Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2012

Physics

Assessment Unit AS 2

Module 2: Waves, Photons and Medical Physics

[AY121]

FRIDAY 20 JANUARY, 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 given for consistent substitution of numerical data, or subsequent arithmetic, **in a physically incorrect equation**. However, answers to subsequent stages of questions that are consistent with an earlier incorrect numerical answer, and are based on physically correct equation, 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}) count only as arithmetical slips and lose the answer mark.

1 **(a)** **(i)** In transverse waves the **vibration** of the medium or particles (if there is one) is at right angles to the direction of wave propagation. [1]

In longitudinal waves the vibration of the medium is parallel to the direction of wave propagation. [1] [2]

(ii)

Microwaves	transverse
Waves on a string	transverse
Waves in a resonance tube	longitudinal
Surface water waves	transverse

[$\frac{1}{2}$] each, round down [2]

(b) Vibrations all in one plane [1]
Transverse [1] [2] 6

2 **(a)** For given pair of media [1], the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant [1] [2]

(b) **(i)** Diagram showing ray box, glass block [1]

(ii)
- 1 Draw round the block and
- 2 direct ray from light box onto the block
- 3 Mark incident and emergent rays and
- 4 remove block
- 5 Join from where the ray enters the block to where it leaves it
- 6 Construct normal and
- 7 measure i and r as marked in the diagram
- 8 Repeat for a range of angles of incidence

[$\frac{1}{2}$] each, round down (maximum [3]) [3]

(iii)
- For each pair find sin i and sin r
- Plot sin i/sin r [1] should be a straight line through origin [1]
  or ratio sin i/sin r [1] is constant [1] [2]

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]

(c) sin (90 – 28)/sin r = 1.38 [1]
r = 40° [1] [2] 12
S.E. r = 19.9° → [1]/[2]

AVAILABLE MARKS

3 **(a)** **(i)** Convex or converging [1]

(ii) 2 correct rays, inverted image and principal focus marked [1] × 4 [4]
Award "principal focus" mark only if diagram is correct
Penalty [–1] for an incorrect third ray
Penalty [–1] if no arrows on ray or rays

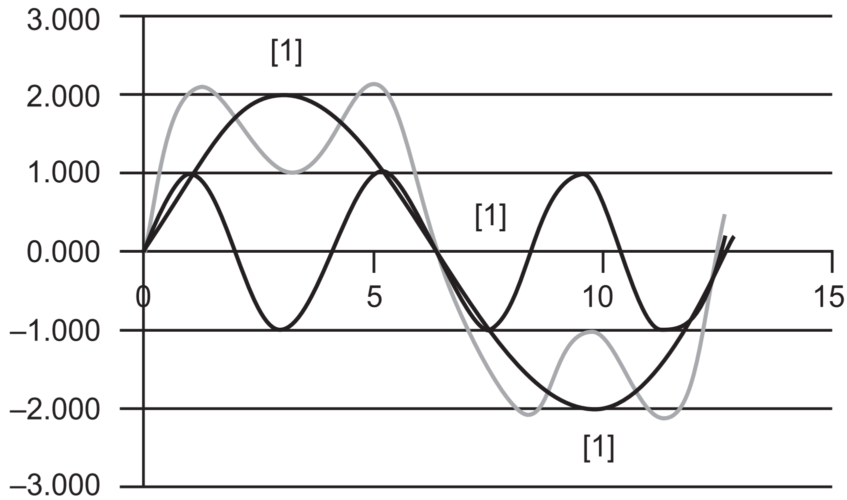
(b) **(i)** u = 0.25 m, v = –1.8 m

Focal length = 29 cm [2], convex or converging [1] lens [3]

(ii) Power = 3.4 D or m^{-1} ecf [2] 10

4 **(a)** When two waves meet [1], the total displacement [1] is the vector (or algebraic) sum of the individual displacements at that point [1] [3]

(b) **(i)** One wave with a dip in each half



[3]

Penalty [–1] applied if all three marking points are correct but overall shape is poor.

(ii) f_0 ✓ [1] 7

5 **(a)** **(i)** constant phase difference [1]

(ii)
- same amplitude and
- phase difference 180° [2]

(b) **(i)** Difference in path distance travelled by two waves which meet at the same point [1]

(ii) (constructive interference) bright fringe [1]

(iii) path difference = (**n** + $\frac{1}{2}$) λ [1] 6

					AVAILABLE MARKS
6	(a)	(i)	Diagram showing tuning fork (or loudspeaker and signal generator) [1], resonance tube in water container [1]	[2]	
		(ii)	Sound fork [1], (slowly) lift [1] the resonance tube until sound gets loud for the **first time** [1]	[3]	
			Speaker and sig-gen method • Use sig-gen to sound speaker [1] • Vary frequency from a low value [1] • until sound is loud [1]		
	(b)	(i)	Time for 1 wave = 2 ms [1] Frequency = $\frac{1}{T} = \frac{1}{2} \times 10^{-3}$ = 500 Hz [1]	[2]	
		(ii)	$\lambda = \frac{v}{f} = \frac{340}{500}$ = 0.68 m [1] length of air column = 0.17 m [1] ecf **(b)(i)**	[2]	9
7	(a)	(i)	• X-ray source directed at patient with • detector below	[2]	
		(ii)	• Source and detector rotate around the patient while • the patient is moved through the scanner • Electronic scans are stored in a computer and they are then built up to form a cross-section image.	[3]	
	(b)		Strong magnetic force on pin	[1]	6
8	(a)	(i)	(Minimum) energy needed to liberate an electron from the surface of a metal	[1]	
		(ii)	E = $\frac{hc}{\lambda}$ = 3.82×10^{-19} J [1] Work function = 2.39 (eV) [1] ecf E in joule	[2]	
	(b)		Light output = 160 × 0.7 = 112 W [1] Number of photons emitted per second = $\frac{112}{3.38 \times 10^{-19}} = 3.31 \times 10^{20}$ [1]	[2]	5
9	(a)	(i)	When the atom is most stable or the electron is in its lowest energy state	[1]	
		(ii)	–13.6 (eV)	[1]	
	(b)	(i)	Longest wavelength is the least energetic transition [1] $0.54 \times 1.6 \times 10^{-19} = \frac{hc}{\lambda}$ [1] ecf their transition ecf So $\lambda = 2.3 \times 10^{-6}$ m = 2.3 (μm) [1]	[3]	
		(ii)	Transition **down**ward from 0 to –0.54 eV clearly marked	[1]	6

10 (a) Diagram showing and/or text referencing:

- Electrons incident
- on metal foil or carbon film
- **fluorescent** screen
- diffraction/interference pattern [4]

(b) (i) Momentum, $p = 9.11 \times 10^{-31} \times 4.19 \times 10^{7} = 3.82 \times 10^{-23}$ kg ms^{-1} [1]

$\lambda = \frac{h}{p} = 1.74 \times 10^{-11}$ (m) [1] [2]

(ii) Momentum or mass is a particle concept [1]

Wavelength is a wave concept [1] [2]

	AVAILABLE MARKS
	8
Total	**75**