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General Certificate of Education (A-level)
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Physics B: Physics in Context PHYB4

(Specification 2455)

Unit 4: Physics inside and out

Final

Mark Scheme

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Question	Part	Sub	Marking guidance		Guidance notes
1	(a)	(i)	Use of $F = GMm/r^2$ Correct substitution of data 491 (490)N	C1 M1 A1	Allow 1 for -correct formula quoted but forgetting square in substitution -missing *m* insubstitution -substutution with incorrect powers of 10 Condone 492 N,
1	(a)	(ii)	Up and down vectors shown (arrows at end) with labels up and down arrows of equal lengths	B1 B1	allow *W, mg* (not gravity)*;* *R* allow if slightly out of line/two vectors shown at feet condone if colinear but not shown acting on body In relation to surface $W \leq R$ (by eye) to allow for weight vector starting in middle of the body Must be colinear unless two arrows shown in which case R vectors ½ W vector(by eye)
1	(b)	(i)	Speed = $2\pi r/T$ $2\pi 6370000/(24 \times 60 \times 60)$ 463 m s^{-1}	B1 B1 B1	Max 2 if not easy to follow Must be 3sf or more
1	(b)	(ii)	Use of $F = mv^2/r$ 1.7 (1.66 – 1.68) N	C1 A1	Allow 1 for use of $F = mr\omega^2$ with ω= 460
1	(b)	(iii)	Correct direction shown (Perpendicular to and toward the axis of rotation) NB – not towards the centre of the earth	B1	

1	(c)		Force on scales decreases/apparent weight decreases Appreciates scale reading = reaction force The reading would become 489 (489.3)N or reduced by 1.7 N) Some of the gravitational force provides the necessary centripetal force	C1 A1 B1	or $R = mg - mv^2/r$
2	(a)	(i)	At infinity gravitational potential is zero 12.6 MJ is needed for each kg moved to get to infinity (OWTTE)	C1 A1	
2	(a)	(ii)	Use of ratios (inverse *r* law attempt) or 6.32 MJ kg^{-1} −6.32 MJ kg^{-1}	C1 A1	Alternative: attempt to calculates mass of Mars and use to find *V*
2	(b)	(i)	No change in gravitational PE/still on same equipotential No work done moving along the equipotential surface	B1	PE is the same
2	(b)	(ii)	KE At D = 1.143 GJ (Allow substitution in formula) Change in gravitational PE = 850 × 1.04 MJ= 0.884GJ Total energy at B = 1.143 + 0.884 (GJ) = 2.027GJ Speed at B = 2190 m s^{-1}	B1 B1 B1 B1	
2	(b)	(iii)	Angular momentum $L = I\omega$ and $\omega = v/r$ Combine so $L = mr^2 \times v/r = mvr$ *m* is constant so if *vr* is constant then *L* is constant	B1 B1 B1	Allow demonstration using data
2	(b)	(iv)	There is no external torques/force acting on the satellite	B1	

2	(c)	(i)	$mr\omega^2$ or $\frac{mv^2}{r}=\frac{GMm}{r^2}$ or $v=\frac{2\pi r}{T}$ Use of period = 24.6 × 60 × 60 (8.86×10^4 s) or ω=7.09x10^{-5}(rad s^{-1}) Correct substitution of data $(r^3=\frac{6.7\times10^{-11}\times6.4\times10^{23}}{4\times3.14^2})(8.86\times10^4)^2$ or $r^3=\frac{6.7\times10^{-11}\times6.4\times10^{23}}{(7.09\times10^{-5})^2}$ 2.04 × 10^7 m (20 400 km)	C1 C1 C1 A1	Condone 1 sf

2	(c)	(ii)	Use of $\Delta E_p=GMm\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$ Correct substitution or 10.4 MJ (per kg) 8.9(3) GJ	C1 C1 A1	Allow ecf from (c)(i) Condone incorrect powers of 10 Condone use of formula for energy per kg

3	(a)	(i)	correct period read from graph or use of *f=1/T* 0.84±0.01 correct frequency 1.2 (1.18– 1.25 to 3 sf)	C1 A1	2.4 Hz gets C1

3	(a)	(ii)	correct shape (inverse) Crossover PE = KE	B1 B1	

3	(b)	(i)	Use of $T=2\pi\sqrt{\frac{l}{g}}$ 48.7 (49) m	C1 A1	

3	(b)	(ii)	v = 120 000/3600 = 33(.3) m s^{-1} Use of $F = mv^2/r$ (allow v in km h^{-1}) Total tension = 6337 + (280 ×9.81) = 9.083×10^3 N Allow their central force Divide by 4 2.27 × 10^3 N Allow their central force	B1 B1 B1 B1	

3	(b)	(iii)	$mgh = ½ mv^2$ 9.8×44 = 0.5 v^2 Allow 45 in substitution 29.4 m s^{-1} (Use of 45 gives 29.7) 106 km h^{-1} (their m s^{-1} correctly converted) Or compares with 33 m s^{-1}	B1 B1 B1 B1	Condone: Use of $v = 2\pi fA$ (max2) Condone 22 m s^{-1}

3	(b)	(iv)	1/16th(0.625) % of KE left if correct KE at start = 5.6 x 10^4 J or states energy ∝ speed^2 so speed is ¼ Final speed calculated = 5 m s^{-1}	M1 M1 A1	Allow 1/8 (0.125)or 1/32(0.313) Allow for correct sub^n E =½ 280 x 20^2 x factor from incorrect number of swings calculated correctly Must be from correct working

4	(a)	(i)	Attempt to use Pythagoras' theorem using 4700 and 1200 4850 m s^{-1} (3sf only)	C1 A1	Allow final speed close to 1200

4	(a)	(ii)	Change in direction given by tan θ = 1200/4700 14(.3)°	C1 A1	Method may use data from 4(a)(i) Allow C1 for 75.7°

4	(b)		Attempt to find area under the graph Count squares = 55 ±2 or distance per square = 400 m 22 km (21.2 km → 22.8 km)	B1 B1 B1	Allow 1 for thinking the graph is linear (gets 24 km)

4	(c)	(i)	Substitution of final speed and fuel ejection speed correct in rocket equation $1200 = 2500\ln (3500/m_f)$ m_f = 2166kg rate of ejection of fuel = (3500 – 2166)/40 = 33 (.4) (allow their m_f) kg s^{-1}	C1 C1 C1 A1 B1	Allow if speeds wrong way round Correct substitution
4	(c)	(ii)	Thrust = change in momentum of fuel per second 83 000 N(ecf from (c)(i)	C1 A1	Thrust = initial acceleration of the rocket Allow 1 for rate of change from change in momentum of rocket(3500 x 1200/40) If allowance made for fuel loss to give mean mass during asseleration then answer can score 2 (i.e.3500-1330/2)1200/40) 3500 x gradient at t=0 approach can score 2
4	(d)		Fuel used up so mass of spacecraft falls Since $F = ma$ Thrust is constant Acceleration increases – gradient of graph increases	B1 B1 B1 B1	
5	(a)	(i)	arrow shown left to right between the poles of the magnets	B1	
5	(a)	(ii)	Attempt to use of $F=BIL$ **Correct** calculation of the force 1.07×10^{-5} leading to 30 μT T	M1 A1 B1	Condone 3 x 10^{-5} (1 sf)
5	(b)		Component of B perpendicular to wire decreases Reading falls Or Field changes direction / force changes direction reading would decrease	M1 A1 M1 A1	

5	(c)		refers to an object (eg a top/proton spinning axis of rotation also rotates : accept sensible diagram protons aligned by strong magnetic field produced by a coil Aligning field switched off protons undergo precession around the field present at that point precessing protons induce e.m.f. in a coil measure the frequency of the induced emf mention of Lamor frequency frequency is proportional to the strength of the field reward useful diagrams used in the explanation	B6	5-6 Addresses precession and covers alignment of protons/preceesion frequency/induced emf/precession frequency proportional to *B* 3 -4 Makes sensible attempt at explaining precession and covers some aspects of the operation of the magnetometer. Likely to appreciate that it is the precession frequency that is measured 1-2 Makes some sensible comments in an attempt to explain precession and/or the operation of the magnetometer

6	(a)		downward transition arrow seen correct transition (-951 to -8980	B1 B1	Must be from one energy level to another

6	(b)		correct wavelength used 2.8×10^{-11} m use of energy in J = hc/λ 7.07×10^{-15}J 44 200 (44 000) V (Allow (Their energy from hc/λ in J)/1.6x10^{-19} calculated correctly)	C1 C1 A1	

6	(c)		always above first curve similar shape peaks in same place shortest wavelength and peak wavelength of continuous spectrum decreases	B1 B1 B1	 Shortest wavelength must be non-zero

6	(d)	(i)	$E=hf$ used with 22.1 condoning no conversion to J 5.3 - 5.4 × 10^{18} Hz	C1 A1	

6	(d)	(ii)	Attempt to show $E/(Z\text{-}1)^2$ = *constant* stated Or correct alternative method two calculation correct three correct with conclusion/or states/or shows clearly that $E \propto f$	 B1 B1 B1	

6	(e)		short wavelength needed silver (has the highest energy so lowest wavelength)	B1 B1	

6	(f)		Use of a grid in front of the photographic plate/detector (allow diagram) grid eliminates X rays that have been scattered or only allows direct rays/photons from the source to hit the plate	B1 B1	

6	(g)		X-rays are absorbed /transmitted differently by different density material OWTTE ultrasound is reflected differently by different density material OWTTE	B1 B1	