Abbrieviations, annotations and conventions used in the Mark Scheme

m = method mark
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____ = (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		
1	steel = B ; biscuit = C ; cast iron = A	3	
2(a)	400 ± 100 (m $pixel^{-1}$) 300 - 500	1	no method needed
(b)	25 ± 10 (km) 15 - 35	1	no method needed
(c)	Global warming / sea level rising / climate change / icebergs danger to shipping lanes etc.	1	any sensible attempt to make physics "connect" NOT just icebergs moving
3(a)	Area of cross-section / circle	1	NOT just area accept labelled sketch
3(b)	x ½ ; x ¼	2	accept halved; quartered
4(a)	semiconductor(s) ;	1	
4(b)	$\rho = 1/\sigma$ / $= 1/9\times10^5$ m ;= $1.(1)\times10^{-6}$ e ; Ω m / $S^{-1}m$	3	accept 1.1 μΩ m
5(a)	any 2 valid and distinct comparisons e.g. eee has higher frequencies / aaa has higher amplitude components / aaa has lower fundamental frequency / eee has more harmonics	2	
5(b)	consistent lower amplitude between 1V and 1.5V ;	1	by eye
	1 reasonable sine wave per time divison	1	allow any phase
6(a)	$R_{parallel}$ = 50Ω / R_{total} = 100 + $R_{parallel}$ m ; 150 (Ω) e	2	100.02(Ω) scores 1
6(b)	(I = V/ R = 12/150) = 0.08 A or 80 mA	1	evaluation only no method mark ecf from (a) on R_{total}
	Total section A	20	

	Section B		
7(a)	elastic ; tough	2	
(b)	$A = F / \sigma_B$ / 550 / 2 x 10^9 m ; = 2.8 x 10^{-7} e	2	accept 2.75 x 10^{-7}
(ci)	Permanent stretch / yield AW	1	or better
(ii)	($E = \sigma / \varepsilon$ =) 1.6 x 10^9 / 0.35 m ; = 4.6 x 10^9 e	2	by number substitution 2 or 3 SF otherwise SF penalty accept 4.57 x 10^9
(d)	molecule(s) tangled / twisted / coiled / zig-zagged molecule(s) untangled / untwisted / uncoiled / straighter molecule(s) untangled / untwisted / uncoiled / bond rotation allows different shapes / effect of cross-links / effect of side chains	1 1 1 10	stick / ball+stick / line quality mark could come from good labels
8(ai)	$\mathcal{E}$ rises as T rises / starts proportionally ; slight upward curve / increase in gradient AW	1 1	
(ii)	method (such as Δ or gradient = 0.23 mV / 40°C) ; evaluation = 5.8 ± 0.3 (μV / °C)	1 1	Accept 6 μV / °C
(bi)	e.g. $V = \varepsilon - \varepsilon \{r / (R+r)\}$; $V = \varepsilon(R+r - r) / (R+r) = \ldots$	2	1st mark for valid subn V = IR route scores 1
(ii)	V = ε {10 / 10.2} ; = 0.98 (ε)	2	
(c)	any **two** reasons for moving coil or against the other instruments: e.g. gives a measurable deflection (65 mm) / meter resistance only affects emf by 2% / c.r.o. deflection too small (0.7 mm) / DVM is overloaded with 700 μV	2 10	NOT low resistance NOT more or most sensitive
9(ai)	sampling ; levels ; further quality e.g. binary levels labelled 000 to 111 / quantisation errors indicated / regular sampling	2 1	credit annotated diagram / description or 1/2/3 style
(ii)	(2^{10}) = 1024	1	accept 1023
(iii)	resolution = p.d. / intervals / = 9 / 1023 m ; = 8.8 mV e	2	accept 1024/ ecf (ii)
(b)	4 sensors x (10/8) bytes x (4 x 24 x 30) samples m ; 14.(4) kbytes e / accept 115200 bits	1 1	method in words / numbers
(c)	$t = Q / I$ / = 500 / 0.02 m ; = 25000 s e ; = 25000/(60x60) hrs = 6.9 hrs / 0.29 days e	1 2 11	ora 30 d ≈ 2.6 x 10^6 s ora Q = 51840 C scores 3 marks
10ai)	**F** where rays parallel to principal axis meet	1	if principal focus OK
(ii)	rays cross over at **F** or better	1	
(bi)	straight line through points by eye	1	
(ii)	intercept = 0.1 (m)	1	allow ± 0.01 (m)
(iii)	it is the closest to the lens a real image can be formed / object at ∞ / 1/v = 1/f / incoming waves zero curvature	1	AW NOT h = 0 NOT $v = f$
(ci)	= 1/ -0.2 (= - 5.0 D)	1	
(ii)	1/v = 1/u + P = 5 / 1/v = -5 + 10 = (+) 5 ; ∴ v = 1/5 = 0.20 m e	1 1	method in words or number
(iii)	v = u / (magnification =) v /u = 1 / object at 2f	1 9	
	Total section B	40	

	Section C		
11ai)	image e.g. the planet Jupiter		NO mark for example
(ii)	**two** kinds of information identified e.g. Giant red spot in Jupiter's atmosphere ; bands of coloured gases in the atmosphere **two** explanations of usefulness e.g. study of the large cyclone enables planetary atmospheric modelling to be tested ; study of light spectra enables deduction of composition of Jupiter's atmosphere	1 1 1 1	allow one mark for two weak / similar responses allow one mark for two weak / similar explanations
(b)	1/2/3 style according to quality of answer e.g. Hubble space telescope uses a large concave reflecting mirror to gather reflected sunlight from Jupiter and its moons. Mirror focuses image onto a CCD camera that records colour pixel values forming the image.	3	full marks available for: well annotated diagrams of imaging system / good descriptions only
(c)	image processing technique identified e.g. contrast enhancement ; description of process e.g. range of pixel values used can be stretched ; improvement clear e.g. to make bright colours brighter and dark colours darker so that features are clearer	1 1 1	use 1/2/3 style marking if students answers don't fit this model
(d)	sensible estimate of number of pixels e.g. 2 Megapixels sensible estimate of number of bits / pixel e.g. = 24 bits combination for amount of information e.g. = 2 M x 24 = 48 Mbits / 6Mbytes	1 1 1 13	evidence in numbers (for colour pixels) not essential accept bits or bytes plausible value without method scores 1
12a)	material chosen e.g. silicon details e.g. used in the manufacture of microprocessor chips in the form of an integrated circuit containing millions of discrete electrical components	1 1 1	vague or unqualified references e.g. 'in electronics' max 1 mark
(b)	physical property identified e.g. semiconduction explanation of importance e.g. doped areas can be used to construct diodes / transistors to build circuits	1 1 1	must be relevant ' easy ' mark ' quality ' mark
(c)	scale of structural diagram correct 1/2/3 style tetrahedral / "diamond" structure / each Si atom having four bonds in 3-d ; bonds formed by shared pair of electrons a few of which are free to move through the crystal and conduct a current ; the low density of free electrons compared to a typical metal gives a much lower conductivity	1 1 1 1	UP full marks available for a well annotated diagram
(di)	second physical property e.g. doped Silicon junctions can emit light when excited electrically	1	
(ii)	application e.g. light emitting diode explanation: as a low power warning light for battery circuits	1 1 13	' easy ' mark ' quality ' mark
	QoWC	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.

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1 (a)	A ✓	1	
(b)	C ✓	1	
2	B ✓	1	
3 (a)	20 ✓ (m s^{-1})	1	
(b)	0.5 ✓ (s)	1	
(c)	(20 x 0.5) + ($^1/_2$ x 20 x 3.5) ✓ = 45 ✓ (m)	2	45 m ✓✓
4 (a)	energy (= 6.6 x 10^{-34} x 3.2 x 10^{14}) = 2.1 x 10^{-19} ✓ (J)	1	2 or 3 **s.f** only
(b)	(1.0 x 10^{-7})/(2.1 x 10^{-19}) ✓ = 4.8 x 10^{11} ✓ **ecf** from (a)	2	
5	s = $^1/_2at^2$ t^2 = (2 x 0.15)/9.8 ✓✓ t = 0.18 s ✓ g = 10 gives 0.17 s	3	using t = 0.2 s to find s = 0.196 m ✓✓ then explained ✓
6(a)	F = 10 000 x 3.1 ✓ = 31 000 ✓ (N)	2	
(b)	weight = 75 000 – 31 000 = 44 000 (N) ✓	1	
(c)	g = 44 000 / 10 000 = 4.4 ✓ (N kg^{-1}) ecf from (b)	1	no ecf if g = 9.8 N kg^{-1} assumed in (b)
7	test proposed k = y/x^2 ✓ carried out on all data ✓ conclusion based on test ✓ (lack of clarity will be penalised)	3	test can be implicit in working internal consistency✓✓
	Section A total	**20**	

Qn	Expected Answers	Marks	Additional guidance
8 (a)(i)	$v^2 = 2gh$ approach $v^2 = 2.\ 9.8.\ 169$ ✓ v = 57.6✓ (m s^{-1})	2	
(ii)	resistive force idea ….. ✓	1	air(wind) resistance/ drag/drag force/friction/energy loss ✓
(b)	v = 100/2.12 ✓ = 47.2 m s^{-1} ✓	2	47.2 ✓✓
(c)(i)	weight = 72 x 9.8 = 706 N ✓	1	accept 720 N
(ii)	706 sin 15° ✓ = 182.7 N ✓ **ecf** from (c)(i) (720 sin 15° = 186.3 N)	2	
(iii)	balanced forces idea (resultant force = zero) ✓	1	argued in terms of forces
	total	**9**	
9 (a)(i)	symmetrical about central max central maximum is brightest intensity decreases with 'order' maxima are equi-spaced peaks narrower than spacing ✓✓	2	maximum 2
(ii)	A: constructive interference (or waves add) …. waves superimpose IN PHASE ✓ B: destructive interference (or waves cancel) … waves in ANTIPHASE (out of) ✓ (for just constructive and destructive interference ✓)	2	pd is a whole number of λ pd is an odd number of half wavelengths
(b)(i)	1 / 80 000 or $(1 \times 10^{-3})/80$ ✓ ($= 1.25 \times 10^{-5}$)	1	
(ii)	tan θ = 0.06 / 1.2 ✓ θ = 2.86 ° ✓	2	for **sin** θ = 0.06/1.2 $\mathbf{x_m}$ = 2.87 $✓_e$
(iii)	$\lambda = 1.25 \times 10^{-5} \times \sin 3°$ ✓ = 6.5×10^{-7} <u>**m**</u> ✓ **[UP]** (2.86° gives 6.2×10^{-7})	2	λ = d sin θ or λ = xd/D
(c)	More lines mm^{-1} ✓ larger spacing to measure ✓ or move screen further … smaller % error in distances measure to higher order … smaller % error in distances	2	sensible change ✓ justified ✓
	total	**11**	

Qn	level	Expected Answers	Marks	Additional guidance
10 (a)	E/U B	N/kg x kg/m^3 x m^2 = N m^{-1} ✓ (beware fudge) J = N m so N = J m^{-1} etc ✓	2	Stages must be **shown** clearly
(b)(i)	E/U	0.9 m ✓	1	
(ii)	E/U	½ x 9.8 x 1030 x (0.9)^2 ✓ = 4089 ✓ (J m^{-2}) ~ 4100 **ecf** from (b)(i)	2	
(iii)	D B	4089 x 12 ✓ = 49 068 ✓ (W) (ecf from (b)(ii) ✓$_m$ x$_e$)	2	
(iv)	E/U E	49 068 x 500 ✓ = 24 534 000 = 25 MW ✓ **ecf**	2	
(v)	E/U	lots of damage/erosion / for conversion to electrical power ✓	1	
		total	**10**	
11 (a)	E/U C A	increases and decreases ✓ 16% mentioned ✓ cyclic/repeating / no sign of dying out ✓	3	varies between 16% and 0% ✓✓
(b)(i)	E/U D B	for x: rpa = 4 ✓ for y: rpa = (4 + 4)^{½} ✓ = 2.8 ✓ (scale drawing tolerance 2.6 to 3.0)	3	for missing scale factor 2 marks max
(ii)	C A	prob related to (amplitude)^2 idea ✓ 16 for x, 8 for y ✓	2	4 for x, 2 for y ✓ (ecf) from (b)(i)
(iii)	C A	Phasors antiphase ✓ so prob (or RPA) is zero ✓ (quantum explanation only)	2	'<u>photons</u>' are out of phase (no marks)
		total	**10**	
		Section B total	**40**	

Qn	level	Expected Answers	Marks	Additional guidance
12 (a)(i)	E/U	distance measurement stated ✓	1	
(ii)	E	correct order of magnitude for distance with unit ✓	1	
(b)(i)	E/U E D A	diagram is essentially correct ✓✓✓ diagram is satisfactory, but some errors/omissions ✓✓ some attempt has been made ✓ ……… + important equipment labelled ✓	4	
(ii)	E/U E D	description is essentially correct ✓✓✓ description is satisfactory, but some errors/omissions ✓✓ some attempt has been made ✓	3	
(c)(i)	E B A	method is essentially correct ✓✓✓ method is satisfactory, but some errors/omissions ✓✓ some attempt has been made ✓	3	
(ii)	B	factor limiting accuracy in this measurement ✓	1	
		total	**13**	
13 (a)	E/U	standing wave example stated ✓	1	
(b)	E/U D C A	diagram is essentially correct ✓✓✓ diagram is satisfactory, but some errors/omissions ✓✓ some attempt has been made ✓ ……… labelled ✓	4	
(c)	E B	description sufficient to execute ✓✓ description satisfactory, but some errors/omissions ✓	2	e.g blow across top of pipe until loud sound ..
(d) (i)	E D	fundamental standing wave (for situation described) ✓ **N** and **A** in appropriate places on standing wave shown✓	2	any representation accepted
(ii)	B A	2 progressive waves superposing idea ✓ **A** and **N** explained ✓	2	
(e)	A E	harmonic shown (ecf from (c)(i)) ✓ higher frequency ✓ must refer to **same** physical situation (e.g. **closed** pipe)	2	
		total	**13**	
		Quality of Written Communication	**4**	
		Section C total	**30**	

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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.
- 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.
- Quality of written communication will be assessed where there are opportunities to write extended prose.

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

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Qn	Expected Answers	Marks	Additional guidance
1	Force, spring or stiffness constant ✓ Energy stored or work done or strain energy ✓	1 1	 Not just 'energy' or p.e.
2	B ✓	1	
3a	1200 x 1.4 x 10^{-23} ✓ = 1.7 x 10^{-20} J	1	Can use 3/2 kT to give 2.5 x 10^{-20}J
b	9 x 10^{-20}/1.7 x 10^{-20} = 5.3 ✓	1	5.4 if 1.68 x 10^{-20} J used 3.6 if 2.5 x 10^{-20}J used.. 4.5 if 2.0 x 10^{-20}J used.
c	f = $e^{-5.3}$ ✓ = 5 x 10^{-3}✓	2	carry forward answer to (b) Common answer is 0.01 if 2.0 x 10^{-20}J used
4a	pV = nRT ✓so n = pV/RT = 4.5 x 10^5 x 8 x 10^{-4}/8.31 x 293 ✓ = 0.148 mol	2	Must give own value of answer if working not clear. Evaluation only is worth one mark.
b	4.5 x 10^5/293 = 4.6 x 10^5/ T_2 ✓ = 300 K ✓ (295 for 0.15) 295 if using pV = nRT	2	Can use alternative methods. ECF
5a	velocity tangential to path ✓	1	Doesn't have to be clockwise!
b	force acting towards Sun ✓	1	
6a	mv - (- mv) = 2 mv or in words ✓	1	
b	V = $\frac{0.0051}{(2 \times 5.0 \times 10^{-4})}$ ✓ = 5.1 m s^{-1}	1	Own value or clear method
c	Area under line less for damaged pea ✓	1	
7a	wavelength has 'stretched'✓ with the expansion of space✓ AW	2	
b	Small temperature variation/almost uniform temp AW ✓ Link between current background and past temp/density✓ AW	2	

Qn	Expected Answers	Marks	Additional guidance
8a	volume = $\pi r^2h = \pi \times 13^2 \times 1.6 = 850\ m^3$ ✓ mass = density x volume = 1000 x 850= ✓ 8.5×10^5 kg	2	Must show working clearly if own value not given.
b	Q = $8.5 \times 10^5 \times 4200 \times 21$✓ = 7.5×10^{10} J ✓	2	
c	Rate of fall in degrees per sec= 90 000/(8.5×10^5 x 4200) ✓ = 2.5×10^{-5} rate of fall in degrees per hour = x 3600 ✓ = 0.09	2	Many acceptable routes to answer.
d	k = 0.09/19 ✓ = 4.7×10^{-3} ✓ If 0.1 used: 0.0053	2	If per second 1.3×10^{-6} one mark
e	Temperature difference will reduce during the 24 hour period ✓	1	Allow implicit
f	e.g. lower air temperature, effect of cloud cover, decreased humidity, wind, snow… ✓✓	2	
9a (I)	Q = I t argument ✓/ dimensions argument	1	
a(ii)	Counting squares ✓gives answer in range 2.5 – 3.5 mC✓	2	Other methods acceptable
a(iii)	C =Q/V = 2.8×10^{-3}/6✓ = 4.7×10^{-4} ✓F✓ 5×10^{-4} F if paper value used. (If 1/3 used for RC proportion answer is 5.5×10^{-4} F)	3	μF fine. Other methods acceptable
b	E = ½ Q V = ½ x 2.8×10^{-3} x 6 ✓= 8.4×10^{-3} J ✓ (ecf)	2	Other methods acceptable.
c	y intercept 0.3 mA ✓ time constant✓ shallower curve✓ (valid method)	3	0.11 mA at 10 s or 0.15 at 7 s. accept displaced curve.
10a	r = $6.4 \times 10^6 + 4 \times 10^5 = 6.8 \times 10^6$ m ✓	1	
b (i)	Gmm/r✓ = $-6.7 \times 10^{-11} \times 6.0 \times 10^{24} \times 9.5 \times 10^4 / 6.8 \times 10^6$✓ = (-) 5.6×10^{12}	2	Formula can be implicit. Evaluation only is worth one mark.
b (ii)	½ m v^2 = ½ x $9.5 \times 10^4 \times 7700^2$ ✓ = 2.8×10^{12} ✓	2	
b (iii)	- 2.8×10^{12} or - 3.2×10^{12} ✓	1	e.c.f. with b (i) as –ve
c	Gpe becomes more negative ✓ and (some of) this gpe is transferred to ke✓ AW	2	accept decreases
d (i)	Particles bounce off shield, (rate of) change of momentum ✓ gives decelerating force. Or clear Newton 3 argument. (kinetic) energy transformed into thermal energy, ✓ increasing particle vibrations and raising the temperature of shield. ✓	3	One mark for first bullet. One for energy transform from atmosphere to SHIELD. One mark for link to microscopic effect in heat shield. NB this question is more complex than it looks – the shuttle loses translational ke as the heat shields gains vibrational energy.
d (ii)	E/K = $1 \times 10^{-19}/1.4 \times 10^{-23}$ ✓= 7×10^3 K✓	2	

Qn	Expected Answers	Marks	Additional guidance
11a i	period =1/2500 = 4 x 10^{-4} s ✓	1	
a (ii)	Period ✓ amplitude ✓shape ✓	3	Shape includes phase (sin or –sin) ecf from a i
a (iii)	$a = 4\pi^2 f^2 A = 4\pi^2$ x 2500^2 x 1 x 10^{-7} ✓= 24.7 m s^{-2} ✓	2	
b	F = PA = 4 x 10^{-5} x 20 x 10^{-6}✓ = 8 x 10^{-10} N ✓	2	8 x 10^{-7} N worth one mark
c (i)	Large amplitude at specific frequency ✓due to matching with driving frequency ✓AW	2	Must have external driver / forced for second mark
(ii)	Amplitude of oscillations (of drum) at this frequency will be larger than at other frequencies✓ AW	1	Look at both parts of question.

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- 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.
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- 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.
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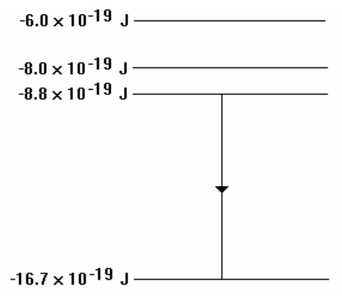
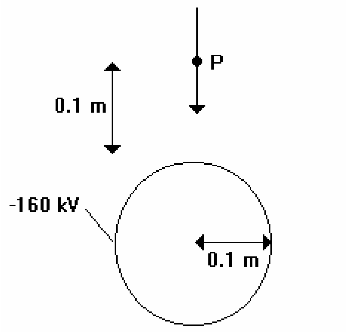
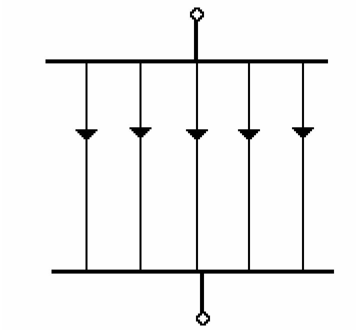
NOT	= answers which are not worthy of credit
( )	= words which are not essential to gain credit
___	= (underlining) key words which **must** be used to gain credit
ecf	= error carried forward
ora	= or reverse argument
eor	= evidence of rule

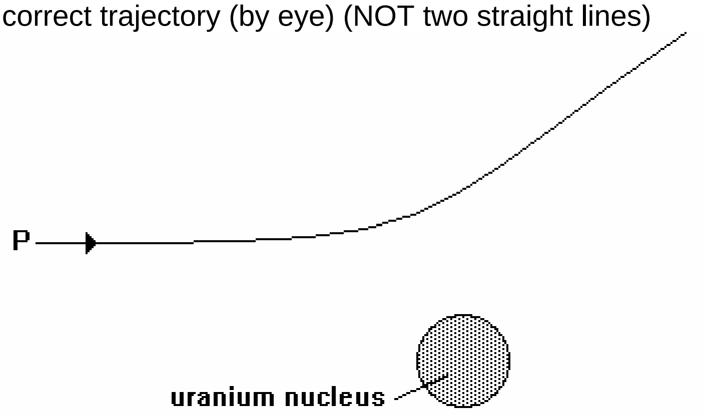
Question	Expected Answer	Mark
1 (a)	In any order: uud ACCEPT +2/3e, +2/3e, -1/3e	1
(b)	In any order: udd ACCEPT +2/3e, -1/3e, -1/3e	1
2	mass change = 3.00160 - 2.00141 - 1.00867 = -0.00848 ecf incorrect u: m = 0.00848 $\times$ 1.7$\times$10^{-27} = 1.44$\times$10^{-29} kg ecf incorrect m: E (= mc^2) = 1.44$\times$10^{-29} $\times$ (3$\times$10^8)^2 = <u>1.3$\times$10^{-12}</u> J ACCEPT reverse calculation	1 1 1
3 (a)	$E = hf$ = 6.6$\times$10^{-34} $\times$ 1.2$\times$10^{15} = <u>7.9</u>$\times$10^{-19} J	1
(b)	ignore direction of arrow 	1
(c)	A	1

Question	Expected Answer	Mark
4 (a)	vertical	1
	downwards	1
		
(b)	-80 kV	1
(c)	At right angles to field arrow	1
	Complete circle through P centred on sphere	1
	(IGNORE arrows on equipotential)	
5 (a)	5 cm = 5×10^{-2} m, 25 mT = 25×10^{-3} T	1
	ecf incorrect conversion:	
	$F = IlB = 2.0 \times 5\times10^{-2} \times 25\times10^{-3} = 2.5\times10^{-3}$ N	1
(b)	C	1
6 (a)	B	1
(b)	A	1
(c)	C	1
7	C	1
		[20]

Question	Expected Answer	Mark
8 (a)	five evenly spaced parallel lines at right angles to electrodes	1
	(accept correct end effects)	
	arrow on each pointing downwards	1
		
(b) (i)	$F = qE$ (wtte)	1
	$E = F/q = 7.0\times10^{-13} / 3.2\times10^{-19}$ C = $\underline{2.2}\times10^{6}$ N C^{-1}	1
(b) (ii)	$E = V/d$ (eor)	1
	$V = Ed = 2.2\times10^{6} \times 3.0\times10^{-3} = 6.6\times10^{3}$ V	1
	ACCEPT 6×10^{3} V for 2×10^{6} N C^{-1}	
(c) (i)	90° (wtte)	1
	90° (wtte)	1
(c) (ii)	$F = Bqv$	0
	rearrangement: $v = F/Bq = 7.0\times10^{-13} / 0.13 \times 3.2\times10^{-19}$	1
	$v = 1.7\times10^{7}$ m s^{-1}	1
(d)	any of the following, maximum [2]	2
	• particles are moving faster	
	• so magnetic deflection force is increased	
	• but electric force stays the same	
	• and is no longer balanced by electric force	**[12]**

Question	Expected Answer	Mark
9 (a) (i)	${}^{131}_{53}\text{I} \rightarrow {}^{131}_{54}\text{Xe} + {}^{0}_{-1}\text{e} + {}^{0}_{0}\bar{\nu}$	
	nucleon number correct	1
	proton number correct	1
(a) (ii)	antineutrino	1
(b) (i)	$\lambda T_{1/2} = 0.69$	0
	rearrangement and substitution: $\lambda = 0.69 / 8.1 \times 86\,400$	1
	$\lambda = \underline{9.9}\times10^{-7}\ \text{s}^{-1}$	1
	ACCEPT reverse calculation	
(c) (i)	$A = \lambda N$	0
	rearrangement: $N = A / \lambda$ (NOT eor)	1
	substitution: $N = 2.5\times10^{5} / 9.9\times10^{-7}$ (= 2.5×10^{11})	1
	ACCEPT reverse argument	
(c) (ii)	beta particle energy = $0.81\times10^{6} \times 1.6\times10^{-19} = 1.30\times10^{-13}$ J	1
	ecf incorrect energy:	
	dose equivalent = $1.30\times10^{-13} \times 2.5\times10^{11} / 0.06 = \underline{0.54}$ Sv	1
(c) (iii)	3% Sv^{-1} means 0.033 Sv for 0.1%	1
	0.54 Sv requires 2.5×10^{11} nuclei	
	so 0.033 Sv requires $2.5\times10^{11} \times 0.033 / 0.54 = 1.5\times10^{10}$ nuclei	1
	(0.5 Sv gives 1.65×10^{10})	
(d)	any of the following, maximum [2]	2
	• 0.81 MeV is the maximum energy of the beta particles (wtte)	
	• not all beta particles will be absorbed by thyroid (wtte)	
	• iodine-131 may be flushed out before it all decays (wtte)	
		[13]

Question	Grade	Expected Answer	Mark
10 (a)	U	flux lines stay within iron	1
	U	two complete and separate loops which do not overlap	1
		IGNORE breaks where loops cross coils)	
(b)	E	correct shape (sinusoidal) and period (by eye), any constant amplitude	1
	C	correct phase (90° ahead or behind)	
			1
(c)		$V_p = N_p \frac{d\Phi}{dt}, \quad V_s = N_s \frac{d\Phi}{dt}$ (wtte)	
	B	$\frac{d\Phi}{dt} = \frac{V_p}{N_s} = \frac{V_s}{N_s}$ (wtte)	1
	A		1
(d) (i)	C	any of the following, maximum [2]	2
	B	• changes of flux/field in the core	
		• set up emf across core	
		• causing current to flow	
		• creating flux/field in core	
		• which opposes original change of flux / statement of Lenz's Law	
		NEUTRAL: reduces the flux	
(d) (ii)	C	laminate the core / thin sheets of iron stuck together (wtte)	1
	B	to raise resistance / add insulating layers / alter path of eddy current	1
			[10]

Question	Grade	Expected Answer	Mark
11 (a)	D	$eV = 0.5mv^2$	1
	E	$V = 0.5 \times 1.66\times10^{-27} \times (1.5\times10^7)^2 / 1.6\times10^{-19}$	1
		$V = 1.2\times10^6$ V	1
(b) (i)	D	correct trajectory (by eye) (NOT two straight lines) 	1
(b) (ii)	U E	any of the following, maximum [2] • nucleus has positive charge • so repels protons • proton gains momentum at right angles to its initial momentum • phasors from all paths add up to a maximum value (wtte)	2
(c) (i)	A A	any of the following, maximum [2] • as the protons move faster • they spend less time being deflected/accelerated • so acquire smaller change of velocity • so are scattered through smaller angle / deflected less	2
(c) (ii)	B	$kQq/d = E_k$	1
	C	$d = 9\times10^9 \times 92 \times 1 \times (1.6\times10^{-19})^2 / 5\times10^6 \times 1.6\times10^{-19}$	
		$d = 2.6\times10^{-14}$ m	1
(c) (iii)	A	some protons can enter the nucleus and induce fission / decay (wtte)	1
			[11]

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.

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.

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)	Regular✓ three-dimensional ✓ Arrangement of atoms/ions/molecules✓	2	Any two points. A sketch will suffice
(b)	Rigid/directional bonds prevent movement ✓ brittle because atoms cannot readily move ✓ grain boundaries in material ✓ Can crack along grain boundaries ✓	2	Any two valid points.
(c)	Conductivity/resistivity midway on scale between conductors and insulators ✓ Does conduct, but less well than e.g. metals ✓ Can refer to mechanisms, e.g. Conduction due to available mobile charges ✓ Relate number of mobile charges to conductors / insulators ✓	2	Any two valid points.
(d)	Not one continuous atomic lattice/ grain boundaries ✓ Grain boundaries/crystallite edges prevent free conduction/regular electrical behaviour✓ behaviour of single crystal more consistent in e.g. doping ✓ single crystal more regular than separate grains ✓	2	Any two valid points. Any reasonable suggestion can gain credit, eg. diffusion of foreign atoms at boundaries
		8	
2 (a)	(i) melting point too low ✓ (ii) too poor a conductor ✓	2	
(b)	(i) a.c produces (alternating) flux in crucible ✓ alternating flux induces emf in crucible which then produces a current. ✓/ By analogy with transformer: 7-turn coil is primary ✓ crucible is secondary ✓	2	Any two points
(c)	(i) $B = \mu_0 \frac{NI}{L}$ = 1.3×10^{-6} ×7×1100/0.4 = 0.025 T≈ 0.02 T ✓ s ✓ e	2	Using 4π × 10^{-7} gives 0.024 T
	(ii) $\phi = BA$ = 0.02×0.2 = 0.004 Wb ≈ 5 x 10^{-3} Wb ✓	1	Can use 0.025 T or 0.024 T
	(iii) T = 1/10000 = 1×10^{-4} s so Δt = 0.25×10^{-4} s✓ and $\Delta\phi/\Delta t$= 5 x 10^{-3} Wb/0.25×10^{-4} s = 200 V ✓m✓e Can use $\varepsilon = (2\pi f)\phi_{max}$ ✓m followed by ✓s and ✓e	3	Ecf from (ii) and within (iii) possible. Could calculate maximum value (250 V) assuming sunusoidal.
		10	

Qn	Expected Answers	Marks	Additional guidance
3 (a)	'Hump' shape ✓ with subsidiary maxima ✓	2	
(b)	Smaller wavelength ✓ so diffracts less (as $\theta \approx \lambda/d$)✓	2	
(c)	(i)$E=eV$ ✓m=1.6×10^{-19}×3000 (=4.8×10^{-16}J) ≈ 5×10^{-16}J ✓e (ii) 3 × 10^{7} m s^{-1}✓ Least accurate datum has 1 sig fig ✓ allow one ✓ if 2 sf justified by reference to *e* and m_e (iii) $p=mv$=9.1 × 10^{-31} × 3.3×10^{7} = 3.0× 10^{-23} kg m s^{-1}✓ (iv) $\lambda=h/p$=6.6×10^{-34}/3× 10^{-23} = 2.2×10^{-11}m ✓ This very much smaller than the gap so diffracts very little ✓ / λ much smaller than for UV/visible ✓	2 2 1 2	
		11	
4 (a)	(i) BF is a fraction/ratio/proportion so no units ✓ (ii) BF = exp(-5.92×10^{-19}/{1.38×10^{-23}×1300}) = 4.66×10^{-15}✓ <u>comparison with graph</u> (about 4.7×10^{-15}) ✓ (iii) BF is proportion of atoms diffusing ✓ BF very small so few atoms diffuse ✓	1 2 2	Accept dimensionless nature of argument of exponential. Reward also increased atomic speed
(b)	BF is greater ✓ / more atoms have sufficient energy ✓ Greatest proportion move, so diffusion is as fast as possible✓	2	Increased speed also gains credit.
		7	

Qn	Expected Answers	Marks	Additional guidance
5 (a)	Constant increase in time ✓ produces a constant ratio/proportion of number of transistors ✓	2	Can compare doubling time with e.g. radioactive decay or bacterial growth, etc.
(b)	Straight log(-linear)graph ✓/constant ratio in equal time✓	1	Can use actual values e.g. 10× increase every 7 years ✓
(c)	(i) 7.3×10^3 (>7k, <8k) ✓ and 7×10^6 ✓ (ii) 20 years is 10 doubling times✓ ×2 every 2 years and so $\times(2^{10}) = \times1024$ ✓ which (roughly) agrees with data ✓	2 3	Can do arithmetically
(d)	(i) In 20 years, reduced by $(0.89)^{20} = 0.097 \approx 0.1$ which would be ten times smaller ✓m✓e (ii) area = $(0.35 \times 10^{-6}\ \text{m})^2 \times 1\times10^9$ $= 1.2 \times 10^{-4}\ \text{m}^2 < 1.6 \times 10^{-4}\ \text{m}^2$✓m✓e (iii) Number of transistors/unit area=7×10^6 ✓ 7×10^6 <1% of 10^9✓	2 2 2	Can work back from 0.25 μm in year 2000. ora
		14	
6 (a)	$C = \varepsilon_r \varepsilon_0 \dfrac{A}{d}$ $= 2.4 \times 8.9 \times 10^{-12} \times (0.8 \times10^{-6} \times 10 \times 10^{-3})/ 0.5 \times10^{-6}$ $= 3.42 \times 10^{-13}$ F $\approx 3 \times 10^{-13}$ F ✓m✓e	2	
(b)	$\tau = RC = 900 \times 3 \times 10^{-13} = 2.7 \times 10^{-10}$ s $\approx 3 \times 10^{-10}$ s ✓m✓e	2	3.42×10^{-13} F gives 3.08×10^{-10} s
(c)	Graph rises to 5 V ✓ convex curve ✓ with smoothly decreasing gradient ✓ takes between 3τ & 7τ ✓	4	
		8	

7 (a)	(i) $v = f\lambda$ (any form) ✓ (ii) radio anywhere below microwave ✓ light between 3×10^{-7} m and 3×10^{-4} m ✓	1 2	
(b)	(i)One ✓ for each type of radiation <u>with information to be gathered</u>, e.g. IR:- crop use/cloud positions; visible:- cloud positions/troop movements; microwave/radio, radar information about topography/g variations (ii) low altitude: closer so better resolution/ stronger signal ✓ high altitude: greater coverage/less rapid movement of satellite so less blurred image ✓.	2 2	Any reasonable suggestions for either part of (b) Any reasonable advantages acceptable
(c)	(i) No atmospheric distortion/uv or ir absorption/light pollution/obscuring clouds ✓ (ii) Light is red-shifted ✓ by greater amounts for more distant galaxies ✓ caused by expansion of Universe stretching light in transit ✓ light from further galaxies longer in transit so stretched more ✓ (any 3 points) (iii) Inverse square (stated or implied)✓ 7 × further ⇒ 7^2 × less intense = 49 × less intense ≈ 50 fainter as stated ✓m✓e Condition: similar luminosities/no intervening dust etc. ✓	1 3 4	Any distinct relevant point is worth a ✓
(d)	Microwave NOT radio	1	
		16	
8 (a)	(i) Method:Calculating area / counting squares ✓m Correct values ✓s ✓e (ii) $E_k = ½mv^2 = 0.5 \times 69 \times 10^2 = 3450$ J ≈ 3.5 kJ ✓m ✓e (iii) 3500 J = 69 kg × 9.8 N kg^{-1} × h h = 5.2 m ✓m✓e (iv) Idea of centre of gravity being the point which is considered to move : by turning sideways, need to get less far above the bar owtte ✓	3 2 2 1	Answer between 17 m and 25 m 3450 J gives 5.1 m The idea that it is the 'middle' of the pole vaulter that rises gets✓ Give credit for positive feedback ideas (watching bar to avoid hitting it as you cross)
(b)	(i) $\Delta p = m\Delta v = 69 \times 10 = 690 \approx 700$ kg m s^{-1} ✓m ✓e (ii) $F = \Delta p/\Delta t$ = 690 kg m s^{-1}/0.35 s =1970 N ≈ 2000 N ✓m✓e	2 2	=1970 N
		12	

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.

2860: Physics in Action (Written Examination)

General Comments

Overall the paper was of an appropriate difficulty. There were sufficient marks available to weaker candidates with ample challenges for the more able to distinguish themselves. As with the June 2004 paper, the mean mark was considerably lower than for the previous season's paper, and the standard deviation a little larger. Hence the effects of scaling to achieve the UMS marks are less dramatic, candidates having to score near to 40% of paper marks to achieve the E pass level. In past seasons a paper mark nearer to 50% was often required to achieve E pass standard when the mean mark was much higher. All the contexts for Section C have now seen the light of day on a number of occasions. Sadly, there remains a wide gap between the prepared and the unprepared. In a considerable number of Centres it seems that the students have little idea about the sort of contexts that are appropriate. Digital photo images (of trivial contexts) rarely access the higher mark ranges but they proliferate in the answers of many students. Similarly, materials questions answers such as 'glass for windows' (unless well developed) are inevitably 'capped' in the number of marks they can access. In other Centres where the candidates have thoroughly prepared themselves, the varied answers are a delight to read and score extremely well.

Comments on Individual Questions

Q No)

Section A

1 About a strength / toughness plot for different materials was an easy starter and the vast majority of candidates scored all 3 marks. The most common misconception was that cast iron under tension is tough and weak, rather than brittle and strong.

2 (a) This, as it turned out, highly topical question on a pair of images of a melting Antarctic glacier proved to be more challenging. Many candidates still erroneously consider resolution to be an area-based concept, although the units of m per pixel were given in the answer line.

(b) Most candidates got this correct by comparing the distance moved during the two week interval between photographs with the marker arrow of 40 km, and not using ideas of resolution.

(c) This part was far more accessible and many could offer a suitable 'physics connects' context. A weaker answer that was not credited e.g. was "the glacier has moved" or "could become an unspecified hazard."

3 (a) Most candidates correctly identified the cross-sectional area (actually on their data sheets), only a few were incorrect with "surface area" and a very few who just put "area".

(b) This was a better discriminator, but many candidates gained both marks. The most common error was to expect conductance to **increase** when the radius of the wire is halved.

4 (a) Most correctly identified the class of semi-conductors, between metals and insulators, but a minority misunderstood the question and gave answers like "ceramics", "plastics", or "semi-metals."

(b) About half of candidates got the reciprocal calculation for resistivity correct, but surprisingly few got the correct units. The most common errors included Ωm^{-1}, Sm, Ω and the use of the value 10^5 for conductivity. This was despite the units for conductivity being given in the question and data of Fig. 4.1.

5 (a) Vague responses cost many marks here. It is apparent that many candidates misinterpreted either or both axes, the most common error here was to refer to the frequency axis as a time axis. Leading to answers such as the "aaa" sound dies away earlier or quicker. Also the use of 'higher' led to much ambiguity about higher pitch and / or a 'taller' peak.

(b) This part asked them to sketch a component waveform at four times the fundamental frequency. It discriminated well - many candidates do not take sufficient care over such drawing questions to give themselves a chance of obtaining the available marks. Precision and care are required. Here there were separate marks for the correct amplitude and frequency.

6 (a) It became disappointingly apparent during marking that the topic of combining resistors is not well understood. Few candidates were able to obtain the correct value for the resistance of the combination of 150 Ω. Many gained some method credit for attempting to resolve the parallel combination and adding this to the 100 Ω in series.

(b) Reassuringly, many were able to achieve a mark by ecf for the correct use of $I = V / R$. Although weaker candidates tried using power formulae such as $P = I V = I^2 R$.

Section B

7 This question on the mechanical properties of spider silk was well answered, many candidates gaining all of the first 7 marks.

(a) Most candidates got the two properties elastic and tough. The most common errors were plastic and hard.

(b) Several candidates tried to calculate area = stress / tension and got a ridiculously large area – clearly not checking the magnitude of their answers. Others realised they had the inverse of the correct answer and managed to recover without penalty.

(c)(i) This was generally well answered, although some candidates confused elastic limit with the breaking point.

(ii) In the calculation for Young's Modulus, nearly all got the method mark, the most common error was to write down the answer to 7 or 8 SF, which was penalised.

(d) This was intentionally discriminating, but there were many pleasing well-illustrated answers, the best including reference to single bond rotations allowing coiled polymer molecules to uncoil and straighten under stress. Weaker candidates described metallic type, or other inappropriate structures.

8 This proved to be very challenging all round, resulting in a low mean mark on this question, although it was designed to test skills and knowledge in instrumentation selection, which are required for the coursework sensing project.

(a)(i) Most candidates got the first easy mark for noticing the increase in emf with temperature, but many omitted describing the upwards curve from the straight line proportional behaviour at the start.

(ii) Many candidates calculated a correct gradient, (although some triangles were very small) getting the method mark, but missed the mV units of the graph and / or the μV units in the answer line.

The sensitivity concept was too hard for many weak candidates who multiplied numbers from the graph, again despite the units having been given on the answer line.

(b)(i) This was poorly answered – students clearly had difficulty with the algebraic manipulation, although many good candidates were able to gain one mark for starting the substitution, or by the simple substitution of $V = I R$, which made some sense, and was credited. Very few seemed to recognise the situation as being the same as a potential divider, with the emf of the active sensor being divided up by the internal and external resistances.

(ii) Many took the equation from bi) and put in the values showing that $V = 0.98\ \varepsilon$ as required.

(c) Very few candidates gained these subtle and difficult marks. Most went for the "obvious" but incorrect responses: that the moving coil meter has the lowest resistance (good voltmeters need high resistance compared to that which they are measuring across); and has the best sensitivity (not true). A few sharp candidates saw the link back to bii) and realised that the error introduced by the meter would only be an acceptable 2% (its low resistance is still much higher than the very low resistance of the active sensor). Sadly the question paper did not provide sufficient space for the level of answers required by the mark scheme.

9 There was a mixed response to this question – clearly some centres were much better prepared than others, and it appeared that some had not covered the topic of analogue to digital conversion.

(a) Many candidates described regular sampling to some degree and scored 2 / 3 marks available. The most common error was to miss out the idea of discrete levels / quantisation for p.d. There were some excellent answers here involving sampling at, at least double the highest frequency present in the waveform. Also some very clearly annotated diagrams pleasingly gained maximum credit.

(b) Many candidates scored full marks, showing that the memory capacity required for the data logger was about 14.4 kbytes. There was a variety of incorrect responses, many missed the four sensors, or incorrectly multiplied by 15 for the time in minutes between samples. Others confused bits and bytes, once two separate errors had occurred both marks for the question had been lost.

(c) Many candidates scored full marks; using the equation $Q = I\ t$ any of the 3 ways round. An encouraging fraction scored well throughout especially in the challenging calculations. Candidates who did not understand the question tried to use their answer from (b) inappropriately, or used other electrical formulae for energy or power incorrectly.

10 This offered a novel context for a lens question, considering the image height, it was reasonably well received but, the parts calling for 'explanation' often elicited weak or ill-considered responses. Problems with the Cartesian sign convention are also still prevalent.

(a)(i) Most candidates could label the focal point, although some labelled the centre of the lens or the centre of the image on the screen, a few missed the instruction altogether.

(ii) Interpreting the non-standard ray diagram took some thought, weaker candidates clearly expected the image to be formed at the principal focus.

(b)(i) (ii) Plotting the line of best fit and intercept were easy marks for nearly all candidates, but some forced the line to go through the origin.

(iii) Most candidates wrote too literal an interpretation of the graph, about h = 0, rather than explain the physics of image formation for a very distant object.

(c)(i) Many forgot the minus sign for the waves from the object entering the lens and lost the mark.

(ii) Many candidates used the lens equation badly. Rather than seeing it as a statement that the lens adds curvature to the incoming waves equal to its power in dioptres, they plug in values without real understanding. Confusion with minus signs and/or f = 10, and failure to calculate the final reciprocal, lost many candidates one or both marks.

(iii) This was only well answered by strong candidates, along with centres who had emphasised that at the special object distance $u = 2f$ the magnification = 1. Or that the curvatures into and out of the lens are of equal magnitude but opposite sign, giving a symmetrical ray or wavefront diagram.

Section C

The examiners felt that a significant proportion of candidates had not been given the opportunity to prepare for this section.

11 (a) Most candidates managed to describe some useful information obtained from an image of their choice. However, there were a few who did not understand the gist of the question and described digital photos having colour pixels and resolution for example. Some made inappropriate choices such as a FAX or a CD image, which were clearly examples of a signalling system. There were many vague answers that gave two types of information that clearly could not be gained from **an** image – e.g. depth of ocean and sex of baby.

(b) The quality of answer in here depended largely on the type of image chosen, although diagrams tend to be too small and poorly labelled.

(c) Most candidates scored a couple of marks discussing image processing, but many answers lacked sufficient detail to secure the third quality mark, as candidates described many types of pixel modification rather than one in detail.

(d) There was some confusion amongst weaker candidates again about bits and bytes, and several tried to calculate resolution rather than the amount of information stored by the image. It seems that weaker candidates do not read the question carefully enough and try to fit their knowledge into the questions at hand.

12 The responses to this familiar type of materials coursework question were quite pleasing, with an excellent range of materials and novel applications that were interesting to mark. Only a few Centres this session had drilled all their candidates to give a standard reply, e.g. rubber for tyres or copper for wiring.

(a) Details of application were often limited to one-word answers e.g. concrete for buildings, and so clearly no third quality mark could be awarded.

(b) Most wrote well about a relevant physical property of their material, but a significant minority showed their confusion over the meanings of hard, tough, stiff and strong. Some candidates still choose to talk about ill-defined properties such as durability and put some of the marks in jeopardy.

(c) Labelled diagrams of material structures have shown little improvement since early versions of this question. The scale mark is lost by the majority, where a distance, to a sensible order of magnitude is expected. Many also ignored the caveat that the structure should help to explain the property chosen in b).

(d) The most common error was for candidates to continue to describe the same application as part a), despite clear emphasis to the contrary.

2861: Understanding Processes

General Comments

The questions proved accessible to candidates across the range of abilities. Most scripts were fully worked and candidates were able to show, and be rewarded for the physics that they had learned and understood. There were, of course, parts of questions specifically designed to test the more able and provide differentiation at the higher levels of performance. It was pleasing to see so many candidates prepared to show their reasoning clearly and to carry out calculations in a systematic and orderly manner. Generally speaking, the quality of answers in Section C was impressively good, covering an interesting range of contexts that had been studied.

Comments on Individual Questions

Section A

This section comprised 7 short questions designed to test a range of knowledge, understanding and skills. Good marks were achieved by many of the candidates and there were some candidates who gained all of the marks available. Question 1 tested candidates' ability to interpret graphical information, and proved to be quite a challenge. In part (a), graph C was thought by many to represent the relationship between kinetic energy and velocity for a tennis ball and, in part (b), graph B to represent the relation between the acceleration of objects each experiencing the same force and the mass of the object. Question 2 was well done by a majority who appreciated the rotating phasor explanation. Question 3 required information to be deduced from a graph. Parts (a) and (b) were quite straightforward and were well done, but in part (c) many were unable to successfully deduce that the stopping distance of the car was 45 m. A common mistake in question 4(a) was to quote the answer to an excessive number of significant figures, and part (b) revealed the conceptual difficulty that many candidates have in dealing with very small numbers. It was pleasing to see the confident way in which most candidates dealt with the calculation on accelerated motion in question 5, and question 6(a) provided a gentle introduction to the next part of the question. The most common error in 6(b) was to assume that g = 9.8 N kg^{-1} on the planet in the erroneous calculation weight = 10000x9.8 = 98000 N and then go on, in part (c), to find g = 98000/10000 = 9.8 N kg^{-1}. In contrast, it was good to see the competence of the majority in executing an arithmetic test on the data in question 7.

Section B

8 This question was about the physics of 'speed skiing'.

(a) In part (i) the approach using the idea of gravitational potential energy changing into kinetic energy, led to the relationship $v^2 = 2gh$ and a value for the maximum speed of 57.6 m s^{-1}. Candidates who used the equations of accelerated motion as applied to this situation were equally rewarded. Their working involved using the value g sinθ for the acceleration along the slope and 169/sinθ for the distance travelled from rest in the formula $v^2 = u^2 + 2as$.

Most candidates were successful in asserting that resistive forces meant that the actual speed achieved would be a lot less than 60 m s^{-1}, in part (ii).

(b) The average speed calculation was accessible to all but a few weak candidates.

(c) Most candidates successfully calculated the weight in part (i), but part (ii) was quite discriminating, as was the idea of balanced forces acting through the timed section in part (iii).

9 (a) It was pleasing to see so many candidates able to translate information from one form into another in their answers to part (i). In part (ii) many failed to close the argument by simply asserting that there was constructive and destructive interference. Examiners were looking for statements such as 'The intensity maximum at A is due to waves superimposing in phase, giving constructive interference'.

(b) The most commonly occurring error in part (i) was to fail to spot that 80 lines mm^{-1} needed to be converted to lines m^{-1}. But this part was generally well done. Sin θ and tan θ were confused by some in part (ii), though a simple statement that for θ small the approximation was valid would have sufficed. Most were able to use the appropriate formula in part (iii), along with the given value of θ, to calculate the wavelength.

(c) This part proved to be very difficult for most candidates. This was not so much to do with suggesting an appropriate change, because many did, but so few seem to have an appreciation of the idea of 'accuracy' in measurement. I wonder why that might be?

10 This question proved that candidates can apply their knowledge in novel situations and make sense of connections in physics.

(a) This part was found to be quite challenging by all but the most able candidates, but provided a degree of differentiation. Reasonably competent candidates were able to show that the unit could take the form N m^{-1}, but only the best candidates could link the 'N' to the 'J m^{-1}', and in so doing earn the second mark.

(b) The sequence of answers from part (i) to part (iv) demanded a degree of scientific comprehension, and the ability to apply basic ideas of physics in a relatively novel situation. It was very encouraging to see how many candidates could think their way through the argument. Part (v) produced spontaneous, yet varied responses from candidates who seemed excited by the discovery that nearly 25 MW was being delivered by the waves described.

11 (a) The ability to describe the pattern of behaviour shown in the graph was tested effectively in this part. The better candidates wrote fluently and framed their responses neatly. Others were less successful in relating the information in Fig. 11.2 to the physical situation shown in Fig. 11.1. It was not uncommon for weaker candidates to show a misunderstanding of the question.

(b) It was pleasing to see that combining phasors to obtain the resultant phasor amplitude was well understood by a majority of the candidates. However, only the better candidates seemed able to use the idea that probability is proportional to the square of the resultant phasor amplitude to show the relative probability of reflection. In part (iii) the idea that dark bands indicating that few, if any, photons were reflected there could not be accounted for in terms of phasors by many.

Section C

In this section there were two questions, each requiring candidates to choose the context in which they gave their answers. Question 12 was about a method of measuring the distance to a remote or inaccessible object. Question 13 required candidates to write about a method of producing and observing standing waves. The former was answered very well by a majority of candidates. Many diagrams were well drawn and appropriately labelled, and the descriptions of how the method worked, and how the data could be used to find the distance involved, similarly were of a pleasing standard in many cases. Once again, a majority of candidates demonstrated that they have little idea of what is meant by ‘accuracy’ in measurement. In the last question on the Paper most were able to choose an example of stationary waves (standing wave resonance) to describe, but there were those whose selected phenomenon was not one of standing waves

2862 Physics in Practice

General Comments

104 candidates presented coursework portfolios in January, this was from an original entry of 146 with many centres withdrawing all their candidates. It was very helpful that most centres met the 10th January deadline – or were very close to it. A few administrative points are worth mentioning and these are raised to help in the summer session:

- As mentioned last year, it would be helpful if Centres who do withdraw all candidates still send their MS1 forms to the Moderator, with ‘A’ clearly marked by the candidates’ name. This avoids Moderators having to telephone the Centres to confirm this. These withdrawals also suggest that a number of candidates may have had the intention of resubmitting better coursework in the Autumn Term but, for whatever reason, did not finally get round to doing the work.

- The resubmission of previous coursework gave rise to another problem in that certain Centres only sent the reworked part of the student’s portfolio and not the work that had been submitted in the Summer examination period. Centres must realise that the January unit is viewed by OCR as a totally new unit and therefore the whole coursework portfolio for any student entering this unit must be sent to the Moderator for moderation.

- If your Centre has only a small entry (10 or less) then all the work should be sent to the moderator before the deadline date along with your MS1 form and other relevant paperwork

- It is essential that a Centre Authentication form is enclosed with the work; this is the form signed by the internal assessors responsible for the course. Centres are expected to keep the student’s Authentication forms on file until the whole results process is completed.

- It would be most helpful if internal assessors checked their arithmetic on totalling the different strands on the mark forms and in calculating a candidate’s total mark. A considerable amount of Moderator’s time is taken up in sending amendment forms back to Centres because of arithmetical errors.

The work done by the students had in the large majority of cases been carefully marked by the internal assessors and in the main was helpfully annotated. Only a small proportion of Centres had to have their marks adjusted and it is clear that Centres now fully understand the requirements of the module and are providing good advice to candidates on how to maximise their performance. There are, however, some points which are worth re-iterating:

- In the Instrumentation Task there are a significant number of students who do not include a safety statement, causing a loss of marks in strand A(ii). Only very weak candidates now use direct measurements from, say, a thermocouple connected across a multimeter. The majority do place their sensor in a potential divider circuit. Also, many students do not really consider the ‘fitness for purpose’ aspect in sufficient detail i.e. actually make measurements from their graphs etc, to score well in D(ii).

- In the Material Research Task many candidates do not submit a plan of their research and presentation. This is really necessary to score well in strand A(i). However, candidates are getting much better at linking their sources to their presentation and many should be congratulated on the standard of their work. It should be emphasised to candidates that this is a Physics course and not Chemistry and they should therefore only go into great detail on the production of a material if this production is directly linked to its Physical properties.

- The Data Task is often the task that is assessed most leniently. As with last year's report there were often instances where the essential physics of the experiment had not been clearly discussed (B(ii)) and where the analysis was rather superficial (strand D). Yet the work was still rated highly. With this task, it is very helpful to moderators when centres provide the information or data about the experiment that has been given to the candidates.

The topics chosen for all three tasks tended to follow work seen in previous sessions. However, one interesting data analysis task used ultra sound to measure distance and time of a ball falling onto a hard surface and then bouncing up and down.This particular experiment could lead to several worthwhile avenues of analysis.

2863/02 Practical Investigation

General Comments

There were approximately 2500 Candidates from 200 Centres entered for the coursework component in the January session. Moderators reported an increase on previous years in the number of Centres having difficulty meeting the coursework submission deadlines.

The moderating teams have also seen a rapid rise in the number of investigations where the independence of the work is in doubt. The specification for this component states that the work should be the Candidate's own and the best way to meet this requirement is to ensure each Candidate undertakes a demonstrably different piece of work. The recently introduced Candidate and Centre Authentication forms are testament to the importance OCR places on this aspect of coursework. A Centre entering twelve Candidates with four of them investigating projectiles, three looking at friction on an inclined plane and five measuring crater impact sizes is clearly unacceptable and not within the spirit of the Advancing Physics concept. When in addition to this potential for collusion some of the reports presented are exactly the same with the same data points on the same axes with the same incorrectly labelled quantities there can only be one conclusion. The appearance of the plural "we did this.." in reports also signifies shared effort or even a whole class activity.

One of the most common reasons for a Centre's assessments being reduced and brought into line is the limited extent of the work carried out. Many Candidates wrongly assume that a simple prediction and test approach, as used in earlier years, will suffice. For example "…… if I increase the surface area of a parachute it will take longer to reach the ground when dropped from the same height". The experimental confirmation of this type of prediction could be regarded as a preliminary experiment. At A2 level the work must progress much, much further.

The higher ratings on the assessment forms should only be given to those Candidates who have used the ideas of physics to determine the direction of the work and have shown concern to explain what they have found. It is unlikely that a Candidate who presents a simple observational record with repeat readings and some variety will reach the upper quarter of the mark range. To get to that level there must also be something more than a reasonably structured piece of work with basic evaluations.

The Moderator only has the report with which to form a view of the Candidate's performance. Some Candidates have difficulty expressing themselves so it is surprising to find so many neatly word processed reports whose authors have clearly ignored the advice to get a friend or family member to read through the work looking primarily for sense rather than content. If in the Conclusion section a Moderator reads "… of course this is pure speculation and investigation, either research of experimental, is defiantly needed to draw a conclusion" one can understand that there will have been problems appreciating the rest of the work.

In taking measurements it is important that Candidates record their raw results in the units used by the measuring instrument and not just the derived values. For example velocity alone should not be quoted when the primary measurement is time to cover a fixed distance. This is not the case if light gates have been used but even here I have seen tabulated values of kinetic energy with no velocity values in the tables. Another example is recorded values of cross sectional area but no record of wire diameter. These might appear to be minor errors but in combination with missing quantities and units in column headings and powers of ten conversion errors it can be impossible to see what a Candidate is measuring. If Candidates use spreadsheets it is expected that they use them properly firstly by giving a sample calculation, so the reader can understand the origin of the values in each cell, and secondly by controlling the significant figures. Taking the average of several readings, all of which should be shown, is generally good practice but the shine is lost if there is significant figure inflation in the tables. Many candidates think that the spread of repeat measurements is the same as the uncertainty in the measurement and if a percentage error is quoted, very few are able to justify the value. Computer generated graphs should be of a size large enough to convince the reader of any claims made about straight line relationships etc. Grid lines on graphs, both vertical and horizontal, are essential for the proper presentation of data. The observations and data may well be recorded clearly and in an organised way using appropriate ICT but if the shortcomings above are evident then it is more art than physics.

There is a wide spectrum of Candidate achievement in this component. The comments above highlight some of the common deficiencies, which should map onto the ratings given. It is equally important to recognise that many Centres do have high expectations and Candidates who rise to the challenge and produce thought provoking work of the highest standard. If I am to be found fiddling about with equipment trying to replicate some of their work then it has been a good year.

2863/01: Rise and Fall of the Clockwork Universe

General Comments

This paper produced a wide range of marks. A very small minority of candidates scored below twenty whilst scores over fifty were not uncommon. The mean mark on the paper was 41 out of seventy. The quality of the work at the top end of the mark range was most impressive.

The majority of the candidates were well-prepared for the examination although there was some evidence that areas of physics had not been covered in a minority of cases. There were fewer mathematical errors than in previous sessions and only a few candidates lost marks on the 'show that' questions. The paper was completed by the majority of the candidates and there was little evidence to show that instructions had been misinterpreted.

Comments on Individual Questions

Section A Most candidates scored more than ten marks out of the twenty available for this section.

1 (a) This question was accessible to all but the weakest candidates.

(b) This proved to be surprisingly discriminating. Some candidates lost marks because they were not sufficiently precise in their answers; for example, the response 'energy' was not markworthy.

2 Mostly well answered

3 This was answered well by the majority of the candidates. It was encouraging to see that they could use the exponential function with ease.

4 This ideal gas question was answered more confidently than similar ideas covered in past papers. Many candidates correctly recalled the equation.

5 This proved to be extremely discriminating. Many arrows did not begin at the comet and many candidates assumed that the force and velocity were at right angles. The most common error was to draw the velocity along the orbit rather than tangentially to it.

6 The force-momentum relationship always proves difficult for candidates and it may be the case that more careful preparation is needed in this area. Only the highest-ranked candidates connected changes of momentum with the area under a force-time graph.

7 Encouragingly, this question was well answered by the majority. It is clear that Centres are ensuring that the candidates know about cosmological redshift and its cause. There was little evidence of confusion with Doppler shift.

Section B

8 This question was about an open-air swimming pool and covered ideas from Chapter 13 and Chapter 10. It presented candidates with a simple mathematical model of an unfamiliar situation.

(a) A very gentle opening that gave no problems.

(b) Most candidates can handle calculations involving specific thermal capacity.

(c) This part was not well answered – the unfamiliar idea clearly confused some candidates and there was evidence of candidates making calculations more in hope than in expectation.

(d) There was evidence that those candidates who found (c) difficult simply ignored this part. Those who did attempt it generally scored well.

(e) This was discriminating and tested understanding of the flow chart.

(f) An easy question if the stem was read. However, many candidates plunged in with ideas of changing the pool rather than changes to the environment.

9 This was about capacitor discharge and was intended to be a recognisable piece of standard physics. Although many candidates scored highly there was evidence of lack of understanding of some fundamental ideas from a surprising number of papers.

(a)(i) Most candidates gained the mark by stating the equation $Q = It$.

(ii) Although the principle of area under the graph was given in the question stem surprisingly few candidates actually attempted to ‘count squares’ or clearly use trapeziums or triangles. This is a tried and tested method in many areas of physics at this level.

(iii) Generally answered well although there was evidence of confusion over units.

(b) Generally well answered.

(c) Most candidates gained marks for an intuitive understanding of the decay taking longer. However, very few analysed the situation sufficiently to begin the discharge curve at 0.3 mA.

10 This question was about a descent of a space shuttle. It tested ideas of gravitational potential and kinetic theory. It proved to be rather difficult for the weaker candidates who gave evidence of poor understanding of the mathematics of gravitation.

(a) This was meant to be a very easy starter. This was the case.

(b)(i) This part, needing a calculation of gravitational potential energy proved to be problematic for candidates even though it was a ‘show that’ question. It is clear that the difference between field strength, potential and potential energy is not well understood. Many candidates omitted the required minus sign.

(ii) Candidates were on safer ground with kinetic energy.

(iii) In this part it was disappointing to see that many answers merely summed the magnitudes. This is a difficult area of the course for many.

(c) There was a lot of GCSE physics on display here with answers assuming that the space shuttle is freely (and vertically) falling towards the Earth.

(d) This section proved highly discriminating. Many responses suggested that the question had not been read through carefully enough – the request to explain in terms of collisions was simply ignored in many cases. This reflects the poor performance in question 6 – more problems with force and momentum.

11 (a) This part was performed well by the majority – a few lost marks because of poor or rushed graphs. Some candidates appear to think that any periodic graph line will illustrate simple harmonic motion.

(b) This was intended to be differentiating and proved to be so. It was a good marker for A grade candidates.

(c) This calculation was rather easier than (b) but many could not rearrange the equation $p = F/A$ or handle the change of unit from mm^2 to m^2 .

(d) The answers here were disappointingly vague. This may be because the question was at the end of the paper but may reflect a lack of understanding of resonance. The most common statement was that resonance ‘is the natural; frequency something oscillates at’. Although gives half the definition it is clearly not markworthy.

2864/01: Field and Particle Pictures (Written Examination)

General Comments

Most candidates who sit this paper do so in June. A few brave Centres appear to enter all of their candidates for the January paper, otherwise the entry consists of one or two candidates from many different Centres. This suggests that many are repeating the module after a disappointing result first time round. Nevertheless, candidates displayed the full range of ability in their responses to the questions.

There was no evidence from scripts that time was an issue for the candidates. Furthermore, most candidates wrote an answer to every question, suggesting that the paper was reasonably accessible for weak candidates.

Weak candidates still do not realise the difference between the commands “calculate” and “show that”. For the latter, they have to show *all* the steps in the calculation, including formulae used and the result shown on the display of their calculator.

Questions which require candidates to write about physics rather than just do calculations continue to effective discriminators for the stronger candidates. Quite clearly, many candidates would have profited by having more practice at doing this before they sat this paper.

Comments on Individual Questions

Section A
These questions are intended to be a straightforward start to the paper, covering a wide range of topics in the module. It was pleasing to see that the majority of candidates were able to score most of the marks.

1 The vast majority of candidates were able to use the information in the question to work out the correct answer.

2 In order to obtain the correct answer of 1.3×10^{-12} J, candidates needed to find the mass difference in u, convert this to kg and finally use $E = mc^2$. This three-step calculation was, not surprisingly, clearly beyond many weak candidates. However, a number of candidates who wrote down the correct numbers lost marks by not showing clearly all of the steps involved.

3 (a) Nearly all candidates realised that they had to use $E = hf$ to obtain 7.9×10^{-19} J.

(b) The second part of the question required candidates to identify the transition responsible for the emission of the photon. Many candidates incorrectly chose the levels at -8.0×10^{-19} and -8.8×10^{-19} J, wrong by a factor of ten. Disappointingly, many candidates who correctly selected the levels at -16.7×10^{-19} and -8.8×10^{-19} J drew the arrow round the wrong way. Since there was only one mark for the question, they were not penalised for this.

(c) Too many candidates went for the obvious distractor, associating the negative sign of the electron’s energy with its charge.

4 (a) Although most candidates realised that the electric field at P is vertical, many drew the field line pointing up instead of down, losing a mark.

(b) The majority of candidates worked out that the correct answer for the potential at P is –80 kV.

(c) Most candidates drew an equipotential at right angles to their field line, but some lost the second mark by failing to show the shape of the equipotential by drawing the complete circle.

5 (a) One of the marks was awarded to candidates who realised that the units of mT and cm needed conversion to T and m before doing the calculation. A disappointing number of candidates lost that mark.

(b) Most candidates knew that the wire parallel to the magnetic field has no force on it.

6 Many candidates obtained all three marks, showing that they knew the implications of the binding energy curve for nuclei. Some probably confused the words fission and fusion, losing two marks.

7 Interpreting the meaning of the area under the field-distance graph was probably the hardest mark to earn in Section A. Only a minority of candidates earned it.

Section B

The four questions in this section are harder, with a sprinkling of easy marks to encourage weaker candidates to keep going. Each question has a different context, often a real-life application of the physics being examined. As always, weak candidates often fail to keep the context in mind as they work through the question, losing marks as their answers drift far from the mark.

8 The context for the question is a velocity selector using crossed electric and magnetic fields. Although this context has been used before, it was not expected that candidates would be familiar with it.

(a) Only a few candidates lost marks by omitting the arrows on the field lines or drawing them up instead of down.

(b) In order to obtain the marks, candidates had to use $E = F / q$ to show that the electric field strength is 2.2×10^6 N C^{-1}. Weak candidates lost a mark by not explicitly writing down the formula used. Calculating the potential of the top electrode proved straightforward for most candidates. Either 6.0×10^3 or 6.6×10^3 V was accepted, as many candidates chose to use the value of 2×10^6 N C^{-1} given, rather than the value they had just calculated.

(c) Few candidates were able to say that direction of motion, the electric field and the magnetic field all needed to be at right angles to each other. Despite this, most candidates had no trouble calculating the correct value of the alpha particle velocity (1.7×10^7 m s^{-1}).

(d) Only a minority of candidates wrote sensible answers to the final part of this question, although most candidates felt able to write something. Many candidates erroneously argued that if the particles were moving faster, they would spend less time in the field region and therefore be deflected less by the magnetic force. They had clearly forgotten the context of balanced electric and magnetic forces.

9 This question proved to be the hardest of the whole paper.

(a) Although the majority of candidates were able to deduce the nucleon number and proton number of the Xenon isotope, only a minority could correctly identify the particle with no mass or charge as an antineutrino. Neutron, antineutron and neutrino were all popular as incorrect answers.

(b) Calculating the decay constant proved to be straightforward for most candidates.

(c) Most candidates lost many marks for this part. They often did not know where to start when calculating the number of nuclei in the thyroid gland, resorting to multiplying and dividing the numbers at random until they came up with the answer. Too many candidates failed to take account of the mass of the gland in calculating its dose equivalent. As expected, many candidates failed to convert 0.81 MeV into 1.3×10^{-13} J before doing the calculation. The correct answer is 0.54 Sv, which rounds down to the 0.5 Sv given in the question. Finally, only the strongest candidates could work out that 1.5×10^{10} nuclei of the iodine isotope would give a risk of 0.1%. This was not unexpected.

(d) Many candidates realised that because beta particles have a range of energies, the dose equivalent calculation gives an upper limit. Furthermore, the penetrating power of beta particles means that not all of them will leave all of their energy in the gland. However, too many candidates lost their grasp of the context and wrote about how some of the nuclei would decay before reaching the gland or end up somewhere else in the body.

10 No Field and Particle Pictures paper would be complete without a question on flux loops in iron and the effect on surrounding conductors of changing the flux.

(a) Drawing two complete loops of flux, with no gaps or crossings or departures from the iron proved to be easy for nearly all candidates.

(b) Many candidates sketch excellent sine curves. Dots showed that many have been taught to identify the points where the curve is a maximum and zero before drawing it with the correct phase.

(c) Most candidates were totally unable to explain why the emf across the coil of a transformer is proportional to the number of turns of wire. Only a minority started with $E = \mathrm{d}N\Phi/\mathrm{d}t$ and applied it to both coils.

(d) Although most candidates know how to construct a transformer core which reduces eddy currents, only a few can explain why they appear in the first place. It was disappointing to find many candidates referring to flux rather than change of flux in their explanations.

11 This question tested candidate’s understanding of particle accelerators and Rutherford scattering.

(a) Most candidates could equate the changes of electrical and kinetic energy to calculate a potential difference of 1.2 MV.

(b) The majority of candidates drew the trajectory correctly. Most of those who lost the mark did so because the particle did not appear to have been deflected by 45°. However, explaining the path of the proton was not so easy, with many candidates failing to mention that the nucleus has the same sign of charge as the proton.

(c) Many candidates knew that increasing the speed of the protons results in their spending less time being deflected by the nucleus. However, many used the wrong formula to calculate the distance of closest approach for a head-on collision, as well as forgetting to convert MeV into J before doing the calculation. Finally, as expected, only a few candidates suggested that the sudden increase of detected particles was due to induced fission of the target nuclei.

2864/02: Field and Particle Pictures (Coursework)

General Comments

There were about 50 candidates from approximately 30 centres. Of these 30 centres a good number, over half, had entered candidates in error. In order to retake the assessment module called 'Field & Particle Pictures' it is not a requirement that the coursework component, 'Research Report' is redone. A number of centres really meant their students to have their coursework marks carried forward.

Of the centres that had entered students correctly only about 5 entered more than 3 students. Some candidates who entered were probably trying to improve their grade after a summer disaster whilst the remainder came from centres that have chosen to tackle the course in reverse order. That is chapters 15-19 first (Electromagnetic machines, Fields, Radioactivity) followed by 10-14 (Models, Space & cosmology, Thermodynamics). This gives these centres perhaps a more restricted range of titles than the synoptic summer entrants in the May session and a slight tendency to tackle topics more firmly rooted in the AS course than one might expect.

There was very little evidence of worthless work from the students reviewed i.e scoring < 15 but similarly fairly few that produced very high marks. Some coursework still arrives from centres with no evidence what so ever that they have been marked at all. It cannot be stressed too much that centres not providing supporting evidence for the marks that they submit are much more likely to risk being adjusted.

It is clearly a difficult task for centre moderators working in isolation to make judgements about the required standard at this level. To this end OCR offers Autumn Coursework training sessions usually in London and the Midlands in October and November. Where Centres feel they are in need of extra guidance it would be well worth considering attendance. Another service provided free of charge called Coursework Consultancy allows centres to submit a sample of their marked work for detailed analysis and feedback by an expert.

2865 Advances in Physics

As with previous January entries, there were few (76) candidates, many of whom were unsuccessful last summer, and therefore not representative of the year 13 cohort, with about a third being entered for the first time, rather than re-sitting.

Most candidates had obviously read and prepared the advance notice article; the few who had clearly not done so did very poorly. The principal difficulties shown by less successful candidates in this paper were the lack of clarity in working out numerical answers, the inability to appreciate an appropriate number of significant figures, and the inability to give extended explanatory answers in written prose, bulleted lists or similar styles of communication.

Question 1

This question on material properties was generally not well answered. Weaker candidates did not answer the question set, and in each section often gave insufficient detail to allow both marks to be awarded.

Question 2

This question on magnetic fields and induction was generally well answered, although weaker candidates had difficulty distinguishing the primary 7-turn coil from the effectively single-turn crucible in calculating induced emf.

Question 3

This question on etching fine detail on ICs was generally well done, with diffraction well appreciated. The part asking for a calculated quantity (given) to be expressed in an appropriate number of figures – one in this case – was done well only by the very strongest candidates.

Question 4

The numerical parts of this question on the Boltzmann factor and diffusion in silicon was reasonably tackled by most candidates, but the explanatory parts proved much harder for most.

Question 5

This question was on exponential growth. Reading from a graph with a logarithmic scale proved difficult for many candidates, but most were able to handle the data obtained from it - if the data had been incorrectly read, 'error carried forward' allowed them to gain subsequent marks.

Question 6

Weaker candidates managed the beginning of this question, on RC circuits in ICs, well, but predicting a charging graph was well tackled only by the very best candidates.

Question 7

The question was on remote sensing. The cosmological aspects were tackled much better this time than in earlier examinations, but questions on uses and advantages of aspects of remote sensing of the Earth were often superficial and lacking appropriate detail.

Question 8

In this question on pole vaulting, most candidates were successful at interpreting a velocity time graph in all details, and could calculate momentum change and force, although only A-grade answers used the momentum change to calculate the force: most candidates went back to first principle and used $F=ma$.

Chief Examiner Report

I am pleased to report that the entire suite of papers (2860, 2861, 2863/01, 2864/01 and 2865) worked well in providing candidates from across the ability range with fair opportunities to show what they had learned and understood. The quality of work at the A/B and E/U grade boundaries was consistent with the levels of performance in previous sessions. The quality of work from the more able candidates was superb, but in this session there was some evidence of a slight increase in the number of candidates whose written work fell below the standard required to reach the grade E threshold. The questions were clear and unambiguous and candidates seemed able to complete their work in the time allocated. The entries for 2864/01 and 2865 were, as usual, relatively small in the January session. 2863 enjoyed a substantial entry from Centres whose candidates had completed their practical investigation in the autumn term and for whom a January entry for 'The Rise and Fall of the Clockwork Universe' has become the established pattern. The entries for 2860 and 2861 tend to be a mixture of candidates from the first year of the course and candidates from the second year who are re-sitting a module. The detailed reports on the individual components of the examination are given below.

Advanced GCE (Physics B (Advancing Physics)) (3888/7888)
January 2005 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	62	55	49	43	37	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	62	55	48	41	35	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
2863A	Raw	127	96	86	76	66	57	0
	UMS	100	80	70	60	50	40	0
2863 B	Raw	127	96	86	76	66	57	0
	UMS	100	80	70	60	50	40	0
2864A	Raw	119	92	82	72	62	53	0
	UMS	110	88	77	66	55	44	0
2864B	Raw	119	92	82	72	62	53	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	65	58	51	44	37	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	18.2	38.3	58.0	79.2	94.9	100.0	292
7888	17.1	43.9	70.7	92.7	95.1	100.0	42