UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME					
CENTRE NUMBER					
CANDIDATE NUMBER					

PHYSICS 9702/21

Paper 2 AS Structured Questions

October/November 2012

1 hour

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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
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.

For Examiner's Use	
1	
2	
3	
4	
5	
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Total	

This document consists of **16** printed pages.

DC (NF/SW) 43268/5

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[Turn over

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 constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
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,	$\phi = -\frac{Gm}{r}$
hydrostatic pressure,	$p = \rho gh$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
simple harmonic motion,	$a = -\omega^2 x$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
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,	$W = \frac{1}{2}QV$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
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.

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1 (a) (i) Define *acceleration*.

Rate of change of velocity.

[1]

(ii) State Newton's first law of motion.

A body in motion or rest remains in motion or rest until an external force is applied.

[1]

(b) The variation with time t of vertical speed v of a parachutist falling from an aircraft is shown in Fig. 1.1.

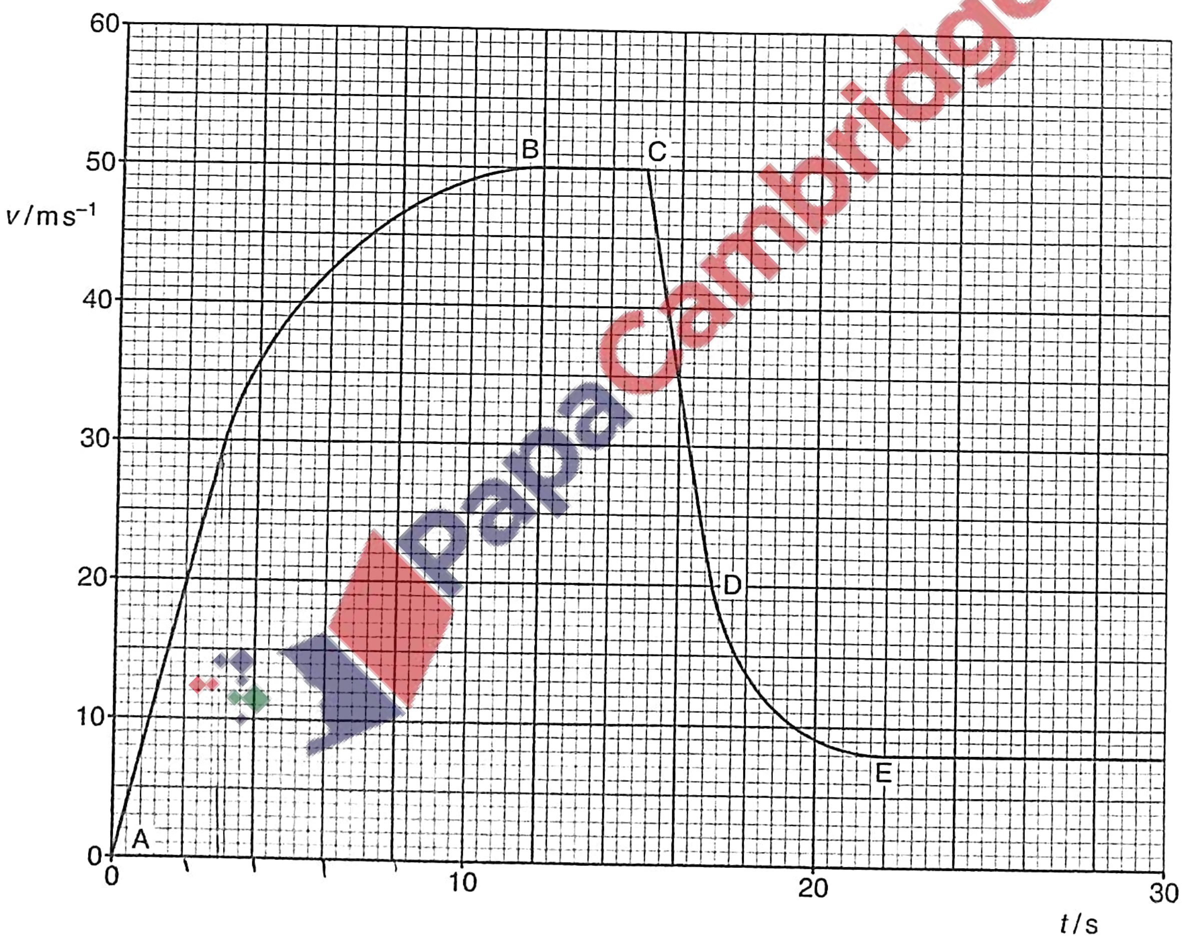

Fig. 1.1

(i) Calculate the distance travelled by the parachutist in the first 3.0 s of the motion.

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$\frac{1}{2} \times 29.5 \times 3 = 44.25$

≈ 44.3

distance = 44.3 m [2]

(ii) Explain the variation of the resultant force acting on the parachutist from $t = 0$ (point A) to $t = 15$ s (point C).

The resultant force acting on the parachutist decreases as the frictional force increases. As resultant force = weight − frictional force, at the begining the frictional force is 0 and as the speed increases the frictional forces increases until it is equal to the weight. [3]

(iii) Describe the changes to the frictional force on the parachutist

1. at $t = 15$ s (point C),

frictional force increases (as velocity starts to decrease)

[1]

2. between $t = 15$ s (point C) and $t = 22$ s (point E).

The velocity decreases so the frictional force increases and is then constant.

[1]

V↓ at

(iv) The mass of the parachutist is 95 kg.

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Calculate, for the parachutist between $t = 15$ s (point C) and $t = 17$ s (point D),

1. the average acceleration,

$a = \frac{\Delta V}{t} = \frac{50 - 20}{2} = 15 \text{ ms}^{-2}$

acceleration = ...15.......... ms^{-2} [2]

2. the average frictional force.

RF = W − frictional force

frictional force = weight − resultant force

= mg − ma

= (95×9.81) − (95 × (− 15)

= 931.95 + 1425

= 2357 ≈ 2360 N

frictional force = ...2360.......... N [3]

Please turn over for Question 2.

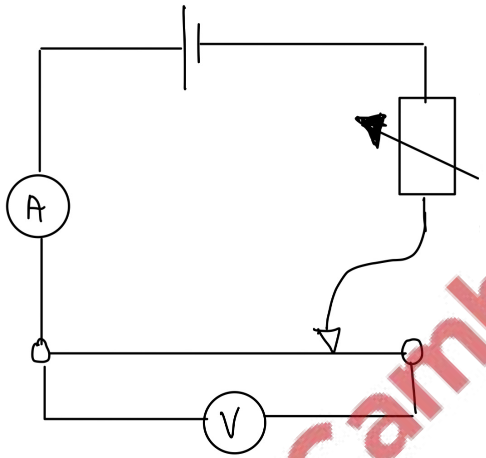
V = IR   R = V/I

2 **(a)** Define electrical *resistance*.

Resistance is equal to potenial difference devided by current (R = V/I) [1]

(b) A circuit is set up to measure the resistance R of a metal wire. The potential difference (p.d.) V across the wire and the current I in the wire are to be measured.

(i) Draw a circuit diagram of the apparatus that could be used to make these measurements.



[3]

(ii) Readings for p.d. V and the corresponding current I are obtained. These are shown in Fig. 2.1.

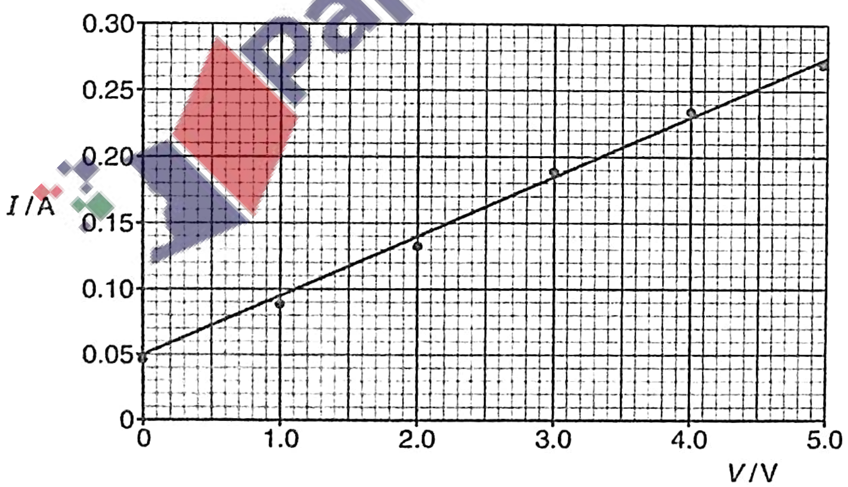


Fig. 2.1

Explain how Fig. 2.1 indicates that the readings are subject to

1. a systematic uncertainty,

there is a y intercept [1]

2. random uncertainties.

The points ~~man~~ are scattered around the best fit line. [1]

(iii) Use data from Fig. 2.1 to determine R. Explain your working.

When $V = 0$, I should be 0 $(V = IR)$

$\therefore$ Error due to zero error $= 0.05$

$\therefore$ at $V = 2.0$ $I = (0.14 - 0.05)$

$V = IR$

$R = \frac{V}{I} = \frac{2.0}{0.09} = 22.22\,\Omega \approx 22\,\Omega$

$R =$ 22 Ω [3]

(c) In another experiment, a value of R is determined from the following data:

Current $I = 0.64 \pm 0.01$ A and p.d. $V = 6.8 \pm 0.1$ V.

Calculate the value of R, together with its uncertainty. Give your answer to an appropriate number of significant figures.

$V = IR$ $\therefore R = \frac{V}{I} = \frac{6.8}{0.64} = 10.625\,\Omega$
≈ 10.6 (3sf)

% Uncertainity = Percentage uncertainity V + Percentage uncertainity I

$= \left(\frac{0.1}{6.8} \times 100\right) + \left(\frac{0.01}{0.64} \times 100\right)$

$= 3.033$

Abs ~~M~~ Unce $= \frac{3.033}{100} \times 10.625$

$= 0.322 \approx 0.3\,\Omega$

$R =$ 10.6 ± 0.3 Ω [3]

3 (a) Define *pressure.*

Pressure is equal to the force per unit area

.... [1]

(b) Explain, in terms of the air molecules, why the pressure at the top of a mountain is less than at sea level.

The temprature at the top of the mountain is lesser hence partides are closer togeather and have a lower speed, since the collisons per unit area reduce the change in momentum causing a force is less & hence pressure is less. (The opposite applies at sea level) [3]

(c) Fig. 3.1 shows a liquid in a cylindrical container.

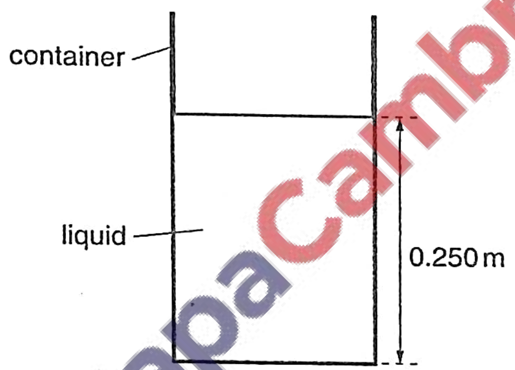


Fig. 3.1

The cross-sectional area of the container is $0.450\,m^2$. The height of the column of liquid is 0.250 m and the density of the liquid is $13600\,kg\,m^{-3}$.

(i) Calculate the weight of the column of liquid.

Density = Mass / Volume ∴ 136000 = M / (0.450 × 0.250) M = 15300 kg

Weight = mg = ~~136~~ 15300 × 9.81 = ~~150093 N~~
= 15009.3 N
≈ 15000 N

weight = ...15000...................... N [3]

(ii) Calculate the pressure on the base of the container caused by the weight of the liquid.

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pressure = hρg

= 0.250 × 13600 × 9.81

= 33354

≈ 3.3 × 10^4

pressure = 3.3 × 10^4 Pa [1]

(iii) Explain why the pressure exerted on the base of the container is different from the value calculated in **(ii)**.

As air ~~force~~ pressure also acts on the liquid's surface the pressure will be more. [1]

4 (a) Describe the diffraction of monochromatic light as it passes through a diffraction grating.

The wave passes through the slits in the grating & gets spread.

.... [2]

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(b) White light is incident on a diffraction grating, as shown in Fig. 4.1.

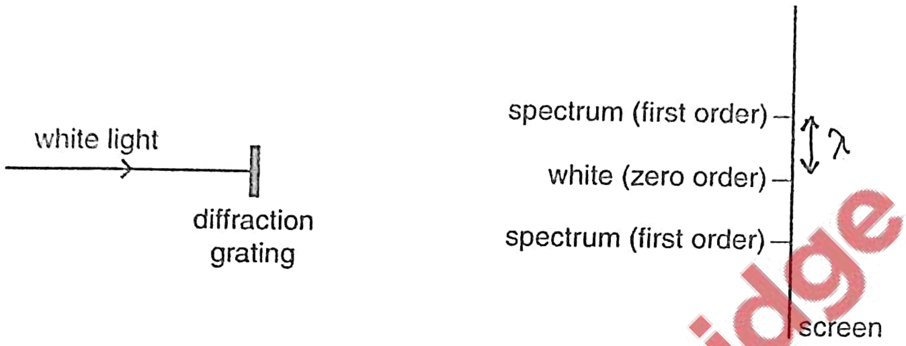

Fig. 4.1 (not to scale)

The diffraction pattern formed on the screen has white light, called zero order, and coloured spectra in other orders.

(i) Describe how the principle of superposition is used to explain

1. white light at the zero order,

A maxima is formed at zero order as the displacements of the wave sum to give a constructive interference. As they are all in phase with each other. [2]

2. the difference in position of red and blue light in the first-order spectrum.

The wavelength of the Red & blue light are different so when their path diffrence is λ (1st order) they will form a maxima & hence but they will form the maximas at different angles from the zero order. [2]

V
I
B
G
Y
OUR

(ii) Light of wavelength 625 nm produces a second-order maximum at an angle of 61.0° to the incident direction.
Determine the number of lines per metre of the diffraction grating.

$d\sin\theta = n\lambda$ $d = 1/N$ $\therefore N = \frac{1}{7.1\times10^{-7}\times2}$

$d = \frac{n\lambda}{\sin\theta} = \frac{2\times625\times10^{-9}}{\sin 61.0}$ $= 7.0\times10^{5}$

$= 7.1\times10^{-7}\times2$

$N = 1/d = \frac{1}{(7.1\times10^{-7}\times2)}$

number of lines = 7.0 × 10⁵ m⁻¹ [2]

(iii) Calculate the wavelength of another part of the visible spectrum that gives a maximum for a different order at the same angle as in **(ii)**.

$d = 7.1\times10^{-7}\times2$
$= 1.42\times10^{-6}$ m

$d\sin\theta = n\lambda$ $n\lambda = \text{constant} \therefore n\lambda = 625\times10^{-9}\times2 = 1.25\times10^{-6}$

@ $n=1$ $1.42\times10^{-6}\times\sin 61 = \lambda$
$\lambda = 1.25\times10^{-6}$ (outside)

@ $n=1$ $\frac{(1.42\times10^{-6}\times\sin 61)}{2} = 6.2\times10^{-7}$

wavelength = 420 nm [2]

@ $n=3$ $\frac{1.42\times10^{-6}\times\sin 61}{3} = 4.2\times10^{-7}$

$\therefore \lambda = 4.2\times10^{-7}$ m $= 420$ nm

5 (a) Explain what is meant by *plastic deformation*.

When stress is no longer proportional to extension

.... [1]

(b) A copper wire of uniform cross-sectional area $1.54 \times 10^{-6}\,m^2$ and length 1.75 m has a breaking stress of 2.20×10^8 Pa. The Young modulus of copper is 1.20×10^{11} Pa.

(i) Calculate the breaking force of the wire.

$stress = \frac{F}{A}$ $\quad strain = \frac{\Delta x}{x}$

$F = 2.20 \times 10^8 \times 1.54 \times 10^{-6}$

$= 338.8$ N

≈ 340 N

breaking force = 340 N [2]

(ii) A stress of 9.0×10^7 Pa is applied to the wire. Calculate the extension.

Young's Modulus = stress/strain

$\therefore$ strain = stress/(1.20×10^{11})

$\frac{\Delta x}{1.75} = \frac{9.0 \times 10^7}{1.20 \times 10^{11}}$ $\quad \therefore \Delta x = 1.31 \times 10^{-3}$ m

extension = 1.3×10^{-3} m [2]

(c) Explain why it is not appropriate to use the Young modulus to determine the extension when the breaking force is applied.

Stress no longer $\propto$ to extension.

.... [1]

6 **(a)** Describe the structure of an atom of the nuclide $^{235}_{92}U$.

It has 92 protons & 143 neutrons in the nucleus & 92 electron around the nucleus (revolving around in electron clouds)

.... [2]

(b) The deflection of α-particles by a thin metal foil is investigated with the arrangement shown in Fig. 6.1. All the apparatus is enclosed in a vacuum.

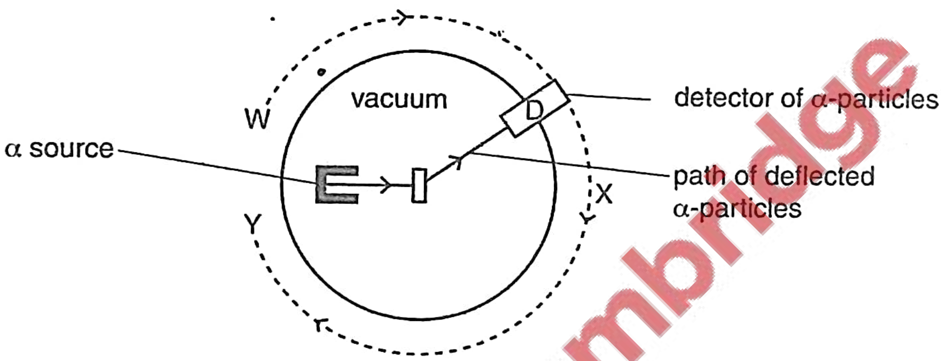

Fig. 6.1

The detector of α-particles, D, is moved around the path labelled WXY.

(i) Explain why the apparatus is enclosed in a vacuum.

A α particles are absorbed by few cm of air (cant travel far enough / low penetration) [1]

(ii) State and explain the readings detected by D when it is moved along WXY.

Maximum Reading will be observed at X as majority of the α particles will travel without being deflected and few deflected by small angles can also be detected. Only few of them will be deflected backward (∴ Minimum Reading at W & Y) this is because most of atom is an empty space as mass [3] is concentrated at the nucleus which is also charged.

Question 6 continues on page 16.

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(c) A beam of α-particles produces a current of 1.5 pA. Calculate the number of α-particles per second passing a point in the beam.

$q = It$

$f = I/q = \dfrac{1.5 \times 10^{-12}}{2 \times 1.6 \times 10^{-19}}$

^4_2He

$2 \times 1.6 \times 10^{-19}$

$f = 4687500$

$\approx 4.7 \times 10^{6}\ s^{-1}$

number = 4.7×10^{6} s^{-1} [3]

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