AQA

A-LEVEL
Physics B

PHYB4 – Physics Inside and Out
Mark scheme

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Version 1:Final Mark Scheme

Mark schemes are prepared by the Lead Assessment Writer 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 associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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.

Further copies of this mark scheme are available from aqa.org.uk

Question	Part	Sub Part	Marking Guidance	Mark Type	Mark	Comments
1	a	i	Weight /*W* /*mg* - vertically downwards from some point on the body Friction – vertically upwards and touching both the wall and the body Centripetal force/normal reaction/R – horizontally to the left from the body Each must be correct and correctly labelled Minus one for each additional inappropriate force	B1 B1 B1	3	
1	a	ii	Centripetal force/reaction/R is smaller Frictional force reduces Frictional force is less than weight Resultant force is downward Friction is proportional to (normal) reaction	B1 B1	2	
1	b	i	$r\omega^2 = 29$ or $v^2/r = 29$ use of correct radius leading to 3.590 (rad s^{-1}) to at least 3 sig figs	B1 B1	2	2.54 using wrong *r* = 1 mark
1	b	ii	Angular acceleration , $\alpha = 3.6/20$ OR 3.59/20 or 0.18 or 0.1795 3.8 (3.77, 3.78) x 10^4 cao N m or kg m^2 s^{-2}	C1 A1 B1	3	
1	b	iii	2200 N cao	B1	1	

1	c	i	C	B1	1	

1	c	ii	Speed greatest (as all PE turned to KE) Total reaction force = $mr\omega^2 + mg$ or $v^2/r + mg$ or R is largest or $R = ma + mg$ OR Acceleration = v^2/r	B1 B1	2	
2	a	i	(Minimum) Speed (given at the Earth's surface) that will allow an object to leave/escape the (Earth's) gravitational field (with no further energy input)	B1	1	Not gravity Condone gravitational pull/attraction

2	a	ii	$\frac{1}{2} mv^2 = \frac{GMm}{r}$ Evidence of correct manipulation	B1 B1	2	At least one other step before answer

2	a	iii	Substitutes data and obtains $M = 7.33 \times 10^{22}$(kg) or volume = $(1.33 \times 3.14 \times (1.74 \times 10^6)^3$ or 2.2×10^{19} 3300 (kg m^{-3})	C1 A1	2	or $\rho = \frac{3v^2}{8\pi G r^2}$

2	b		(Not given all their KE at Earth's surface) energy continually added in flight/continuous thrust provided/can use fuel (continuously) Less energy needed to achieve orbit than to escape from Earth's gravitational field/it is not leaving the gravitational field	B1 B1	2	

3	a	i	(States that) r is in m and v is in m s^{-1} Correct substitution seen with or without rearrangement Correct manipulation including F/A or N/m^2 is Pa	M1 M1 A1	3	
3	a	ii	coefficient of viscosity varies with pressure or temperature or is not constant Only applies at slow speed or with laminar flow/vehicle going too fast/turbulent flow Applies to spheres with smooth surfaces/vehicle is not a sphere	B1 B1 B1	Max 2	
3	b		Idea that both astronaut and vehicle are travelling at same (orbital) speed or have the same (centripetal) acceleration/are in freefall No (normal) reaction (between astronaut and vehicle)	B1 B1	2	Not falling at the same speed
3	c	i	Equates centripetal force with gravitational force using appropriate formulae E.g. $\frac{GMm}{r^2} = \frac{mv^2}{r}$ or $mr\omega^2$ Correct substitution seen e.g. $v^2 = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{\text{any value of radius}}$ (radius of) 7.28×10^6 seen or $6.38 \times 10^6 + 0.9 \times 10^6$ 7396 (m s^{-1}) to at least 4 sf or $v^2 = 5.47 \times 10^7$ seen	B1 B1 B1 B1	4	

3	c	ii	$\Delta PE = 6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 1.68 \times 10^{4} (1/(7.28 \times 10^{6}) - 1/(6.78 \times 10^{6}))$ -6.8×10^{10} J $\Delta KE = 0.5 \times 1.68 \times 10^{4} \times (7700^{2} - 7400^{2}) = 3.81 \times 10^{10}$J $\Delta KE - \Delta PE = (-) 2.99 \times 10^{10}$ (J) OR Total energy in original orbit shown to be $(-)GMm/2r$ or $mv^2/2 - GMm/r$ Initial energy $= - 6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 1.68 \times 10^{4}/(2 \times 7.28 \times 10^{6})$ $= 4.59 \times 10^{11}$ Final energy $= - 6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 1.68 \times 10^{4}/(2 \times 6.78 \times 10^{6})$ $= 4.93 \times 10^{11}$ 3.4×10^{10}(J)	C1 C1 C1 A1 C1 C1 C1 A1	4	Condone power of 10 error for C marks

4	a		emf = $\Delta(BAN)/t$ *Change in flux* = $A \times \Delta B$ or 12 x (23 – 9) seen Substitution ignoring powers of 10 1.2 V	C1 C1 A1	3	

4	b		Reduced Magnet will move (with the case) Increased flux linkage increases or emf is proportional to *N*	M0 A1 M0 A1	2	

4	c	i	Formula used $\frac{4\pi^2 \times 8\times10^{-3}}{2.6}$ seen 0.348/0.349 seen to at least 3 sf	B1 B1	2	

4	c	ii	Period consistent at 0.35 s or V_o = 8 V Shape shows decreasing amplitude at least 3 cycles starting at 8 V	B1 M1 A1	3	

5	a	i	Weight = (2.7 to 2.8) x 10^7 resultant force = thrust – weight (6 to 6.5 MN if correct) Uses $F = ma$ in any form 2.3 to 2.4 (m s^{-2})	C1 C1 C1 A1	4	
5	a	ii	Gravitational field strength / g /gravitational pull decreases (with height) Mass decreases (as fuel is used) Further detail explaining one factor or the other e.g. resultant force increases as g decreases OR reference to $F=ma$ to explain why reduction of mass increases acceleration	B1 B1 B1	3	
5	a	iii	(Thrust constant but) Drag / air resistance (reduces the resultant force) Air resistance increases with increasing speed	M1 A1	2	Not friction
5	a	iv	Attempts to use F = rate of change of momentum Calculates rate of mass loss: 2.42 x 10^6/ 168 / 1.4(4) x 10^4 (kg s^{-1}) 34 x 10^6/their rate of mass loss 2360 (2400) (m s^{-1})	C1 C1 C1 A1	4	
5	a	v	(Q negative) hot gases heat the surroundings (W negative) gas does work in expanding Internal energy falls or ΔU is negative	B1 B1 B1	3	

5	b		Rearranges rocket equation into exponential form. $\frac{m_o}{m_f} = e^{\frac{v_f}{v_e}}$ or iniverted form m_o/m_f = 6.4 or m_f/m_0 = 0.156 (0.16) 84% is fuel	C1 C1 A1	3	6.4 or 0.156 = 2 marks
6	a	i	*Z* values calculated correctly 1.617 x 10^6 and 1.341 x 10^6 Substitute their values in formula for I_r / I_i 0.87%	C1 C1 A1	3	Allow substitutions in equation

6	a	ii	Uses $v=f\lambda$ in any form condone incorrect power of 10 7.7 x 10^{-4} (m)	C1 A1	2	

6	b		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 of ideas with only minor errors of grammar, punctuation and spelling **Level 2 – modest**		6	**5-6** Answer addresses both bullets. The first is should be very clear and have no significant omissions. The send may be less well done but the effect of different acoustic impedances at the boundaries should be there should be covered clearly. **3-4** Both aspects are likely to be addressed but there will be les coherence in the response and significant points may be omitted. **1-2** There is likely to be a superficial qualitative response probably more inclined toward the first bullet point

			-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 **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 or lack of fluency **Level 0** -incorrect, inappropriate or no response 5/6 Expect a coherent account incorporating at least 4 form each section 3/4 Account may cover the first part well and give a more superficial account of the second giving one or two points. Or two or three points from each section.The structure may not make it easy to follow 1/2 Provides superficial response for one of the topics and may be brief and poorly expressed.			Examples of creditworthy statements: 1Transducer swept across surface of skin 2Emits pulsed ultrasound signal 3Reflected at boundaries where acoustic impedance changes 4Time for pulse to return is measured 5Depth of boundary calculated / position of boundary is plotted 6Equation relating to establishing depth. 1Acoustic impedance is resistance to passage of sound through the medium 2Causes attenuation of ultrasound 3Causes reflection of sound at a boundary 4Is needed in order to produce image 5Reduced by use of gel on skin

6	c		Ability to distinguish between objects that are close together. Smallest angle that objects can subtend the observer and be seen as separate OWTTE Idea that the smallest structure visible on image is comparable with wavelength Mention of diffraction	B1 B1	2L	Not clarity or number of pixels

7	a		Idea that fibres in a coherent bundle maintain the same relative position to each other In incoherent bundles the fibres may be in different /random positions (at each end) Coherent bundle needs to be used for the observation image incoherent bundle may be used for the light transmission	B1 B1 B1	3	

7	b		Mentions charge coupled device/CCD Capacitor/photosite/photodiode charges/stores charge as light falls on it (Photons arriving cause)electrons to be excited/emitted Charge depends on light intensity Lots of photosites /concept of pixels ANY 3	B1 B1 B1 B1 B1	Max 3	

7	c	i	Core so that total internal reflection can occur	M0 A1	1	

7	c	ii	79(.4)(^{o})	B1	1	
7	c	iii	Ray leaving one fibre and entering adjacent fibre Reduces resolution /image will be blurred/less clear/ limits angle through which fibre may be bent	B1 B1	2	
8	a	i	Kerosene / paraffin /water proton/hydrogen rich / has a lot of protons/high proton density	M0 A1	1	
8	a	ii	Current causes a magnetic field through the tank Protons align themselves with the magnetic field	B1 B1	2	
8	a	iii	Applied (magnetic) field collapses / stops Protons realign with/affected by ambient field/Earth's field	B1 B1	2	
8	a	iv	Measures the frequency of the signal (from the material in the tank)/the precession frequency Protons (in the tank) precess at the Lamor frequency (Lamor) frequency is proportional to or depends on the ambient/Earth's magnetic field Idea that anomalies / variations in the magnetic field/frequencies can suggest the presence of artefacts or structures beneath the surface	B1 B1 B1 B1	4	
8	b		Amplitude / strength/intensity of signal is measured Amplitude reveals the proton/hydrogen density of the tissue Idea that different proton/hydrogen densities indicate different types of tissue e.g. tumour Idea that images are built up using different "slices" of the body ANY 3	B1 B1 B1 B1	Max 3	