Advanced GCE Physics
June 2003 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	71	65	59	53	47	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	64	57	50	43	36	0
	UMS	110	88	77	66	55	44	0
2862	Raw	120	97	85	73	62	51	0
	UMS	90	72	63	54	45	36	0
2863 *Option A*	Raw	127	103	94	85	76	67	0
	UMS	100	80	70	60	50	40	0
2863 *Option B*	Raw	127	103	94	85	76	67	0
	UMS	100	80	70	60	50	40	0
2864 *Option A*	Raw	119	91	83	75	67	59	0
	UMS	110	88	77	66	55	44	0
2864 *Option B*	Raw	119	91	83	75	67	59	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	62	56	50	44	38	0
	UMS	90	72	63	54	45	36	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3888	300	240	210	180	150	120	0
7888	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3888	24.4	44.1	63.4	79.0	90.3	100	6805

7888	30.0	52.0	71.2	86.5	96.0	100	5723

RECOGNISING ACHIEVEMENT

2860/01 Physics in Action

June 2003

Mark Scheme

Physics B (Advancing Physics) mark schemes - an introduction

Just as the philosophy of the *Advancing Physics* course develops the student's understanding of Physics, so the philosophy of the examination rewards the candidate for showing that understanding. These mark schemes must be viewed in that light, for in practice the examiners' standardisation meeting is of at least equal importance.

The following points need to be borne in mind when reading the published mark schemes:

- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Open questions, such as the questions in section C permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts.
- Final and intermediate calculated values in the schemes are given to assist the examiners in spotting whether candidates are proceeding correctly. Mark schemes frequently give calculated values to degrees of precision greater than those warranted by the data, to show values that one might expect to see in candidates' working.
- Where a calculation is worth two marks, one mark is generally given for the method, and the other for the evaluation of the quantity to be calculated.
- If part of a question uses a value calculated earlier, any error in the former result is not penalised further, being counted as *error carried forwar*d: the candidate's own previous result is taken as correct for the subsequent calculation.
- Inappropriate numbers of significant figures in a final answer are penalised by the loss of a mark, generally once per examination paper. The maximum number of significant figures deemed to be permissible is one more than that given in the data; two more significant figures would be excessive. This does not apply in questions where candidates are required to show that a given value is correct.
- Where units are not provided in the question or answer line the candidate is expected to give the units used in the answer.
- Quality of written communication will be assessed where there are opportunities to write extended prose.

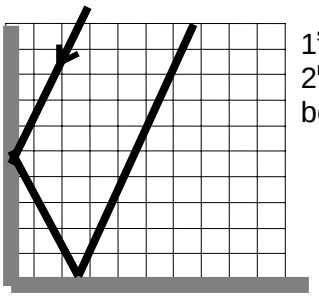
SECTION C

The outline mark schemes given here will be given more clarity by the papers seen when the examination is taken. Some of these scripts will be used as case law to establish the quality of answer required to gain the marks available.
It is not possible to write a mark scheme that anticipates every example which students have studied.

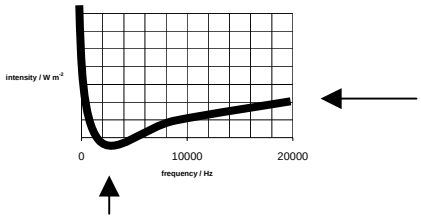
For some of the longer descriptive questions three marks will be used (in scheme called the 1/2/3 style).

1 will indicate an attempt has been made
2 will indicate the description is satisfactory, but contains errors
3 will indicate the description is essentially correct

Abbreviations, annotations and conventions used in the Mark Scheme	m = method mark s = substitution mark e = evaluation mark / = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Qn	Expected Answers	Marks	Additional guidance
	Section A		
1a	aluminium ✓	1	
b	glass ✓	1	
c	rubber ✓	1	
2a	 1st ray to (2,0) ✓ 2nd ray parallel to incident beam by eye ✓	2	first reflected ray only allow one mark allow partial second reflected ray
b	beam returns to sender / parallel / back ✓ sensible physics e.g. intensity / independence of angle ✓	2	AW allow "more visible"
3a	**C** ✓	1	
b	**B** ✓	1	
4a	oscillations / waves / cycles / vibrations / samples per second ✓	1	AW NOT pitch / events
b	digital: discrete / quantised / binary / 0 or 1 ✓	1	AW accept diagrams
	sampling in time explained ✓	1	AW accept diagrams
c	binary digit / 0 or 1 / 1/8 byte ora ✓	1	AW NOT piece
5a	any correct diff: brighter / more contrast / clearer ✓	1	allow clearer edges NOT smoothed
b	decrease pixel value / range of values used is stretched but allow ecf ✓	1	accept - / ÷ / x NOT +
6a	**A** ✓	1	
b	**C** ✓	1	
c	**C** ✓	1	
7	flatter <u>convex</u> wavefronts ✓ ;	1	continuity not essential
	slightly greater and constant λ 2.6 < 2 λ < 3.8 cm ✓	1	
	Section A Total	**20**	

Qn	Expected Answers	Marks	Additional guidance
	Section B		
8a	(very) high ✓ ; plastic / allow rubber ✓	2	AW
b(i)	$G = (\sigma A) / L$ = (5.9 x 10^7 x 1.8 x 10^{-6}) / 60 ✓; = 1.77 S✓	2	substitution ; evaluation
(ii)	$V = I / G$ / = 13 / 1.77✓ ; = 7.3(4) V ✓ (7.2 V OK)	2	transposition V=IR or G=I/V insufficient ; eval.
(iii)	$P = I V$ = 13 x 7.34 = 95.5 W ✓ (93.9 W OK) ecf	1	I^2 / G or $V^2 G$ OK
(iv)	cable heats up ✓ ; heat cannot dissipate if coiled / cable could melt or become damaged / unsafe ✓	1 1	AW or other sensible suggestions
9a	**T** anywhere on outside of loop ✓ ; **C** on inside of loop ✓	2	
b	2 π (R + r) either bracket ✓ ; 2 π r ✓ ; 2 π r / 2 π R ✓	3	
c	permanent / plastic deformation / beyond elastic limit ✓	1	AW
d(i)	R = r / ε / = 0.75 x 10^{-3} / 0.002 ✓ ; = 0.375 m / 375 mm ✓	1 1	method symbol / number evaluation with unit
(ii)	R = r / ε / 0.17 x 10^{-3} / 0.002 ✓ ; = 0.085 m / 85 mm ✓ (use of x5 or x19 strands no marks)	2	method; evaluation + unit
(iii)	cable is more flexible / can be coiled more tightly / can be coiled elastically with little force / circuit not broken if one strand breaks ✓	1	AW sensible suggestion OK
10 a	20 (nm) / 14 ✓ = 1.(43) x 10^{-9} m accept 1 nm ✓ SF	2	method ; evaluation penalise 4 or more SF
b(i)	V = 4 π (0.50 / 2)^3 / 3 ✓ ; = 0.0654 mm^3 ✓	2	substitution ; evaluation
(ii)	(300 + 280 + 280 + 260) / 4 = (1120) / 4 = 280 mm ✓	1	accept bare answer ecf on (ii)
(iii)	A = π (280 / 2)^2 ✓ ; = 6.16 x 10^4 mm^2 ✓	2	
(iv)	$h = V/A$ ✓; =0.0654 / (6.16 x 10^4) ✓ ;= 1.06 x 10^{-6} mm ✓ / 1.1 nm etc accept estimates to 1 SF	3	rearrangement ; subs ; evaluation with appropriate unit ecf

Qn	Expected Answers	Marks	Additional guidance
11a	2000 Hz ✓	1	
b(i)	scale (y axis) goes up in powers / multiples of 10 ✓	1	AW
(ii)	large range of values / 7 orders magnitude ✓	1	accept ear's response is logarithmic NOT to fit in
c(i)	correct high f end + approx. shape ✓ ; <u>min at 2000Hz</u> ✓ 	2	
(ii)	Lower / speech / most frequencies compressed / higher frequencies are stretched / good gradient comments ✓	1	AW harder to read at low frequencies
d(i)	a valid comparison e.g. intensities for her to hear are larger after / decreased sensitivity / graph is higher ✓	1	accept lower before AW
(ii)	accept between 4 and 5 ✓	1	
(iii)	wear ear protectors / stand further back from display ✓ ; reduce sound before reaching the ear / intensity reduces with distance from the source ✓	1 1	AW or other sensible AW
	Section B Total	**40**	

Qn	Expected Answers	Marks	Additional guidance
	Section C		
12 a	any image e.g. surface of Europa no tick no mark plates of ice resolved ✓ ; striations / buckling of plates ✓	0 2	sets context any useful details
b	identify radiation e.g. light ✓ accept from (a) then 1/2/3 style ✓✓✓ e.g. image focussed by camera lens / refraction ; onto pixels of CCD ; here charge builds up in proportion to light intensity / charge per pixel yields data for pixel value	1 3	well labelled diagram can score full marks
c(i)	sensible estimates e.g. 10^3 < pixels < 10^7 ✓ ; expect between 8 and 24 ✓ ;	1 1	unless special case unless special case
(ii)	combined gives e.g. 8×10^3 < bits < 2.4×10^8 ✓	1	ecf on (i) method ; eval.
(iii)	time = info / 56000 ✓ ; e.g. 8×10^6 / 56000 = 143 s ✓	2	
(iv)	image compression ✓ ; reduces transmission time ✓ / other users on line / noise ; increases transmission time NOT different systems	2	AW any plausible idea linked to correct sense of change

Qn	Expected Answers	Marks	Additional guidance
13a	Variable identified e.g. frequency ✓ ; suitable component identified e.g. bimorph element ✓	2	
b(i)	circuit diagram 1/2/3 style ✓✓✓ e.g. bimorph to c.r.o.		2 max for active sensor with suitable monitor
(ii)	description of circuit 1/2/3 style ✓✓✓ to max 5 marks e.g. ceramic bimorph generates 4 V peak to peak ; for movement of 10 μm ; c.r.o. suitably fast response to detect rapid oscillations in p.d.	5	circuit up to 5 max.
c(i)	change physical variable e.g. sig. gen. ✓	1	
	suitable measure of input variable e.g. c.r.o. to measure frequency ✓	1	
	test for linearity e.g. straight line graph / suitable numerical analysis ✓	1	
(ii)	any benefit e.g. inter / extrapolation of calibration is easier with constant sensitivity / linear LUT / simple to calculate ✓	1	
d	any two correct points repeatability ; reliability / removal of human error / anomalies ; random errors reduced / improve accuracy ; take an average of the results ✓ ✓	2	
12 & 13	Quality of written communication	4	
	Section C Total	**30**	

QoWC **Marking quality of written communication**

The appropriate mark (0-4) should be awarded based on the candidate's quality of written communication in Section C of the paper.

4 max The candidate will express complex ideas extremely clearly and fluently. Answers are structured logically and concisely, so that the candidate communicates effectively. Information is presented in the most appropriate form (which may include graphs, diagrams or charts where their use would enhance communication). The candidate spells, punctuates and uses the rules of grammar with almost faultless accuracy, deploying a wide range of grammatical constructions and specialist terms.

3 The candidate will express moderately complex ideas clearly and reasonably fluently. Answers are structured logically and concisely, so that the candidate generally communicates effectively. Information is not always presented in the most appropriate form. The candidate spells, punctuates and uses the rules of grammar with reasonable accuracy; a range of specialist terms are used appropriately.

2 The candidate will express moderately complex ideas fairly clearly but not always fluently. Answers may not be structured clearly. The candidate spells, punctuates and uses the rules of grammar with some errors; a limited range of specialist terms are used appropriately.

1 The candidate will express simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weakness in these areas.

0 The candidate is unable to express simple ideas clearly; there are severe shortcomings in the organisation and presentation of the answer, leading to a failure to communicate knowledge and ideas. There are significant errors in the use of language which makes the candidate's meaning uncertain.

RECOGNISING ACHIEVEMENT

2861 Understanding Processes

June 2003

Mark Scheme

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^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

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2 will indicate the description is satisfactory, but contains errors
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Qn	Expected Answers	Marks	Additional guidance
1 (a)	Answer: B ✓	1	
(b)	Answer: A ✓	1	
(c)	Answer: C ✓	1	
2 (a)	$t = 1.5 \times 10^{11} / 3.0 \times 10^8$ ✓$_m$ $= 500$ s ✓$_e$	2	
(b)	$s = 3.0 \times 10^8 \times 3 \times 60$ ✓$_m$ $= 5.4 \times 10^{10}$ ✓$_e$ (m)	2	$s = 3.0 \times 10^8 \times 3$ ✓$_m$
3 (a)	$v = s/t$ ✓$_m$ for squaring and equating $s^2/t^2 = kd$ ✓$_m$	2	any correct method ✓ followed through ✓
(b)	for clear working $m^2/(s^2 m)$ ✓$_m$ gives m/s^2 ✓$_e$	2	
4 (a)	by trig or any triangle construction ✓$_m$ about 4.5 (N) ✓$_e$	2	
(b)	θ is **about** 27° / 153° / 333° $_e$	1	
5 (a)	f x l = constant idea ✓ carried out on any 3 sets of data✓	2	Calculate k for one pair, use on any 2 sets of data
(b)	conclusion consistent with test ✓	1	
6 (a)	power = 8.0 x 30 ✓$_m$ = 240 (W) ✓$_e$	2	
(b)	F = 2000 / 14.0 ✓$_m$ = 143 (N) ✓$_e$ (accept 140 N) **3 sf max**	2	work done = KE
	total	**21 marks**	

7 (a)	(i) X,X on screen essentially opposite ends of slit ✓	1	little or no spreading shown by X X disregard curving at edges
	(ii) 3 **plane** wavefronts ✓ λ more or less unchanged ✓	2	
(b)	(i) broader ✓ and dimmer ✓ or narrower✓ then broader✓ or fringes ✓ …bright central maximum✓	2	
	(ii) for 3 curved wavefronts ✓	1	
	diffraction/spreading (at edges of door) ✓ (or Multiple reflections ✓)	1	
(c)	(i) λ = 340/100 = 3.4 (m) ✓$_e$ λ = 340/2000 = 0.17 m ✓$_e$	2	Only 1 mark if wrong way round
	(ii) bass/longer λ diffract more ✓ some reference to door size ✓	2	
	total	**11 marks**	
8(a)	s = 20x0.5 ✓$_m$ (= 10m)	1	
(b)	(i) 1. a = (7.1 x 10^3) / 1200 ✓$_m$ = **5.92** m s^{-2} ✓$_e$	2	
	2. ($v^2 = u^2 + 2as$) 0 = 400 – 2.(5.9).s ✓$_m$ s = 400/11.8 = **33.9** (m) ✓$_e$	2	or t = 3.4s, s = 34.1 m
	(ii) ((b)(i) 2 + 10) (allow ecf from (b)(i)2)	1	
(c)	(i) for clear construction on graph ✓	1	
	(ii) ~ 101 to 109 m ✓	1	
(d)	braking friction decreases ✓ as they get hotter ✓ or brake pad may vaporise✓ so braking force less✓) or (air resistance increases with speed✓ 1 mark max)	2	Look for sensible idea & reasoning
	total	**10 marks**	
9(a)	(i) f = 5.6 x 10^{-19} / 6.6 x 10^{-34} ✓$_m$ = 8.5 x 10^{14} (Hz) ✓$_e$	2	
	(ii) (1.8 x 10^6)/(5.6 x 10^{-19}) ✓$_m$	1	
	(iii) (1.8 x 10^6)/(5.0 x 10^{-9}) ✓$_m$ = 3.6 x 10^{14} ✓$_e$ **W** ✓$_u$ (must be a calc to get the unit mark)	3	**wrong calc** x_m x_e**,** **then** allow unit mark
(b)	(i) 5.6 x 10^{-19} - 4.8 x 10^{-19} ✓$_m$ (= 8.0 x 10^{-20})	1	
	(ii) 8.0 x 10^{-20} = 1/2x(9.1 x 10^{-31})x v^2✓$_m$ v = 4.2 x 10^5✓$_e$	2	
	(iii) λ = 1.8 x 10^{-9} m ✓$_e$ (or 1.73 x 10^{-9} m from 4.2x10^5))	1	
	total	**10 marks**	

10(a)	(i) interference / superposition / diffraction ✓	1	
	(ii) path difference is a whole number of wavelengths waves are in phase phasors line up ✓✓ constructive interference	2	Any 2 from 4
	(iii) path difference is not a whole number of wavelengths waves are out of phase phasors cancel ✓✓ destructive interference	2	Any 2 from 4
(b)	for **using** $n\lambda = d \sin\theta$ ✓ **correct** substitution✓ $= 6.0 \times 10^{-7}$ m✓	3	
(c)	brighter ✓ sharper ✓	2	Missing order, greater variation in intensity across
	total	**10 marks**	
11(a)	quantum phenomenon ✓	1	
(b)	showing arrangement of the necessary apparatus✓✓✓	3/2/1	
	for labelling the apparatus appropriately ✓	1	
(c)	for a clear, detailed description of the observed phenomenon ✓✓✓	3/2/1	
(d)	for dealing with the relevant physics appropriate to the observations ✓✓✓	3/2/1	
	total	**11 marks**	
12(a)	showing arrangement of the necessary apparatus✓✓✓	3/2/1	
	for labelling the apparatus appropriately ✓	1	
(b)	for a clear description of how to produce standing waves using the apparatus described ✓✓✓	3/2/1	
(c) & (d)	for a clear, detailed description of the standing wave(s) observed $✓_o✓_o✓_o$	3/2/1	3 obs max
	dealing with the relevant physics appropriate to the observations $✓_e✓_e✓_e$	3/2/1	3 explanations max
	total	**13 marks**	
	Quality of written communication	**4**	

QoWC **Marking quality of written communication**

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fluently. Answers may not be structured clearly. The candidate spells, punctuates and uses the rules of grammar with some errors; a limited range of specialist terms are used appropriately.

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intrusive, suggesting weakness in these areas.

0 The candidate is unable to express simple ideas clearly; there are severe shortcomings in the organisation and presentation of the answer, leading to a failure to communicate knowledge and ideas. There are significant errors in the use of language which makes the candidate's meaning uncertain.

RECOGNISING ACHIEVEMENT

2863/01 Rise & Fall of the Clockwork Universe

June 2003

Mark Scheme

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X	=	incorrect response (errors may also be underlined)
^	=	omission mark
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Question	Expected Answers	Marks
1 (a)	B	1
(b)	A	1
2 (a)	Q	1
(b)	R	1
3	s^{-1}	1
4 (a)	The time values shown are not equally spaced ✓AW	1
(b)(i)	Rate of change of height is equal to the height of water multiplied by a constant/ rate of change of height proportional to height.✓The negative sign shows that the height is decreasing. ✓ OR: rate of fall ✓ of height proportional to height✓. OR: height falls✓ exponentially✓.	2
(ii)	e.g. size of hole/ c.s.a of container/viscosity/temperature ✓	1
5 (a)	E = 300 x 1.4 x 10^{-23} = 4.2 x 10^{-21} ✓or clear method	1
(b)	(3.2 x 10^{-20} x 2)/ 4.2 x 10^{-21} ✓= 15.2 (or 16.0 if 4.0 x 10^{-21} used) ORA.	1
(c)	Two from*: kT* gives a measure of average energy, some molecules will have greater energy ✓ through chance interchanges AW ✓/if T is bigger then KT (or molecular energy) increases ✓Stating 'E/kT of 15 to 30 allows processes to occur'.✓	2
6 (a)	$m v$ = 0.35 x 22 = 7.7 kg m s^{-1} ✓or clear method	1
(b)	v = .25 x 7.7 /.05 ✓ = 39 m s^{-1} ✓(40 if 8 kg m s^{-1} used)	2
7 (a)	$f = 1/T$ = 1/2.4✓ = 0.42 Hz✓ penalise rounding errors here. (allow.4,.42,.417)	2
(b)	x = 0.2 cos (2 π x .42 x 2)✓ = 0.11 m ✓(2.4 in the equation is not markworthy)	2
8 (a)(i)	E = ½ C V^2 = ½ x 10 x 2.5^2✓ = 31.3 J✓ need own value. ORA gives C = 9.6 F for 30J energy stored.	2
(ii)	RC = 10 x 9.0 x 10^3 = 90 000 s ✓ = 90 000/60 x 60 = 25 hrs✓ ORA one day = 8.6x10^4 s.	2
(b)(i)	Pd values: 0.93 V ✓.34V ✓(allow .92)	2
(ii)	Points✓ curved line✓	2
(iii)	Use of graph to show that p.d. is not sufficient✓ (eg line from x axis to line and from line to y axis) ORA	1

9(a)(i)	$g = (-)\ GM/r^2$ ✓	1
(ii)	correct units on RHS of eqn: N m^2 kg^{-2} m kg m^{-3} ✓= N kg^{-1} ✓	2
(iii)	g = 4/3 x 6.7 x 10^{-11} x π x 10 000 x 4.0 x 10^{14}✓ = 1.1 x 10^9 (N kg^{-1}) ✓ (one mark if r = 10 used)	2
(b)(i)	2 π r/(1/50) ✓ = 2 π x 10 000/0.02 = 3.1 x 10^6 ✓ m s^{-1} comparision made ✓	3
(ii)	a = v^2/r = (3.1 x 10^6)^2/ 10 000✓ = 9.6 x 10^8 ✓m s^{-2} ✓(other values generated by different values of b(i) e.g. 9 x 10^8 if 3 x 10^6 used)	3
(c)	Any two from: To keep a particle on the surface the magnitude of field strength must equal or exceed the magnitude of centripetal acceleration.✓ gravitational force on particle equal to or greater than centripetal force needed to keep particle on surface.✓ This is the case in the star considered.✓Or consistent argument from ecf using own values from a (iii) NB only one mark max if centrifugal arguments used.	2
10(a)	2.8 x 10^{-2}/ 6.0 x 10^{23}= 4.7 x 10^{-26} kg ✓ or clear method	1
(b)	v^2 = 3/2(2kT/m) = 3 x 1.4 x 10^{-23} x 300/ 5 x 10 $^{-26}$✓ -> v = 498 m s^{-1}✓ need own value	2
(c)(i)	t = s/v = 7/500 ✓= 0.014s ✓ need own value	2
(ii)	Much greater distance travelled ✓ because of collisions ✓diagram or extra detail✓	3
(d)	Much more massive so for same energy✓ the velocity will be smaller✓ (hence) the rate of diffusion will be lower. ✓ OR: perfume molecules larger so more likely to collide✓ more changes in direction (shorter mean free path)✓ (hence) rate of diffusion slower ✓ .	3
11 (a)	s = v t/2 = 3 x 10^8 x 40.2/2 = 6.03 x 10^9 m ✓or clear method. Assumption: distance asteroid or Earth moves during 20.2 s is very small and can be disregarded./ the velocity of light is unchanged on reflection/ other sensible✓'velocity of signal constant' insufficient for mark.	2
(b) (i)	Δ t = 0.1s ✓ Δs = 0.1 x 3 x 10^8 ✓= 3 x 10^7m (or by calculating new s and subtracting)	2
(ii)	v = 3 x 10^7/ (14 x 60)✓ = 3.6 x 10^4 m s^{-1}✓ (m✓ e✓) . sf penalty for more than 3 sf	2
(c)	weaker reflected signal ✓ long delay in detection✓ or other sensible. Do not accept stars moving.	2
(d) (i)	d = v/Ho = 1 x 10^6/2.2 x 10^{-18} ✓= 4.55 x 10^{23} ✓or clear method	1
(ii)	(Light travels at finite velocity therefore long distances) takes long time AW ✓ Calculation on time taken for light from Y to reach Earth: t = s/v = 1.5 x 10^{15} s ✓ (=47 million years) (If calculation given, 'long time' is implicit)	2
(e)	H_0 = 70 km s^{-1} M pc^{-1} = 70 x 10^3 / 3.1x 10^{22} ✓ = 2.3 x 10^{-18} s^{-1} ✓ need own value.	2
	Quality of Written Communication ✓✓✓✓	4

11 (a)	$s = v\,t/2 = 3 \times 10^8 \times 40.2/2 = 6.03 \times 10^9$ m ✓or clear method. Assumption: distance asteroid or Earth moves during 20.2 s is very small and can be disregarded./ the velocity of light is unchanged on reflection/ other sensible✓'velocity of signal constant' insufficient for mark.	2 2 2
(b) (i)	$\Delta t = 0.1$s ✓ $\Delta s = 0.1 \times 3 \times 10^8$ ✓$= 3 \times 10^7$m (or by calculating new s and subtracting)	2
(ii)	$v = 3 \times 10^7 / (14 \times 60)$✓ $= 3.6 \times 10^4$ m s^{-1}✓ (m✓ e✓) . sf penalty for more than 3 sf	1
(c)	weaker reflected signal ✓ long delay in detection✓ or other sensible. Do not accept stars moving.	
(d) (i)	$d = v/Ho = 1 \times 10^6 / 2.2 \times 10^{-18}$ ✓$= 4.55 \times 10^{23}$ ✓or clear method	2
(ii)	(Light travels at finite velocity therefore long distances) takes long time AW ✓ Calculation on time taken for light from Y to reach Earth: $t = s/v = 1.5 \times 10^{15}$ s ✓ (=47 million years) (If calculation given, 'long time' is implicit)	2
(e)	$H_0 = 70$ km s^{-1} M $pc^{-1} = 70 \times 10^3 / 3.1 \times 10^{22}$ ✓ = 2.3×10^{-18} s^{-1} ✓ need own value.	4
	Quality of Written Communication ✓✓✓✓	

Marking quality of written communication

The appropriate mark (0-4) should be awarded based on the candidate's quality of written communication in Section B of the paper.

4 The candidate will express complex ideas extremely clearly and fluently. Answers are structured logically and concisely, so that the candidate communicates effectively. Information is presented in the most appropriate form (which may include graphs, diagrams or charts where their use would enhance communication). The candidate spells, punctuates and uses the rules of grammar with almost faultless accuracy, deploying a wide range of grammatical constructions and specialist terms.

3 The candidate will express moderately complex ideas clearly and reasonably fluently. Answers are structured logically and concisely, so that the candidate generally communicates effectively. Information is not always presented in the most appropriate form. The candidate spells, punctuates and uses the rules of grammar with reasonable accuracy; a range of specialist terms are used appropriately.

2 The candidate will express moderately complex ideas fairly clearly but not always fluently. Answers may not be structured clearly. The candidate spells, punctuates and uses the rules of grammar with some errors; a limited range of specialist terms are used appropriately.

1 The candidate will express simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weakness in these areas.

0 The candidate is unable to express simple ideas clearly; there are severe shortcomings in the organisation and presentation of the answer, leading to a failure to communicate knowledge and ideas. There are significant errors in the use of language which makes the candidate's meaning uncertain.

RECOGNISING ACHIEVEMENT

2864/01 Field and Particle Pictures

June 2003

Mark Scheme

The following annotations may be used when marking:

X	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

Abbreviations, annotations and conventions used in the Mark Scheme:

m	=	method mark
s	=	substitution mark
e	=	evaluation mark
/	=	alternative correct answers
;	=	separates marking points
NOT	=	answers which are not worthy of credit
( )	=	words which are not essential to gain credit
___	=	(underlining) key words which **must** be used to gain credit
ecf	=	error carried forward
ora	=	or reverse argument
eor	=	evidence of rule
wtte	=	words to that effect

Physics B (Advancing Physics) mark schemes - an introduction

Just as the philosophy of the *Advancing Physics* course develops the student's understanding of Physics, so the philosophy of the examination rewards the candidate for showing that understanding. These mark schemes must be viewed in that light, for in practice the examiners' standardisation meeting is of at least equal importance.

The following points need to be borne in mind when reading the published mark schemes:

- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Open questions permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts.
- Final and intermediate calculated values in the scheme are given to assist the examiners in spotting whether candidates are proceeding correctly. Mark schemes frequently give calculated values to degrees of precision greater than those warranted by the data, to show values that one might expect to see in candidate's working.
- Where a calculation is worth two marks, one mark is generally given for the method, and the other for the evaluation of the quantity to be calculated.
- If part of a question uses a value calculated earlier, any error in the former result is not penalised further, being counted as *error carried forward*: the candidate's own previous result is taken as correct for the subsequent calculation.
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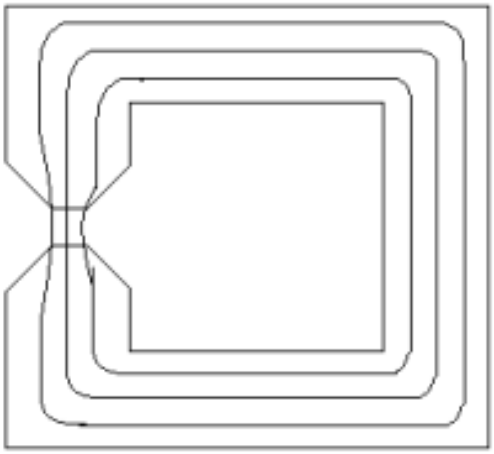
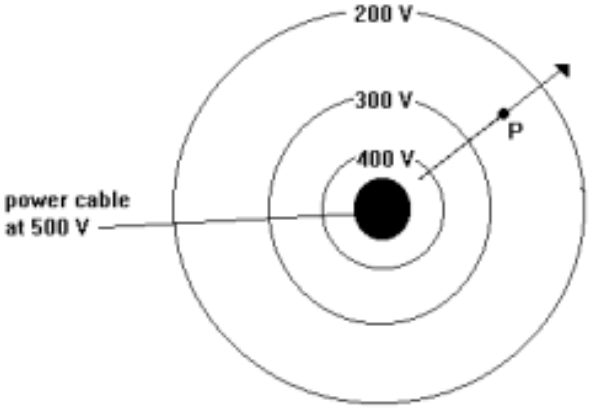
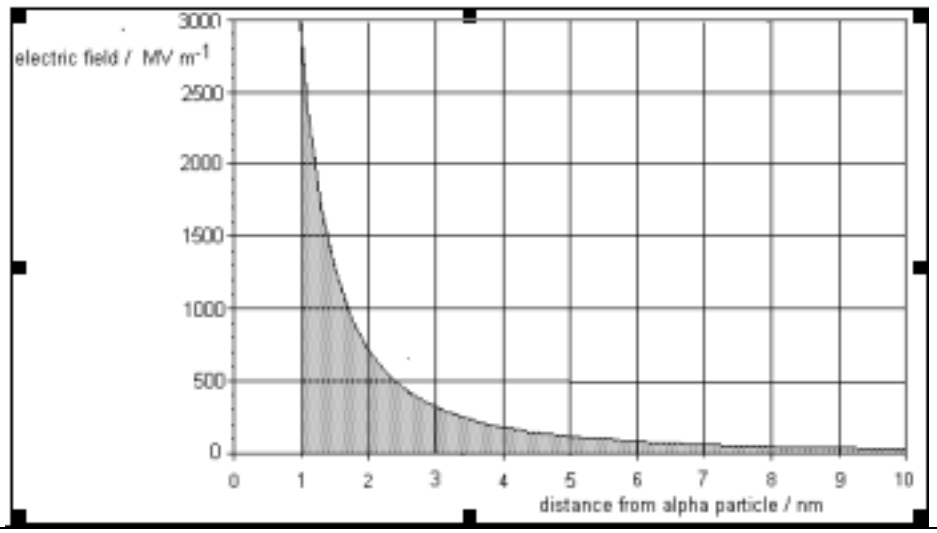
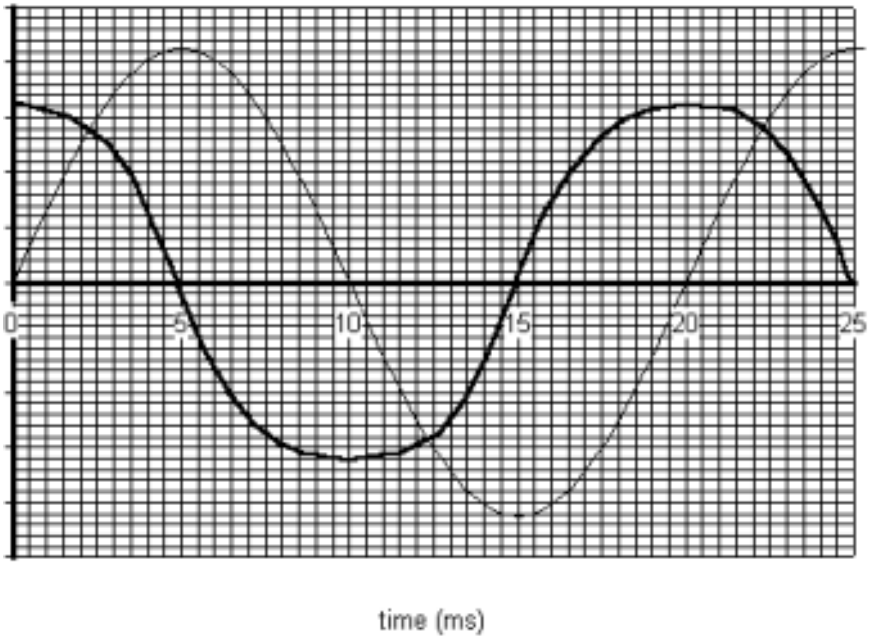
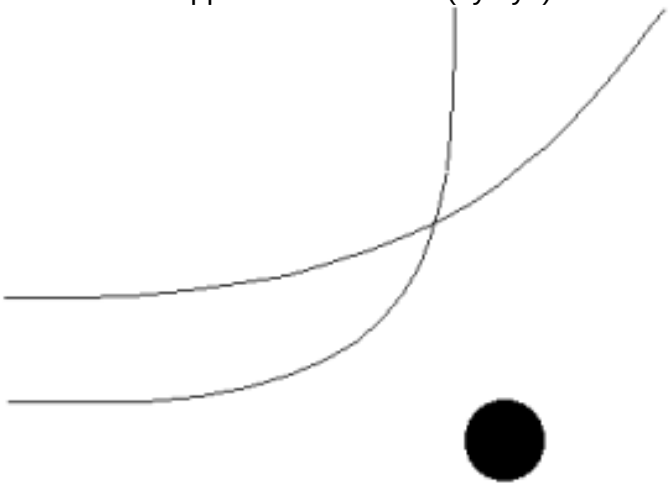
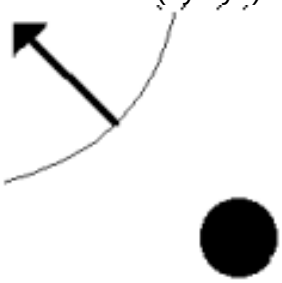
- Where units are not provided in the question or answer line the candidate is expected to give the units used in the answer.
- Quality of written communication will be assessed where there are opportunities to write extended prose.

1(a)	U	J C^{-1} (NOT correct alternative)	1
(b)	U	T (NOT correct alternative)	1
2(a)	U E	two complete loops, passing through coil and not crossing each other lines closer together as they cross the gap (by eye) ACCEPT 90° bends in lines, and partly outside the core 	1 1
(b)	U	B	1
3(a)	U	$\lambda = \ln(2)/T_{1/2} = 0.693/9.4\times10^{3} = \underline{7.4}\times10^{-5}$ s^{-1} ACCEPT reverse calculation: $T_{0.5} = 9.9\times10^{3}$ s	1
(b)	C	wtte the following points • *t* has units of s • both *N* and ΔN cancel / *N* (or ΔN) has no units • correct substitution of units into formula	1
(c)	E	$N = A/\lambda = 3\times10^{3} / 7.4\times10^{-5} = 4.1\times10^{7}$ ACCEPT 4×10^{7} ecf $\lambda = 7\times10^{5}$: $N = 4.3\times10^{7}$	1

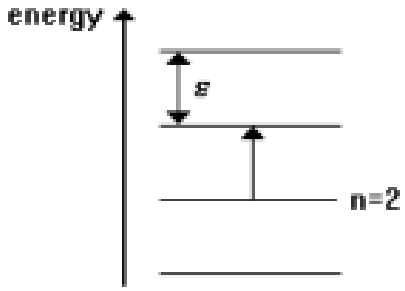
4(a)	E	closest / closer spacing of equipotentials (ora, wtte) ASSUME answer refers to close to the cable	1
(b)	U E	straight line at right angles to any equipotentials crossed (by eye) arrow pointing away from cable  	1 1
5	E	C	1
6(a)	C	$500\times\mathbf{10^{6}} \times 1\times\mathbf{10^{-9}}$ (= 0.5)	1
(b)	C	 	1
7	D D	risk = dose equivalent × probability (eor) dose equivalent = $25 \times 200\times10^{-6}$ Sv = 5×10^{-3} Sv ecf incorrect dose equivalent: risk = $5\times10^{-3} \times 3$ = 0.015 % / 1.5×10^{-2} % (d.e. of 2×10^{-4} Sv gives 6×10^{-4} % risk)	1 1
8(a)	D	A	1
(b)	U U U	$V_s = V_p \frac{n_s}{n_p}$ (eor) 80 V 50 Hz	2 1

9(a)(i)	U U	$E = V/d$ (eor) E = 325 / 1.25 = 260 V m^{-1}	1 1

(ii)	A A	ANY of following, maximum [2] **atomic** electrons: • are removed from atoms / molecules / particles • electrons <u>and</u> nucleus forced apart by field / (charged) electrodes • as electrons and nucleus have opposite charge (wtte) **free** electrons: • are <u>accelerated</u> by field / (charged) electrodes / through p.d. • collisions with atoms / molecules result in more free electrons (wtte)	2
(b)(i)	D D	gradient indicated at 0 ms, 10 ms, or 20 ms (ACCEPT triangles, tangents ..) NO ecf incorrect place for gradient: 250 V ± 50 V	1 1
(ii)	C	cosine curve with zero at only 5, 15 and 25 ms (any amplitude) ACCEPT 180° out of phase at least one complete cycle, ignore changes of amplitude, by eye  	1
(c)	C B	any of the following, maximum [2] • <u>changing</u> flux / field <u>in</u> the iron / coil / choke (wtte) • induces (back) emf (across the choke / coil) • reducing p.d. across the tube / putting extra "resistance" in the circuit / opposing the applied emf / inducing a current in opposite direction	2

10(a)(i)	U E D	curves upwards (by eye) smaller overall angular deflection greater distance of closest approach to nucleus (by eye)	1 1 1
			
(ii)		assume answer refers to B:	
	D C	greater distance from nucleus results in smaller force (wtte)	1 1
(b)(i)	C C C	$Q = 82 \times 1.6\times10^{-19} = 1.3\times10^{-17}$ C ecf incorrect Q:= 1.6×10^{-19} EITHER	1
		$F = kQq/d^2$ (eor) $F = 9.0\times10^{9} \times 1.6\times10^{-19} \times 1.3\times10^{-17} / (3.4\times10^{-14})^2 = 16$ N OR	1 1
		$E = kQ/d^2$, $F = qE$ (eor) $E = 9.0\times10^{9} \times 1.3\times10^{-17} / (3.4\times10^{-14})^2 = 1.01\times10^{20}$ V m^{-1}; $F = 16$ N (ecf $Q = 1.6\times10^{-19}$ C gives $F = 0.197$ N (accept 0.2 N))	
(ii)	E	in direction from centre of nucleus to P (by eye)	1
			
(c)	B A	less than one in 100 million / fraction decreases (wtte) because deflecting force acts for less time / greater impulse needed for same deflection (wtte) (references to increased speed alone are neutral)	1 1

11(a)(i)	C	nucleus breaks up (wtte) ACCEPT atom but not molecule or particle	1
(ii)	A B	any of the following, maximum [2] • binding energy is difference in energy between nucleons and separated nucleons • total binding energy changes / total mass decreases • mass:energy relationship (wtte) • surplus energy becomes kinetic energy • sketch of binding energy - mass curve	2
(iii)	E D C	any of the following, maximum [3] • neutrons trigger further fissions of uranium • need to remove some neutrons from each fission • so that one neutron per fission causes another fission • neutrons are absorbed in control rods/boron/cadmium • neutrons are slowed down • through collisions with moderator/carbon/water • slow neutrons easily absorbed by uranium	3
(b)	D	none of the beta particles will escape the water, but most of the gamma photons will (wtte) (answer must refer to both particles and photons, references to energy are neutral)	1
(c)	C C B B	any of the following pairs, maximum [2] + [2] • increase distance between astronauts and reactor • to reduce intensity of gamma photons at astronaut (wtte) • reduce power output of reactor • so that fission rate / gamma emissions is reduced • place extra shielding (e.g. supplies, lead) between astronaut and reactor • to absorb (some more) gamma photons • change material of existing shielding • to one which is a better absorber of gamma photons (wtte)	4

12(a)(i)	E D E	λ= 72 or 73×10^{-6} m ecf incorrect value for λ: $c = f\lambda$ (symbols or words) f = 3.0×10^{8} / 73×10^{-6} = 4.1×10^{12} Hz or 4.2×10^{12} Hz	1 1 1
(ii)	E	arrow from n = 2 to n = 3, pointing up  	1
(iii)	D E	$E = hf$ (eor), ecf answer from 12(a)(i) ε = 6.6×10^{-34} × 4.1×10^{12} = 2.7×10^{-21} J (accept 3×10^{-21} J)	1 1
(b)(i)	U E	standing wave with nodes at each end and just one antinode at centre (by eye) 	1 1
(ii)	C B B	$p = \frac{h}{\lambda}$ $E = \frac{p^2}{2m} = (\frac{h}{\lambda})^2 \frac{1}{2m} = \frac{h^2}{2m\lambda^2}$ $\lambda^2 = \frac{h^2}{2mE}$ or reverse argument	1 1 1
(iii)	C	$\lambda = \sqrt{\frac{h^2}{2mE}} = \sqrt{\frac{(6.6\times10^{-34})^2}{2\times5.1\times10^{-26}\times1.35\times10^{-21}}} = 5.6\times10^{-11}$m	1
(c)(i)	C	ecf incorrect value of λ: length = 0.5 × 5.6×10^{-11} m = 2.8×10^{-11} m	1
(ii)	A A	ecf incorrect value for ε in (a)(iii): for n = 3, E = 2×2.70×10^{-21} + 1.35×10^{-21} = 6.75×10^{-21} J ecf incorrect value for E: leading to λ= 2.52×10^{-11} m length for n = 3 is 1.5λ = 3.8×10^{-11} m	1 1
		Quality of Written Communication	4

Marking quality of written communication

The appropriate mark (0-4) should be awarded based on the candidate's quality of written communication in Section B of the paper.

4 The candidate will express complex ideas extremely clearly and fluently. Answers are structured logically and concisely, so that the candidate communicates effectively. Information is presented in the most appropriate form (which may include graphs, diagrams or charts where their use would enhance communication). The candidate spells, punctuates and uses the rules of grammar with almost faultless accuracy, deploying a wide range of grammatical constructions and specialist terms.

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RECOGNISING ACHIEVEMENT

2865/01 Advances in Physics

June 2003

Mark Scheme

Physics B (Advancing Physics) mark schemes - an introduction

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- Open questions, such as the questions in section C in AS, permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts
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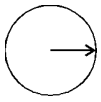
Abbreviations, annotations and conventions used in the Mark Scheme	m = method mark s = substitution mark e = evaluation mark / = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Qn	Expected Answers	Marks	Additional guidance
1 (a)	The Universe / all of space /all of space-time / owtte ✓	1	Do not penalise any reference to edge or boundary
(b)	The surface (area) of the balloon has increased/ initially rapid, then slower✓	1	No explicit mention of balloon model needed
(c)	Distance between our galaxy and B is increasing faster than/more than the distance between our galaxy & A ✓	1	
(d)i)	Straight line ✓ Through (0,0) ✓	2	'Is (directly) proportional' gets✓✓
(d)ii)	$H_0 = v/d$ = 2800 km s^{-1}/40 Mpc =70 ✓m✓e km s^{-1} Mpc^{-1} ✓(unit mark for the paper)	3	Or 0.07 m s^{-1} pc^{-1} Penalise > 3 s.f.
2 (a)	Method of dispersion e.g. grating, prism ✓ Added detail, e.g. how detected/observed, collimation, detail on diagram ✓	2	Labelled sketch will do
(b)	Galaxy A ✓ Correctly identifying redshift as movement to right on these diagrams✓	2	
(c)	Outline of Big Bang theory e.g. expanding Universe/ started small/hot/etc ✓ Wavelengths stretch with expanding Universe✓ Galaxies moving away from us/each other (faster)✓ Further galaxies have greater redshifts✓	3	Up to 3 ✓. Can refer to balloon model of question 1
3 (a)	(i) Constant ratio / 10 × each time / owtte✓ (ii) Cover a greater range of frequencies owtte / linear region <10^{10} allows calculation ✓	2	
(b)	Estimating peak frequency (>1to 3.0) × 10^{11} Hz✓ T = 1.6 × 10^{11} Hz / 5.9 × 10^{10} Hz K^{-1} = 2.7 K ✓	2	Reverse argument from 3 K to f is acceptable, with ✓ for calc. of f and ✓ for comparison with graph
(c)	Intensity lower ✓ Peak at smaller frequency ✓ Peak occurs roughly one grid-spacing back ✓	3	Peak just to right of 10^{10} Hz

Qn	Expected Answers	Marks	Additional guidance
4 (a)	Weight = 1.4×10^3 kg × 9.8 N kg^{-1} = 1.4×10^4 N ✓	1	Allow 1.37×10^4 N
(b)	Mass of air = 1.2 kg m^{-3} × 1.0×10^4 m^3 = 1.2×10^4 kg✓ Weight = 1.2×10^4 kg × 9.8 N kg^{-1} = 1.2×10^5 N✓	2	
(c)	F = 1.2×10^5 N - 1.4×10^4 N = 1.1×10^5 N ✓ $a = F/m$ = 1.1×10^5 N/1.4×10^3 kg =76 (m s^{-2}) ✓m✓e if < 3✓ given above, credit can be given for comments on subsequent role of air resistance	3	1.0×10^5 N if not rounded earlier; a=76 m s^{-2} if 1.1×10^5 N is used
(d)	Each first mark is a consequence of the change, and the second mark is a force consequence. i. volume of balloon increases✓ upthrust is increased✓ ii. weight of displaced air is reduced✓/ upthrust is reduced ✓ iii. volume of balloon decreases ✓ upthrust is reduced✓/ density of external air increases or pressure decreases✓ consequence✓	6	Quality of Written Communication can be assessed in this question 'Force' marks could refer to changes in air resistance.
5 (a)	Wavefronts straight/ 'rays' parallel✓	1	
(b)	(i)  (ii) Fig. 5.1 in phase ✓ Fig. 5.2/Fig 5.3 out of phase/ in antiphase ✓ Consequence of adding ✓ (iii) $\sin\theta = \frac{½\lambda}{d} = \frac{\lambda}{2d}$ ✓ (iv) $\sin\theta = \frac{\lambda}{2d} = \frac{0.21\text{ m}}{2\times 50\text{ m}} = 0.0021 \Rightarrow \theta = 0.12°$ ✓	1 3 1 1	Allow '2 o'clock' to '4 o'clock' Ecf from 5 (b) if phase difference < $\pi/2$ ✓ (iii) Needs evidence of reference to triangle in Fig. 5.2 e.g. on diagram (iv) or θ=0.0021 rad
(c)	(i) $d \uparrow \Rightarrow \sin\theta / \theta \downarrow$ ✓ smaller improves resolution ✓ relating improvement to ratio 10^5/50 / resolution 2000× better ✓ (ii)Very high frequency/very small period ✓ needs very accurate timing to maintain correct phase relationship✓	3 2	Should refer to timing.

Qn	Expected Answers	Marks	Additional guidance
6 (a)	(i) Value is close to (and >)1 ✓ because refractive index is ratio of these speeds ✓		QoWC opportunity here also.
	(ii) n=1/sin C ✓ $n \approx 1 \Rightarrow C = 90^o$ ✓	4	
(b)	A plane mirror would reflect the parallel beam as a parallel beam owtte✓ so the lower part/section near A must be curved in to make the beam converge✓		Could draw on diagram to indicate the relevant reflection physics.
	Must be focussed to be detected✓ (up to two points)	2	
7 (a)	$E_p = mV_{grav} = -\frac{GMm}{R}$ ✓		Or by recall Magnitude only needed.
	$= -\frac{6.7\times10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 6 \times 10^{39}\ \text{kg} \times 1.7\times 10^{-27}\ \text{kg}}{1 \times 10^{13}\ \text{m}}$		Max of one if wrong expression correctly
	$= -6.8\times10^{-11}$ J $\approx -7 \times 10^{-11}$ J ✓m✓e	3	evaluated✓
(b)	Realising that, at ∞, $E_p = 0$ ✓		Can refer to potential
	Application of by conservation of energy ✓	2	well 7×10^{-11} J deep.
(c)	(i) $E_k = 7\times10^{-11}$ J/1.6×10^{-19} J eV^{-1}= 4.3×10^8 eV✓		
	(ii) Gamma (allow X-rays) because very high energy ✓	2	
8 (a)	$R = \frac{\rho l}{A}$ ✓ $= 2.0 \times 10^{-8}\ \Omega\ \text{m} \times \frac{(10\ \times 2(0.03\ \text{m} + 0.02\ \text{m}))}{1.2 \times 10^{-7}\ \text{m}^2}$		Must show correct use of equation or correct
	= 0.17 Ω ≈ 0.2 Ω ✓s✓e	3	values including l =1m
(b)	From N face to S face ✓ not crossing, and either parallel or spreading out in the centre (must not start at same point on either face)✓	2	One ✓for arrows, one ✓ for shape of field
(c)	Higher permeance/better magnetic circuit owtte ✓ greater flux through armature (coil)✓	2	
(d)	$I=V/R$ ✓= 3.0 V/(2×0.6 Ω+0.2 Ω) = 2.1 A ✓m✓e	3	Can use 0.17 Ω for coil
(e)	emf induced by motion ✓ opposes 3.0 V supply so I ↓✓ induced emf increases with motor speed ✓	2	Can quote Lenz's Law. Any two .✓
(f)	More massive ✓(problem) reduced acceleration/longer to brake/must go slower around corners✓(explanation)	2	Any valid **physical** effect and explanation.

Qn	Expected Answers	Marks	Additional guidance
9 (a)	Light intensity very low that far from the Sun ✓	1	
(b)	5.6 MeV = 5.6×10^{6} J × 1.6×10^{-19} J eV^{-1} = 8.96×10^{-13} J ≈ 9×10^{-13} J ✓m✓e	2	
(c)	(i) Number of decays = 630 W/ 9.0×10^{-13} J = 7×10^{14} s^{-1} ✓ (8.96×10^{-13}J gives 7.03×10^{14} s^{-1}) (ii) Mission is about $T_{½}$ /8 ✓ Assume linear change in this time for estimate ✓ Decreases by ½ in a half life so in 1/8 of a half life it decreases by 1/16. This means that 7×10^{14} s^{-1} = 15/16 of original so original count = 16/15 × 7×10^{14} s^{-1}= 7.5×10^{14} s^{-1}✓ / $T_{½} \Rightarrow \lambda$✓ and then $Count = Count_0 e^{-\lambda t}$ where $Count$ =7×10^{14} s^{-1} (gives $Count_0$=7.6×10^{14} s^{-1}) ✓m✓e	1 3	Ora from 7×10^{14} s^{-1} λ= 7.9×10^{-3} $year^{-1}$ = 2.5×10^{-10} s^{-1} Can also use $7\times10^{14}s^{-1}$= $Count_0\times(½)^{1/8}$✓m✓e
(d)	Energy = 3 × 630 W × 3.2×10^{7} s = 6.0×10^{10} J ✓ Energy absorbed by astronaut = 6.0×10^{10} J /10^{11} = 0.6J✓ Dose = 0.6 J/70 kg = 0.0086 Gy ✓	3	
(e)	(Very many) electrons liberated in hotter region✓ More free electrons results in higher conductivity✓ Rate of release of electrons governed by Boltzmann factor /Boltzmann factor increases exponentially/expression for factor quoted with temperature✓	3	Any relevant reference to k will do here. Either comparison between kT and E or reference to $e^{-\frac{E}{kT}}$

QoWC **Marking quality of written communication**

The appropriate mark (0-4) should be awarded based on the candidate's quality of written communication in the whole paper.

4 max The candidate will express complex ideas extremely clearly and fluently. Answers are structured logically and concisely, so that the candidate communicates effectively. Information is presented in the most appropriate form (which may include graphs, diagrams or charts where their use would enhance communication). The candidate spells, punctuates and uses the rules of grammar with almost faultless accuracy, deploying a wide range of grammatical constructions and specialist terms.

3 The candidate will express moderately complex ideas clearly and reasonably fluently. Answers are structured logically and concisely, so that the candidate generally communicates effectively. Information is not always presented in the most appropriate form. The candidate spells, punctuates and uses the rules of grammar with reasonable accuracy; a range of specialist terms are used appropriately.

2 The candidate will express moderately complex ideas fairly clearly but not always fluently. Answers may not be structured clearly. The candidate spells, punctuates and uses the rules of grammar with some errors; a limited range of specialist terms are used appropriately.

1 The candidate will express simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weakness in these areas.

0 The candidate is unable to express simple ideas clearly; there are severe shortcomings in the organisation and presentation of the answer, leading to a failure to communicate knowledge and ideas. There are significant errors in the use of language which makes the candidate's meaning uncertain.