Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2009

Physics

Assessment Unit AS 2

assessing

Module 2: Waves and Photons

[ASY21]

ASY21

FRIDAY 19 JUNE, MORNING

TIME

1 hour.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all eight** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 60.
Quality of written communication will be assessed in question **4**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

5824

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If you need the values of physical constants to answer any questions in this paper, they may be found on the Data and Formulae Sheet.

Answer **all eight** questions

1 Electromagnetic waves have wavelengths in the range from about 10^{-14} m to about 10^{4} m and form a spectrum. The spectrum is divided into seven regions. Waves within a region have common properties. For example, visible light is that region of the spectrum detected by the eye.

(a) Name the seven regions of the electromagnetic spectrum in order of **decreasing** wavelength. Answer in the spaces provided.

Decreasing wavelength →

[3]

Examiner Only	
Marks	Remark

(b) State a typical wavelength for visible light.

Wavelength = ________________ [1]

(c) An electromagnetic wave from a different region of the spectrum has a frequency of 620 GHz. What is its wavelength if it is travelling in a vacuum?

Wavelength = ________________ m [3]

2 Snell's law of refraction states:

The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for any two transparent materials.

Describe an experiment to verify Snell's law when the transparent materials are air and glass.
In your description you should:

(a) draw a labelled diagram of the apparatus and its arrangement,

(b) describe how the apparatus is used to obtain the angles of incidence and refraction required.

(a) Labelled diagram

[2]

Examiner Only	
Marks	Remark

(b) Use of apparatus to obtain angles of incidence and refraction

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____ [3]

(c) The data may be analysed by drawing a suitable graph.

(i) Label the axes of **Fig 2.1** and sketch this graph. Label it **1**.

Fig. 2.1 [2]

(ii) On **Fig 2.1** draw a second graph to show the effect of repeating the experiment with a material of **lower** refractive index than glass. Label this graph **2**. [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

3 The graphical representation of a standing wave on a stretched string is shown in **Fig. 3.1**.

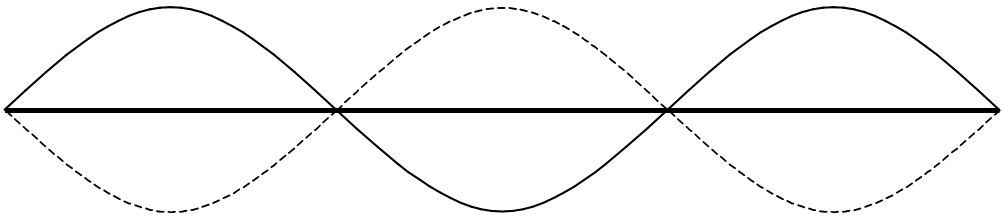

Fig. 3.1

(a) Which mode of vibration (resonance vibration) is represented in **Fig. 3.1**?

Mode of vibration = ____________________ [1]

(b) On **Fig. 3.1**, clearly mark the position of **one** antinode (label this A). [1]

(c) The distance between two consecutive antinodes is 0.08 m. What is the wavelength of the standing wave?

Wavelength = ________________ m [1]

(d) On **Fig. 3.2**, draw the fundamental or first mode of vibration. The original string has been drawn for you.

Original string

Fig. 3.2 [1]

Examiner Only	
Marks	Remark

(e) *F* is the ratio defined by **Equation 3.1** and *W* is the ratio defined by **Equation 3.2**.

$$F = \frac{\text{Frequency of first mode of vibration}}{\text{Frequency of mode of vibration in } \textbf{Fig. 3.1}}$$ **Equation 3.1**

$$W = \frac{\text{Wavelength of mode of vibration in } \textbf{Fig. 3.1}}{\text{Wavelength of first mode of vibration}}$$ **Equation 3.2**

(i) State the value of *F*.

F = _____________ [1]

(ii) State the value of *W*.

W = _____________ [1]

As appropriate in this question, you should answer in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only	
Marks	Remark

4 **(a)** Explain what is meant by the term **diffraction**.

____

____

____ [2]

(b) **Fig. 4.1** is a scale diagram showing parallel wavefronts approaching an aperture. Complete **Fig. 4.1** by carefully drawing **four** wavefronts after they have passed through the aperture.

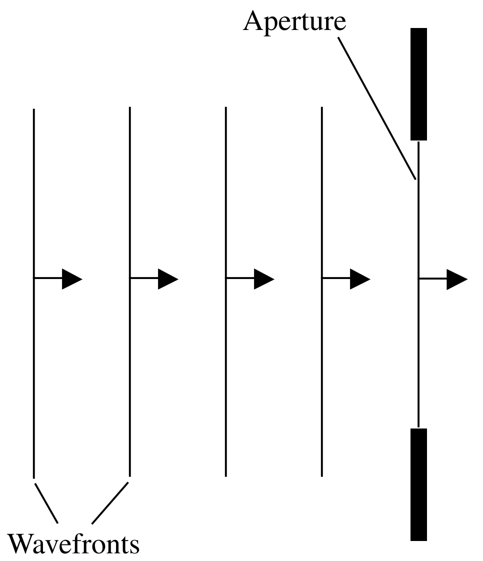

Fig. 4.1 [3]

(c) In terms of diffraction, explain why people can hear a conversation through an open door even when they cannot see the people talking.

____

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____

____

____ [3]

Quality of written communication [1]

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(Questions continue overleaf)

5 An experiment is conducted to measure the speed of sound in air using a resonance tube and tuning forks. The frequency of each tuning fork is recorded and the corresponding tube length at the first position of resonance measured. The data are recorded in **Table 5.1**.

Table 5.1

Frequency/Hz	256	288	320	456	512
Tube length/m	0.312	0.277	0.258	0.186	0.166
$\left(\frac{1}{\text{tube length}}\right)/\text{m}^{-1}$					

(a) Calculate the values of 1/(tube length) and complete the row in **Table 5.1**. [1]

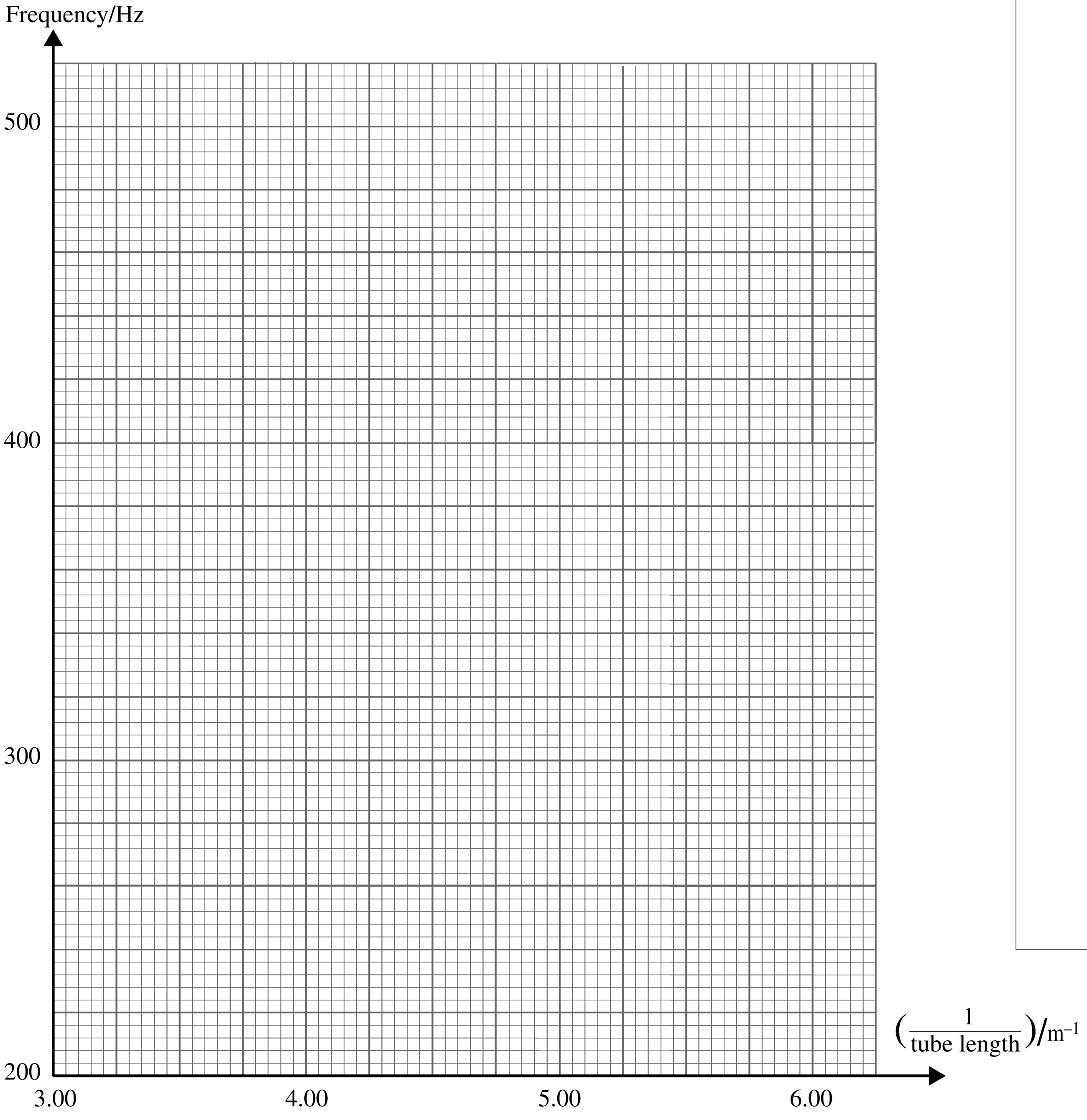

Fig. 5.1

Examiner Only
Marks Remark

(b) On the axes of **Fig. 5.1** plot a graph of frequency against $\frac{1}{\text{tube length}}$ and draw a best-fit line. [2]

(c) Measure the gradient of your graph and state the unit in which it is measured.

Gradient = ______________ [2]

Unit = ______________ [1]

(d) Use the gradient to calculate the speed of sound in air.

Speed = ______________ $m\,s^{-1}$ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

6 A polished zinc plate is illuminated with ultraviolet radiation of frequency 6.00×10^{16} Hz, as shown in **Fig. 6.1**.

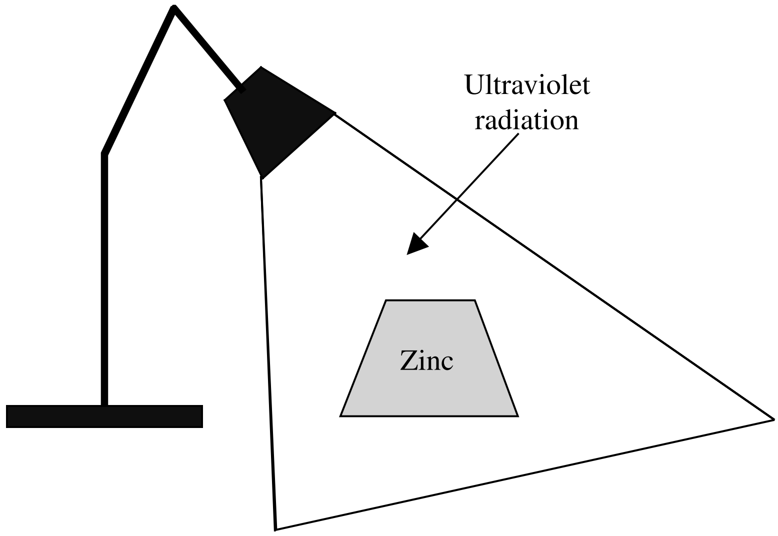

Fig. 6.1

(a) What is a **photon**?

____

____ [1]

(b) Calculate the energy of a photon of the ultraviolet radiation.

Energy = ________________ J [3]

(c) Explain what is meant by the term **photoelectric emission** and state the conditions under which it can occur for the zinc plate illuminated by the ultraviolet radiation.

____

____

____

____ [3]

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(Questions continue overleaf)

7 The term 'laser' stands for Light Amplification by the Stimulated Emission of Radiation.

Fig. 7.1 illustrates the electron arrangement within the atoms of a laser before it has been switched on. Most of the electrons are in their ground state with an occasional electron in an excited state.

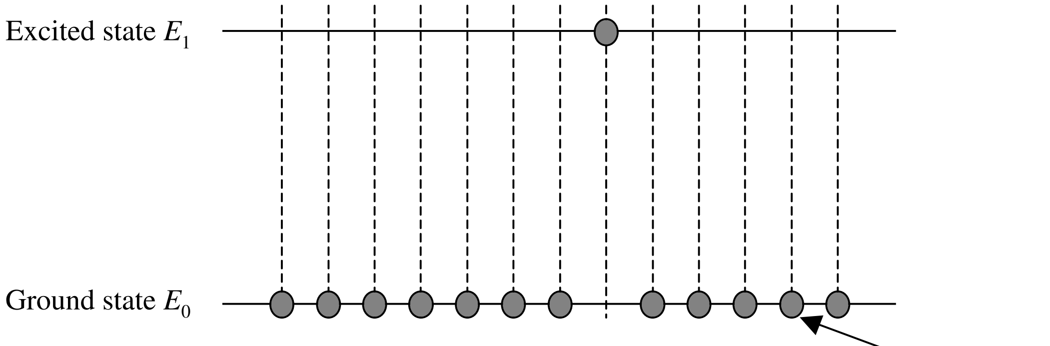

Fig. 7.1

(a) (i) On **Fig. 7.2** draw a possible electron arrangement when the laser is switched on.

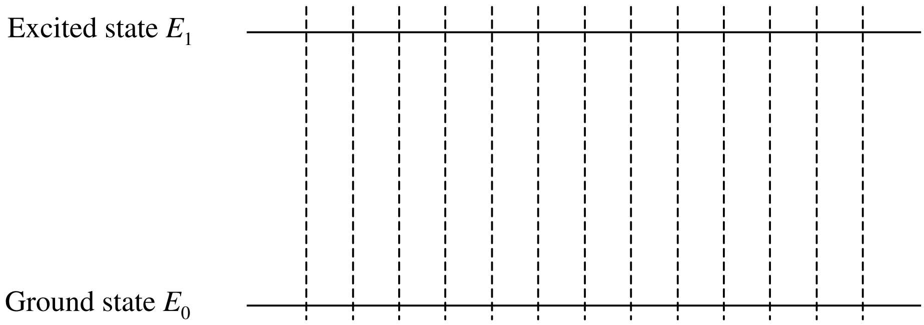

Fig. 7.2 [2]

(ii) What name is given to this situation?

Name ____ [1]

(b) Spontaneous emission occurs when an electron randomly falls to the ground state. What causes the electron to fall due to **stimulated** emission?

____ [1]

Examiner Only	
Marks	Remark

(c) Laser eye surgery uses a computer-controlled excimer laser. One such laser has argon fluoride as the lasing material. It produces electromagnetic radiation of wavelength 193 nm.

Calculate the energy of an electron's excited state if it relaxes to a state with an energy of –9.18 eV and emits radiation of wavelength 193 nm as a result.

Energy ___________ eV [4]

Examiner Only	
Marks	Remark

8 The de Broglie formula is quoted in your Data and Formulae Sheet as **Equation 8.1**.

$$\lambda = \frac{h}{p}$$ **Equation 8.1**

(a) What does each of the terms represent?

λ = ______________________

h = ______________________

p = ______________________ [1]

(b) **Fig. 8.1** is a graph of $1/p$ against λ.

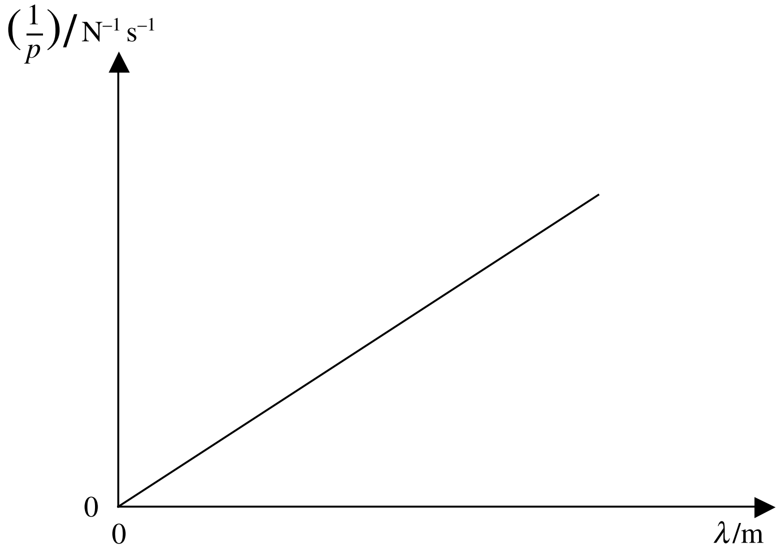

Fig. 8.1

State the numerical value for the gradient of the graph in **Fig. 8.1**. Include its units.

Gradient = ______________________ [2]

Unit ______________________ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(c) Calculate the de Broglie wavelength of an electron moving at 90% of the speed of light in a vacuum.

Wavelength ________________ m [3]

THIS IS THE END OF THE QUESTION PAPER

GCE Physics (Advanced Subsidiary and Advanced)

Data and Formulae Sheet

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$
permeability of a vacuum	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\ m^{-1}}$
permittivity of a vacuum	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$ $\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \mathrm{F^{-1}\ m}\right)$
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	$1\ \mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$
mass of electron	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
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 on the Earth's surface	$g = 9.81\ \mathrm{m\ s^{-2}}$
electron volt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$

USEFUL FORMULAE

The following equations may be useful in answering some of the questions in the examination:

Mechanics

Momentum-impulse relation	$mv - mu = Ft$ for a constant force
Power	$P = Fv$
Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force

Simple harmonic motion

Displacement	$x = x_0 \cos \omega t$ or $x = x_0 \sin \omega t$
Velocity	$v = \pm\omega\sqrt{x_0{}^2 - x^2}$
Simple pendulum	$T = 2\pi\sqrt{l/g}$
Loaded helical spring	$T = 2\pi\sqrt{m/k}$

Medical physics

Sound intensity level/dB	$= 10 \lg_{10}(I/I_0)$
Sound intensity difference/dB	$= 10 \lg_{10}(I_2/I_1)$
Resolving power	$\sin \theta = \lambda/D$

Waves

Two-slit interference	$\lambda = ay/d$
Diffraction grating	$d \sin \theta = n\lambda$

Light

Lens formula	$1/u + 1/v = 1/f$

Stress and Strain

Hooke's law	$F = kx$
Strain energy	$E = \langle F \rangle x$ $(= \frac{1}{2}Fx = \frac{1}{2}kx^2$ if Hooke's law is obeyed)

Electricity

Potential divider	$V_{out} = R_1 V_{in}/(R_1 + R_2)$

Thermal physics

Average kinetic energy of a molecule	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Kinetic theory	$pV = \frac{1}{3}Nm\langle c^2\rangle$

Capacitors

Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
Capacitors in parallel	$C = C_1 + C_2 + C_3$
Time constant	$\tau = RC$

Electromagnetism

Magnetic flux density due to current in

(i) long straight solenoid	$B = \frac{\mu_0 NI}{l}$
(ii) long straight conductor	$B = \frac{\mu_0 I}{2\pi a}$

Alternating currents

A.c. generator	$E = E_0 \sin \omega t = BAN\omega \sin \omega t$

Particles and photons

Radioactive decay	$A = \lambda N$; $A = A_0 e^{-\lambda t}$
Half life	$t_{\frac{1}{2}} = 0.693/\lambda$
Photoelectric effect	$\frac{1}{2}mv^2_{max} = hf - hf_0$
de Broglie equation	$\lambda = h/p$

Particle Physics

Nuclear radius	$r = r_0 A^{\frac{1}{3}}$