A-LEVEL

PHYSICS B: PHYSICS IN CONTEXT

PHYB4 – Physics Inside and Out

Mark scheme

2455

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COMPONENT NAME: Unit 4 – Physics Inside and Out

COMPONENT NUMBER: PHYB4

Question	Part	Sub part	Marking guidance	Mark type	Mark	Comment
1	(a)	(i)	Idea of balance Prevent (lateral) forces /stress/strain/bending at the axle To make centre of mass close to the axis	B1 B1	2	Not balancing torques Look out for energy saving answers
1	(a)	(ii)	Heavier / higher mass/higher weight than gondola Moments/product of mass and distance should be the same / moment of inertia the same	B1 B1	2	
1	(a)	(iii)	Angular acceleration = 0.54 (rad s^{-2}) or 1.4/2.6 Use of $T = I\alpha$ (1.9 x 10^5 x their angular acceleration) 1.0(2) x 10^5 (N m)	C1 C1 A1	3	
1	(a)	(iv)	Use of $mr\omega^2$ 86 x 6.8 x 1.4^2 1150 N (allow 1100 or 1200)	C1 A1	2	If equation quoted condone not showing the squaring in substitution

1	(a)	(v)	W = 86 x 9.81 / 844 (N) Or attempts to subtract W from their (a) (iv) ; e.g. using 10 for g 306 (N) their (a)(iv) - 844 **ecf**	C1 A1	2	

1	(a)	(vi)	reaction greatest at the bottom of the circle / least at top approx 2000N at bottom and 300N at top or idea of adding and subtracting mg to/from centripetal force correctly Reaction half way up -1150 N or $=mv^2/r$ **ANY 2**	B1 B1	2	

1	(b)	(i)	Use of $0.5I\omega^2$ 0.5 x 270 x 5.3^2 3790 (J)	C1 A1	2	If formula quoted condone 5.3 not squared for C1

1	(b)	(ii)	Reference to two of the (independent) motions/forces I.e. Rotation horizontally(roundabout motion): rotation around axis perpendicular to the bed: Vertical motion (up and down) of cars on the undulating bed Reference to all three component idea of resultant force being the (vector) addition of these forces or resultant force is variable and unpredictable at different positions	C1 M1 A1	3	Rotation may be referred to in terms of centripetal force(but not when referring to the bed)

1	(b)	(iii)	smaller passengers reduce/ have smaller moment of inertia (angular) accelerations bigger/dangerous (angular) accelerations restraints designed for larger riders condone reference to the need to be strapped in for safety **ANY 2**	B1 B1	2	

2	(a)	(i)	$GMm/r^2 = mv^2/r$ $v = (GM/r)^{1/2}$ **or** $\left(\frac{6.7 \times 10^{-11} \times 6.0 \times 10^{24}}{6.71 \times 10^{6}}\right)^{1/2}$ condoning powers of ten 7740 or 7720 seen	B1 B1 B1	3	Use of 6,67 leads to 7720

2	(a)	(ii)	3.29 or 3.3×10^{12} (J)	B1	1	

2	(a)	(iii)	Substitution into $\Delta E_p = GMm(1/r_1 - 1/r_2)$ seen condoning powers of 10 and wrong values for r all correct: $6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 1.1 \times 10^{5} \left(\frac{1}{6.38 \times 10^{6}} - \frac{1}{6.71 \times 10^{6}}\right)$ 3.4×10^{11} seen adds their answer from a(ii) 3.64×10^{12} (J) **ecf** for incorrect calculation of ΔE_p or (a)(ii)	C1 C1 A1 M1 A1	5	Use of *mgh* can score last two marks(3.7 x ,,,) Condone bracket either way

2	(a)	(iv)	Greater mass (at launch) due to fuel / boosters Engines inefficient or states cause of inefficiency (internal energy/KE of ejected fuel/heating of surroundings Energy needed so that fuel/boosters gain PE Energy needed so that fuel/boosters gain KE **ANY 2**	B1 B1	2	

2	(b)	(i)	takes data from graph = (8.9 ±0.1) x 10^{8} (J kg^{-1}) (9.8 ±0.1) x 10^{13} (J)	M1 A1	2	

2	(b)	(ii)	energy needed/work has to be done to change speed/ momentum / KE of the shuttle correct orbital speed will be $\sqrt{\frac{GM}{r}}$ where *M* is the mass of PC Speed must be such as to prevent the shuttle being pulled into PC At the required orbit radius velocity must be in the correct direction/perpendicular to the radius at the required radius PE + KE or KE in orbit must be 0.5 x 10^{8} J PE + KE must be less than zero **1st B1 plus any one of the above**	B1 B1	2	This option must be consistent with the first B1 statement

3	(a)	(i)	1 T when force is 1 N on conductor of length 1 m when current is 1 A	B1	2	Condone minor communication deviations

			magnetic field is perpendicular to conductor/current	B1		Well expressed definition with condition

3	(a)	(ii)	Force given by (Fleming's) LHR Current and field perpendicular so force on electrons is perpendicular to electron movement /OWTTE Force on current carrying conductor is to the left / electron drift/move to the left Charge imbalance between the two sides /More electrons one side than the other OWTTE **ANY 3**	B1 B1 B1	3	

3	(a)	(iii)	magnetic materials /iron/steel/ magnetic objects Anomaly / object where magnetic field or voltage differs from norm **ANY 2**	B1 B1	2	

3	(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** -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		6	

			Production of induced current in the buried object current in (transmitter) coil produces mag field magnetic field is alternating metal material is in the field Faraday's law states……. emf induce in conducting material when field changes Eddy current in material Eddy current produces magnetic field **Detection of the induced emf due to buried object** Pulsed current / magnetic field switches off eddy current decay produces changing magnetic field Detector coil detects (changing) magnetic field from metallic object emf induced in detector coil. Induced emf measured. Use of sound or meter for detection Strength / duration of pulse indicates depth /. size of buried metallic object **Level 3** Answers should address both these in detail. The account may omit some aspects of the process but overall it should be a coherent description of the operation. There may be a useful well labelled diagram. **Level 2** This is likely to have some omissions which leave questions as to how detection is achieved but will contain most of the key ideas particularly about the process of producing induced emfs. It may be vague in terms of the use of pulses and the link between eddy current and the detected field. The diagram will have some use showing current loops but lack clarity. **Level 1** This is likely to be a superficial attempt with at least some attempt to explain the production of induced emfs and that the induced fields are then detected by another induced emf process. It may lack coherence **Level 0** This will contain no physics of relevance or inaccurate physics.			

4	(a)	(i)	Substitutes into $pV=nRT$ or rearranges to $n = pV/RT$ Converts to kelvin; 3473 seen or 3200 +273 8565 (mol) / 8560 /8570 / 8600	C1 C1 A1	3	For substitution condone power of 10 error minor misreads of data Use of temperature in °C

4	(a)	(ii)	Change is adiabatic (if thinking instant it leaves) Q =0 Q is negative (if small) as gas cools(if thinking a little afterwards) gas does work as it expands W is negative ($\Delta U = Q + W$) Internal energy falls	B1 B1 B1 B1	4	

4	(a)	(iii)	More expansion could have taken place and provide more thrust / higher exhaust speed / higher exhaust momentum Energy wasted by gas continuing to expand after leaving the rocket Or gas does less work than it could so less thrust	B1	1	

4	(b)		Rearranges rocket equation to give $\frac{m_f}{m_o} = e^{-v_f/v_e}$ or $\ln\frac{m_f}{m_o} = -\frac{v_f}{v_e}$ Substitutes in any form of rocket equation eg 6400=3800 ln(m_o/m_f) 0.186 or 0.814 or 5.38 or $\left(1-\frac{1}{5.38}\right)$ or (1 – 0.186) 81.4%	C1 C1 C1 A1	4	Or equivalent

4	(c)	(i)	Higher exhaust speeds / allows higher speed for same fuel mass or same speed for	B1	1	

			less fuel /less fuel used			
4	(c)	(ii)	Can't be used in atmosphere / large energies needed / low thrust / low acceleration	B1	1	
4	(c)	(iii)	Small adjustments / long distance flights/low acceleration propulsion in space	B1	1	
5	(a)	(i)	Deceleration of electrons (when they hit target) Emission of photons Can lose energy in one collision or many / can lose any amount of energy in each collision (up to max available) Bremsstrahlung mentioned **ANY 3**	B1 B1 B1	3	Collision must be mentioned somewhere in the answer for this mark
5	(a)	(ii)	Selects150 keV correctly changes to J / multiplies by 1.6×10^{-19} / rearranges to give $\lambda = hc/E$ 8.25 or 8.3×10^{-12} m	C1 C1 A1	3	
5	(b)		Uses $I=I_0e^{-150 \times 0.035}$ condoning powers of 10 -5.25 (=150 x 0.035) or 0.0052(5) ($=e^{-150 \times 0.035}$) seen 0.52% or 0.525%	C1 C1 A1	3	

5	(c)		Contrast medium provides greater absorbance/attenuation of x rays (than body tissue) Higher absorption coefficient Contrast medium goes to particular area/ area of interest / highlights a particular area	B1 B1	2	

6	(a)	i	Magnetic field Varies (linearly) in strength across the body/in different parts of the body	B1 B1	2	

6	(a)	ii	Idea that protons precess at particular / Lamor frequency Frequency depends on/is proportional to the B field rf waves cause resonance only where they match Lamor frequency	B1 B1 B1	3	

6	(a)	iii	rf waves switched off Precession decays/precessing protons relax Protons radiate energy as radio waves Intensity depends on number of hydrogen atoms present **ANY 3**	B1 B1 B1	3	

6	(a)	iv	Change rf to different frequency (Each) rf produces image of 1 slice/cross-section (Computer constructs) whole body image from many individual slices **ANY 2**	B1 B1	2	

6	(b)		**Advantages of MRI:** doesn't involve harmful/ionising radiation/low energy photons (condone radiation) can image tissue within bone better contrast between tissues condone resolution **Disadvantages of MRI**: cost time taken for scan/time to wait for a scan limited patient size problems with metals (eg hip replacements / orthopaedic pins) some patients claustrophobic patient may have to be sedated	B1 B1	2	

7	(a)		sin c = 1/n or sin c = n_2/n_1 (=v_1/v_2) n = OR 3000/1800 or 1.67 OR sin c = 1800/3000 36.9^o	B1 B1 A1	3	

7	(b)		5.44 x 10^{-3} s	B1	1	

7	(c)		PQ =RS = 3.26 m 2.6 tan37 or 3,26 sin37 or 1.96 seen or QR = 5.88 m i.e QR = 9.8 – (2 x 1.96) t = (2 x their 3.26/1800) + (their5.88/3000) { 0.00362 +0.00196 if correct} 5.58 x 10^{-3} (s) cao to 2 or 3 sf	B1 C1 C1 C1 A1	5	Or alternative geometry

8	(a)		Percentage uncertainty in timing (0.00001/0.09)x100 or 0.011% Or uncertainty in timing = 1/9000 or 0.00011 Appreciation that % uncertainty or absolute uncertainty in *t* has to be doubled 0.042 seen	B1 B1 B1	3	

8	(b)		0.042% of 9.81 / 3.9 x10^{-3} / 4.0 x10^{-3} /4.1 x10^{-3} (m s^{-2}) or g = 987 gal or 1 gal = 0.001 N kg^{-1} 0.39 / 0.40 / 0.41 gal Allow 1 sf	M1 A1	2	