Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2011

Physics

Assessment Unit AS 2

Module 2: Waves, Photons and Medical Physics

[AY121]

MONDAY 27 JUNE, MORNING

MARK SCHEME

Subject-specific Instructions

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this "correct answer" rule does not apply for formal proofs and derivations, which must be valid in all stages to obtain full credit.

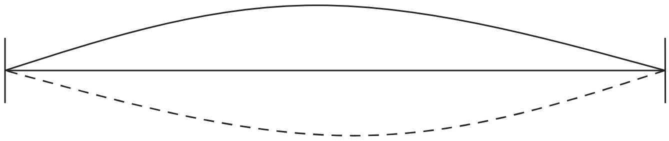
Do not reward wrong physics. No credit is give for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later parts of questions that are consistent with an earlier incorrect numerical answer, and are based on physically correct equations, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

					AVAILABLE MARKS
1	**(a)** Same amplitude (penalise if additional responses given)			[1]	
	(b) **(i)** $2\lambda = 2.4$ m		[1]		
	$\lambda = 1.2$ (m)		[1]	[2]	
	(ii) $4.5T = 0.036$ s		[1]		
	$T = 8 \times 10^{-3}$ s		[1]		
	$f = 125$ (Hz)		[1]	[3]	
	(iii) $v = f\lambda$		[1]		
	$v = 150$ (m s^{-1})	allow ecf **(b)(i)** and **(b)(ii)**	[1]	[2]	8
2	**(a)** $\sin C = 1/n$		[1]		
	$C = 41.8°$		[1]	[2]	
	(b) **(i)** Box PQ ticked (ecf **(a)**)			[1]	
	(ii) Bends away from the normal				
	+ No bending at PR			[1]	
	(iii) Incident angle = 35°		[1]		
	Refractive index = 1/1.50 (= 0.667) or $n = \frac{\sin i}{\sin r}$		[1]		
	$r = 59.4°$		[1]	[3]	7

	AVAILABLE MARKS
3 (a) Ray parallel to PA refracting as if from F1 **and** refracted ray produced back **or** Ray incident towards F2 refracting parallel to PA **and** refracted ray produced back [1] Image position located with an arrow, labelled I, pointing up [1] [2] Converging ray diagram ⟶ [0]/[2]	
(b) Method 1: Lens between lamp house and plane mirror [1] Adjust lens position until image formed in plane of lamp house [1] Focal length is distance between lens and lamp house [1] Repeat procedure and average [1] **or** Method 2: Series of u values [1] Adjust screen position until a sharp image is formed [1] Measure lens to screen distance [1] Result analysis consistent with method [1] [4] Distant object method, maximum [3]/[4]	
Quality of written communication **2 marks** The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling. **1 mark** The candidate expresses ideas clearly, if not always fluently. There are some errors in grammar, punctuation and spelling, but not such as to suggest weakness in these areas. **0 marks** The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]	8

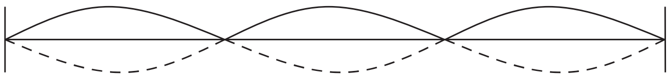
AVAILABLE MARKS

4 **(a)** **(i)**  [1]

(ii) N marked at each end, [1]
A marked midway between ends [1] [2]
([−1] for each addition, omission and wrong response)

(b) **(i)** 1.68 (m) [1]

(ii) $f_1 = 4\ f_0$ or $\lambda_0 = 4\ \lambda_1$; ratio = 4 [1]
Distance = 0.21 m [1] [2]

(c)  [1] 7

5 **(a)** Constant phase difference [1]

(b) At this location both waves reach equal displacements simultaneously or crests coincide with crests [1]

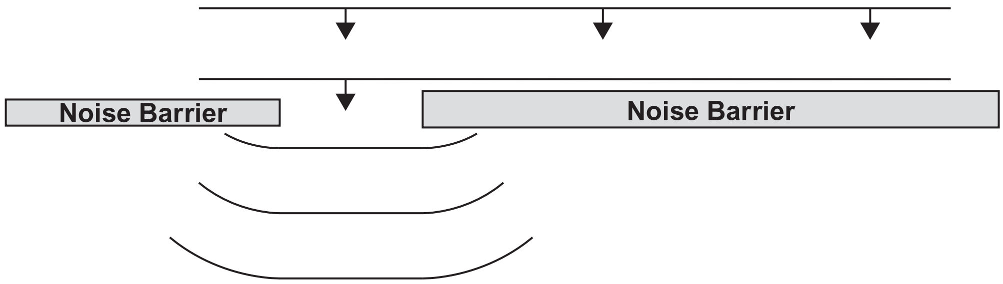
(c) Bright fringe means constructive interference [1]
Path difference = integer number of wavelengths [1] [2]

(d) y = 24.3/6* mm or equivalent [2]
subs into $d = ay/\lambda = 0.66 \times 10^{-3} \times 4.05 \times 10^{-3} / 6.42 \times 10^{-7}$ ecf for y [1]
d = 4.16 (m) [1] [4] 8

*Use of 7; SE = 3.57 m [3]/[4]

					AVAILABLE MARKS
6	**(a)**	($T = 160\ \mu s$ $T = 160 \times 10^{-6}$ s)	Identifies 4 cm per cycle Calculates T consistently	[1] [1]	
		$f = 1/T$		[1]	
		$f = 6250$ (Hz) ecf for T		[1]	[4]

(b) **(i)** Three equally spaced, parallel wavefronts [1]
Slight spreading at edges (increasing with each wavefront) [1] [2]



(ii) Shadow zone decreases [1]
Spreading increases as wavelength increases
or Diffraction is maximum when gap $\approx \lambda$ [1] [2] 8

7 **(a)** Cross-sectional image (in the plane of a scan) [1]

(b) Incident electron deceleration (braking radiation or bremsstrahlung) [1]
Target electron ionised from inner shell [1]
Another target electron relaxing into vacated shell [1] [3]

(c) **(i)** 99% converted to thermal energy [1]
Copper forms a heat sink for the tungsten target [1]
Target rotates to reduce localised heating [1] [3]

(ii) To reduce the X-ray dose received by the patient
X-rays absorbed by aluminium would otherwise be absorbed by patient [1] 8

						AVAILABLE MARKS
8	(a)		A particle/packet	[1]		
			of electromagnetic/light energy	[1]	[2]	
	(b)		1/h	[1]		
			1.51×10^{33}	[1]	[2]	
	(c)		$E = hf$	[1]		
			$E = 6.63 \times 10^{-34} \times 200 \times 10^{6}$	[1]		
			$E = 1.33 \times 10^{-25}$ (J)	[1]	[3]	7
9	(a)		Electron absorbs the energy and is ionised	[1]		
			Emitted with (245.6 eV of) kinetic energy	[1]	[2]	
	(b)		Electron does not absorb the photon	[1]		
			Can only absorb the exact amount of energy to move it to a higher energy level	[1]	[2]	
	(c)		3.94×10^{16} Hz $\longrightarrow E = 2.61 \times 10^{-17}$ J	[1]		
			$E = 163.3$ eV J $\longrightarrow$ eV − ecf	[1]		
			Electron falls	[1]		
			between $n = 2$ to $n = 1$	[1]	[4]	8
10	(a)	(i)	1. Wave model	[1]		
			2. Particle model	[1]	[2]	
		(ii)	Reflection, refraction		[1]	
	(b)		$\lambda = h/p$	[1]		
			$\lambda = 6.63 \times 10^{-34}/(6.64 \times 10^{-27} \times 4.50 \times 10^{6})$ Subs	[1]		
			$\lambda = 2.22 \times 10^{-14}$ (m)	[1]	[3]	6
					Total	**75**