(ii) Mechanical power P can be calculated using the formula $P = Fv$.

Use the concept of work and the definition of power to show how this formula is derived.

[2]

(b) The engine of a lorry provides 130 kW of power to the lorry's wheels when it is travelling at a constant speed of 25 m s^{-1} along a straight horizontal road.

Show that the resistive force opposing the forward motion of the lorry is 5200 N.

[1]

- (c) The lorry in (b) travels up a straight section of road that is inclined at an angle θ to the horizontal, as shown in Fig. 3.1.

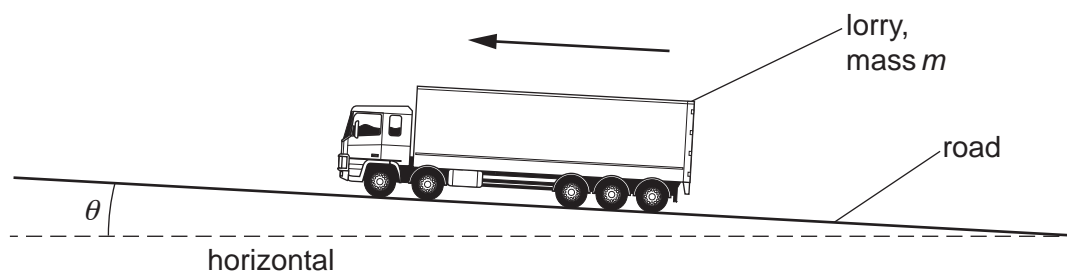


Fig. 3.1 (not to scale)

The lorry has mass m and the acceleration of free fall is g .

- (i) Determine an expression, in terms of m , g and θ , for the component of the weight of the lorry that acts parallel to the surface of the road.

[1]

- (ii) The total resistive force remains unchanged at 5200 N and the engine now provides greater power to maintain the speed of 25 m s^{-1} . The total mass m of the lorry is 36 000 kg. The angle θ is 1.4° .

Determine the power, in kW, now provided by the engine.

power = kW [3]

[Total: 8]

4 (a) Polarisation is a phenomenon associated with light waves but not with sound waves.

(i) State the meaning of polarisation.

.....

 [1]

(ii) State why light waves can be plane polarised but sound waves cannot.

.....

 [1]

(b) Two polarising filters A and B are positioned so that their planes are parallel to each other and perpendicular to a central axis line XY, as shown in Fig. 4.1.

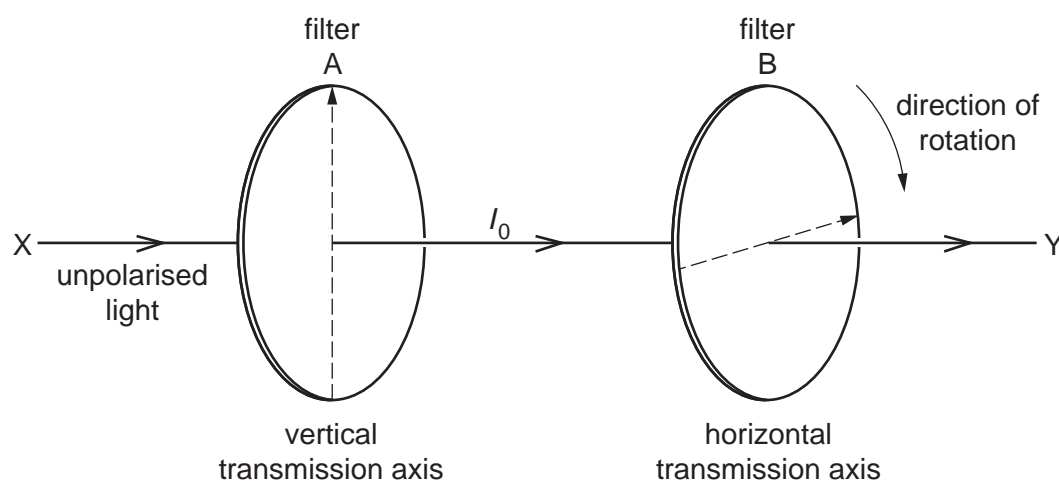


Fig. 4.1

The transmission axis of filter A is vertical and the transmission axis of filter B is horizontal.

Unpolarised light of a single frequency is directed along the line XY from a source positioned at X. The light emerging from filter A is vertically plane polarised and has intensity I_0 .

Filter B is rotated from its starting position about the line XY, as shown in Fig. 4.1.

After rotation, the intensity of the light emerging from filter B is $\frac{1}{4} I_0$.

Calculate the angle of rotation of filter B from its starting position.

angle of rotation = ° [3]

- (c) A microwave of intensity I_0 and amplitude A_0 meets another microwave of the same frequency and of intensity $\frac{1}{4} I_0$ travelling in the opposite direction. Both microwaves are vertically plane polarised and superpose where they meet.

- (i) Explain, without calculation, why these two waves cannot form a stationary wave with zero amplitude at its nodes.

.....

 [2]

- (ii) Determine, in terms of A_0 , the maximum amplitude of the wave formed.

maximum amplitude = A_0 [3]

[Total: 10]

5 (a) State Ohm's law.

.....

 [2]

(b) The variation of current I with potential difference V for a filament lamp is shown in Fig. 5.1.

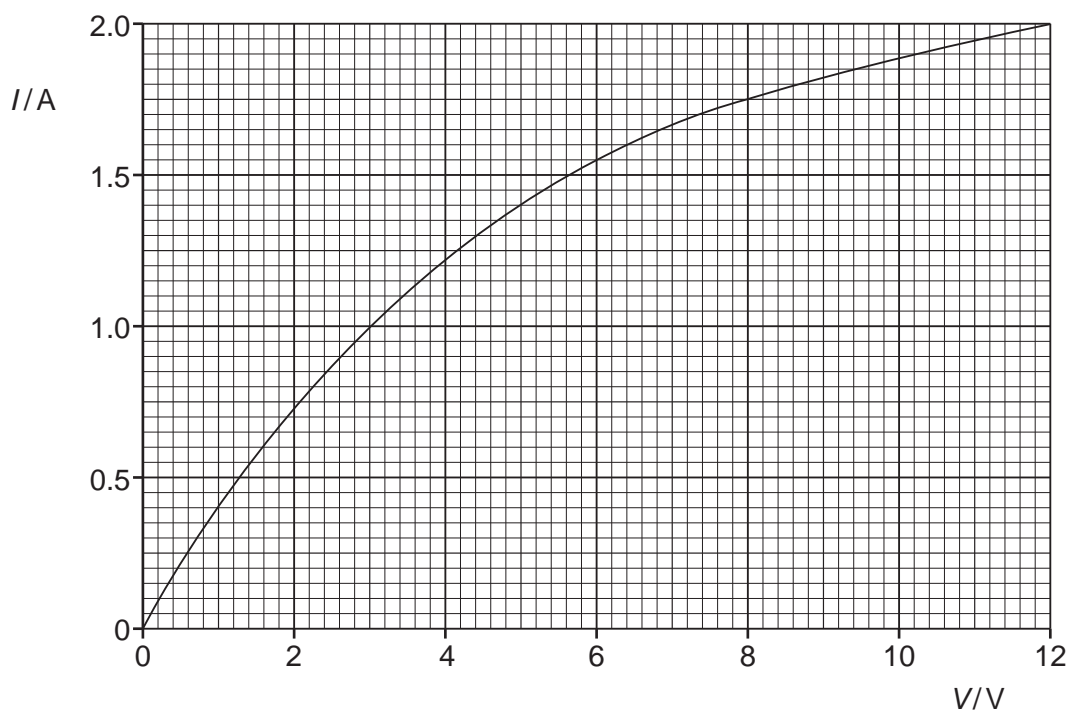


Fig. 5.1

The resistance of the filament lamp increases with potential difference.

(i) State how Fig. 5.1 shows this.

.....
 [1]

(ii) Explain why the resistance varies in this way.

.....
 [1]

- (c) Fig. 5.2 shows a circuit with a battery of electromotive force (e.m.f.) 12.0V connected to a linear potentiometer AB and two identical filament lamps P and Q.

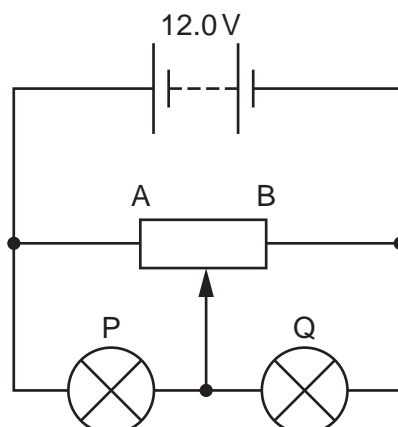


Fig. 5.2

The battery has negligible internal resistance and the lamps each have the same I - V characteristic shown in Fig. 5.1.

When the slider of the potentiometer is at its midpoint, as shown in Fig. 5.2, the current I in the battery is 1.78A.

Determine:

- (i) the current in lamp P

current = A [1]

- (ii) the total power dissipated in lamps P and Q

total power = W [2]

- (iii) the resistance of the potentiometer between its ends A and B.

resistance = Ω [2]

(d) The slider of the potentiometer in (c) is moved to end A.

State and explain the effect on the brightness of lamps P and Q.

lamp P:

.....

lamp Q:

.....

[2]

[Total: 11]

- 6 (a) A lepton is an example of a fundamental particle.

State what is meant by fundamental particle.

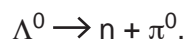
.....
 [1]

- (b) A lambda particle Λ^0 is a hadron that consists of an up (u) quark, a down (d) quark and a strange (s) quark.

Show that the charge on the Λ^0 particle is zero.

[2]

- (c) The Λ^0 particle is unstable. It can decay into a neutron (n) and a pion (π^0) as shown by



The π^0 particle consists of an up quark and an up antiquark.

- (i) Compare the properties of an up quark and an up antiquark.

.....

 [2]

- (ii) Explain why the neutron is classed as a baryon and the π^0 particle is classed as a meson.

.....

 [2]

[Total: 7]

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