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General Certificate of Education (A-level)
June 2011

Physics B: Physics in Context PHYB4

(Specification 2455)

Unit 4: Physics inside and out

Final

Mark Scheme

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process 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 standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised 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.

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NOTES

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.

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

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

cnao 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).

Marks should be awarded for **correct** alternative approaches to numerical question that are not covered by the marking 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.

GCE Physics, Specification B: Physics in Context, PHYB4, Physics Inside and Out

Question 1				
a		mass depends only on the amount of matter present owtte	**B1**	**3**
		weight is force between body and Earth/depends on *g*/*mg*/ gravitational field strength or answers in terms of Newton's gravitational law	**B1**	
		g (etc) varies at different points on and above the Earth or is different on different planets etc	**B1**	
b	i	reference is 'infinity' where potential is 0	**B1**	**2**
		energy has to be put in/work has to be done to move mass to infinity **or** a bodies energy/PE decreases as a body moves from infinity towards the Earth	**B1**	
b	ii	need to show *Vr* to be constant, clear from algebra or final statement	**B1**	**3**
		two sets of data used correctly	**B1**	
		all three sets of data used correctly (4.02, 4.025, 4.028)	**B1**	
b	iii	energy change per kg = $(5.36 - 3.22) \times 10^7$ (J)	**B1**	**2**
		total change = 963 (960) $\times 10^7$ J	**B1**	
c	i	$GMm/r^2 = mv^2/r$ or $v = \sqrt{(GM/r)}$	**C1**	**4**
		$v^2 = 3.2 \times 10^7\ m^2 s^{-2}$ or $v = 5670\ m\,s^{-1}$	**C1**	
		use of KE = ½ mv^2 using their *v*	**C1**	
		7.2 GJ	**A1**	
c	ii	KE changes by 4.8 GJ (allow ecf, 12 – their ci)	**B1**	**1**
c	iii	total energy (supplied) = (4.8) GJ (cnao)	**B1**	**1**
		(allow 5.2 GJ using 10 GJ for change in $\boldsymbol{E}_p$) (allow variations due to rounding off if physics is correct in previous parts)		
			Total	**16**

Question 2				
a		attempt to use power = *mgh*/*t* or *P* = *Fv* and *v* = *s*/*t*	**C1**	**3**
		7546/7550/7600	**A1**	
		W (allow $J\,s^{-1}$ and condone $N\,m\,s^{-1}$)	**B1**	
b		loss of GPE = 550 × 9.81 × 35 = 189 kJ	**C1**	**4**
		gain in KE = 0.5 × 550 × 22^2 = 133 kJ	**C1**	
		resistance force = their difference/63 (890 N if correct)	**A1**	
		answer to 2 sf (allow if answer is from working even if incorrect)	**B1**	

c	air resistance varies/increases frictional force varies/increases further detail: air resistance increases with speed/v **or** normal reaction force varies with angle of the slope	**B1** **B1** **B1**	**3**
d	use of $F = mv^2/r$ arrives at r = 12 m (ignoring the weight) 16.4 m	**C1** **C1** **A1**	**3**
		Total	**13**

Question 3				
a	i	use of $mg = k\Delta L$ or $F = k\Delta L$ **and** $F = mg$ extension = 5.9 m total length = 25.9 m (allow 20 + their extension)	**C1** **A1** **B1**	**3**
a	ii	20 + twice (5.9) amplitude + 2.6; 34.4 m; allow ecf from ai	**B1**	**1**
b	i	$T = 2\pi\sqrt{m/k}$ and $T = 1/f$ or $f = 1/2\pi\sqrt{k/m}$ correct substitution: allow for calculation of T (4.85 s) 0.21 or 0.206 (Hz)	**B1** **B1** **B1**	**3**
b	ii	substitutes data in $v_{max} = 2\pi fA$ 5.4 m s^{-1} (5.28 to 5.53)	**C1** **A1**	**2**
b	iii	two complete oscillations shown with positive and negative velocities and acceptable shape (condone more than 2) **and two from** period of 5 s used in graph (allow ecf for T from earlier part) start at 0 and positive velocity change at T = 0 with positive and negative velocities shown max velocity shown decreasing	**B1** **B1** **B1** **B1**	**3**
c	i	it would have to raised rest extension would be greater/rider would be nearer the ground if extension unchanged the rider has to move down a distance = to the amplitude (5.9 m) from the new rest position **or** with same initial extension/energy stored in rope, the rider would reach a lower height amplitude would be lower **or** due to the larger mass more energy (= mgh) is needed to reach the same height so initial extension would have to be increased	**B1** **B1** **B1**	**3**

c	ii	the rope would become slack at the top of the ride so the rider would go into free flight/rider would overshoot the highest point	**B1**	**3**
		the rider would fall and, with negligible air resistance, the rope would again absorb the energy arriving back at the start point **or** rider is more likely to fail to reach the ground after one oscillation due to energy losses/air resistance	**B1**	
		the PE gained (at the top of the flight) can (at most) only be converted back to the elastic energy that was stored in the rope at the start	**B1**	
		(allow a statement to the effect that to hit the floor would contravene conservation of energy or require an energy input)		
			Total	**18**

Question 4				
a		**any four from**		**max 4**
		fuel is 'burned' (mention of reaction between fuel and oxidiser) to raise the temperature/pressure of the gases produced in the combustion chamber	**B1**	
		as the gas (condone fuel) expands out of the chamber it has kinetic energy/momentum	**B1**	
		fuel ejected (through a narrow opening so fuel so) has a high speed	**B1**	
		the total momentum of the rocket and fuel must be conserved	**B1**	
		rocket momentum increase forwards is equal to the increase in momentum of the fuel backwards	**B1**	
		force on rocket = change in momentum of fuel per second	**B1**	
b	i	use of $v_f = v_e \ln(m_0/m_f)$ with substitution of either 2500 or 35000/5000	**C1**	**4**
		2500 and 35000/5000 substituted correctly	**C1**	
		$4.86\,km\,s^{-1}$	**A1**	
		$19.9\,km\,s^{-1}$ (this change in speed + 15)	**B1**	
b	ii	rate of change of momentum = force or numerical equivalent	**C1**	**3**
		acceleration = rate of change of momentum/ass or numerical equivalent	**C1**	
		$3.9\,m\,s^{-2}$	**A1**	
b	iii	start at $km\,s^{-1}$	**B1**	**3**
		correct curvature showing rate of change of velocity increasing	**B1**	
		and finally horizontal starting at 'all fuel used up'	**B1**	

b iv	(thrust is constant so) the rate of increase of velocity (acceleration) increases as the mass of the spacecraft decreases **or** comments that there is no acceleration after the fuel is used up or no accelerating or resistive forces	**B1**	**1**
		Total	**15**

Question 5			
a i	correct reading of wavelength $1.4 \pm 0.01 \times 10^{-10}$ use of $E = hc/\lambda$ $1.4\ (1.38) \times 10^{-15}$ J	**C1** **C1** **A1**	**3**
a ii	energy = eV and 1.6×10^{-19} used for e 60 kV	**C1** **A1**	**2**
a iii	power = their aii × 5.5 (ignore powers of 10) 330 W **ecf** their a × 5.5 × 10^{-3}	**C1** **A1**	**2**
b	energy in electron beam produces heating of target only a small proportion of the energy is converted to X-rays **or** most of energy is thermal energy at point of impact if not rotated the target would melt (condone overheat)	**B1** **B1** **B1**	**3**
c	The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question. **Descriptor** – an answer will be expected to meet most of the criteria in the level descriptor. **Level 3 – Good** ● claims supported by an appropriate range of evidence ● good use of information or ideas about physics, going beyond those given in the question ● argument well structured with minimal repetition or irrelevant points ● accurate and clear expression or ideas with only minor errors of grammar, punctuation and spelling **Level 2 – Modest** ● claims partly supported by evidence ● good use of information or ideas about physics given in the question but limited beyond this ● the argument shows some attempt at structure ● the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling		**5-6** **3-4**

	Level 1 – Limited ● valid points but not clearly linked to an argument structure ● limited use of information about physics ● unstructured ● errors in spelling, punctuation and grammar of lack of fluency **Level 0** ● incorrect, inappropriate or no response **Examples of the sort of information or ideas that might be used to support an argument:** ● mention of X-rays produced by collisions of fast moving electrons with the target ● lose energy/decelerate when incident on the target ● energy loss in collision becomes X-ray photon ● *change in energy = hf* ● may lose different and non-defined amounts of energy ● from 0 to energy of electron ● different frequencies of X rays produced ● maximum frequency energy is when photon energy = electron energy ● electrons excite electrons in the target atoms ● electrons excited are those in the inner energy levels ● when they relax x-ray photon produced ● electrons lose energy and move into lower energy levels ● the energy levels are well defined so line spectrum produced ● answer may be supported by an energy level diagram ● electrons are those in the inner energy levels ● when they relax x-ray photon produced ● the energy levels are well defined so line spectrum produced		**1-2** **0**
		Total	**16**

Question 6				
a	i	A_2 deflects **momentarily** (allow emf induced **momentarily**)	**B1**	**3**
		flux produced by 1 links 2	**B1**	
		(increase/change in flux) causes an induced emf/current in 2	**B1**	
a	ii	A_2 deflects in opposite direction to that in stage 1	**B1**	**3**
		flux decreases so emf induced	**B1**	
		to oppose the decrease or other reasonable attempt to explain in terms of Lenz's law	**B1**	
a	iii	deflections of both meters are larger	**B1**	**3**
		(higher current produces) increase in maximum flux/flux density	**B1**	
		rate of change of flux is greater so greater emf induced	**B1**	
b	i	attempt to measure gradient at 0.5 s	**C1**	**4**
		40 mT s^{-1} or area of coil = 1.13×10^{-3} m^2 or $\pi (19 \times 10^{-3})^2$	**C1**	
		attempt to use ε = rate of change of flux density × AN or N d(BA)/dt	**C1**	
		0.24 ± 0.03 V	**A1**	
b	ii	speed of pulse = 1159 m s^{-1}	**M1**	**2**
		sandstone	**A1**	
c		**any three from**		**max 3**
		explosions could damage remains/not a good idea on such sites	**B1**	
		suggestion of another way of making the wave pulse	**B1**	
		source and geophone need to be close together	**B1**	
		suggestion of separation to be used with reason	**B1**	
		need a more sensitive geophone with sensible reason	**B1**	
		need more precise timer because times are short or suggestion of suitable precision for timer	**B1**	
		will need to do a systematic survey over the site rather than just one measurement	**B1**	
		use a grid system	**B1**	

d	**any two from** ultrasound are longitudinal/mechanical radio waves are transverse/electromagnetic radio waves have much higher frequency than ultrasound radio waves travel much faster than ultrasound (numerical comparison okay) microwaves more penetrating **plus** send a pulse and measure time between sending the pulse and receiving the echo depth is **half** the speed × time	 **B1** **B1** **B1** **B1** **B1** **B1** **B1**	 **max 4**
		Total	**22**

	UMS conversion calculator www.aqa.org.uk/umsconversion		