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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 5456
Specification B

PHB2 Waves and Nuclear Physics

Mark Scheme

2006 examination – June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Notes for Examiners

Letters are used to distinguish between different types of marks in the scheme.

M indicates OBLIGATORY METHOD MARK
This is usually awarded for the physical principles involved, or for a particular point in the argument or definition. It is followed by one or more accuracy marks which cannot be scored unless the M mark has already been scored.

C indicates COMPENSATION METHOD MARK
This is awarded for the correct method or physical principle. In this case the method can be seen or implied by a correct answer or other correct subsequent steps. In this way an answer might score full marks even if some working has been omitted.

A indicates ACCURACY MARK
These marks are awarded for correct calculation or further detail. They follow an M mark or a C mark.

B indicates INDEPENDENT MARK
This is a mark which is independent of M and C marks.

e.c.f. is used to indicate that marks can be awarded if an error has been carried forward (e.c.f. must be written on the script). This is also referred to as a 'transferred error' or 'consequential marking'.

Where a correct answer only **(c.a.o.)** is required, this means that the answer must be as in the Mark Scheme, including significant figures and units.

c.n.a.o. is used to indicate that the answer must be numerically correct but the unit is only penalised if it is the first error or omission in the section (see below).

Only **one** unit penalty **(u.p.)** in this paper unless there is a mark allocated specifically for giving a correct unit in the marking. Note that the unit is only penalised in the final answer to the question.

Only **one** significant figure penalty **(s.f.)** in this paper.
Allow 2 or 3 s.f. unless otherwise stated. s.f. penalties include recurring figures and fractions for answers.

Marks should be awarded for **correct** alternative approaches to numerical questions that are not covered by the mark scheme. A correct answer from working that contains a physics error (PE) should not be given credit. Examiners should contact the Team Leader or Principal Examiner for confirmation of the validity of the method, if in doubt.

Quality of Written Communication

Before accessing marks for the Quality of Written Communication (QWC) a candidate must first score a minimum of one mark for the physics that is being communicated – this will allow access to 1 mark for QWC. If the candidate scores more marks for physics (a minimum of two or three – depending upon the total mark for that part of the question) then this will allow access to 2 marks for QWC.

Good QWC: the answer is fluent/well argued with few errors in spelling, punctuation and grammar	**2**	
Poor QWC: the answer lacks coherence or spelling, punctuation and grammar are poor	**1**	**Max 2**
Very Poor QWC: the answer is disjointed, with significant errors in spelling, punctuation and grammar	**0**	

PHB2 Waves and Nuclear Physics

Question 1			
(a)	gamma	**B1**	**1**
(b)	two left-hand boxes correct **or** two right-hand boxes correct all regions correct	**B1** **B1**	**2**
			Total 3

Question 2			
(a)	one medical, e.g. pre-natal scan, blood flow, imaging tissues, stone destruction etc *do not allow vague statements* one industrial, e.g. crack detection, cleaning, thickness determination, etc *do not allow vague, unexplained references to sonar*	**B1** **B1**	**2**
(b)	cannot be polarised it is longitudinal *allow* 'cannot be polarised so is not transverse'	**M1** **A1**	**2**
			Total 4

Question 3			
(a)	(proton) down 2/-2 (nucleon) down 4/-4	**B1** **B1**	**2**
(b)	gamma greater, *must express comparison, don't allow simple list*	**B1**	**1**
(c)	use of inverse-square law $\frac{1}{9}$/0.11	**C1** **A1**	**2**
			Total 5

Question 4			
(a) (i)	Z down	**B1**	**4**
	X **and** Y up	**B1**	
(ii)	any **two** of: **same** frequency/wavelength *not* 'it has same frequency' moving in opposite directions, reflected **at end of string**, same/similar amplitude integer no of ½ wavelengths between walls	**B2**	
(b)	indicates *f* is 3 times fundamental in some way **or** that length is 3λ/2	**C1**	**2**
	40 Hz	**A1**	
			Total 6

Question 5			
(a)	intensity proportional to A^2	**C1**	**2**
	¼ / 0.25 /0.250 (c.a.o.) *watch for u.p.*	**A1**	
(b)	**partial** (or implied partial) reflection from the board	**B1**	**2**
	absorption (attenuation) in hardboard/energy or intensity lost as beam travels through hardboard/energy is scattered out of beam/photon interaction/deflected into **more than one** path *do not allow diffraction or refraction statements*	**B1**	
			Total 4

Question 6			
(a)	B	**B1**	**1**
(b)	A *(more than one drawn unless clearly notated, 0)*	**C1**	**2**
	always **curves** downwards	**A1**	
			Total 3

Question 7			
(a)	all plots correct to ½ small square *deduct 1 mark for one incorrect, 2 marks for 2+ incorrect* line appropriate	**B2** **B1**	**3**
(b)	one correct determination from correct numbers 154 ± 10 s two correct determinations and average	**B1** **B1** **B1**	**3**
(c)	(use of $A = \lambda N$) $480 = \lambda \times 1.1 \times 10^{-5}$ **[**allow $\lambda = \ln 2/t_{½}$] $4.4 \times 10^{-3}\ s^{-1}$ [4.36]	**C1** **A1**	**2**
			Total 8

Question 8				
(a)	(i)	idea of constructive interference **or** superposition (peak to peakness) *do not allow* add/interact/combine path difference between signals is integer number of λ/**arrives** in phase *allow* 'meet'	**B1** **B1**	**4**
	(ii)	distance apart = [$\lambda \times D$/f..s.] = $0.54 \times 570/1.7$ = 181 km	**C1** **A1**	
(b)		any **two** of: 8 kHz because this is within range of human hearing 560 kHz is **carrier** wave 560 kHz wave is electromagnetic (radio) wave **and** 8 kHz is sound (or audio) wave sensible comment explaining why 560 kHz used	**B2**	**2**
(c)		any three from: idea of sampling at time intervals/repeatedly sampled sensible sampling rate discussed 1ms between samples, 1 kHz sampling rate or higher value is converted/*sense of* voltage being processed binary/0 and 1/bits/bytes OWTTE output	**B3**	**3**

(d)	any three from: idea that one channel available to many users *do not allow idea of simultaneity* digital signal divided into chunks/allocated time slot information sent sequentially/ABCDABCD *etc*/info compressed re-combined to recreate original	**B3**	**3**
			Total 12

Question 9			
(a)	*speed of astronomical object* = *constant* × *distance*/ *speed of object* proportional to *distance*/*speed*/*distance* constant speed is **relative/recession** between **Earth/solar system** and object **and** distance specified as separation (between observer and object)	**C1** **A1**	**2**
(b)	$H = 4.6 \times 10^3/2.2 \times 10^{21}$ $= 2.1 \times 10^{-18}$ (s^{-1}) [2.09]	**C1** **A1**	**2**
(c)	use $\Delta f/f = v/c = 4.6 \times 10^3/3.0 \times 10^8$ [$= 1.5[3] \times 10^{-5}$] *must see substitution or number* ***if formula quoted it must be correct*** so 1.5×10^{-3}%	**C1** **A1**	**2**
(d)	temperature of star/star type/intensity/colour composition (*elements, gaseous atmosphere*)/age of star *not* distance from Earth *not* colour, brightness, size	**B1** **B1**	**2**
			Total 8

Question 10			
	describes neutron decay correctly including anti-neutrino emission *condone missing* electron *in* electron anti-neutrino	**B1**	
	max four from: compares hadrons and leptons correctly: non-fundamental fundamental **strong** nuclear force **weak** nuclear force large mass small/zero mass *accept heavy – light, but not* 'weight'	**B1**	**max 5**
	gives e- or $\overline{\upsilon}$ as example of lepton gives n or p as example of hadron quarks used to describe hadron describes n **or** p correctly in quark terms quarks (may be) fundamental	**B1** **B1** **B1** **B1** **B1**	
	At least 2 marks for physics + **Good QWC** At least 2 marks for physics + **Poor QWC** At least 2 marks for physics + **Very Poor QWC** 1 or 2 marks for physics + sufficient attempt + **Good or Poor QWC** 1 or 2 marks for physics + insufficient attempt or **Very Poor QWC** No marks for physics or **Very Poor QWC**	**2** **1** **0** **1** **0** **0**	**max 2**
			Total 7

Question 11				
(a)	(i)	20/47 = 0.43 s [0.426]	**B1**	**3**
	(ii)	distance = 340 × 0.43 *condone doubling for this mark* *[v = fλ solutions score zero]* *e.c.f. possible from* 11 (a) (i)	**M1**	
		72 m [72.3] [73.1]	**A1**	
(b)	(i)	λ = 340/2400 *condone power of ten error in this mark*	**C1**	**6**
		= 0.14(2) m	**A1**	
	(ii)	uses $d = n\lambda/\sin\theta$ *do not allow working from* $\sin\theta = \lambda/b$; this scores 0 overall	**B1**	
		= 0.14[2]/ sin 28° =0.30(2) m *e.c.f. possible*	**B1**	
	(iii)	calculates n = 2.14 when θ = 90° *if states n ≈ 2 then allow this mark*	**M1**	
		highest *n* is 2	**A1**	
				Total 9

Question 12			
	resolution is the ability to see/distinguish two objects as separate objects OWTTE	**B1**	
	mouse eye smaller so poorer resolution than human (for given wavelength)	**B1**	
	plus up to 2 of:		
	resolution is a diffraction effect *a drawn diffraction pattern may score this mark*	**B1**	
	resolution is defined by central max of diff pattern for one object coinciding with first diffraction min for other *can be on diagram*	**B1**	
	(minimum) angle (subtended at eye) for resolution is $\theta = \sin^{-1} \lambda/b$	**B1**	**max 4**
	resolution factors are wavelength **and** aperture *talked out by any incorrect factor*	**B1**	
	some suitable biological comment, e.g. nerve density on retina, low-light effects explained, chromatic aberration effects explained	**B1**	
	alternative route: **max 2 from**		
	sensible estimate of wavelength (400 – 700 nm) and aperture of pupil (0.1 mm – 10 mm) in both animals		
	two correct calculations of resolving angle		
	leading to second mark above		
	At least 2 marks for physics + **Good QWC** At least 2 marks for physics + **Poor QWC** At least 2 marks for physics + **Very Poor QWC** 1 or 2 marks for physics + sufficient attempt + **Good or Poor QWC** 1 or 2 marks for physics + insufficient attempt or **Very Poor QWC** No marks for physics or **Very Poor QWC**	**2** **1** **0** **1** **0** **0**	**max 2**
			Total 6