

Oxford Cambridge and RSA Examinations



**ADVANCED GCE
ADVANCED SUBSIDIARY GCE**

**A2 7888
AS 3888**

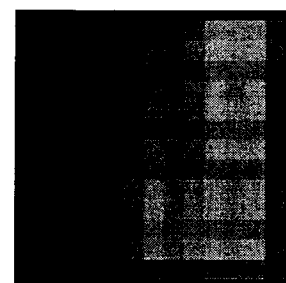
PHYSICS B (ADVANCING PHYSICS)

Second Edition (post-Tomlinson Enquiry statistics)

Published October 2002

**MARK SCHEME FOR THE UNITS
JUNE 2002**

AS/A2



3888/7888/MS/02

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by Examiners. It does not indicate the details of the discussions which took place at an Examiners' meeting before marking commenced.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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**Advanced Subsidiary GCE/Advanced GCE Physics B (Advancing Physics) 3888/7888
June 2002 Assessment Session**

This specification was re-graded following the Tomlinson enquiry into A Level standards.
Therefore, these thresholds and statistics were revisited in October 2002.
Thresholds and statistics which have changed are marked in bold.

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	69	63	57	51	46	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	97	87	77	67	58	0
	UMS	100	80	70	60	50	40	0
2863 Option B	Raw	127	97	85	74	63	52	0
	UMS	100	80	70	60	50	40	0
2864 Option A	Raw	119	90	81	72	63	54	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	66	59	52	46	40	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	24.7	44.5	63.2	78.8	90.1	100.0	7407
7888	30.0	51.3	70.0	85.7	95.9	100.0	5892

These percentages are correct at the time of going to press (October 2002).

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 forward*: 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. Missing or incorrect units in a final answer are penalised by the loss of a mark, generally once per examination paper.
- Quality of written communication will be assessed in Section C where there are more 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

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


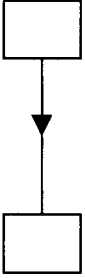
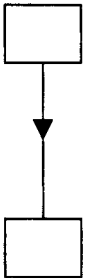
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/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
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()	=	words which are not essential to gain credit
<u> </u> (underlining)	=	key words which <u>must</u> be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument

Question	Expected Answers	Marks
Section A		
1. a	idea of constant error (in all readings) / error on same side of true value / off by 0.5 / 0.6 A (+/- sign) AW ✓ NOT any description of random error ;	1
b	7 / 7.0 / 7.1 A ✓ NOT 5.9 / 6.0 A	1
2. a	stiff / hard / tough / low density / low friction / non porous / other relevant mechanical property ✓ ; NOT (durability / strength / plasticity / brittleness)	1
b	correct meaning of any relevant property explained ✓ NOT cost ; importance to hip joint explained: e.g. stiffness matched to bone OR to avoid bending of replacement / to avoid frictional wear at socket / will not break under impulsive loads AW ✓ ecf on incorrect meaning from (a)	1
3.	greater initial gradient ✓ ; gradient decreases then increases ✓ ; breaks at 30 MPa stress and 0.3 strain ✓	3
4. a;b	D ✓ ; Sm^{-1} ✓	2
5. a	$M = 1.2 / 0.2 = 6$ ✓ ;	1
b	$M = v/u$ / $u = v/M$ / $= 2.4 / 6$ ✓ ; $= 0.4(0)$ (m) ✓ ecf wrong M in (a)	2
6.	$v = f\lambda$ / $\lambda = c/f$ / $= 300 \text{ Mm s}^{-1} / 99.8 \text{ MHz}$ ✓ ; $= 3(.01)$ m ✓	2
7. a;b	C ✓ ; A ✓	2
8.	$n = \sin 50^\circ / \sin 35^\circ$ ✓ ; $= 1.3(4)$ ✓ ; SF mark - accept 2 or 3 ✓ (rads mode yields 0.61(3)) n.b. incorrect values can still score the SF mark	3
Total		20

		Section B	
9.	a	alternatives ($= 2^4$) = 16 ✓ ; 16 (or ecf) > 10 so 4 bits sufficient / appropriate binary coding e.g. (0 to) 9 ✓	1
	b	bits = $100 \times 12 \times 4 = 4800$ ✓ ; bytes = bits / 8 = 600 ✓ ecf wrong bits	2
	c	correct comment on number of letters e.g. more letters than digits / 26 letters ✓ ; better quality answer e.g. 26 letters need 5 bits / 52 letters need 6 bits / 4 bits codes only 16 letters AW ✓	1
	d i	5 kHz / 5000 Hz ✓	1
	ii	(any two reasons beware repetition) music may contain wider frequency spectrum than speech / lower quality reproduction of speech is acceptable to human perception / music has more complex waveform / poor speaker quality / stereo needed for music / sampling rate / quantisation errors / music suffers more from: high frequency cut-off / aliasing / spurious frequencies / AW ✓✓	1
			total 9
10.	a	correct symbols ✓ ; R in series with Ammeter ✓ ; Voltmeter in parallel with R / solar cell ✓ (-1 for superfluous components)	2
	b i	p.d. drops (as current increases) ✓ ; gradually at first then at a greater rate ✓ ; AW	1
	ii	solar cell has (internal) resistance / mention of <u>internal</u> r / photon flux limits the output AW ✓	1
	c i	correct values ✓ ; $P (= IV) = 0.05 \times 0.5$ ✓ ecf ; = 0.025 W ✓ ecf ;	3
	ii	At B I is a lot less AW ✓ ; at C V is a lot less ✓ / calculations of powers at B ≈ 6 (mW) , at C ≈ 6 (mW) ecf on <u>m</u> A AW	2
			total 11
11.	a	extension \propto force / linear through origin / F doubles as e doubles AW ✓	1
	b i	$\frac{1}{2} \times 90 \times (4.0 \times 10^{-3})$ ✓ ; = 0.18 (0.36 or 180 score 1 ecf) ✓ ; J / Nm ✓	3
	ii	stress = $90 / (2.5 \times 10^{-7})$ ✓ = 3.6×10^8 (N m^{-2}) ecf ✓	2
		strain = $(4.0 \times 10^{-3}) / 2.0$ ✓ = 2.0×10^{-3} ecf ✓	2
		$E = (3.6 \times 10^8) / (2.0 \times 10^{-3}) = 1.8 \times 10^{11} \text{ N m}^{-2}$ ecf ✓	1
c i	straight line graph of double gradient i.e. passing (2.0, 90) ✓	1	
ii	E is the same ✓ ; because E is constant for a material NOT wire / $\frac{1}{2}$ length means $\frac{1}{2}$ extension and same strain at given stress AW ✓	1	
			total 12
12.	a i	equal increments along the amplitude / frequency axis represent equal multiples in value ($\times 10$) AW ✓	1
	ii	logs used to accommodate the large range of values / logs represent data more clearly AW ✓	1
	b i	200 Hz ✓	1
	ii	reference to spreading / scattering / absorption / energy transfer to surroundings AW ✓	1
	iii	0.1 or $\frac{1}{10}$ ✓ ; 0.01 or $\frac{1}{100}$ ✓ (if both correct raw ratios score 1)	2
iv	20 000 (Hz) ✓ ; any plausible comparison e.g. - shorter waves are scattered more (by rough surfaces with variations of order of wavelength) / accept lower frequencies are more penetrating ora / molecular vibrations can absorb translational kinetic energy AW ✓	1	
			total 8
section B total			40

Section C: see also guidelines				
13.	a i	type of information identified (image, sound, data, alphabetic etc.) ✓ ; relevant signal system identified (satellite, radio wave, modem, telegraph)✓	1 1	
	ii	block or schematic diagram of production ; transmission ; reception of signal 1/2/3 style ✓✓✓	3	
	b i	statement of how noise recognised in information – glitches in data AW ✓; more relevant detail - snow on images / crackle on sound etc. ✓	1 1	
	ii	mention of screening / blocking / filtering etc. ✓ ; more details: coax screened cable / image processing / frequency filtering✓	1 1	
	c i	two factors identified – speed of carrier / signal frequency / bandwidth / compression / internet usage loading / modem speed ✓✓ NOT resolution or sampling rate	2	
	ii	a sensible unit e.g. kbit per s / GHz / A4 Fax sheets per hour✓ a sensible value for the estimate ✓	2	
			total 13	
	14.	a	Imaging system selected e.g. satellite image of N. Europe ✓ ; 3 pieces of information – cloud cover ; temperature ; land use etc. 1/2/3 style ✓✓✓	1 3
		b i	Nature of waves / radiation made clear – infra-red / microwave ✓ ;	1
		ii	labelled diagram and description of how image is obtained 1/2/3 style ✓✓✓ satellite scans Earth ; infra-red sensor detects energy per pixel ; A to D converts to binary data value or other sensible details	3
c i		resolution is size represented by length of pixel ✓ ; reasonable resolution estimate e.g. 100 m per pixel side ✓	1 1	
ii		two factors limiting resolution e.g. wavelength of radiation / diameter of detector dish / pixel density (number) on detector / distance at which object is being imaged / bits per pixel ✓✓	2	
		some detail on either factor e.g. numerical or descriptive detail ✓	1	
Quality of written communication		4		
		total 17		
total section C		30		

13ai	speech information analogue telephone system	text message mobile phone system	binary computer data data bus from hard disk to memory
ii	<p>speech to electrical signal by mic. in handset</p>  <p>signal along wire conductors</p> <p>electrical signal to sound by loudspeaker in the receiver</p>	<p>text entered on mobile keypad converted to digital code</p>  <p>signal through air by microwave transmission</p> <p>signal received, decoded and displayed as text at receiver</p>	<p>binary data read from hard disk by read head</p>  <p>data switched through databus to processor / memory</p> <p>data displayed on screen of pc</p>
bi	crackles on speech whistling tones	incorrect characters unexpected graphics	data or graphic glitches on screen programme crashes
ii	use fibre optic link rather than copper wire optics do not pick up external electrical noise like lightning	Ensuring that no other nearby signal is using the same transmitting frequency avoids cross-talk between channels	cleaning the surface of hard disk and read head prevents dust from corrupting data as it is read from disk
ci	carrier signal speed electric signal on wires at near light speed frequency / bandwidth	carrier wave speed microwaves at light speed number of other local users loading the system	carrier signal speed electric pulses travel on databus at near light speed frequency rating of the databus / number of parallel wire in the bus
ii	10's of kbits / s OR a few words / s	100's of kbits / s OR a message / few ms	100's of Mbits / s OR 10's of pc screens / s

14a	Satellite imaging system cloud cover land use farmers sea surface temperature	Ultrasound medical scanner size / orientation of foetus heart rate of foetus in womb sex of foetus determined	Radio telescope system presence of pulsars mapping galactic radio sources SETI research
bi	infra-red / microwaves	ultrasonic waves	radio waves
ii	satellite mounted camera scans the Earth's surface by pixels radiation is reflected onto sensor that develops a voltage in proportion to the infra-red signal received A to D converter then codes signal into binary which can be relayed to Earth by radio waves	piezoelectric crystal is pulsed by high frequency oscillations ultrasound penetrates the abdomen and is reflected from layers of tissue of different densities strengths and time delays of the reflected waves returning to the piezo crystal develop voltage signals which can be displayed as a scanned image on a c.r.t.	large aperture steerable parabolic dish reflects radio waves incoming from one direction in the sky waves are focused onto a receiving circuit generating a small voltage this voltage can be amplified and recorded and turned into a false colour image of radio intensity as various angles are scanned
ci	size of smallest detectable detail in the original object represented by the length along the edge of one pixel of the image a small field is resolved / about 100m (per pixel)	size of smallest detectable detail in the original object represented by the length along the edge of one pixel of the image blood vessels resolved / about a mm (per pixel)	size of smallest detectable detail in the original object represented by the length along the edge of one pixel of the image hydrogen gas clouds in our galaxy / several light minutes (per pixel)
ii	wavelength of microwaves number / density pixels in the detector	wavelength of ultrasound response time in the crystal detector circuit	radio wavelength selected diameter of detecting dish / distance to source studied

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.

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AW	=	alternative wording
ora	=	or reverse argument
e	=	evaluation mark
m	=	method mark
s	=	substitution mark

Section A

1. (a) **using** $\lambda = v/f$ or $340/170$ ✓ m = 2 m ✓ e 2
 (b) $(l = 2.0/4)$ = 0.5 m ✓ e 1
2. appropriate drawing or Pythagoras ✓ resultant = 1750 to 1850 N ✓ 2
3. (a) **using** $E = hf$ or $6.6 \times 10^{-34} \times 6.0 \times 10^{14}$ ✓ m
 = 3.96×10^{-19} J ✓ e (accept 4.0 or $4 \dots \times 10^{-19}$) 2
 (b) $(1.1 \times 10^{-18}) / (3.96 \times 10^{-19})$ ✓ m (= 2.78) = 3 photons ✓ e 2
4. $t = x/v$ or $t^2 = x^2/v^2$ idea ✓ **used in** $y = \frac{1}{2}gt^2$ ✓ 2
 (or working backwards from $\frac{1}{2}gx^2/v^2$ to $y = \frac{1}{2}gt^2$ **using** $x = vt$)
5. (a) 0.15 (m) (accept $\lambda/2$ or 'half a wavelength') ✓ e
 (no marks for **phase difference** = 180°) 1
 (b) spacing **INCREASES** ✓ e
 $\sin \theta = \lambda / d$ (or $FS = \lambda D/a$) idea ✓ m
 (or 'increased distance to travel to arrive IN/OUT of phase' ✓ m) 2
6. (a) $s = \frac{1}{2} \times 9.8 \times (4.0)^2$ ✓ m = 78.4 m ✓ e 2
 (b) resistive/frictional forces ✓ so acceleration less / time too long ✓ 2
 (or takes time for sound to come back ✓, so time actually less ✓ than 4s)
7. for relating probability to **(amplitude)²** ✓ m ratio = 16 ✓ e 2

Section A total 20

Section B

8. (a) $W = 75 \times 9.8 \quad \checkmark \quad = 735 \text{ N} \quad \checkmark$
 (accept $(75 \times 10) = 750$ or $(75 \times 9.81) = 735.75$) 2
- (b)(i) mention air resistance/drag force \checkmark
 air resistance/drag ... increases with speed \checkmark
 resultant/accelerating force decreases \checkmark 3
- (ii) the idea of balanced forces/resultant force zero \checkmark
 (allow 'forces equal') 1
- (c)(i) air resistance/drag increases \checkmark
 .. idea of increased area / unbalanced force upwards \checkmark 2
- (ii) for the idea that
 'the speed at which air resistance = weight is less/different' $\checkmark\checkmark$
 (or 'he has slowed down to a speed when drag = weight'
 or 'once parachute opens the forces again 'level out' reaching
 equilibrium but at a different speed') 2
 (for just 'forces become balanced again' 1 mark)

total 10 marks

9. (a) **A:** idea that acceleration is high initially \checkmark
 ... then decreases \checkmark ('acceleration decreases' = 2 marks)
 (or speed increases rapidly then more slowly $\checkmark\checkmark$) 2
- B:** idea that acceleration goes from low – high – low $\checkmark\checkmark\checkmark$
 (or speed increases slowly, then more rapidly, then more slowly = 3 marks)
 (or acceleration increases and then decreases = 3 marks)
 *** ['speed decreases' is wrong] 3
- (b)(i) area under graph represents distance travelled \checkmark
 ramps same length \checkmark (accept distance travelled the same) 2
 *** (do **not accept** vertical height distance or gpe the same)
- (ii) 2 points to look for from:
- B has a smaller initial acceleration/ (rate of) accn. on B is less
 - B has smaller average acceleration
 - acceleration on B is less than on A (accept omission of 'average')
 - B has lower average speed
 - at all times, speed is smaller on B than on A
 - B reaches higher speeds later than on A
 - B travels at higher speeds for less distance
 - gradient of v-t graph is 'a', and generally gradient of B graph is less than on A
 - gradient of ramp B is generally less than ramp A 2

total 9 marks

10. (a) in phase ✓ 1
- (b)(i) out of phase / destructive interference ✓ since extra $\lambda/2$ ✓ 2
- (ii) amplitudes may not be same ✓ (no mark for not quite out of phase)
idea that may not get total cancelling/total destructive interference ✓ 2
(or because of extra distance travelled ✓)
- (c)(i) $T = 1/(2000)$ ✓ m = 0.0005 ✓ (5×10^{-4}) s ✓ e 3
*** (no credit for attempt via $v = f\lambda$)
- (ii) for **using** a $v = s/t$ idea ✓
= $(2 \times 7.5 \times 10^{-3})/0.0005$ ✓ (ecf from (c)(i)) 2
*** (no credit for attempt via $v = f\lambda$)

total 10 marks

11. (a)(i) $4.2 \times 10^{-2} / 2.8 \times 10^{-10}$ ✓ m = 1.5×10^8 m ✓ e 2
- (ii) $(1.5 \times 10^8)^2$ ✓ m = 2.25×10^{16} ✓ e 2
- (b)(i) $9.0 \times 10^{-7} / 2.25 \times 10^{16}$ ✓ m = 4×10^{-23} J ✓ e 2
(or $9.0 \times 10^{-7} / 2.3 \times 10^{16}$ ✓ = 3.9×10^{-23} ✓)
- (ii) $3.2 \times 10^{-18} / 4.0 \times 10^{-23}$ ✓ m = 8.0×10^4 s (80,000) ✓ e 2
- (c) $E = 6.63 \times 10^{-34} \times 6.0 \times 10^{15}$ ✓ m = 3.96×10^{-18} J ✓ e 2
for stating $3.96 \times 10^{-18} > 3.2 \times 10^{-18}$ / or comment ✓ 1

total 11 marks

Section B total 40

Section C

12. (a)(i) for an example of wave **superposition** ✓ 1
 (ii) relevant historical/aesthetic/practical/physical comment ✓ 1
- (b) some indication of dimensions ✓ wavelength ✓ 2
 diagram essentially correct, detailed and labelled ✓✓✓ 3/2/1
 diagram essentially correct, but some omissions or errors ✓✓
 some attempt made ✓
- (c) 3 relevant observations ✓✓✓ 3
- (d) 4 relevant comments showing understanding of physics 4

total 14 marks

13. (a)(i) (s and t) or (u, v and t) or (u,v and s) or (F and m) ✓✓
 (as appropriate to method) 2
- (ii) $s = ut + \frac{1}{2}at^2$ ✓ $a = \frac{2s}{t^2}$ ✓
or $v = u + at$ $a = \frac{(v - u)}{t}$
or $v^2 = u^2 + 2as$ $a = \frac{(v^2 - u^2)}{2s}$
or $F = ma$ $a = F/m$ 2
- (b) for clearly specifying measurements needed to be made ✓✓
 for stating the instrument(s) to be used ✓✓ 4
- (c)(i) for two different factors affecting accuracy ✓✓
 ** (not friction at pulley/wheels/surface) 2
- (ii) for 2 appropriate suggestions ✓✓ (could be an improved method)
 ** (not ways of reducing friction) 2

total 12 marks

Quality of written communication 4

Section C total 30

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Section A

1. D ✓ (N m⁻²) [1]
2. C ✓ (4500) [1]
3. $F = (-) GMm/r^2$ ✓ = $(-) 6.67 \times 10^{-11} \times 2.5^2 / 1.5^2$ ✓ = $(-) 1.85 \times 10^{-10}$ N (two marks if the equation or evaluation implicit. If numerical answer alone, one mark only) [2]
4. (a) $E = \frac{1}{2} k x^2 = \frac{1}{2} \times 220 \times 0.03^2$ ✓ = 0.099 J ✓
(can go from energy to compression) [2]
- (b) reasonable assumption ✓ $0.099 = 0.08 \times 9.8 \times h$ ✓ $h = 0.13$ m ✓ (ecf)
Can use $\frac{1}{2} m v^2 = 0.099$ and $v^2 = u^2 + 2as$. [3]
5. (a) $Q = 110 \times 4200 \times 30$ ✓ = 1.4×10^7 J ✓ [2]
- (b) $1.4 \times 10^7 \times (5/110) / 60$ ✓ = 10.6 kW (10.5 kW) ✓ [2]
6. (a) amplitude (or max. gradient. NB velocity not acceptable) decreases ✓
(with time)
- (b) gradient of line ✓ crossing x axis ✓ AW ('max gradient' scores 2) [3]
7. The force on 1 kg ✓ due to gravitational field/attraction of Earth (or another mass)
AW ✓ [2]
8. correct intercepts with x-axis and total energy line ✓ correct curve (lines cross in the middle square) ✓ [2]

Total [20]

Section B

9. (a) $Q = CV = 4700 \times 10^{-6} \times 100$ ✓ = 0.47 C ✓ [2]
- (b) $0.7 = 4700 \times 10^{-6} R$ ✓ $R = 150 \Omega$ ✓ [2]
- (c) (i) $E = \frac{1}{2} \times 4700 \times 10^{-6} \times 72^2$ ✓ = 12.18 J ✓
(ii) $t = 12/150$ ✓ = 0.08 s ✓ [4]
(iii) charging time longer than discharge time ✓ sensible reason (e.g. resistance comparison) ✓ (look for clarity) [2]
10. (a) (i) $E = 1.6 \times 10^{-19} \times 250$ ✓ = 4×10^{-17} J
(ii) $\frac{1}{2} m v^2 = 4 \times 10^{-17}$ ✓ $v^2 = 2 \times 4 \times 10^{-17} / 2.2 \times 10^{-25}$ ✓ $v = 1.91 \times 10^4$ ✓ m s⁻¹ [4]
- (b) (i) $2.9 \times 10^{-6} \times 1.9 \times 10^4$ ✓ = 0.058 ✓ (0.055 if 1.91 used)
(ii) force = $\Delta p / \Delta t$ ✓ (or clear statement of Newton III ✓)
(iii) $a = 0.057 / 490$ ✓ = 1.2×10^{-4} m s⁻² ✓ look for other acceptable values [5]
- (c) Microscopic effect e.g.
krypton ions leave faster ✓ because same energy gain for lower mass ✓
or less thrust per ion ✓ as (smaller mass so) less momentum per ion ✓
or other sensible.
(Macroscopic effect with sensible conclusion ✓ consistent with suggested effect ✓) [2]

11. (a) $V \times 2 \times 10^5 = V/3 \times \text{new pressure}$ ✓ pressure = $6.0 \times 10^5 \text{ Pa}$ ✓ [2]
- (b) $PV = nRT$ (or NkT) = $1/3 N m c^2$ ✓ r.m.s = $(3 \times 8.31 \times 300 / 4 \times 10^{-3})^{1/2}$
= 1370 m s^{-1} ✓
(or $\frac{1}{2} mv^2 = \frac{3}{2} kT$ ✓ leading to 1370 m s^{-1} ✓) [2]
- (c) r.m.s. = $(3 RT/m_m)^{1/2}$
new/old = $(3 R 400/m_m)^{1/2} / (3 R 300/m_m)^{1/2}$ ✓ = $(400/300)^{1/2}$ ✓ = $(4/3)^{1/2}$
(or by calculation or $c^2 \propto T$ ✓ leading to correct evaluation ✓) [2]
12. (a) $3 \times 10^8 \times 3.2 \times 10^7$ ✓ = 10^{16} m [1]
- (b) (i) light takes 10 000 million years to reach Earth so the information received is
10 000 million years old. ✓
(ii) distance = speed x time = $10,000 \times 10^6 \times 10^{16}$ ✓ = 10^{26} m [2]
- (c) (i) lengthening of wavelength
or shift (of spectral lines) to red end of spectrum ✓ AW [1]
- (ii) as radiation travels through space the wavelength stretches ✓ with
expanding space ✓ AW quality
(Mark parts one and two together) [2]
- (iii) light has been travelling for longer ✓ so more time for stretching of
waves/Universe has changed more ✓ (one mark for Hubble-type argument) [2]
13. (a) $kT = 1.38 \times 10^{-23} \times 300$ ✓ = $4.1 \times 10^{-21} \text{ J}$ ($3/2 kT$ gives 6×10^{-21}) [1]
- (b) $4.6 \times 10^{-26} \times 3000 \times 9.8$ ✓ = $1.35 \times 10^{-21} \text{ J}$ [1]
- (c) $E/kT = 1.35/4.1$ ✓ = $e^{-0.35}$ ✓ (or implicit) = 0.72 [2]
- (d) (i) Any two from:
Boltzmann factor measure of ratio of numbers of particles in states differing
by E ✓
less dense because fewer particles ✓
particles have less chance of having sufficient energy to attain greater
height. ✓AW
- (ii) test ✓ carried out ✓ conclusion ✓ (understanding of test implicit in
arithmetic OK, implied conclusion OK) [5]
- OR: practical test developed ✓ leading to equal ratio or log discussion ✓ max 2
- (e) T or kT is smaller as height increases (or implicit) so E/KT is bigger ✓ so -
 E/kT becomes more negative OR $e^{-E/kT}$ gets smaller ✓ [2]
- Quality of Communication** [4]
- Section B total** [50]
- Paper total** [70]

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:

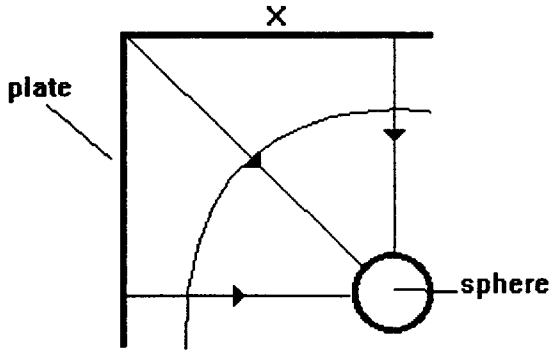
- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Open questions 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.
- 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.

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
up	=	omission of units with answer

Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
()	=	words which are not essential to gain credit
___ (underlining)	=	key words which <u>must</u> be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument
m	=	method mark
s	=	substitution mark
e	=	evaluation mark
eor	=	evidence of rule

1	 <p>curve between sphere and plate with correct curvature line at right angles to field lines (by eye) accept dotted curves</p>	1 1
2	A	1
3 (a)	20	1
(b)	B	1
4 (a)	$4.0 \times 10^{-4} / 400 = 1.0 \times 10^{-6} \text{ Wb}$ (accept 10^{-6})	1
(b)	$\Phi = BA$ (eor) ecf (a): $B = \Phi/A = 1.0 \times 10^{-6} / 1.25 \times 10^{-5} = 8.0 \times 10^{-2} \text{ T}$ ecf: $4 \times 10^{-4} / 1.25 \times 10^{-5} = 32$ worth [1]	1 1
5	energy = mass \times dose (eor) energy = $0.12 \times 4.0 = 0.48 \text{ J}$	1 1