

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Mark Scheme for the Units

June 2009

3883/7883/MS/R/09

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of pupils of all ages and abilities. OCR qualifications include AS/A Levels, GCSEs, OCR Nationals, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new syllabuses to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support which keep pace with the changing needs of today's society.

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

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

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

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

© OCR 2009

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

CONTENTS

GCE Physics A (7883)

Advanced Subsidiary GCE Physics (3883)

MARK SCHEMES FOR THE UNITS

Unit/Content	Page
2821 Forces and Motion	1
2822 Electrons and Photons	8
2823/01 Wave Properties/Experimental Skills 1 Written Paper	14
2823/03 Wave Properties/Experimental Skills 1 Practical Examination	18
2824 Forces, Fields and Energy	24
2825/01 Cosmology	28
2825/02 Health Physics	33
2825/03 Materials	38
2825/04 Nuclear and Particle Physics	42
2825/05 Telecommunications	49
2826/01 Unifying Concepts in Physics	57
2826/03 Experimental Skills 2 Practical Examination	59
Grade Thresholds	63

2821 Forces and Motion

Question 1			Expected Answers	Marks	Additional Guidance
(a)			A vector <u>has a direction</u>	B1	Ignore additional comments unless there is a contradiction
(b)			Kinetic energy, mass and power all correct (no others underlined)	B1	
(c)	(i)	1	$T\cos 20 = W$ ($W = 650$) $T = 692$ (N) allow 2 sf	C1 A1	Solution involving triangles: correct triangle and three arrows C1 Scale diagram requires scale and correct triangle (no arrows)C1 allow +/- of 20 (N) for scale diagram do not allow 691 (N) but penalise only once on the paper
		2	$T\sin 20 = R$ $R = 692\sin 20 = 237$ 236(.6) (N) Allow 240 (N)	A1	Allow ecf for T from (c)(i)1 Allow +/- 220 to 250 (N) for scale diagram Correct answer for 1 and 2 in reverse can score 1 mark
	(ii)		With the angle made with rock face less the tension is closer to equalling the weight value or example quoted $\cos 10$ is greater than $\cos 20$ i.e. closer to one	A1	Expect clear answer here. Do not allow answers such as R decreases therefore T increases. Allow answers that refer to cos angle is greater (for smaller angles) hence T will be less
			Total	6	

Question 2			Expected Answers	Marks	Additional Guidance
(a)	(i)		$s = ut + \frac{1}{2} a t^2$ $t^2 = (400 \times 2) / 3.9$ $t = 14.3 \text{ (s) allow } 14 \text{ (s) (2 sf)}$	C1 A1	Allow any subject Do not allow 14.0
	(ii)		$v^2 = u^2 + 2as$ $v = (2 \times 3.9 \times 400)^{1/2} = 55.9 \text{ (m s}^{-1}\text{)}$ allow 55.8	A1	Allow: $s = (u + v) / t$ or $v = u + at$ but note possible time ecf from part (a)(i)
	(iii)		$\langle s \rangle = 100 / 1.82 = 54.9 \text{ (m s}^{-1}\text{)}$	A1	Allow: 55 but not 55.0
(b)			methods of reducing drag/streamlining: eg streamlined helmet, tight fitting clothing to reduce drag methods of increasing acceleration/force: use of poles, 'speed skating' (at start) push off ground method of reducing friction due to the skis e.g waxing skis / longer/ wider skis	B1 B1 B1 MAX 2	Require what is done and the reason for doing it
			Total	6	

Question 3			Expected Answers	Marks	Additional Guidance
(a)			Potential energy = mgh $= 930 \times 2.2$ $= 2046 \text{ (J)}$	C1 A1	PE = Wgh scores zero
(b)			power = work done / time or $= \text{energy (transformed)} / \text{time}$	B1	Do not allow work done over time If symbols are used they need to be defined
(c)	(i)		weight component = $930 \sin 40.3$ $= 602 \text{ (N)}$ [601.5]	A1	
	(ii)		power = $(601.5 \times 3.4) / 42$ or $2046 / 42$ $= 48.7$ unit: W	C1 A1 B1	Note ecf from (a) or (c)(i) Allow J s^{-1}
			Total	7	

[illegible]

Question 4		Expected Answers	Marks	Additional Guidance
	(ii)	Positive and negative section drawn approximately symmetrical in each half Correct shape in both sections	M1 A1	
QWC		SPAG fewer than three errors Logical order	B1 B1	Need at least two sentences
		Total	12	

Question 5		Expected Answers	Marks	Additional Guidance
(a)	(i)	Torque = 120×2 / clear definition of torque of a couple = 240 (N m)	C1 A1	
	(ii)	torque not zero / there is a resultant torque / moment	B1	Allow there is a couple or clockwise moment not equal to anticlockwise moment Do not allow there is a turning effect or there is a turning force
(b)		resultant force <u>and</u> torque are zero	B1	Allow total up force equals (total) down force and sum of clockwise moments equals sum of anticlockwise moments Do not allow forces are balanced
(c)		0.5×240 or $1.5 \times Y$ $0.5 \times 240 = 1.5 \times Y$ $Y = 80$ (N)	C1 C1 A1	First mark for either moment
		Total	7	

Question 6			Expected Answers	Marks	Additional Guidance
(a)	(i)		Stress = force / (cross-sectional) area	B1	Allow 'over' If symbols are used then they need to be defined
	(ii)		Strain = extension / <u>original length</u>	B1	
(b)	(i)		$E = (F / A) / (e / l)$ $e = (15 \times 1.75) / (2 \times 10^{11} \times 1.96 \times 10^{-7})$ $= 6.70 \times 10^{-4} \text{ (m)} \quad (6.696 \times 10^{-4})$	C1 C1 A1	Allow E = stress / strain for the first mark Allow any subject for the first two marks
	(ii)		twice the length gives twice the extension half the area gives twice the extension 4e / greater than	B1 B1 A0	Allow: increase in 'e' due to increase in length B1 increase in 'e' due to decrease in area B1 hence overall increase A0
			Total	7	

Question 7			Expected Answers	Marks	Additional Guidance
(a)			Gradient values from graph to give $k = 25 \text{ (N m}^{-1}\text{)}$	B1	The conversion from mm to m must be clear
(b)	(i)		Work done = area under graph / $W = \frac{1}{2} Fx \quad / \quad W = \frac{1}{2} kx^2$ $= \frac{1}{2} \times 0.3 \times 0.012 / = \frac{1}{2} \times 25 \times (0.012)^2$ $= 0.0018 \text{ (J)}$	B1 B1 A0	
	(ii)		k.e. = $\frac{1}{2} m v^2$ $v^2 = (0.0018 \times 2) / 0.45$ $v = 0.089(4) \text{ m s}^{-1}$	C1 C1 A1	Allow any subject 2 sf needed

Question 7			Expected Answers	Marks	Additional Guidance
(c)	(i)		4x k.e. or 4 x work to be done (w.d. = $\frac{1}{2} k x^2$) hence double the compression	M1 A1	Do not allow the force doubles hence compression doubles
			Total	8	

Question 8			Expected Answers	Marks	Additional Guidance
(a)	(i)		$v^2 = u^2 + 2as$ $a = 16^2 / 2 \times 28$ $= 4.57 \text{ (m s}^{-2}\text{)}$	C1 A1	Allow any subject Using 40, 16 or 12 (m) can score one mark providing some working shown. (Ans. 3.2, 8.0 or 10.7)
	(ii)		$F = ma$ / $F = 850 \times 4.57$ $F = 3900 \text{ (3886) (N)}$	C1 A1	Allow ecf from (a)(i) (eg. ans 2720, 6800 or 9100)
(b)	(i)		road supplies frictional force on tyre / wheel Friction provides a force <u>backwards or opposite direction to motion</u> (on tyre / wheel / car).	B1 B1	Do not allow on the car
	(ii)		Reduced friction	B1	
			Total	7	

2822 Electrons and Photons

Question			Expected Answers	Marks	Additional Guidance
1	a	i	(Filament) lamp / bulb	B1	
		ii	Resistance is $\frac{V}{I}$ (and not the gradient) – wtte	B1	Allow Resistance is the ratio of V and I. Not units in definition
		iii	current = 1.2 (A) / $R = \frac{2.0}{1.2}$ resistance = 1.7 (Ω)	C1 A1	Bald 1.7 (Ω) scores 2/2 marks
	b		Straight line through the <u>origin</u> (for first three squares for V) Correct curve (after three squares of V)	B1 B1	These are independent marks
	c	i	current = 0 (A)	B1	
		ii	potential difference = 0.4 (V)	B1	
			Total	8	

Question			Expected Answers	Marks	Additional Guidance
2	a		One similarity from: travel in a vacuum / same speed (in vacuum) / transverse (or can be polarised) /	B1	Allow They travel at $c / 3 \times 10^8 \text{ m s}^{-1}$ / <u>vibrating</u> electric <u>and</u> magnetic <u>fields</u> / reference to photons
			One difference from: different wavelength / frequency / photon energy	B1	
	b		$v = f\lambda$ / $3.0 \times 10^8 = 4.0 \times 10^9 \times \lambda$	C1	Bald 0.075 (m) scores 2/2
			$\lambda = 0.075 \text{ (m)}$	A1	
	c	i	$5 \times 10^{-10} \text{ (m)}$ circled	B1	
		ii	$E = hf$ / $E = hc / \lambda$ / $f = 6.0 \times 10^{17} \text{ (Hz)}$ $E = h \times 6.0 \times 10^{17}$ energy = $3.98 \times 10^{-16} \approx 4.0 \times 10^{-16} \text{ (J)}$ energy = $2.49 \times 10^3 \text{ (eV)} \approx 2.5 \times 10^3 \text{ (eV)}$	C1 A1 A1	Possible ecf if the wavelength in (c) is different Bald answer in joules scores 2/2 Allow 1 sf answer in joules Possible ECF Bald answer of $2.5 \times 10^3 \text{ (eV)}$ scores 3/3
			Total	8	

[illegible]

Question			Expected Answers	Marks	Additional Guidance
4	a		$F = BIL$ (Allow any subject) F = force (on conductor), I = current (in wire at 90° to field) and L = length (of conductor) <u>in the field</u> .	M1 A1	Allow 2/2 marks for the word equation 'magnetic flux density = force / (current \times <u>length in field</u>)
	b		They are in opposite directions Field at X is stronger (ora)	B1 B1	Allow field lines are closer together at X (ora)
	c	i	Into (the plane of) the paper	B1	
		ii 1.	$F = 0.18 \times 8.0 \times 0.025$ force = 3.6×10^{-2} (N)	C1 A1	Bald 3.6×10^{-2} (N) scores 2/2 Bald 3.6 (N) scores 1/2 (because the cm have not been converted into m)
		ii 2.	number = $1.2 \times 10^{-7} \times 0.025 \times 8.5 \times 10^{28}$ (= 2.55×10^{20}) $\text{force} = \frac{3.6 \times 10^{-2}}{2.55 \times 10^{20}}$ force = 1.4×10^{-22} (N)	C1 A1	Possible ecf
			Total	9	

Question			Expected Answers	Marks	Additional Guidance
5	a	i	Straight line (by eye)	B1	
		ii	$Q = It$ $Q = 5.2 \times (3.5 \times 3600)$ charge = 6.55×10^4 unit: <u>coulomb</u> / <u>C</u>	C1 A1 B1	Allow 2 sf answer Allow 6.6×10^4 This unit mark is an independent mark
	b	i	$R = \frac{\rho L}{A}$ $L = \frac{3.6 \times 2.0 \times 10^{-8}}{7.9 \times 10^{-7}}$ length = 9.1×10^{-2} (m)	C1 C1 A1	Allow any subject Bald 9.1×10^{-2} m scores 3/3
		ii 1.	resistance of lamps = $\frac{3.6}{3}$ (= 1.2) total resistance = $1.2 + 0.48$ total resistance = 1.68Ω	C1 A1	Possible ecf from above step for resistance of lamps in parallel Allow 1.7Ω
		ii 2.	current = $\frac{12}{1.68}$ current 7.1(4) (A)	B1	Possible ecf Allow 2 sf answer
		iii	Appreciation that 'internal resistance' is responsible for dimness (Larger) voltage across internal resistance / less p.d across lamps	B1 B1	
			Total	12	

Question			Expected Answers	Marks	Additional Guidance
6	a		Removing electron(s) using light / photons/ e.m waves / e m radiation (from metal surface)	B1	
	b		1. Blue light has higher frequency / shorter wavelength (than the red light) 2. <u>Energy</u> of blue light photon is greater (than that of red light) 3. The energy of blue light photon > / = <u>work function</u> (energy) (ora) 4. Intensity is related to <u>rate</u> of photons / does not change energy of photon	B1 B1 B1 B1	Show ticks on scoris Allow The frequency of blue light >= <u>threshold</u> frequency (ora)
	c	i	F marked correctly on the <i>f</i> -axis W marked correctly on the vertical axis	B1 B1	
		ii	Line shifts to the 'right' / 'down' Gradient of line remains the same because it is equal to Planck constant / <i>h</i>	B1 M1 A1	
	d	i	Not all are emitted from the surface / Some collide (with other atoms)	B1	
	d	ii	$hf = \phi + KE_{\max}$ / $\phi = (6.63 \times 10^{-34} \times 1.36 \times 10^{15}) - 5.82 \times 10^{-19}$ $= 9.02 \times 10^{-19} - 5.82 \times 10^{-19}$ $\phi = 3.20 \times 10^{-19}$ (J)	C1 A1	 Bald 3.20×10^{-19} (J) scores 2/2
		ii	kinetic energy = $(6.63 \times 10^{-34} \times 0.68 \times 10^{15}) - 3.20 \times 10^{-19}$ kinetic energy = 1.31×10^{-19} (J)	C1 A1	Possible ECF from ii.1 Bald 1.3×10^{-19} (J) scores 2/2 – allow 2 sf answer
			Total	15	

2823/01 Wave Properties/Experimental Skills 1 Written Paper

Question			Expected Answers	Marks	Additional Guidance
1	a		speed of light in vacuum/speed of light in medium	B1	Allow: 'air' or 'free space'; allow $n = c_1 / c_2$ and $n = \sin i / \sin r$ provided all symbols are defined and it is clear that light is moving from air/vacuum into the medium
1	b	i	correct substitution into $n = c/v$; e.g. $v = 3.0 \times 10^8 / 1.53$ $v = \mathbf{1.96 \times 10^8 \text{ ms}^{-1}}$	C1 A1	
1	b	ii	correct substitution into $n = 1/\sin C$: e.g. $1.53 = 1/\sin C$ $C = \sin^{-1}(0.65) = \mathbf{41^\circ}$ (40.8)	C1 A1	
1	b	iii	total internal reflection at sloping surface (angles roughly equal) refraction AWAY from normal shown at side BC	B1 B1	For rays that are reflected by 90° and leave BC along the normal award 1 mark max
1	c	i	ray entering hypotenuse (along a normal) TIR at both internal surfaces and light leaves <u>along the normal</u>	M1 A1	Ignore lack of arrows
1	c	ii	Any valid device: e.g. bike reflector, cat's eyes, binoculars, SLR camera, periscope,	B1	Do not allow 'mirror'
			Total	10	

Question			Expected Answers	Marks	Additional Guidance
2	a		some light takes DIFFERENT PATHS (WTTE) some light ARRIVES at DIFFERENT TIMES (WTTE) hence pulse “smeared”/distorted/corrupted/dispersed/spread out (WTTE)	B1 B1 B1	Do not allow weakened signal
2	b		(large critical angle means) <u>most of the light will be refracted out</u> (WTTE) so most rays follow same path/ rays arrive at same time (WTTE)	M1 A1	Allow ‘reduces the amount of TIR’
			Total	5	

Question			Expected Answers	Marks	Additional Guidance
3	a		(a) <u>SPREADING</u> of waves (into a ‘shadow region’) (WTTE)	B1	Allow plane waves become circular but do not allow bending OR dispersion Ignore diagrams – question says STATE
3	b	i	(plane waves) drawn with wavelength ‘same’ as gap ($0.5a < \lambda < 1.5a$) ‘semi-circular’ waves drawn (i.e nothing straight) wavelength shown to be constant (or same λ labelled before & after)	B1 B1 B1	
3	b	ii	LESS diffraction (WTTE) wavefronts mainly straight/less curved/do not spread into shadow	C1 A1	a good diagram can score full marks OR simply a description of how the waves change scores both marks (i.e C1, A1)
			Total	6	

Question			Expected Answers	Marks	Additional Guidance
4	a	i	3.6 mm	B1	Correct answer only
4	a	ii	1. 3.4 (mm) (3.3 to 3.5) 2. - 2.0 (mm) (1.9 to 2.1)	B1 B1	negative sign must be seen
4	a	iii	period = 2ms OR 0.002s	B1	Do not allow 0.002 ms
4	a	iv	recall of $f = 1/T$ f = 500 Hz	C1 A1	Allow ecf for 0.002 ms i.e period = 500,000HZ
4	b		correct shape i.e $\frac{1}{2}$ wave in 0.002 sec amplitude of 1.8 mm (within $\frac{1}{2}$ small square)	B1 B1	judged by eye
4	c	i	wavelength correctly labelled : e.g. peak to next peak	B1	
4	c	ii	wavelength = $2 \times 0.18 = \mathbf{0.36\ m}$ recall of $v = f\lambda$ $v = 5 \times 0.36 = \mathbf{1.8\ m\ s^{-1}}$	B1 C1 A1	No ecf from c(i) but allow ecf for cand's incorrect value of λ for max of 2 marks (e.g $v = 0.9\ m/s$ scores 2)
4	c	iii	same shape shifted slightly to the right (at least one full wave drawn)	B1	Do not allow an extension of the given wave
	c	iv	arrows showing B \uparrow C \downarrow	B1 B1	
4	c	v	phase difference = 180° or 540° OR π OR 3π radians correct unit quoted	B1 B1	Correct unit for cand's phase angle seen anywhere for unit mark.
			Total	17	

Question			Expected Answers	Marks	Additional Guidance
5	a		when waves meet/cross/interfere/superpose/superimpose/overlap/collide/interaction/mix/add resultant <u>displacement</u> = sum of <u>displacements</u>	B1 B1	Do not allow amplitude
5	b	i	(path difference =) $S_2P - S_1P = \frac{1}{2} \lambda$	B1	
5	b	ii	point B labelled above P a distance equal to OP OR below O a distance 2OP	B1	judged by eye
5	b	iii	(fringe separation) $x = 3.6 \times 2 = 7.2$ mm recall of $\lambda = ax/D$ $a = \lambda D/x = (6.4 \times 10^{-7} \times 1.6)/7.2 \times 10^{-3} = 1.4 \times 10^{-4}$ m (1.78)	B1 C1 A1	many will forget to double 3.6 and will get 2.8×10^{-4} m this scores 2 marks
			Total	7	

2823/03 Wave Properties/Experimental Skills 1

Practical Examination

Planning Exercise - Skill P

- A1** Diagram of workable arrangement of apparatus. 1
i.e. inclined rails or inclined box shape, supporting axle and wheel
- A2** Correct procedure 1
(i.e. measure diameter and determine acceleration, change diameter and determine new acceleration – allow graph or table). Method must be workable.
- A3** Clear evidence that axle rolls down the slope 1
- B1** Calliper method to measure diameter of wheel 1
- B2** Method of determining acceleration eg. time taken by wheel to travel known distance 1
- B3** Relevant equation to determine acceleration 1
- C1** Use the same axle (NB Treat MASS as neutral) 1
- C2** Keep the angle of the slope constant 1
- D** Any further relevant detail. Examples of creditworthy points might be; max 4

Preliminary experiment

Use a large distance so as to measure a large time

Detailed method for finding acceleration from experimental data

Discussion about structure of track e.g. rigidity / parallel rails / height at bottom end / securing rails (Need a feature and a reason for 1 mark)

Discussion of the effect of friction / Method of ensuring wheel rolls

Discussion of the angle of the slope

Repeat individual measurements and average / Take several readings of diameter and average.

- 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 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) (ii) Sets up the apparatus and carries out the basic experiment 2/1/0
 Td calculated correctly scores 1 mark. Ignore units – penalised in (d)
 Minor help from Supervisor then –1.
 Major help (equipment set up for the candidate) then -2.
- (c) Justification of significant figures in Td 2/1/0
 Expect to see sf in Td related to sf in T and d . Scores 2 marks
 Vague answers relating sf in raw data scores one mark.
 Reference to decimal places or plotting graphs scores zero.
- (d) Measurements 2/1/0
 Write the number of readings as a ringed total next to the table of results.
 Seven sets of values for x and T scores 1 mark.
 x in the range 0.100 m to > 0.699 m scores 1 mark.
- (d) Consistency of measurements 2/1/0
 x measured to the nearest mm scores 1 mark.
 T measured to 0.1N scores 1 mark. (Allow 0.05N but not all values with trailing Zero)
 (Ignore POT)
- (d) Column headings in the table 2/1/0
 One mark for x and T headings correct.
 One mark for Td heading correct.
 Ignore units in the body of the table.
- (e) Axes 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 label.
 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"
 One mark for each correct axis.
- (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 six 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 scores 1 mark
 read offs correct and ratio correct scores 1 mark.

- (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) (i) Value of W = candidate's gradient value
Sig Figs of F : allow 2 or 3 only
Unit (Newton). 3/2/1/0
- (ii) Candidate's y -intercept value equated with $Rgd/2$
Value of R determined correctly
Sig Figs of R : allow 2 or 3 only. 3/2/1/0
- (h) (i) R within 20% 1/0
Percentage difference calculated correctly 1/0
- (h) (ii) Expect to see reference to scatter of points on their graph and appropriate conclusion 1/0

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

Question 2

- (b) (ii) Repeats taken in t (Do not allow mis-read of stopwatch) 1
- (iii) t^2 determined 1
- (c) $\Delta t = 0.1 - 0.5$ s 1
percentage uncertainty ratio correct. 1
2 x percentage uncertainty 1
- (d) New value of t larger than (b)(ii) 1
- (e) Direct proportionality ideas
Method to prove or disprove direct proportionality
(e.g. determines k) 1
Appropriate conclusion based on their method of proving or disproving proportionality. 1
Vague answers will not score this second mark.
No method loses both these marks
- (f) Evaluation of procedure 6
Relevant points must be underlined and ticked with the appropriate marking letter.

	Problem	Solution
A	Difficulty in timing over a given length	Use a marker at the top or bottom / good method for starting or stopping rolling e.g. use of a buffer
B	Cylinder does not roll straight	Use smoother cylinder
C	Wood not level / ramp twisted / ramp flexes	Use of two retort stands explained / use spirit level / a more rigid ramp
D	Times are too short	Use longer distance / smaller height
E	Reaction time affects timings (Allow Human error in timing)	Use light gates with suitable timer (detail needed)
F	Two readings are not enough to verify the relationship	Take many readings for a range of h <u>and</u> plot a graph of $1/t^2$ v h

One mark for each box to a maximum of 6.

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

X / m	T / N	$Td / \text{N m}$
0.100	1.0	0.80
0.200	1.6	1.28
0.300	2.0	1.60
0.400	2.5	2.00
0.500	3.0	2.40
0.600	3.5	2.80
0.700	4.0	3.20

Gradient = 3.94

y-intercept = 0.4343

$W = 3.94 \text{ N}$

$R = 0.111 \text{ kg}$

R by top pan balance = 0.124 kg

h / cm	Average t / s	$t^2 h / \text{s}^2 \text{ cm}$
6.0	3.12	58
12.0	2.06	51

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
✓ Δ	Used to show that the size of a triangle is appropriate (gradient calculation)
✓ _{A1}	Used to show the type of mark awarded for a particular piece of work
✓ _C	Used to show that the raw readings are consistent
✓ _d	Used to show that the raw readings have correct spacing
✓ _{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

Question	Expected Answers	Marks
1	<p>a</p> <p>i momentum before = $2mv - 3mv = -mv$ momentum after = $4mv - m5v = -mv$</p> <p>ii initial k.e. = $2.5 mv^2$; final k.e. = $14.5 mv^2$ (so $\Delta k.e. = 12 mv^2$)</p> <p>iii k.e. of n is $12.5 mv^2$; so takes all of the extra k.e./AW</p> <p>iv $12 mv^2 = 12 \times 1.67 \times 10^{-27} \times 1.19^2 \times 10^{14} = 2.84 \times 10^{-12} \text{ (J)}$ <i>ecf ii</i></p> <p>b $\Delta E = c^2 \Delta m$; $\Delta m = 0.019 \times 1.66 \times 10^{-27}$ $\Delta E = 2.84 \times 10^{-12} \text{ (J)}$</p>	<p>1</p> <p>1 2</p> <p>2 2</p> <p>2 2</p> <p>1 1</p> <p>2</p> <p>1 3</p> <p>Total 10</p>
2	<p>a A motion in which the acceleration/force is proportional to the displacement; directed towards the centre of oscillation/equilibrium position/AW or $a \propto -x$ or $a = -\omega^2 x$ or $a = -4\pi^2 f^2 x$; symbols must be identified</p> <p>b Two arrows, one vertical, the other along string; correctly labelled weight/mg and tension/T</p> <p>c</p> <p>i $T = 1.6 \text{ s}$ so $f = 0.625 \text{ Hz}$ $l = g/(2\pi \times 0.625)^2$; $= 0.636 \text{ (m)}$</p> <p>ii $a = (4\pi^2 f^2)A$; $= (2\pi \times 0.625)^2 \times 0.05 = 0.77 \text{ (m s}^{-2}\text{)}$</p> <p>d For circular motion $a = (4\pi^2 f^2)r$ / AW the projection of the circular motion onto a diameter gives the same equation as SHM (the detail of the minus sign can be ignored)/AW or expressed mathematically thus both have the same frequency or for circular motion $a = (4\pi^2 f^2)r$, for pendulum $a = (4\pi^2 f^2)A$ restoring force same so a's equal; $r = A$ so f's same</p> <p>Total</p>	<p>1</p> <p>1 2</p> <p>1 2</p> <p>1 3</p> <p>2 2</p> <p>1</p> <p>1</p> <p>1</p> <p>2 3</p> <p>12</p>
3	<p>a $F = GMm/R^2$; $= mv^2/R$; rearrange to show $v = (GM/R)^{1/2}$</p> <p>b formula in (a) shows v is larger as r is smaller ($r < R$) so T smaller because either v is larger or $r/\text{circumference}$ is smaller or both or $2\pi r/v$ is smaller</p> <p>c</p> <p>i the orbit circumference is less than that of the Earth so v must be less for same orbital period/AW</p> <p>ii arrow (labelled F_S) towards Sun longer than arrow (labelled F_E) towards Earth</p> <p>iii centripetal pull towards the Sun is smaller allowing resultant force to give required $F = mv^2/r$ (i.e. where v is the correct value to give a period of one year)/AW so the observatory stays at the same point relative to Earth/similarity to geostationary orbit so aerial directions fixed/convenience of positioning aerals to pick up signals from observatory/AW</p> <p>Total</p>	<p>3 3</p> <p>1</p> <p>1 2</p> <p>1 1</p> <p>1 1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1 3</p> <p>3</p> <p>10</p>

Question		Expected Answers	Marks	
4	a	i	No charge on capacitor so held at 0 V	1
			0 V across R means no current in A_1	1 2
		ii	12 V across 4.0 k Ω ; gives A_2 reading 3.0 mA	2 2
	b	i1	$A_1 = 2.0$ mA	1
		2	$A_2 = 0$	1 2
		ii	potential divider argument or current in circuit is 2.0 mA so V across 2.0 k Ω is 4.0 V; capacitor in parallel or charged so draws no current/AW	1 2
		iii	$Q = CV$; $= 1 \times 10^{-3}$ C	2 2
	c	i	$A_1 = A_2 = 2.0$ mA	1 1
		ii	$RC = 0.5$ s	1 1
		iii	suitable scale and attempt at decay curve;	1
			decay curve going through (0, 2); <i>ecf</i>	1
			using $RC = 0.5$ s , e.g. passing through (0.5,0.735), (1.0,0.27), (1.5,0.1)	1 3
		Total		15
5	a		Closed loops linking primary coil	1
			quality mark, e.g. lines not touching/crossing, both passing only through iron core	1 2
	b	i	magnetic flux = magnetic flux density B multiplied by the area A; \perp to it	2 2
			or magnetic flux is the number of lines of the magnetic field ; magnetic flux density is a measure of how close these lines are together/ the number of lines per unit cross-sectional area/AW	
		ii	magnetic flux ϕ ; the loops of magnetic field (are continuous and) all pass (through the iron core) through each coil	1 2
		iii	for magnetic flux density: 3 turn coil	1
		&	as A is smallest (i.e. ϕ is same in each coil, $B = \phi/A$)	1 2
		iv	for magnetic flux linkage: 5 turn coil	1
			as largest number of turns (i.e. ϕ is same in each coil, $mfl = \phi N$)	1 2
	c		Changing flux (associated with alternating current in coil) causes induced voltage in the core or statement of Faraday's law	1
			(eddy) currents are caused/proportional to induced voltage	1
			(eddy) currents cause a heating effect in core	1
			power loss given by $I^2 R$ (R is the resistance of the current loop within the iron) or description of any factor affecting power loss	1 3
			<i>max 3 marks</i>	
		Total		13
6	a		94; proton number; neutron	3 3
	b	i	$N = N_A m/M = 6 \times 10^{23} \times 2.5 \times 10^{-10} / 0.241 = 6.2 \times 10^{14}$	2 2
			or $2.5 \times 10^{-10} / 241 \times 1.67 \times 10^{-27}$	
		ii	$0.693 / (480 \times 3.15 \times 10^7) = 4.58 \times 10^{-11} \text{ (s}^{-1} \text{)}$	1 1
		iii	$A = \lambda N = 4.6 \times 10^{-11} \times 6.2 \times 10^{14} ; = 2.9 \times 10^4 ; \text{Bq or s}^{-1}$	3 3
		iv	use $A = 2.9 \times 10^4$	
			$dN = 2.9 \times 10^4 dt = 6.2 \times 10^{12} ; dt = 6.2 \times 10^{12} / 2.9 \times 10^4 = 2.1 \times 10^8 \text{ s}$	
			or use $N = N_0 e^{-\lambda t}$	3 3
			$\ln N/N_0 = -\lambda t ; -0.01 = -4.6 \times 10^{-11} t ; t = 2.2 \times 10^8 \text{ s}$	
	c	i	alpha particles stopped by the walls of container/few cm of air	1 1
		ii	interacts strongly with/ionises matter; so <u>if ingested</u> will damage gut, etc	2 2
		Total		15

Question	Expected Answers	Marks
7 a	Diagram showing or description of incident beam scattered by or diffracted through crystal at only certain angles either for X-rays or electrons	1
	diffraction tube with vacuum and rings on fluorescent screen at end of tube or moveable detector to measure angles for X -rays	1
	electrons or X-rays are scattered from crystal planes like a diffraction grating/because of the regular array of atoms <i>allow crystalline structure</i>	1
	<i>electron specific marks:</i> Electrons behave as waves	1
	A significant/measurable diffraction pattern is only observed when the electrons have a de Broglie wavelength λ of the order of the spacing d of the atoms/ size of pattern (rings) depends on ratio of λ/d .	1
	The wavelength of the electrons depends on their speed/momentum. Acceleration is only through a few hundred volts/low energy electrons (100 – 400 eV <i>allow up to 1 keV</i>)	1
	<i>X-ray specific marks:</i> X-rays need wavelength λ of the order of the spacing of the atoms; wavelength of X-rays or spacing of atoms order of magnitude given ,e.g. 0.1nm	1
	constructive interference only occurs at certain angles depending on λ and d	1
	knowing λ , d can be found <i>max 5</i>	5
b	α -particle scattering proves existence of a nucleus to the atom:	1
	suitable diagram and/or description to illustrate experiment	1
	most particles have little if any deflection	1
	large deflection of very few shows nucleus is small	1
	and very massive/dense	1
	deflection explained on basis of charged particle interaction (Coulomb's law)	1
	<i>to estimate nuclear size :</i> of order of 10^{-14} m	1
	head-on collision/back scattering	1
	enables distance of closest approach to be calculated	1
	using conservation of energy argument (by equating distant k.e. to Coulomb potential energy)	1
	6 <i>max</i>	6
	Total	11
	Quality of Written Communication (see separate sheet)	4

Quality of Written Communication**Criteria for assessment of written communication**

4 marks

- The candidate expresses complex ideas extremely clearly and fluently. Sentences and paragraphs follow on from one another smoothly and logically.
- Arguments are consistently relevant, based on sound knowledge of physics, and are well structured.
- There are few, if any, errors in grammar, punctuation and spelling.

3 marks

- The candidate expresses moderately complex ideas clearly and reasonably fluently through well-linked sentences and paragraphs.
- Arguments are generally relevant being based on a good knowledge of physics, and are well structured.
- There may be occasional errors in grammar, punctuation and spelling.

2 marks

- The candidate expresses straightforward ideas clearly and accurately, if not always fluently. Sentences and paragraphs may not always be well connected.
- Arguments may sometimes stray from the point or be weakly presented.
- There may be some errors in grammar, punctuation and spelling, but not as such to suggest a serious weakness in these areas.

1 mark

- The candidate expresses 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.
- Error in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weaknesses in these areas.

0 marks

- Even simple ideas are not expressed clearly.
- Arguments are irrelevant or poorly stated.
- There will be gross errors in grammar, punctuation and spelling.

2825/01 Cosmology

1	(a) (i)	Description of shape change (accept diagram showing minimum of 2 <u>different</u> shapes).	1	
	(ii)	Illuminated area (facing Earth) changes as Venus / Earth rotates about Sun	1	
	(b)	Moons observed orbiting Jupiter	1	
		(First) celestial bodies shown not to be orbiting Earth	1	
	(c)	Heliocentric model implied Earth has orbital/ rotational velocity	1	
		Object released from rest was expected to show backward displacement	1	
		Alternative view from geocentric perspective may score full marks		
		Total 6		
2	(a)	Planets move in ellipses	1	
		Sun at one focus	1	
		Equal areas swept out in equal times	1	
	(b) (i)	r^3 calculated correctly (5.31 and 5.93)	1	
	(ii)	<u>5 points</u> plotted (ecf from b.i)	1	
		best straight line drawn (ecf from b.i)	1	
	(iii)	either		
		calculation $1.0 \times 10^{-13} \text{ s}^2 \text{ r}^{-3}$	1	
		$M = 6.0 \times 10^{24} \text{ kg}$	1	
		Or		
		Substitution of values from graph into $T^2 = 4\pi^2 r^3 / GM$	1	
		$M = 6.0 \times 10^{24} \text{ kg}$	1	2
	(iv)	Closer to Earth's surface means less powerful transmitter required / easier access to effect repairs / all sensible points accepted including comparison to ground-based observations	1	
	(v)	gradient would be smaller / shallower because <u>Jupiter has greater mass</u>	1	
		Total 11		

3	(a) the brightness/luminosity/ <u>apparent</u> magnitude at distance of <u>10 parsecs</u>	1 1
(b)	(i) (700,000 x 3.26 =) <u>2.28 x 10⁶</u> ly (accept 2.3 x 10 ⁶)	1
	(ii) $m - M = 5\log(d/ 10)$ $M = 3.5 - 5 \log(70,000)$ $M = - 20.7$	1 1 1
	(iii) 2 or more <u>curved</u> arms coming from centre (accept diagram)	1
	(iv) elliptical/ spherical/ irregular/ (barred) lenticular / <u>barred</u> spiral	1
(c)	central bulge arm each side	1 1
	Sun approximately 2/3 from centre in one arm	1

Total 11

4	(a)	fusion of hydrogen <u>nuclei</u> / protons	1	
		helium nuclei formed	1	
		mass loss produces energy / $E = mc^2$ (pp equations give first 2 marks)	1	
	(b)	(i) correct position labelled	1	
		temperature = 6000K (+/- 500K)	1	
	(ii)	Position to the left of X and on main sequence	1	
	(iii)	2 from:		
		Star will have higher core temperature	1	
		rate of fusion greater	1	
		lifetime of star is shorter (accept only if correct reason is given)	1	2
	(c)	luminosity increases because surface area increases	1	
		surface temperature decreases because work done expanding out	1	
	(d)	AU is average distance of Earth from Sun	1	
		$1.49 (1.5) \times 10^{11}$ metres	1	
	(e)	B marked above line, with ratio greater than 1, to the right of Sun (ie surface temp. less than Sun)	1	
	(f)	any 6 from the following		
		• Hydrogen burning in core has ceased/ Hydrogen is used up.	1	
		• Planetary nebula formed/core collapses	1	
		• Helium burning takes place/shell burning	1	
		• reference to further expansion or contraction	1	
		• (Core) mass greater than $2.5 - 3.0 M_{\odot}$	1	
		• Supernova explosion occurs	1	
		• Formation of black hole	1	
		• Other relevant point eg formation of heavier Elements/reference to Schwarzschild radius	1	6

Total 19

5	(a)	(i)	$\Delta\lambda / \lambda = v / c$		1
			$(656.3 - 651.0) / 656.3 = v / 3.0 \times 10^8$		1
			$v = 2.42 \times 10^6 \text{ m s}^{-1}$		1
		(ii)	the star is approaching Earth (ora)		1
		(iii)	any 5 from		
			measurements made of $\Delta\lambda$ for many galaxies (stars)		1
			measured distance to many galaxies (stars)		1
			light from galaxies was red-shifted		1
			calculated velocity of galaxies (stars)		1
			showed that $v = H_0 r$ ($v \propto r$)		1
			H_0 is Hubble's constant		1
			Universe is expanding		1
			Age of Universe is $1 / H_0$		1
			Other detail	1	5
	(b)	Either	any 2 from		
			uniform intensity in all directions		1
			very small ripples in intensity		1
			equivalent black body temperature of 2.7K (3K)	1	2
		Or	any 2 from		
			Accept argument based upon expansion of space		
			Gamma waves move through Universe after recombination		1
			Wavelength increases as Universe/space expands		1
			equivalent black body temperature of 2.7K (3K)	1	2
			conclude that Universe began with big bang		1

Total 12

6	(a)	a place where Newton's first law is obeyed/ all laws of Physics are obeyed/ non-accelerating	1
	(b)	(a valid thought experiment described) any 5 from train, tunnel, 2 lamps, observer A at rest at mid-point of tunnel observer B on train (at constant velocity) A observes simultaneous flash of lamps A measures train to be same length as tunnel B observes front lamps flash before rear B measures train to be longer than tunnel speed of light constant other relevant detail (a practical experiment described scores 3 max)	1 1 1 1 1 1 1 5
	(c)	(i) $0.9 \times 3.0 \times 10^8 = 1.5 \times 10^3 / t$ $t = 5.56 \times 10^{-6} \text{s}$ (accept 2 sig fig)	1 2
		(ii) $l = l_0 \times (1 - v^2 / c^2)^{1/2}$ $l = 1.5 \times 10^3 \times (1 - 0.9^2 c^2 / c^2)^{1/2}$ $l = 653.8 \text{ m}$	1 1 3
			Total 11

7 See 2825/05 for Common question mark scheme.

2825/02 Health Physics

- 1 (a) two rays from the same point on the object shown refracting correctly at the cornea (1)
meeting in front of the retina (1)
- (b) normal far point at infinity (1)
normal near point is about 25 cm (1)
the person is short-sight / myopia (1)
person can see things clearly and comfortably at distances closer than a person with normal sight (1)
objects beyond 60 cm / beyond the far point form blurred images (1)
- (c) (i) shape of lens is concave / negative power / diverging (1)
(ii) rays now meet at the retina / on the fovea (1)
- (d) (i) $p (= 1/f) = 1/v + 1/u$ (1)
 $P = 1 / 0.60 + 1 / 0.019$ (1)
 $P = 54.3 \text{ D}$ allow 54D (1)
- (ii) power when focused at infinity = $1 / 0.019 + 1 / \infty$ (1)
 $P = 52.63 \text{ D}$ (1)
 $52.63 = 54.3 + (\text{lens power})$ (1)
lens power = -1.69 D +1.69 or 1.7 gets (3) (1)
- (iii) power of eye is less (with corrective lens) / $1 / f$ is less / or optical power less (1)
so $1 / u$ must also be less (by the same factor as $1 / v$ is constant) (1)
so u must be larger / near point must further from the cornea (1)
or
Near point moves further away (1)
Corrective lens diverges rays / has a negative power / reduces the power of the eye (1)
Rays from new near point further away will be diverging so the eye can just focus them on the retina / rays from old near point will now be diverging too much to meet on the retina / at near point the eye's power is at its greatest / (1)

- (e) astigmatism is a defect whereby the sufferer can see clearly in one plane (1)
(but not (clearly) in another) do not allow '.....in one direction' unless supported by a diagram which is clear

Possible cause /due to uneven curvature of cornea (1)

2 THE CHOSEN SYSTEM. (4 marks – label ticks 's'). e.g. forearm, lower leg, head (if load-fulcrum distance is greater than effort-fulcrum distance, bent back

A correct example of lever system, stated or drawn. (1)

Up to **THREE** from the following:-

Muscle (or named muscle, eg biceps) stated/labelled as effort or marked 'E' on diagram. (1)

Load described/shown as weight acting at a distance from the fulcrum – may just be marked 'L'. (1)

If forearm is the lever, object in hand and weight of forearm itself both considered. (1)

Typical values of load and distances. Acceptable values for forearm would be: fulcrum to hand 0.2 to 0.4 m; fulcrum to c.g. of arm around half that; effort to fulcrum 1 to 5 cm; load in hand any liftable value from 1 N (0.10 kg) upwards; weight of forearm 10 to 50 N. (1)

THE PRINCIPLE OF MOMENTS. (4 marks – label ticks 'm').

Correct equation in figures or defined symbols – even if the values used are outside acceptable range. (1)

Up to **THREE** from the following:-

Moment = force x distance to fulcrum - stated, or used as such in calculation. (1)

... perpendicular distance to fulcrum stated / attempt made to resolve oblique forces perpendicular to lever. (1)

For equilibrium ... (1)

... (sum of) clockwise moments = (sum of) anticlockwise moments stated. Accept cm = acm. (1)

THE CALCULATION OF THE MECHANICAL ADVANTAGE. (2 marks – label ticks 'c').

MA = load / effort. (The inverse scores zero for this whole part). (1)

Correct numerical calculation from candidate's values for load and effort – even if effort worked out wrongly or merely stated instead of calculated, so long as the value of the MA comes out less than 1. (1)

- 3 (a)** curve drawn of correct shape (1)
- minimum at $f = 1000 - 3000$ Hz (1)
- minimum at intensity of $10^{-12} \text{ W m}^{-2}$ (1)
- minimum frequency of 20 Hz and minimum frequency of 20 kHz (1)
- (b) (i)** line starts at same place as the normal hearing graph (1)
- differs at frequency of 200 Hz (1)
- minimum at 10^{-9} W m^{-2} for frequency of 1000 Hz (1)
- and rejoins before 10000Hz (1)
- (ii)** some people will have more acute/ sensitive hearing / owtte (1)
- So intensity level of sound must be reduced for these people so that the sound is just detectable (1)
- (c)** 50 dB is extra intensity level required (1)
- $50 = 10 \log I / 10^{-12}$ (1)
- $I = 10^{-7} \text{ W m}^{-2}$ (1)

- 4 (a) description of incoherent bundles / order at each end of bundle is random or (1)
 description of coherent bundles / order of fibres at each end is the same (1)
 incoherent bundle used to carry light to the viewing area (1)
 coherent bundle used to carry light information of the image back to viewer / explanation of order (1)
 Reference to total internal reflection (1)
 Detail: explanation of total internal reflection / detail about refractive index of cladding compared with core (1)
 to max. 5
- (b) (i) $P = E / t$ (1)
 $P = 0.80 / 200 \times 10^{-3} \times 4.0 / 100$ (1)
 $P = 100 \text{ W}$ 4W gets 2/3 (1)
- (ii) $I = P / A$ (1)
 $I = P / \pi (d/2)^2 = 100 / 1.26 \times 10^{-7} \text{ m}^2$ (1)
 $I = 7.96 \times 10^8 \text{ W m}^{-2}$ $1.99 \times 10^8 \text{ W m}^{-2}$ gets 2/3 (1)
- (c) reason why healing is quicker (1) each link to qualifying statement about laser (1)
 each e.g.
 capillaries are sealed / bloodless surgery (1)
 as laser vaporises water content of cell / causes heating which makes cell shrivel and die (1)
 sterile surgery (1)
 as laser light is sterile / no contact (1)
 less repair to take place / quicker repair (1)
 as laser cut is finer than conventional scalpel (1)
 less invasive / keyhole surgery / no anaesthetic (1)
 ref. to endoscopy / rather than cutting patients open (1)
 to max.4

- 5 (a) (i) $D = f \times X$ (0)
- $D = 100 \times 0.014 \times 10^{-6}$ (1)
- J kg^{-1} or Gy (1)
- (ii) $5.2 \times 10^{-7} \text{ J kg}^{-1} / \text{Gy}$ (1)
- (b) Energy = absorbed dose x mass (1)
- $E = 1.4 \times 10^{-6} \times 0.50$
- $E = 7.0 \times 10^{-7} \text{ J}$ (1)
- (c) 80 keV source / lower energy X-ray source / ref. to photoelectric effect (0)
- larger difference in absorption of X-rays in bone than surrounding tissue for 80 keV X-rays (1)
- so large contrast in image (1)
- or
- smaller difference in absorption of X-rays in bone than surrounding tissue for 200 keV (1)
- so little contrast / poor image (1)
- (d) (i) alpha is strongly ionising (1)
- ionisation from alpha radiation is more densely concentrated (1)
- (ii) $H = D \times Q$
- $H = 1.4 \times 10^{-6} \times 1.2 = 1.68 \times 10^{-6}$ (1)
- Sv (1)

6 See 2825/05 for Common question mark scheme.

2825/03 Materials

- 1 (a) (i) Equilibrium separation = 0.22 – 0.23 nm [1]
 (ii) Resultant force = $1.4 - 1.5 \times 10^{-10}$ N [1]
- (b) (i) No of atoms = C.S.A. of wire / C.S.A. of atom OR $A_{\text{wire}} / A_{\text{atom}}$ stated; (1)
 $= 1.8 \times 10^{-7} / \pi \times (1.4 \times 10^{-10})^2$ OR $1.8 \times 10^{-7} / (2.8 \times 10^{-10})^2$ (1)
 $= 2.9 \times 10^{12}$ OR 2.29×10^{12} (1) [3]
- (ii) Use of value from (i) (1)
 theoretical breaking force = $4.8 \times 10^{-11} \times$ value from (i) = 141 N / 110 N (1) [2]
- (c) Calculation assumes:
 Planes of atoms in same plane as cross-section; (1)
 All cross-sections of the wire contain the same number of atoms; (1)
 Wire has a perfect crystal structure OR has no defects / point defects / dislocations / grain boundaries; (1)
 Atoms occupy all the area of a plane / Spaces between 'circular' atoms not allowed for; (1)
 Lines of atoms lie in the same direction as force applied; (1)
 All bonds between atoms in adjacent layers break simultaneously. (1)
 In practice:
 Vacancies / grain boundaries cause planes to contain fewer atoms; (1)
 Dislocations allow plastic behaviour leading to thinning / necking of wire / slipping between planes; (1)
 Layers of atoms not perpendicular to axis of wire / are tilted; (1)
 Atoms are not vertically above each other. (1) max [6]
- Appropriate reference as to how breaking force is affected. [1]
- 2 (a) (i) Motion in random directions; (1)
 with a range of speeds; (1)
 and changes of direction on collision with metal atoms. (1) [3]
- (ii) Random motion with varying speeds continues; (1)
 Electrons accelerate (between collisions with atoms); (1)
 in opposite direction to the current / towards the positive terminal or wtte; (1) [3]
- (b) (i) Mean / average velocity / rate of change of displacement (along the wire). [1]
- (ii) Sketch of cylinder with length labelled OR reference to specific length of wire; (1)
 Total charge of free electrons in this cylinder / length = e.g. $nALe$ (1)
 $I = Q / t$ stated and used to give $I = nAve$ (1) [3]
- (c) (i) $R = \rho L / A$ OR $L / \sigma A$ OR $\rho = 1 / \sigma$ OR $\sigma = 1 / \rho$ (1)
 $R = 1.07 \times 10^{-4}$ (Ω) (1)
 $I = 0.013 / R = 121$ A (1) [3]
- (ii) $v = I / nAe = 120 / (5.0 \times 10^{28} \times 1.58 \times 10^{-4} \times 1.6 \times 10^{-19})$ (1)
 $= 9.48 \times 10^{-5} \text{ m s}^{-1}$ (1) [2]

- 3 (a) (i) a vacancy; (1)
 a substitution impurity atom / impurity atom of different size to lattice atoms; (1)
 an interstitial impurity atom / impurity atom fitting into a space in the lattice. (1) [3]
 [impurity atom unexplained (1)]
- (ii) bubble raft / 2-dimensional ball-bearing model. [1]
- (b) A dislocation is a linear defect / an extra half-plane of atoms; (1)
 Dislocations move if sufficient stress / force is applied; (1)
 Plastic deformation involves movement of dislocations. (1) max[2]
- A slip plane is a plane in a crystal along which dislocations move / slip occurs. [1]
- (c) (i) Sketch to show:
 Layer 1 atoms with close-packing; (1)
 Layer 2 atoms correctly placed relative to atoms in layer 1. (1) [2]
- (ii) 1 For hcp, position of atoms in layer 3 correctly described (abab). (1)
 2 For ccp, position of atoms in layer 3 correctly described (abcabc) (1) [2]
- 4 (a) Use 'wire' made of superconductor to make a solenoid; (1)
 Make a solenoid of sufficient length and cross-section to accommodate a body; (1)
 Use liquid nitrogen / helium for a cooling system; (1)
 Keep the solenoid at a temperature below its transition temperature; (1)
 Apply a (low) voltage to the solenoid; (1)
 to pass a very large current; (1) max[4]
 Producing the same field with conventional conductors would mean:
 a solenoid with many more turns; (1)
 a solenoid of much greater size / made of much thicker (copper) wire; (1)
 a less stable field / a field which varied over time (owing to variation in temperature); (1)
 production of large quantities of heat; (1)
 the need for a cooling system; (1)
 intermittent use to allow time for cooling; (1) max[4]
- (b) $V_H = Bvd$ / $B = V_H / (vd)$ (1)
 $B = 0.28 / (36 \times 0.0065) = 1.20 \text{ T}$ (1) [2]

- 5 (a) Dipoles easily rotate for magnetisation; (1)
 Higher resistivity / resistance means eddy currents power losses from core are smaller; (1)
 Smaller hysteresis loop means energy loss per cycle is less; (1)
 With more cycles this energy loss is more significant at high frequency. (1) [4]
- (b) (i) Efficiency = secondary power / primary power (or equivalent expression) (1)
 $0.98 = 25 / (25 + 0.18 + 0.12 + P_c)$ (1)
 $P_c = (25 / 0.98) - 25.3 (= 0.21 \text{ W})$ (1) [3]
- (ii) power loss in coils = 0.21 W (1)
 Hysteresis power loss = $3 \times 0.18 = 0.54 \text{ W}$ (1)
 Eddy current power loss = $3^2 \times 0.12 = 1.08 \text{ W}$ (1) [3]
- 6 (a) $\Delta E = hc / \lambda$ (1)
 $= 6.63 \times 10^{-34} \times 3.0 \times 10^8 / 694 \times 10^{-9} = 2.87 \times 10^{-19} \text{ J}$ (1)
 $= 2.87 \times 10^{-19} / 1.6 \times 10^{-19} = 1.79 \text{ eV}$ (1) [3]
- (b) Rayleigh scattering $\propto 1 / \lambda^4$ (or equivalent expression) (1)

$$\frac{\% \text{ Rayleigh scattering at } 694 \text{ nm}}{\% \text{ " " at } 632 \text{ nm}} = \frac{X}{1.5} = \frac{632^4}{694^4}$$
 (1)
 $X = 1.03 \%$ (1) [3]
- (c) (i) Rayleigh scattering is less; (1)
 because wavelength of infra-red is greater than wavelength of visible light; (1) [2]
- (ii) More power from a laser beam can enter a fibre; (1)
 because a laser beam has less divergence; (1) [2]
 OR
 There is less material / multipath dispersion of a laser beam; (1)
 because infra-red from a laser has a smaller range of wavelengths / less divergence. (1) [2]
 OR
 Can be turned on and off more quickly than LED emitting visible; (1)
 So more information can be passed per second / unit time. (1) [2]

- 7 See 2825/05 for Common question mark scheme.

2825/04 Nuclear and Particle Physics

Question	Expected Answers	Marks
1 (a)	curve of correct general shape and in correct quadrant; crosses strong force line for $[F] \ll [F_{\max}]$;	1 1 [2]
(b)	strong force (graph) falls to zero / hits x axis ; electrostatic force (graph) does not quite become zero /is asymptotic to x axis	1 1 [2]
(c)	$F_e \propto 1/x^2$ or $F_e = Q_1 Q_2 / (4\pi\epsilon_0 x^2)$ accept relationship is inverse square, in words	1 [1]
(d)(i)	$F_E = \frac{Q_1 Q_2}{4\pi\epsilon_0 x^2}$ Accept $\frac{1}{4\pi\epsilon_0} = k$ $F_G = \frac{m_1 m_2 G}{x^2}$ Allow direct substitution into expression for R so $\frac{F_E}{F_G} = R = \frac{Q_1 Q_2}{4\pi\epsilon_0 m_1 m_2 G}$ eliminates x correctly	1 1 1
(ii)	states $Q_1 Q_2 m_1 m_2 \epsilon_0 G$ all constant or AW $R = \frac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times (1.67 \times 10^{-27})^2 \times 6.67 \times 10^{-11}}$ subs. $= 1.24 \times 10^{36}$ ans. 8.1×10^{-37} (inverse) gets 1/2	1 1 [5] 10

3(a)(i)	24 000 y ans.	1 [1]
(ii)	Pu graph showing exponential decay from N_0 ; falls to about $1/4$ of N_0 ; U graph: N sensibly = $N_0 - N_{Pu}$ no labels -1	1 1 1 [3]
(iii)	24 000 y allow ecf	1 [1]
(iv)	<i>either</i> because U-235 itself decays (very) slowly <i>or</i> because of randomness half-life is an average value or AW	1 [1]
(b)	mass defect = $239.000\ 58 - (234.993\ 45 + 4.001\ 51) = 0.005\ 62\ u$ so energy released / $E = mc^2$ $= 0.005\ 62 \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ subs. (= $8.4 \times 10^{-13}\ J$) allow use of $1\ u = 931\ MeV$	1 1 1 [3]
(c)(i)	$E_k = \frac{1}{2}mv^2$ $8.4 \times 10^{-13} = \frac{1}{2} \times 4 \times 1.67 \times 10^{-27} v^2$ $v = 1.59 \times 10^7\ ms^{-1}$ allow 1.6×10^7 (8×10^{-13} gives $1.55 \times 10^7\ ms^{-1}$)	1 1 [2]
(ii)	<i>either</i> mass of alpha-particle has increased (slightly) (due to relativity) <i>or</i> recoiling U-235 nucleus has (absorbed) some energy/momentum <i>or</i> γ -emission which takes some energy	1 [1] 12

4 (a)	P: up / out of sketch, Q: up / out of sketch ;	1 [1]
(b)	<p><i>either</i> large radius means small centripetal force / acceleration (for given speed) ; hence smaller magnetic field (strength) needed ;</p> <p><i>or</i> reduces (intensity of) synchrotron radiation ; hence less energy loss (and less energy input needed) ;</p>	1 1 [2]
(c)(i)	<p>time period = $1 / (9.25 \times 10^5)$ (= 1.08×10^{-6} s)</p> <p>circumference = 100π (= 314 m)</p> <p>so speed of particles = $314 / (1.08 \times 10^{-6})$ (= 2.90 <i>or</i> 2.91×10^8 m s⁻¹)</p> <p><i>or</i> speed = $\omega r = 2\pi \times 9.25 \times 10^5 \times 50$ (= 2.90×10^8 m s⁻¹)</p>	1 1 [2]
(ii)	<p>$\frac{mv^2}{R} = Bev$</p> <p>$m = \frac{BeR}{v} = \frac{1.3 \times 10^{-4} \times 1.6 \times 10^{-19} \times 50}{2.9 \times 10^8}$</p> <p>subs.</p> <p>= 3.6×10^{-30} kg</p> <p>ans.</p> <p>accept $m = (9.11 \times 10^{-31}) / \sqrt{(1 - v^2/c^2)}$</p> <p>(1)</p> <p>= $(9.11 \times 10^{-31}) / \sqrt{(1 - 2.906^2/3.00^2)}$</p> <p>(1)</p> <p>= $(9.11 \times 10^{-31}) / 0.256$</p> <p>= 3.56×10^{-30} kg</p> <p>(1)</p>	1 1 1 [3]
(iii)	<p>speed is close to speed of light / high speed / reference to relativity ;</p> <p>mass (of particle) increases with speed ;</p>	1 1 [2]
(d)	<p>initial momentum of electron and positron is zero ;</p> <p>two photons moving in opposite directions have zero momentum (so mtm. conserved) ;</p> <p>one photon cannot have zero mtm. (so mtm. cannot be conserved) ;</p>	1 1 1 [3]
		13

5(a)(i)	<div style="display: flex; justify-content: space-around;"> <div>LHS</div> <div>RHS</div> </div> <div style="margin-top: 10px;"> reaction 1 Q 0 0+1 (B 1 1 +0) (S 0 -1+0) </div> <div style="margin-top: 10px;"> (No) because Q (and S) do not balance </div>	1
	<div style="margin-top: 10px;"> reaction 2 Q 0 +1-1+0 B 1 1+0+0 S 0 0+0+0 </div> <div style="margin-top: 10px;"> (Yes) because Q B and S / all balance two out of three gets 1/2 </div>	2
	<div style="margin-top: 10px;"> reaction 3 Q +1 +1+0 B +1 0+0 (S 0 0+0) </div> <div style="margin-top: 10px;"> (No) because B doesn't balance </div>	1
	<div style="margin-top: 10px;"> reaction 4 Q +1 0+1+0 B +1 +1+0+0 S 0 0+0+0 </div> <div style="margin-top: 10px;"> (Yes) because Q B S / all balance two out of three gets 1/2 </div>	2 [6]
(b)	if not, baryon numbers could not balance ; answers involving quarks score zero	1 [1]
(c)	no baryon has mass less than proton mass ; (neutron decay:) ${}^1_0\text{n} \rightarrow {}^1_1\text{p} + {}^0_{-1}\text{e} + \bar{\nu}$ gets 2/2 $\text{n} \rightarrow \text{p}^+ + \text{e}^- + \bar{\nu}$ gets 2/2 $\text{n} \rightarrow \text{p} + \text{e} + \nu(-\text{bar})$ gets 1/2 proton mass + electron mass < neutron mass ;	1 2 1 [4]

(d)	when inside a (stable) nucleus ;	1 [1]	
		12	
6(a)	(very) high temperature ; not 'very hot'	1	
1	(very) high density / no. of nuclei per unit volume <i>or</i> AW ; not 'high pressure'	1	
2	matter in plasma state ;		
3	(1)		
4	mixture of nuclei/ions and electrons ;		
5	(1)		
6	plasma forms because high temperature gives electrons enough energy to break free from atom / nucleus ;		
7	(1)		
8	high density because gravity pull / attraction pulls nuclei / particles / plasma together ; not 'confines'		
9	(1)		
10	high density means many collisions /per second <i>or</i> greater rate of collisions ;	1	
	(1)		
	high temperature because gravity has caused matter to heat up during star formation <i>or</i> AW ;		
	(1)	2	[5]
	high temperature (not 'heat') means protons (not 'particles') have enough (kinetic) energy ;		
	-to overcome (electrostatic) repulsion (between them / Coulomb barrier ;		
	(1)		
	any 2	1	
		1	
	$4\text{}^1_1\text{H} \rightarrow \text{}^4_2\text{He} + 2\text{}^0_1\text{e} + 2\nu$ -1 each error	1	
(b)	equation without neutrino includes		
	neutrino (1)		
11	(energy generated because)		
12	<i>either</i> fusion results in greater BE / nucleon <i>or</i> there is a loss of (rest) mass in fusion ;		

13	(few fusions because) mean k.e. (of protons) not enough to overcome repulsion / Coulomb barrier ;	4	[7]
14	nuclei have a range of speeds / energies (at a given temperature) ; (1)	12	
15	only a few have enough energy to fuse ; (1)		
16	multistage process which few protons actually complete <i>or</i> AW ; (1)		
	most collisions not head-on (so not all of k.e. available) ; (1)		
		any 4	

2825/05 Telecommunications

Question 1

- (a) AM Amplitude Modulation [1]
allow a satisfactory explanation of AM for the mark
- (b) (i) carrier period = $1 / 40\,000$ [1]
= $25\,\mu\text{s}$ [1]
- (ii) audio period = $1 / 4\,000$ [1]
= $250\,\mu\text{s}$
- (iii) Any AM waveform drawn [1]
With a carrier period of $25\,\mu\text{s}$ [1]
Carrier amplitude modulation reasonably smooth and symmetrical [1]
Modulation time period of $250\,\mu\text{s}$ [1]
- (c) Waveband is the Low Frequency (or Long Wave) [1]
- (d) (i) x-axis correctly labelled as Frequency [1]
Spectrum of any vertical lines [1]
Correct spectrum of carrier surrounded by two equally spaced smaller sidebands [1]
Three lines correctly marked as
36kHz 40kHz 44kHz [1]
- (ii) Bandwidth = 8 [1] kHz [1]

Question 2

- (a) (i) Noise is any unwanted electrical energy / power added to a signal [1]
 (ii) The signal-to-noise ratio decreases because [1]
 signal power falls due to attenuation while noise power stays constant. [1]
- (b) X Laser or LED [1]
 Y Photodiode or phototransistor or LDR [1]
- (c) (i) Signal-to-noise ratio $27 = 10 \log P_{\text{rec}} / 4.8 \times 10^{-6}$ [1]
 Received power $P_{\text{rec}} = 4.8 \times 10^{-6} \times 10^{2.7}$ [1]
 $= 0.0024 \text{ W}$ [1]
- (ii) Coaxial attenuation $= 10 \log 0.76 / 0.0024$ [1]
 $= 25 \text{ dB}$ [1]
- (iii) Maximum length coax $= 25 / 6.4$
 $= 3.9 \text{ km}$ [1]
- (iv) Power input to fibre $= 12\% \times 0.76 = 0.091 \text{ W}$ [1]
 Power output from fibre $= 0.0024 \div 12\% = 0.020 \text{ W}$ [1]
 Attenuation in fibre $= 10 \log 0.091 / 0.020$
 $= 6.58 \text{ dB}$ [1]
- (v) Maximum length fibre $= 6.58 / 0.47$
 $= 14 \text{ km}$ [1]
- (d) Optic fibre has greater bandwidth
 So has a much greater information carrying capacity

 Optic fibre has lower attenuation
 So can be transmitted uninterrupted over greater distances

 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 fibres / more secure

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

 Glass is manufactured from commonly available substance (or wtte)
 So optic fibre is much cheaper than copper
 any two points [1][1] [1][1]

Question 3

- (a)** Dual trace / beam (cathode ray) oscilloscope (allow cro) [1]
Allow voltmeter but only if it is specified as a.c.

Trace Y_1 should be connected to V_{in} while Y_2 should be connected to V_{out} . [1]
(ignore connections to 0v / earth)

- (b)** The student should find V_{in} and V_{out} are 180° out of phase (at least at low freq) [1]

Any suitable sketch drawn of two 180° out of phase signals [1]

- (c) (i)** Voltage gain = $-R_f / R_i$ [1]

$$= -880 / 2.2 \quad [1]$$

$$= -400 \quad [1]$$

(deduct mark if no negative sign)

- (ii)** If the input voltage is too great the op-amp will saturate [1]

Voltage gain cannot be measured in a saturated amplifier (or write) [1]
or allow any sensible comment that gain would appear to decrease

- (iii)** Maximum input voltage = $\pm 14 / 400$ (allow ± 13 or ± 15) [1]

$$= \pm 35 \text{ mV} \quad (\text{allow } 37.5 \text{ or } 32.) \quad [1]$$

- (d)** The student must measure input and corresponding output voltage over a range of frequencies

Then the gain must be calculated for each frequency [1]

The range of frequencies over which the gain has its maximum value (more precisely 0.7 of its maximum value) is the bandwidth. [1]

Question 4

(a) (i) Refractive index = speed of light in vacuum / speed of light in medium [1]

(ii) n core is greater than n cladding so that total internal reflection can occur [1]
or allow sensible comment on preventing light entering cladding

(b) (i) Critical angle is angle of incidence which would produce a refracted ray at 90°
or allow any sensible explanation of critical angle [1]

(ii) $1.50 \sin i_c = 1.48 \sin 90$ [1]

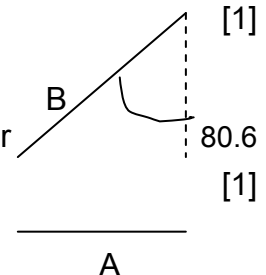
Thus $i_c = \sin^{-1} 1.48 / 1.50 = 80.6^\circ$ [1]

(c) (i) Speed of light in core $= 3 \times 10^8 / 1.5$
 $= 2 \times 10^8$ [1]

A's time in core $= 24\,000 / 2 \times 10^8$ [1]

$= 120 \mu\text{s}$ [1]

(ii) For any given horizontal distance A, the distance B is longer
by a factor of B / A and this is $1 / \sin 80.6$
(must have some consideration of distances for this mark)



Increase factor = $B / A = 1 / \sin 80.6$
 $= 1.50 / 1.48$
 $= 1.0135$ [1]

(iii) B's time in core = $24\,000 \times 1.0135 / 2 \times 10^8$
 $= 121.6 \mu\text{s}$ [1]

(d) (i) The fastest ray A from the start of pulse will reach the end of the fibre in $120 \mu\text{s}$.
 $1 \mu\text{s}$ later the slowest ray B from the end of each pulse will reach then end in $1 + 121.6 \mu\text{s}$
Thus the exit pulse lasts from $120 \mu\text{s}$ to $122.6 \mu\text{s}$

So the pulse duration on exit = $2.6 \mu\text{s}$ [1] [1] [1]

Note The answer should be (c)(iii) – (c)(i) + $1 \mu\text{s}$

(ii) Highest frequency input $= 1 / \text{period}$
 $= 1 / (2.6 \mu\text{s})$
 $= 385 \text{ kHz}$ [1]

Question 5

(a) Wavelength of radio-waves $\lambda = 2 \times 0.25 = 0.5 \text{ m}$ [1]

Frequency of radio-waves $f = c / \lambda$
 $= 3 \times 10^8 / 0.5 = 600 \text{ MHz}$ [1]

Allow 1 mark if answer is 1200 MHz.

(b) Signal-strength meter reading will not change [1]

Because e.m. waves radiate equally in all horizontal directions from dipole [1]

(c) Waves radiating from dipole are polarised [1]

Signal-strength meter reading will fall to zero when aerials are at 90°

Then it will return / increase to original reading when aerials are at 180° [1]

Then it will fall to zero again when aerials are at 270°

Before returning to original reading once aerials have been turned through 360° [1]

(d) The reading on the signal-strength meter will decrease [1]

Question 6 (Common question for all Options)

- (a) (i) Loss in GPE = (mgh)

$$= 0.240 \times 9.81 \times 0.060$$
 (deduct mark for $g = 10$ and for each power of ten error) [1]

$$= 0.141 \text{ J}$$
 [1]
- (ii) Work done = $84 \times 0.141 = 11.9 \text{ J}$ [1]
- (iii) Student must not only repeatedly lift or rotate or do work on magnet, but also rest of torch or components or hand [1]
- (b) operating time = Energy stored / mean power

$$= 10.5 / 55 \times 10^{-3}$$
 [1]

$$= 191 \text{ s}$$
 (accept 190) [1]
- (c) (i) The magnet falls under gravity [1]
 Magnet is accelerating / moving more slowly on entry than on exit [1]
- (ii) As the magnet falls the coil cuts the lines of flux / magnetic field. [1]
 Accept "there is a change in (magnetic) flux (linkage)".
 Do not accept a bald answer of "there is a change in magnetic field" unless qualified by "in the coil".
- (iii) Induced e.m.f. is proportional to the rate of change of magnetic flux (or wtte) [1]
 So e.m.f. is lower where magnet is slower / larger where magnet is faster [1]
 Note, the area under an induced e.m.f. / time graph is flux linkage $N \Delta \Phi$ so flux increase on entry is equal to the flux decrease on exit so allow a reasoned answer referring to equal areas.
- (iv) As the magnet enters, the flux builds up from zero to a maximum value and this generates one polarity of e.m.f. As the magnet exits, the flux change is in the opposite direction [1]
 Allow any reference to AB representing the magnet entering while BC represents the magnet leaving.

(d) (i) Charge $Q = I t = (\text{emf} / \text{resistance}) t$ [1]

$$= (N \Phi / t / R) t \quad t \text{ cancels} \quad [1]$$

$$= N \Phi / R$$

Charge $Q = 420 \times 0.54 \times 10^{-3} / 28$ [1]

$$= 8.1 \times 10^{-3} \text{ C}$$

Must have correct substitution (with or without the milli) and correct answer of 8.1 with an appropriate unit.

- (ii) Do not allow a bald statement of diode characteristics.
 Diodes are necessary because the generated charge flow is equal and opposite during the magnet fall so the net effect without the diodes would be a zero charge left on the capacitor [1]
 The answer must relate to the capacitor and the avoidance of discharging.
 Allow "so that current can only flow one way to the capacitor"

- (iii) A single magnet fall generates two equal and opposite charging pulses.
 The diodes allow the capacitor to store Q in both pulses. [1]
 Accept any reference to time BC allowing another 8 mC to be stored.

- (iv) For each inversion, $2 \times Q$ is stored on the capacitor (assuming zero diode turn-on voltage)

$$\begin{aligned} \text{Thus total charge stored} &= 84 \times 2 \times 8.1 \times 10^{-3} \\ &= 1.36 \text{ C} \end{aligned} \quad [1]$$

$$\text{Energy stored} = \frac{1}{2} Q^2 / C \quad [1]$$

$$= \frac{1}{2} \times 1.36^2 / 88 \times 10^{-3} \quad [1]$$

$$= 10.5 \text{ J}$$

If answer uses 84 only once (ie $84 \times \frac{1}{2} 16 \text{ milli}^2 / 88 \text{ milli} = 0.122 \text{ J}$) allow 2 marks.

Alternative method:

$$\begin{aligned} \text{Final capacitor pd } V &= Q / C \\ &= 84 \times 16 \text{ mC} / 88 \text{ mF} \\ &= 15.3 \text{ V} \end{aligned} \quad [1]$$

$$\begin{aligned}\text{Thus energy stored} &= \frac{1}{2} C V^2 & [1] \\ &= \frac{1}{2} \times 88 \times 10^{-3} \times 15.3^2 & [1] \\ &= 10.3 \text{ J}\end{aligned}$$

Only allow mark for formula $\frac{1}{2} CV^2$ if correct attempt has been made to calculate V.

2826/01 Unifying Concepts in Physics

- 1 (a) e.g. conservation of mass
conservation of energy
conservation of charge/current
conservation of momentum [1] each [3] {3}
- (b) (i) charge: [1]
current is charge per unit time [1]
at a point time for charge in = time for charge out [1] {3}
- (ii) energy [1]
electromotive force as energy provided per unit charge [1]
potential difference as energy used per unit charges (p.ds) around the loop. [1] {3}
- (iii) momentum [1]
momentum of cannonball forward equals momentum of cannon backwards [1]
momentum before equals zero; momentum after equals zero [1] {3}
- (iv) energy [1]
energy is received from the Sun (during the day) [1]
all the Earth radiates (infrared) during night (and day) [1]
these balance out (over a few years) to (give a constant temperature) [1] {4}
- [Total: 6]**
- 2 (a) (i) reading from graph weight before take-off = 600 N
mass = $600/9.8(1) = 61.2 \text{ kg}$ [1] {1}
- (ii) reading from graph = $3280 \pm 10 \text{ (N)}$ [1] {1}
- (iii) reading from graph $g = 9.2 \text{ N kg}^{-1}$ [1]
pull on astronaut = $9.2 \times 61.2 = 563 \text{ N}$ [1] {2}
- (b) (i) (fuel is burnt up so) mass of rocket gets less [1]
same force on less mass gives greater acceleration [1]
OR less friction as atmosphere is less dense [1]
OR g less as distance from Earth increases [1]
so in these cases resultant force is greater [1]
- (ii) the graph only gives the magnitude of the force [1]
momentum is a vector so direction would need to be constant [1] {2}
- (c) centripetal acceleration = value of g
distance from Earth = $(6.71 - 6.37) \times 10^6 = 340 \text{ km}$ [1]
which gives $g = 8.83 \text{ m s}^{-2}$ from the graph [0] {1}
- (d) (i) centripetal acceleration = $8.83 \text{ m s}^{-2} = v^2/r$ [1]
 $v^2 = 8.83 \times 6.71 \times 10^6$ [1]
 $v = 7700 \text{ m s}^{-1}$ [1] {3}
- (ii) k.e. = $\frac{1}{2}mv^2 = \frac{1}{2} \times 61.2 \times (7700)^2$ [1]
 $= 1.81 \times 10^9 \text{ J}$ [1] {2}
- [Total: 14]**

- 3 (a) vertical support provided by cable 5 = $8.75 \times 10^6 \times \cos 55 = 5.0 \times 10^6 \text{ N}$ [1]
vertical support provided by cable 11 = $14.5 \times 10^6 \times \cos 70 = 5.0 \times 10^6 \text{ N}$ [1] {2}
- (b) 11 cables on each side, 22 supports altogether [1]
force = $22 \times 5.0 \times 10^6 = 1.10 \times 10^8 \text{ N}$ [1] {2}
- (c) Constant forces, 2 required e.g. weight of decking, lights, crash barriers 1 each [2]
Variable forces, 2 required e.g. weight of traffic wind forces [2]
water/snow on viaduct [2]
Explanation, 2 points required e.g. bridge might last (80 years) and how do you know maximum wind forces over such a long time, Too many heavily laden lorries all bunched together Accident causing pile up
wind induced oscillations 1 each [2] {6}

[Total: 10]

- 4 (a) (i) photons/ radiation arriving at a (metal) surface [1]
and freeing (photo) electrons from the surface [1] {2}
- (ii) hf is the energy of a (single) photon (of frequency f) [1]
 ϕ is the work done on an electron to free it from the surface [1]
 $\frac{1}{2}mv_{\text{max}}^2$ is the maximum kinetic energy of a freed electron [1] {3}
- (iii) some of the electrons lose some energy in reaching the surface / collision with atoms (of the metal) [1] {1}
- (b) put a variable p.d. across the tube [1]
measure the current with a sensitive meter [1]
make anode negative until the flow ceases [1]
maximum k.e. of electrons = $e \times V_{\text{stopping}}$ [1] {4}
OR deflection by electric / magnetic fields to maximum [4]
OR de Broglie diffraction to maximum [3]
(Information required may be given on diagram)

[Total: 10]

- 5 (a) Answers must concentrate on the physics of the question.
e.g. "power annually" is impossible [1]
suggested alteration – e.g. "will save 20 MWh....." [1] {2}
- (b) e.g. to think that this is at all times,/ variable load, variable supply [1]
suggested alteration "when averaged out over a period of time" [1] {2}
- (c) to assume that only flow matters [1]
suggested alteration; the height of fall matters as well
use a dam to create fall and use just one generator 2 ideas wanted 1 each [2] {3}
- (d) tides must still occur (if variation in height of water is to be achieved) [1]
suggested alteration: tide times will be different, duration of low water may be different, feeding time may be shorter 2 ideas wanted 1 each [2] {3}

[Total: 10]

2826/03 Experimental Skills 2 Practical Examination

Question 1

(b)(ii)	Repeats of raw times (t). One mark. (but allow if in table of results) Calculation of period T using $T = t/n$. One mark. The raw timing of a single oscillation loses this mark.	2/1
(b)(iii)	Justification for number of sf in T. i.e. same sf as t (i.e same sf as raw data), or a sensible reference to human reaction time. Ignore references to dp. Answers must be <u>consistent with (b) (ii)</u> .	1
(c)	Readings Write the number of readings as a ringed total by the results table. 6 sets of readings of d and t scores two marks, 5 sets scores 1 mark. If minor help has been given then -1. Excessive help given then -2. 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.	2/1
(c)	Values of d must cover a range of at least 24 cm and be reasonably spaced ($\Delta d \geq 4$ cm), one mark.	1
(c)	Check a value for T^4 . Underline and ✓ checked value. Allow small rounding errors. One mark	1
(c)	Column headings for d, raw time t, and T. There must be some distinguishing mark between the quantity and its unit. E.g. T/s , T(s), T in seconds, are OK, but not (T)s , T _s , or just "seconds"	1
(c)	Consistency of raw readings d must be to nearest mm. One mark. Raw times must all be to 1 or 2 decimal places. One mark. Allow trailing zeros in d. Indicate using ✓ _c at the foot of each column if the raw readings are correct.	2/1
(c)	Quality of results Judge by scatter of points about the line of best fit. Five or six trend points, with little or no scatter, within 1 small square for a full size graph. Two marks. Some scatter, 5 or 6 points within a couple of small squares. One mark. Large scatter/no trend, scores zero. These marks cannot be scored if the wrong graph has been plotted.	2/1
(d)(i)	Axes. Each axis must be labelled with a quantity. Ignore unit. One mark for each axis. Scales must 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

(d)(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.	1
(d)(i)	Line of best fit There must be a reasonable balance of points about the line of best fit. If one of the points is a long way from the trend of the other plots then allow this plot to be ignored when the line is drawn. The mark can be awarded if the line of best fit is 'reasonable' but not quite right. This mark can only be awarded if a straight line has been drawn through a linear trend.	1
(d)(ii)	Measurement of gradient. Read-offs must be accurate to half a small square and the ratio must be correct, one mark. Please indicate the vertices of the triangle used by labelling with Δ . The hypotenuse must be greater than half the length of the drawn line, one mark. Negative value given for negative gradient, one mark.	3/2/1
(d)(ii)	y-intercept If possible, check the read-off. Allow errors up to and including half a small square. Correct substitution from a point on the line into $y = mx + c$ will only score a mark if the answer agrees with your read-off. If a false origin has been used or the read-off is off the grid, $y = mx + c$ must be used correctly (i.e. no algebraic errors), then one mark. A bald intercept with no working or possible read-off from graph scores zero.	1
(e)	Gradient = $-8\pi^4 L/g^2$, or use of this formula implied. One mark	1
(e)	Calculation of g. Check calculation. Be suspicious of 9.81 N/kg <i>Write down the value of L (p.3). Use $g^2 = -779L/\text{gradient}$ to find g. Write down your answer.</i>	1
(e)	Intercept = $4\pi^4 LK/g^2$, hence K. No need to check calculation, but K must equal L, allow ± 0.1 m. K must be calculated from the intercept. No ecf	1
(e)	Units of g (N/kg or m/s^2) and K (m)	1
(e)	Significant figures for g and K. Allow 2 or 3 sf	1
(f)	Percentage uncertainty in T. $\Delta t/t$ must be used (t = raw time). Sensible Δt , from 0.01s to 0.5s, or from spread of results. One mark Correct use of formula $\Delta t/t \times 100$. t must be a <u>raw</u> reading from table of results. No need to check calculation. One mark	2
(f)	Percentage uncertainty in T^4 . 4 x % uncertainty in T.	1

Total 28

Question 2

(c) (i)	Measurement of h_1 to nearest mm. Supervisor help loses this mark; make a note on the script to this effect.	1
(c) (ii)	y_1 calculated correctly, to nearest mm	1
(d)	y_2 calculated correctly, $> y_1$	1
(e)	$y^2 \propto I^3$ (or $y = I^{1.5}$). Comparison of ratios, or calculation of k's; one mark. Check calculations; if all correct, one mark. One mark for conclusion that $y^2 \propto I^3$, based on K calculation (only if values are within 10% of each other). Allow opposite conclusion if values are not within this range.	3/2/1/0
(f)	Evaluation of procedure. Relevant points must be underlined and ticked. One mark for each line.. Some of these might be: P = problem S = solution 1 P 2 sets of readings are not enough 2 S Take more sets of readings of y and I , and plot a graph 3 S The graph plotted should be y^2 against I^3 , and it should be a straight line 4 P h keeps fluctuating slightly / is unreliable (and is difficult to read) 5 S Repeat the readings of h , and <u>average</u> them 6 P The wire moves for some seconds after the change of current 7 S Wait for a few seconds until the reading of h is <u>steady</u> 8 P It is difficult to be sure that the connectors have not slipped in the clamps, or the wire in the connectors. 9 S Make sure connections are really tight (or other sensible suggestion). 10 P The cold wire may have bends and kinks in it 11 S Start the experiment by passing maximum current for a few seconds, with the wire under slight tension, 12 P Difficult to measure h accurately, because changes are so small. 13 S Use a magnifying glass. Allow other sensible ideas, but not lasers or pointers. 14 15 P Parallax error in reading h S Read h at eye level Motion sensors, videos, light gates, data loggers, etc. are not relevant here, and should not be credited. Do not credit draughts. Allow other relevant points.	8
	2 marks are reserved for quality of written communication (SPAG)	2

16 marks maximum to be awarded

Planning Exercise – Stokes' Law Mark Scheme

A1	Labelled diagram of vertical tube containing a specified viscous liquid. Levels must be marked on the tube (unless light gates are used) to mark range over which velocity is measured. An acceleration zone must be there at the top.	1
A2	The procedure to be followed, i.e measure velocity for a series of different radii. s/t must be stated or implied. There must be <u>repeats</u> .	1
B1	Method to confirm that terminal velocity has been reached, i.e. measure t or v twice as the ball falls down the tube.	1
B2	Method of measuring diameter/radius with micrometer, and time with stop watch or stop clock. Allow light gates.	1
C1 1 2	Labelled sketch graph of results, i.e v against r^2 , or log v against log r. Straight for the smaller balls, (curved over for the larger balls). One mark. Show how η is obtained from gradient of graph, η must be subject of equation. One mark.	2/1/0
C2	End of v / r^2 graph is slightly curved over.	1
D1 1 2 3 4 5	Detail marks, up to max of 3 Evidence of preliminary work (some figures for v or t needed) Limitations: Larger balls travel too fast for streamline flow Tube is not wide enough (for liquid to pass by larger balls) Bubbles can get stuck to top of the balls/ soak in oil first Retrieval of ball e.g. by a magnet / Precautions to ensure tube is vertical	3/2/1/0
D2 1 2 3 4	Why Stokes' law is not useful for parachutist: Speed is too high (so flow must be turbulent), and formula will not apply. Substitution of estimated figures to show that equation cannot apply. Parachutist is not a sphere, so formula will not apply. Reynold's number too high with an explanation	2/1/0
R	Evidence of research of material. i.e. at least two detailed references, from different sources, have been given (i.e page numbers must be given). Allow internet <u>pages</u> to be sourced. Two or more vague references (i.e. no page reference) score one mark One detailed reference scores one mark. One vague reference scores zero.	2/1/0
	Underline and tick each relevant point in the body of the text. The ticks must have a subscript showing <u>which</u> marking point is being rewarded (e.g. \checkmark_{A1}).	
Q	Quality of written communication (organisation) Rambling and poorly presented material cannot score both marks.	2

Total 16

Grade Thresholds

Advanced GCE Physics A (3883/7883)
June 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2821	Raw	60	47	43	39	35	31	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	45	41	37	34	31	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	96	86	77	68	59	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	96	86	77	68	59	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	92	85	78	71	64	0
	UMS	120	96	84	72	60	48	0
2824	Raw	90	58	51	44	38	32	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	67	61	56	51	46	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	70	64	58	52	47	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	59	53	47	41	35	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	61	54	47	41	35	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	66	59	52	45	38	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	83	74	65	56	47	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	83	74	65	56	47	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	77	70	63	56	50	0
	UMS	120	96	84	72	60	48	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	25.7	47.2	66.6	82.5	94.9	100	1387
7883	28.9	50.5	69.1	84.9	95.8	100	5901

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.

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity



OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553