Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME: Solved Papers

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5954088864

PHYSICS **9702/22**

Paper 2 AS Level Structured Questions **October/November 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **15** printed pages and **1** blank page.

DC (KS/TP) 164216/3

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Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_\text{o} = \dfrac{f_\text{s} v}{v \pm v_\text{s}}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_\text{H} = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

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

1 **(a)** Distinguish between vector and scalar quantities.

Vector quantities have both magnitude & direction whereas scalar quantities have only direction

.... [2]

(b) The electric field strength E at a distance x from an isolated point charge Q is given by the equation

$$E = \frac{Q}{x^2 b}$$

where b is a constant.

(i) Use the definition of electric field strength to show that E has SI base units of $\text{kg}\,\text{m}\,\text{A}^{-1}\,\text{s}^{-3}$.

$$E = \frac{F}{Q} = \frac{ma}{It} = \frac{\text{Kgms}^{-2}}{\text{AS}} = \text{Kg m A}^{-1}\text{S}^{-3}$$

[2]

(ii) Use the units for E given in **(b)(i)** to determine the SI base units of b.

$$\text{KgmA}^{-1}\text{S}^{-3} = \frac{\text{It}}{d^2 b} \qquad \frac{\text{Kgm}}{\text{A S}^3} = \frac{\text{AS}}{\text{m}^2 b}$$

$$\frac{\text{Kgm}^3}{\text{A}^2\text{S}^4} = \frac{1}{b} \qquad b = \frac{\text{A}^2\text{S}^4}{\text{Kgm}^3} = \text{A}^2\text{S}^4\,\text{Kg}^{-1}\,\text{m}^{-3}$$

SI base units of b ....$\text{A}^2\text{S}^4\,\text{Kg}^{-1}\,\text{m}^{-3}$....... [2]

[Total: 6]

2 **(a)** Define *acceleration*.

Rate of change of velocity .... [1]

(b) A steel ball of diameter 0.080 m is released from rest and falls vertically in air, as illustrated in Fig. 2.1.

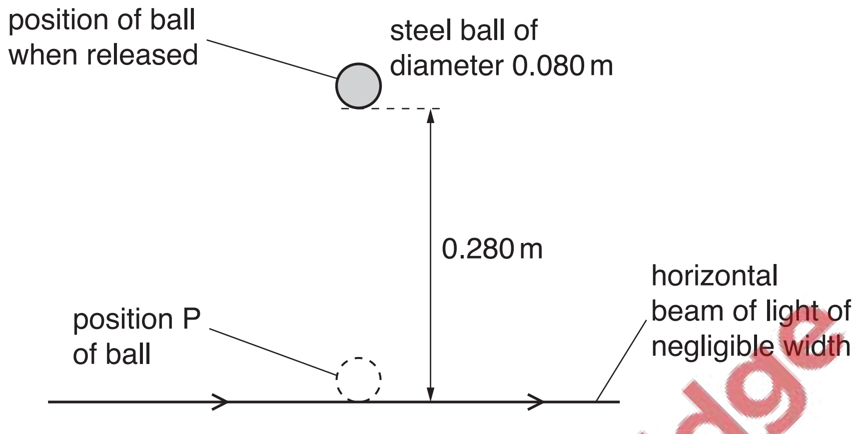


Fig. 2.1 (not to scale)

A horizontal beam of light of negligible width is a vertical distance of 0.280 m below the bottom of the ball when it is released. The ball falls through and breaks the beam of light.

(i) Explain why the force due to air resistance acting on the ball may be neglected when calculating the time taken for the ball to reach the beam of light.

The force due to air resistance is negligible compared to weight .... [1]

(ii) Calculate the time taken for the ball to fall from rest to position P where the bottom of the ball touches the beam of light.

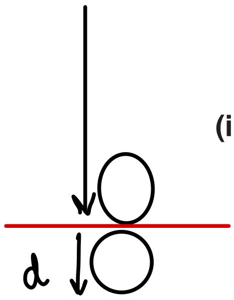
$s = ut + \frac{1}{2}at^2$

$0.280 = \frac{1}{2} \times 9.81 \times t^2$

$t = 0.2389$

$\simeq 0.24$

time taken = ... 0.24 .... s [2]



(iii) Determine the time interval during which the beam of light is broken by the ball.

distance fallen = 0.280m
distance the ball will have to cover to pass beam of light = 0.080m

$(s = ut + \frac{1}{2}at^2)$

$d_{Total} = 0.280 + 0.080 = 0.36m$

$0.36 = \frac{1}{2} \times 9.81 \times t^2$

$t = 0.2709$

$\therefore T = 0.271 - 0.24$

≈ 0.03

time interval = 0.03 s [2]

(c) A different ball is released from the same position as the steel ball in **(b)**. This ball has the same diameter but a much lower density. For this ball, the force due to air resistance cannot be neglected as the ball falls.

State and explain the change, if any, to the time interval during which the beam of light is broken by the ball.

Since air resistance increases, the acceleration decreases hence the time interval during which the beam of light is broken increases.

[2]

[Total: 8]

3 **(a)** State Newton's third law of motion.

Force on body A is equal on force on body B, force on body A is opposite to force on body B.

.... [2]

(b) A block X of mass m_X slides in a straight line along a horizontal frictionless surface, as shown in Fig. 3.1.

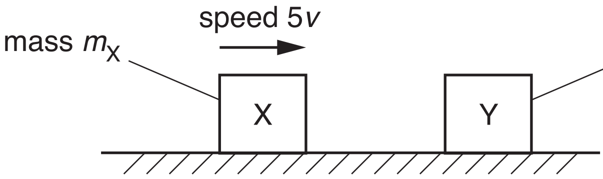


Fig. 3.1

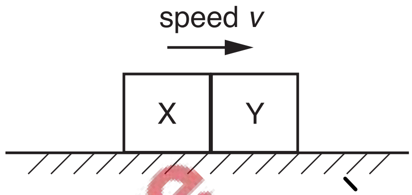


Fig. 3.2

The block X, moving with speed 5v, collides head-on with a stationary block Y of mass m_Y. The two blocks stick together and then move with common speed v, as shown in Fig. 3.2.

(i) Use conservation of momentum to show that the ratio $\frac{m_Y}{m_X}$ is equal to 4.

momentum before collison = momentum after collison

$5v \times M_x = (M_x + M_y)v$

$5 \times M_x = M_x + M_y$

$5M_x = M_x + M_y$

$4M_x = M_y$

$\therefore 4 = \frac{M_y}{M_x}$

[2]

(ii) Calculate the ratio

$$\frac{\text{total kinetic energy of X and Y after collision}}{\text{total kinetic energy of X and Y before collision}}.$$

$$\frac{\frac{1}{2} \times (M_x + M_y) \times v^2}{\frac{1}{2} \times (M_x) \times (5v)^2} = \frac{(M_x + M_y)\cancel{v^2}}{(M_x)\,25\cancel{v^2}} = \frac{M_x + M_y}{25 M_x} = \frac{\cancel{M_x}}{25\cancel{M_x}} + \frac{M_y}{25 M_x}$$

$$\frac{1}{25} + \frac{4}{25} = \frac{5}{25} = \frac{1}{5} = 0.2$$

ratio = 0.2 [3]

(iii) State the value of the ratio in **(ii)** for a perfectly elastic collision.

ratio = ...1.. [1]

(c) The variation with time *t* of the momentum of block X in **(b)** is shown in Fig. 3.3.

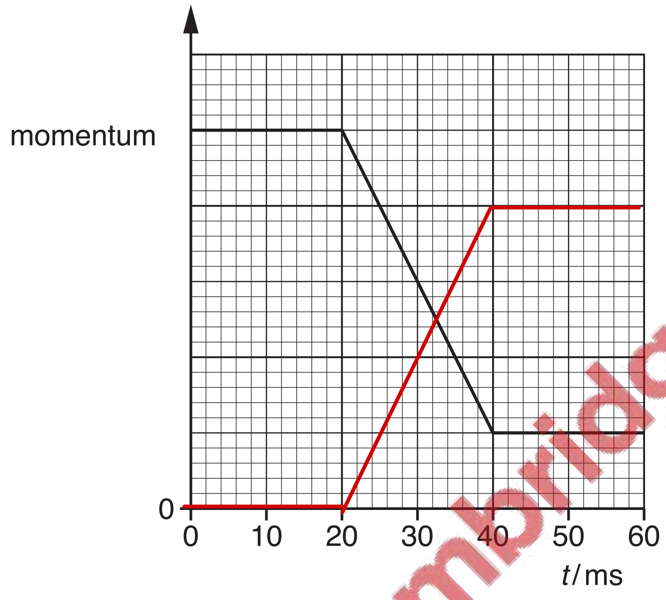


Fig. 3.3

Block X makes contact with block Y at time $t = 20$ ms.

(i) Describe, qualitatively, the magnitude and direction of the resultant force, if any, acting on block X in the time interval:

$F = \frac{\Delta p}{t} = 0$

1. $t = 0$ to $t = 20$ ms

....0..

$F = \frac{\Delta p}{t}$ → change in momentum constant

2. $t = 20$ ms to $t = 40$ ms.

....The magnitude of the Resultant force is constant, (as ΔP is constant)....

....and in the opposite direction to the momentum.................................

[3]

(ii) On Fig. 3.3, sketch the variation of the momentum of block Y with time *t* from $t = 0$ to $t = 60$ ms. [3]

[Total: 14]

4 **(a)** A sphere in a liquid accelerates vertically downwards from rest. For the viscous force acting on the moving sphere, state:

(i) the direction

upwards .... [1]

(ii) the variation, if any, in the magnitude.

increases .... [1]

(b) A man of weight 750 N stands a distance of 3.6 m from end D of a horizontal uniform beam AD, as shown in Fig. 4.1.

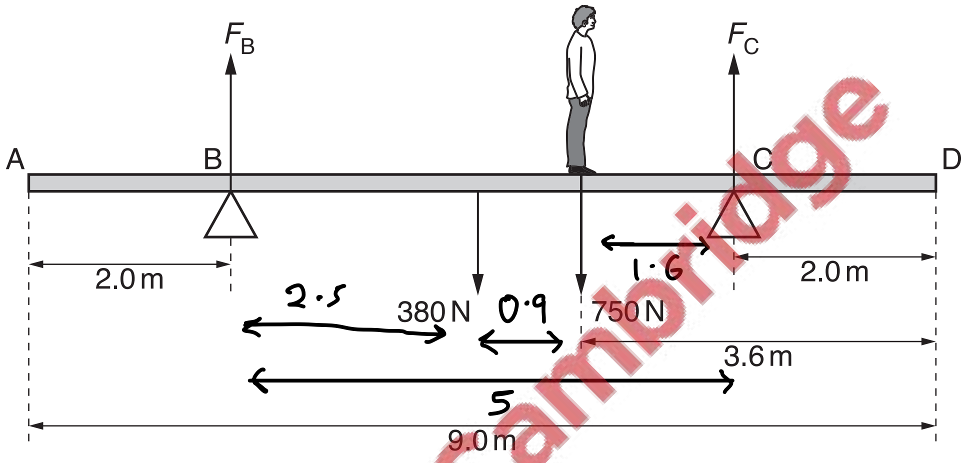


Fig. 4.1 (not to scale)

The beam has a weight of 380 N and a length of 9.0 m. The beam is supported by a vertical force F_B at pivot B and a vertical force F_C at pivot C. Pivot B is a distance of 2.0 m from end A and pivot C is a distance of 2.0 m from end D. The beam is in equilibrium.

(i) State the principle of moments.

for a body in equilibrium, the sum of clockwise moments about a point = sum of anticlockwise moments about a point.

.... [2]

(ii) By using moments about pivot C, calculate F_B.

$(2.5 \times 380) + (1.6 \times 750) = 5F_B$

$F_B = 430$ N

F_B = ...430.... N [2]

(iii) The man walks towards end D. The beam is about to tip when F_B becomes zero.

Determine the minimum distance x from end D that the man can stand without tipping the beam.

$(2.5 \times 380) = (750x)$

(upward force Normal RCN due to weight) (Downward force)

$x = 1.266$ m (distance from C)

distance from D = 2 - 1.266 ≈ 0.73

x = ...0.7.... m [2]

[Total: 8]

5 **(a)** State what is meant by the *wavelength* of a progressive wave.

Minimum distance between 2 wave fronts.

.... [1]

(b) A cathode-ray oscilloscope (CRO) is used to analyse a sound wave. The screen of the CRO is shown in Fig. 5.1.

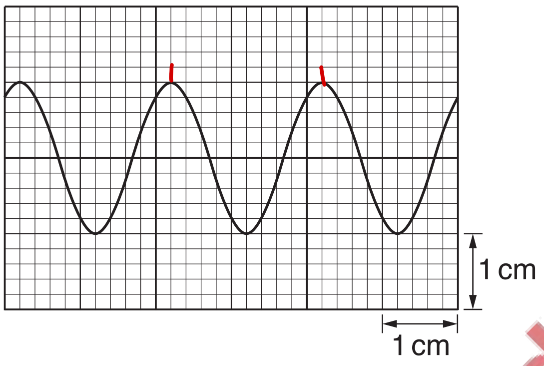


Fig. 5.1

The time-base setting of the CRO is 2.5 ms cm^{-1}.

Determine the frequency of the sound wave.

Number of cm in graph one wave covers = 2 cm

$\therefore$ time = $2.5 \times 2 \times 10^{-3}$ sec

= 5×10^{-3} s

$f = \frac{1}{5 \times 10^{-3}} = 200$ Hz

frequency = 200 Hz [2]

(c) The source emitting the sound in **(b)** is at point A. Waves travel from the source to point C along two different paths, AC and ABC, as shown in Fig. 5.2.

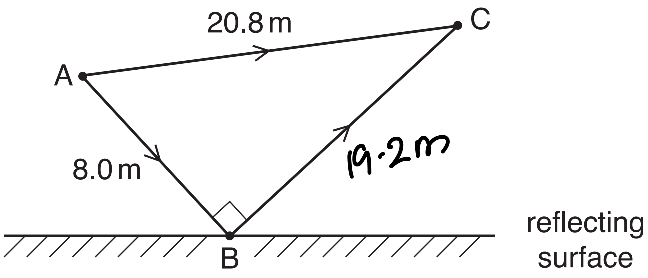


Fig. 5.2 (not to scale)

Distance AB is 8.0 m and distance AC is 20.8 m. Angle ABC is 90°. Assume that there is no phase change of the sound wave due to the reflection at point B. The wavelength of the waves is 1.6 m.

(i) Show that the waves meeting at C have a path difference of 6.4 m.

Path Diffrence = Length ABC − length AC

= (8+ 19.2) − 20.8

= 6.4m

$8^2 + b^2 = 20.8^2$

$b = 19.2$

[1]

(ii) Explain why an intensity maximum is detected at point C.

As the path diffrence = 4λ (4 times wavelength) (whole no. of λ's) and the wave lengths meet in phase constructive interference will be observed [2]

(iii) Determine the difference between the times taken for the sound to travel from the source to point C along the two different paths.

$v = f\lambda$

$= 200 \times 1.6$

$= 320 ms^{-1}$

$\Delta t = \frac{27.2}{320} - \frac{20.8}{320} = 0.02$

$s = \frac{D}{t}$

$t = \frac{D}{s}$

time difference = 0.02 s [2]

(iv) The wavelength of the sound is gradually increased. Calculate the wavelength of the sound when an intensity maximum is next detected at point C.

$d\sin\theta = n\lambda$ λ↓ n↓

∴ 4λ → 3λ

3λ = 6.4

λ = 2.13

wavelength = 2.1 m [1]

[Total: 9]

6 **(a)** State Kirchhoff's first law.

Sum of currents into junction = Sum of current out of the junction [1]

(b) The variations with potential difference V of the current I for a resistor X and for a semiconductor diode are shown in Fig. 6.1.

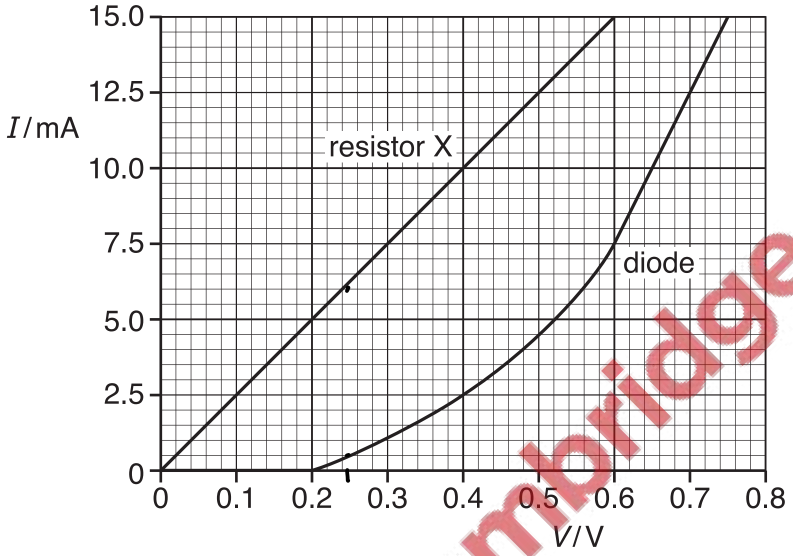


Fig. 6.1

(i) Determine the resistance of the diode for a potential difference V of 0.60 V.

$V = IR$

$R = \frac{0.6}{7.5 \times 10^{-3}}$

$= 80$

resistance = 80 Ω [3]

(ii) Describe, qualitatively, the variation of the resistance of the diode as V increases from 0.60 V to 0.75 V.

Resistance decreases [1]

R @ 0.6V = 80Ω

R @ 0.75V = $\frac{0.75}{15 \times 10^{-3}} = 50\Omega$

∴ R↓

(c) The diode and the resistor X in **(b)** are connected into the circuit shown in Fig. 6.2.

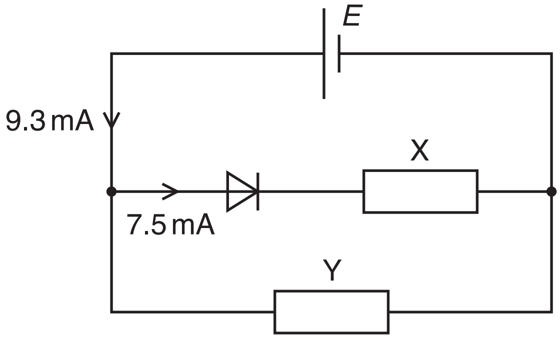


Fig. 6.2

The cell has electromotive force (e.m.f.) *E* and negligible internal resistance. Resistor Y is connected in parallel with resistor X and the diode. The current in the cell is 9.3 mA and the current in the diode is 7.5 mA.

(i) Use Fig. 6.1 to determine *E*.

V of diode = 0·6 V
V of X = 0·3 V
0·9 V

E = ...0·9........ V [1]

(ii) Determine the resistance of resistor Y.

$V = IR$
$R = \frac{V}{I}$

$I = 9.3 - 7.5 = 1.8\,mA$
$V = 0.9\,V$
$R = \frac{0.9}{1.8 \times 10^{-3}} = 500$

resistance = ...500........ Ω [2]

(iii) Calculate the power dissipated in the diode.

$P = VI$
$V = IR$
$\therefore P = I^2R$

$P = I^2R$
$= (7.5 \times 10^{-3})^2 \times 80$
$= 4.5 \times 10^{-3}$

power = ...4.5×10^{-3}........ W [2]

(iv) The cell is now replaced by a new cell of e.m.f. 0.50 V and negligible internal resistance. Use Fig. 6.1 to determine the new current in the diode.

current = ...2.5........ mA [1]

[Total: 11]

7 A nucleus of plutonium-238 ($^{238}_{94}Pu$) decays by emitting an α-particle to produce a new nucleus X and 5.6 MeV of energy. The decay is represented by

$$^{238}_{94}Pu \longrightarrow X + ^{4}_{2}\alpha + 5.6\,MeV.$$

(a) Determine the number of protons and the number of neutrons in nucleus X.

234 − 92 = 142

number of protons = 92

number of neutrons = 142

[2]

(b) Calculate the number of plutonium-238 nuclei that must decay in a time of 1.0 s to produce a power of 0.15 W.

$$\frac{0.15}{5.6 \times 1.6 \times 10^{-13}} = 1.674 \times 10^{11}$$

$$\approx 1.7 \times 10^{11}$$

number = 1.7×10^{11} [2]

[Total: 4]