OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Mark Scheme for the Units

January 2008

3883/7883/MS/R/08J

Oxford Cambridge and RSA Examinations

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

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

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

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Advanced Subsidiary GCE Physics (3883)

MARK SCHEMES FOR THE UNITS

2821 Forces and Motion

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
   You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

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

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

Mark Scheme Page 1 of 6	Unit Code 2821	Session JANUARY	Year 2008	Version FINAL
Abbreviations, annotations and conventions used in the Mark Scheme	/ = 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			

Question 1	Expected Answers	Marks
1 (a) (i)	$s = \frac{1}{2} at^2$ / $0.5 = 0.5 \times 9.81 \times t^2$	M1
	$t^2 = (2 \times 0.5) / 9.81$ / $t = \sqrt{1/9.81}$ / $t = \sqrt{0.102}$	M1
	t = 0.319 (s)	A0
(ii)	speed / s = d / t / s = 0.5 / 0.319	C1
	= 1.57 / 1.6 (m s^{-1})	A1
(b) (i)	$v^2 = u^2 + 2as$	
	$3.75^2 = 3.05^2 + 2 \times a \times 0.25$	C1
	= 9.5(2) (m s^{-2})	A1
(ii)	air resistance; acceleration reduced	M1, A1
	length incorrect, e.g. sheet falling at an angle, length measured incorrectly	M1,
	hence average speeds incorrect	A1
	incorrect value for d; d too large gives lower a	M1, A1
	t incorrect so average velocity incorrect; running slow	M1, A1
	(longer t) gives lower acceleration	Max 2 M1
		Max 3
		Total 9

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Question	Expected Answers	Marks
2		
(a) (i)	a = (v – u) / t = (5 – 0) / 2 = gradient of line	C1
	= 2.5 (m s^{-2})	A1
(ii)	area under line / 180 +	C1
	5 + 180 +5	M1
	distance = 190 (m)	A0
(iii)	K E = ½ m x v^2 / = 0.5 x 75 x $(5)^2$	C1
	= 940 (937.5) (J)	A1
(iv)	P E = mgh / = 75 x 9.81 x 190	C1
	= 140 k(J) [139.8]	A1
(v)	rate of PE gain = P E / t	
	= (75 x 9.81 x 190) / 40	C1
	= 3.5 (kW)	A1
	unit: kW / kJ s^{-1} / W / J s^{-1}	B1
(b) (i)	P = F / A	C1
	A = (75 x 9.81) / (55 x 10^3)	
	= 0.013(4) (m^2)	A1
(ii)	It (pressure) is greater in <u>first period</u> of acceleration force up needs to be > weight (It) (pressure) less in deceleration / second period of acceleration weight > force up [by the same amount] any three	B3 Total: 16

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Question	Expected Answers	Marks
3 (a)	(For a system in equilibrium) the sum of the clockwise moments = sum of the anticlockwise moments (about the same point) / the sum of the moments equals zero	B1
(b) (i)	B x 800 = 26.5 x 200 + 17.5 x 400 = 5300 + 7000 B = 15.4 (N) Sum = 44 (N)	C2 A1
(ii)	The total force acting down is equal to the total force acting up	B1
(iii)	The sum is constant A becomes less and B becomes greater Same amount of increase and decrease At centre A = B	B1 Any 2 MAX B2
		Total: 8

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Question	Expected Answers	Marks
4 (a)	$T_1 \cos 50 = T_2 \cos 40$ / $T_2 = 392\sin 40$ / $T_1 = 392\sin 50$	
	$T_1^2 + T_2^2 = (392)^2$ / $T_1\sin 50 + T_2\sin 40 = 392$ / correct vector triangle drawn and labelled / scale given for triangle	C2
	$T_1 = 300$ (N)	A1
	$T_2 = 252$ (N)	A1
(b)	Method cannot be used as system not in equilibrium	B1
	Upward forces are greater than the downward forces / resultant force is not zero / cannot form a closed triangle	
	OR	
	Stretching the ropes more gives greater upward force (than downward)	B1
		Total: 6

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Question 5	Expected Answers	Marks
Apparatus	Clearly labelled diagram could score both marks (Long) wire fixed at one end, pulley, masses required to produce extension shown at other end / Searles apparatus (workable arrangement) Micrometer; metre rule (for length and extension); or other instrument for measuring the extension described or shown	M1 A1
Readings	(Original) length with a ruler Extension with relevant instrument Extension related to the correct original length <u>Diameter</u> with micrometer screw gauge /<u>digital</u> vernier callipers mg for the load / balance for mass / newton meter for weight long wire e.g. > 2m / measure length to marker in correct region / measure diameter in several places /second wire to allow for temperature changes	B4 max
Analysis	graph of F / e or graph of stress / strain determine gradient stress and strain defined E = (grad x original length) / area gradient is E E = stress / strain E = Fl / eA; symbols defined Area = $\pi d^2 / 4$ Good physics determine E in the elastic region	B4 max
QWC	SPAG B1 (< 4 errors) Organisation B1	B2 Total: 12

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Question	Expected Answers	Marks
6 (a) (i)	Distance travelled from the instant the driver sees the problem until the brakes are applied	B1
(ii)	Distance travelled by car after the brakes are applied and the car has come to rest	B1
(b) (i)	Distance = 25 x 0.62	C1
	= 15.5 (m)	A1
(ii)	F =ma	B1
	Force down slope = Wsin5.8 / 843	B1
	B – Wsin5.8 = ma	B1
	a = (5520 – [850 x 9.81 x sin 5.8]) / 850	B1 Max B3
	= 5.50 m s^{-2}	A0
(iii)	$s = u^2 / 2a$ / $= (25)^2 / 2 \times 5.5$	C1
	= 56.8 m	A1
		Total: 9

2822 Electrons and Photons

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Abbreviations, annotations and conventions used in the Mark Scheme	/	=	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

1

(a) Correct symbols for the cell (not battery), resistor and thermistor B1
Correctly drawn circuit B1

(b)(i) $V = IR$ / $V = 0.005 \times 120$ C1
potential difference = 0.60 (V) (Allow 1 sf) A1

(b)(ii) V = 1.4 – 0.6 (= 0.8 V) (Possible ecf) C1

$$R = \frac{0.8}{0.005}$$

resistance = 160 (Ω) A1
[Allow 1 mark for total resistance calculation: $R = 1.4 / 0.005 = 280$ (Ω)]

(c) The resistance of the thermistor increases / the current decreases B1
Hence, the p.d across the resistor decreases. B1

[Total: 8]

2

(a) All I-V graphs identified correctly B1

(b)(i) The resistance / R remains constant B1
$I \propto V$ / Graph has a constant slope / gradient / Obeys Ohm's law B1

(b)(ii) R is infinite / large when: I = 0 / no conduction / 'reverse' direction / 'up to a point' / negative V / negatively biased B1
R is small / decreases / low(er) when: I is not zero / there is conduction / 'positive' direction / 'beyond a point' / positive V / positively biased B1
(No credit for 'conducts in one direction only')

(b)(iii) The resistance increases as I (or V) increases B1
The temperature increases (as I increases) / more electrons collisions (with the vibrating atoms / ions) B1

QWC
The answer must involve physics, which attempts to answer the question.

Structure and organisation -
Award this mark if the whole answer is well structured. B1

Spelling and Grammar mark -
More than two spelling mistakes or more than two grammatical errors means the SPAG mark is lost. B1

[Total: 9]

3

(a) Same unit / measured in volts / (both defined as) energy per (unit) charge / (both to do with) transfer of energy B1

(b) 1 J (of energy transfer) per coulomb (of charge) (Allow 1 V = 1 JC^{-1}) B1

(c)(i) It is the <u>energy</u> transferred by a 1 kW device working for 1 hour B1

(c)(ii) 1 kWh = 1000 × 3600
1 kWh = 3.6×10^6 (J) B1

(d)(i) $P = \frac{V^2}{R}$ / $P = I^2R$ / I = 1.5 (A) C1

$4.5 = \frac{V^2}{2.0}$ / $V = 1.5 \times 2.0$ / $4.5 = 1.5 \times V$ C1

potential difference = 3.0 (V) (Allow 1 sf) A1
(Allow R in range 1.8 Ω to 2.2 Ω. This gives p.d. in the range 2.85 V to 3.15 V)

(d)(ii) The supply has internal resistance B1
There is also a p.d. across the internal resistance / 'lost volts' / energy wasted within the supply or internal resistance B1

[Total: 9]

4

(a) Correct arrow(s) between the north and south poles B1

(b) $F = BIL$ C1

current = $\frac{1.5}{8.0} = 0.1875$ (A) (Allow 0.19 A)

$F = 1.2 \times 10^{-2} \times 0.1875 \times 24$ C1

force = 0.054 (Current of 0.19 A gives 0.055 (N)) A1

unit: N / newton / TAm B1

(c) The resistance of the wire *increases* by a factor of four (because $R \propto \frac{1}{A}$) / the current *decreases* by a factor of four B1

Hence, the force decreases by a factor of four B1

(Allow 1 mark for: Resistance is larger / current smaller <u>and</u> force smaller)

[Total: 7]

5

(a) The current is (directly) proportional to the p.d. / voltage B1
as long as the temperature remains constant (Allow 'physical conditions') B1

(b) Only 'energy' is circled B1

(c)(i) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ C1

$\frac{1}{R_{(t)}} = \frac{1+2}{2R}$

$R_{(t)} = \frac{2R}{3}$ / resistance = 0.67 R A1

(c)(ii) current = $= \frac{3E}{2R}$ / current = $\frac{1.5E}{R}$ / current = $\frac{E}{2/3R}$ (Possible ecf) B1

(d)(i) $Q = It$ C1

$Q = 0.48 \times 150$

charge = 72 (C) A1

(d)(ii) number (= $\frac{72}{1.6 \times 10^{-19}}$) = 4.5×10^{20} (Possible ecf) B1

(d)(iii) current = 0.32 (A) B1

(d)(iv) total resistance of 18 Ω and 36 Ω in parallel = 12 Ω
total resistance of circuit = 12 + 12 = (24 Ω) C1
$E = 0.48 \times 24$
e.m.f. = 11.52 (V) ≈ 12 (V) A1

Or

$V_{12} = 0.48 \times 12 (= 5.76)$ / $V_{18} = 18 \times 0.32 (= 5.76)$ / $V_{36} = 36 \times 0.16 (= 5.76)$ C1
$E = 5.76 + 5.76$
e.m.f = 11.52 (V) ≈ 12 (V) A1

[Total: 12]

6

(a) Any <u>one</u> from: B1
Travel through vacuum / 'free space'
Travel at the speed of light / c / 3×10^8 <u>m s^{-1}</u> (in vacuum)
They are all transverse waves / can be polarised
Consist of oscillating electric / magnetic fields
Consist of photons

(b) gamma rays, visible light, infrared and microwaves B1

(c)(i) The <u>minimum</u> energy required to remove an electron (from the metal surface) B1

(c)(ii) Potassium (has the lowest threshold frequency) M1
$\phi = hf_{(o)}$ with some explanation / $f_{(o)} \propto \phi$ / threshold frequency is (directly) proportional to work function (energy) A1

(c)(iii)1. Any <u>three</u> from the statements 1 to 4:

1. Photon mentioned B1
2. A single photon interacts with a single electron B1
3. Energy is conserved between photon-electron interaction (wtte) B1
4. Electron is released when photon energy > / = work function (energy) / frequency > / = threshold frequency B1

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5. Electrons have a range of KE because some electrons are 'tightly held'/ are 'deep below the surface' / electrons make collisions with atoms / ions B1

(c)(iii)2. hf or $\frac{hc}{\lambda} = \phi + KE_{(\max)}$ / $f = 9.38 \times 10^{14}$ (Hz) / (hf =) 6.22×10^{-19} (J) C1

$\phi = 1.6 \times 10^{-19} \times 3.7 \ (= 5.92 \times 10^{-19})$ C1

$KE_{(max)} = (\frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{3.2 \times 10^{-7}}) - 5.92 \times 10^{-19}$ C1

maximum kinetic energy = 3.0×10^{-20} (J) A0

(c)(iii)3. $\lambda = \frac{h}{mv}$ / $\lambda = \frac{h}{p}$ C1

KE = $\frac{1}{2}mv^2$

$v = \sqrt{(2 \times 3.0 \times 10^{-20}) / 9.11 \times 10^{-31}} \ (= 2.57 \times 10^5)$ C1

$\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 2.57 \times 10^5}$

$\lambda = 2.8 \times 10^{-9}$ (m) A1

2823/01 Wave Properties / Experimental Skills 1 Written Paper

1(a)	(i)	speed of light (in air/vacuum) / speed (of light) in medium *accept c/v but reject c_i /c_r and speed of incident ray/speed of refracted ray}*	B1	[1]
	(ii)	sin*i*/sin*r* {do not allow $n_1 \sin i = n_2 \sin r$ etc}	B1	[1]
(b)	(i)	evidence of knowledge that ${}_g n_a$ = 1/1.46 (= 0.685) correct substitution into n = sin*i*/sin*r*: e.g. sin*r* = 1.46 x sin 40 $\Rightarrow$ *r* = **69.8^o (or 70)** *{If n=1.46 is used, leading to r = 26.1^O allow 1 mar }*	C1 C1 A1	[3]
	(ii)	Use of *n*= 1/sinC: e.g. sinC = 1/1.46 - C = sin $^{-1}$(1/1.46) OR sin C = **0.685** or **C = 43.2** (hence C =43^o)	C1 A1	[2]
	(iii)	(Ray will be totally internally) **reflected**	B1	[1]
(c)	(i)	1. speed of light in core = 3 x 10^8 /1.46 = **2.05 x 10^8** m/s	B1	[1]
		2. speed of light in cladding = 3 x 10^8 /1.40 = **2.14 x 10^8** m/s *{if calculations are correct but 2.1 is quoted for either or both give maximum of 1 mark}*	B1	[1]
	(ii)	Critical angle (much) **BIGGER** (for core/cladding) **change** in speed (much) **smaller** OR /difference in RI smaller (WTTE) *{allow first mark for new value of C correctly calculated as 73.3^O}*	**M1** A1	[2]
	(iii)	only rays nearly parallel with axis of optic fibre will undergo TIR (WTTE) *{allow "more light escapes" OR "less light is internally reflected"}* less multipath dispersion/smearing OR all rays arrive at the same time (WTTE) *{do not allow "better quality"(WTTE) OR cladding protects core }*	B1 B1	[2]

QUESTION TOTAL = **14**

2(a) ALL correct 3 marks – minus 1 for each error – stopping at ZERO B3 [3]

Definition	Symbol
number of cycles produced per unit time	F
maximum displacement	A
minimum distance between points on the wave moving in phase.	λ
distance travelled by the wave per unit time	V
Time taken for a complete one wave cycle	T

(b) (i) period = 1/*f* = 1/125 = 0.008 s *{allow 8ms, but 8 scores zero}* B1 [1]

(ii) smooth & consistent wave drawn (judged by eye) (ANY SHAPE!) B1
{i.e consistent amplitude and period and must start at origin}
amplitude correctly shown: 3 mm above AND 3 mm below time axis B1
correct period shown on graph {allow ecf from (i)} B1 [3]

(iii) correct phase difference shown (: e.g. *x*=3 (or -3) when *t*= 0) B1
same shape, amplitude and period as original wave B1 [2]
{generously judged by eye}
{If graphs are not labelled assume graph A is the one through the origin}

(iv) correct substitution into $v=f\lambda$: e.g. $340 = 125\lambda$ C1
$\lambda = 340/125 =$ **2.72** m A1 [2]

QUESTION TOTAL = **11**

3(a) transverse waves: vibrations 90^o to wave direction (WTTE) **AND**
longitudinal waves: vibrations parallel to wave direction (WTTE) B1
example of transverse waves: e.g light B1
example of longitudinal waves: e.g sound B1 [3]

(b) ***similarity***: anything valid: e.g. both have wavelength/frequency/vibrations B1
difference: anything valid: e.g. B1 [2]
no transfer of energy in standing waves
standing waves have nodes (&/or antinodes)
neighbouring pts vibrate in phase in standing waves but have a phase diff. in progressive

(c) (i) node = point of no movement/zero displacement (allow amplitude) B1
(ii) antinode = point of maximum movement/max displacement (amplitude) B1 [2]
{for diagrams with no words maximum of 1 mark}

(d) wavelength = 4x0.12 = **0.48**m B1 [1]

(e) (labelled) diagram of valid arrangement: i.e for **longitudinal** waves B1
wave source stated: e.g. tuning fork/loud-speaker/oscillator/hand moving slinky- B1

explanation of how the standing wave is formed: e.g.
waves leaving wave sources **interfere/superpose** with reflected waves B1

*{allow this mark for correct **procedure** used to produce **longitudinal** the standing wave}*

node (N) AND antinodes (A) shown in correct positions and labelled anywhere B1 [4]
{all ecf from cand's defns in (c)}
{answers in terms of transfer waves may score a max of 3 marks}

QUESTION TOTAL = **12**

4(a) when waves meet/cross/interfere/superpose/interact (WTTE) B1
displacements (not amplitude) are added to give the resultant (WTTE) B1 [2]

(b) (i) path difference: any 2 correct values – e.g. λ AND 2λ, B1 [1]
{any mention of 0 prevents the mark}

(ii) recall of $\lambda = ax/D$ C1
correct substitution: e.g. $x = \lambda D/a = (6.4 \times 10^{-7} \times 1.8)/0.2 \times 10^{-3}$ A1
x = **5.76 mm** (or 5.8mm or 5.76×10^{-3} m) A1 [3]
*{allow ecf for one error: e.g incorrectly changing the value of **a** from mm to m}*

(iii) bright images would move closer together (WTTE) B1
because higher frequency waves have shorter wavelength (WTTE) B1 [2]
{"there will be more interference/fringes" is too vague and scores zero"}

QUESTION TOTAL = **8**

Question totals = 14 + 11 + 12 + 8 = 45

2823/03 Wave Properties / Experimental Skills 1 Practical Examination

Planning Exercise - Skill P

A1 Diagram of workable circuit. **1**
i.e. diode, ammeter and power supply

A2 Correct procedure **1**
(i.e. measure temperature and measure current, change temperature and measure new current – allow graph or table). Method must be workable.

A3 Diode is correctly connected with the correct symbol. **1**

B1 Workable method of achieving low temperatures e.g.freezer not fridge. **1**

B2 Workable method of achieving high temperatures e.g.oven, sand/fluid+named heat source **1**

B3 Wait for temperature to stabilise **1**

C1 Safety precautions: e.g.Use gloves to handle equipment in freezer/oven. **1**

C2 Keep potential difference constant **1**

C3 Use of milliammeter **1**

D1/2/3 Any further relevant detail. Examples of creditworthy points might be; max **3**

1. Use of uninsulated/teflon coated wires inside hot area as plastic melts
2. Use of thermocouple or justified use of mercury thermometer/valid thermometer
3. Calculation of range of ammeter /calculation of value for protective resistor
4. Use of protective /current limiting resistor
5. Detail of measuring devices outside the method of changing temperature
6. Method of keeping V constant across the diode
7. Evidence of preliminary investigation in the laboratory
8. Stated value of Boiling Point for liquid used

R1/2 Evidence of the sources of the researched material **2/1/0**
Two or more (vague) references or one detailed reference score one mark.
Two or more detailed independent references scores two marks.
Detailed references should have page numbers or be internet pages.

Q Quality of written communication **2/1/0**
This is for the organisation and sentence construction. Accounts that are rambling, or where the material is not presented in a logical order will not score these marks.
Do not award both of these marks if the word count exceeds 750 words.

16 marks total

Question 1

(b) Values of R and 1/I. **2/1/0**
One mark for R.
One mark for 1/I.

(c) Justification of significant figures in R. **2/1/0**
Expect to see sf in R is the same or one more than sf in I and V.
No. of sf in R is the same or one more than sf in raw data/I / V/meter readings scores 1 mark
Do not credit answers in terms of decimal places or related to graph plotting.

(d) Measurements **2/1/0**
Write the number of readings as a ringed total next to the table of results.
Six distinct sets of values for I and V scores 2 marks. Five sets scores 1 mark
Minor help from Supervisor then –1.
Major help (equipment set up for the candidate) then -2.
No trend (i.e. random scatter of plots) then -2.

(d) Column headings in the table **2/1/0**
One mark for I and V headings correct.
One mark for 1/I and R headings correct.
Ignore units in the body of the table.

(d) Consistency of raw readings **2/1/0**
One mark for I which must be to the same number of d.p.
One mark for V which must be to the same number of d.p.

(e) Axes - One mark for each correct axis. **2/1/0**
Sensible scales must be used. Awkward scales (e.g. 3:10, 6:10, 7:10) are not allowed.
The scales must be labelled with the quantities plotted. Ignore units.
Do not allow more than three large squares without a scale value.
Plotted points must occupy at least half the graph grid in both x and y directions (i.e. 4 x 6 large squares). If false origin, indicate with "FO"

(e) Plotting of points **2/1/0**
Count the number of plots and write as a ringed number on the graph grid.
All observations must be plotted. Check a suspect plot. Tick if correct otherwise indicate the correct position.
If the plot is accurate $\leq$ half a small square, then two marks awarded.
One mark if the plot is out by > half a small square and < than one small square.

(e) Line of best fit **1/0**
Judge by scatter of points about the line.
There must be a fair scatter of points either side of the line of best fit.
Allow line through five trend plots for full credit (if done well).
Do not allow a line through a curved trend.

Quality of results **1/0**
Judge by scatter of points about the line of best fit.
Six good trend plots on the graph grid needed for mark to be scored.

(f)(i) Gradient **2/1/0**
The hypotenuse of the Δ must be $\geq$ half the length of the drawn line. 1 mark.
Read-offs must be accurate to half a small square and ratio correct. 1 mark.

(f)(ii) *y*-intercept **1/0**
Expect the value to be read from the *y*-axis to an accuracy of half a small square.
Or correct substitution from point on line into $y = mx + c$.

(g) Sensible emf – allow range 3.0 V to 7.0 V, compare to S_v **1/0**
Help from Supervisor then –1.

(h) (i) Candidate's gradient value equated with E-V_D (can be implied from working)
Value of V_D found using the gradient value
Sig Figs of V_D: allow 2 or 3 only
Unit of V_D. **4/3/2/1/0**

(h) (ii) Candidate's *y*-intercept equated with -P (can be implied from working).
Value of P within the range of 200 – 240 using intercept
Sig Figs of P: allow 2 or 3 only. **3/2/1/0**

(h) (iii) Calculation of percentage difference/ use of 10% of 220 and appropriate conclusion **1/0**
Expect to see difference/220 x 100

28 marks available. Write the mark as a ringed total at the bottom of page 7.

Question 2

(b) (ii) Value of *F* correct **1**

(c) Δx = 0.1-0.5 cm **1**
percentage uncertainty ratio correct. **1**
percentage uncertainty x2 **1**
Note: $\Delta x/x^2$ x 100 scores first mark only if Δx is in range.

(d) New value of *R* smaller than **(b)(ii)** **1**

(e) Inverse proportionality ideas
Method to prove or disprove inverse proportionality
(e.g. determines *k values or similar*) **1**
Appropriate conclusion based on a comparison of k values or similar.
Vague answers will not score this second mark. **1**
No method loses both these marks

(f) Evaluation of procedure **7**
Relevant points must be underlined and ticked with the appropriate marking letter.

	Problem	**Solution**
A	Difficulty in measuring *x*/Parallax	Use vernier callipers/clamped ruler/marker on top magnet/eye level
B	Magnets wobble/not vertical	Measure *x* at different places and take average
C	Large percentage error in measuring *x*	Increase separation distance/linked to use of stronger magnets
D	Magnets not directly above one another	Use (vertical rules as) guide/straight edge/use a plumb line
E	Magnetic retort stand may affect reading	Use non magnetic retort stand
F	Two readings are not enough to verify the relation(between *F* and *x)*	Take many readings of a range of *F* and *x* and plot a graph relating F and x^2

One mark for each box to a maximum of 7.

No credit for simple 'repeats',

Quality of written communication (i.e. spelling, sentence construction, grammar) **2/1/0**
Capital letters at the beginning of sentences, full stops at the end scores one mark
Correct spelling scores one mark. Allow max two errors.

16 marks total

Results

Question 1

I/ mA	V/V	1/I / A^{-1}	R/ Ω
9.2	2.04	109	222
6.1	2.74	164	449
4.5	3.10	222	689
12.3	1.35	81.3	110
13.8	1.01	72.5	73.2
7.3	2.46	137	337
11.0	1.62	90.9	147

Plotting a graph of R against 1/I produces:
Gradient = 4.11
y-intercept = -225

E = 4.73 V

gradient = (E-V_D)
V_D = 4.78 – 4.11 = 0.67 V

y-intercept = - r
r = 225 Ω

Weight of magnet: 0.53 N

R = 0.68 N
x = 2.1 cm
F = 0.15 N
x^2 = 4.41 cm^2

$k = F x^2$ = 0.66

R = 0.60 N
x = 3.3 cm
F = 0.07 N
x^2 = 10.9 cm^2

$k = F x^2$ = 0.76

Since k is not constant F is not inversely proportional to x^2

Summary of shorthand notation which may be used in annotating scripts:

SFP	Significant figure penalty
ECF	Error carried forward
AE	Arithmetical error
POT	Power of ten error
NV	Not valid
NR	Not relevant
GAP	Insufficient scale markings on an axis
NBL	Not best line
FO	False origin
NGE	Not good enough
BOD	Benefit of the doubt
R	Point repeated (no further credit)
NA	Not allowed
SV	Supervisor's value
SR	Supervisor's report
OOR	Candidate's value is out of range
CON	contradictory physics not to be credited
$\checkmark_{\Delta}$	Used to show that the size of a triangle is appropriate (gradient calculation)
$\checkmark_{A1}$	Used to show the type of mark awarded for a particular piece of work
$\checkmark_{C}$	Used to show that the raw readings are consistent
$\checkmark_{d}$	Used to show that the raw readings have correct spacing
$\checkmark_{SF}$	Used to show calculated quantities have been given to an appropriate number of significant figures
^	Piece of work missing (one mark penalty)
^^	Several pieces of work missing (more than one mark penalty)
↔	Scale can be doubled in the x-direction
↕	Scale can be doubled in the y-direction

2824 Forces, Fields and Energy

Mark Scheme Page 1 of 3	Unit Code 2824	Session January	Year 2008	final version

Abbreviations, annotations and conventions used in the Mark Scheme

/ = alternative and acceptable answers for the same marking point
; = separates marking points
() = words which are not essential to gain credit
ecf = error carried forward
AW = alternative wording

Question			Expected Answers	Marks	
1	a		mgh or 0.014 x 9.8 x h ;	1	
			= 0.22 J so h = 1.6 m	1	2
	b		k.e. increases;	1	
			at a decreasing rate	1	2
	c	i	½ mv^2 = 0.11	1	
			v = √(0.11 / 0.007) = (3.96 m s^{-1})	1	
		ii	F = mg = 0.014 x 9.8 = 0.137 or 0.14 (N)	1	
		iii	Fv = mgv or 0.14 x 4.0	1	
			= 0.54 to 0.56 (W) *ecf c(ii)*	1	5
	d		k.e. after bounce = 0.088 J giving u = √(0.088/0.007) = 3.55 m s^{-1}	1	
				1	
			change in momentum = m (v ± u)	1	
			= 0.014(7.55)= 0.11;	1	4
			kg m s^{-1} /N s		
			Total		13
2	a		the sum of the <u>random</u> kinetic ; and potential energies of the	1	
			<u>atoms/molecules/particles</u> of a body ;	1	
			the energy required to raise the temperature of 1 kg of a substance by 1 K	1	3
	b		Q = mcθ ; = 0.90 x 990 x 160	2	
			= 1.4(3) x 10^5 (J)	1	3
	c	i	n = pV/RT	1	
			Δm = pVM/R(1/T_c – 1/T_h) ; = 1.0 x 10^5 x 0.1 x 0.03/8.31(1/ 293 – 1/453) ;	2	
			alternative methods acceptable, e.g. in terms of n giving Δm = 0.0435 (kg)	1	
		ii	k.e. or internal energy α T or temperature; v α √T or v^2 α T	2	
			ratio = √(453/293) = 1.24	1	7
			Total		13
3	a	i	vertical arrow through seat labelled weight/W/mg	1	
			arrow upwards along chain labelled tension/T	1	
		ii	<u>resultant/unbalanced</u> force/vector sum of tension and	1	
			weight/(horizontal) component of tension; directed/acting towards centre of circle/rotation/axis/pillar	1	
		iii	F = mv^2/r	1	5

b	**i**	$a = 3.528$ ($m\ s^{-2}$) or		
		$T \sin \theta = mv^2/r$	**1**	
		and/or $T \cos \theta = mg$	**1**	
		$\tan \theta = v^2/rg$ or $4.2^2/5 \times 9.8$; $= 0.36$ (giving $\theta = 19.8^o$) *max 4 marks*	**2**	
	ii	No change as mass cancels out in b(i)/angle is independent of mass	**1**	**5**
			Total	**10**

Mark Scheme Page 2 of 3	Unit Code 2824	Session January	Year 2008	final version

Question			Expected Answers		Marks	
4	a	i	appropriate shape; lines perpendicular to and touching plate and sphere;		2	
			arrows towards negative charge		1	3
	b	i	E = V/d = 50000/0.04; =1.25 x 10^6 (N C^{-1})		2	
		ii	F = QE = 5 x 10^{-9} x 1.25 x 10^6 ; = 6.25 x 10^{-3} (N) *ecf b(i)*		2	4
	c	i	F = Q^2 /4πε$_o$ r^2 ; = 9 x 10^9 x25 x 10^{-18} /16 x 10^{-4} ; = 1.406 x 10^{-4} (N)		3	
		ii	Δm = 1.4 x 10^{-5} kg or 0.014 g ; giving new reading as 8.219 g		2	5
				Total		12
5	a	i	F upwards between poles		1	
		ii	F = BIl or 0.032 x 2.5 x 0.06 ;		1	
			= 4.8 x 10^{-3} (N)		1	3
	b	i	T = 20 ms ; f = 1/T = 50 (Hz)		2	
		ii	amplitude varies at every point ; standing wave (with antinode at		1	
			centre)/simple harmonic vibration ; acceleration α displacement/amplitude		1	
			hence accelerations different		1	5
	c	i	resonance		1	
		ii	50 Hz at peak with linear scale markings from zero *ecf from (b)(i)*		1	
		iii	approx. same (or slightly lower) resonance frequency		1	
			smaller amplitude/broader peak *but curves must not cross*		1	
			passes through same point on y-axis as original curve		1	5
				Total		13
6	a		39; number of protons (in Y-90 nucleus)/atomic no. (of Y)		2	
			81; number of neutrons (in the Ba-137 nucleus)		2	4
	b	i	the number of <u>atoms/nuclei</u> which decay per second or number of			
			<u>atomic/nuclear</u> decays per second		1	
		ii	0.693/(30 x 3.15 x 10^7)		1	
			= 7.3(3) x 10^{-10} (s^{-1})		1	3
	c	i	(A = λN)= 7.33 x 10^{-10} x 3.525 x10^{15} *ecf b(ii)*		1	
			or can take the gradient of the tangent to the curve at (15,3.525)			
			= 2.58 x 10^6 Bq or 2.60 MBq		1	
		ii	e.g. take N at t = 15 y then N = N_o √2 giving 3.525 x 10^{15} = 0.707 N_o			
			hence N_o = 4.99 x 10^{15}			
			or use N = $N_o e^{-\lambda t}$ with appropriate substitution for N and t			
			award marks as follows: viable method; suitable substitutions; achieving		2	
			correct solution		1	
		iii	N = (m/M)N_A or 4.99 x 10^{15} = (m/137) x 6.02 x 10^{23}		1	
			hence m = 1.14 x 10^{-6} g *ecf c(ii)*		1	7
				Total		14

Mark Scheme Page 3 of 3	Unit Code 2824	Session January	Year 2008	final version

Question		Expected Answers		Marks	
7	a	A significant/measurable diffraction pattern is only observed when the electrons behaving like waves;		1	
		have a de Broglie wavelength λ of the order of the spacing d of the atoms/ size of pattern depends on ratio of λ/d.		1	
		The wavelength of the electrons depends on their speed/momentum.		1	
		Acceleration is only through a few hundred volts/low energy electrons (100 – 400 eV).		1	
		X-rays need wavelength λ of the order of the spacing of the atoms;		1	
		use of c = fλ to give some idea of frequency or energy;		1	
		wavelength of X-rays or spacing of atoms order of magnitude given ,e.g. 0.1nm		1	
		Diagram showing **or** description of incident beam scattered by or diffracted through crystal at only certain angles either for X-rays or electrons;		1	
		moveable detector to measure angles;			
		electrons or X-rays are scattered from crystal planes like a diffraction grating/because of the regular array of atoms;		2	
		constructive interference only occurs at certain angles ; depending on λ and d;		1	
		pattern of maximum signals can be very complex depending on structure/AW;			
		or maxima occur at angles of about nλ/d;		1	
		de Broglie's relation p = h/λ for electrons shows why different energies are needed *with this detail worth 2 marks*;		1	
		as λ is known d can be found	*max 7*	1	
				1	
				2	
				1	7
	b	ratio of atom to nuclear diameter/radius: about 10^4 or 10^5;		1	
		atomic or nuclear diameter given, i.e 10^{-10} m or 10^{-14} m or 10^{-15} m *do not score twice if mark already given in (a) for atomic diameter*		1	
		or giving both atomic and nuclear diameters can score both marks above			
		electrons can be accelerated to give speeds where wavelength is of order of		1	
		nuclear radius/diameter; so that diffraction effects are observable		1	
		statement that hard X-rays are still at atomic size wavelengths		1	
		energy of X-rays required well above electron transition energies to achieve such		1	
		small wavelengths/some calculation using c = fλ and energy = hf to show energy		1	
		of X-rays required *up to 3 marks*		1	4
		pattern/size of ring enables radius of the nucleus to be found	*max 4*	1	
			Total		11
		Quality of Written Communication (see separate sheet)			4

2825/01 Cosmology

Cosmology 2825/01 Mark Scheme Final Jan 2008

1	a(i)	Any **4** from		
		Reference to Sun in centre/planets orbit Sun	1	
		References to phases of Venus/ diagram	1	
		Explanation of crescent shape	1	
		(Apparent) change in size of Venus	1	
		Explains apparent size change/ distance changes	1	4
	(ii)	Any 2 from		
		Mountains/craters on Moon	1	
		(Planets) are not perfectly spherical	1	
		Moons orbiting Jupiter	1	
		Earth is not at the centre of all orbits	1	
		Stellar parallax not observed	1	
		Stars much more distant	1	
		Sunspots	1	
		Sun not a perfectly smooth sphere	1	4
			Total	8
2	(a)	Gravity attractive force	1	
		Gravity acts on masses	1	
		Finite Universe has contractive force/ will collapse	1	3
	(b)	Any 2 from:		
		Equal areas swept out in equal times	1	
		maximum speed at closest approach	1	
		minimum speed at furthest point	1	2 max
		reason:		
		kinetic energy converted to potential energy/ variation of force with distance/ conservation of angular momentum	1	3
	(c)(i)	star's gravitational field strength stronger for A	1	
		star's grav. field strength provides centripetal force	1	
	(ii)	at least one arrow drawn along line AB	1	
		arrows same length and in opposite directions	1	
	(iii)	A accelerates/ B decelerates (ora)	1	
		reference to perturbations in planetary orbits	1	
		additional perturbation for Uranus/Saturn/ Jupiter	1	7
			Total	13

3	(a)	the luminosity/brightness of a star	1	
		as seen from Earth	1	2
	(b)(i)	0.07; 0.05	1	
	(ii)	graph: all 4 points plotted correctly	1	
		graph: best straight line drawn, ignoring origin	1	2
	(iii)	k gradient of graph	1	
		$k = 7 \times 10^{-3}$		1
		units of k : W m^{-2} pc^2	1	3
	(c)(i)	log *I* = -2log(d) - 2.2	2	
	(ii)	correct substitution of log *I* eg m = - 2.5 [- 2 lg (*d*) - 2.2] + a m = 5 lg (*d*) + (5.5 + a)	1	
		calculation of new constant / b = 5.5 + a	1	2
	(d)	m – M = 5 log(d/10)	1	
		M = 6.39	1	2
			Total	14

4	(a)	**Any 5 from**		
		x axis: temperature	1	
		x axis: temperature increases right to left	1	
		y axis: luminosity/ absolute magnitude	1	
		y axis: luminosity increases from bottom to top	1	
		red giants	1	
		main sequence indicated	1	
		white dwarf	1	
		line showing evolution of main sequence star through red giants finishing at white dwarfs	1	5
	(b)(i)	mass converted into energy/ $E = mc^2$	1	
	(ii)	energy in joules = $26 \times 10^6 \times 1.6 \times 10^{-19} = 4.16 \times 10^{-12}$ J	1	
		fusion frequency = $3.9 \times 10^{26} / 4.16 \times 10^{-12} = 9.38 \times 10^{37} s^{-1}$	1	2
			Total	8

5	(a)	**Any 6 from**			
		light from galaxies is red shifted	1		
		speed of recession proportional to distance	1		
		universe is expanding	1		
		cosmic microwave background radiation(CMBR)	1		
		peak at 2.7K	1		
		uniform intensity in all directions/ very small ripple	1		
		ratio of helium to hydrogen	1		
		higher than can be accounted for by stellar fusion alone	1		
		created during initial high temperatures	1	6	
	(b)(i)	$H = 1/ t$	1		
		Conversion process (alternative conversions allowed)	1		
		Correct answer (215 km s^{-1} Mpc^{-1})	1	3	
		($H = 7 \times 10^{-18}$ s^{-1} scores 2 max.)			
	(ii)	<u>minimum time</u> so H is a maximum	1		
	(iii).		$v = H \times r$		1
		velocity from red shift data/ distance from Cepheid variable	1		
		ref. to change of acceleration with increasing size of Universe	1	3	
			Total	13	
6	(a)	speed of light constant	1		
		in all inertial reference frames	1	2	
	(b)(i)	3×10^8 ms^{-1} / accept *c*	1		
	(ii)	$3 \times 10^8 / 2 \times \pi \times 15 \times 10^3$	1		
		max frequency = 3.18×10^3 s^{-1}	1	2	
	(iii)	ref to increase in rest mass/ increase in energy	1		
		when speed nears c	1		
		or			
		centripetal force	1		
		would exceed inter-particular force of attraction	1	2	
	(c)	any 5 from			
		spacecraft with glass sides, moving in straight line	1		
		spacecraft accelerates	1		
		light beam moves across craft	1		
		light beam curved	1		
		principle of equivalence stated	1		
		light beam crossing gravitational field lines is deflected	1	5	
	(d)	change in apparent position of star when light grazes Sun	1		
		experimental evidence for GTR	1	2	
			Total	14	

7	(a)	Situation; 2 observers, clocks, relative motion and time interval defined	1
		Interval measured	1
		Improper observer measures longer time because longer path.	1
		Speed of light constant	1
		Other detail	1
	(b)(i)	$t = 2\pi\ 900 / 0.94c$	1
	(ii)	fraction remaining = 0.25	1
	(iii)	$\sqrt{(1 - v^2/c^2)} = 0.34$ / $\gamma = 2.93$	1
		$t = t_o / \sqrt{(1 - v^2/c^2)}$ / $t = \gamma t_o$	1
		$t = 5.88 \times 10^{-5}$ s ecf from b.i.	1
	(iv)	ref. to time dilation	1
		'clocks' / time of stationary particles same rate as lab./ half life shorter	1
			Total 12
8	(a)	gravitational fields/gravity and acceleration	1
		produce the same effect / cannot be distinguished	1
	(b)(i)	spacecraft is accelerating (ora)	1
		clock in spacecraft runs faster (ora)	1
	(ii)	Moon: smaller gravitational field (ora)	1
		Clock in spacecraft runs slower (ora)	1
			Total 6

2825/02 Health Physics

1(a) (i) (sum of) clockwise moments = (sum of) anticlockwise moments (1)
b sin 30 x 3 (1) = 80 x 34 + (12 x 15) (1)
b = 1116 N (1)

(ii) MA = load / effort (1)
= 0.072 (1)

(b) (i) explanation e.g. perpendicular distance of *b* to pivot F decreases (M1)
so *b* must increase (A1)

(ii) effort increases **and** load is unchanged so MA decreases (1)

2(a) (i) rays meet before retina (1)
rays refract at both the cornea and lens (1)

(ii) out of focus / blurred (1)

(b) (i) concave / diverging (1)

(ii) near point will be further away (1)

corrective lens diverges the light more / has a negative power … (1)

… (so) lowers combined power / eye was previously too powerful / refracted the light too much … (1)

… (so) now not enough power to focus at N / light can't be refracted enough (to meet on the retina) / as v is constant, 1/u must be less. (1)

(c) (i) 1/u + 1/ v = 1/ f (1)
1/0.60 + 1/0.019 = 1/f = p (1)
p = 54.3 D (1)

(ii) p = $\frac{1}{\infty} + \frac{1}{0.019} = \frac{1}{f} = p$ (1)

p = 52.6 D (1)

(iii) -54.3 + 52.6 (1)
= - 1.7 D (1)

3 **for first 3 marks** either labelled diagram or in words
audible frequency range of 20 – 20 000 Hz (1)
most sensitive at 2-3 kHz (1)
10^{-12} W m^{-2} is the lowest detectable intensity (1)

any 5 from

max. sensitivity related to resonance in the auditory canal (1)

at frequencies either side, minimum detectable intensity rises / sounds have to be at a greater intensity to be perceived at the same loudness / meaning of line drawn on graph made clear (1)

any one physical cause of hearing problem, e.g. ear drum insufficiently elastic, wax in ear (1)

any one possible consequence of hearing problem, e.g. narrower range of frequencies / higher threshold intensity (1)

problems can be age-related (1)

background noise so higher threshold intensity / difficult to hear quiet sounds (1)

exposure to loud noise over long periods can damage hearing (1)

discomfort at 120 dB (1 W m^{-2}) / Pain at 140 dB 100 W m^{-2} (1)

for a sound source at a greater distance, the intensity is less so the loudness is reduced (1)

to max. 8

4(a) (i) $t = s/v$ (1)

$= 2.5 \times 10^{-2} / 4.0 \times 10^{3} \quad = 6.26 \times 10^{-6}$ s (1)

$6.25 \times 10^{-6} / 2.0 \times 10^{-6} \quad = 3.125$ cm

$3.125 \times 2 = 6.25$ cm

(ii) correct peak position i.e. >6cm from first peak and < 6.5 cm (2)

3.125 cm position or just > 3 cm (1)

(b) e.g. scanning foetus *owtte* (not *baby*) (1)

safer as no ionising radiation (1)

scanning joints / ligaments (1)

quicker / instant image / cheaper (1)

5(a) (i) $f = 140$ J C^{-1} (+ /- 20) (1)

$D = f \times X$ /

$= 140 \times 3.5 \times 10^{-4}$ (1)

$= 4.9 \times 10^{-2}$ (1)

Gy or J kg^{-1} (1)

(ii) e.g. (30 to 40) 30 / 150 = 0.20 (1)

(b) bone absorbs low-energy photons more than high-energy ones / more with photoelectric effect than with Compton scattering (1)

bone and soft tissue absorb high-energy photons at similar rates (1)

a valid conclusion from one of these, eg with high-energy photons you would need a greater exposure (to absorb the necessary amount in bone) / with high-energy photons soft tissue would be affected just as much as bone (1)

any 6 from

energy deposited = no. of photons absorbed x photon energy (1)

X-rays cause ionisation … (1)

… which can affect DNA (1)

… which kills cells (1)

… which can cause cancers / mutations / burns (1)

cells are more vulnerable when dividing (1)

cancerous cells divide (more) rapidly (than healthy cells) ... (1)

… so are preferentially targeted (1)

healthy cells recover more quickly (1)

6(a) (i) $I = P / A$ (1)

$= 5.0 / \pi (0.125 \times 10^{-3})^2$ (1)

$= 1.02 \times 10^{8}$ (1)

unit: $W\ m^{-2}$ (1)

(ii) reference to eye lens so additional focusing (1)

(b) (i) $E = h c / \lambda$ (1)

$= 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / 515 \times 10^{-9}$ (1)

$= 3.86 \times 10^{-19}$ J (1)

(ii) total power = 5.0 W

so power of each type of photon beam is 2.5 W (1)

$2.5 / 3.86 \times 10^{-19}$ (1)

$= 6.5 \times 10^{18}$ (1)

assumption: e.g. zero absorption by filter of green light (1)

(iii) (birth marks are red and) red light is reflected at red surfaces (1)

so less red light absorbed (1)

or alternative argument with green light

(c) **any three** e.g.

(laser light boils water content of cell so) surgery is sterile (1)

focusing is very fine / much finer than a scalpel (1)

seals blood vessels as it cuts so less blood (1)

so vision is easier during incision (1)

any relevant to a max. of 3.

2825/03 Materials

1(a) **(i)** Example of single-crystal structure: e.g. quartz, diamond, silicon; (1)
(ii) Example of polycrystalline structure: e.g. metal or example, alloy or example; (1)
(iii) e.g.Polycrystalline structures contain grain boundaries. (1) [3]

(b) **(i)** Metallic glass is amorphous; [1]
(ii) All directions of magnetisation are equally possible / Atomic dipoles can align in any direction / easy to reverse magnetism; (1)
Magnetic saturation is easily achieved; (1)
Material has high resistivity / conductivity. (1)
max [2]

(c) One correct (1); Both correct (2); Both correct but reversed (1). [2]
[At least 3 **X**s required in each figure. Only 2 **X**s maximum 2. One **X** maximum 1.]

(d) No of atoms in 1 kg = $1/1.50 \times 10^{-26} = 6.667 \times 10^{25}$ (1)
Volume of atom = $(4\pi / 3) \times (1.13 \times 10^{-10})^3 = 6.044 \times 10^{-30}$ m^3 (1)
Space occupied by atoms in 1 kg = $\dfrac{6.667 \times 10^{25} \times 6.044 \times 10^{-30}}{0.74}$
$= 5.445 \times 10^{-4}$ m^3 (1)

Density = $1/ 5.445 \times 10^{-4} = 1840$ kg m^{-3} (1) [4]

[Total: 12]

2(a) **(i)** Separation = 2.8×10^{-10} m [1]
(ii) Maximum attractive force = 8.5×10^{-10} N [1]

(b) For small changes in separation from equilibrium separation graph is a straight line; (1) so extension (or compression) of wire is proportional to stretching (or compressing) force, (complying with Hooke's law). (1) [2]

(c) **(i)** Radius of atom = ½ equilibrium separation = 1.4×10^{-10} m (e.c.f.) (1)
Cross-section of atom = $\pi (1.4 \times 10^{-10})^2 = 6.16 \times 10^{-20}$ m^2 (1)
OR $= (2.8 \times 10^{-10})^2 = 7.84 \times 10^{-20}$ m^2
No of atoms in cross-section = $1.8 \times 10^{-7} / 6.16 \times 10^{-20}$ $(= 2.9 \times 10^{12})$ (1) [3]
OR $= 1.8 \times 10^{-7} / 7.84 \times 10^{-20}$ $(= 2.3 \times 10^{12})$

(ii) Force to break wire = $2.9 / 2.3 \times 10^{-12} \times 8.5 \times 10^{-10} = 2500 / 2000$ N (e.c.f) [1]

(iii) Calculation assumes complete layers of atoms; (1)
in the plane of the cross-section of the wire; (1)
with bonds between atoms in adjacent layers all breaking simultaneously; (1)
(In practice), there are vacancies / impurity atoms / point defects in layers ; (1)
Layers are not in the plane of the cross-section; (1)
Dislocations / grain boundaries upset the regular array; (1)
(After elastic extension) wire undergoes plastic extension / slip; (1)
causing slipping of layers of atoms; (1)
Wire forms a neck (1)
Bonds between atoms break successively / unzip. (1) max [8]

[Total: 16]

3(a) **(i)** R = V/I = 6.0 / 0.0063 = 950 Ω [1]

(ii) σ = L/RA (1)
= 0.012 / (950 x 7.5 x 10^{-6}) (Allow e.c.f.) (1)
= 1.68 Ω^{-1} m^{-1} (1) [3]
[Allow (1) If resistivity calculated correctly.

(b) v = I/nAe (1)
$v_{Cu} / v_{Ge} = (nA)_{Ge} / (nA)_{Cu}$ (1)
= 4.3 x 10^{21} x 7.5 / (7.8 x 10^{28} x 0.8) = 5.2 x 10^{-7} (1) [3]

(c) In copper increased temperature has no effect on number of electrons / charge carriers in the conduction band; (1)
Increased (lattice) vibrations of copper atoms inhibit electron flow (to a small extent;(1)
Minimal / negligible change in resistance of copper wire; (1) max [2]

In germanium increased temperature gives more energy to electrons in the valence band; (1)
so more electrons are promoted to the conduction band; (1)
and more holes are left in the valence band; (1)
More conduction electrons / charge carriers in the germanium allow more current flow (so resistance of the germanium reduced). (1) max [3]

[Total: 12]

4(a) The temperature at which the resistance / resistivity of a material falls (suddenly) to zero (or wtte). [1]

(b) **(i)** I = 1 x 2.1 / (1.3 x 10^{-6} x 15000) = (108 A) [1]

(ii) Copper wire must be very thick to carry 110 A without excessive heating; (1)
15000 turns of very thick wire would occupy a huge space. (1) [2]

The copper wire solenoid would generate large quantities of heat; (1)
requiring complicated cooling systems / so could not be operated continuously. (1) [2]

(iii) **1** The resistance of the copper is very high compared with the resistance of the superconducting alloy. [1]

2 The temperature of the alloy may rise (by accident) above the transition temperature; (1)
The copper could then act (temporarily) as a conductor until the power is switched off. (1)
Copper conducts excess heat away (from niobium-titanium filaments). [2]

[Total: 9]

5(a) **(i)** A spinning electron / electron orbiting a nucleus produces a magnetic field; (1)
An atom produces a magnetic field if the resultant fields of all its electrons is not zero. (1) [2]

(ii) A magnetic domain is a region (in a ferromagnetic material) in which all the atomic magnets / dipoles are aligned. [1]

(b) Fig 5.2 to show that domains in the direction of B have grown; (1)
Domains not in the direction of B have shrunk. (1) [2]

(c) **(i)** One curve of correct shape; (1)
Two curves with correct relative remanences.and coercivities. (1)
Curves correctly labelled. (1) [3]

(ii) **1** Hard iron retains more magnetism when magnetising field switched off; (1)
Relevant reference to graphs; (1) [2]

2 Soft iron requires smaller reverse field to reduce magnetism to zero;
Relevant reference to graphs; (1) [2]

[Total:12]

6(a) $E = hc/\lambda$ (1)
$\lambda = hc/E = 6.6 \times 10^{-34} \times 3.0 \times 10^{8} / 1.3 \times 10^{-19} = 1.52 \times 10^{-6}$ m (1) [2]

(b) Laser radiates more power; (1)
Laser beam is narrower; (1)
Laser beam is parallel, LED beam is diverging; (1)
so a more powerful beam can be directed into a glass fibre; (1)
Lasers switch much faster than an LED; (1)
so can transmit more information per second; (1)
Laser radiation has a smaller range of frequencies than an LED radiation; (1)
so having a smaller range of speeds in a fibre; (1)
and producing less distortion of a signal. (1) max [7]

[Total: 9]

2825/04 Nuclear and Particle Physics

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme. You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

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

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

8. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

Abbreviations, annotations and conventions used in the Mark Scheme	/ = 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

Question	Expected Answers	Marks
1(a)	A is the equilibrium position / (resultant) force at A is zero; separation between two neutrons / diameter of a neutron;	1 1 [2]
(b)	gradient of line = $\frac{[+20 - (-20)] \times 10^3}{(-1.5 + 1.3)\,10^{-15}}$ = $(-)2.0 \times 10^{20}$ (N m^{-1}) minus sign magnitude accept -2.0×10^{17} kN m^{-1}) no units but minus sign accept -200 kN fm^{-1}) given can get 1/2	1 1 [2]
(c)	$F_E = \frac{Q^2}{4\pi\varepsilon_0 x^2}$ $= \frac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} (1.4 \times 10^{-15})^2} = 117$ N accept $1/(4\pi \times 8.85 \times 10^{-12}) = 9 \times 10^9$ gives 117.6 accept ans. = 118 N	1 1 [2]
(d)(i)	*either* strong force + electrostatic force = 0 *or* attractive strong force = repulsive electrostatic force *or* they are equal and opposite	1 [1]
(ii)	at equilibrium, strong force = 117 N (1) so separation of B from A = $\frac{117}{2.0 \times 10^{20}} = 5.9 \times 10^{-19}$ m (= 5.9×10^{-4} fm) B is greater than / to the right of A (on graph) (1) because electrostatic force is repulsive (1) (slight) increase in strong (attractive) force to compensate for electrostatic force (1) any 2	1 (+1) 2 [3] **10**

2(a)	reaction 1 $^{238}_{92}U + ^{1}_{0}n \tau ^{239}_{92}U$ reaction 2 $^{239}_{92}U \tau ^{0}_{-1}e + ^{239}_{93}Np + \bar{\nu}$ reaction 3 $^{239}_{93}Np \tau ^{0}_{-1}e + ^{239}_{94}Pu + \bar{\nu}$ no neutrino gets 1 + 1 + 0 = 2/4 max. wrong neutrino(s) gets 1 + 1 + 1 = 3/4 incorrect symbol for beta i.e. e^- or β^- -1 once	1 2 1	[4]
(b) (i)	measured from graph $T_{½}$ = 2.36 days (accept 2.3 - 2.4) so $T_{½}$ = $2.36 \times 24 \times 3600 = 2.04 \times 10^5$ s accept $(1.98 - 2.10) \times 10^5$	1 1	[2]
(ii)	$\lambda = \frac{\ln 2}{T_{½}} = \frac{0.693}{2.04 \times 10^5}$ $(= 3.4 \times 10^{-6}\ s^{-1})$	1	[1]
(iii)	$A = \lambda N$ from graph $A = 2.77 \times 10^{12}\ s^{-1}$ accept $(2.75 - 2.80) \times 10^{12}$ so $N = \frac{2.77 \times 10^{12}}{3.4 \times 10^{-6}} = 8.15 \times 10^{17}$ accept $(8.05 - 8.24) \times 10^{17}$ *alternative* finds A by calculation from $A_0 = 5.0 \times 10^{12}$ Bq etc. can score 3/3	1 1 1	[3]
(c)(i)	24000 y	1	[1]
(ii)	horizontal line	1	[1]
			12

3(a)	mass = 1.67×10^{-27} kg not 1.66×10^{-27} kg charge = -1.60×10^{-19} C minus sign essential	1 1	[2]
(b)	in particle accelerator / near high-energy particle collision *or* AW / in cosmic rays / in Sun;	1	[1]
(c)(i)	two γ-photons are produced;) *or* from with equal energy / frequency;) sketch travelling in opposite directions;) in **(iii)**	1 1 1	[3]
(ii)	total energy of a proton = (rest energy + k.e.) = $mc^2 + \frac{1}{2}mv^2$ equation so total energy = $2 \times 1.67 \times 10^{-27} \times (3.00 \times 10^8)^2 + 2 \times 8.00 \times 10^{-11}$ subs. (= $3.00 \times 10^{-10} + 1.60 \times 10^{-10} = 4.60 \times 10^{-10}$ J) for two photons, total energy = 4.60×10^{-10} J energy of one photon = hf i.e. $2hf$ for two photons so $2 \times 6.63 \times 10^{-34} f = 4.60 \times 10^{-10}$ and $f = 3.47 \times 10^{23}$ Hz ans. ignores rest mass and gets $f = 1.2 \times 10^{23}$ Hz can get 2/4 ignores k.e. and gets 2.3×10^{23} Hz can get 2/4 factor 2 omission: -1	1 1 1 1	[4]
(iii)	photons in **(ii)** would be of higher frequency; sketch to show approximate relation between velocity of particles and directions of photons;	1 2	[3]
			13

4(a)	${}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \tau {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$	1	[1]
(b)	reactants mass: 2.0141 + 3.0160 = 5.0301 u products mass: 4.0026 + 1.0086 = 5.0112 u so mass defect = 5.0301 - 5.0112 = 0.0189 u = $0.0189 \times 1.66 \times 10^{-27}$ kg (= 3.14×10^{-29} kg) energy = mc^2 = $3.14 \times 10^{-29} \times (3.00 \times 10^{8})^2$ = 2.82×10^{-12} J ans. *or* $E = 0.0189 \times 932$ (= 17.6 MeV) = 2.82×10^{-12} J	1 1 1 1	[4]
(c)	mean neutron k.e. = $\frac{80}{100} \times 2.83 \times 10^{-12}$ = 2.26×10^{-12} J	1	[1]
(d)	neutron has smaller ($^1/_4 \times$) mass than ${}^{4}_{2}\mathrm{He}$; (1) because of conservation of mtm. it has larger ($4 \times$) speed than ${}^{4}_{2}\mathrm{He}$; (1) k.e. = $\frac{1}{2} m v^2$ *or* k.e. proportional to v^2; (1) deduces that faster moving neutron carries more energy (than ${}^{4}_{2}\mathrm{He}$); (1) because k.e. proportional to v^2, this outweighs greater mass of ${}^{4}_{2}\mathrm{He}$; (1) any 3 remaining energy absorbed by / becomes k.e. of ${}^{4}_{2}\mathrm{He}$ nucleus;	3 1	[4]
(e)	(surround reactor with) 'lithium blanket'; *either* lithium nucleus absorbs a neutron *or* gives nuclear equation: ${}^{6}_{3}\mathrm{Li} + {}^{1}_{0}\mathrm{n} \tau {}^{4}_{2}\mathrm{He} + {}^{3}_{1}\mathrm{H}$ *or* ${}^{7}_{3}\mathrm{Li} + {}^{1}_{0}\mathrm{n} \tau {}^{4}_{2}\mathrm{He} + {}^{3}_{1}\mathrm{H} + {}^{1}_{0}\mathrm{n}$; helium / tritium / product nuclei collide with other lithium nuclei / atoms so energy becomes randomised / energy becomes heat / temperature of lithium rises;	1 1 1	[3]
			13

5(a)	$^{14}_{6}C$ $^{14}_{8}O$ $^{14}_{7}N$ 2/3 correct gets 1/2	2	[2]
(b)	$^{14}_{6}C \tau {}^{14}_{7}N + {}^{0}_{-1}e + \bar{\nu}$ first equation (1) $^{14}_{8}O \tau {}^{14}_{7}N + {}^{0}_{1}e + \nu$ second equation (1) incorrect beta particle symbol (i.e. e^- or β^-) loses -1 once $^{0}_{-1}e$ or $^{0}_{1}e$ omitted gets 0/1 for relevant equation neutrino incorrectly shown loses -1 once neutrino omitted from an equation 0/1 omitted altogether 0/2	2	[2]
(c)	$n \tau p + e^- + \bar{\nu}$ and $p \tau n + e^+ + \nu$; n is udd, p is uud; udd τ uud + e^- + $\bar{\nu}$ and uud τ udd + e^+ + ν gets first two marks then deduces that: $d \tau u + e^- + \bar{\nu}$ $u \tau d + e^+ + \nu$ allow neutrino ecf from **(b)**	1 1 1 1	[4]
(d)	C N and O points shown and labelled with N as the smallest mass; when decay occurs there is (always) a loss of (rest) mass;	1 1	[2]
			10

6	1	uranium-235 is the (main) fissile material;	1	
	2	thermal neutron is *either* a slow-moving (neutron) *or* has k.e. ≃ mean k.e. of atoms / molecules due to thermal agitation;	1	
	3	(fissile) nucleus absorbs a neutron;	1	
	4	only / mainly thermal neutrons cause (further) fission	1	
	5	nucleus splits / fissions into two nuclei / parts;	1	
	6	emitted neutrons can cause further fissions / cause chain reaction;	1	
	7	(most neutrons) need slowing down / moderating; (1)		
	8	reference to delayed neutrons or AW; (1)		
	9	importance of delayed neutrons in relation to controlling rate of reaction; (1)		
	10	*either* product nuclei 'bunched' around two mass numbers *or* graph showing peaks, sensibly symmetrical	1	
	11	symmetry of graph about nuclide whose mass ≃ ½ mass of $^{235}_{92}U$;		
	12	(1)		
	13	fission generates (kinetic) energy; (1)		
	14	hence temperature of uranium rises; (1)		
	15	coolant carries heat from uranium / reactor core; (1)	1	
	16	heat used to change water to steam; *either* steam drives turbines linked to (electrical) generators *or* steam drives turbines and generates electricity;	1 3	[12]
		any 3		**12**

2825/05 Telecommunications

Mark Scheme	Unit Code 2825	Session January	Year 2008	Version
Question 1				Marks

(a) High Frequency (or Short wave) ①

from 3 MHz ①

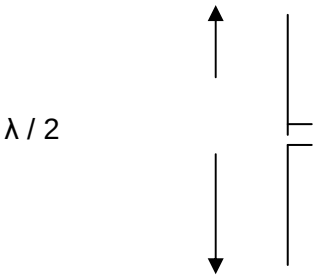
to 30 MHz ① (deduct 1 mark if Hz omitted)

(b) (i) Ionosphere drawn and labelled ①

Multiple reflections shown between Earth's surface and ionosphere ①

(ii) HF radio waves reflect from ionosphere back to Earth
from where they make multiple reflections in travelling around the Earth ①

(c) Drawing of dipole aerial ①



Typical frequency f = 10 MHz
So typical wavelength λ = c / f
= $3 \times 10^8 / 10 \times 10^6$ ①
= 30 m

Hence dipole length = λ / 2 = 15 m ①

Mark Scheme	Unit Code 2825	Session January	Year 2008	Version
Question 2				Marks

(a) Open copper wires have a huge attenuation
so signals do not travel very far before amplification is necessary

Open copper wires radiate into space as an aerial
So serious crosstalk occurs in other wires

Open copper wires suffer from serious interference/noise
Because they are simply an aerial picking up signals in their vicinity

Open copper wires have a limited bandwidth over long distances
Which limits their information carrying ability

(any one point plus qualification) ① ①

(b) Glass is an extremely common substance
and is thus cheaper than copper

Optic fibre cables are much thinner and lighter
So are easier for technicians to handle

Optic fibre has a much lower attenuation
So allows much longer uninterrupted transmission

Optic fibre has a much higher bandwidth
So has a much greater information carrying ability

Optic fibres are immune to electromagnetic interference
So can be used in noisy environments

Optic fibres do not radiate energy
So there is no crosstalk between adjacent fibres

Optic fibres are very secure
Because they cannot be tapped

Optic fibres are ideal channels for time-division multiplexing
Which uses digital signals in the form of light pulses

any four ① ①
① ①
① ①
① ①

Mark Scheme	Unit Code 2825	Session January	Year 2008	Version
Question 3				Marks

(a) (i) Peak output voltage = 2 cm x 2 V cm^{-1} = 4 V ①

(ii) Peak input voltage = 1 cm x 0.05 V cm^{-1} = 0. 05 V ①

(iii) voltage gain = 4 / 0.05 ①

= 80 (ignore -ve sign) ①

(iv) frequency of signal = 1 / 4 x 5 x 10^{-3} ①

= 50 Hz ①

(b) The amplifier is inverting because the output is 180^0 out of phase with the input ①
(or the output is in anti phase with the input or wtte)

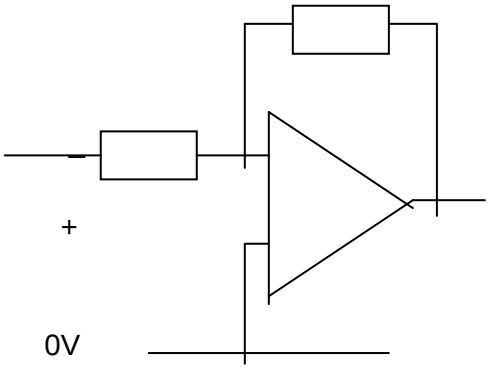
(c) Op-amp and 0V line symbol correctly drawn ①

Non-inverting input correctly connected to 0V line ①

Input resistor correctly connected to inverting input ①

Feedback resistor correctly connected ①

Ratio of resistors R_f / R_1 equals gain of 80 ①



Input and output labelled and resistor values quoted in range 100Ω to 10 M Ω ①

Mark Scheme	Unit Code	Session	Year	Version
	2825	January	2008	
Question 4				Marks

(a) (i) Attenuation The gradual loss in energy / power along a transmission path ①

caused by electrical resistance / heat losses ①
radiation losses from cable

(ii) Noise Any unwanted energy added (at random) to signal ①

(iii) Noise power in a transmission path is more or less constant ①

If signal is transmitted too far attenuation causes signal power to fall below noise ①

In which case the signal can not (normally) be recovered ①

(b) Each amplification of 42 dB must just compensate for the 5.6 dB loss every km. ①

Thus L = 42 / 5.6 = 7.5 km ①

(c) (i) Total attenuation = 4 x 8.5 x 5.6 = 190.4 dB ①

(ii) Total amplification = 4 x 42 = 168 dB ①

(iii) Overall power loss = 190.4 - 168 = 22.4 dB ①

Thus final power output P_{out} is given by

$-22.4 = 10 \log P_{out} / P_{in} = 10 \log P_{out} / 86$ ①

$P_{out} = 86 \times 10^{-2.24}$

$= 0.495 W$ ①

(iv) The power input P_{in} to the final amplifier is given by

$42 = 10 \log 0.495 / P_{in}$ ①

$P_{in} = 0.495 \times 10^{-4.2}$

$= 3.12 \times 10^{-5}$ W ①

Signal-to-noise ratio = $10 \log 3.12 \times 10^{-5}$ W / 31.2 μW

= 0 dB ①

(d) Such a ratio would make it very difficult to extract meaning from the signal ①

Mark Scheme	Unit Code 2825	Session January	Year 2008	Version
Question 5				Marks

Polar orbiting satellites

Diagram drawn showing low Earth orbit over poles with poles marked
Height of orbit is usually a few hundred kilometres
Satellite is moving very fast and completes an orbit in about 90 minutes
It repeatedly passes over one pole and then the other in any orbit
The Earth spins slowly underneath satellite
So every point on Earth is visible for a brief period repeatedly
These satellites are ideal for remote sensing
Military reconnaissance
Meteorology
Oceanography
Cartography
Geological prospecting

① ① ① ① ①

Geostationary satellites

Diagram drawn huge orbit around equator with equator marked
Height of orbit is many thousands of kilometres (36 000 km)
Satellite is moving at less than half the speed of polar and completes an orbit in 24 hours
It rotates in synchronism with Earth so appears stationary from any point on Earth
Thus satellite always sees same face of Earth
These satellites are ideal for
Weather monitoring
Microwave links for telephone and Internet traffic
Broadcasting high bandwidth signals over large area
Thus one transmitter on one carrier frequency does the work of thousands of Earth transmitters

① ① ① ① ① ①

Mark Scheme	Unit Code	Session	Year	Version
	2825	January	2008	
Question 6				Marks

(a) (i) Any drawing of roughly constant high frequency with amplitude slowly wobbling ①

(ii) A high frequency carrier ①
has its amplitude controlled ①
by the value of a lower frequency information signal ①

(b) (i) Any drawing of high frequency wobbling at a roughly constant amplitude ①

(ii) A high frequency carrier
has its frequency controlled
by the value of a lower frequency information signal ①

(c) Any noise picked up on AM cannot easily be removed
Information resides in amplitude of AM signal so noise adds to this and pollutes it
Hence AM is inherently noisy on reception
But AM occupies a relatively low bandwidth
So makes more economic use of frequency space

FM contains no information in the amplitude of the carrier
So any noise picked up can be removed (by limiter) in the receiver
Hence FM results in a very clear signal
But FM occupies a relatively large bandwidth (at least for wideband FM)
So can only reasonably be used where there is already a large channel bandwidth

FM has potentially a greater dynamic range than AM

① ① ① ①

2825 Common Question

(a) (i) Energy provided =) Power x time / Pt / 250 x 1.7 x 10^4 (= 4.25 x 10^6 J) (1)
Period of rest = 4.25 x 10^6 / 75 = 5.67 x 10^4 s = 15.7 / 16 hr (1) [2]

(ii) Heat / energy is lost (to the surroundings / from the body); (1)
at the same rate as it is produced by conversion of energy from food / or wtte. (1) [2]

(b) (i) (Potential energy gained =) mgh / 70 x 9.81 x 800 (1)
= 5.49 / 5.5 x 10^5 J (1) [2]

(ii) mass of carbohydrate used to provide ΔE_p = 5.5 x 10^5 /1.7 x 10^4 = 32.3 / 32 g [1]
[If 20 % efficiency value used at this stage to give 161 / 160 g allow 1 mark for (ii) and forward credit 1 mark as first mark in (iii)

(iii) mass used to produce heat due to 20 % efficiency = 4 x 32.3 = 129.2 g / 130 g
use of 20 % efficiency value to calculate 161 / 160 g (1)

mass used in maintaining base metabolic rate = 1.5 x 3600 x 75 / 1.7 x 10^4
= 23.8 / 24 g (1)

total mass used = 32.3 + 129.2 + 23.8 / 161.5 + 23.8 = 185.3 g / 190 g (e.c.f.) (1) [3]

(c) (i) Q = mcΔθ / Δθ = Q/mc / correct substitution in either expression (1)
In 1 s, Δθ = 900 / 65 x 4200 = 0.0033 K (1) [2]
OR Use Δθ/Δt = (ΔQ/Δt)/mc (1) = 0.0033 K s^{-1} (1)

(ii) Comparison of body and external temperatures; (1)
Comment on direction of heat flow. (1) [2]

(iii) Heat to be lost in 2.5 hours = 900 x 2.5 x 60 x 60 (= 8.1 x 10^6 J) (1)
mass of water evaporated = 8.1 x 10^6 / 2.4 x 10^6 = 3.4 kg (1) [2]

(iv) To avoid dehydration / replace fluid loss from body; (1)
Drink a large quantity of water; (1) [2}

One of each following reason + action **but no mark for action alone.**

To maximise ability of water vapour to escape from the body surface; (1)
Wear loose clothing. (1)

To allow easy transport of water away from the skin; (1)
Wear porous clothing. (1)

To increase rate / amount of evaporation / cooling of body; (1)
Pour water over body during race. (1)

To provide energy during run; (1)
Eat carbohydrate before / during race. (1)

To minimise heating by Sun / avoid sunburn; (1)
Shield body from direct sunlight. (1) max [2]

2826/01 Unifying Concepts in Physics

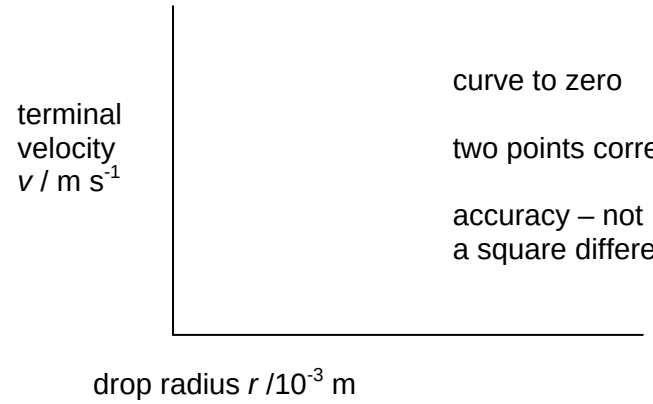
1(a) N = [k] m m s^{-1} each item correct [1]
unit of k = N s m^{-2} or equivalent e.g. kg m^{-1} s^{-1} [1] {2}

(b) (i) Drag upwards equal and opposite to weight downwards [1]

(ii) drag = krv, weight = $4\pi r^3\rho g/3$ [1]
$\therefore v = \frac{4\pi\rho g}{3k} r^2$ hence $v \propto r^2$ [1] {3}

(c) k x 0.001 x 8.7 = 4π x $(0.001)^3$ x 1000 x 9.81/ 3 [1]
$k = \frac{4\pi \times 10^{-3} \times 9.81}{3 \times 8.7}$ [1]
k = 4.72 x 10^{-3} (N s m^{-2}) [1] {3}

(d)



curve to zero [1]
two points correct [1]
accuracy – not more than a square different from this [1] {3}

(e) there must be an upward force [1]
therefore air (under cloud) must be rising [1]
rising air will give glider lift [1]
other relevant point [1] MAX 3 {3} (14)

2(a) (i) area = πr^2 [1]
= π x $(6.4 \times 10^6)^2$ = 1.29 x 10^{14} m^2 [1]

(ii) 1.29 x 10^{14} x 1.2 x 10^3 x 365 x 24 x 3600 [1]
= 4.9 x 10^{24} J [0] {3}

(b) 4.9 x 10^{24} / 3 x 10^{20} = 1.6(3) x 10^4 [1] {1}

(c) (i) panel angled so that sunlight strikes panel at right angles [1]

(ii) e.g. cloudy skies
angle cannot easily be kept at right angles to rays
night time
fog or mist
dirt accumulating on surface 1 mark for each to MAXIMUM 3 [3]

(iii) to provide energy when panel is not being illuminated [1]
OR to enable it to provide more than 80 W when required {5}

(d) (i) output is 120 W m^{-2} so 80 W from 0.67 m^2 [1]

(ii) 80 W 12 V maximum power = maximum current x *V* [1]
maximum current = 80 / 12 = 6.7 A [1]

(iii) 1000 W h / 20 W = 50 hours [1]

(iv) £500 would buy 5000 kWh [1]
time = 50 x 5000 = 250 000 hours [1] {6}
(allow full credit for use of £400 giving 200 000 hours)

(e) e.g. (30 years) is a long time for it to have to work [1]
so unlikely to be economic unless there are special circumstances [1]
allow alternative answers such as 'no greenhouse gases' or 'use where there is no mains supply of electricity' {2} (17)

3(a) (i) a particular type of nucleus [1]

(ii) two atoms with the same number of protons (in their nucleus) but with different numbers of neutrons [1]

(iii) an atom with a different number of electrons from the number of protons [1] {3}
OR the equivalent in terms of gaining or losing an electron

(b) (i) 1.6 x 10^{-19} x 5.4 x 10^{7} = 8.64 x 10^{-12} A [1]

(ii) use of 1 mol having 6.02 x 10^{23} atoms [1]
1 mol is 39 gram [1]
mass = 0.039/6.02 x 10^{23} = 6.48 x 10^{-26} kg [1] {4}
OR using 18e + 19p + 20n Allow 2/3 for 6.48 x 10^{-23} kg

(c) force on particle = Bqv [1]
= mass x acceleration = m x v^2/r [1]
$r = \frac{mv}{Bq} = \frac{6.48 \times 10^{-26} \times 5 \times 10^{5}}{0.84 \times 1.6 \times 10^{-19}}$ [1]
= 0.24 m e.c.f from (b) gives 240 m [1] {4}

(d) there must be some ions with a larger mass [1]
another isotope of potassium [1] {2} (13)

4(a) (i) allow anything in audible range [1]

(ii) ring around 3×10^2 m s^{-1} [1]

(iii) correct calculation (250 Hz and 300 m s^{-1} give 1.2 m) [1] {3}

(b) diffraction as the spreading of a wave [1]
interference caused by superposition [1]
diagram or clear explanation of double slit arrangement [1]
diffraction through slits allows the necessary overlap for interference to occur [1] {4} (7)

5(a) e.g. discharge of a capacitor
radioactive decay
cooling a hot object (in a draught) 2 required 1 mark each [2] {2}
absorption of gamma radiation

(b) values taken from the graph are required
e.g. 4.8 −> 2.4 on y-axis requires 0 −> 2.3 on x-axis [1]
2.4 −> 1.2 is 2.3 −> 4.6 on x-axis [1]
i.e. constant fraction of fall for equal times give Fig. 5.1(a) the exponential [1]

Fig. 5.1(b) is asymptotic on both axes so cannot be exponential
OR is an inverse square law [1]

Fig. 5.1(c) does not fit the half life pattern [1] {5}

For both Fig. 5.1 (b) and Fig. 5.1 (c) the marking can be 1 mark for the idea
and one mark for the evidence

(c) (i) for equal intervals (of time) on the x-axis there will be a constant multiplying factor
OR could be done by the equation $y = Ae^{+kt}$ [1]

(ii) e.g. compound interest,
biological growth (in early stages)
spread of epidemic (in early stages)
chain reaction (in early stages) [1] {2} (9)

2826/03 Experimental Skills 2 Practical Examination

Question 1

(a) (i)	Position of Centre of gravity Value for OG; one mark. (this should be between 25 and 35 cm, but check supervisor's notes first).	**1**
(a) (ii)	Calculation of h**.** Correct value for h, = OX – OG; one mark. Allow incorrect s.f.	**1**
(b) (i)	Period of oscillation. Raw times > 10s; one mark. *Allow 5 osc at ≈ 8 s. as a BOD* (Repeats credited in b (ii))	**1**
(b) (ii)	Readings Write the number of readings as a ringed total by the results table. 6 sets of values of T and h score 2 marks, 5 sets 1 mark, 4 sets score zero. Raw readings for OX and time; one mark. Accept *T* if no evidence of *nt*. If help is given, then lose one mark. Please indicate when help has been given to a candidate by writing **SR** at the top of the front page of the candidate's script. Also, please indicate the type of help that has been given by writing a brief comment by the table of results.	**3/2/1/0**
(b) (ii)	Repeated Readings (not if all repeats are identical)	**1**
(b) (ii)	Quality Good quality of results (as judged by scatter of points). If no minimum, zero marks	**2/1/0**
(b) (ii)	Column headings. All columns for must be headed with a quantity and correct unit. There must be some distinguishing mark between the quantity and the unit. Please ✓ each correct column heading to show that it has been seen.	**1**
(b) (ii)	Consistency of raw readings in the table of results. Applies to time and distance OX (or h). Time to 1 or 2 d.p. Distance to nearest mm. Allow 3 dp if raw *t* not given & *nT* is in b(i) Values in the table must agree with the unit at the head of the column. One mark for time column; one mark for distance column. Please ✓ each column checked.	**2/1/0**
(c) (i)	Axes. Each axis must be labelled with a quantity. Ignore unit. One mark for each axis. Scales much be such that the plotted points occupy at least half the graph grid in both the x and y directions. Do not allow more than 3 large squares between scale markings. Do not allow awkward scales (e.g. 3:10, 6:10, 7:10, 8:10 etc.).	**2/1/0**

(c) (i)	Plotting of points**.** Count the number of plots on the grid and write this value by the line and ring it. Do not allow plots in the margin area. The number of plots must correspond with the number of observations. Do not award this mark if the number of plots is less than the number of observations. Check one suspect plot. Circle this plot. Tick if correct. If incorrect then mark the correct position with a small cross and use an arrow to indicate where the plots should have been. Allow errors up to and including half a small square. Do not allow "blobs".	**1**
(c) (ii)	Curve of best fit. There must be a reasonable balance of points about the curve. This mark can only be awarded if a curve has been drawn through a curved trend. Do not allow thick (≥ 1 mm) or 'hairy' lines. Allow one stray point.	**1**
(c) (iii)	Measurement of gradient of tangent. Read-offs must be accurate to half a small square and the ratio must be correct. Please indicate the vertices of the triangle used by labelling with Δ. No marks lost for triangle size. One mark for quality of tangent to curve (Tangent must be of reasonable length i.e. at least 10cm long.) No tangent loses all three marks. One mark for read-offs and ratio correct. One mark for negative value given for negative gradient.	**3/2/1/0**
(d)	Values for T_{min} and h; one mark Use of correct formula; i.e. $g = 8\pi^2 h/T^2$. One mark *(i.e. $g = 79.0\ h / T^2$)* Correct calculations, following from correct formula, to be checked (be wary of g = 9.81 N/kg); one mark (Allow use of cm to give g in cm s^{-2}) Units for g, N/kg or m s^{-2} (or cm s^{-2}); one mark Do not allow N/kg or ms^{-2}, if no evidence of cm conversion to m. Significant figures for g, 2 or 3 sf; one mark (any final rounding must be correct).	**1** **1** **1** **1** **1**
(e)	. T^2h (y-axis) plotted against h^2 (or $4\pi^2h^2$) (x-axis). One mark (NOT T^2 against h). Gradient is $4\pi^2/g$, hence g. One mark	**1** **1**
(f)	Comment on methods for g. Straight line graph more accurate, because all values used; one mark, Because difficult to get an accurate minimum from curve; one mark	**2/1/0**
	Total	**[28]**

Question 2 – Lenses. Mark Scheme

2 (b)	Measurement of u_1 and v_1. (If f = 10cm and u = about 12 cm, v will be about 60 cm). Allow s.f. errors.	**1**
2 (c)	Sensible figure for Δv, e.g. ±0.5cm or ±2 cm, one mark. Correct ratio and x 100, one mark. No need to check arithmetic	**2**
2 (d)	Measurements of u_2 and v_2. u_2 should increase; v_2 should decrease.	**1**
2 (e)	One mark for ratio idea, i.e. uv/(u + v) is constant, or calculation of k's One mark for conclusion that uv $\propto$ (u + v) which follows from the reasoning (only if k values are within 10% of each other). Vague 'uv might be proportional to (u + v)' or 'uv is not proportional to (u + v)' does not score this second mark. AE loses first mark but second mark allow ecf.	**2/1/0**
2 (g)	Evaluation of procedure. Relevant points must be underlined and ticked. Some of these might be (in the form of problem followed by solution): 1 P. 2 sets of u and v not enough. 2 S. Measure more than 2 sets of u and v , and plot a <u>graph</u> 3 S. plot a graph of <u>uv against (u + v).</u> 4 P. One measurement of each pair of values of u and v is not enough 5 S. Repeat readings should be taken, and <u>averaged</u>. 6 P. Difficult to measure u and v accurately to centre of lens, or bulb filament. 7 S. Measure lens (or bulb) thickness, and add t/2 to readings. 8 S. Use optical bench, with explanation / clamp ruler 9 P. v is difficult to measure, because of the range within which it is in focus. 10 S. Take the mid-point of the range. 11 P/S Parallax error; use set square or mirror. A The stop gives a sharper image, or wtte, (advantage), B The stop increases the depth of field or wtte (advantage), but C the image is less bright (disadvantage). 12 P/S The image has coloured fringes, and these are reduced by the stop. Do not allow brighter bulb, darken windows etc.	
2 (g)	Quality of written communication (SPAG)	**2**
	Total 16 marks	

Planning Exercise Mark Scheme – Sound & Windows

A1	Labelled diagram showing workable arrangement of apparatus e.g. signal generator (or wtte), speaker, one mark microphone connected to CRO, one mark	**2/1/0**
A2	Correct procedure. Compare input and output volumes for a certain frequency and air gap. Change frequency and repeat for several different frequencies in audible range, then repeat for different spacings, one mark	**2/1/0**
A3	Sensible construction of specimen window in laboratory, e.g sensible size, use spacers, or slots in box.	**1**
B1	Use of time base to measure frequency. i.e. connect to y-plates, select time-base (or time scale), measure period, one mark. Hence frequency = 1/T, one mark.	**2/1/0**
B2	Measurement of sound amplitude, i.e. amplitude of CRO trace, in volts	**1**
D **1** **2** **3** **4** **5** **6** **7** **8** **10** **11**	Any further relevant detail, e.g. Quiet room needed, or sound proof box / best outside to avoid reflections. Sensible choice of air gaps. 5mm ≤ gap ≤ 5cm. Vernier or micrometer (internal calipers) to measure air gap. Non-rigid spacers, so that sound is not conducted. Microphone and speaker close to but not touching glass, e.g. sensible distance stated, ≤ 5 cm Evidence of preliminary work. Expected results presented graphically, labelled axes. (i) Wider gaps give better sound-proofing, (ii) frequency makes little difference). Frequency response of speaker and microphone Difficulties associated with standing waves/resonance	**4/3/2/1/0**
R	Evidence of research of material i.e. at least two detailed references from different sources have been given (i.e. chapter and/or page numbers must be given). Allow Internet pages to be sourced. Two or more vague references (i.e. no chapter or page references), one mark. One detailed reference scores one mark. One vague reference scores zero.	**2/1/0**
Q	**2 marks** are reserved for quality of written communication (organisation). Rambling and poorly presented material cannot score both marks.	**2/1/0**

Underline and tick each relevant point in the body of the text. The ticks must have a subscript showing which marking point is being awarded (e.g. $\checkmark_{A2}$).

16 marks in total

Q.2 Lenses – Results

u_1 = 12.0 cm and v_1 = 62 cm ±1 cm

then

u_2 = 15.0 cm and v_2 = 30.5 cm ± 0.5 cm

$k_1 = u_1v_1/(u_1 + v_1)$ = 10.05(4) $k_2 = u_2v_2/(u_2 + v_2)$ = 10.05(5)

within 0.05%

Grade Thresholds

Advanced GCE Physics A (3883/7883)
January 2008 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2821	Raw	60	42	37	32	27	23	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	45	40	35	31	27	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	97	86	75	65	55	0
	UMS	120	96	84	72	63	54	0
2823B	Raw	120	97	86	75	65	55	0
	UMS	120	96	84	72	63	54	0
2823C	Raw	120	92	83	74	65	56	0
	UMS	120	96	84	72	63	54	0
2824	Raw	90	62	55	48	42	36	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	63	57	51	45	40	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	65	59	53	48	43	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	65	57	50	43	36	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	62	55	48	42	36	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	64	57	50	44	38	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	92	81	70	60	50	0
	UMS	120	96	84	72	63	54	0
2826B	Raw	120	92	81	70	60	50	0
	UMS	120	96	84	72	63	54	0
2826C	Raw	120	89	80	72	64	56	0
	UMS	120	96	84	72	63	54	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3883	300	240	210	180	150	120	0
7883	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
3883	13.2	33.0	56.3	78.9	95.1	100	334
7883	12.8	47.4	70.5	87.2	97.4	100	89

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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