

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Mark Scheme for the Units

January 2009

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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	9
2823/01 Wave Properties/Experimental Skills 1 Written Paper	17
2823/03 Wave Properties/Experimental Skills 1 Practical Examination	21
2824 Forces, Fields and Energy	26
2825/01 Cosmology	29
2825/02 Health Physics	32
2825/03 Materials	36
2825/04 Nuclear and Particle Physics	39
2825/05 Telecommunications	44
2825 Common Question	50
2826/01 Unifying Concepts in Physics	52
2826/03 Experimental Skills 2 Practical Examination	55
Grade Thresholds	59

2821 Forces and Motion

Question 1			Expected Answers	Marks	Additional Guidance
(a)	(i)	1	Vertical: <u>constant</u> deceleration / at g	B1	allow <u>constant</u> acceleration; allow uniformly instead of constant velocity / speed decreasing at a constant. Do not allow steady or motion decreases....
		2	Horizontal: constant velocity / speed (horizontal line)	B1	allow uniform or no change in.... or acceleration zero Do not allow steady speed / motion
	(ii)	1	vertical y = area under line = $0.5 \times 40 \times 4.1 = 82$ (m)	C1 A1	<u>using equation of motion</u> to give $s = \frac{1}{2} g(t)^2$ or $s = u^2 / 2a$ using $g = 10$ -1 (only once on the paper)
		2	horizontal x = 30×4.1 = 123 (m)	A1	using $50\cos 53$ gives 123.4 (m)
(b)			displacement is the straight line from start to max height or range described distance is the actual path taken / curve for the projectile	B1 B1	straight line from the initial to the final points not just distance is a scalar and displacement is a vector
(c)	(i)		$v_v = 20 \text{ (m s}^{-1}\text{)}$ $v_h = 30 \text{ (m s}^{-1}\text{)}$	A1	Limit of 20 to 21 Note ecf from misreading of v_h in (a)(ii) 2
	(ii)		calculation or correct scale diagram $v = [(20)^2 + (30)^2]^{1/2}$ = $36.1 \text{ (m s}^{-1}\text{)}$ allow 2 sf angle = $\tan^{-1}(20 / 30)$ scale given = $33.7 (^{\circ})$ allow 2sf (an answer of 56.3 scores 1)	C1 A1 C1 A1	note ecf from (c)(i) using 21 gives 36.6 using 20 gives 33.7 and using 21 gives 35 allow correct use of sin or cos using value for v 90 -these values scores one only scale diagram limits: $35 \text{ to } 37 \text{ m s}^{-1}$ and $33 \text{ to } 36^{\circ}$
	(iii)		velocity = 30 m s^{-1}	A1	Note ecf from (a)(ii) 2 BUT NOT ZERO / 0 !!

Question 1			Expected Answers	Marks	Additional Guidance
(d)			vertical: same gradient to (6.0 , ± 19) line has same negative gradient	B1 B1	ALLOW LINE BETWEEN -18 AND -20 Within -16 to -22
			horizontal: continued horizontal line to 6.0 s	B1	
			Total	16	

Question			Expected Answers	Marks	Additional Guidance
2	(a)		Use of $s = ut + \frac{1}{2}at^2$ i.e. $s = \frac{1}{2}at^2$ $t^2 = 2s / a$ related to $y = mx$	C1 A1	with $u = 0$, allow the use of g in the equation e.g. gradient = $2 / a$
	(b)	(i)	(gradient = using correct values from graph) = 0.20	C1 A1	 Allow 0.19 to 0.21 allow 0.2 (1 sf) inverse gradient scores zero
		(ii)	$s = ut + \frac{1}{2}at^2$ with substitution of points read from graph. Or $t^2 = 2s/a$, therefore gradient = $2/a$ $a = 2 / \text{gradient}$ = $2 / 0.20 = 10.0 \text{ (m s}^{-2}\text{)}$ allow 10	M1 A1	 note ecf from (b)(i) but not (a)
	(c)		width of the ball / end error in readings from the ruler / time delay due to electromagnet or release of ball or trapdoor / air resistance	Max B2	no credit for any random errors in readings
			Total	8	

Question 3			Expected Answers	Marks	Additional Guidance
(a)	(i)		A newton is the <u>force</u> that causes a (mass of) one <u>kilogram</u> to <u>accelerate</u> at one m s^{-2}	B1	not just 1 kg m s^{-2}
	(ii)		Work equals the force multiplied by the distance moved <u>in the direction of the force</u>	B1	force x displacement in line of force
(b)	(i)	1	$W = Fs$	B1	Allow d / x instead of s
		2	and $F = ma$		Allow equations in words
	(ii)		$W = m \times a \times s$ allow $W / s = ma$ $a = (v-u) / t$ and $s = [(u + v)/2] \times t$ or $a \times s = (v^2 - u^2) / 2$ $W = m \times (v-u) / t \times [(v+u)/2] \times t$ and $v=0$ Or $W = m \times (v^2 - u^2) / 2$ and $v = 0$ <u>$W = \frac{1}{2} mu^2$</u>	B1 B1	need W in answer line or somewhere $W = KE(\text{lost})$ need u here or initial velocity defined as v if v given
	(iii)		Distance is proportional to (velocity) ²	B1	allow double the speed causes four times distance etc
(c)	(i)		$F \times s = \frac{1}{2} mu^2$ $F = 0.5 \times 1550 \times (13.3)^2 / 25$ = 5500 (5483) (N)	C1 A1	note calculating acceleration = 3.54 scores this mark allow 5480 (m) note using 1500 (-1) gives 5300 (N)
	(ii)		100 (m)	B1	
			Total	10	

Question 4		Expected Answers	Marks	Additional Guidance
(a)	(i)	Pressure = force (normal) / area	B1	do not allow over unless clear from later working do not allow symbols unless defined
	(ii)	Density = mass / volume	B1	do not allow over unless clear from later working. do not penalise this twice in (i) and (ii).
(b)	(i)	Mass = volume x density = 27 x 2600 = 70200 (kg)	A1	Allow 2 sf
	(ii)	pressure = (mass x g) / area = (A x d x ρ x g) / A [mass = 144000 kg] = 1.5 x 1000 x 9.8 = 14700 (Pa)	C1 A1	Allow weight / area g = 10 (-1 if not already penalised) if bald answer of 15000 given then -1 (as if g = 10 used) if answer given to 15000 after using g = 9.8 then 2/2 scored
	(iii)	concrete walls has greater depth / density	M0 A1	not area or mass
		Total	6	

Question 5		Expected Answers	Marks	Additional Guidance
(a)		c of g is the <u>point</u> where the weight of a body (appears to) act	B1	not where 'gravity' acts
(b)	(i)	No resultant force <u>and</u> no resultant torque / constant velocity / acceleration is zero	B1	allow clockwise moments = anticlockwise moments and resultant force is zero. Not constant speed.
	(ii)	Moment = $W \times d$ = 22000×0.4 = 8800 unit: N m	B1 B1	Allow 8.8 Allow kN m value and units must be consistent
	(iii)	$T_1 \times 1.6 = 8800$ $T_1 = 5500 \text{ (N)}$	C1 A1	note ecf from (b)(ii) i.e. $T = (b)(ii) / 1.6$ using 1.2 instead of 1.6 scores zero
	(iv)	$T_2 = 22000 - 5500$ = 16500 (N)	A1	note ecf from (b)(iii) i.e. $22000 - (b)(iii)$
	(v)	$P = F \times v$ = 22000×0.015 = 330 (W)	C1 A1	no credit for $P = W / t$ not $P = 1/2 m v^2$
(c)		when the boat is accelerating / speed or velocity not constant / at the start or end	B1	not when it is on the ground
		Total	10	

Question 6	Expected Answers	Marks	Additional Guidance
(a)	<p>Extension: extended length – original length / the increase in length (when force is applied to spring)</p> <p>Hooke's Law: force is proportional to the extension or stress is proportional to strain (provided not past limit of proportionality)</p> <p>Elastic limit: spring returns to original length when <u>the force is removed</u> / or suffers <u>permanent</u> deformation</p> <p>Force constant: force / extension / $F = ke$ / $F = kx$</p>	MAX B3	<p>Not how much a wire stretches.</p> <p>Gradient of a force / extension graph or inverse gradient of an extension / force graph</p> <p>Allow symbols not defined</p>
(b)	<p>Y M = stress / strain (up to the limit of proportionality)</p> <p>strain = extension / (original) length and stress = force / area</p> <p>A stiff material has high / large Y M</p> <p>stiffness related to how difficult it is to deform a material</p> <p>a strong material can take a high (maximum) <u>stress</u> (before breaking)</p> <p>brittle <u>no</u> plastic region / breaks in elastic region or at elastic limit</p> <p>ductile can be drawn into a wire / <u>large</u> plastic region / retains new or deformed shape</p>	MAX B5	<p>both required but allow symbols only – do not accept a single combined expression for Young modulus</p> <p>e.g. bending, stretching,</p> <p>not large force</p>

Question 6			Expected Answers	Marks	Additional Guidance
QWC			<p>The answer must involve physics, which attempts to answer the question.</p> <p>Structure and organisation: Award this mark if the whole answer is well structured / description easy to follow in reasonable order of terms</p> <p>SPAG do not award this mark if there are more than three spelling mistakes and grammatical errors.</p>	<p>B1</p> <p>B1</p>	need at least two sentences before these marks can be given
			Total	10	

2822 Electrons and Photons

Question			Expected Answers	Marks	Additional Guidance
1	a		volt per amp(ere) / (1) V A^{-1}	B1	Allow 'It is the resistance when current is 1A and voltage is 1V' (1) Not $R = V / I$ or 'volt per current' or 'voltage per amp(ere)'
	b	i	1. The resistance remains constant 2. The resistance increases (as p.d increases) ora	B1 B1	
		ii	At 7.(0)(V) Resistance is V/I <u>and</u> both V and I are the same	M1 A1	$R=V/I$ allowed in any form. No back/forward credit on $R=V/I$
		iii	At <u>$V = 4.0 \text{ V}$</u> , currents are 2.6 (A) and 3.6 (A) total current = 6.2 (A) resistance = $\frac{4.0}{6.2}$ resistance = $0.645 \text{ } (\Omega) \approx 0.65 \text{ } (\Omega)$	C1 C1 A1	Do not allow any other voltage. Allow first mark for: $R_r = 1.5(4) \text{ } (\Omega)$ / $R_b = 1.1(1) \text{ } (\Omega)$ Allow between 3.6 and 3.65A Allow 2 marks if candidates has written: $R = \frac{1.54 \times 1.11}{1.54 + 1.11} / \frac{1}{R_T} = \frac{1}{1.54} + \frac{1}{1.11}$ (Allow full credit for 2 sf substitution above) Bald 0.645 or 0.65 or 0.64 or 0.635 scores 3 marks
			Total	8	

Question		Expected Answers	Marks	Additional Guidance
2	a	Circle round C s ⁻¹	B1	
	b	Correct arrows at O and P – ‘clockwise’	B1	Allow a single arrow.
	c	$I = Q/t$ / charge = current \times time $Q = 9.4 \times 10^{20} \times 1.6 \times 10^{-19}$ (= 150.4 C) $I = \frac{150.4}{30}$ current = 5.0(1) (A)	C1 C1 C1 A0	The first mark is for a correct equation – any subject There are 3 marks for correct values of charge and time substituted into the equation – current must be the subject Reject A bald answer of 5 A (since this is given in the question) Allow 1 mark for a bald answer of 5.01 (A) – 3 sf or more.
	d	Horizontal line at 5.0 (A)	B1	
	e	energy = $24 \times 1.6 \times 10^{-19}$ energy = $3.8(4) \times 10^{-18}$ (J)	C1 A1	Do not allow the use of 150.4C (only allow electron charge). A bald answer of 3.8×10^{-18} scores 2 marks
		Total	8	

Question		Expected Answers	Marks	Additional Guidance
3	a	For p.d: <u>Charge(s) / electron(s)</u> lose energy / change <u>electrical</u> energy to another form Or For e.m.f: <u>Charge(s) / electron(s)</u> gain energy / change energy to <u>electrical</u> energy	B1	
	b	Both (have the same unit) volts / V / J C ⁻¹	B1	Allow Both 'energy/charge' (1) Do not allow the word "voltage(s)"
	c i	There is p.d. across the <u>internal</u> resistor / resistance.	B1	Allow 'Energy / power lost in internal resistor / resistance' (1) Allow p.d./ voltage is <i>used</i> across the internal resistance.
	ii	$V_{out} = \left(\frac{R_2}{R_1 + R_2}\right)V_{in} \quad / \quad \frac{V_1}{V_2} = \frac{R_1}{R_2}$ $(V_{out}) = \frac{R}{R + 4R} \times 6.0 \quad / \quad (V_{out}) = \frac{1}{5} \times 6.0$ <p>p.d. = 1.2 (V)</p>	C1 C1 A1	Allow 'Voltage splits in the ratio 4:1 (for X and Y)' for the first mark Allow 2 marks if second equation is written Bald 1.2 V scores 3 marks Special case Allow 2/3 marks if the p.d. of 4.8 V is determined for X
	iii	Wire Y Justified in terms of $P = \frac{V^2}{R}$ or $P \propto 1/R$	M1 A1	Note This second mark is dependent on getting the first (M1) mark
		Total	8	

Question			Expected Answers	Marks	Additional Guidance
4	a		$\rho = RA/L$	B1	Allow Any subject for the equation
	b		$R = \frac{\rho \times 0.5}{0.5^2}$ resistance = 2ρ	C1 A1	Allow 2 marks for bald 2ρ or $\rho/0.5$
	c	i	$A = 1.6 \times 10^{-5} / 5.3 \times 10^{-2}$ $A = 3.0(2) \times 10^{-4} \text{ (m}^2\text{)}$	M1 A0	Reject Bald $3.02... \times 10^{-4}$ – since it is a ‘show’ calculation
		ii	$\rho = \frac{7.8 \times 10^{-5} \times 3.02 \times 10^{-4}}{5.3 \times 10^{-2}}$ resistivity = $4.4(4) \times 10^{-7} \text{ (}\Omega \text{ m)}$	C1 A1	The first mark is for substitution into a correct equation – any subject Allow 2 marks for a bald 4.4×10^{-7}
	d		No change (to the value of resistivity) Resistivity depends (only) on the material / independent of A and L	M1 A1	
			Total	8	

Question		Expected Answers	Marks	Additional Guidance
5	a	<p>Kirchhoff's first law:</p> <ul style="list-style-type: none"> Charge is conserved Sum of currents into a point = sum of currents out from (the same) point <p>Kirchhoff's second law:</p> <ul style="list-style-type: none"> Energy is conserved Sum of e.m.fs in a loop = sum p.ds in the (same) loop <p>Photoelectric effect:</p> <ul style="list-style-type: none"> Energy is conserved <p>Any <u>two</u> further marks from:</p> <ul style="list-style-type: none"> A single photon interacts with an electron $hf = \phi + KE_{(\max)}$ Electron removed when photon energy $\geq \phi$ / frequency \geq threshold frequency (wtte) 	<p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p> <p>B1×2</p>	<p>Must show ticks on the script to indicate where marks are being awarded</p> <p>Must see "sum of/total" wtte, on both sides of equals.</p>
		<p>QWC</p> <p>Structure and organisation mark</p> <p>Spelling and Grammar mark</p>	<p>B1</p> <p>B1</p>	<p>For QWC marks, the answer must involve physics, which attempts to answer the question – otherwise the mark for QWC is zero.</p> <p>Award this mark if the whole answer is well structured (Bulleted answers are allowed)</p> <p>More than two spelling mistakes <u>or</u> more than two grammatical errors mean that this mark is lost</p>
		Total	9	

Question		Expected Answers	Marks	Additional Guidance
6	a	<p>Any <u>four</u> from:</p> $\lambda = \frac{h}{mv}$ <p>λ = wavelength, m = mass (of particle) h = Planck constant and v = speed (of particle)</p> <p>λ (of electron) is similar to separation between / size of atoms (wtte)</p> <p>λ of electron $\sim 10^{-10}$ <u>m</u></p> <p>The wavelength of the ball is (very) small compared with the window gap (wtte)</p>	<p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>B1</p>	<p>Must show ticks on the script to indicate where marks are being awarded</p> <p>Allow Wavelength in the range (10^{-9} to 10^{-13}) <u>m</u></p> <p>For this mark, there must be clear reference to the size / width / gap of window; hence no mark for 'wavelength of electron is very small'</p>
	b	<p>speed = $0.025 \times 3.0 \times 10^8$ or 7.5×10^6 (m s⁻¹)</p> $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 7.5 \times 10^6}$ <p>$\lambda = 9.7 \times 10^{-11}$ (m)</p>	<p>C1</p> <p>C1</p> <p>A1</p>	<p>Allow 2 marks for correct substitution of all numbers in the equation – any subject</p> <p>Allow 3 marks for a bald answer of 9.7×10^{-11} (m)</p>
		Total	7	

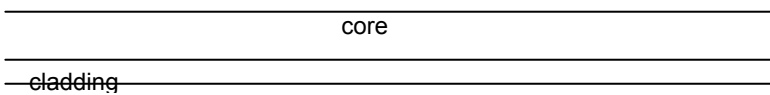
Question			Expected Answers	Marks	Additional Guidance
7	a		Tick for the third statement	B1	
	b		(The error is) the (field) lines are equidistant (wtte)	B1	Allow 'There is no (magnetic) field close to the wire' (1) Allow the drawing of a correct field pattern..
	c	i	$F = BIL \quad / \quad B = \frac{9.5 \times 10^{-4}}{12 \times 0.15}$ flux density = $5.28 \times 10^{-4} \text{ (T)} \approx 5.3 \times 10^{-4} \text{ (T)}$	C1 A1	
		ii	$r = \frac{1.26 \times 10^{-5}}{5.28 \times 10^{-4}} \quad \text{(Possible ecf)}$ separation = $2.39 \times 10^{-2} \text{ (m)} \approx 2.4 \times 10^{-2} \text{ (m)}$	B1	(bald 0.02 is an sf error)
			Total	5	

Question			Expected Answers	Marks	Additional Guidance
8	a		Any <u>two</u> from: <ul style="list-style-type: none"> • Packet of energy / quantum of energy / electromagnetic radiation • Travels at the speed of light / $3.0 \times 10^8 \text{ ms}^{-1}$ • Has no charge • Energy given by: $E = hf$ / $E = hc / \lambda$ • Can travel through a vacuum / free space 	B1×2	Must show ticks on the script to indicate where marks are being awarded Allow has zero mass Do not allow wave effects such as polarisation/diffraction/reflection.
	b	i	$E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{5.5 \times 10^{-7}}$ $E = 3.6(2) \times 10^{-19} \text{ (J)}$	C1 A1	Allow The first mark for: $E = hf$ <u>and</u> $f = \frac{3.0 \times 10^8}{5.5 \times 10^{-7}} (= 5.46 \times 10^{14})$
		ii	total power = $6.3 \times 10^7 \times 6.1 \times 10^{18}$ (= 3.843×10^{26}) number per sec = $\frac{3.843 \times 10^{26}}{3.62 \times 10^{-19}}$ (Possible ecf) number per sec = $1.0(6) \times 10^{45} \text{ (s}^{-1}\text{)}$	C1 A1	Allow 1 mark if candidate gets as far as the second step Allow 2 marks for a bald answer of $1.1 \times 10^{45} \text{ (s}^{-1}\text{)}$ – 2sf or more Special case 1 mark for $1.74 \times 10^{26} \text{ (s}^{-1}\text{)}$ (i.e. per m ²)
		iii	Infrared / IR	B1	
			Total	7	

2823/01 Wave Properties/Experimental Skills 1 Written Paper

Question			Expected Answers	Marks	Additional Guidance
1	a	i	<i>i</i> AND <i>r</i> correctly labelled	B1	
1	a	ii	recall of $n = \sin i / \sin r$ correct substitution: e.g. $1.4 = \sin 30 / \sin r$ $r = 21^\circ$ (20.9)	C1 C1 A1	Look out for those who simply divide 30 by 1.4 and get 21.4 – i.e 21 (the correct answer) This scores ZERO!
1	a	iii	angle of refraction would be bigger than 21° (but less than 30) any correct reference to speed in water compared to speed in liquid: e.g. light does not slow down as much (in water) (WTTE)	B1 B1	allow use of the formula: e.g. dividing by 1.3 makes sinr bigger ----- B1 hence r is bigger ----- B1
1	b	i	recall of $n = c_1 / c_2$ $c_2 = 3 \times 10^8 / 1.3 = \mathbf{2.3 \times 10^8 \text{ ms}^{-1}}$ (2.308)	C1 A1	Any ratio of speeds scores the first mark.
1	b	ii 1	recall of $v = f \lambda$ correct substitution: e.g. $f = 3 \times 10^8 / 5.2 \times 10^{-7}$ $f = 5.8 \times 10^{14} \text{ Hz}$ (5.769)	C1 C1 A1	$\mathbf{5.7 \times 10^{14}}$ scores 2 marks
1	b	ii 2	evidence of knowledge of $\lambda_1 / \lambda_2 = c_1 / c_2 (= n_1 / n_2)$ $\lambda_2 = 5.2 \times 10^{-7} / 1.3 = 4.0 \times 10^{-7} \text{ m}$ (3.714)	C1 A1	allow $\lambda_2 = v/f = 2.3 \times 10^8 / 5.8 \times 10^{14} = 4.0 \times 10^{-7} \text{ m}$ allow 3.9×10^{-7} for full marks
1	b	ii 3	$f = 5.8 \times 10^{14} \text{ Hz}$ /frequency is the same as in air	B1	allow ecf from cand's answer in b (ii) 1
			Total	14	

Question			Expected Answers	Marks	Additional Guidance
2	a		waves meet/cross/interfere(nce)/overlap/combine (WTTE) resultant displacement is sum of displacements of each wave WTTE) constructive interference: resultant wave has increased displacement/or waves meet in phase destructive resultant wave has reduced (or zero) displacement (WTTE: e.g. allow “waves cancel each other”) /or waves meet in antiphase	B1 B1 B1 B1	The first 2 marks are for a STATEMENT of what superposition means. Allow superimpose but not superpose. Complete diagrams for construction and destructive interference can score a maximum of 2 marks.
2	b	i	straight line drawn from T to D AND straight line drawn from T being reflected from steel plate to reach D	B1	ignore ‘accuracy’ of reflected ray
2	b	ii	path difference for maxima = λ , OR 2λ OR 3λ etc (allow $n\lambda$, and 0) path diff for minima path difference = 0.5λ , OR 1.5λ OR 2.5λ etc [allow $(n + \frac{1}{2})\lambda$].	B1 B1	Give <u>full credit</u> for clear answers involving phase change due to reflection. Correct answers in terms of phase angles score a maximum of 1.
2	c		recall of $\lambda = ax/D$ (stated in any valid form) correct substitution : $a = \lambda D/x = 6.4 \times 10^{-7} \times 1.8 / 2.4 \times 10^{-3}$ $a = 4.8 \times 10^{-4} \text{ m}$ (or 0.48mm)	C1 C1 A1	Some will forget to change 2.4 mm into $2.4 \times 10^{-3} \text{ m}$ and consequently will have $a = 4.8 \times 10^{-7}$ – this scores a total of 2 marks. No other ecf allowed
			Total	10	

Question			Expected Answers	Marks	Additional Guidance
3	a	i	any correct <u>labelled</u> diagram straight or curved: 	B1	Either the core OR the cladding labelled scores the mark.
3	a	ii	To <u>allow (WTTE) total internal reflection</u> to occur	B1	
3	b	i	$1.52 = 1/\sin C$ in any valid form e.g. $\sin C = 1/1.52$ hence $C = 41^\circ$ (41.1)	C1 A1	
3	b	ii	(n =) $2.014/1.974$ (= 1.020) OR (n =) $1.974/2.014$ (= 0.980) ($\sin C = 1/1.02$) hence C = 78.6°	C1 A1	Any ratio of correct speeds scores this mark Accept 78° or 79°
3	b	iii	(Without a high C we get) multipath dispersion/different paths and different times/smearing/overlapping signals(WTTE) With high C <u>most of the light is refracted out</u> (and hence reduces the chance of TIR occurring) most light follows the same path (WTTE)	B1 B1 B1	allow answers that refer to avoiding overlap of signals or 'bit rate'
			Total	9	

Question			Expected Answers	Marks	Additional Guidance
4	a	i	coils vibrate parallel to wave direction (WTTE) coils vibrate perpendicular to wave direction (WTTE)	B1	allow correct reference to axis of slinky instead of wave direction and labelled diagrams for full marks
4	a	ii		B1	
4	b	i	two differences: e.g. standing waves have nodes and antinodes progressive waves transfer energy (standing waves do not)	B1 B1	Also allow: neighbouring points vibrate in phase in standing waves; have same amplitude in prog. waves
		ii	any valid similarity: e.g. both have a frequency/period/wavelength	B1	
4	c	i	node correctly labelled as N at base of cylinder antinode correctly labelled as A near top of cylinder	B1 B1	To score the second mark it must be the fundamental that is drawn (i.e. 1/4 of a wave).
4	c	ii	$0.64 = \frac{1}{4} \lambda \Rightarrow \lambda = 4 \times 0.64 = 2.56 \text{ m}$ (or 2.6) correct substitution of cand's λ into $v=f\lambda$: e.g. $f = 330/2.56$ $f = 129 \text{ Hz}$ OR 130 Hz (or correct ecf answer)	C1 C1 A1	Allow e.c.f. for correct determination of λ from cand's standing wave in c(i). If they use 2.6 for λ $f = 127 \text{ Hz}$ for 2 marks Also allow ecf within this section for correct use of incorrect λ or v
4	d	i	N shown roughly at centre of tube and As at each end	B1	Look at letters only
4	d	ii	frequency = 258 Hz OR 2 x cand's answer for c (ii)	B1	Allow e.c.f. from d (i)
			Total	12	

2823/03 Wave Properties/Experimental Skills 1

Practical Examination

Planning Exercise - Skill P

- | | | |
|-----------|--|--------------|
| A1 | <u>Workable</u> circuit diagram.
i.e. wire under test and method of determining resistance | 1 |
| A2 | Correct procedure
(i.e. measure temperature and determine resistance of wire, change temperature and determine new resistance of wire – allow graph or table). Method must be <u>workable</u> . | 1 |
| A3 | Use long wire ≥ 1 m | 1 |
| B1 | Method of achieving temperature range e.g. water/oil bath/incubator/freezer/ice
Do not allow bald Bunsen burner. | 1 |
| B2 | Method of determining temperature of wire e.g use of thermometer/read dial | 1 |
| B3 | Wait for temperature to stabilise or keep uniform temperature e.g. stirring | 1 |
| C1 | Temperature related safety precautions: Use gloves to handle equipment when hot/cold | 1 |
| C2 | Keep cross-sectional area/length/type of wire constant | 1 |
| D | Any further relevant detail. Examples of creditworthy points might be; | max 4 |

Wire must not have kinks

Typical resistance very low or quotes resistivity value

Determination of typical resistance of wire

Check diameter of wire using micrometer in different places

Take several readings of temperature to ensure that temperature is constant

Calculation of range of meter

Use of a protective resistor

Calculation of protective resistor

Prevent wire shorting

Use of insulated wire

Use of remote measuring devices

Use of I-V or V-I characteristics to determine resistance at each temperature

Detailed explanation of bridge methods

Explanation for use of insulated wire within water

Evidence of preliminary investigation in the laboratory/resistivity of metal

- | | | |
|-------------|---|--------------|
| R1/2 | Evidence of the sources of the researched material | 2/1/0 |
| | Two or more (vague) references from different sources or one detailed reference score one mark. | |
| | Two or more detailed references from different sources 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

- (c) Justification of significant figures in V 2/1/0
 Sf in V related to sf in I and R scores two marks.
 Vague answers relating sf in raw data, I only or R only 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.
 Six sets of values for I and V scores 1 mark.
 V calculated correctly scores 1 mark; ignore POT errors but penalise AE.
 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) Measurements and consistency 2/1/0
 Values of R determined correctly scores 1 mark (15.7, 23.5, 31.3, 47, 70.5, 94, 141)
 I measured to the same number of dp scores 1 mark.
- (d) Column headings in the table 2/1/0
 One mark for R and I headings correct.
 One mark for V heading correct.
 Ignore units in the body of the table.
- (d) Significant figures in calculated values 2/1/0
 R given to 2 or 3 sf scores one mark
 V given to 2 or 3 sf (or 4 sf if appropriate) scores one mark.
- (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 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.
 Five 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.
 Ratio correct and read offs correct and negative gradient 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 F = magnitude of candidate's gradient value
 F in range of 35 to 45 using candidate's gradient value
 Sig Figs of F : allow 2 or 3 only
 Consistent unit of F (Ω or VA^{-1}). 4/3/2/1/0
- (ii) Value of E = candidate's y-intercept value
 Value of E within the range of 3 – 7 using candidate's y-intercept value
 Sig Figs of E : allow 2 or 3 only and unit of E (V) scores 1 mark. 3/2/1/0
- (h) (i) Calculation of percentage difference and appropriate conclusion 1/0
 Expect to see $(\text{difference})/39 \times 100$
- (h) (ii) Expect to see reference to scatter of points on 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) (iii) e determined correctly to the nearest millimetre 1
- (c) $\Delta L = 1-5$ mm 1
percentage uncertainty ratio correct using their L value. 1
- (d) New value of e correct and larger than (b)(iii) 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
using correct masses. Vague answers will not score this second mark. 1
No method loses both these marks
- (f) Evaluation of procedure 8
Relevant points must be underlined and ticked with the appropriate marking letter.

	Problem	Solution
A	Difficulty in measuring L	Use a marker at the top and bottom of the spring system/clamp ruler
B		Use vernier callipers/travelling microscope
C	Difficult to ensure that same amount of mass holder is submerged/masses have different masses	Measure or mark mass holder or use thin cotton and masses; measure masses individually.
D	Spring system oscillates	Wait for some time/use wider mass holder so as increase damping
E	Small length readings	Use more springs in series/smaller k /larger masses.
F	Two readings are not enough to verify the relation between mass added and e	Take many readings for a range of mass added and e <u>and</u> plot a graph of e v total mass added.

One mark for each box to a maximum of 8.

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.

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 a i	area under curve (= momentum gained) $Ft = (\text{change in}) \text{ momentum} / AW$	1 1
ii	taken as two triangles of base 3 ms and height 900 N gives 2.7 (N s) or count squares	1
iii	$N = \text{kg m s}^{-2}$ so $N \text{ s} = \text{kg m s}^{-1}$ or momentum = mv unit kg m s^{-1} $(\Delta)mv = Ft$ unit N s	1
iv1	area = 2.7 = mv = 0.06v giving $v = 45 \text{ (m s}^{-1}\text{)}$	1
2	$F(\text{max}) = 900 = ma = 0.06a$; $a = 15000 \text{ (m s}^{-2}\text{)}$	2 7
b i	$\mu + mv = 0.06(40 + 38) = 4.68 \text{ (kg m s}^{-1}\text{)}$	1
ii	$\Delta \text{k.e.} = 1/2m(v^2 - u^2) = 0.03(40^2 - 38^2) = 4.68 \text{ (J)}$	2
iii	$F = \Delta p / \Delta t = 4.68 / 0.012 = 390 \text{ (N)}$ ecf	2 5
Total		12
2 a	p is the pressure, V the volume, n is the number of mole/amount of gas, R is (universal) gas constant, T is the absolute temperature /in K <i>if one error/omission give one mark if two give zero</i>	1 1 2
b i	$p/p_o = T/T_o$; $= 900/300$ giving $p = 3p_o$	2
ii	use of $pV/T = \text{constant}$; $p_o 2.5V_o/T_f = 3p_o V_o/900$; giving $T_f = 750 \text{ K} = 477^\circ \text{C}$	2 1 5
c i	$pV = nRT$ giving $1 \times 10^5 \times 3 \times 10^{-5} = n \times 8.31 \times 300$ giving $n = 1.2 \times 10^{-3} \text{ (mol)}$	1 1
ii	$m = nM = 1.2 \times 10^{-3} \times 0.016 = 1.9 \times 10^{-5}$ ecf	1
iii	$\Delta U = mc\theta = 1.9 \times 10^{-5} \times 1300 \times 600 = 15 \text{ (J)}$ ecf	2 5
Total		12
3 a i	Towards centre of circle	1
ii	$F = mv^2/r$; $= 800 \times 15^2/30 = 6000 \text{ (N)}$	3
iii1	Two arrows, one vertical, the other along string; correctly labelled weight/W/mg and tension/T	1 1
2	(Moves along same circular path at higher speed so) <u>needs</u> greater centripetal force provided by larger horizontal component of tension (can only be) achieved by having larger angle (and larger T)	1 1 9
b i	$T = 0.3 \text{ s}$; so $f = 1/T = 3.3 \text{ (Hz)}$	2
ii1	using $s = vt$, $6.2 = 20 T$ giving $f = 20/6.2 = 3.2 \text{ (Hz)}$	1
2	Resonance occurs caused by driving force frequency being close to the natural frequency of the oscillating system when there is maximum energy transfer between driver and driven/maximum amplitude achieved	1 1 1 6
Total		15

Question	Expected Answers	Marks
4 a	six or more equally spaced horizontal lines from plate to plate arrows towards -36 V plate	1 1 2
b i	$E = V/d = 36/8 \times 10^{-3} = 4500 \text{ (N C}^{-1}\text{)}$	1
ii	$F = eE = 1.6 \times 10^{-19} \times 4500 = 7.2 \times 10^{-16} \text{ (N)}$	1
iii	$\Delta\epsilon = eV$ or $Fd = 1.6 \times 10^{-19} \times 36$ or $7.2 \times 10^{-16} \times 8 \times 10^{-3} = 5.76 \times 10^{-18} \text{ (J)}$	1
iv	$1/2mv^2 = 1/2mu^2 \pm \Delta\epsilon$ or $v^2 = u^2 \pm 2Fd/m$ $v^2 = 16 \times 10^{12} - 11.5 \times 10^{-18}/9.1 \times 10^{-31} = 3.4 \times 10^{12}$ <i>ecf b(ii) or (iii)</i> $\Delta v = u - v = 4.0 \times 10^6 - 1.8 \times 10^6 = 2.2 \times 10^6 \text{ (m s}^{-1}\text{)}$	1 1 6
c i	F is / from P to Q/downwards/towards -36 V plate	1
ii	magnetic force (Bev) is in the opposite direction to the electric force (eE) these can be made equal and opposite (by adjusting B) (so that the electrons are undeviated by Newton 1)	1 1
iii	$Bev = eE$; $B = E/v = 4500/4 \times 10^6$; $= 1.125 \times 10^{-3}$; T or 1.125 mT	4 7
	Total	15
5 a i	9 V	1
ii	correct method, e.g same Q so $V = Q/C$ so larger C has half V of smaller one/ratio of V's inverse to C values 3 V	1 1 3
b i	$Q = CV$; $= 150 \times 9 = 1350 \text{ (}\mu\text{C)}$	2
ii	$Q = CV = 150 \times 6 = 900 \text{ (}\mu\text{C)}$ <i>ecf (a)(ii)</i>	1 3
c	$E = 1/2CV^2$ in Fig. 5.1 $\frac{1}{2} \times 450 \times 9^2$ in Fig. 5.2 $\frac{1}{2} \times 100 \times 9^2$; so ratio $f = 4.5$	1 1 2 4
	Total	10
6 a	a nucleus (of a chosen element) a particle/constituent of a nucleus, i.e. proton or neutron	1 1 2
b i	A is at (81;208)	2
ii	B is at (84,212)	1
iii	There is no change in nucleon and proton number/ the emission is pure energy/e-m radiation/AW	1 4
c i	a few cm/3 to 10 cm; about 1 m/0.3 – 2 m/several m; 1 to 5 mm Al/1 mm Pb 1 – 10 cm of Pb/several m of concrete 2 correct 1 mark, 4 correct 2 marks	2 1 2
ii	source, absorbers placed in front of suitable detector on diagram how results identify source; allowance for background allow up to 2 marks for distance experiment	1 2
	Total	5 11

Question	Expected Answers	Marks
7 a	indicates suitable test, i.e. $yx^2 = \text{constant}$, etc	1
	carried out successfully	1
	Coulomb's law/Newton's law of gravitation/ e-m radiation, etc	1
	Statement in words	1
	and mathematically ;with e.g. $y = F$ and $x = \text{distance between point charges/masses}$	1
	Point masses/charges or equivalent or any other relevant statement	1
	<i>max 6 marks</i>	6
b	indicates suitable test, i.e. ratio test, half-life,etc	1
	carried out successfully	1
	Decay law, e.g. radioactivity, capacitor discharge or other	1
	Statement in words	1
	and mathematically	1
	with e.g. $y = N, Q$ and $x = \text{time}$	1
	<i>max 5 marks</i>	5
	Quality of Written Communication	4
	Total	15

2825/01 Cosmology

1	a.	(1 parsec) = 3×10^{16} m (mass of Sun) = 2×10^{30} kg	1 1	
	b.i.	epicycle is additional circular motion (of planet) superior planets appear to move backwards epicycles required for departure from circular orbits	1 1 1	
	b.ii.	Sun in centre of Solar System planets have different periods/ angular velocities Earth overtakes superior planets	1 1 1	
	c.	phases of Venus Indicate Venus orbits Sun or moons of Jupiter show orbits not centred on Earth	1 1 1 1	2
		max of 1 for any of the following: mountains on Moon show Moon not perfectly spherical Sun spots show Sun not a perfect body/ has imperfections		
				total 10
2.	a.i	mass loss = $0.02759 \times 1.66 \times 10^{-27} = 0.0458 \times 10^{-27}$ kg $E = \Delta mc^2$ $E = 0.0458 \times 10^{-27} \times (3 \times 10^8)^2 = 4.12 \times 10^{-12}$ J	1 1 1	
	a.ii.	4: number of protons and neutrons/ mass number/ nucleon number. 2: number of protons/ proton number		1
	b.	greater coulomb repulsion between He nuclei/ He nuclei have greater charge		1
	c.	Any 3 from Hydrogen fuel exhausted Core contracts/ onset of He burning/ shell H burning Outer layers expand and cool absolute magnitude decreases/ more negative, or (larger surface area) increases luminosity	1 1 1 1	3
	d.	any 3 from very high temperature very high density much smaller than a star gravity balanced by electron degeneracy pressure	1 1 1 1	3
				total 11

3.	a.	change in frequency/wavelength of radiation/ sound due to velocity of source/observer/both	1 1
	b.i	(continuous spectrum) contains all frequencies	1
	b.ii	(absorption line) atoms take in radiation re-radiate in all directions	1 1
	b.iii	galaxies are receding	1
	b.iv	$\Delta\lambda = 86.1 \text{ nm}$	1
	b.v	$\Delta\lambda/\lambda = v/c$ or $86.1 / 410 = v / 3 \times 10^8$ $v = 6.3 \times 10^7 \text{ ms}^{-1}$	1 1
	c.	all points plotted correctly best straight line drawn	1 1
	d.	gradient = 2.6×10^{-18} or $1/\text{gradient} = 3.9 \times 10^{17}$ age of Universe = $1/\text{gradient} = 3.9 \times 10^{17}$ unit : seconds	1 1 1
			total 14
4.	a.	homogeneous isotropic	1 1
	b.i	$F = GMm/r^2$ $F = 6.7 \times 10^{-11} \times 2 \times 10^{41} \times 5 \times 10^{40} / (4 \times 10^{22})^2$ $F = 4.2 \times 10^{26} \text{ N}$	1 1 1
	b.ii.	arrow begins on galaxy X, directed towards Y	1
	b.iii	to enable universe to be static / so that resultant force on galaxy is zero/ prevent Universe from collapsing	1
	c.	suppose the universe is infinite all lines of sight end on a star night sky should be bright/ not dark either age of universe is finite all light not yet had time to reach earth or expansion of space causes cosmological redshift energy of radiation is decreased or movement of galaxies causes redshift energy of radiation is decreased	1 1 1 1 1 1 1 1 1 2
			total 12

5. a. **any 5 from**
- | | | |
|---|---|---|
| singularity/ <u>very</u> high temperature | 1 | |
| matter and antimatter produced | 1 | |
| <u>excess</u> matter over antimatter | 1 | |
| forces freeze out | 1 | |
| electrons/positrons/neutrinos formed | 1 | |
| protons and neutrons formed | 1 | |
| helium <u>nuclei</u> formed | 1 | |
| approx <u>25% nuclei are helium</u> | 1 | |
| hydrogen and helium <u>atoms</u> formed | 1 | 5 |
- b. **any 2 from**
- | | | |
|--|---|---|
| reference to mass increase with velocity | 1 | |
| cannot reproduce energies | 1 | |
| high temperatures result in high KE/ high velocity | 1 | 2 |
- c.i. **any 2 from**
- | | | |
|--|---|---|
| uniform intensity | | 1 |
| black body temperature 2.7 (accept 3) K | | 1 |
| left over from gamma radiation which passed through universe after recombination | 1 | |
| expansion of Universe/space increased gamma wavelength to microwave | 1 | 2 |
- c.ii. different densities/ show places where galaxies forming
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- d. $v = H_0 r$
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- $KE = \frac{1}{2} Mv^2 = \frac{1}{2} M H_0^2 r^2$
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- e. critical density: expansion stops after infinite time
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- open universe/ universe will expand forever, if density $< \rho_0$
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- closed universe/ universe contracts, if density $> \rho_0$
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- total 15
6. a. all inertial frames are equivalent
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- speed of light constant in different inertial frames
- | | | |
|--|--|---|
| | | 1 |
|--|--|---|
- b. rate of clocks slower measured from moving reference frame1
- c. **any 5 from**
- | | | |
|--|---|---|
| 2 observers, 2 clocks | 1 | |
| relative motion | 1 | |
| time interval defined | 1 | |
| time interval measured by both observers | 1 | |
| improper observer measures longer time | 1 | |
| other relevant detail | 1 | 5 |
- total 8

2825/02 Health Physics

Question	Expected Answers	Marks
1 (a)(i)	$R = W = mg = 72 \times 9.81 = 706 \text{ N}$	1
(ii)	One correct moment e.g. $E \times 11$ or 706×6 Second moment and equated e.g. $706 \times 6 = E \times 11$ ecf(i) $= 385 \text{ N}$	1 1 1
(iii)	$385 + 706 = 1091 \text{ N}$ ecf(i)(ii)	1
(b)	reference to additional force due to (calf) muscles pulling down on leg / needed for leg to maintain equilibrium	1
		Total: 6

Question	Expected Answers	Marks
2 (a)	one each to a max. 10 e.g. Atoms with uneven number of protons and neutrons spin, Ref. to hydrogen as being commonly used So act like tiny magnets Align in an external magnetic field / parallel and anti- parallel Precess / wobble Rf sent in (at frequency of precession/ Larmour frequency) Resonance occurs / they flip Rf turned off and amplitude of precession dies down Atoms emit rf while returning to equilibrium state Rf detected by (induced emf in) pick up coils Precession frequency is proportional to B-field Magnetic field gradient means precessions frequency depends upon position Hence 3-D scan possible	10
(b)	Time to return to equilibrium state called relaxation time 2 relaxation times Each tissue has a different relaxation time so tissues may be identified to max. of 4 example (1) reason (1) e.g. brain scan Skull absorbs ct signal or X-rays / pregnant subject might be exposed MRI signal not affected by more dense material / bone has proton density similar to / less than other tissues so similar MRI strength Good at soft tissue differentiation Not good where metal implants / pacemakers etc Not good for eye / due to local heating	
		4 Total:14

Question	Expected Answers	Marks
3 (a)	$I = I_0 e^{-\mu x}$ (equation)	1
	$0.2 = e^{-\mu \times 3.5}$ (substitution)	1
	$\ln 0.2 = -\mu \times 3.5$	1
	$\mu = 0.460$ (answer) 460 mm^{-1} (unit) m^{-1}	1
(b) (i)	table completed -0.64 -0.96 -1.28	1
	First and last points correctly plotted	1
	Other 3 points correctly plotted ecf (b)(i)	1
	line of best fit drawn	1
(iii)	triangle drawn / gradient equation used	1
	correct calc., e.g. 0.016 mm^{-1} , 0.16 cm^{-1} , 16 m^{-1}	1
	conversion of 0.16 to 16	1
(c)	$I = 2.2 \times 10^9 e^{-0.16 \times 2.3} = 1.52 \times 10^9 \text{ W m}^{-2}$	1
	Power at tumour = $1.52 \times 10^9 \times \text{area of beam at tumour}$ $= 1.52 \times 10^9 \times 4.1 \times 10^{-6} = 6242 \text{ W}$	1
	12% of 6242 = 749 W	1
	$3000 / 749 = 4.0 \text{ s}$	1
		Total:15

Question	Expected Answers	Marks
4 (a)	$2.0 \times 10^{-6} / 65 \times 10^{-6}$	1
(b) (i)	I.L.= $10 \lg 0.031 / 10^{-12}$	1
	= 105 dB	1
(ii)	$104.9 + 0.8 = 105.7 \text{ dB}$	1
	converts to an intensity of 0.037 W m^{-2} allow 0.038	1
	$\Delta I / I = (0.0373 - 0.031) / 0.031$	
	$\times 100\% = 0.202 \times 100 = 20\%$	1
(c)	either with reference to closed tube / ear canal:	Max. 5
	antinode at open end	1
	node at closed end (labelled)	1
	length of tube = $\lambda / 4$	1
	as length of tube increases (with age) so λ gets larger	1
	as $v = f \times \lambda$ and v is constant, f must get smaller	1
	explains how resonance is recognised e.g. sound louder	1
		Total:11

Question	Expected Answers	Marks
5 (a)(i)	two rays drawn to cornea which then meet at the retina refraction shown at cornea / lens image clearly above fovea	1 1 1
(ii)	image in direct line forms on the fovea the fovea contains (mostly) cones the surrounding parts of the retina contain (mostly) rods cones related to good definition / rods to poor definition cones have their own nerve fibre / rods share nerve fibres	1 1 1 1 1
(b)(i)	both lines start at 0 W m ⁻² rod line rises sharply and then tails off as intensity increases cone line rises gradually as intensity increases	1 1 1 Max. 4
(ii)	when lighting conditions are dim, cones do not respond cone line is close to axis until some threshold intensity is reached cones are responsible for colour discrimination / rods do not differentiate colour as there are no rods on fovea, there is no response along the axis of the lens there are rods around fovea, so vision is peripheral	1 1 1 1 1 Total:14

Question	Expected Answers	Marks
6(a)	absorbed dose = conversion factor x exposure / $D = f \times X$	1
(b)(i)	$3.0 \times 10^{18} \times 1.6 \times 10^{-19} = 0.48 \text{ C}$ $X = Q / m$	1
	$0.48 / 0.25$	1
	$= 1.92 \text{ (C kg}^{-1}\text{)}$	1
(ii)	$60 \text{ (+/- 10)} \times 1.92 = 115.2$ ecf (b)(i)	1
	Gy or J kg^{-1}	1
(c)	to treat tumour, photons must be absorbed	1
	a clear reference to the data on Fig 6.1	1
	bone absorbs low energy photons more...	1
	...so bone is targeted better than soft tissue / so less risk to soft tissue	1
	low energy photons rely on photo-electric effect	1
	absorption in soft tissue (almost) independent of photon energy	1
	use higher energy photons to treat tissue tumour near bone...	1
	...because at higher energies, absorption by bone and soft tissue similar / no difference for tissue but much less absorbed by bone	1
	at higher energies ref to Compton scattering	1
		Total:10

2825/03 Materials

- 1 (a) (i) 1 A crystalline structure: a regular repeating pattern (of layers) of atoms; (1)
 2 A polycrystalline solid: many crystals / grains with random orientations; (1)
 3 A single crystal: same regular pattern throughout (with no grain boundaries).
 Allow one crystal if 1 completely correct. (1) [3]
- (ii) Suitable example: e.g. quartz, diamond; (1)
 Suitable example: e.g. metal / example of metal. (1) [2]
- (b) (i) Regular pattern with gap / different size atom clearly shown or labelled; (1)
- (ii) Sketch includes incomplete plane of atoms; (1)
 with neighbouring planes suitably rearranged. (1) [3]
- (c) (i) Minimum number = $0.05 \times 10^{-3} / 2.5 \times 10^{-10}$ (or both in mm) (1)
 $= 2.0 \times 10^5$ (1) [2]
- (ii) e.g. Dislocations may not have moved in the direction of the extension.
 (Reference to pinning negates the mark.) [1]

[Total: 11]

- 2 (a) Graph crosses x-axis at smaller value; (1)
 Minimum of curve is at larger negative F value; (1)
 Above x-axis line is steeper by eye. (1) [3]
- (b) 8930 kg of copper have volume 1.0 m^3 (1)
 8930 kg of copper atoms have volume 0.74 m^3 (1)
 1 atom of copper has volume $0.74 \times 1.06 \times 10^{-25} / 8930$ ($= 8.8 \times 10^{-30} \text{ m}^3$) (1) [3]
- (c) $(4/3) \pi r^3 = 8.8 \times 10^{-30}$ (1)
 $r = 1.3 \times 10^{-10} \text{ m}$ (1)
 equilibrium separation = $2r = 2.6 \times 10^{-10} \text{ m}$ (1) [3]
 [If atom taken to occupy a cubic space, but all correct, maximum 2 marks]
 OR
 No of atoms in $1 \text{ m}^3 = 8930 / 1.06 \times 10^{-25} = 8.43 \times 10^{28}$ (1)
 Each atom occupies a (cubic) volume of $1/(8.43 \times 10^{28}) = 1.19 \times 10^{-29} \text{ m}^3$ (1)
 Diameter of atom = $(1.19 \times 10^{-29})^{1/3} = 2.28 \times 10^{-10} \text{ m}$ (1) [3]
 OR
 Alternative valid method.

[Total: 9]

- 3 (a) Conductivity = $1/0.60 = 1.7$ (1) $\Omega^{-1} \text{ m}^{-1}$ (1) [2]
- (b) (i) $I = V / R$ (1)
 $= V / (\rho L / A) / = VA / (\rho L)$ OR $R = 640 \Omega$ (1)
 $= 9.0 \times 7.5 \times 1.5 \times 10^{-6} / (0.60 \times 12 \times 10^{-3}) (= 0.014 \text{ A} / 14 \text{ mA})$ (1) [3]
- (ii) $1 V_H = Bvd$ or $v = V_H / (Bd)$ (1)
 $v = 3.4 \times 10^{-3} / (0.25 \times 7.5 \times 10^{-3}) = 1.8 \text{ m s}^{-1}$ (1) [2]
- $2 n = I / (Ave) = 0.014 / (7.5 \times 1.5 \times 10^{-6} \times 1.8 \times 1.6 \times 10^{-19})$ (1)
 $= 4.3 \times 10^{21} \text{ m}^{-3}$ (Allow use of 15 mA to give $4.6 \times 10^{21} \text{ m}^{-3}$) (1) [2]
- (c) Increased length of block makes R bigger and I smaller; (1)
 I smaller makes v smaller; (1)
 v smaller makes V_H smaller. (1) [3]

[Total: 12]

- 4 Use of $I = nAve$; (1)
 Metals: (1)
 Valence and conduction bands overlap; (1)
 (so) some electrons permanently occupy the (partly filled) conduction band; (1)
 This number does not change with temperature; (1)
 Conductivity decreases as temperature rises; (1)
 because of increased lattice vibration; (1)
 Semiconductors: (1)
 Energy gap between valence and conduction bands; (1)
 As temperature rises more electrons in the valence band gain sufficient energy to cross into the conduction band; (1)
 so conductivity increases as temperature rises; (1)
 Effect due to increase in free electron density outweighs effect due to Increase in lattice vibration. (1) max [8]

[Total: 8]

- 5 (a) Magnetic domain is a region/area in a (ferro)magnetic material; (1)
 in which the atomic dipoles are aligned with each other. (1) [2]
- (b) (i) In magnetisation, domains aligned with an applied magnetic field grow; (1)
 and domains not aligned with the applied field rotate; (1) [2]
- (ii) Hard magnetic materials have more grain boundaries / imperfections to limit the movement of domain walls / growth of domains (than soft ones); (1)
 Hard magnetic materials have crystal structures with fewer favoured directions / crystal axes for dipoles to line up with (than soft ones). (1) [2]

[Total: 6]

- 6 (a) (i) Variable frequency supply; (1)
 Primary circuit with ammeter and voltmeter; (1)
 Secondary circuit with any two of ammeter, voltmeter and (known) resistor. (1) [3]
- (ii) Use of apparatus: (1)
 Set and record frequency of supply; (1)
 Set voltage output of supply; (1)
 Read and record readings of primary current, primary voltage, secondary current and secondary voltage (or resistor value if $P_S = I_S^2 R$ is used later); (1)
 Repeat over a range of evenly spaced frequency values; (1)
 Suggestion of choice of meter scales to maximise accuracy. (1)
 Suggestion of use of current / voltage values to avoid overheating (1) max [4]
- Use of data (may be shown in headings of a table);
 Calculate primary power using $P_P = I_P V_P$; (1)
 Calculate secondary power using $P_S = I_S V_S$ or $P_S = I_S^2 R$; (1)
 Calculate efficiency from P_S / P_P ; (1)
 Plot a graph of efficiency against frequency. (1) [4]
- (b) In either order:
- 1 In each cycle of a.c. core work is done in magnetising and demagnetising the core (1)
 and appears as heat in the core; (1)
 (If hysteresis quoted without reference to above, 1 mark only)
 With increase in frequency more cycles per second so more heat produced per second (so efficiency reduced). (1) [3]
- 2 Changing flux in the core induces voltage in the core; (1)
 causing current in the core which generates heat; (1)
 (If eddy currents quoted without reference to induced voltage, 1 mark only)
 With increase in frequency induced voltage and current are higher so more heat is produced per second (so efficiency reduced). (1) [3]
- [Total: 17]
- 7 (a) (Rayleigh scattering is the) scattering of photons (of radiation); (1)
 by irregularities / disordered structure / density variations in the glass. (1) [2]
- (b) (i) (Amount of) Rayleigh scattering / reduction in intensity of radiation is proportional to $1/\lambda^4$; (1)
- $$\frac{\text{reduction in intensity of 1750 nm radiation}}{\text{reduction in intensity of 1550 nm radiation}} = \frac{1550^4}{1750^4}$$
 (1)
- reduction in intensity of 1750 nm radiation = $\frac{1550^4}{1750^4} \times 5$ (= 3.1 %) (1) [3]
- (ii) Absorption of photons (by polar bonds in the glass) is (much) greater at 1750 nm than at 1550 nm; (1)
 This factor (far) outweighs the advantage of having less Rayleigh scattering. (1) [2]
- [Total: 7]

2825/04 Nuclear and Particle Physics

Question	Expected Answers	Marks
1(a)	readings of r and A and calculation of r_0 answer in range $(1.41 - 1.45)10^{-15} \text{ m}$; misreads graph, gets 0/2	1 1 [2]
(b) (i)	radius $r = 1.43 \times 10^{-15} \times 235^{1/3} (= 8.82 \times 10^{-15} \text{ m})$	1 [1]
(ii)	mass of ${}^{235}_{92}\text{U} = 235 \times 1.67 \times 10^{-27} = 3.92 \times 10^{-25} \text{ (kg)}$	1 [1]
(iii)	density $\rho = m/V$ $= (3.92 \times 10^{-25}) / (\frac{4}{3} \pi [8.82 \times 10^{-15}]^3)$ $= 1.4 \times 10^{17} \text{ kg m}^{-3}$	1 1 1 [3]
(iv)	$X = 152 \quad Y = 58$	2 [2]
(v)	$r_1 = r_0 A_1^{1/3} \quad r_2 = r_0 A_2^{1/3} \quad \text{so } r_1 / r_2 = (A_1 / A_2)^{1/3}$ $= (152 / 83)^{1/3} = 1.2(2)$ or calculates $r_1 = 7.63 \times 10^{-15} \text{ m}$ $r_2 = 6.24 \times 10^{-15} \text{ m}$ etc.	1 1 [2]
(vi)	<i>either</i> nucleons / protons and neutrons all equally spaced; <i>or</i> neutrons and protons have same size and are touching; (1) proton and neutron have (approx.) same mass; (1) spacing constant because strong force is short range (and much greater than electrostatic force); (1) any 2	2 [2]
		13

Question	Expected Answers	Marks
2(a)	because they cannot have less energy (on average) than the mean k.e. of the uranium atoms they collide with or AW; or (for zero k.e.) would need to move through material at absolute zero;	1 [1]
(b) (i)	processes: β^{-} decays; or Pu-239 emits alpha-radiation; nuclides: uranium/U-239; (1) plutonium/Pu-239; (1) neptunium/Np-239; (1) any 1	1 1 [2]
(ii)	otherwise, greater chance of absorption by U-238 ; this absorption does not produce a fission;	1 1 [2]
(c)(i)	binding energies per nucleus: ${}_{92}^{235}\text{U}$ 7.6×235 (= 1786 MeV) ${}_{56}^{141}\text{Ba}$ 8.4×141 (= 1184 MeV) ${}_{36}^{92}\text{Kr}$ 8.6×92 (= 791 MeV) so energy released = (1184 + 791) - 1786 = 189 MeV fails to multiply by nucleon number: $8.4+8.6-7.6 = 9.4$ gets (0,1,0) = 1/3	1 1 1 [3]
(ii)	number of U-235 atoms in 1.00 kg = $1.00 / (235 \times 1.67 \times 10^{-27}) = 2.55 \times 10^{24}$ or $6.02 \times 10^{23} / (0.235) = 2.56 \times 10^{24}$ so energy released by fission of 1.00 kg of U-235 = $2.55 \times 10^{24} \times 200 \times 1.6 \times 10^{-19} \times 10^6$ = $8.2 \times 10^{13} \text{ J}$ accept 8×10^{13} or $2.55 \times 10^{24} \times 189 \times 1.6 \times 10^{-19} \times 10^6 = 7.7 \times 10^{13} \text{ J}$	1 1 1 [3]
(d)	idea that more / bigger proportion of neutrons escape from smaller mass; idea that chain reaction accelerates / more neutrons produced in each generation or AW; or alternative answer in terms of smaller bodies (with greater surface area/volume) cool more quickly (than larger bodies); can get 1/2	1 1 [2]
		13

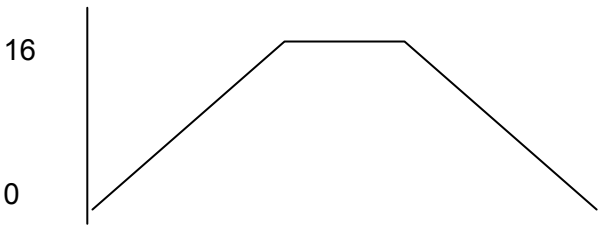
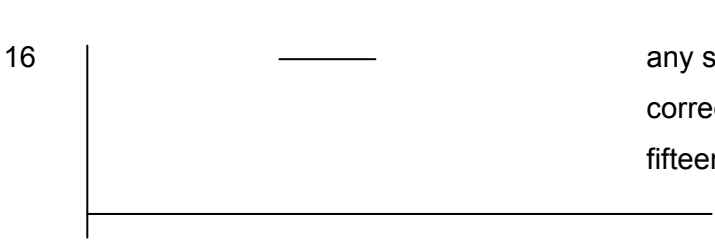
Question	Expected Answers	Marks
3(a)	<p>particles (to be fused) have positive / like charges, so repel / cause coulomb barrier; they have to be brought (very) close together for fusion / strong force to be attractive; so work has to be done / p.e. of system has to increase; (1) this work / p.e. has to come from k.e. of particles <i>or</i> AW; (1) any 1 for particles to have high k.e., (plasma) must have high temperature;</p>	<p>1 1 1 1 [4]</p>
(b)(i)	<p>reaction 2 reactant mass = $2.01410 + 3.01605$ (= 5.03015) product mass = $4.00260 + 1.00866$ (= 5.01126) arith. mass defect = 0.01889 u ans.</p> <p>reaction 2 is more suitable because it generates more energy (per fusion reaction);</p>	<p>1 1 1 [3]</p>
(ii)	<p>(accuracy would not / could not be improved) because same number of electrons on both sides (of equation);</p>	<p>1 [1]</p>
(iii)	<p>all reactant nuclei have same charge / number of protons; so Coulomb barrier / repulsion / p.e. gained is same in both cases;</p>	<p>1 1 [2] 10</p>
4(a)	<p>$E = mc^2$ proton mass = 1.67×10^{-27} kg proton energy = $1.67 \times 10^{-27} \times (3.0 \times 10^8)^2$ (= 1.503×10^{-10} J) 1 GeV = $1.60 \times 10^{-19} \times 10^9$ (= 1.60×10^{-10} J) so proton mass = $\frac{1.503 \times 10^{-10}}{1.60 \times 10^{-10}}$ = 0.939 GeV</p>	<p>1 1 1 1 [4]</p>
(b)	<p>percentage increase = $\frac{6.00 \times 100}{0.939}$ = 640 %</p>	<p>1 [1]</p>
(c)(i)	<p>proton mass = antiproton mass <i>or</i> figures make this clear</p> <p>energy required = 2×0.939 = 1.88 GeV</p>	<p>1 1 [2]</p>
(ii)	<p>incoming proton has momentum so products must have momentum <i>or</i> aware conservation of momentum for 1/2</p> <p>so products have k.e.</p>	<p>1 1 1 [3]</p>

Question	Expected Answers	Marks
(iii)	collide protons head-on, with equal speeds in opposite directions; (incoming protons have) no overall initial mtm so products have no mtm ;	1 1 [2] 12
5(a)	$R = \frac{0.72}{99.28} = 0.00725$	1 [1]
(b)	uranium/U-235 has a shorter half-life	1 [1]
(c)	uses $R = R_0 (\frac{1}{2})^x$ x = no. of half-lives no. of half-lives = $\frac{4.6 \times 10^9}{8.4 \times 10^8}$ (= 5.48) $0.00725 = R_0 (\frac{1}{2})^{5.48}$ so $R_0 = 0.32(3)$ ans. sensible attempt using repeated doubling can get 1/3 or $R = R_0 e^{-\lambda t}$ where $\lambda = \frac{\ln 2}{8.4 \times 10^8} = 8.30 \times 10^{-10} \text{ y}^{-1} (1)$ $0.00725 = R_0 e^{-8.30 \times \exp.(-10) \times 4.6 \times \exp.(9)} (1)$ $= R_0 e^{-3.82}$ $R_0 = 0.32(3) (1)$	1 1 1 [3]
(d)	N_0 for U-235 approx. 1/3 of N_0 for U-238; R clearly decreasing with time;	1 1 [2]
(e)(i)	proton number = -2 neutron number = -2	1 [1]
(ii)	proton number = +1 neutron number = -1	1 [1]
(iii)	$p = 92 - 7 \times 2 + 4 \times 1 = 82$ $n = (235 - 92) - 7 \times 2 - 4 \times 1 = 125$	1 1 [2] 11

Question	Expected Answers	Marks
6(a)	<p>lists all quarks: u d s c t b or in words ; (1) quarks are fundamental particles or AW ; (1) every quark has an antiquark ; (1) every antiquark has opposite values of Q, B, S ; (1) quarks are held together by strong force / gluons ; (1) Q, B, S are conserved in quark reactions ; (1)</p> <p style="text-align: right;">any 3</p> <p>either neutron is udd or proton is uud ;</p> <p>either $Q = \frac{2}{3} - \frac{1}{3} - \frac{1}{3} = 0$ so charge (on neutron) is zero or $Q = \frac{2}{3} + \frac{2}{3} - \frac{1}{3} = 1$ so charge (on proton) is 1 ;</p> <p>$B = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$ so baryon number = 1 and $S = 0 + 0 + 0 = 0$ so strangeness = 0 NOT particles / neutron, proton have no strangeness</p>	<p>3</p> <p>1</p> <p>1</p> <p>1</p> <p>[6]</p>
(b)	<p>electron (1) ; positron (1) ; muon (1) ; tau (1) ; electron neutrino (1) ; muon neutrino (1) ; kaon neutrino (1) ; allow any antiparticle to any of these</p> <p style="text-align: right;">any 4 -1 each error/omission</p> <p>weak force ;</p> <p>$p^+ \rightarrow n^0 + e^+ + \nu$ (2) $n^0 \rightarrow p^+ + e^- + \bar{\nu}$ (2) $u \rightarrow d + e^+ + \nu$ (2) $d \rightarrow u + e^- + \nu$ (2) or ${}_{92}^{239}\text{U} \rightarrow {}_{93}^{239}\text{Np} + {}_{-1}^0e + \bar{\nu}$ (2) or ${}_{93}^{239}\text{Np} \rightarrow {}_{94}^{239}\text{Pu} + {}_{-1}^0e + \bar{\nu}$ (2) equation omits ν, gets 1/2</p>	<p>2</p> <p>1</p> <p>2</p> <p>[5]</p> <p>11</p>

2825/05 Telecommunications

Question 1	Expected Answers	Marks
(a)	FM Frequency Modulation	①
	The frequency of a carrier wave is controlled by the instantaneous value of a lower frequency information signal. (or wtte)	①
(b) (i)	Carrier frequency 25 cycles in 250 ns Hence 10ns period Frequency = $1 / 10\text{ns}$ = 100 MHz	① ①
(ii)	Modulating frequency 1 cycle in 250 ns Frequency = $1 / 250\text{ns}$ = 4 MHz	① ①
(c) (i)	Noise is any unwanted electrical energy added to a signal	①
(ii)	A perfect FM signal would have a constant amplitude	①
	The amplitude of Fig.1.1 changes in a random manner	①
(d) (i)	In an FM signal any variations in amplitude can be removed in the receiver So the FM is inherently less noisy than AM In a wideband FM signal the amplitude of the carrier is relatively small So most of the transmitted power is in the sidebands where the information is In wideband FM the dynamic range can be made greater than AM So a greater range of sounds (from quiet to loud) can be produced (any one point ①①)	
(ii)	The FM bandwidth is much greater than AM So fewer FM stations can fit into any given waveband Modulators and demodulators are more complex for FM than for AM So FM is a more expensive system to install (either point ①①)	

Question 2	Expected Answers	Marks
(a)	<p>An Analogue signal is one which varies in an analogous manner to the physical property which generated it.</p> <p>An Analogue signal can have any value between two limits</p> <p>An Analogue signal varies continuously in time.</p>	(any two ① ①)
(b)	<p>ADC Analogue-to-Digital Converter</p> <p>DAC Digital-to-Analogue Converter</p>	① ①
(c) (i)	 <p>any straight line from zero</p> <p>correct truncated triangle</p> <p>voltage axis correctly labelled</p>	① ① ①
(ii)	 <p>any stepped line from zero</p> <p>correct staircase</p> <p>fifteen steps</p>	① ① ①
(iii)	<p>V_1 is a pure analogue signal proportional to the angular position of the wiper.</p> <p>The wiper can be positioned at any angle so the voltmeter V_1 can read any value.</p> <p>The teacher moves the wiper steadily so the output V_1 is linear with time.</p> <p>The ADC is 4-bit so it can only produce $2^4 = 16$ possible output states.</p> <p>The DAC does not receive a continuously varying voltage.</p> <p>The DAC can only receive one of 16 input words</p> <p>Thus the output V_2 can only be one of 16 possible output voltages.</p> <p>The output V_2 can only increase or decrease in steps of 1V.</p>	(any three ① ① ①)
(d) (i)	<p>The parallel digital signal would exhibit skew over long distances (ie the bits take different times to travel along individual wires)</p> <p>The cost of a long parallel cable would be prohibitive</p>	① ①
(ii)	<p>The output from the ADC would go into a Parallel-to-Serial shift register</p> <p>This shifts each bit of the parallel word along a single line one at a time</p> <p>At the receiver, a Serial-to-Parallel shift register reassembles each word</p>	① ① ①

Question 3	Expected Answers	Marks
(a)	<p>Multimode fibres cause modal or multipath dispersion This causes pulses to stretch in time Because different rays travel different distances within the core All at the same speed So with increasing transmission distance, pulses smear into one another So bandwidth is severely limited So the opportunity to reduce costs / make money is severely limited (any three ①①①)</p>	
(b) (i)	<p>A laser is almost monochromatic whereas a LED is not So material dispersion occurs in fibre (varying n with λ) limiting bandwidth ① A laser outputs a much greater power into a much smaller area than a LED So much greater uninterrupted transmission distances can be used ①</p>	
(ii)	<p>Speed of light in core $= 3 \times 10^8 / 1.5$ $= 2 \times 10^8$ ①</p> <p>Time in fibre $= 12\,000 \times 10^3 / 2 \times 10^8$ $= 0.060$ s ①</p>	
(c) (i)	<p>Signal-to-noise at receiver 27 $= 10 \log P_{\text{rec}} / 0.28 \times 10^{-6}$ ①</p> <p>received signal power $P_{\text{rec}} = 102.7 \times 0.28 \times 10^{-6}$ ① $= 1.4 \times 10^{-4}$ W ①</p>	
(ii)	<p>Total attenuation in fibre $= 10 \log 45 \times 10^{-3} / 1.4 \times 10^{-4}$ ① $= 25$ dB ①</p>	
(iii)	<p>Attenuation per kilometre $= 25 / 12\,000$ $= 0.0021$ dB km^{-1} ①</p>	
(d) (i)	<p>Attenuation for the maximum uninterrupted length must not be more than 25 dB So each amplifier should provide 25 dB in compensation. ①</p>	
(ii)	<p>Maximum uninterrupted distance $= 25 / 0.17$ $= 147$ km ①</p> <p>Number of amplifiers required $= 12000 / 147$ $= 82$ ①</p>	

Question 4	Expected Answers	Marks
(a)	Circle placed around the thermistor	①
(b)	Thermistor	①
(c)	Resistance decreases as the temperature increases	①
(d)	(i) At 5°C the thermistor has a resistance of 5 kΩ	①
	Thus voltage at A $= (1 / 5 + 1) \times 9$	①
	$= 1.5 \text{ V}$	①
	(ii) Voltage gain of the amplifier $= - R_f / R_i$	①
	$= - 88 / 22$	
	$= - 4$	①
	Thus voltage at B $= - 4 \times 1.5$	
	$= - 6.0 \text{ V}$	①
(e)	At 25°C the thermistor has a resistance of 2 kΩ	
	Voltage at A $(1 / 3) \times 9 = 3\text{V}$	①
	Thus voltage at B $= -4 \times 3$	
	$= - 12\text{V}$	①
	but this is impossible because the op-amp is being operated off $\pm 9\text{V}$ supplies. So the voltage at B is the saturation voltage of about -8V.	①
(f)	When the temperature is very low the voltage at point A will also be very low So the output B will be relatively low also and the bulb will glow faintly	①
	As the temperature is increased the voltage at A rises and the voltage at B falls by four times as much so the bulb becomes brighter and brighter.	①
	At around 15°C the op-amp saturates so the bulb cannot become any brighter.	
	Increasing the temperature beyond this value will produce no effect on the bulb.	①

Question 5	Expected Answers	Marks
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(a) User's computer links into PSTN (makes telephone call)

To their Internet Service Provider (ISP) who provides access to internet

File Transfer Protocol (or HTTP) causes information / data to be broken into packets

Packets contain limited volume of information + addresses etc

Packets are not transmitted as one continuous stream

Packets from the same database do not necessarily follow the same switched line / route

Packets do not necessarily arrive in the same order as that in which they were sent

Receiver's ISP links back to PSTN (makes telephone call) to receiving computer

(any five points ① ① ① ① ①)

(b) Many jobs have been created to provide technical maintenance for Internet

Many jobs have been created to provide software for Internet

Many jobs have been created to sell goods and services over the Internet

Internet provides alternative to traditional shopping

Internet allows easy communication by e-mail

Internet allows people with little expertise easy access to huge volumes of information

Internet allows remote information gathering (eg medical without visiting doctor)

Internet allows many individuals to work from home

(any three sensible and valid points ① ① ①)

2825 Common Question

- (a) (i) Speed of bullet $= 1.28 / 1.50$ (1) (method must be shown)
 $= (853 \text{ m s}^{-1})$
- (ii) Acceleration $= 850^2 / 2 \times 0.72$ (1)
 $= 5.017 \times 10^5 \text{ m s}^{-2}$ (1) (for correct rearrangement)
- (iii) Average force on bullet $= 0.028 \times 5.0 \times 10^5$ (1) (for substitution in formula)
 $= 14 \text{ kN}$ (1) (for correct answer)
- (iv) (No marks for any simple statement of Newton's third law)
 (No marks for simply stating the rifle will recoil)
 There must be an equal and opposite force (on the rifle system) (1)
 Any sensible comment on momentum / impulse / acceleration of rifle (1)
 e.g.
 acceleration of rifle is lower because of greater mass of rifle
 final speed of rifle will be less than that of the bullet because of greater mass
 impulse lasts for a very brief period of $t = 850 / 5.0 \times 10^5 = 1.7 \text{ ms}$
- (b) (i) t given by 2.41 $= 0 \times t + \frac{1}{2} \times 9.81 \times t^2$ (1)
 (for substitution in formula)
 hence t $= \sqrt{2 \times 2.41 / 9.81}$ $= 0.70 \text{ s}$ (1)
 (for correct rearrangement)
- (ii) Projection speed $= 4.60 / 0.70$ (1)
 (for correct substitution in formula)
 $= (6.56 \text{ ms}^{-1})$
- (iii) (1) (for conservation of momentum stated or implied by formula)
 (1) (for correct substitution in formulae)
 (1) (for correct answer - deduct 1 mark if 28g bullet mass omitted)
- Momentum of block and bullet $= 3.628 \times 6.56$
 $= 23.8 \text{ kg ms}^{-1}$
 Speed of bullet $= 23.8 / 0.028 = 850 \text{ ms}^{-1}$
- (c) (i) KE bullet $= \frac{1}{2} \times 0.028 \times 851^2 (= 10150 \text{ J})$ (1)
 (evidence of calculation)
- KE of block/bullet $= \frac{1}{2} \times 3.628 \times 6.57^2 (= 78.3 \text{ J})$ (1)
 (evidence of calculation)
- (for linking thermal energy or $m c \Delta\theta$ to the KE loss (1)
 $m c \Delta\theta = 10150 - 78.3 = 10071.7$

Rise in temperature $\Delta\theta$ = $10071.7 / 3.6 \times 126$ (1)
(for correct substitution in formula)

= 22.2 K (1)
(for correct answer)

(ii) Assumptions : (1)(1) for any **two** sensible and relevant points

e.g.

The calculation assumes no energy is transferred from the block to surroundings

The calculation ignores energy lost from block as it is heating up from KE bullet

The calculation ignores the heat capacity of the bullet itself

The calculations ignores the energy required to deform bullet and lead

The calculation assumes the KE "lost" by bullet is uniformly distributed in lead.
(This assumes a huge thermal conductivity for lead).

Non-uniform distribution in lead (more likely) will see highly localised heating.

Intense localised heating may cause melting and evaporation of lead metal.

Allow any sensible comment on energy loss due to friction as block flies off.

2826/01 Unifying Concepts in Physics

- 1 (a) *refraction* (of light) causes bending as a result in the change in the speed of light. (1)
(allow on entering a (denser) medium)

diffraction (of light) causes a change in direction as a result of the waves going through a small aperture (1) [2]

- (b) *heat* is a form of (energy moving from one place to another) (1)
as a result of a temperature gradient (1)
OR total kinetic energy of molecules/atoms (1)

temperature determines the direction of (net) heat flow (1)
OR is proportional to the mean kinetic energy of a molecules (1) (1) [3]

- (c) *electromotive force* is energy per unit charge from any form of energy into electrical energy (1)

potential difference is also energy per unit charge when electrical energy is converted into a different form of energy (1) [2]
OR e.m.f. is energy from other forms of energy into electrical energy and p.d. is energy change from electrical energy into other forms of energy (1)

- (d) *energy* is the (stored) ability to do work (1)

power is the rate at which work is done (1) [2]

- (e) *magnetic flux density* determines the force on a current in a magnetic field (1)

magnetic flux is the total flux and is flux density multiplied by the area (1) [2]
[Total: 11]

- 2 (a) (i) 1. spring constant = F/x (1)
2. work done = $\frac{1}{2}Fx$ (1) [2]

(ii)

spring	spring constant	force	extension	work done
A	k	F	F/k	$F^2/2k$ (1)
B	$2k$	F	$F/2k$ (1)	$F^2/4k$ (1)

[1]

[2]

(b)	resistor	resistance	current	potential difference	work done per second	
	X	R	I	IR	I^2R (1)	[1]
	Y	$2R$	I	$2IR$ (1)	$2I^2R$ (1)	[2]

- (c) registers that in spring case values halve in 2k spring and in resistors values double (1)
 if spring constant were extension per unit force (1)
 then spring with larger spring constant would have twice extension (1) [3]
 twice energy stored [Total: 11]

3. (a) (i) e.g. if T_L were negative (1)
 efficiencies would be greater than 100% (1) [2]
- (ii) maximum theoretical efficiency = $1 - (340/850) = 0.6 = 60\%$ (1)
 (Either allowed) [1]
- (iii) Input temperature must be as high as possible (1)
 Output temperature must be as low as possible [1]
- (iv) To keep a high input temperature means (1)
 (1) very high pressure (danger of bursting)
 (2) equipment may melt
 (3) deterioration may take place too quickly
 (1) for each idea to max (2) (2)
- To keep a low output temperature means
 (1) a huge quantity of cooling water
 (2) may freeze if attempt is made to keep it lower
 (3) cooling temperature cannot be below ambient temperature
 (4) steam will condense
 (1) for each idea to max (2) (2) [4]
- (b)(i) output power/ input power = 0.42 (1)
 input power = $20 \text{ MW} / 0.42 = 47.6 \text{ MW}$ (1) [2]
- (ii) power wasted = $47.6 \text{ MW} - 20 \text{ MW} = 27.6 \text{ MW}$ (1) [1]
- (iii) $m \times 4200 \times 50 = 27\,600\,000$
 $m = 27\,600\,000 / 4200 \times 50 = 131 \text{ (kg s}^{-1}\text{)}$ (1) for formula
 (1) for powers of 10
 (1) for calculation correct [3]

- (iv) e.g.
 If the water is hot, the outlet temperature is high (1)
 so the efficiency of the generator is less (1) } one of these ideas needed
 OR with high water temperature more heat loss (1)
 in transmission (1)
 OR the buildings need to be near to the power station (1)
 to minimise heat loss (1)
 OR no one wants tepid water (1)
 OR suitable alternative (1) (4) [4]

Max (2) for one of first ideas

Max (2) for additional ideas

(1) mark transferable

[Total: 18]

4 (a)(i) $Q_0 = CV$ (1)
 $= 80 \times 10^{-3} \times 20 = 1.6 \text{ (C)}$ (1) [2]

(ii) $E = \frac{1}{2}CV^2 = \frac{1}{2} \times 80 \times 10^{-3} \times 20^2$ (1)
 $= 16 \text{ (J)}$ (1) [2]

(b)(i) $t = CR$ (1)
 $= 80 \times 10^{-3} \times 50\,000 = 4000 \text{ s}$ (0) [1]

(ii) $Q = Q_0 e^{-t/CR}$ (1)
 $\ln Q = \ln Q_0 - t/CR$ (1) [2]

(iii)

t/s	t/CR	$\ln Q_0$	$\ln Q$
0	0	0.47	0.47
1000	0.25	0.47	0.22
4000	1.00	0.47	-0.53
6000	1.50	0.47	-1.03

table: starting point correct (1)
 other points correct in table (2)
 axes sensible (1)
 graph plotted correctly (1) [5]

(iv) 1. -2.50×10^{-4} (1)
 2. $-1/CR$ (1) Allow (1) if both – signs are missing [2]

(v) $\ln Q = \ln (1.6 \times 0.0010) = -6.438$ (1)
 gradient $= -(0.47 + 6.438)/t = -2.50 \times 10^{-4}$ (1)
 $t = 6.908/2.50 \times 10^{-4} = 27\,600 \text{ s}$ (1) [3]
 OR alternative methods starting from scratch.

(c)(i) $E = \frac{1}{2}Q^2/C$ (1) [1]

(ii) $\ln E = 2 \ln Q - \ln 2C$ or equivalent (1)
 twice gradient of $\ln Q$ graph (1) [2]
 [Total: 20]

2826/03 Experimental Skills 2 Practical Examination

Question 1

(b) (iii)	Calculation of resistance $R = V/I$. One mark POT correct, i.e. correct conversion of mA. One mark.	2/1/0
(c)	Percentage uncertainty Sensible estimates for ΔI and ΔV ($\pm 0.5\text{mA}/1\text{mA}$, $\pm 0.01\text{V}$). One mark. ***** Correct use of % formula. No need to check calculation. One mark. Adding % uncertainties together. One mark OR Substitution to find max and min R, hence % uncertainty. Two marks	1 2/1/0
(d)	Readings Write the number of readings as a ringed total by the results table. 6 sets of values of $\ln(R)$ and T^{-1} scores two marks. 5 sets one mark. Check a value for $\ln(R)$ and a value for T^{-1} . Underline and \checkmark if correct. One mark. Do not credit $\log(R)$. Ignore small rounding errors. If minor help has been given, then -1 . Excessive help given e.g. circuit constructed for candidate, 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.	3/2/1/0
(d)	Raw values Raw values of I, V, θ must all be in the table. One mark	1
(d)	Column headings for I, V, and R Units must be correct i.e. A or mA, V, Ω or $\text{k}\Omega$ There must be some distinguishing mark between the quantity and its unit. E.g. V/V, V(V), V in volts, are OK, but not (V)V, V_V , or just "volts"	1
(d)	Column headings for T, T^{-1} Units must be correct i.e. K, K^{-1} , and correctly placed as above.	1
(d)	Consistency of raw readings (I, V, and θ) I to 1 (or 0.1) mA. V to 0.1V or 0.01V. θ to 1°C or 0.5°C . Trailing zeros lose this mark. Indicate using \checkmark_c at the foot of the column if correct.	1
(d)	Quality of results Judge by scatter of points about line of best fit. 5 or 6 good trend plots needed. Large scatter/no trend scores zero. This mark cannot be scored if \ln values have been miscalculated (but accept \log values).	1
(e) (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.).	2/1/0

(e) (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' of diameter greater than $\frac{1}{2}$ small square.	1
(e) (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. Do not allow thick or 'hairy' lines.	1
(e) (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 of the triangle must be greater than half the length of the drawn line, one mark. Indicate by $\Delta\checkmark$. Do not allow a line of thickness greater than $\frac{1}{2}$ a small square.	2/1/0
(e) (ii)	y-intercept One mark for a correct read-off. Allow errors up to and including half a small square. If a read-off is not possible, allow correct substitution from a point on the line into $y = mx + c$. If a read-off is possible, but $y = mx + c$ has been used, the answer must agree with that read directly from the graph A bald intercept with no working or possible read-off from graph scores zero.	1
(f)	$\ln(R) = \ln(A) + B/T$. Allow log values if ecf from (d). Can be implied from the working.	1
(f)	Value for A, (from $A = e^{\text{y-intercept}}$, or $10^{\text{y-intercept}}$ if log values have been used).	1
(f)	Value for B (from gradient)	1
(f)	Units of A and B. Ω and K (but allow ecf for K from part d)	1
(f)	Significant figures for A and B. 2 or 3 s.f.	1
(g)	Any $\Delta R/\Delta T$ straight from results table, one mark. $\Delta R/\Delta T$ over whole range, with points on line, one more mark.	2/1/0
(g)	Sensitivity greatest at low temperatures, with reasoning.	1

[Total 28]

Question 2

(a) (i)	Raw time > 8s, recorded to at least 2 dp, with T correct (= t/n), one mark. Do not credit the raw timing of a single oscillation. Repeated values of raw times, <u>averaged</u> , for a second value of T, one mark.	2/1/0
(a) (ii)	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 consistent with (a) (i).	1
(b)	New values of T (> first value of T), one mark.	1
(c)	$T \propto \sqrt{m}$ or $T^2 \propto m$ One mark for comparison of ratios, or calculation of k's. Check one calculation. If correct, one mark. One mark for conclusion that $T \propto \sqrt{m}$, or $T^2 \propto m$ (only if k values are within about 10% of each other). Allow opposite conclusion otherwise. Evidence of correct ratio for one value of k is necessary to access this mark. Allow up to 20% if % difference has been calculated.	3/2/1/0
(d)	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 Raw time too small 2 S Time more oscillations 3 S Video the mass, <u>details</u> needed, i.e. timer in frame or similar / light gates with detail 4 P Masses are too loosely attached to spring / masses slide over each other / fall off 5 S Secure hook/masses by some means e.g. Plasticine 6 P Problem with pendulum behaviour/with vertical motion 7 S Use small amplitude (NOT spring in tube) 8 S Take care not to give sideways/vertical impulse on launch 9 P Human error in timing or counting / hard to see beginning or end of oscillation. Do not credit difficulty of starting watch and oscillation together. 10 S Use a marker, in any position 11 S Place (fiducial) marker at <u>centre</u> of oscillation 12 P Two sets of readings of T and m are not enough. 13 S Use a greater range of values of m and plot a <u>graph</u> 14 S Plot a graph of T^2 against m, or T against \sqrt{m} Do not give marks for repeating readings of T for the same m (already credited in part (a). Do not allow draughts etc. Do not allow vague "light gates", "use a computer", or "video the mass", unless further clarification is given. Allow other relevant points (7 maximum).	7
	2 marks are reserved for quality of written communication (SPAG)	2/1/0

16 marks maximum to be awarded

Mark Scheme for Planning Exercise

A1	Correct circuit diagram, with voltmeter and ammeter (or joulemeter), variable resistor / variable power supply voltage	1
A2	<u>Diagram</u> of <u>experimental</u> arrangement, showing a small mass being raised.	1
A3	Correct procedure. For a <u>fixed</u> load, for several values of the input power, measure input and output power and speed. Allow other sensible procedures. Method must be workable in principle.	1
B1	Input power = VI (or from joulemeter for a fixed time). and , Output power = mgh/t	1
B2	Measurement of rotational speed. E.g. Stroboscope, indicating brief method / rev counter, or a timing method.	1
B3	Efficiency = output power/input power (x 100)	1
C	Selection of a suitable load, so that times are measurable e.g. > 5s. Figures should be quoted.	1
D1	Reasons for inefficiency, e.g. (max 3) 1 Heat generated in windings of motor and circuit 2 Mechanical friction (in gearing and axle) 3 Incomplete flux linkage inside motor 4 Sensible suggestions of how efficiency may vary with speed	3/2/1/0
D2	Any further relevant detail, e.g. (max 2) 1 Evidence of preliminary work (figures to be quoted) 2 Repeating readings 3 More details of stroboscope use / good detail on timing method to measure speed 4 Motor secured to bench by screws or clamp Note that efficiency also varies with input or output power and not just speed.	2/1/0
R	Evidence of research of material. i.e. at least two detailed references have been given (i.e. chapter and/or page numbers must be given). Allow internet <u>pages</u> to be sourced. Two or more vague references (i.e. no chapter or 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. ✓ _{A1}).	
Q	Quality of written communication (organisation) Rambling and poorly presented material cannot score both marks.	2/1/0

16 marks in total

Grade Thresholds

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

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2821	Raw	60	39	34	30	26	22	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	43	38	34	30	26	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	101	91	81	71	61	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	101	91	81	71	61	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	97	89	81	73	65	0
	UMS	120	96	84	72	60	48	0
2824	Raw	90	65	58	51	45	39	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	68	62	56	50	44	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	63	56	49	43	37	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	65	58	51	44	38	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	62	56	50	44	39	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	90	90	80	70	60	50	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	90	80	70	60	50	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	88	80	72	64	57	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	12.9	37.4	63.5	81.4	96.4	100	592
7883	12.0	30.0	56.0	81.0	96.0	100	113

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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