Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2009

Physics

Assessment Unit AS 2

assessing

Module 2: Waves and Photons

[ASY21]

ASY21

TUESDAY 27 JANUARY, 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** 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 **3(a)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part 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	
Total Marks	

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.

Examiner Only	
Marks	Remark

Answer **all seven** questions

1 **(a)** A wave of fixed velocity passes along a stretched string. **Fig. 1.1** shows a graph of the displacement *d* of a particle of the string against time *t*.

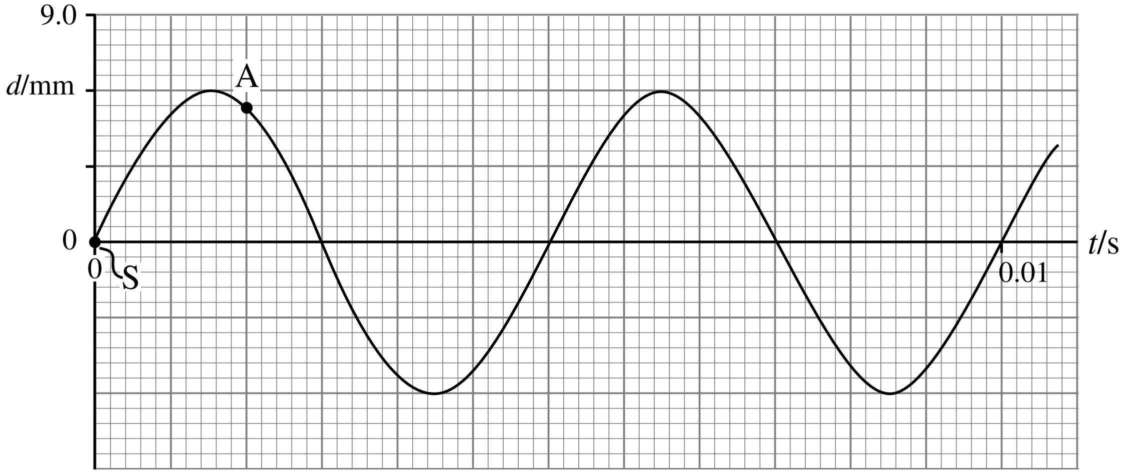

Fig. 1.1

(i) Describe the direction of the particle's displacement relative to the velocity of the wave.

____

Hence state the type of wave on the string.

Type of wave: ________________________________ [2]

(ii) Determine the amplitude of the wave.

Amplitude = _________ mm [1]

(iii) Determine the frequency of the wave.

Frequency = _________ Hz [2]

(iv) The velocity of the wave is $80.0\,\mathrm{m\,s^{-1}}$. Calculate the wavelength of the wave.

Wavelength = _________ m [3]

(b) Calculate the phase difference between the point A on **Fig. 1.1** and the origin S.

Phase difference = _________

Unit: _________ [4]

Examiner Only	
Marks	Remark

2 **(a)** **Fig. 2.1** shows three rays X, Y and Z incident on the interface between glass and air.

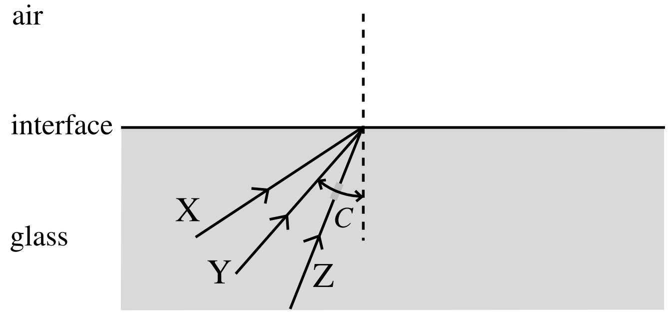

Fig. 2.1

The critical angle C for glass is shown on the diagram.

On **Fig. 2.1**, sketch the path of each ray after it leaves the interface. Label these paths X, Y and Z respectively. [3]

(b) A short pulse of light enters a straight optical fibre of length 1.20 km. The pulse travels along the axis of the fibre, as shown in **Fig. 2.2**.

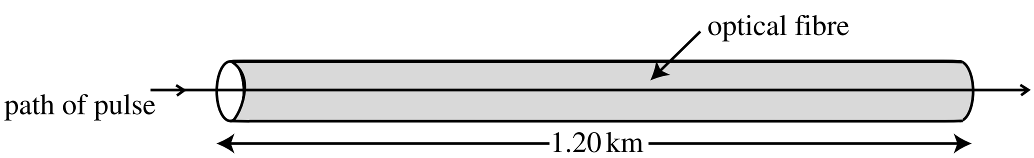

Fig. 2.2

(i) The pulse takes 5880 ns to pass along the fibre. Calculate the velocity of light in the material of the fibre.

Velocity of light = ________ m s^{-1} [2]

Examiner Only	
Marks	Remark

(ii) Calculate the refractive index of the material.

Refractive index = _________ [2]

(iii) Calculate the critical angle of the material of the fibre.

Critical angle = _________ ° [2]

QUESTION 2 CONTINUES ON PAGE 6

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(c) A ray of light enters the plane surface of a block of ice at an angle of 27.0° to the surface, as shown in **Fig. 2.3**.

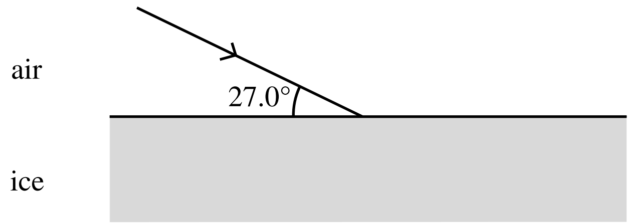

Fig. 2.3

(i) State the value of the angle of incidence of the light ray on the ice.

Angle of incidence = _________° [1]

(ii) The refractive index of ice is 1.31. Calculate the angle of refraction of the ray at the air–ice interface.

Angle of refraction = _________° [2]

(iii) Hence calculate the angle through which the refracted ray has been deviated from its original direction before refraction.

Angle of deviation = _________° [1]

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(Questions continue overleaf)

3 In part (a) of this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only	
Marks	Remark

(a) (i) Distinguish between a **real** and a **virtual** image.

____

____ [1]

(ii) A small, upright object is placed on the principal axis of a **diverging** lens. The object is a long way from the lens, almost at infinity. Its image is upright, virtual and diminished, and is very close to the principal focus of the lens.
The object is then moved slowly from this distant position to a point close to the lens, within its focal length.
Describe how the nature and position of the image change as a result.
(You may make sketches in the space below to deduce what happens, but you will be credited **only** for your prose description.)

Description: ____

____

____

____

____

____ [2]

Quality of written communication [1]

Examiner Only

Marks	Remark

(b) The lens of a projector produces an image of a square slide of side 2.00 cm on a screen 2.40 m from the lens. The image on the screen is a square of side 0.80 m.

(i) Describe the nature of the image formed on the screen.

____

____ [1]

(ii) Calculate the distance between the projector lens and the slide.

Distance = ______________ cm [1]

(iii) Hence calculate the focal length of the projection lens.

Focal length = ______________ cm [2]

4 **(a)** When waves come together, **stationary waves** may be formed. State the necessary conditions for this to occur.

____

____

____

____ [3]

(b) **Fig. 4.1** shows a pipe of length 0.88 m, closed at one end, in air.

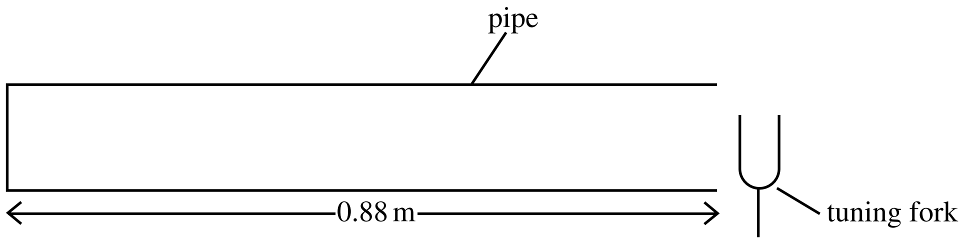

Fig. 4.1

Resonance is obtained when a vibrating tuning fork of frequency 288 Hz is held over the open end. The air in the pipe is then in its **second** mode of oscillation.

(i) On **Fig. 4.1**, illustrate the second mode of oscillation. Mark the positions of all nodes and antinodes. Use the letter N for each node, and the letter A for each antinode. [2]

(ii) Calculate the speed of sound in air.

Speed of sound = _____________ $m\,s^{-1}$ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

5 **(a)** Describe a transmission diffraction grating.

____

____

____ [2]

(b) A diffraction grating is illuminated normally by light of wavelength 589 nm. The first-order diffracted maximum occurs at an angle of 20.7° to the normal.

(i) Show that this grating has 600 lines per millimetre.

[2]

(ii) Find the highest order of diffraction that can be observed with this grating using light of wavelength 589 nm at normal incidence.

Highest order = ______________ [2]

Examiner Only	
Marks	Remark

6 **(a)** A metal surface is illuminated by electromagnetic radiation of varying frequencies *f*. Photoelectrons of maximum kinetic energy E_{max} are emitted. **Fig. 6.1** shows a graph of E_{max} against *f*.

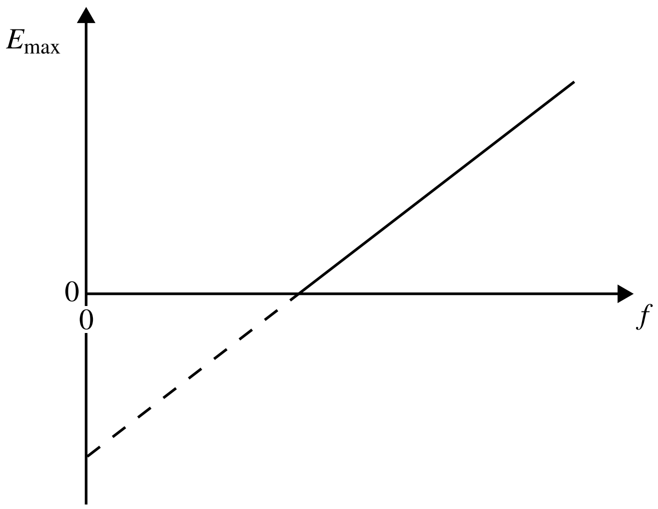

Fig. 6.1

The gradient of the graph is m and the intercept on the E_{max} axis is $-c$. In terms of m and c, as appropriate, write down expressions for

(i) the Planck constant h,

h = ______________________ [1]

(ii) the work function ϕ of the metal.

ϕ = ______________________ [1]

Examiner Only	
Marks	Remark

(b) A zinc surface emits photoelectrons when exposed to very faint ultra-violet radiation. It does not emit photoelectrons when exposed to visible red light of high intensity.

(i) Explain this situation.

____

____

____ [2]

(ii) State how the number of photoelectrons released per second from the zinc surface could be increased.

____

____ [1]

(c) A sodium surface emits photoelectrons of maximum kinetic energy 1.06×10^{-19} J when illuminated by light of frequency 6.00×10^{14} Hz. Calculate the work function of the sodium surface in eV.

Work function = ______________ eV [3]

7 **(a)** **Fig. 7.1** illustrates an experiment to demonstrate electron diffraction. A fine beam of electrons is incident on a thin metal foil inside an evacuated glass container.

Examiner Only	
Marks	Remark

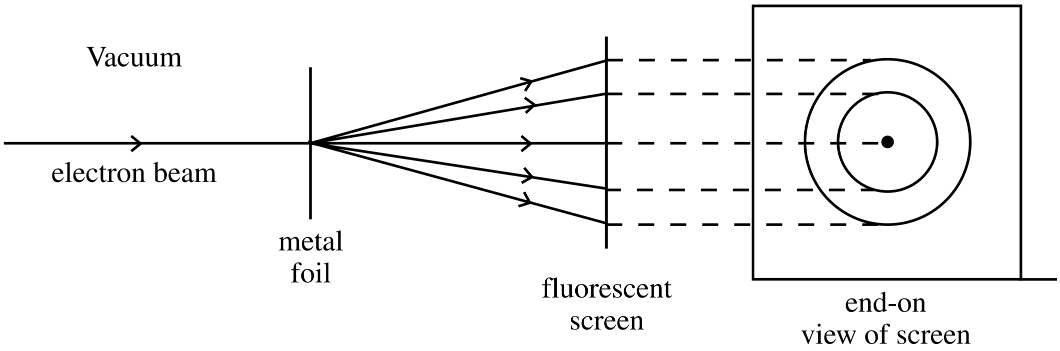

Fig. 7.1

The pattern on the screen is one of concentric circles.

The accelerating potential difference applied to the electrons is **increased**. This causes the diameter of the circles to **decrease**. Explain why this happens.

____

____

____

____

____ [3]

(b) The velocity of electrons in a beam is $1.20 \times 10^7\,\mathrm{m\,s^{-1}}$. Calculate the wavelength of an electron in the beam.

Wavelength = _________ nm [2]

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	$1\,\mathrm{eV} = 1.60 \times 10^{-19}\,\mathrm{J}$

ASY21INS

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	$E = <F> x$ ($= \frac{1}{2}Fx = \frac{1}{2}kx^2$ 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	$\frac{1}{2}m<c^2> = \frac{3}{2}kT$
Kinetic theory	$pV = \frac{1}{3}Nm<c^2>$

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