OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Mark Scheme for the Units

June 2008

3883/7883/MS/R/08

Oxford Cambridge and RSA Examinations

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MARK SCHEMES FOR THE UNITS

2821 Forces and Motion

Question			Expected Answers	Marks	Additional Guidance
1	a	i	**A vector has a direction**	**B1**	This is the minimum required. The reverse argument that a scalar does not have a direction can be implied. Allow extra comments such as magnitude, size, number and quantity but identified quantities such as a scalar has a distance and a vector has a distance and direction should **not** be allowed.
		ii	**[acceleration, force and weight] 3 correct scores 2** **2 correct scores 1. (–1 for incorrect scalar answers)**	**B2**	e.g, acceleration, force and power would score 0 (+1 and -1) acceleration, force, power and weight would score1 (+2 and -1)
	b	i 1	**(v_v =) 25 sin60 or 25cos30** **= 21.7 (21.65) (m s^{-1})**	**M1** **A0**	
		2	**v = u + at** **0 = 21.7 – (9.81 x t)** **t = 2.2(1) (s)**	**C1** **A1**	Or t = (v-u) / a or a = (v-u) / t Do not accept t = 2 (**SF** error). If g=10 used then penalise -1 but only once on the paper
		3	**distance = speed x time**	**M0**	Any equation with acceleration cannot score these marks unless a=0 stated
			using speed = 25 cos60 or 25sin30	**C1**	Correct horizontal component (12.5)
			using time = 2t	**C1**	Note **ECF** from **(b)(i) 2**
			= 55(.2) (m)	**A1**	

Question			Expected Answers	Marks	Additional Guidance
		ii 1	**straight line negative / positive gradient**	**B1**	The velocity must start from a non zero point and be a straight line as far as the time axis
			line continues into negative / positive v values with the same gradient	**B1**	
			same time in both + and – regions and to same v (only if correct line drawn)	**B1**	If time not labelled at half way mark, then use the ruler available to check times and allow 3 mm difference. Judge velocities by eye
		2	**decreasing gradient**	**B1**	But not reaching a vertical line at end
			increasing gradient (roughly same gradient at beginning and end)	**B1**	
	b	iii	**ANY FOUR:** **PE zero or minimum at A / rises from A to H / maximum at H / falls from H to B.** **KE max at A / falls from A to H / rises from H to B.** **KE is a <u>minimum</u> at H (*not zero)*** **KE is <u>converted</u> to PE / PE is <u>converted</u> to KE / <u>loss</u> in PE = <u>gain</u> in KE** **KE / PE at B is the <u>same</u> as at A**	**MAX B4**	Only one of these is required for the mark **but** any further contradictions about the PE would cancel this mark. Similarly for the KE statements The candidate's first four statements should be marked with **a cross or a tick** on script and the remainder checked for contradictions only. **Do not allow or penalise:** PE = KE half way up (AW)
		QWC	**Spelling and punctuation**	**B1**	Penalise if more than two errors in spelling or punctuation. No tick or cross needed. Allow GPE and KE
			Total	**19**	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	**Resultant force or sum of forces is zero** **Resultant or sum of torque / moments is zero**	**B1** **B1**	**Do not allow**: upward forces equal downward forces / forces are balanced / all forces are equal (and opposite) **Allow:** sum of clockwise moments equals sum of anticlockwise moments
		ii	**Force x perpendicular distance from the pivot / point / axis**	**B1**	
	b	i	**850 x 2 or 4400 x 4 or T x 3** **(Sum of clockwise =) 850 x 2 + 4400 x 4** **equating this sum with the anticlockwise moment T x 3 and solving to give T = 6400 (6433) (N)**	**B1** **B1** **B1**	Any correct moment scores the first mark The two correct clockwise moments added The clockwise and anticlockwise moments are then equated and solved and not just the clockwise divided by 3
		ii	**Force at A drawn up and to the right of vertical allow up to parallel with beam** **Another force is required to give zero resultant force or up and down / left and right forces do not balance**	**B1** **B1**	Mark diagram with **a tick or cross** to show F has been looked for Do not accept the system is not in equilibrium (that is in the question)
			Total	**8**	

Question			Expected Answers	Marks	Additional Guidance
3	a		**V = 6 x 2 x 0.25** **ρ = m / V** **m = 3 x 2500** **= 7500 (kg)**	 **C1** **A1**	 In any form
	b		**P = F / A** **= [7500 x 9.8(1)] / (6x 0.25)** **= 4.9 x 10^4 (Pa)**	**C1** **C1** **A1**	Wrong formula used (e.g. P = Mass / A) then 0/3 ECF for the mass from part (a) Penalise for g = 10 if not penalised previously. If no g used then cannot score last two marks No ECF for incorrect area used.
			Total	**5**	

Question			Expected Answers	Marks	Additional Guidance
4	a		**Either:**		
			Resolve horizontally F = T cos60	**C1**	
			Resolve vertically 2000 = Tsin60	**C1**	
			F = 1155 (N)	**A1**	Allow answers to two SF (1200)
			Or correct triangle of forces	**C1**	Basic shape (30, 60 and 90), two forces labelled (arrows not needed). Give this mark even if 30 and 60 reversed (this gives 3464N and would gain 1 mark max).
			correct trig. statement	**C1**	
			F = 1155 (N)	**A1**	Allow answers to two SF (1200)
			Or correct scale diagram	**C1**	As above (for triangle of forces)
			Scale given	**C1**	
			F = 1155 (N)	**A1**	Allow answers from 1100 to 1200 (N)
	b	i	**Larger mass, weight, larger angle or larger force F**	**B1**	Not longer cable
			Greater kinetic energy (change) or greater momentum (change)	**B1**	Do not accept It hits with greater force on its own
			Allow greater speed <u>at the point of collision</u> /where <u>it hits the wall</u> or mass is larger hence force <u>on wall</u> is larger using F=ma		Do not accept travels with greater acceleration hence force is larger using F=ma.
			Total	**5**	

Question			Expected Answers	Marks	Additional Guidance
5	a	i	**$W_c = 2.4 \times 10^5 \times \sin 4.8$** **$= 2.0 \times 10^4$**	**M1** **A0**	Allow W x sin 4.8
	b		**W = F x d** **W / t = F x v** **= 12000 x 15** **= 180000 ($J\ s^{-1}$)**	 **C1** **A1**	
	c		**P = W / t P = F x v** **$P = 3.2 \times 10^4 \times 15$** **= 480000 (W)**	**C1** **A1**	
	d		**pe / t = 480000 – 180000** **= 300000** **allow alternative method of determining the vertical height moved in one second and use of mgh** **e.g. h = 15 sin4.8 = 1.255** **W/t = mgh/t = $2.4 \times 10^5 \times 1.255$** **= 300000** **unit: W or J s^{-1}**	**C1** **A1** **C1** **A1** **B1**	Do not give a mark for PE = mgh on its own. Do not give a mark for W/t or mgh/t on their own Do not give a mark for W/t or mgh/t on their own Allow kJ s^{-1} / kW if consistent with numbers used Allow N m s^{-1} but not kg m^2 s^{-3}

Question			Expected Answers	Marks	Additional Guidance
	e		**less**	**M0**	
			Component of weight acts down the slope	**A1**	Weight / force of gravity helps the braking (AW) (not gravity helps braking) Some KE is converted to PE and hence less work has to be done by the braking force
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
6	a	i	**E = stress / strain**	**C1**	
			= (F x *l*) / (A x e)	**C1**	
			= (60 x 4) / (0.63 x 10^{-6} x 3.3 x 10^{-3})	**C1**	Any correct points from the graph up 82 (N) Max 2/4 if force value is greater than 82 N
			= 1.15 x 10^{11} (Pa)	**A1**	Allow 1.2 and 1.1 if consistent with correct values from graph e.g 36 N and 2.0 mm.
		ii	**Strain energy = ½ x F x e or area under graph**	**C1**	
			= 0.5 x 80 x (4.4 x 10^{-3})		Allow 4.35 x 10^{-3} to give 0.174 (J)
			= 0.176 (J)	**A1**	Do not penalise the omission of 10^{-3} in this part if already penalised in section (a)(i)
	b		**graph does not return to zero extension (may be on the graph) / there is permanent extension**	**B1**	Do not allow answers that suggest it will return **if** it has not passed its elastic limit or any statement that explicitly states that the extension is the same as when the force was applied
	c		**wire:** **ductile / malleable** **Hooke's law obeyed / force proportional to extension at start / over straight line section** **Elastic in first section** **Plastic when larger forces applied**		Ignore comparative values of Young modulus, breaking force etc (but do not take these statements as part of the six assessed statements).

Question			Expected Answers	Marks	Additional Guidance
			Glass is brittle **Glass has <u>no</u> plastic region** **Glass has straight line section <u>only</u>**	**MAX B6**	Allow from a sketch graph. Stop marking after ticks and crosses add up to 6 but check for contradictions in any remaining text.
		QWC	**Use of technical language**	**B1**	Candidates are using correctly 2 of Hooke's law, extension proportional to force, elastic, plastic, ductile, malleable and brittle. We are not assessing spelling etc. in this section.
			Total	**14**	

2822 Electrons and Photons

Question			Expected Answers	Marks	Additional Guidance
1	a		Opposite (direction)	B1	**Allow** 'positive to negative for one and negative to positive for other' even if physics is incorrect (1) **Not** 'different' direction(s) - because this is stated in question
	b		(p.d =) energy (transfer)/charge	B1	**Allow** $(V =)\frac{W}{Q}$ or $(V =)\frac{E}{Q}$ where *W* (or *E*) = energy / work (done) and *Q* = charge. (1) For mark above, there is no need to define *V*. **Not** energy lost **by** unit charge / by coulomb **For a mark the idea of 'division' or 'per' is important**
	c	i	(The kilowatt-hour is) the <u>energy</u> (transferred) / <u>work</u> (done) when a <u>1 kW</u> device is operated for <u>1 hour</u>	M1 A1	The first mark is for realising that kW h is an <u>energy</u> or <u>work</u> (done) unit. The second mark is for referring to 1kW (or 1000 W) <u>and</u> 1 hour (or 3600 s). **The second mark can only be awarded if the first mark has been scored.** **Not** 'power transferred by a 1 kW device working for 1 hour'.
		ii	(Number of kW h =) 1.8 × 1500 (= 2700) (cost =) 2700 × 9.0 cost = (£) 243 or 240	C1 A1	**Special cases:** **Allow** 1 mark for bald 2700 **Allow** 2 marks for bald 243 or 240 **Allow** 1 mark for £2.43 × 10^5 (only one error made for not converting the power into kilowatts) **Allow** 1 mark for £2.43 × 10^4 (only one error made for not converting pence into pounds) **Not** £2.43 × 10^7 or £24300000 because two errors have been made (working in pence and watts) **Reject** bald '2.7 × 10^6' for multiplying 1800 and 1500
			Total	**6**	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	A diagram with three resistors in <u>series</u>	B1	There is one mark for the diagram and one mark for the resistance value – the marks are **independent** of each other The resistors values are not necessary on the diagram The resistors must be shown as oblongs
			total resistance = 44 (Ω)	B1	
		ii	A diagram with three resistors in <u>parallel</u>	B1	There is one mark for the diagram and two marks for the resistance value – the marks are **independent** of each other The resistors values are not necessary on the diagram. The resistor symbol is oblong or consistent with (a)(i)
			Use of $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}(+\frac{1}{R_3})$	C1	
			$R=1/(10^{-1}+12^{-1}+22^{-1})$ total resistance = 4.37 (Ω)	A1	**Allow** A bald 4.37 (Ω) or 4.4 (Ω) scores two marks for calculation Answer can be 2 sf or more **Special case**: 4 (Ω) scores 1 mark for the calculation part
	b		108	B1	
			9	B1	
			45	B1	**Allow** 5 × 'previous answer' - ecf (1)
			Total	**8**	

Question			Expected Answers	Marks	Additional Guidance
3	a	i	Correct symbol for thermistor	B1	To score the symbol mark, must have an oblong with a 'line + bend at one end' through the oblong in **any** orientation (do not allow arrow)
			The resistance decreases as the temperature (of thermistor) increases (ora)	B1	**Allow** It increases as the temperature decreases (1) **Not** any reference to 'heat' instead of temperature
		ii	Correct symbol for LDR	B1	To score the symbol mark, must have an oblong plus a minimum of one arrow towards the oblong – the circle round the oblong is not necessary.
			The resistance decreases as intensity / light increases (ora)	B1	**Allow** In light the resistance is low / small (1) **Allow** In dark(ness) the resistance is high / large / big (1)
		iii	A diagram with a resistor / variable resistor and an LDR connected in series to a supply / battery / cell	M1	The LDR symbol is ecf from (a)(ii)
			A voltmeter connected is across the resistor or the LDR	A1	**The second mark can only be scored if the first mark is awarded and a correct symbol for a voltmeter (circle with a letter V)**
	b	i	A line / curve of positive gradient	B1	To score this mark, the line or curve must have a finite resistance value at 0 ^{o}C - allow resistance intercept at or above the 'top of zero' on the l.h.s. **Not** A line/curve that becomes horizontal

Question			Expected Answers	Marks	Additional Guidance
		ii			**Must show ticks on the script to indicate where marks are being awarded**
			Place the wire in a (water) bath / use a hot plate / oven	B1	**Not** 'heat the wire'
			Any remaining <u>four</u> from: 1. Connect conductor / wire in series with a battery / cell / power supply 2. Ammeter placed in series (with wire) / voltmeter placed in parallel (with wire) 3. Record / read / measure current / voltage (across the wire) (AW) 4. (Calculate the resistance using the equation:) $R = \frac{V}{I}$ 5. Thermometer / 'temperature probe' mentioned 6. Measurements (for *V* and *I*) repeated for different temperatures	B1 × 4	Numbered marking points 1 and 2 can be scored on diagram or in the text but **all** others marking points must be written Not '*V* = *IR*' for numbered marking point 4 **Not** '*Plot a graph of R against temperature'* for numbered marking point 6
			QWC		For **QWC** marks, the answer must involve physics, which attempts to answer the question – otherwise the mark for QWC is zero.
			Structure and organisation mark	B1	Award this mark if the whole answer is well structured Bulleted answers are allowed – must have full stops
			Spelling and Grammar mark	B1	More than two spelling mistakes <u>or</u> more than two grammatical errors mean that this mark is lost
			Total	**14**	

Question			Expected Answers	Marks	Additional Guidance
4	a	i	$R = \frac{\rho L}{A}$ (area =) $\pi \times (3.5 \times 10^{-5})^2$ or 3.8(49) × 10^{-9} $(R =) \frac{1.70 \times 10^{-8} \times 12}{\pi (3.50 \times 10^{-5})^2}$ resistance = 53 (Ω)	C1 C1 C1 A0	**Allow** any subject for the equation Award all three marks if candidate just writes this line **Allow** $(R =) \frac{1.70 \times 10^{-8} \times 12}{3.8(49) \times 10^{-9}}$ (3) **Not** bald 53 (Ω) since this is a 'show' question
		ii	The (26) wires are in <u>parallel</u>	B1	**Allow** '53/26 (= 2.04 Ω)' (1) **Allow** (cross-sectional) area is <u>26</u> times greater (AW) (1)
	b	i	$P = \frac{V^2}{R}$ / $I = \frac{24}{6.0} (= 4.0)$ $R = \frac{6.0^2}{24}$ / $R = \frac{6.0}{4.0}$ resistance = 1.5 (Ω)	C1 A1	**Allow** 2 marks for a bald 1.5 (Ω)
		ii	There is a potential difference across the cable(s)	B1	**Allow** reference to voltage instead of p.d. (1) **Allow** 'heat / energy / power lost in the cable/wire' (1) **Not** 'power supply has internal resistance' (AW)
		iii	(p.d across cable =) 4.0 × 2.04 = 8.16 (V) or (p.d across cable =) 4.0 × 2 = 8 (V) e.m.f = 6.0 + 2 × 8.16 or e.m.f = 6.0 + 2 × 8 e.m.f = 22.3 (V) or 22 (V)	C1 A1	**Allow** (total resistance =) 5.5(8) (ohms) or 5.5 (ohms) (1) **Allow** 2 marks for bald 22.3 (V) or 22 (V) **Special case**: 14 (V) scores 1 mark (only one cable used) **Special case**: 20 (V) scores 1 mark because of sf.
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
5	a		$B = \frac{F}{IL}$ where *F* = force (acting at right angles to the wire), *L* = length (of wire in the field) and *I* = current	M1 A1	**Allow** any subject for the equation **The second mark can only be scored if a correct equation is given above**
	b	i	**F** / arrow (on Y) is towards X	B1	
		ii	$F = 12 \times 10^{-5} \times 18 \times 0.25$ force = 5.4×10^{-4} newton / N	C1 A1 B1	The first mark is for correct substitution with $\underline{12} \times 10^{-5}$ (and not *F* = *BIL*) – there is no ecf for misreading the graph **Allow** 2 marks for (a bald) answer of 5.4×10^{-4} **Allow** 1 mark for 54 because of 10^{n} error This is an **independent mark**; no numerical answer for force is expected **Allow** TAm (1)
			Total	**6**	

Question			Expected Answers	Marks	Additional Guidance
6	a		Any <u>four</u> from: 1. Electrons <u>travel</u> / <u>move</u> as 'waves' 2. Electrons are diffracted 3. Diffraction by atomic planes / gaps between atoms / atoms (AW) 4. The wavelength of the electron is similar to atomic separation / gap / size (AW) 5. Reference to $\lambda = \frac{h}{mv}$ / $\lambda = \frac{h}{p}$ 6. where λ = wavelength, *h* is Planck constant, *m* = mass (of electron) and *v* = speed / velocity (or *p* = momentum)	B1 × 4	**Must show ticks on the script to indicate where marks are being awarded** **Not** Electrons 'pass through' as waves for first marking point **Not** 'diffracted by *gaps* / *holes* in graphite*'* for marking point 3. **Marking point 6. can only be scored if the de Broglie equation is given**
	b	i	Allow a number in the range 1 ×10^{-13} (m) to 5 ×10^{-8} (m)	B1	
		ii	speed = *h*/(9.11 × 10^{-31} × answer to (b)(i)) correct value for the speed	C1 A1	The first mark is for correct substitution of their value for wavelength – the value for *h* is not required. It is the same as: speed = 7.28 × 10^{-4}/(b)(i) **Allow** 2 marks for a bald correct answer (in m s^{-1}) The answer must be 2 sf or more
			Total	**7**	

Question			Expected Answers	Marks	Additional Guidance
7	a		$Q = It$ (current or charge =) 4.2×10^{-9} (number per second =) $\frac{4.2\times10^{-9}}{1.6\times10^{-19}}$ $2.6(3) \times 10^{10}$ (s^{-1})	C1 C1 C1 A0	**Allow** 3 marks for: number per second = $\frac{4.2\times10^{-9}}{1.6\times10^{-19}}$ **Allow** 2 marks for bald 2.6**3** $\times 10^{10}$ (s^{-1}) **Allow** 2 marks for $\frac{4.1\times10^{-9}}{1.6\times10^{-19}} (= 2.5(6)\times10^{10})$ - misread graph **Allow** 2 marks for $\frac{4.2}{1.6\times10^{-19}} (= 2.63\times10^{19})$ - POT error **Reject** bald answer of 2.6×10^{10} (s^{-1}) – since answer is given
	b		$\phi = 1.6\times10^{-19}\times2.2 (= 3.52\times10^{-19})$ $hf = \phi + KE_{(max)}$ / $\frac{hc}{\lambda} = \phi + KE_{(max)}$ KE = $(\frac{6.63\times10^{-34}\times3.0\times10^{8}}{2.5\times10^{-7}}) - 3.52\times10^{-19}$ kinetic energy = $4.4(36) \times 10^{-19}$ (J)	C1 C1 C1 A1	**Allow** 3 marks if candidate reaches as far as this third marking point – any subject (**Note**: frequency = 1.2×10^{15} (Hz)) **Allow** all 4 marks for a bald 4.4×10^{-19} (J) **Allow** 2 sf or more for the answer **Special case**: 4×10^{-19} (s^{-1}) scores 3 mark**s**
	c	i	No change (AW)	B1	
		ii	The (photoelectric) current is <u>proportional</u> to the intensity (AW) Increasing the intensity increases the (rate of) photons	B1 B1	These are **independent** marks For the second marking point the reference must be to the **photons** and not the electrons (since this idea has already been given a mark above)
			Total	**10**	

2823/01 Wave Properties/Experimental Skills 1 Written Paper

Question			Expected Answers	Marks	Additional Guidance
1	a		(a) R.I. = speed of light in air/speed of light in medium	B1	Allow c/v, c_i / c_r, sini/sinr – all terms must be defined other than c
	b		speed of light in liquid = 3 x 10^8 /1.40 = 2.14 x 10^8 m/s	B1	Allow 2 x 10^8, 2.1 x 10^8
	c		Use of *n* = sini/sinr sinr = sin60/1.4 $\Rightarrow$ r = 38 (38.2)	C1 A1	Any use (correct or incorrect) of sini/sinr scores the first mark. Ignore incorrect diagrams
			Total	**4**	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	diagram correctly showing ***C***	B1	If no diagram allow a **statement** that ***C*** is the angle (of incidence) that results in angle of refraction of 90^{O} (WTTE).
			for light passing from **dense to less dense** medium (WTTE OR shown)	B1	Allow refracted ray shown close to interface Statement made or C shown in more dense medium (this mark may be scored even if C is shown between ray and interface)
		ii	TIR: when **angle of incidence is greater than critical angle** (or C) all the light is reflected internally (WTTE) OR SHOWN on diagram	B1	If only a diagram is shown with no statement – the angle of incidence must be shown within the diagram or labelled as being bigger than **C**.
	b		Correct use of n= 1/sinC: e.g. n = 1/sin 39 n = **1.59**	C1 A1	Allow 1.6 but not 1.5 or 2
	c	i	different rays take **different paths** (WTTE)	B1	
			they arrive at **different times** (WTTE)	B1	Do not allow 'some rays travel faster'
			causing **distortion** (of signal) (WTTE).	B1	allow 'smear' 'spread' etc but do not allow 'weaker'
		ii	accept any valid method, e.g. use a monomode fibre (WTTE) OR use cladding	B1	Allow **very** thin/narrow fibre. Do not allow small fibre
			to reduce number of alternative paths (WTTE)	B1	For cladding explanations this mark may also be scored for stating that more rays are now refracted out/lost.
			Total	**10**	

Question			Expected Answers	Marks	Additional Guidance
3	a		PARALLEL (WTTE) **and** PERPENDICULAR (WTTE)	B1	
	b	i	POLARISATION	B1	
	b	ii	Any 3 each scores 1 mark e.g.: REFLECTION, REFRACTION, DIFFRACTION, INTERFERENCE, DISPERSION.CARRY ENERGY/INFORMATION{do not accept characteristics like wavelength, frequency, period, velocity, amplitude etc}	B1 B1 B1	
	c	i	period = **0.004** s (or 4.0 x 10^{-3} s or 4ms)	B1	1/250 is insufficient to score this mark
	c	ii	'length' of a wave drawn **4cm** (allow ecf from (c) (i) 'amplitude' of **both** crests and troughs drawn is **3cm**	B1 B1	Must see something above and below the time-axis If less than one cycle drawn no mark can be scored If two waves are carelessly drawn with different 'lengths' award mark if at least one is correct.
	c	iii	**10 times more** waves in CRO trace (WTTE)	B1	If 10 or1/10 is not seen, no mark is scored.
	c	iv	recall of $v=f\lambda$ substitution of correct values for v and f λ = **1.32** m	C1 C1 A1	 Award this mark even if the equation is incorrect. Allow 1.3 but not 1
			Total	**12**	

Question			Expected Answers	Marks	Additional Guidance
4	a		**waves** meet/cross/interfere/superpose/combine /interact resultant displacement is the sum of the individual waves (WTTE)	B1 B1	Do NOT allow wave sources meet Must see **displacement** NOT amplitude; must see **sum** or words to that effect such as total or add.
	b	i	S_1P-S_2P OR difference in length between paths from S_1 and S_2 (WTTE)	B1	Do not allow general answers that **do not make reference** to S_1 and S_2 or P.
	b	ii	**1** 0, λ, (or 2λ, 3λ etc) any two correct **2** 1/2λ, 3/2λ (OR 5/2λ, 7/2λ etc) any two correct	B1 B1	nλ alone may score this mark only if n is defined as an integer (WTTE) somewhere. Allow (n +1/2) λ provided n is defined somewhere (n) λ and(n +1/2) λ scores 1 mark if n undefined no ecf
	c	i	*labelled diagram of arrangement*: light source, double-slit and screen in correct relative positions correct labelling (at least 2 of the above 3) *measurements*: measure distance between neighbouring bright (or dark) images {allow 'fringe separation'} measure distance between double-slit and screen *formula:* recall of λ = ax/D ALL symbols correctly defined or correctly shown on diagram:	 B1 B1 B1 B1 B1 B1	 Ignore the presence or absence of a single-slit Cannot score labelling mark for invalid arrangement Do not award these marks unless the word measure (WTTE) is seen. Some candidates may merely list all the factors involved. Ignore reference to measurement of a. Allow any other formula if correct for their defined symbols a = slit separation; x = fringe separation D = distance from slits to screen Allow BOD for loose definition of D if already penalised in measurement section.
	c	ii	ANY TWO valid suggestions e.g. white central image **colour** (fringes) OR spectra (on either side)	 B1 B1	 Also allow 'red fringes are further from centre'
			Total	**13**	

Question			Expected Answers	Marks	Additional Guidance
5	a		pluck/stroke/disturb/vibrate/twang string	B1	Allow this mark for oscillating P or Q
	b	i	correct diagram of fundamental i.e one loop	B1	Either full envelope or instantaneous pattern scores mark. Ignore any labelling of nodes and antinodes
		ii	wavelength = 2x1.2 = **2.4** m	B1	Allow ecf for candidates diagram
	c		Correct standing wave drawn i.e 3 'loops' All correct nodes labelled N for candidates diagram All correct antinodes labelled A for candidates diagram	B1 B1 B1	Either full envelope or instantaneous pattern scores mark Allow lack of Ns labelled at P and Q if the others are correct. If all A and N are exactly reversed then award one of these two marks.
			Total	**6**	

2823/03 Wave Properties/Experimental Skills 1 Practical Examination

Planning Exercise - Skill P

A1 Labelled diagram showing strain gauge attached to the wood with thermometer. **1**

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

A3 Use of kiln/oven/freezer to change temperature **1**

B1 Use of glue/adhesive/superglue to fix strain gauge to wood **1**

B2 Circuit diagram for measuring resistance (ammeter/voltmeter; ohmmeter; wheatstone bridge) **1**

B3 Wait for temperature of wood to stabilise **1**

C1 Safety precaution with reason. **1**
e.g. gloves to handle hot/cold surfaces, gloves to protect skin when applying glue; ventilation/ fume cupboard for fumes from glue.

C2 Keep humidity constant. **1**

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.
Detailed references from two or more independent sources scores two marks.
Detailed references should have page or chapter numbers or be internet pages.

D1/2/3/4 Any further relevant detail. Examples of creditworthy points are listed below. max **4**

- ✓ Typical resistances of a strain gauge (20 Ω - 1000 Ω).
- ✓ Determination of ammeter range or ohmmeter range.
- ✓ Method of checking humidity (humidity sensor or hygrometer).
- ✓ Discussion of strain along and across the grain.
- ✓ Discussion of temperature compensation (including self compensation).
- ✓ Discussion of choice of glue to avoid differential expansion.
- ✓ Method of determining resistance for bridge methods.
- ✓ Evidence of preliminary investigation in the laboratory.

QWC 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

16 marks total.

Question 1

(c) Measurements **2/1/0**
Write the number of readings as a ringed total next to the table of results.
Six sets of values for *x* and *d* scores 2 marks, five sets scores 1 mark.

(c) Measurements **2/1/0**
At least one value of x **>** 0.200 m scores one mark.
Tick $\checkmark_R$ for first value greater than 0.200 m. Do not accept 0.200 m.
No help from Supervisor scores one mark.

(c) Column headings in the table and consistency of raw readings **2/1/0**
One mark for column headings for *x* and *d* correct. Tick $\checkmark_H$ or $\times_H$.
Allow *x* /m; *x* (m); *x* in m.
Ignore units in the body of the table.
One mark for the consistency of *x* and *d* which must be to the nearest mm e.g. 0.001m.
Tick $\checkmark_C$ or $\times_C$

(d) Axes **2/1/0**
If false origin on *x*-axis, indicate with "FO".
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 two and a half large squares without a scale label.
One mark for each correct axis. Tick $\checkmark_A$ or $\times_A$

(d) Size of graph **2/1/0**
Plotted points must occupy at least half the graph grid in both *x* and *y* directions (i.e. 4 x 6 large squares).
One mark for each correct axis. Tick $\checkmark_S$ or $\times_S$ or $\leftrightarrow$ or $\updownarrow$

(d) 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 <u>otherwise indicate the correct position</u>.
If the plot is accurate <u>≤</u> 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.

(d) Line of best fit and quality of results. **2/1/0**
For best fit line 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 or kinked line.
$\checkmark_L$ or $\times_L$. If incorrect indicate how the line can be rotated.

For quality, judge by scatter of points about the examiner's line of best fit.
Six good trend plots on the graph grid needed for this mark to be scored. $\checkmark_Q$ or $\times_Q$.

(e)(i) Gradient **2/1/0**
The hypotenuse of the Δ must be $\geq$ half the length of the drawn line. 1 mark.
Read-offs must be accurate to half a small square and ratio correct. 1 mark.
If a read-off is incorrect, ring it and write in the correct value.

(e)(ii) *y*-intercept **1/0**
Must be negative and
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 $y = mx + c$.
Allow ecf from gradient calculation.

(f) (i) Candidate's gradient value equated with Q/M (can be implied from working)
Value of *Q* correctly determined (= *gradient* x *M* = *gradient* x 0.100).
Sig Figs of *Q*: allow 2 or 3 only.
Unit of *Q* (kg unless clear from working that it is g). **4/3/2/1/0**

(f) (ii) *y*-intercept equated with $-0.2R/M$ (can be implied from working).
Value of *R* correctly determined (= *y*-intercept x $M/0.2$ = *y*-intercept x 0.5)
Sig Figs of *R*: allow 2 or 3 only **3/2/1/0**

(g) (i) Calculation of percentage difference and quality.
Expect to see difference/either *R* value x100. **1/0**

Candidate's value of *R* within 10% scores one mark. **1/0**
Indicate OOR if mark not awarded.
Do not award this mark if the method in (f) (ii) is incorrect.

(g) (ii) 1. Random error. **1/0**
Reference to scatter of points and appropriate conclusion.
2. Systematic error. **1/0**
Reference to percentage difference and appropriate conclusion.

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

Question 2

(a) *l* and w measured to nearest millimetre and A calculated correctly (about 150 cm^2). **1**

(b) (i) Evidence needed to award these marks.
$\Delta w = \Delta l = 0.1$ cm **1**
Calculates percentage uncertainties correctly (about 1% and 0.67%). **1**

(ii) Adds percentage uncertainties from (b) (i). **1**

(e) Repeats experiment gaining a larger value for *t* and *t* > 1 s **1**

(f) Inverse proportionality ideas.
Method to prove or disprove inverse proportionality
(e.g. determines constant of proportionality). **1**
Appropriate conclusion based on their method of proving or disproving proportionality.
Vague answers will not score this second mark. **1**
No method or wrong method loses both these marks

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

	Problem	**Solution**
A	Difficulty in releasing bob and starting the timing simultaneously.	Release from a larger amplitude and start when amplitude is 6 cm.
B	Difficulty in knowing when to stop timing or difficulty in judging amplitude (parallax).	Use of a reference mark/ slow motion video / motion sensor with much detail Bob closer to ruler.
C	Oscillations not always in the vertical plane or wobbling or hit stand.	Repeat (timings) and find average.
D	Time taken too short/discussion of reaction time related to recorded time.	Use a larger initial amplitude/smaller (non-zero) final displacement. Use longer string/smaller areas of card.
E	Two readings of *t* and *A* are not enough to verify the suggestion.	Take many readings of *A* and plot a graph *t* v *A* or of *t* v 1/*A*.

(7 maximum).

No credit for simple 'repeats' or 'using a computer'or digital meters.
Do not allow vague human error in measurements.

Quality of written communication (i.e. spelling, punctuation and grammar). **2/1/0**
Capital letters at the beginning of sentences, full stops at the end scores one mark.
Correct spelling and grammar scores one mark. Allow maximum of two errors.
Difficult to read evaluations scores maximum one mark.

16 marks available. Write the mark as a ringed total at the bottom of page 11.

Results

Question 1

x / m	d / m
0.100	0.105
0.110	0.140
0.140	0.247
0.170	0.348
0.200	0.448
0.230	0.550
0.260	0.660

Plotting a graph of *d* against *x* produces:
Gradient = 3.44
y-intercept = -0.24

Q = 0.35 kg

R = 0.122 kg

Mass from top pan balance 120 g

Question 2

Results:

l = 15.0 cm

w = 10.0 cm

A = 150 cm^2

t = 6.9 s

l = 7.5 cm

w = 10.0 cm

A = 75 cm^2

t = 12.9 s

When the area is halved the time is approximately doubled, therefore t is inversely proportional to A.

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

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

2824 Forces, Fields and Energy

Question			Expected Answers	Marks	
1	a	i	Using F = ma gives P = 3ma hence a = P/3m	1	
		ii	P/3	1	
		iii 1	P/3m	1	
		2	P/3	1	
		iv 1	P/3	1	
		2	2P/3	1	6
	b	i	$mu = mv_1 + mv_2$	1	
			$1/2mu^2 = 1/2mv_1^2 + 1/2mv_2^2$	1	
		ii	some details of algebra/substitution to be shown resulting in e.g. $u = v_2$ and $u^2 = v_2^2$	1	3
	c	i	all momentum is passed to block 2,(block 1 stops); then	1	
			momentum is passed to block 3 (so block 2 does not move)/AW **or** argument in terms of k.e.	1	
		ii	block 1 bounces back; and blocks 2 & 3 move (to right/together)	2	4
			Total		13
2	a		T = 1.2 s; f = 1/T = 0.83 (Hz)	2	2
	b		gradient of line at x-axis gives acceleration; accept 0.42 ± 0.04 ($m\ s^{-2}$)	2	2
			or $a = v_{max}2\pi f = 0.08 \times 2 \times 3.14 \times 0.83 = 0.419\ (m\ s^{-2})$		
	c		$a = (-)(2\pi f)^2x$; correct substitution;	2	
			solution with a = 0.40 gives x = 14.6 mm **or** a = 0.42 gives x = 15.3 mm	1	3
			or $v_{max} = A2\pi f$; $A = 0.08/2\pi \times 0.83$; = 15.3 mm		
	d	i	negative cosine wave touching x-axis; 2 oscillations; correct scale	1	
			on right hand axis oscillating about 0.6 mJ, amplitude 0.6 mJ	2	3
		ii	$1/2mv_{max}^2 = 0.0012$;gives m = 0.375 kg	2	2
			Total		12
3	a		Force per unit mass (at that point)	1	1
	b		From Newton 2/F = ma, a = F/m (= W/m) for a freely falling object	1	
			(without air resistance, etc); the same value as g = F/m (=W/m)	1	
			(as measured by a spring balance)		2
	c	i	$v = 2\pi r/T$; $= 2\pi \times 3500 \times 10^3/(110 \times 60) = 3300\ (m\ s^{-1})$	2	
	c	ii	mv^2/r ;$= GMm/r^2$;	2	
			$M = v^2r/G = 3.3^2 \times 3500 \times 10^9/6.67 \times 10^{-11}$; $= 5.7 \times 10^{23}$ (kg)	2	6
	d	i	$g = GM/R^2$	1	
		ii	3.7 = 6.67 x 10-11 x 5.7 x 1023/R2 ;gives R = 3200 (km) to 3300 (km)	2	3
			Total		12

Question			Expected Answers	Marks	
4	a		The charge flows one way/onto capacitor deflecting ammeter one way;	1	
			at discharge charge flows other way/off capacitor deflecting ammeter other way; **or** equal deflections at equal times from start of process; but in opposite directions **or** time constants same; currents opposite /AW	1	2
	b		$I_0 = 6.0 \times 10^{-4}$;$V = I_0R$ gives $12 = 6.0 \times 10^{-4} \times R$ and $R = 2 \times 10^4$ Ω	2	2
	c	i	current falls to 1/e (0.37) of initially chosen value in time constant;	1	
			indication on graph, e.g. $I = 2.2 \times 10^{-4}$ A at 5.0 s for initial current I_0	1	
		ii	$RC = 5.0$ s ;so $C = (5.0/2.0) \times 10^{-4}$ $(= 2.5 \times 10^{-4}$ F)	2	4
	d	i	$Q = CV$;$= 12 \times 250 \times 10^{-6} = 3.0 \times 10^{-3}$ C	2	
		ii	$I_0t = 6.0 \times 10^{-4} \times 5.0 = 3.0 \times 10^{-3}$ C	1	
		iii	calculate the area under the graph (as Q = It)	1	4
			Total		12
5	a		$E = V/d$;$= 40 \times 10^3/6 \times 10^{-4} = 6.7 \times 10^7$; N C^{-1} **or** V m^{-1}	3	3
	b	i	one closed loops through primary passing through iron core and secondary; second line along same path not touching/crossing, etc.,	1	
				1	
		ii	all magnetic flux (created by primary current) passes through iron core/ low reluctance path (so links both coils)/AW	1	
			(magnetic flux = BA and) magnetic flux linkage = BAn ;	1	
			the secondary coil has a different number/many more turns than the primary so flux linkage is different	1	
			max 2		
		iii	voltage is only induced across spark gap when the magnetic flux is changing	1	
		iv 1	the shorter the time the greater the voltage; because V α rate of change of flux linkage	1	
				1	
		2	$V_p/V_s = n_p/n_s$ (in an ideal transformer); so larger n_s is relative to n_p the larger the secondary voltage	1	
				1	9
			Total		12
6	a	i	choose two from: penetrations; ionisation; charge; nature; mass; speed; monoenergetic v continuous spectrum of energy/speed	2	
			some qualification/detail for each	2	
		ii	choose two from: source; energy range/ wavelength or frequency range; penetrating power	2	
			some qualification/detail for each	2	8
	b	i	$I = I_0/r^2$ or $I = kr^{-2}$	1	
			$k = 40$ so $I = 40/(0.25)^2 = 40 \times 16 = 640$	1	
		ii 1	1280	1	
		2	$1280 = 40/r^2$;so $r = \sqrt{(40/1280)} = 0.18$ (m)	2	5
			Total		13

Question		Expected Answers	Marks	
7	a	internal energy = sum of p.e. + k.e. of molecules	1	
		no p.e. as no force of attraction	1	
		mean k.e. of molecules α absolute temperature	1	
		so internal energy α absolute temperature	1	
		no internal energy, no temperature/energy cannot be less than zero/AW	1	5
	b	**AB**: k.e. /speed increases with temperature; in liquid phase	2	
		p.e. /separation remains constant or increase very slightly	1	
		BC: k.e. /speed remains constant as temperature constant	1	
		p.e./separation increases greatly; as change of phase/state occurs	2	
		CD: k.e. /speed increases with temperature; in vapour/gas phase	2	
		p.e. /separation remains constant	1	
		internal energy increases throughout *max 7 marks*	1	7
		Quality of written communication		4
		Total		16

2825/01 Cosmology

1	**(a)**	**(i)**	Sun in centre (of solar system)		**1**
	(a)	**(ii)**	any 2 from planets move at different speeds 1 one planet overtakes another 1 planet changes direction compared to stars behind 1		**2**
	(b)	**(i)**	1 light-year		**1**
			distance travelled by light (in vacuo) in 1 year.		**1**
			2 astronomical unit		**1**
			(average) distance of Earth from Sun / (average) radius of Earth's orbit about Sun		**1**
	(b)	**(ii)**	all in correct order pc, ly, AU, m		**1**
					total 8
2	**(a)**		$F = GMm/ r^2$ or $F \alpha Mm/ r^2$ with all labels		**1**
	(b)	**(i)**	central bulge		**1**
			stars on disc extending each side		**1**
	(b)	**(ii)**	X approximately 2/3 from centre		**1**
			arrow starting on X and directed towards centre		**1**
	(c)		$GMm/ r^2 = mv^2 / r$ / accept gravitational force provides centripetal force		**1**
			$M = r \times v^2 / G$		**1**
			$M = 2.6 \times 10^{20} \times (230 \times 10^3)^2 / 6.67 \times 10^{-11}$		**1**
			$M = 2.1 \times 10^{41}$ kg		**1**
					total 9

3	**(a)**	any three from			
		fusion of protons/ hydrogen nuclei	1		
		helium nuclei formed	1		
		energy from loss of mass / $E = \Delta mc^2$ explained	1		
		detail of p-p reactions	1		**3**
	(b)	continuous spectrum/all wavelengths			**1**
		crossed by dark lines/ absorption spectra			**1**
	(c)	Ultr-violet			**1**
		Infra-red			**1**
		Radio			**1**
	(d)	**(i)** $v = 7 \times 10^8 / 200{,}000 \times 365 \times 24 \times 3600$			**1**
		$v = 1.1 \times 10^{-4}$ m s^{-1}			**1**
		(ii) velocity less than *c* / ref to diffusion or scattering of photons/ ref to collision of photons with particles	.		**1**
					total 11
4	**(a)**	occurs at end of main sequence/ when hydrogen burning ceases	1		
		core compresses/ increase in outward pressure/ star expands/ planetary nebular/ density decreases	1		
		lower surface temperature/ increased luminosity	1		**3**
	(b)	**(i)** maximum absolute magnitude = -1			**1**
		(ii) $m - M = 5\lg(d/10)$			**1**
		$7 - (-1) = 5\lg(d/10$			**1**
		d = 398 (pc)			**1**
		(iii) any 2 from			
		absolute magnitude assumes all stars at 10 pc	1		
		stars are at a range of distances/ intensity proportional to $1/r^2$	1		
		apparent magnitude is star's magnitude viewed from Earth	1		**2**
					total 9

5	**(a)**	any 5 from			
		very high temperature	1		
		expansion/ inflation	1		
		electrons formed	1		
		leptons/ positrons/ neutrinos/ quarks formed	1		
		reference to forces separating	1		
		protons/ neutrons/ hadrons formed	1		
		helium nuclei formed	1		
		extra detail	1		**5**
	(b)	**(i)** all points correct			**1**
		(ii) smooth curve each side			**1**
		continuous curve at peak			**1**
		correct frequency read from graph for max intensity			**1**
		(iii) $3 \times 10^8 = \lambda_p \times$ (frequency from b.ii)			**1**
		calculation of λ_p			**1**
		(iv) correct calculation of T (ecf from b.ii)			**1**
	(c)	any 2 from			
		gamma radiation from Big Bang red shifted to microwave	1		
		T = 2.7K (3K) predicted by big bang theory/ measurements provide evidence for big bang theory	1		
		measurements contradicted steady state theory	1		**2**
					total 14
6	**(a)**	any 3 from			
		light from galaxies (accept stars) shows red-shift	1		
		galaxies (stars) moving away/ Universe expanding	1		
		red-shift proportional to distance (from Earth)/ v=H x d	1		
		distances to (Cepeid variable) stars measured	1		**3**
	(b)	expansion may continue forever (open universe) universe may collapse back (closed universe) expansion may continue to a limit (flat universe)			
		Any 2 of these alternatives	1		
		Third alternative	1		
		Consistently correct reference to critical density compared to density of open, closed or flat Universe	1		**3**
					total 6

7 (a) 1. one where Newton's 1st law is obeyed/moving at constant velocity (reject speed) **1**

2. (measured) time interval longer/ ate of clocks is decreased **1**
when time observed from outside a moving reference frame **1**

(b) (i) graph shows rest mass when v = 0 **1**
correct shape curve (increasing gradient) **1**
asymptote to v=c **1**

(ii) **either**
at low energies, more ke gives increase in speed 1
at high energies, more ke gives increase in mass 1

or
interpretation of $m = m_0 / (1 – v^2/ c^2)^{1/2}$
at v = 0 m = m_0 1
at v = c m = ∞ 1 **2**

(c) any 5 from
rocket, lamp and observer 1
rocket accelerates 1
lamp flashes 1
time between flashes measured 1
time between flashes increases for lamp behind (ora) 1
principle of equivalence 1
light red-shifted when moving in opposite direction to gravitational field/rate of clocks is less in gravitational field 1 **5**

total 13

2825/02 Health Physics

1 (a) shape (1)
with min. 1 to 3 kHz (1)
frequency range from 20 - 30 Hz to 16 -20 kHz (1)
min. intensity at 10^{-12} W m^{-2} (1)

(b) (i) I.L. = 10 lg I / I_o
20 = 10 lg I / 10^{-12} (1)
$I_1 = 10^{-10}$ W m^{-2} (1)
$I_2 = 10^{-4}$ W m^{-2} (1)
10^{-4} / 10^{-10} = 10^6 (larger by a factor of …..) (1)

(ii) Intensity is the power of sound (normal) per unit area / I = P/A (1)
loudness is a ***subjective*** response to intensity or response varies from individual to individual (1)

(iii) No or Yes + a comment that is relevant to a max. of 2 eg
You can't tell as loudness is subjective
/ differs from person to person (1)
It is probably closer to 4 x than to 10^6 . (1)
A doubling in intensity level does not correspond to a doubling in loudness (1)
the loudness we hear depends upon the frequency of the sound (1)
intensity level isn't the same as loudness /
intensity level correlates to loudness (1)

2 (a) (i) short sight / myopia (1)

(ii) effect on power (1) effect on rays (1) detail mark (1) e.g.
effect on power: cornea is less curved / lens too strong / eyeball too long / parallel light brought to a focus in front of the retina (1)
the effect on rays: so power of eye is less / focal length increased / light refracted less 1)
detail: which is equivalent to adding negative lens / or so less refraction needed to focus image on retina / cornea does most of the refracting (1)
to a maximum of 3

(a) (i) or astigmatism (1)
(ii) uneven curvature of the cornea in different planes (1)
Make surface spherical e.g. same curvature (1)
Detail: horizontal and vertical lines both appear clear at the same time (1)

(b) any relevant response up to a maximum of 8 e.g.
lasers cause heating effect in cell tissue (1)
water content in cell / tissue is vaporised / heated (1)
cell shrivels and dies (1)
lasers cauterise blood vessels / seal vessels as they cut (1)
so less blood during surgery / cleaner to view in surgery (1)
sterile cutting as no direct contact (1)
much finer cut / more accurate cut (1)
shorter recovery time (1)
less scarring (1)
key-hole surgery / non-invasive (1)

3 any relevant response to a maximum of 8 e.g.
atoms with unequal numbers of protons and neutrons spin (1)
act as tiny magnets (1)
align in external magnetic field (1)
and precess / wobble (1)
rf radiation is sent in (1)
at resonant frequency of precession / at Larmor frequency (1)
r.f. radiation is emitted (1)
(as atoms return to the unexcited state) (1)
relaxation times are measured / relaxation times identify different atoms (1)

One detail mark for eg
hydrogen is most commonly used / different relaxation times in fat and water / value for size of magnetic field > 1 T / gradient in magnetic field needed (1)

Agreement with student's comment
(no because) radio frequency radiation is sent into the patient (1)
(but yes because the radiation sent in is) not ionising, so is safer (1)
(no because) less safe if you have metal implants / pacemaker due to strong magnetic field (1)

4 **(a)** $I = I_o e^{-\mu x}$ (1)
μ is the (total) linear attenuation / absorption coefficient (1)

(b) **(i)** table completed (1)
(ii) all points plotted correctly (2)
4 points plotted correctly (1)
line of best fit (1)
(iii) gradient substitution e.g. $-(22 - 5) / 2.6 \times 10^{-2}$ (1)
answer = -654 m^{-1} (-600 - - 800) (1)
(iv) Ln I_o = 22 (+/- 1) ecf (1)
3.6×10^{9} (1)
(v) ln(0.25) = -654 x (substitution of μ ecf(iii)) (1)
x = 2.1×10^{-3} m ecf (iii) (1)

5 **(a)** **(i)** H=Q x D, quality factor x absorbed dose / takes into account the type of radiation (1)

(ii) D = dose equivalent / quality factor (1)
$D = 1.5 \times 10^{-3}$ (1)
Gy or J kg^{-1} (1)
(iii) $1.6 \times 1.5 \times 10^{-3}$ (1)
$= 2.4 \times 10^{-3}$J (1)

(b) **(i)** it damages / changes / alters / ionises DNA (1)
forms free radicals (from water molecules which go on to damage cell walls / cause chemical changes within cell / by producing hydrogen peroxide (1)
Causing cancer / tumour / mutation / etc. (1)

(ii) stochastic effects are random (1)
stochastic do not have a threshold above which they occur (1)

6 **(a)** arm: 6.1 L< E (1)
leg 6.2 L > E (1)
MA < 1.0 for arm and MA > 1.0 for leg (1)

(b) **(i)** moment = force x perpendicular distance to line of action of the force (1)
55 x 0.25 sin 60 (1)
= 11.9 (1)
N m (1)

(ii) 12 = E x 0.02 cos 60 (1)
1190 N (1)

(iii) MA = load / effort (1)
= 55 / 1190 = 0.046 (1)

(iv) as leg becomes almost horizontal E increases (from zero) (1)
either ref. to clockwise moment increasing due to increasing distance of L from P (1)
<u>perpendicular</u> distance of E to pivot decreases (1)
E increases from zero, when leg is vertical E is zero / as leg approaches horizontal, E increases towards infinity / becomes very large (1)

or numerical reasoning e.g.
L x 25 sin 60 = E x 2 cos 60 (1)
E = L x 12.5 x tan 60 (1)
so when $\theta = 0$ E = 0
when $\theta = 90$ E = infinity (1)

2825/03 Materials

1 **(a)** (single-)crystal – not crystalline (1)
amorphous. (1) **[2]**

(b) **(i)** impurity atom / vacancy / missing atom / substitution defect / interstitial defect. **[1]**

(ii) atoms occupy the least possible space or wtte / diagram of a plane with 6 atoms surrounding any atom; (1)
permanent deformation (of a material) after removal of deforming. force / stress (1) **[2]**

(c) **(i)** a dislocation. **[1]**

(ii) incomplete plane of atoms moved to the right; (1)
new bonding of atoms correct. (1) **[2]**

(iii) The dislocation allows bonds to break / atoms to move one by one; (1)
Without the dislocation adjacent planes could only slip (relative to each other) if many bonds broke at the same time (requiring a much bigger force). (1) **[2]**

(d) suitable example: e.g. copper wire / cable, car body; (1)
process: extrusion / stretching pressing. (1) **[2]**

[Total: 12]

2 **(a)** **(i)** Incident light power = 0.1 x 3.0 = 0.30 W; (1)
Power per unit area = $0.30 / 4 \pi 0.10^2 = 0.30 / 0.126$ (1) **[2]**
(= 2.39 W m^{-2})

(ii) power = $2.39 \times 8.0 \times 10^{-5} = 1.90 \times 10^{-4}$ W **[1]**

(b) **(i)** Circuit with battery, ammeter and LDR; (1)
Voltmeter correctly placed; (1) **[2]**

(ii) Suitable suggestion e.g between bulb and LDR, tube with dark interior surface; (1)
Measure to avoid back-scattered light from reaching LDR; (1)
Vary and measure distance of bulb from face of LDR; (1)
Calculate power of light falling on LDR / measure with light meter; (1)
using method based on (a) above; (1)
(In LDR circuit) read p.d. from voltmeter and current from ammeter; (1)
Calculate resistance using p.d./ current; (1)
Obtain several sets of readings over a range of distances; (1)
Change to ammeter of greater sensitivity if reading low. (1)
Graph of power against resistance / numerical method to determine relationship (1) **max [7]**

(iii) As power of light increases
resistance of LDR falls; (1)
a greater number of photons per unit time fall on the LDR; (1)
and more electrons are promoted from valence to conduction band. (1) **[3]**

[Total: 16]

3 **(a)** + signs on right-hand side, - signs left-hand side; (1)
electrons / charge carriers moving in magnetic field experience force; (1)
direction of force is given by Fleming's left-hand rule. (1) **[3]**

(b) **(i)** $v = I / nAe$ – not $I = nAve$ (1)
$= 0.35 / (1.1 \times 10^{25} \times 6 \times 10^{-3} \times 0.25 \times 10^{-3} \times 1.6 \times 10^{-19})$ (1) **[2]**
$(= 0.133 \text{ m s}^{-1})$

(ii) $V_H = Bvd$ / $B = V_H / vd$ (1)
$B = 0.080 \times 10^{-3} / (0.133 \times 6.0 \times 10^{-3}) = 0.100$ T (1) **[2]**

(c) Hall voltage is (much) larger (for semiconductor than for metal); (1)
and can be read more accurately; (1)
Sensible attempt at numerical comparison with metal;
Semiconductor has (much) lower n / charge carrier concentration; (1)
so that v / drift velocity is (much) larger; (1) max **[4]**

[Total: 11]

4 **(a)** **(i)** A region (in a ferromagnetic material / iron); (1)
where dipoles / atomic magnets are aligned. (1) **[2]**

(ii) The temperature at which a magnet / magnetic material loses its magnetism; (1)
because dipoles / atomic magnets lose their alignment. (1) **[2]**

(b) <u>Core material must have high Curie temperature</u> (to maintain magnetism);(1)

Core made of soft iron / ferrite / metallic glass; (1)
so that hysteresis loop has small area; (1)
Small area associated with low heat loss; (1)

Core needs high resistance / resistivity; (1)
so is laminated / made of metallic glass / ferrite; (1)
to minimise heat loss due to eddy currents; (1)

Core material needs high saturation flux density; (1)
P and S windings need to be closely wound to maximise flux linkage; (1)
Core material must have high melting point. (1) max **[8]**

[Total: 12]

5 **(a)** **(i)** $E = hc / \lambda$ (1)
$= 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / 950 \times 10^{-9} = 2.09 \times 10^{-19}$ J (1) **[2]**

(ii) $eV = 2.09 \times 10^{-19}$ (1)
$V = 2.09 \times 10^{-19} / 1.6 \times 10^{-19} = 1.31$ V (1) **[2]**

(b) A photon of the infra-red has insufficient energy; (1)
to promote an electron from the valence band to the conduction band of the glass; (1)
so is not absorbed by the glass (and passes through the glass); (1)
In a metal there are many close electron energy levels; (1)
in the conduction band; (1)
An infra-red photon has sufficient energy to promote an electron from one (of these) energy level to another so is absorbed (and does not pass through the metal). (1) max **[5]**

(c) Gamma rays will have lower frequency / longer wavelength / emerge as X-ray. **[1]**

[Total: 10]

6 **(a)** **(i)** Absorption by (impurity) metal atoms; (1)
Absorption by hydroxyl ions. (1)
Absorption by bonds between glass atoms. (1) max **[2]**

(ii) Rayleigh scattering **[1]**

(b) Light slows down; **[1]**

(c) **(i)** Sketch showing distorted pulse, rounded and stretched i.e. time of pulse longer. **[1]**

(ii) Infra-red from an LED has a (small) range of frequencies; (1)
Different frequencies travel at different speeds and have different transit times. (1)

Light from LED enters fibre at different angles / along different l / nAe paths; (1)
Rays follow different paths with different transit times. (1) **[4]**

[Total: 9]

2825/04 Nuclear and Particle Physics

Question	Expected Answers	Marks
1 (a) (i)	number of nucleons = 27 so mass of nucleus = $27 \times 1.67 \times 10^{-27} = 4.5(1) \times 10^{-26}$ kg	1 **[1]**
(ii)	volume of nucleus $V = {}^4/_3 \pi r^3$ $r = 27^{1/3} \times 1.40 \times 10^{-15}$ (= 4.20×10^{-15} m) arith. $V = {}^4/_3 \pi (4.20 \times 10^{-15})^3 = 3.1(0) \times 10^{-43}$ m^3 ans. *alternative answer* $V = {}^4/_3 \pi (A^{1/3} r_0)^3 = {}^4/_3 \pi A r_0^3$ $= {}^4/_3 \pi \times 27 \times (1.40 \times 10^{-15})^3 = 3.1(0) \times 10^{-43}$ m^3 (at least 2 sf)	1 1 1 **[3]**
(iii)	density of nucleus = $\frac{4.51 \times 10^{-26}}{3.10 \times 10^{-43}} = 1.45 \times 10^{17}$ kg m^{-3} must show substitution and *calculated* answer (not just 1.5 x 10^{17})	1 **[1]**
(b)	*either* density of gold nucleus = 1.45×10^{17} kg m^{-3} / 1.5 x 10^{17} *or* density of gold nucleus = density of aluminium nucleus; because spacing of nucleons is same inside both nuclei; (1) proton and neutron have approx. same mass (so proportions of neutrons and protons make no difference); (1) the volume of a nucleus is proportional to number of nucleons; (1) any (1)	1 1 **[2]**
(c) (i)	$\frac{197 \times (1.67 \times 10^{-27})}{27 \times (1.67 \times 10^{-27})} = 7.3$ $\frac{19.3 \times (10^3)}{2.70 \times (10^3)} = 7.1$; *either* have assumed that mass of *atom* = mass of *nucleus* *or* have assumed that electrons (in atom) have negligible mass;	1 1 [2]
(ii)	(average) space occupied by gold atom =/~ (average) space occupied by aluminium atom; allow: volume of gold atom =/~ volume of aluminium atom not 'size' do not allow mass of atom(s) proportional to density	1 **[1]**
		10

Question	Expected Answers	Marks
2 (a)	in nuclear fission, nucleus splits into two parts / nuclei / fragments (of comparable / roughly equal size); (1) in radioactive decay α or β or photon is emitted; (1) nuclear fission is triggered / induced / caused by an (incoming) neutron; (1) radioactive decay is spontaneous; (1) any (2)	2 **[2]**
(b)(i)	sum of nucleon numbers / masses of products is constant / equal to 236; so for every small nucleus there is a (corresponding) large nucleus *or* AW;	1 1 **[2]**
(ii)	proton number = 46 nucleon number = 118;	1 **[1]**
(c)	proton number = 39 nucleon number = 94;	1 **[1]**
(d)(i)	$^{140}_{53}\text{I} \rightarrow {}^{1}_{0}\text{n} + {}^{139}_{53}\text{I}$ $^{140}_{53}\text{I} \rightarrow {}^{0}_{-1}\text{e} + {}^{140}_{54}\text{Xe} + \bar{\nu}$ omits $\bar{\nu}$ gets 1/2 ν instead of $\bar{\nu}$ gets 2/2	1 2 **[3]**
(ii)	idea that fission products have too many neutrons /neutron rich (to be stable) *or* AW; idea that β^- emission reduces number of neutrons / increases number of protons / reduces neutron/proton ratio;	1 1 **[2]**
(iii)	neutron decay: reactant mass: 139.9019 product mass: 138.8969 + 1.0087 = 139.9056 u product mass / energy > reactant mass / energy, so reaction cannot occur beta decay: reactant mass: 139.9019 product mass: 139.8919 + 0.0006 = 139.8925 u product mass / energy < reactant mass / energy, so reaction can occur	1 1 1 1 **[4]** **15**
3 (a)(i)	$E_p = \dfrac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times 2.0 \times 10^{-15}}$ $= 1.15 \times 10^{-13}$ J allow 1.1×10^{-13} or 1.2×10^{-13} but not 1×10^{-13}	1 1 **[2]**

(ii)	$E_p = 2E_k$	1	**[1]**
(iii)	$E_k = \frac{1.15 \times 10^{-13}}{2}$ (= 5.75×10^{-14}) J subs. $5.75 \times 10^{-14} = 2.1 \times 10^{-23} T$ $T = 2.7 \times 10^9$ K ans. allow ecf form (a)(ii) eg $E_K = E_P$ gives $T = 5.48 \times 10^9$	1 1	**[2]**
(iv)	*either* $^1_1$H nuclei have a range of speeds / energies *or* 5.75×10^{-14} J is only an average k.e; (1) some of them have enough energy to fuse; (1) quantum tunnelling can occur; (1) any 2	2	**[2]**
(b)	*either* $^1_1$H consists of a single proton, so no binding has occurred *or* only one nucleon / proton so no further splitting possible;	1	**[1]**
(c)(i)	$4\,^1_1\text{H} \rightarrow {}^4_2\text{He} + 2\,^0_1\text{e} + 2\nu$ omits neutrinos altogether 0/1 allow 1 neutrino instead of 2 allow either neutrino or anti-neutrino	1	**[1]**
(ii)	binding energy of $^4_2$He nucleus = 4×7.2 MeV (= 28.8 MeV) so energy released = $28.8 \times 10^6 \times 1.6 \times 10^{-19} = 4.61 \times 10^{-12}$ J	1 1	**[2]**
			11
4 (a) (i)	for proton in orbit, $\frac{mv^2}{R} = BQv$ equation so $v = \frac{BQR}{m} = \frac{1.2 \times 1.6 \times 10^{-19} \times 0.500}{1.67 \times 10^{-27}}$ subs. $= 5.75 \times 10^7$ m s^{-1} ans. accept 5.7×10^7 m s^{-1}	1 1 1	**[3]**
(ii)	k.e. of proton = $\frac{1}{2}mv^2$ = $\frac{1}{2} \times 1.67 \times 10^{-27} \times (5.75 \times 10^7)^2$ (= 2.76×10^{-12} J) 1 MeV = $1.6 \times 10^{-19} \times 10^6 = 1.6 \times 10^{-13}$ J so k.e. of proton = $\frac{2.76 \times 10^{-12}}{1.60 \times 10^{-13}}$ = 17.3 MeV subs. and calculated answer	1 1 1	**[3]**

(b)	time period of proton $= \frac{2\pi R}{v}$	1	
	so frequency of p.d. $= \frac{1}{T} = \frac{v}{2\pi R}$.	1	
	$= \frac{5.75 \times 10^7}{2\pi \times 0.500} = 1.83 \times 10^7$ Hz, (= 18.3 MHz)	1	**[3]**
(c)	number of revolutions $= \frac{17.3 \times 10^6}{2 \times 80 \times 10^3}$	2	
	$= 108$	1	**[3]**
	omits factor 2 gets 1 + 1 = 2/3		
(d)(i)	magnetic field uniform to keep period of rotation constant;	1	
	reason: period $T = \frac{2\pi R}{v} = \frac{2\pi R}{BQR/m} = \frac{2\pi m}{BQ}$;		
	so T is constant if B is constant since m and Q are always constant;	1	**[2]**
(ii)	*either* magnetic flux density must be greater near the edge / at greater radius		
	or magnetic flux density / field must increase as mass increases to keep T constant;	1	**[1]**
			15
5 1	strong force short range;	1	
2	electrostatic long range;		
(3)	gravitational force long range; (1)	1	
4	strong force sketch graph;		
5	electrostatic F proportional to $1 / r^2$ *or* sketch graph;	1	
(6)	gravitational force F proportional to $1 / r^2$ *or* sketch graph; (1)	1	
7	strong force holds nucleus together (against repulsion between protons);		
8	acts on all nucleons / protons and neutrons;		
9	electrostatic acts only on protons / not on neutrons;	1	
10	always repulsive (in nucleus);	1	
11	gravitational force (very) weak / negligible (inside nucleus);	1	
(12)	attractive only; (1)	1	
(13)	acts on protons and neutrons; (1)	1	
	any (1)	1	**[10]**
			10

6(a)	hadrons / baryons / nucleons;	1 **[1]**
(b) (i)	the proton is (totally) stable (inside the nucleus);	1 **[1]**
(ii)	free protons are stable	1 **[1]**
(c)	*either* $N = N_0 e^{-\lambda t}$ $\lambda = \frac{\ln 2}{613} = \frac{0.693}{613} = 1.13 \times 10^{-3}\ s^{-1}$ $N = 500 \times e^{-1.13 \times 10\exp(-3) \times 200}$ subs. $= 500 \times 0.798$ $= 399$ ans. *or* $N = N_0 (0.5)^x$ where $x = t / T_{½}$ $x = \frac{200}{613} = 0.326$ half lives $N = 500 (0.5)^{0.326}$ $= 500 \times 0.798$ $= 399$ allow 398 allow 2sf	1 1 1 **[3]**
(d) (i)	charge: down quark: $-1/3$; neutron: 0 baryon number: down quark: $1/3$; neutron: 1	1 **[1]**
(ii)	charge: 2/3 - 1/3 - 1/3 = 0 baryon number: 1/3 + 1/3 + 1/3 = 1	1 1 **[2]**
		9

2825/05 Telecommunications

Question 1	Expected Answers	Marks

(a) (i) Amplitude modulation 1

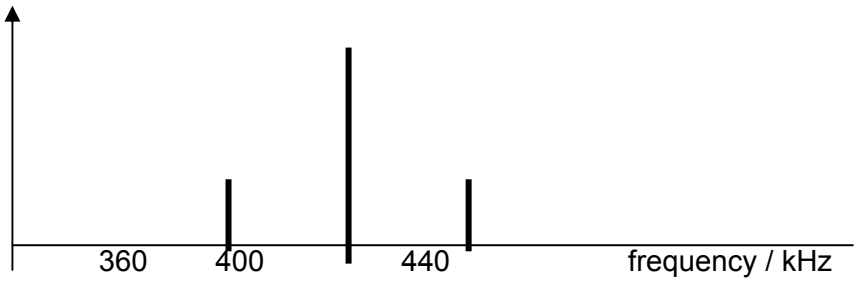
(ii) Transmission frequency = 1 / carrier period 1
= 1 / 2.5 µs
= 400 kHz 1

(iii) modulating frequency = 1 / 25 µs 1
= 40 kHz 1

(iv) Medium frequency (or medium wave) waveband (do not accept MF) 1

(b) Domestic radios which can tune in to the MW are designed to pick up AM
Such AM receivers only allow a bandwidth of a few kHz per station
The bandwidth of 80 kHz is way beyond this capability
or
Domestic radios on the MW are designed to output audio sounds only 1
The 40 kHz is way beyond normal human hearing range 1

(c) (i)



any vertical line 1
three vertical lines as shown 1
frequencies correctly marked 1

(ii) The bandwidth is the range of frequencies present in a signal 1

(iii) Bandwidth = 440 - 360 = 80 kHz. 1

Question 2	Expected Answers	Marks

(a) (i) LDR = Light Dependent Resistor 1

(ii) As the light intensity <u>increases the resistance decreases</u> 1

(b) (i) 1 Current in LDR = V / R_{total}

= 9 / (230 + 270) 1

= 0.018 A 1

2 Voltage at A = 0.018 x 270

= 4.9 V 1

(ii) Voltage at B = 4.9 V 1

(iii) The motor will not turn 1

Because the comparator output is zero (as both inputs are equal) 1

(c) If torch X is switched off then voltage at A will fall

because resistance of LDR X has increased to consume a greater fraction of pd 1

so op-amp comparator saturates positively because $V_B > V_A$ 1

and motor turns (at full speed) 1

(d) (i) If both torches are off then both LDRs see same light intensity and thus have the same resistance so the voltages at A and B are again equal.

And the motor does not turn 1

(ii) Torch X on and Y off causes the motor to turn <u>the other way</u> 1

(e) (i) It is almost impossible to have the two light intensities equal

Hence one input will always be slightly bigger than another

Because op-amp has huge open loop gain

Extremely difficult to arrange the comparator output to be zero

Because both input voltages must be equal to within microvolts

Given tolerance of fixed resistors it is unlikely they are equal

So the comparator is always in saturation one way or the other

Motor turns at full speed so it can never be made to slow down gradually

(any three separate points) 1 1 1

(ii) Any reasonable explanation of stability caused by negative feedback

Negative feedback reduces the overall voltage gain of an amplifier

This allows a much greater range of input voltages before saturation

So the motor can be made to run at non-saturated voltages i.e. slower 1 1

Question 3	Expected Answers	Marks

(a) (i) Resistance of cable $R = \rho L / A$ 1

$= 1.8 \times 10^{-8} \times 2 \times 125 / 0.40 \times 10^{-6}$ 1

$= 11.25\ \Omega$ 1

(ii) Voltmeter $V_2 = [4.8 / (4.8 + 11.25)] \times 24$ 1

$= 7.2$ V 1

(b) (i) Current in cable $= 24 / (11.25 + 4.8) = 1.5$ A

Power input to cable $= 24 \times 24 / (11.25 + 4.8)$ 1

$= 36$ W 1

(ii) Power output from cable $= 7.2^2 / 4.8$ 1

$= 10.8$ W 1

(iii) Attenuation in cable $= 10 \log P_1 / P_2$ 1

$= 10 \times \log (10.8 / 36)$

$= -5.2$ dB 1

Attenuation per kilometre $= 5.2 / 0.125$

$= 42$ dB km^{-1} 1

Question 4		Expected Answers		Marks
1	*aerial*		*converts electromagnetic waves into small currents*	
2	tuning circuit	1	selects an RF <u>carrier</u> (and its sidebands) and rejects other carriers picked up by the aerial	1
3	RF amplifier	1	amplifies the small signal selected by the tuning circuit <u>to allow the demodulator to operate</u>	1
4	Demodulator Detector	1	rejects the carrier and extracts the audio signal	1
5	AF amplifier	1	boosts the output signal in order to drive the loudspeaker	1
6	Loudspeaker	1	converts ac audio signal into sound	1

Question 5	Expected Answers	Marks

(a) (i) Multiplexing is the process of allowing several users to share the same channel 1
Multiplexing is important because it reduces the cost per user 1

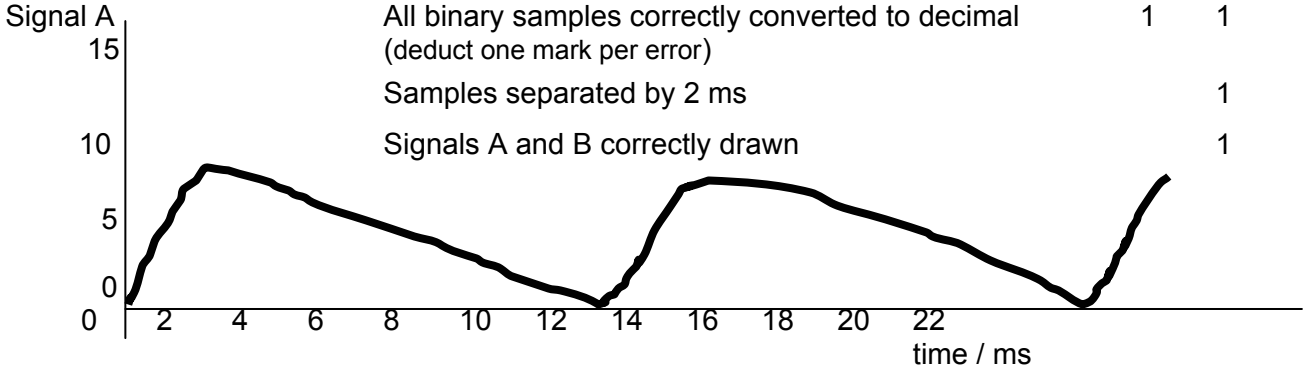
(ii) FDM This allocates to each user a fixed carrier / region of frequency space 1
in which they can transmit at any time 1
TDM This allocates to each user a time slot in which to send a sample 1
before their next time slot appears other samples are sent 1

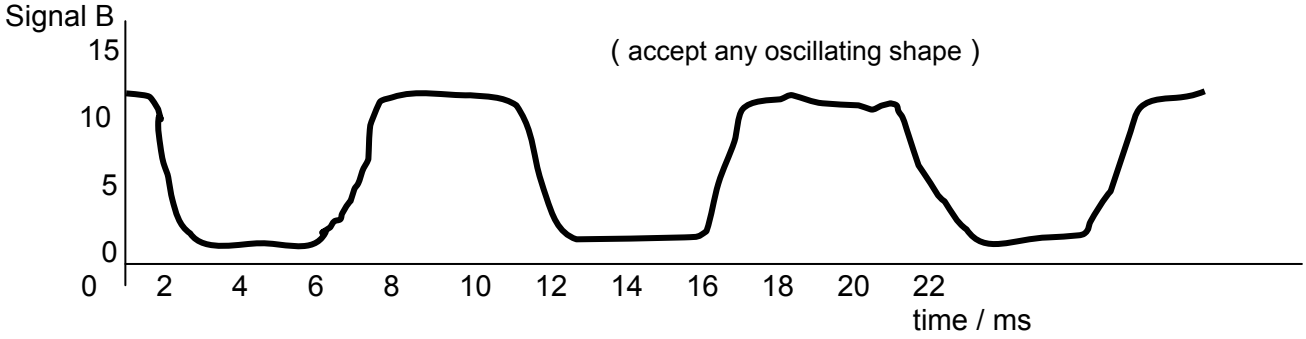
(b) (i) Maximum frequency of analogue signal < 250 Hz (accept 250) 1
because sampling frequency (500 Hz) must be at least twice analogue frequency 1

(ii) Time between each sample = 1 / 500 = 2 ms
Duration of each sample = 4 x 2.5 = 10 µs 1
Maximum number = 2000 µs / 10 µs
= 200 1

(iii)

Evidence of TDM 1
All binary samples correctly converted to decimal 1 1
(deduct one mark per error)
Samples separated by 2 ms 1
Signals A and B correctly drawn 1





(accept any oscillating shape)

(iv) frequency of signal B = 1 / 8 ms 1
= 125 Hz 1

2825 Common Question

(a) (i) **1** Area = $(4\pi R^2) = 4\pi \times (1.5 \times 10^{11})^2$ $(= 2.8 \times 10^{23}\ m^2)$ **[1]**

2 Power emitted = $1400 \times 2.8 \times 10^{23}$ $(= 4.0 \times 10^{26}\ W)$ Allow ecf if consistent **[1]**

(ii) rate of conversion of mass to energy = $4.0 \times 10^{26} / (3.0 \times 10^8)^2$ / P/c^2 (1)

$= 4.4 \times 10^9\ kg\ s^{-1}$(1) **[2]**

(b) (i) The Earth's atmosphere/ionosphere absorbs/reflects/scatters solar energy. **[1]**

(ii) The distance travelled <u>through the atmosphere</u> increases as distance from the equator increases. Accept 'tilt factor.' **[1]**

(c) (i) Power input = $0.080 \times 750 = 60$ W **[1]**

(ii) Power generated = $0.27 \times 17 = 4.6$ W **[1]**

(iii) Efficiency = (power generated / power input) x 100 (1)
= (4.6 / 60) x 100 = 7.7 % (allow e.c.f.) (1) **[2]**

(iv) Power to raise water = 0.35 x 4.6 = 1.6 W (allow e.c.f.) (1)
Mass of water raised per hour = 0.50 x <u>1000</u> = 500 kg (1)
Mass of water raised per second = 500 / <u>3600</u> = 0.14 kg (1)
Maximum height raised = (ΔE / mg) = 1.6 / (0.14 x 9.81) (1)
= 1.2 m (Allow ecf from wrong mass) (1) **[5]**

(d) (i) $\Delta Q = mc\Delta\theta$(1)
$= 0.50 \times 4200 \times 75 = 1.57 \times 10^5$ J (1)
Time to heat water = $1.57 \times 10^5 / 80 = 1970$ s (1) **[3]**

(ii) Takes too long (1)
The power of a conventional mains electric kettle is much greater than the power of the panel; (1)
Electric kettles boil a much greater mass of water in a much shorter time; (1)
To boil water in as short a time as an electric kettle, a very large area of solar panel would be needed; (1)
Time required is so long that rate of heat loss to the surroundings may be nearly as high as the rate of heating; (1)
The cost of a very large panel would make it an uneconomic proposition. (1)
Maximum varies with latitude/time of day/season (1) **max [2]**

2826/01 Unifying Concepts in Physics

1 **(a)** **(i)** at highest point on the graph (1) **[1]**

(ii) mass is less (1)

less mass gives higher acceleration (for the same force) (1) **[2]**

(iii) rocket runs out of fuel (so suddenly no upward force)

OR because fuel burns OR correct use of F = ma (1) **[1]**

(i) weight (1)

air resistance / drag (1) **[2]** 6

(b) **(i)** P at position shown on sketch graph (1)

R showing range of constant velocity (1) **[2]**

(ii) recognises the need to find the area beneath the acceleration time graph (1)

45 ± 5 small squares (1)

1 small square = 0.4 (m s^{-1}) so maximum velocity in range 16 – 22 m s^{-1} (1) **[3]** 5

(c) first section (1)

second section still increasing (1)

constant slope at end to zero height (1) **[2]** 3

[Total : 14]

2 **(a)** There is no (intermolecular) attraction between molecules/atoms in an ideal gas (1)

so molecules cannot have (internal) potential energy (1) **[2]** 2

(b) **(i)** most common speed = 750 m s^{-1} ± 50 m s^{-1}

twice the most common speed = 1500 m s^{-1} (1)

area under graph above this speed = 8 ± 1 small square (1)

in percentage terms this is 4% ± 0.5% (1) **[3]**

(ii) e.g. (chemical) reaction, diffusion, evaporation, escape velocity ONE required (1) **[1]** 4

(c) **(i)** peak to the right (1)

(ii) peak to the left (1)

lower peak in (i) and higher peak in (ii) (1)

area in both (i) and (ii) to be the same (1) [4]

(iii) same (1)

(iv) recognises that the <u>percentages</u> do not change (1) [2] 6

[Total : 12]

3 **(a)** density incorrect OR the total mass is (far) too small (1)
density is 1000 kg m^{-3} (1)
so mass = 4.0 × 1.0 × 0.5 × 1000 = 2000 kg (1) **[3]** 3

(b) nonsensical number of molecules OR figures should be multiplied (1)
$3 \times 6.02 \times 10^{23} = 18.06 \times 10^{23}$ (1) **[2]** 2

(c) temperature is in Celsius OR negative pressure is impossible (1)
$p = 2 \times 8.31 \times 253 / 2.5 \times 10^{-3}$ (1)
$= 1.68 \times 10^{6}$ Pa (1) **[3]** 3

[Total : 8]

4 **(a)** area of estuary = 50×10^{6} m^2 (1)
volume of water = 500×10^{6} m^3
mass of water = 500×10^{6} m^3 × 1030 kg m^{-3} = $5.1(5) \times 10^{11}$ kg (1)
average height of water = 5 m (1)
p.e. = mgh = $5.15 \times 10^{11} \times 9.81 \times 5 = 2.5(3) \times 10^{13}$ J (1) **[4]** 4

(b) volume of water = $\pi \times 10^2 \times 3 = 942$ m^3 (1)
mass of water = $942 \times 1030 = 9.70 \times 10^5$ kg (1)
kinetic energy = ½ mv^2 and knows what to substitute (1)
$= 0.5 \times 9.7 \times 10^5 \times 3^2 = 4.4 \times 10^6$ (J) (1) [4] 4

(c)	Advantages	Disadvantages
Barrage	e.g. no fossil fuel needed huge power output good pressure head of water reliable 2 required (1) mark each	e.g. shipping blocked ecological problems silting up of estuary sewage build up power not necessarily available when it is required 2 required (1) mark each
Tidal stream	e.g. open to shipping 'free power' no ecological effect plenty of places where it can be used 2 required (1) mark each	e.g. much less power output than barrage building costs high slow rate of water flow 2 required (1) mark each

Candidates are told not to use the same comment twice in the same column, but apart from this many of the comments are transferable

4 × (2) **[8]** 8

[Total : 16]

5 (a) alternating current changes direction (of movement of electrons)
many times per second
direct current (has electrons) always moving in the same direction (1) **[1]**

to induce an e.m.f. it is necessary for magnetic field to be cut by a conductor (1)
the rate of cutting (linking) of the field is proportional to the induced e.m.f (1)
E = magnetic flux cut / time (1)
max 3

using high e.m.fs / voltages means that, for a given power (1)
the current can be smaller (1)
since I^2R is the power wasted in the cables (1)
less power is wasted with lower current (1)
the supply cables can be thinner (1) max 3

transformers will only work with a.c. (1)
by adjusting the number of turns the output e.m.f. can be determined (1)
for safety low voltage must be used in houses (1)
transformers can step up or step down (1)
they are very reliable / no moving parts (1)
other valid point (1) max 3

overall maximum **[8]** (out of 10) **[8]** 8

(b) only one of cheapness, no digging, saves time etc (1)
insulation around cables not required / insulation is the air (1)
no cooling required (1)

2 required 1 mark each **[2]** 2

[Total: 10]

2826/03 Experimental Skills 2 Practical Examination

Question 1

(b) (iv)	Readings Write the number of readings as a ringed total by the results table. 6 sets of readings scores three marks. One or more voltage readings outside the range loses one mark. 5 sets two marks. 4 sets one mark. If minor help has been given (e.g. voltmeter in series), then –1. Excessive help (i.e. circuit constructed for candidate) 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.	**3/2/1/0**
(b) (iv)	Check a value for lg(P/W), and a value for lg((R-R_0)/Ω). Underline checked values and ✓ if correct, one mark for each. If incorrect then write in correct value. Allow one mark out of two if ln values are used. Allow small rounding errors.	**2/1/0**
(b) (iv)	Quality of results Judge by scatter of points about line of best fit. 5 good trend plots needed, within 1 square of <u>your</u> best line (or ½ sq. on ½ page). This mark cannot be scored if log values have been miscalculated (but accept ln values).	**1**
(b) (iv)	Column headings 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**
(b) (iv)	Consistency of raw readings Applies to V and I only. One mark for each. All raw readings must be given to 1, 2 or 3 d.p. Trailing zeros in I lose this mark, but allow trailing zeros in V. Indicate using $\checkmark_C$ at the foot of the column if correct.	**2/1/0**
(b) (v)	Largest percentage uncertainty in I One mark for using the <u>smallest</u> value of I. One mark for sensible ΔI (0.001 A to 0.05 A). ΔI must be consistent with d.p. of readings. This will depend on type of meter used. One mark for correct ratio idea and 'x 100'	**3/2/1/0**
(c) (i)	Axes. Each axis must be labelled with a quantity. Ignore unit. One mark for each axis. Scales much be such that the plotted points occupy at least half the graph grid in both the x and y directions. Do not allow more than 3 large squares between scale markings. Do not allow awkward scales (e.g. 3:10, 6:10, 7:10, 8:10 etc.).	**2/1/0**

(c) (i)	Plotting of points**.** Count the number of plots on the grid and write this value by the line and ring it. Do not allow plots in the margin area. The number of plots must correspond with the number of observations. Do not award this mark if the number of plots is less than the number of observations. Check one suspect plot. Circle this plot. Tick if correct. If incorrect then mark the correct position with a small cross and use an arrow to indicate where the plots should have been. Allow errors up to and including half a small square. Do not allow 'blobs' of diameter greater than ½ small square.	**1**
(c) (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**
(c) (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. Do not allow a line of thickness greater than ½ a small square.	**2/1/0**
(c) (ii)	y-intercept If possible, check the read-off. Allow errors up to and including half a small square for two marks. If the error is between half a small square and one small square, then score one mark. If a read-off is not possible, correct substitution from a point <u>on the line</u> into $y = mx + c$ scores two marks. If the point is not on the line, or the answer is not the same as the graph read-off, within ½ square (no false origin), then this method can score one mark. A read-off taken from a graph with an x-axis false origin scores zero. A bald intercept with no working/read-off from graph scores zero.	**2/1/0**
(d) (i)	lg $(P) = n \lg(R - R_0) + \lg(k)$. Allow ln values.	**1**
(d) (i)	Value for n (from gradient)	**1**
(d) (i)	Value for k (from $10^{\text{y-intercept}}$) Method of working must be checked. Allow $e^{\text{y-intercept}}$ if ln values have been used.	**1**
(d) (ii)	Comment on suggested relationship. (Log) graph is a straight line, so relationship is valid (or wtte). Do not allow values to be compared by substitution into the equation Do not award this mark if: the relationship is stated to be proportional if log (or ln) values have not been found. the candidate states that the relationship is invalid, without reasoning statement "relationship is valid" with no explanation.	**1**

(e) (ii)	Correct substitution into valid equation	**1**
(e) (ii)	Calculation of R from $P = k(R-R_0)^n$, or from equivalent log equation. Allow $\log(R-R_0)$ to be read from the graph directly if axes are suitable Correct working (to be checked) one mark.	**1**
(e) (ii)	Calculation of T from $T = RT_0/R_0$. No need to check calculation. T must be between 2500K and 5500K. No ecf.	**1**
(e) (ii)	Correct significant figures for T (2 or 3 s.f.)	**1**

28 marks in total

Question 2

(b) (ii)	Raw time t for 10 or more oscillations recorded to 1 or 2 d.p. One mark. Calculation of T (= t/n). One mark. Misread stopwatch loses both of these marks. Do **not** credit the raw timing of a single oscillation	**2/1/0**
(c)	Justification for number of sf in T i.e. same as t (allow 'raw data' ideas or sensible reference to human reaction time). If t is used in (b) (ii) instead of T (i.e. no calculation done) then do not award this mark. This answer must be consistent with (b) (ii)	**1**
(d)	Repeated readings of raw times for second value of T.	**1**
(e)	Ratio T/h is constant. One mark for ratio idea, or calculation of k's. One mark for conclusion that T $\propto$ h which follows from the reasoning (only if k values are within 10% of each other). If not within 10%, allow T not $\propto$ h, or a sensible discussion. Vague 'T might be $\propto$ to h' or 'T is not $\propto$ to h' does not score this second mark.	**2/1/0**
(f) **1** **2** **3** **4** **5** **6** **7** **8** **9** **10** **11** **12** **13** **14** **15** **16**	Evaluation of procedure. Relevant points must be underlined and ticked. Some of these might be: [P = problem; S = solution] P Two readings not enough to draw conclusions S Take several sets of readings of T and h <u>and</u> plot T against h. P Hard to see beginning/end of oscillation (or human error in timing). Do not credit difficulty in starting watch and oscillation together. S Use a fiducial marker for timing S Use of motion sensor, light gate, or high speed camera with clock in frame or other Indication of time recording. Explanation of set-up needed. S Count more oscillations, more than used in (b) (ii). P Oscillations are fast and difficult to count (when h is small). S Use larger values of h / weaker magnets. P7 needed to score this S. P Pendulum motion of magnet / wobbling up and down S Both ends of magnet held carefully at start of oscillation / use small amplitude of swing P Nearby metal objects could affect oscillations. S Use wooden or plastic clamp stand. P Earth's magnetic field will interfere with experiment. S Try to avoid large values of h. P13 needed to score this S. S Evidence of measurement of T when no magnet on bench. P/S Magnet not level / use a thread cradle, or use glue, or other good suggestion Do not allow repeated readings (already credited in (d)) Do not allow draughts Allow other relevant points (8 maximum). Marks are awarded on the basis of one for each problem and each solution.	**8**
	SPAG	**2**
	Total	**16**

Plan Absorption of Solar Energy

A1	Experimental set-up i.e. circuit diagram for solar cell, to include voltmeter, ammeter (or joulemeter) and load resistance.	**1**
A2	Calculation of power absorbed = VI, or energy = VIt	**1**
B1	Labelled diagram of water container, including thermometer, at a given distance from the bulb. The container should be lagged at the back (allow in text).	**1**
B2	Water container should be blackened (allow in text).	**1**
B3	Measurement of mass, temperature rise, time interval.	**1**
B4	Calculation of power absorbed by water = $mc\Delta\theta/t$. Continuous flow methods are acceptable.	**1**
C1	Measurement of areas: exposed area of cell, and exposed area of container, or statement that areas must be the same.	**1**
C2	Measurement of distances from bulb, or statement that distances must be the same. (Hence possible comparison of powers between the two methods).	**1**
D **1** **2** **3**	Other factors to be taken into account (up to a maximum of 2 marks), e.g. Capital cost; n.b. solar cells are far more expensive than solar panels. Suitability of local weather e.g. hours of sunshine Solar cell provides electricity and not just hot water	**2/1/0**
E 1 2 3 4 5	Further details (up to a maximum of 2 marks), e.g. Selection of a suitable load resistance for maximum power output. ($R_{cell}=R_{load}$) At present pricing, neither method gives value for money Evidence of preliminary work Optimum positioning and angle of panels. Some discussion of different wavelengths required for solar cell, solar panel	**2/1/0**
R	Evidence of research of material. i.e. at least two detailed references from different sources have been given (i.e chapter and/or page numbers must be given). Allow internet pages to be sourced. Two or more vague references (i.e. no chapter or page 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 which marking point is being rewarded (e.g. $\checkmark_{A1}$).	
Q	Quality of written communication (organisation) Rambling and poorly presented material cannot score both marks.	**2/1/0**

Total 16

Question 1, Power of a Lamp. Results of Trial Experiment

(d) (i)

Gradient of log(P/W), log(R-R0)/Ω) graph = 2.344. Intercept = -0.507

Log P = log k + n log ($R-R_0$), therefore n = 2.344

Log k = -0.507, therefore k = 0.311

(e) (ii)

P = 24 W

Log P = log k + n log ($R - R_0$)

Log 24 = -0.507 + 2.344 log($R-R_0$), hence $R - R_0$ = 6.38 Ω and so R = 6.93 Ω

$T = RT_0/R_0$ where T_0 = 293 K and R_0 = 0.55 Ω (from V/R graph)

T = 6.93 x 293/0.55 = 3692 K ≈ 3700K to 2 s.f.

Question 2 Specimen Results (Bar Magnet)

t_1/s	t_2/s	t_{av}/s	T/s	k = T/h (s/cm)
9.85	9.78	9.81	0.981	0.113
4.22	4.56	4.39	0.439	0.105
6.46	6.38	6.42	0.642	0.107
13.34	13.21	13.28	1.328	0.109

(10 oscillations timed)

All values of k within 8%, hence T ∝ h

Without the magnet on the bench, t = 19.50 s for 10 oscillations
Therefore T = 1.950 s when suspended magnet is in Earth's field alone

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

SFP Significant figure penalty

ECF Error carried forward

TE Transferred error

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

NE Not enough

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

wtte Words to that effect

eeoo Each error or omission

CON Contradictory physics not to be credited

$\checkmark_{\Delta}$ Used to show that the size of a triangle is appropriate (gradient calculation)

$\checkmark_{A3}$ Used to show the type of mark awarded for a particular piece of work (Qu. 2)

$\checkmark_{C}$ Used to show that the raw readings are consistent

$\checkmark_{SF}$ Used to show calculated quantities have been given to an appropriate number of significant figures

^ Piece of work missing (one mark penalty)

^^ Several pieces of work missing (more than one mark penalty)

↔ Scale can be doubled in the x-direction

↕ Scale can be doubled in the y-direction

Grade Thresholds

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

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2821	Raw	60	39	34	29	24	19	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	45	40	35	30	25	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	99	88	77	67	57	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	99	88	77	67	57	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	94	85	76	67	58	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	70	64	58	52	46	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	69	62	55	48	41	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	68	62	56	50	45	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	63	56	50	44	38	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	71	64	57	51	45	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	90	87	78	69	60	51	0
	UMS	90	96	84	72	60	48	0
2826B	Raw	90	87	78	69	60	51	0
	UMS	90	96	84	72	60	48	0
2826C	Raw	90	83	76	69	62	55	0
	UMS	90	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	19.2	35.7	53.2	70.0	83.2	100	7612
7883	28.0	50.1	69.6	85.9	95.8	100	5923

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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