CAMBRIDGE
INTERNATIONAL EXAMINATIONS

June 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 40

SYLLABUS/COMPONENT: 9702/01

PHYSICS
Paper 1 (Multiple Choice (AS))

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

Question Number	*Key*	*Question Number*	*Key*
1	**B**	21	**B**
2	**B**	22	**D**
3	**B**	23	**B**
4	**A**	24	**D**
5	**C**	25	**C**
6	**B**	26	**B**
7	**C**	27	**C**
8	**C**	28	**C**
9	**D**	29	**B**
10	**D**	30	**C**
11	**B**	31	**A**
12	**A**	32	**B**
13	**D**	33	**B**
14	**B**	34	**B**
15	**A**	35	**C**
16	**C**	36	**D**
17	**C**	37	**B**
18	**D**	38	**C**
19	**B**	39	**B**
20	**A**	40	**D**

CAMBRIDGE
INTERNATIONAL EXAMINATIONS

June 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME
MAXIMUM MARK: 60
SYLLABUS/COMPONENT: 9702/02 PHYSICS Paper 2 (Structured Questions (AS))

UNIVERSITY *of* CAMBRIDGE
Local Examinations Syndicate

Categorisation of marks

The marking scheme categorises marks on the *MACB* scheme.

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

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

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

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

Conventions within the marking scheme

BRACKETS
Where brackets are shown in the marking scheme, the candidate is not required to give the bracketed information in order to earn the available marks.

UNDERLINING
In the marking scheme, underlining indicates information that is essential for marks to be awarded.

1			$kg\ m^{-3}$	B1	
			frequency or count rate or activity or decay constant	B1	
			NC^{-1} or $V\ m^{-1}$ or $kg\ m\ s^{-2}\ C^{-1}$ etc.	B1	
			momentum or impulse..	B1	[4]
			(Allow solidus notation and non SI units)		
2	(a)	(i)	distance from a (fixed) point..	M1	
			in a specified direction	A1	
			(Allow 1 mark for 'distance in a given direction')		
		(ii)	(displacement from start is zero if) car at its starting position.....	B1	[3]
	(b)	(i)1	$v^2 = u^2 + 2as$		
			$28^2 = 2 \times a \times 450$ (use of component of 450 scores no marks).....	C1	
			$a = 0.87\ m\ s^{-2}$	A1	[2]
			(-1 for 1 sig. fig. but once only in the question)		
		(i)2	$v = u + at$ or any appropriate equation		
			$28 = 0.87t$ or appropriate substitution..................................	C1	
			$t = 32$ s	A1	[2]
		(i)3	$E_k = ½mv^2$	C1	
			$= ½ \times 800 \times 28^2$		
			$= 3.14 \times 10^5$ J..	A1	[2]
		(i)4	$E_p = mgh$	C1	
			$= 800 \times 9.8 \times 450 \sin 5$	C1	
			$= 3.07 \times 10^5$ J	A1	[3]
		(ii)	power = energy/time	C1	
			$=(6.21 \times 10^5)/32.2$	C1	
			$= 1.93 \times 10^4$ W	A1	[3]
			(power = Fv with $F = mg \sin\theta$ scores no marks)		
		(iii)	some <u>work also done against friction</u> forces................................	M1	
			location of frictional forces identified	A1	[2]
			(allow reasonable alternatives)		
3	(a)	(i)	ductile	B1	
		(ii)1	L shown at end of straight line	B1	
		(ii)2	reciprocal of gradient of straight line region	B1	[3]
	(b)	(i)1	circumference = 3π cm or arc = $r\theta$	C1	
			extension = $(6.5/360) \times 3\pi$ = 1.5 sin (or tan) 6.5..........	M1	
			= 0.17 cm	A0	
		(i)2	strain = extension/length..	C1	
			= 0.17/250		
			$= 6.8 \times 10^{-4}$	A1	[4]
		(ii)	stress = force/area	C1	
			$= (6.0 \times 9.8)/(7.9 \times 10^{-7})$	C1	
			$= 7.44 \times 10^7$ Pa	A1	[3]

		(iii)	Young modulus = stress/strain ...	C1	
			= $(7.44 \times 10^{7})/(6.8 \times 10^{-4})$		
			= 1.1×10^{11} Pa ...	A1	[2]
		(iv)	remove extra load and see if pointer returns to original position or wire returns to original length ...	B1	[1]
4	**(a)**		e.g. both transverse/longitudinal/same type meet at a point, same direction of polarisation, etc.......1 *each, max 3* ...	B3	[3]
			(allow 1 mark for any condition for observable interference)		
	(b)	**(i)1**	allow 0.3 mm → 3 mm...	B1	
		(i)2	$\lambda = ax/D$ (allow any subject) ...	B1	
		(ii)1	separation increased...	B1	
			less bright ...	B1	
		(ii)2	separation increased...	B1	
			less bright ...	B1	
		(ii)3	separation unchanged...	B1	
			fringes brighter ...	B1	
			further detail, i.e quantitive aspect in (ii)1 or (ii)2...	B1	[7]
			(in (b), do not allow e.c.f. from (b)(i)2)		
5	**(a)**	**(i)**	resistance = V/I ...	C1	
			= $6.0/(40 \times 10^{-3})$		
			= 150 Ω ...	A1	
			(no marks for use of gradient)		
		(ii)	at 8.0 V, resistance = $8.0/(50 \times 10^{-3})$ = 160 Ω...	C1	
			change = 10 Ω ...	A1	[4]
	(b)	**(i)**	straight line through origin...	M1	
			passes through I = 40 mA, V = 8.0V ...	A1	
		(ii)	current in both must be 40 mA ...	C1	
			e.m.f. = 8.0 + 6.0 = 14.0 V ...	A1	[4]
6	**(a)**	**(i)**	curve is not smooth, fluctuations, etc ...	B1	
		(ii)	curve is same shape or same half-life, not affected by temperature, etc... ...	B1	[2]
	(b)	**(i)**	134... ...	B1	[1]
		(ii)	α-particle shown as ${}^{4}_{2}\mathrm{He}$ or as ${}^{4}_{2}\alpha$ ...	B1	
			nucleon number of Po shown as 216 ...	B1	
			proton number of Po shown as 84...	B1	
					[3]

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GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME
MAXIMUM MARK: 25
SYLLABUS/COMPONENT: 9702/03 PHYSICS Paper 3 (Practical (AS))

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

1 (a) (iv) % uncertainty in θ — 2/1/0

Accept $\Delta\theta$ to $\pm 1^\circ$ $\pm 2^\circ$ (1 mark)
Ratio and percentage ideas correct (1 mark)

(d) (i) Measurements — 3/2/1/0

Expect to see at least 6 sets of results (1 mark)
Less than 6 sets does not score this mark
Check a value of T^{-4}. Underline checked value and tick if correct (1 mark)
Ignore small rounding errors. This mark cannot be awarded if there are no raw times, number of oscillations measured in a fixed time, or the stopwatch has been misread. If there is no record of the number of oscillations then this mark cannot be scored
It may be necessary to refer to page 3 of script for a value of *n*
Check a value for $\cos\theta$. Underline checked value and tick if correct (1 mark)
Ignore small rounding errors. Expect to see a correct sign
If either incorrect, write in correct value and -1 eeoo
Minor help given by Supervisor, -1. Major help, then -2

(d) (i) Repeated readings — 1

For each value of θ there must be at least two values of *t*
An average value does **not** have to be calculate

(d) (i) At least 10° between the readings of θ — 1

(d) (i) Quality of results — 2/1/0

Judge by scatter of points about Examiner line of best fit
6 reasonable trend plots with little scatter (2 marks)
5 trend plots, or some scatter of plots (1 mark)
Large scatter/no trend/wrong quantities plotted (zero)

(d) (i) Column headings — 1

Check the $1/T^4$ column heading only
Quantity and unit (s^{-4}) must be correct

(d) (i) Consistency — 2/1/0

Apply to raw values of θ **and** *t* only (one mark each)
Values of θ must all be given to the nearest degree. Do not allow tenths of a degree
Values of *t* must all be given to the nearest 0.1 s or 0.01 s
Do not apply to average values

(d) (ii) Justification of number of sf in $\cos\theta$ — 1

Answer must relate sf in θ to sf in $\cos\theta$
Do not allow answers in terms of decimal places
Do not allow vague answers that are given in terms of 'raw data'

(e) (i) Axes — 1

Scales must be such that the plotted points occupy at least half the graph grid in both the *x* and *y* directions (i.e. 4 x 6 in portrait or 6 x 4 in landscape)
Axes must be labelled with the <u>quantity</u> plotted. Ignore units. Do not allow awkward scales or gaps of more than three large squares between the scale markings

(e)	**(i)**	Plotting of points Check a suspect plot. Circle and tick if correct. If incorrect, show correct position with arrow, and -1. Work to half a small square. All observations must be plotted	1
(e)	**(i)**	Line of best fit There must be a reasonable balance of points about the line of best fit There must be at least 5 plots on the grid for this mark to be awarded Do not allow a straight line to be drawn through a distinct curve trend Allow an acceptable curve through a curved trend of points	1
(e)	**(ii)**	Determination of gradient Hypotenuse of Δ used must be greater than half the length of the drawn line Check the read-offs and ratio. Read-offs must be accurate to half a small square Do not allow this mark if a curve has been drawn	1
(e)	**(ii)**	y-intercept The value must be read to half a small square Do not allow this mark if a curve has been drawn	1
(f)		A = candidate's value of gradient	1
(f)		B = candidate's value of intercept	1
(f)		Unit of A and B **both** correct (s^{-4})	1
(g)		Measurement of L The value should be in the range 40 cm $\pm$ 2 cm. Can be implied in the working It may be necessary to refer to the Supervisor's Report	1
(g)		Correct method of working to give a value for g in range 9.0 to 11.0 m s^{-2} A POT error anywhere in the working will not score this mark	1
(g)		Sf in g Allow 2 or 3 sf only. Apply to any value given A bald value with no working cannot score this mark	1
(g)		Unit of g correct (and consistent with other measurements, e.g. L) There must be a numerical value of g for this mark to be scored A bald value with no working cannot score this mark	1

25 marks in total

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GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME
MAXIMUM MARK: 60
SYLLABUS/COMPONENT: 9702/04 PHYSICS Paper 4 (Structured Questions (A2 Core))

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

Categorisation of marks

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

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

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

Conventions within the marking scheme

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UNDERLINING
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1 (a) work done in bringing/moving unit mass M1
from infinity to the point.. ...... A1 [2]
(use of 1 kg in the definition – max 1/2)

(b) potential at infinity defined as being zero....................... .... B1
forces are always attractive... B1
so work got out in moving to point... B1 [3]
(max potential is at infinity – allow 1/3)

(c) (i) $\varphi = -GM/R$
change = $6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times (\{6.4 \times 10^{6}\}^{-1} - \{1.94 \times 10^{7}\}^{-1})$ C2
change = 4.19×10^{7} J kg^{-1} (ignore sign) A1

(ii) $½mv^2 = m\Delta\varphi$ C1
$v^2 = 2 \times 4.19 \times 10^7 = 8.38 \times 10^7$
v = 9150 m s^{-1} .... A1 [5]

(d) acceleration is not constant.. B1 [1]

2 (a) (-1 for each error or omission) .... B2 [2]

(b) heat lost by liquid gold = $0.95m \times 129 \times \Delta T$................................. C1
heat gained (silver) = $0.05m \times 235 \times (1340 – 300) + 0.05m \times 105\,000$..C1, C1
$122.5m\Delta T = 17\,470m$
ΔT = 143 K...C1
temperature = 143 + 1340 = 1483 K...A1 [5]

(c) e.g. thermocouple/resistance thermometer .... B1 [1]

3 (a) f_0 is at natural frequency of spring (system) B1
this is at the driver frequency .... B1 [2]
(allow 1 mark for recognition that this is resonance)

(b) line: amplitude less at all frequencies B1
peak flatter B1
peak at f_0 or slightly below f_0.. B1 [3]

(c) (aluminium) sheet cuts the magnetic flux/field............................. B1
(so) currents/e.m.f. induced in the (metal) sheet B1
these currents dissipate energy M1
less energy available for the oscillations A1
so amplitude smaller .... A0 [4]
('current opposes motion of sheet' scores one of the last two marks)

4 (a) field causes forces on the electrons M1
and the nucleus in opposite directions A1
(field causes) electrons (to be) stripped off the atom.................... B1 [3]

(b) (i) $E = Q/4\pi\varepsilon_0 r^2$ C1
$20 \times 10^3 \times 10^2 = Q/(4\pi \times 8.85 \times 10^{-12} \times 0.21^2$...................................C1
charge = 9.8×10^{-6} C ....A1 [3]

	(ii)	$V = Q/4\pi\varepsilon_0 r$		
		$= (9.8 \times 10^{-6})/(4\pi \times 8.85 \times 10^{-12} \times 0.21)$	C1	
		$= 4.2 \times 10^{5}$ V	A1	[2]
(c)		e.g. sphere not smooth, humid air, etc	B1	[1]
5 (a)		centripetal force = mv^2/r	B1	
		magnetic force $F = Bqv$	B1	
		(hence) $mv^2/r = Bqv$	B1	
		$r = mv/Bq$	A0	[3]
(b)		$r_\alpha/r_\beta = (m_\alpha/m_\beta) \times (q_\beta/q_\alpha)$	C1	
		$= (4 \times 1.66 \times 10^{-27})/(9.11 \times 10^{-31} \times 2)$		
		$= 3.64 \times 10^{3}$	A2	[3]
(c)	(i)	$r_\alpha = (4 \times 1.66 \times 10^{-27} \times 1.5 \times 10^{6})/(1.2 \times 10^{-3} \times 2 \times 1.6 \times 10^{-19})$		
		= 25.9 m	A2	
	(ii)	$r_\beta = 25.9 \times 3.64 \times 10^{3} = 7.13 \times 10^{-3}$ m	A1	[3]
(d)	(i)	deflected upwards	B1	
		but close to original direction	B1	
	(ii)	opposite direction to α-particle and 'through side'	B1	[3]
6 (a)		greater binding energy gives rise to release of energy	M1	
		so must be yttrium	A1	[2]
(b)		probability of decay	M1	
		of a nucleus per unit time	A1	[2]
(c)	(i)1	$A = \lambda N$	C1	
		$3.7 \times 10^{6} \times 365 \times 24 \times 3600 = 0.025N$	C1	
		$N = 4.67 \times 10^{15}$	A1	[3]
	(i)2	mass = $0.09 \times (4.67 \times 10^{15})/(6.02 \times 10^{23})$	C1	
		$= 6.98 \times 10^{-10}$ kg	A1	[2]
	(ii)	$A = A_0 e^{-\lambda t}$		
		$A/A_0 = e^{-0.025t}$	C1	
		= 0.88	A1	[2]

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GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME
MAXIMUM MARK: 30
SYLLABUS/COMPONENT: 9702/05 PHYSICS Paper 5 (Practical (A2))

UNIVERSITY *of* CAMBRIDGE
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1	**(a)**	**(v)**	Measurements **6 sets** of readings ($I \neq 0$) scores **1 mark** Allow more than 6 sets without penalty Write the number of readings as a ringed total by the table Choose a row in the table Check a **value for tan** θ. Tick if correct and score **1 mark** If incorrect, write in correct value and do not award the mark Ignore small rounding errors All values of $\theta < 90°$ score **1 mark** Minor help from the Supervisor -1. Major help, then -2 If help has been given then write SR at the top of the front page of the script, and give a brief explanation of the type of help that has been given by the table of results	3
	(a)	**(v)**	Repeats Expect to see at least two sets of readings for θ, with an average calculated Do not award this mark if all the results are the same	1
	(a)	**(v)**	Quality of results Judge by scatter of points about the line of best fit 6 trend points with little scatter scores 2 marks 5 trend points with little scatter scores 1 mark Shallow curve can score 1 mark 4 trend points only scores zero Wrong trend or 'impossible results' cannot score these marks	2/1/0
	(a)	**(v)**	Column headings Apply to the current column only There must be some distinguishing mark between the quantity and the unit Allow I/A, I (A) or I in A	1
	(a)	**(v)**	Consistency Apply to both θ and I All values of θ must be given to the same number of d.p. Allow θ to be given to the nearest half degree or nearest degree All values of I must be given to the same number of d.p. (0.1 A or 0.01 A) Do not accept values to the nearest Ampere or milliampere	2/1/0
	(a)	**(vi)**	Justification of sf in tan θ Answer must relate the number of sf in θ to the number of sf in tan θ Do not allow answers in terms of decimal places 'Raw data' ideas can score 1 mark	2/1/0
	(b)	**(i)**	Axes The axes must be labelled with the quantities plotted Ignore units on the axes The plotted points must occupy at least half the graph grid in both the *x* and *y* directions (i.e. 4 large squares in the *x*-direction and 6 large squares in the *y*-direction) Do not allow more than 3 large squares between the labels on an axis Do not allow awkward scales (e.g. 3:10, 6:10, etc.)	1

(b)	**(i)**	Plotting of points All the observations must be plotted Count the number of plots and ring this total on the grid Do not allow plots in the margin area Check one suspect plot. Circle this plot. Tick if correct. If incorrect, mark the correct position with a small cross and use an arrow to indicate where the plot should have been, and -1. Allow errors up to and including half a small square	1
(b)	**(i)**	Line of best fit Only a drawn straight line through a linear trend is allowable for this mark This mark can only be awarded for 5 or more plots on the grid There must be a reasonable balance of points about the drawn line Do not allow a line of thickness greater than half a small square	1
(b)	**(ii)**	Gradient Ignore any units given with the value Hypotenuse of Δ must be > half the length of line drawn Check the read-offs. Work to half a small square. $\Delta x/\Delta y$ gets zero Values taken from the table that lie on the line to within half a small square are acceptable Do not award this mark if a curve has been drawn	1
(c)		k = candidate's gradient	1
(c)		Unit of k (i.e. A^{-1})	1
(c)		SF in k Allow 2 or 3 sf only	1
(d)	**(i)**	Value of θ when I = 15 A Method of working must be checked. Ignore unit and small rounding errors	1
(d)	**(ii)**	Reasons for not being able to verify experimentally Heating problems with the wires Fuse may blow on psu/max. output current on psu exceeded Do not allow vague answers such as 'It is dangerous'	1

20 marks in total

2 A1	Sensible choice of equipment and procedure OK (i.e. measure count rate and p.d.; change p.d. and measure new count rate) Unworkable methods/inappropriate choice of apparatus cannot score this mark	1
A2	Voltmeter shown in parallel with the GM tube or the supply	1
A3	Ratemeter/scalar/datalogger connected to terminals A and B of GM tube	1
B1	Radium or Cobalt source used	1
B2	Reason for choice Answer must relate to half-life. This mark cannot be scored if **B1 = 0**	1
B3	Method of removing α or β radiation (depending on source used) Appropriate absorber is expected. Accept 'aluminium' or <u>thin</u> lead Could be shown on the diagram. Allow electric or magnetic deflection	1
C1/2	Any two safety precautions e.g. use source handling tool store source in lead lined box when not in use do not point source at people/do not look directly at source Do not allow 'protective clothing', 'lead suits', 'lead gloves', 'goggles', etc.	2
D1/2	Any good/further detail Examples of creditworthy points might be: Repeat readings (to allow for randomness of activity) or scalar + long time Sensible value of p.d. applied to GM tube (i.e. 50 V to 1000 V) Keep distance from source to GM tube <u>constant</u>/<u>fixed</u>/<u>same</u>, etc. <u>Subtract</u> count rate due to background radiation Aluminium sheets must be mm or cm thickness Allow other valid points. Any two, one mark each	2
	10 marks in total	

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GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 40

SYLLABUS/COMPONENT: 9702/06

PHYSICS
Paper 6 (Options (A2))

UNIVERSITY of CAMBRIDGE
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Categorisation of marks

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Conventions within the marking scheme

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Option A – Astrophysics and Cosmology

1	**(a)**		large mass of gas (allow H and He)	B1	
			giving off e.m. radiation (allow light)	B1	
			held together by gravitational forces, or other good physics	B1	[3]
	(b)		group of (many) stars	B1	
			any further detail e.g. some dimension, shape, etc	B1	[2]
	(c)		rocky or gaseous object	B1	
			orbiting a star	B1	
			seen by reflected light	B1	[3]
2			measure wavelength of light received from galaxy	B1	
			measure wavelength of light in laboratory/on Earth	B1	
			(fractional) change in wavelength related to speed or Doppler shift gives speed	B1	[3]
3	**(a)**		$v = H_0 d$		
			$H_0 = (1.8 \times 10^4)/430$	C1	
			$= 42$ km s^{-1} Mpc^{-1}	A1	[2]
	(b)	**(i)**	1 pc $= 3.1 \times 10^{16}$ m	B1	
			age $= 1/H_0$		
			$= (3.1 \times 10^{22})/(42 \times 10^3)$	C1	
			$= 7.4 \times 10^{17}$ s	A1	
		(ii)	Earth-Moon distance $= 3.8 \times 10^5$ km (allow 2 – 7 x 10^5 km)	C1	
			speed $= (3.8 \times 10^8)/(7.4 \times 10^{17})$		
			$= 5.1 \times 10^{-10}$ m s^{-1}	A1	[5]
	(c)		This is local gravitational attraction	B1	
			On wider scale, galaxies are receding	B1	[2]

Option F – The Physics of Fluids

4	**(a)**	**(i)**	equal	B1	
		(ii)	density of ice is less	B1	[2]
	(b)		mass of ice becomes equal mass of water (allow weight)	M1	
			melted ice fills space of water displaced by ice	M1	
			so level does not change	A1	[3]
5	**(a)**		e.g. streamline, incompressible non-viscous, horizontal flow……(1 each, max 3)	B3	[3]
	(b)		air close to train moves at the speed of the train/air dragged along by train	B1	
			air at some distance from the train is stationary/velocity is less	B1	
			(so) air pressure is lower close to the train	M1	
			pressure difference could force passengers into side of train	A1	[4]
6	**(a)**	**(i)**	random/irregular movement (of fluid)	B1	
			any other detail, e.g. eddies, pattern always changing	B1	

(ii) kinetic energy given to air to cause turbulence or work needed to overcome drag force M1
energy comes from car so fuel consumption increases .... A1 [4]

(b) (i) drag coefficient/drag constant B1

(ii) power = Fv and hence M1
$P = ½C_D\rho Av^3$ A0

(iii) $120 \times 10^3 - ½ \times 0.3 \times 1.2 \times 2.5 \times v^3$ C1
$v^3 = 2.67 \times 10^5$
$v = 64$ m s^{-1} .... A1 [4]

Option M – Medical Physics

7 (a) electrons fired at metal target B1
electrons decelerated giving off (e.m.) radiation B1
range of decelerations, so continuous spectrum B1
also, electrons in inner orbits are excited B1
de-excitation gives characteristic line spectrum .... B1 [5]

(b) (i) increase cathode/tube current B1

(ii) increase anode voltage B1

(iii) use aluminium filter (allow metal filter) .... B1 [3]

(c) $I = I_0e^{-\mu x}$ C1
In 2 = 0.40μ
$\mu = 1.733$ cm^{-1} or = In2/0.4 .... C1
$0.1 = e^{-1.733x}$
$x = 1.33$ cm .... A1 [3]

8 (a) produces greater intensity (at focus)
limits region of cell damage
allows for accurate guidance .... B2 [2]

(b) laser beam cauterises tissue
can produce coagulation
vaporisation of water in cells .... B2 [2]
{in (a) and (b), allow 1 mark each up to max of 3 in either, total not to exceed 4}

9 (a) ability to detect (small) changes in loudness/intensity B1
depends on $I / \Delta I$ .... B1 [2]

(b) $\Delta I.L. = 10\ \lg(\Delta I / I)$ or $I.L. = 10\lg(I/I_0)$ C1
$3.0 = 10\ \lg\ (I_2 / (4.5 \times 10^{-5}))$ C1
$I_2 = 9.0 \times 10^{-5}$ Wm^{-2}, $\Delta I = 4.5 \times 10^{-5}$ W m^{-2} .... A1 [3]

Option P – Environmental Physics

10 (a) source of (useful) energy B1
derived from (incomplete) decay of organic matter .... B1 [2]

(b) resources: total deposits of fossil fuels B1
reserves: fossil fuels that can be extracted (economically) .... B1 [2]

11 (a) heavy nucleus/heavy atom/U-235, etc B1
bombarded by neutron.. B1
produces two fragments of about equal mass............................... B1
plus neutron<u>s</u> and energy .... B1 [4]

(b) (i) slows down neutrons B1

(ii) absorbs neutrons. B1

(iii) maintains coolant around reactor core B1
provides biological shield/prevents radiation leakage .... B1 [4]

12 (a) $E_{MAX} = (1 - T_L/T_H)$. C1
$= (1 - 313/813)$ C1
$= 0.61$ .... A1 [3]

(b) (i) e.g. heat loss in exhaust gases/cooling towers B1

(ii) e.g. pre-heat water entering boiler, <u>either</u> increase T_H or decrease T_L
re-heat steam in multistage turbine, CHP system…(1 each, max 2) .... B2 [3]

(c) e.g. thermal, visual, etc.………..(1 each, max 2)................................. B2 [2]

Option T – Telecommunications

13 (a) correct signal voltages………….(-1 each error or omission)........... B2
corresponding binary numbers...(-1 each error or omission)........... B2 [4]

(b) signal changes at correct positions B1
correct levels .... B1 [2]

(c) (use ADC and DAC with) larger number of bits............................. M1
makes smaller 'step height' A1
sample more frequently M1
makes smaller 'step depth' .... A1 [4]

14 (a) central conductor with outer screening.. B1
insulation between inner and outer and also as cladding................ B1 [2]

(b) e.g. greater bandwidth
immune to e.m. interference
radiates less e.m. power
less cross-talk
lower noise levels………. (1 each, max 3)............................... B3 [3]

15

10 m $\rightarrow$ 100 m	worldwide
more than 100 m	1000 km
less than 10 m	line of sight <u>or</u> worldwide using satellites

(-1 each error or omission)...................... B5 [5]