Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2013

Physics

Assessment Unit AS 2

Module 2: Waves, Photons and Medical Physics

[AY121]

FRIDAY 18 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.

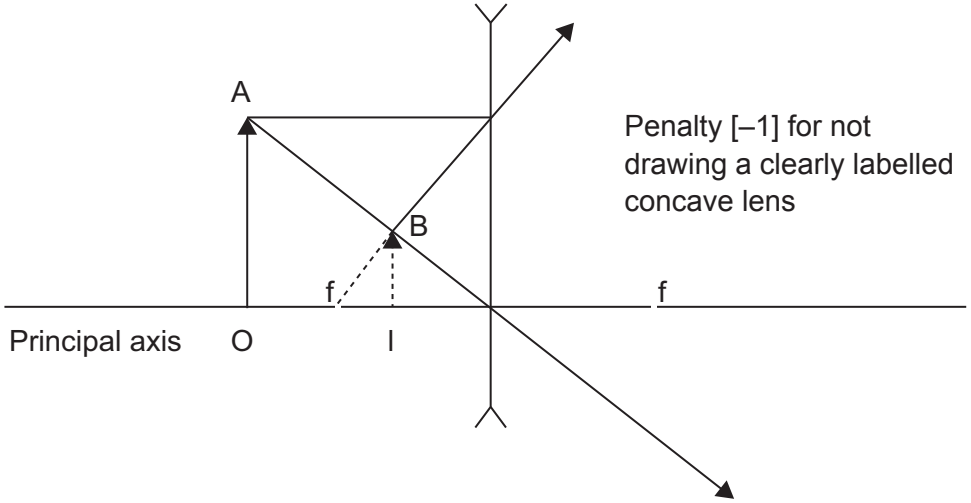
Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, **in a physically incorrect equation**. However, answers to subsequent stages of questions that are consistent with an earlier incorrect numerical answer, and are based on a physically 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} m) count only as arithmetical slips and lose the answer mark.

			AVAILABLE MARKS
1	(a)	Gamma, X-ray, UV, visible, IR, microwave, radio All seven correct [1], correct order [1] [2]	
	(b) (i)	Microwave/Radio wave [1]	
	(ii)	$f = \frac{c}{\lambda} = 3 \times 10^8/0.19$ [1] $f = 1.58 \times 10^9$ $f = 1.58 \times 10^3$ MHz [2]	
	(c) (i)	Transverse, e.g. waves on a string [1]	
	(ii)	Longitudinal, e.g. sound [1]	
	(iii)	L: Vibration along direction of propagation [1] T: Vibration at right angles to the direction of propagation [1] [2]	9
2	(a)	1. Ray box and glass block [1] Correct rays [1] [2]	
		2. Draw block and mark incident ray and exit refracted ray, [1] (remove block and) join two rays, construct normal(s) and [1] *measure* i and r (clearly marked on diagram) [1] [3]	
		3. Plot sin i against sin r [1] and expect a straight line through origin to verify Snell's law [1] [2] [7]	
		3. Alternative Calculate $\frac{\sin i}{\sin r}$ for all pairs [1] ratio is constant if law verified [1]	
		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]	
	(b)	Sin r = sin 58/1.41 or Angle of refraction = 37.0° [1] Angle of deviation = 21° [1] [2]	11

AVAILABLE MARKS

3 (a)



Penalty [–1] for not drawing a clearly labelled concave lens

Fig. 3.1

Two correct rays [2] no arrows [–1] image [1] + both foci marked [1], eye to right of lens [1] [5]

(b) (i)

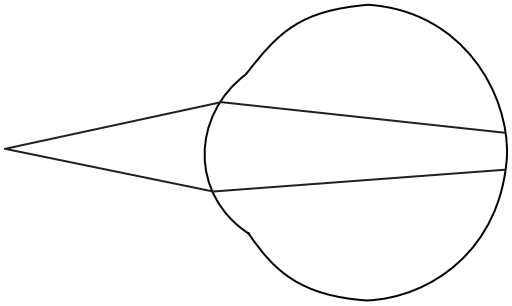
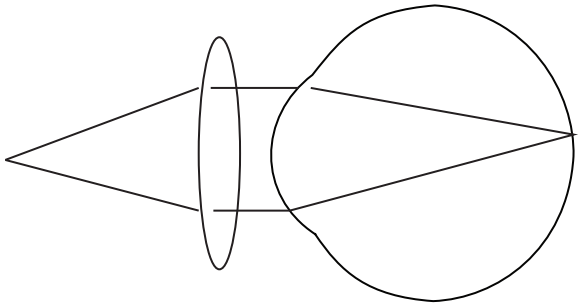


Fig. 3.2 [1]

(ii)



Convex lens [1]
Meeting on retina [1]
(only award if correct lens used)

Fig. 3.3 [2]

(iii) u = 25 cm, v = –40 cm [1]
f = 66.7 (cm) [1] [2]

(iv) Power = 1.5 (D) [1] 11

AVAILABLE MARKS

4 **(a)** **(i)** A wave in which no energy is transferred [1]

(ii) Two identical waves or same frequency and speed (or λ) or coherent [1] travelling in opposite directions [1] [2]

(iii) Superposition [1]

(b) **(i)**

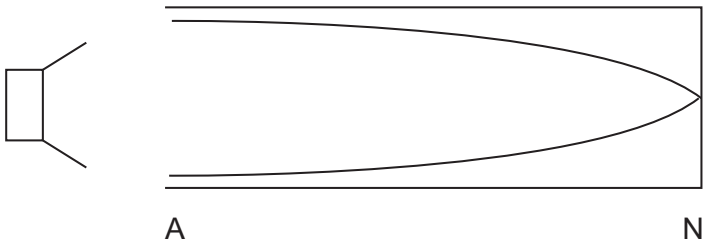
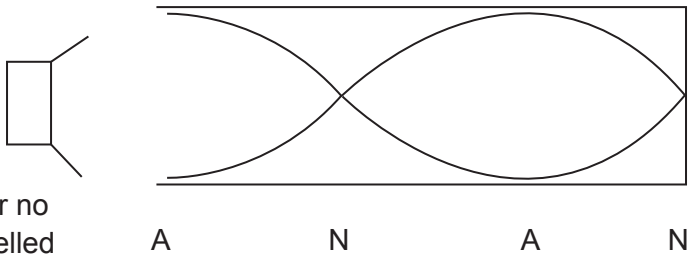


Fig. 4.1 [1]



Penalty [–1] for no anti/nodes labelled

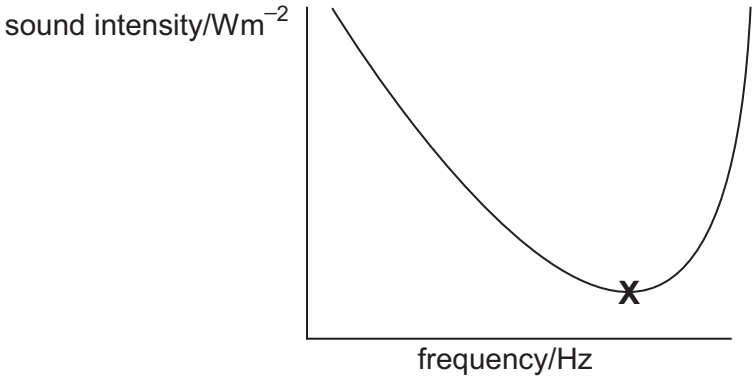
Fig. 4.2 [2] [3]

(ii) $f = v/\lambda = 340/4 \times 0.3$
First position = 283 (Hz) [1]
Second position = 850 (Hz) [1] [2] 9

5 **(a)** **(i)** [1] [1]
Sound intensity level = 10 log ($2.5 \times 10^{-3}/1 \times 10^{-12}$) subs [2]
Sound intensity level = 94 (dB) [1] [3]

(ii) New sound intensity level = 94 – 4 = 90 dB (allow ecf) [1]
Sound intensity = Anti log (90/10) $\times 10^{-12} = 1 \times 10^{-3}$ ($W m^{-2}$) [1] [2]

(b) **(i)**

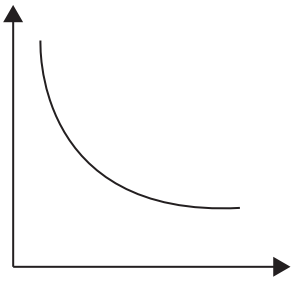
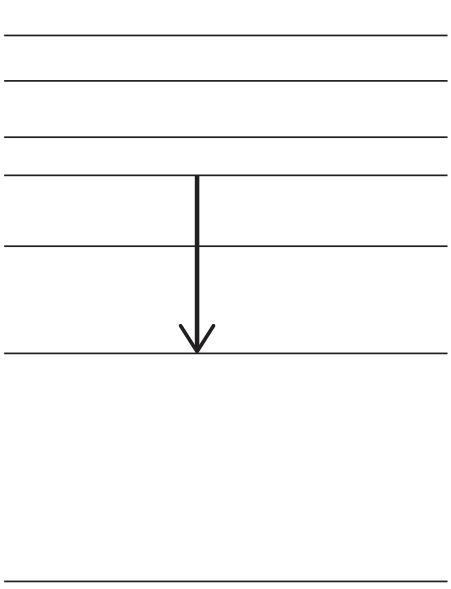


[1]

(ii) Frequency = 1000–2000 Hz [1]

(iii) 3 (Hz) In range 3–6 Hz [1]

(iv) From 20 Hz to about 20 000 Hz [1] 9

					AVAILABLE MARKS
6	(a)	(i)	Bundle 1: carries light into the body/illumination Bundle 2: relays an *image* to the doctor	[1]	
			Bundle 1: (non-coherent) – fibres randomly arranged Bundle 2: (coherent) – fibres maintain a regular order	[2]	
		(ii)	e.g. irrigation/laser/suction/air	[1]	
		(iii)	Time = distance/speed in fibre = $1.45/(3 \times 10^8/1.53)$ [1] $= 7.4 \times 10^{-9}$ (s) [1]	[2]	
	(b)	(i)	Using an electromagnet	[1]	
		(ii)	Superconduction (allow if mentioned in **(b)(i)**)	[1]	
		(iii)	e.g. no ionising radiation/better resolution	[1]	9
7	(a)		energy  wavelength	[1]	
	(b)	(i)	The energy required to remove an electron from a metal surface	[1]	
		(ii)	$\lambda_{max} = hc/eV = hc/W$ [1] $= 6.63 \times 10^{-34} \times 3 \times 10^8/(2.4 \times 1.6 \times 10^{-19})$ [1] 5.18×10^{-7} [1] m → nm [1]	[4]	
	(c)		Energy/eV 0 –0.38 –0.54 –0.85 –1.50 –3.40 –13.6  **Fig. 7.2**		
		(i)	Transition between (–)3.40 eV and (–)0.85 eV	[1]	
		(ii)	Correct downward transition on diagram	[1]	8

					AVAILABLE MARKS
8	(a)	(i)	Description to include evacuated tube with fluorescent screen [1] and graphite target [1]	[2]	
		(ii)	Concentric rings	[1]	
		(iii)	As the velocity is increased the associated wavelength of the electrons decreases [1] (as does the angle at which diffraction is observed) hence smaller radius (rings closer) [1]	[2]	
	(b)	(i)	velocity = $\sqrt{\left(\frac{2 \times KE}{m_e}\right)} = \sqrt{\left(\frac{2 \times 4.0 \times 10^{-17}}{9.11 \times 10^{-31}}\right)}$ Eqn, sub [1]		
			$= 9.37 \times 10^6\ (m\,s^{-1})$	[1] [2]	
		(ii)	$\lambda = \frac{h}{mv} = 6.63 \times 10^{-34}/(9.1 \times 10^{-31} \times 9.37 \times 10^6)$ allow ecf sub [1]		
			Wavelength = 7.76×10^{-11} (m)	[1] [2]	9
				Total	**75**