



# Cambridge International AS & A Level

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**PHYSICS**

**9702/22**

Paper 2 AS Level Structured Questions

**May/June 2020**

**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. Blank pages are indicated.

**Data**

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
	$(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

## Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$



Answer **all** the questions in the spaces provided.

- 1 (a) Define *velocity*.

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

- (b) The drag force  $F_D$  acting on a car moving with speed  $v$  along a straight horizontal road is given by

$$F_D = v^2 Ak$$

where  $k$  is a constant and  $A$  is the cross-sectional area of the car.

Determine the SI base units of  $k$ .

SI base units ..... [2]

- (c) The value of  $k$ , in SI base units, for the car in (b) is 0.24. The cross-sectional area  $A$  of the car is  $5.1 \text{ m}^2$ .

The car is travelling with a constant speed along a straight road and the output power of the engine is  $4.8 \times 10^4 \text{ W}$ . Assume that the output power of the engine is equal to the rate at which the drag force  $F_D$  is doing work against the car.

Determine the speed of the car.

speed = .....  $\text{ms}^{-1}$  [3]

[Total: 6]

- 2 (a) Fig. 2.1 shows the velocity–time graph for an object moving in a straight line.

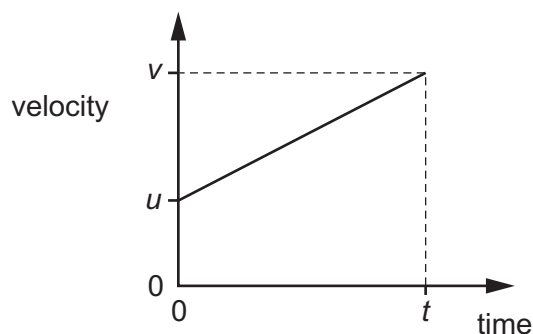


Fig. 2.1

- (i) Determine an expression, in terms of  $u$ ,  $v$  and  $t$ , for the area under the graph.

area = ..... [1]

- (ii) State the name of the quantity represented by the area under the graph.

..... [1]

- (b) A ball is kicked with a velocity of  $15 \text{ m s}^{-1}$  at an angle of  $60^\circ$  to horizontal ground. The ball then strikes a vertical wall at the instant when the path of the ball becomes horizontal, as shown in Fig. 2.2.

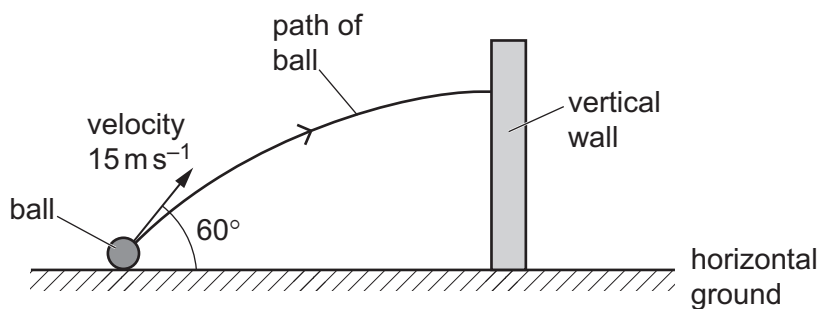


Fig. 2.2 (not to scale)

Assume that air resistance is negligible.

- (i) By considering the vertical motion of the ball, calculate the time it takes to reach the wa...

time = ..... s [3]

- (ii) Explain why the horizontal component of the velocity of the ball remains constant as it moves to the wall.

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

- (iii) Show that the ball strikes the wall with a horizontal velocity of  $7.5 \text{ m s}^{-1}$ .

[1]

- (c) The mass of the ball in (b) is  $0.40 \text{ kg}$ . It is in contact with the wall for a time of  $0.12 \text{ s}$  and rebounds horizontally with a speed of  $4.3 \text{ m s}^{-1}$ .

- (i) Use the information from (b)(iii) to calculate the change in momentum of the ball due to the collision.

change in momentum = .....  $\text{kg m s}^{-1}$  [2]

- (ii) Calculate the magnitude of the average force exerted on the ball by the wall.

average force = ..... N [1]

[Total: 10]

3 (a) Explain what is meant by *work done*.

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

(b) A ball of mass 0.42 kg is dropped from the top of a building. The ball falls from rest through a vertical distance of 78 m to the ground. Air resistance is significant so that the ball reaches constant (terminal) velocity before hitting the ground. The ball hits the ground with a speed of  $23 \text{ m s}^{-1}$ .

(i) Calculate, for the ball falling from the top of the building to the ground:

1. the decrease in gravitational potential energy

decrease in gravitational potential energy = ..... J [2]

2. the increase in kinetic energy.

increase in kinetic energy = ..... J [2]

(ii) Use your answers in (b)(i) to determine the average resistive force acting on the ball as it falls from the top of the building to the ground.

average resistive force = ..... N [2]



- (c) The ball in (b) is dropped at time  $t = 0$  and hits the ground at time  $t = T$ . The acceleration in free fall is  $g$ .

On Fig. 3.1, sketch a line to show the variation of the acceleration  $a$  of the ball with time  $t$  from time  $t = 0$  to  $t = T$ .

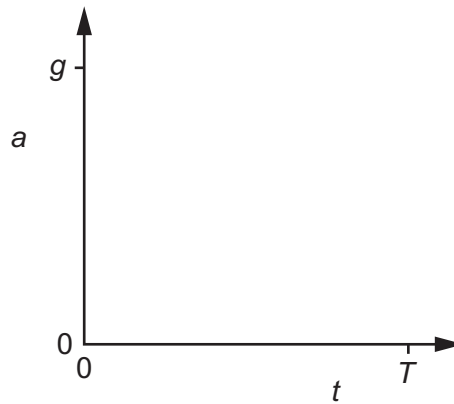


Fig. 3.1

[2]

[Total: 9]

- 4 (a) State the difference between progressive waves and stationary waves in terms of the transfer of energy along the wave.

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

- (b) A progressive wave travels from left to right along a stretched string. Fig. 4.1 shows part of the string at one instant.

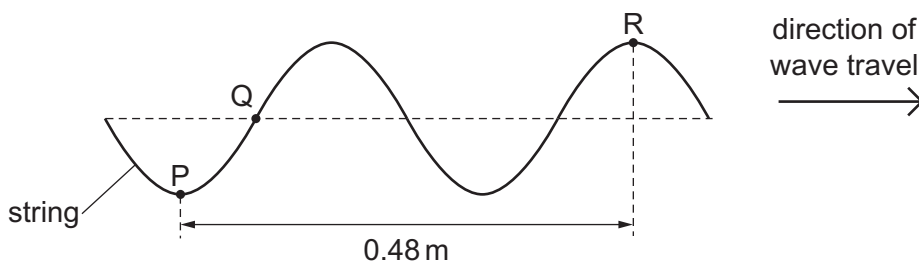


Fig. 4.1

P, Q and R are three different points on the string. The distance between P and R is 0.48 m. The wave has a period of 0.020 s.

- (i) Use Fig. 4.1 to determine the wavelength of the wave.

wavelength = ..... m [1]

- (ii) Calculate the speed of the wave.

speed = .....  $\text{ms}^{-1}$  [2]

- (iii) Determine the phase difference between points Q and R.

phase difference = .....  $^{\circ}$  [1]

- (iv) Fig. 4.1 shows the position of the string at time  $t = 0$ . Describe how the displacement of point Q on the string varies with time from  $t = 0$  to  $t = 0.010$  s.

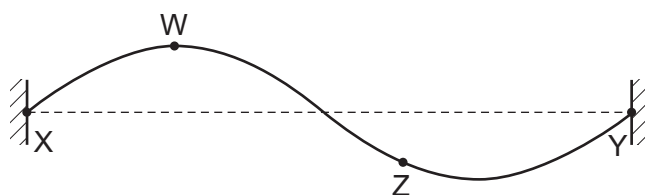
.....

.....

.....

..... [2]

- (c) A stationary wave is formed on a different string that is stretched between two fixed points X and Y. Fig. 4.2 shows the position of the string when each point is at its maximum displacement.



**Fig. 4.2**

- (i) Explain what is meant by a *node* of a stationary wave.

..... [1]

- (ii) State the number of antinodes of the wave shown in Fig. 4.2.

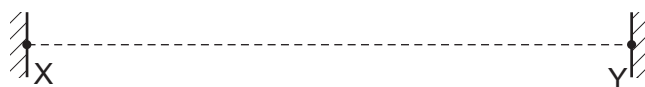
number = ..... [1]

- (iii) State the phase difference between points W and Z on the string.

phase difference = .....° [1]

- (iv) A new stationary wave is now formed on the string. The new wave has a frequency that is half of the frequency of the wave shown in Fig. 4.2. The speed of the wave is unchanged.

On Fig. 4.3, draw a position of the string, for this new wave, when each point is at its maximum displacement.

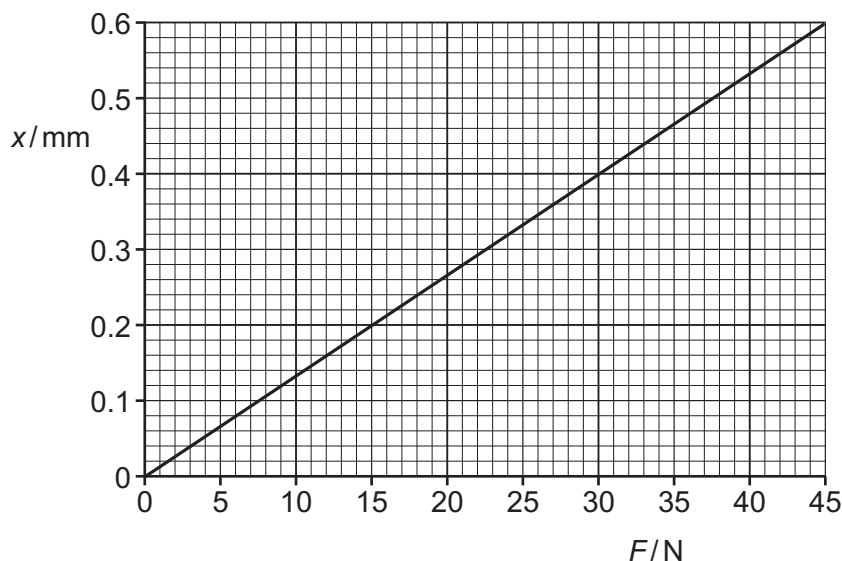


**Fig. 4.3**

[1]

[Total: 11]

- 5 One end of a wire is attached to a fixed point. A force  $F$  is applied to the wire to cause extension  $x$ . The variation with  $F$  of  $x$  is shown in Fig. 5.1.



**Fig. 5.1**

The wire has a cross-sectional area of  $4.1 \times 10^{-7} \text{ m}^2$  and is made of metal of Young modulus  $1.7 \times 10^{11} \text{ Pa}$ . Assume that the cross-sectional area of the wire remains constant as the wire extends.

- (a) State the name of the law that describes the relationship between  $F$  and  $x$  shown in Fig. 5.1.

..... [1]

- (b) The wire has an extension of 0.48 mm.

Determine:

- (i) the stress

stress = ..... Pa [2]

- (ii) the strain.

strain = ..... [2]

- (c) The resistivity of the metal of the wire is  $3.7 \times 10^{-7} \Omega \text{ m}$ .

Determine the change in resistance of the wire when the extension  $x$  of the wire changes from  $x = 0.48 \text{ mm}$  to  $x = 0.60 \text{ mm}$ .

change in resistance = .....  $\Omega$  [3]

- (d) A force of greater than 45 N is now applied to the wire.

Describe how it may be checked that the elastic limit of the wire has not been exceeded.

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

[Total: 9]

- 6 (a) A battery of electromotive force (e.m.f.)  $7.8\text{V}$  and internal resistance  $r$  is connected to a filament lamp, as shown in Fig. 6.1.

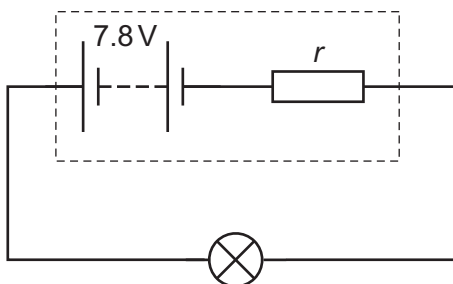


Fig. 6.1

A total charge of  $750\text{C}$  moves through the battery in a time interval of  $1500\text{s}$ . During this time the filament lamp dissipates  $5.7\text{kJ}$  of energy. The e.m.f. of the battery remains constant.

- (i) Explain, in terms of energy and without a calculation, why the potential difference across the lamp must be less than the e.m.f. of the battery.

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

- (ii) Calculate:

1. the current in the circuit

current = ..... A [2]

2. the potential difference across the lamp

potential difference = ..... V [2]

3. the internal resistance of the battery.

internal resistance = .....  $\Omega$  [2]

(b) A student is provided with three resistors of resistances  $90\ \Omega$ ,  $45\ \Omega$  and  $20\ \Omega$ .

- (i) Sketch a circuit diagram showing how **two** of these three resistors may be connected together to give a combined resistance of  $30\ \Omega$  between the terminals shown. Label the values of the resistances on your diagram.



[1]

- (ii) A potential divider circuit is produced by connecting the three resistors to a battery of e.m.f.  $9.0\text{V}$  and negligible internal resistance. The potential divider circuit provides an output potential difference  $V_{\text{OUT}}$  of  $3.6\text{V}$ . The circuit diagram is shown in Fig. 6.2.

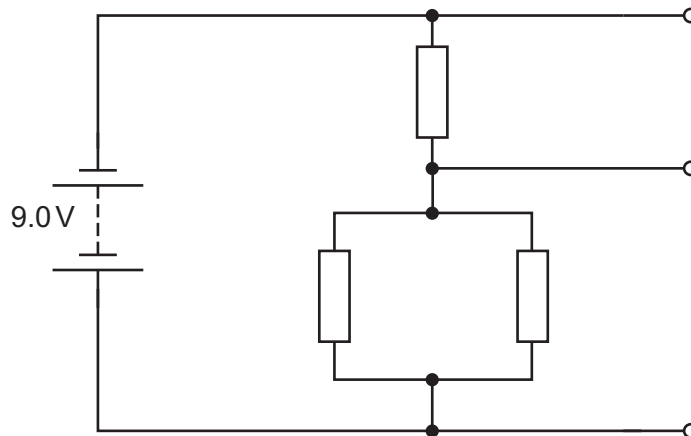


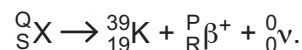
Fig. 6.2

On Fig. 6.2, label the resistances of all three resistors and the potential difference  $V_{\text{OUT}}$ .

[2]

[Total: 10]

- 7 (a) A nucleus of an element X decays by emitting a  $\beta^+$  particle to produce a nucleus of potassium-39 ( ${}_{19}^{39}\text{K}$ ) and a neutrino. The decay is represented by



- (i) State the number represented by each of the following letters.

P .....

Q .....

R .....

S .....

[2]

- (ii) State the name of the interaction (force) that gives rise to  $\beta^+$  decay.

..... [1]

- (b) A hadron is composed of three identical quarks and has a charge of  $+2e$ , where  $e$  is the elementary charge.

Determine a possible type (flavour) of the quarks.

Explain your working.

.....

..... [2]

[Total: 5]

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