UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the June 2004 question papers

9702 PHYSICS

9702/01	Paper 1 (Multiple Choice (AS)), maximum mark 40
9702/02	Paper 2 (Structured Questions (AS)), maximum mark 60
9702/03	Paper 3 (Practical (AS)), maximum mark 25
9702/04	Paper 4 (Structured Questions (A2 Core)), maximum mark 60
9702/05	Paper 5 (Practical (A2)), maximum mark 30
9702/06	Paper 6 (Options (A2)), maximum mark 40

These mark schemes are published as an aid to teachers and students, to indicate the requirements of the examination. They show the basis on which Examiners were initially instructed to award marks. They do not indicate the details of the discussions that took place at an Examiners' meeting before marking began. Any substantial changes to the mark scheme that arose from these discussions will be recorded in the published *Report on the Examination*.

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

Mark schemes must be read in conjunction with the question papers and the *Report on the Examination*.

- CIE will not enter into discussion or correspondence in connection with these mark schemes.

CIE is publishing the mark schemes for the June 2004 question papers for most IGCSE and GCE Advanced Level syllabuses.

UNIVERSITY of CAMBRIDGE
International Examinations

Grade thresholds taken for Syllabus 9702 (Physics) in the June 2004 examination.

	maximum mark available	minimum mark required for grade:		
		A	B	E
Component 1	40	34	32	22
Component 2	60	45	41	27
Component 3	25	19	17	11
Component 4	60	40	33	17
Component 5	30	24	22	14
Component 6	40	21	18	10

The thresholds (minimum marks) for Grades C and D are normally set by dividing the mark range between the B and the E thresholds into three. For example, if the difference between the B and the E threshold is 24 marks, the C threshold is set 8 marks below the B threshold and the D threshold is set another 8 marks down. If dividing the interval by three results in a fraction of a mark, then the threshold is normally rounded down.

June 2004

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
International Examinations

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

June 2004

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
International Examinations

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 (a) scalar: magnitude only — B1
vector: magnitude and direction *(allow scalar with direction)* — B1 **[2]**
(allow 1 mark for scalar has no direction, vector has direction)

(b) diagram has correct shape — M1
with arrows in correct directions — A1
resultant = 13.2 ± 0.2 N *(allow 2 sig. fig)* — A2 **[4]**
(for 12.8 → 13.0 and 13.4 → 13.6, allow 1 mark)
(calculated answer with a correct sketch, allow max 4 marks)
(calculated answer with no sketch – no marks)

Total **[6]**

2 (a) (i) λ = 0.6 m — B1
(ii) frequency (= v/λ) = 330/0.60 — C1
= 550 Hz — A1 **[3]**
(use of $c = 3 \times 10^8$ ms^{-1} scores no marks)

(b) amplitude shown as greater than *a* but less than 2*a* and constant — B1
correct phase — B1 **[2]**
(wave to be at least three half-periods, otherwise -1 overall)

Total **[5]**

3 (a) (i) scatter of points (about the line) — B1
(ii) intercept (on t^2 axis) — B1 **[2]**
(note that answers must relate to the graph)

(b) (i) gradient = $\Delta y/\Delta x$ = (100 – 0)/(10.0 – 0.6) — C1
gradient = 10.6 (cm s^{-2}) *(allow ±0.2)* — A1 **[2]**
(Read points to within $\pm\frac{1}{2}$ square. Allow 1 mark for 11 cm s^{-2}
i.e. 2 sig fig, -1. Answer of 10 scores 0/2 marks)

(ii) $s = ut + \frac{1}{2}at^2$ — B1
so acceleration = 2 x gradient — B1
acceleration = 0.212 m s^{-2} — B1 **[3]**

Total **[7]**

4 (a) (i) (p =) mv — B1
(ii) $E_k = \frac{1}{2}mv^2$ — B1
algebra leading to — M1
$E_k = p^2/2m$ — A0 **[3]**

(b) (i) Δp = 0.035 (4.5 + 3.5) OR a = (4.5 + 3.5)/0.14 — C1
= 0.28 N s = 57.1 m s^{-2}
force= Δp/Δt (= 0.28/0.14) OR F = ma (= 0.035 x 575.1) (allow e.c.f.) — C1
= 2.0 N — A1
Note: candidate may add mg = 0.34 N to this answer, deduct 1 mark upwards — B1 **[4]**

(ii) loss = $\frac{1}{2}$ x 0.035 ($4.5^2 - 3.5^2$) — C1
= 0.14 J — A1 **[2]**
(No credit for $0.28^2/(2 \times 0.035) = 1.12$ J)

(c) e.g. plate (and Earth) gain momentum
i.e. discusses a 'system' — B1
equal and opposite to the change for the ball
i.e. discusses force/momentum — M1
so momentum is conserved
i.e. discusses consequence — A1 **[3]**

Total **[12]**

5	**(a)**	**(i)**	distance = $2\pi nr$			B1	
		(ii)	work done = F x 2 πnr *(accept e.c.f.)*			B1	**[2]**
	(b)		total work done = 2 x F x $2\pi nr$			B1	
			but torque $T = 2Fr$			B1	
			hence work done = T x $2\pi n$			A0	**[2]**
	(c)		power = work done/time (= 470 x 2π x 2400)/60)				
			= 1.2 x 10^5 W			A1	**[2]**
					Total		**[6]**
6	**(a)**		When two (or more) waves meet *(not 'superpose' or 'interfere')*			B1	
			resultant <u>displacement</u>			M1	
			is the sum of individual (displacements)			A1	**[3]**
	(b)	**(i)**	any correct line through points of intersection of crests			B1	
		(ii)	any correct line through intersections of a crest and a trough			B1	**[2]**
	(c)	**(i)**	$\lambda = ax/D$ OR $\lambda = a\sin\theta$ and $\theta = x/D$			C1	
			650 x 10^{-9} = (a x 0.70 x 10^{-3})/1.2			C1	
			a = 1.1 x 10^{-3} m			A1	**[3]**
		(ii) 1	no change			B1	
		2	brighter			B1	
		3	no change *(accept stay/remain dark)*			B1	**[3]**
					Total		**[11]**
7	**(a)**	**(i)**	$P = VI$			C1	
			current = 60/240 = 0.25 A			A1	
		(ii)	R (= V/I) = 240/0.25			M1	
			= 960 Ω			A0	**[3]**
	(b)		$R = \rho L/A$ *(wrong formula, 0/3)*			C1	
			960 = (7.9 x 10^{-7} x L)/(π x {6.0 x 10^{-6}}^{2})			C1	
			L = 0.137 m			A1	**[3]**
			(use of $A = 2\pi r$, then allow 1/3 marks only for resistivity formula)				
	(c)		e.g. the filament must be coiled/it is long for a lamp			B1	**[1]**
			(allow any sensible comment based on candidate's answer for L)				
					Total		**[7]**
8	**(a)**		$V/E = R/R_{tot}$	or	0.5 = I x 3900	C1	
			1.0/1.5 = R/(R + 3900)	or	1.0 = 0.5R/3900	M1	
			R = 7800Ω.	or	R = 7800Ω	A0	**[2]**
	(b)		V = 1.5 x (7800/{7800 + 1250})	or	I = 1.5/(7800 + 1250)	C1	
			= 1.29 V..	or	$V = IR$ = 1.29 V	A1	**[2]**
	(c)		Combined resistance of R and voltmeter is 3900 Ω			C1	
			reading at 0 °C is 0.75 V			A1	**[2]**
					Total		**[6]**

June 2004

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 25

SYLLABUS/COMPONENT: 9702/03

PHYSICS
Paper 3 (Practical (AS))

UNIVERSITY of CAMBRIDGE
International Examinations

(a) Pointer B reading to the nearest half millimetre or millimetre **1**
Extension correct and to nearest millimetre
Condone negative values (i.e. do not penalise 'upside down' rule)

(b) Calculation of spring constant to 2 or 3 sf **1**
$k = 0.98/x$ answer must be given in N m^{-1}.
Ignore any negative signs. Do not allow fractions

(c) (i) Diameter of one mass to at least 3 sf **1**
Accept value ± 0.2 mm of Supervisor's value

(ii) Percentage uncertainty in diameter **2**
One mark for Δd (either 0.1 mm or 0.2 mm).
One mark for correct ratio and multiplication by 100.

(iii) Cross-sectional area **2**
One mark for $A = \pi r^2$.
One mark for correct substitution into $A = \pi r^2$. ECF from **(c)(i)**.
Do not allow the second mark if diameter substituted into $A = \pi r^2$.
Wrong formula scores zero in this section.

(d) (iv) Measurements **2**
Expect to see six sets of results in the table (one mark).
l must be correct; check a value (one mark).
If correct, then tick. If incorrect, then do not award the second mark, and write in the correct value. If pointer reading not shown then this mark cannot be scored.
Minor help given by Supervisor, -1. Major help, then -2.

Column headings for d and l (one mark for each correct heading). **2**
Expect to see a quantity and a correct unit.
There must be a distinguishing feature between the quantity and the unit.

Consistency of d and l readings. **2**
Values should be given to the nearest mm.
One mark each.

(e) (iii) Gradient is negative. **1**
No ecf from misread rule if gradient is positive.

Gradient calculation. **1**
Δ used must be greater than half the length of the drawn line.
Check the read-offs (must be correct to half a small square).
Ratio must be correct (i.e. $\Delta y / \Delta x$ and not $\Delta x / \Delta y$).

Graph 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. at least 6 large squares on the longer side of the grid and at least 4 squares on the shorter side of the grid).
Scales must be labelled. Do not allow awkward scales (e.g. 3:10, 6:10 etc.).
Allow reversed axes (penalise in section **(f)**)

Plotting of points **1**
Count the number of plots and write as a ringed total on the graph grid.
All the observations must be plotted or this mark cannot be scored.
Check a suspect plot. Circle and tick if correct.
If incorrect, show correct position with arrow, and -1.
Work to half a small square.

Line of best fit **1**
There must be at least 5 trend plots for this mark to be scored.
There must be a reasonable balance of points about the line of best fit.

Curved trend cannot score this mark.
Quality of results **1**
Judge by scatter of points about the line of best fit.
There must be at least 5 trend plots for this mark to be scored.
Incorrect trend (i.e. positive gradient) will not score this mark.

(f) Gradient equated with $\frac{-\rho_w Ag}{k}$. Condone misuse of negative sign. **1**

Value in range 800 – 1200 kg m^{-3} (or 0.80 to 1.20g cm^{-3}) **1**
This mark cannot be scored if the gradient has not been used.
This mark will not be scored if there is a Power Of Ten error in the working or reversed axes.

Unit correct (kg m^{-3}) **1**
If another unit has been given then it must be consistent with the value.

Significant figures in ρ_w **1**
Accept 2 or 3 sf only. Ignore trailing zeros (except ρ_w = 1000)

(g) Difficulty **1**
e.g. hard to see the water surface/surface tension problems/refraction effects/parallax errors. Do not allow vague 'human error'.

Improvement **1**
e.g. use calibrated beakers or masses/paper behind/mirror behind/travelling microscope
Do not allow 'use dye'/repeat readings.

25 marks in total

June 2004

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 60

SYLLABUS/COMPONENT: 9702/04

PHYSICS
Paper 4 (Structured Questions (A2 Core))

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	**(a)**		charge is quantised/enabled electron charge to be measured	B1	**[1]**
	(b)		all are (approximately) n x (1.6×10^{-19} C) so $e = 1.6 \times 10^{-19}$ C (allow 2 sig. fig. only) *summing charges and dividing ten, without explanation scores 1/2*	M1 A1	**[2]**
			Total		**[3]**
2	**(a)**		mean (value of the) square of the speeds (velocities) of the atoms/particles/molecules	M1 A1	**[2]**
	(b)	**(i)**	$p = \frac{1}{3} \rho \langle c^2 \rangle$	C1	
			$\langle c^2 \rangle = 3 \times 2 \times 10^5 / 2.4 = 2.5 \times 10^5$	C1	
			r.m.s speed = 500 ms^{-1}	A1	**[3]**
		(ii)	new $\langle c^2 \rangle = 1.0 \times 10^6$ or $\langle c^2 \rangle$ increases by factor of 4	C1	
			$\langle c^2 \rangle \propto T$ or $3/2\ kT = 1/2\ m\langle c^2 \rangle$	C1	
			$T = \{(1.0 \times 10^6) / (2.5 \times 10^5)\} \times 300$ $= 1200$ K	A1	**[3]**
			Total		**[8]**
3	**(a)**	**(i)**	(force) = $GM_1M_2/(R_1 + R_2)^2$	B1	
		(ii)	(force) = $M_1R_1\omega^2$ or $M_2R_2\omega^2$	B1	**[2]**
	(b)		$\omega = 2\pi/(1.26 \times 10^8)$ or $2\pi/T$ $= 4.99 \times 10^{-8}$ rad s^{-1} *allow 2 s.f.: $1.59\pi \times 10^{-8}$ scores 1/2*	C1 A1	**[2]**
	(c)	**(i)**	reference to either taking moments (about C) or same (centripetal) force	B1	
			$M_1R_1 = M_2R_2$ or $M_1R_1\omega^2 = M_2R_2\omega^2$	B1	
			hence $M_1/M_2 = R_2/R_1$	A0	**[2]**
		(ii)	$R_2 = 3/4 \times 3.2 \times 10^{11}$ m $= 2.4 \times 10^{11}$ m	A1	
			$R_1 = (3.2 \times 10^{11}) - R_2 = 8.0 \times 10^{10}$ m (allow *vice versa)* *if values are both wrong but have ratio of four to three, then allow 1/2*	A1	**[2]**
	(d)	**(i)**	$M_2 = \{(R_1 + R_2)^2 \times R_1 \times \omega^2\}\ I\ G$ (any subject for equation)	C1	
			$= (3.2 \times 10^{11})^2 \times 8.0 \times 10^{10} \times (4.99 \times 10^{-8})^2 / (6.67 \times 10^{-11})$	C1	
			$= 3.06 \times 10^{29}$ kg	A1	
		(ii)	less massive (only award this mark if reasonable attempt at **(i)**) (9.17×10^{29} kg for more massive star)	B1	**[4]**
			Total		**[12]**
4	**(a)**		e.g. amplitude is not constant or wave is damped *do not allow 'displacement constant'* should be (-)cos, (not sin)	B1 B1	**[2]**
	(b)		$T = 0.60$ s	C1	
			$\omega = 2\pi/T = 10.5$ rad s^{-1} *(allow 10.4 → 10.6)*	A1	**[2]**
	(c)		same period	B1	
			displacement always less	M1	
			amplitude reducing appropriately *for 2nd and 3rd marks, ignore the first quarter period*	A1	**[3]**
			Total		**[7]**

5	**(a)**		the (value of the) direct current			M1	
			that dissipates (heat) energy at the same rate (in a resistor)			A1	**[2]**
			allow 'same power' and 'same heating effect'				
	(b)		$\sqrt{2}I_{rms} = I_0$			B1	**[1]**
	(c)	**(i)**	power $\propto I^2$ or $P = I^2R$ or $P = VI$			C1	
			ratio = 2.0 (allow 1 s.f.)			A1	**[2]**
		(ii)	advantage: e.g. easy to change the voltage			B1	
			disadvantage: e.g. cables require greater insulation				
			..... rectification – with some justification			B1	**[2]**
	(d)	**(i)**	3.0 A (allow 1 s.f.)			A1	
		(ii)	3.0 A (allow 1 s.f.)			A1	**[2]**
					Total		**[9]**
6			0 - + (-1 for each error)			B2	
			+ + 0 (-1 for each error)			B2	
			+ + 0 (-1 for each error)			B2	**[6]**
					Total		**[6]**
7	**(a)**		$\lambda = h/p$ or $\lambda = h/mv$			M1	
			with λ, h and (or mv) p identified			A1	**[2]**
	(b)		$E = \frac{1}{2} mv^2$			C1	
			$= p^2/2m$ or $v = \sqrt{(2E/m)}$, hence			M1	
			$\lambda = h/\sqrt{(2mE)}$			A0	**[2]**
	(c)		$E = qV$			C1	
			$(0.4 \times 10^{-9})^2 \times 2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times V = (6.63 \times 10^{-34})^2$			C1	
			V = 9.4 V *(2 s.f. scores 2/3)*			A1	**[3]**
					Total		**[7]**
8	**(a)**		S shown at the peak			B1	**[1]**
	(b)	**(i)**	Kr and U on right of peak in correct relative positions			B1	**[1]**
		(ii)1	binding energy of U-235 = 2.8649×10^{-10} J				
			binding energy of Ba-144 = 1.9211×10^{-10} J				
			binding energy of Kr-90 = 1.2478×10^{-10} J			C2	
			energy release = 3.04×10^{-11} J *(-1 if 1 or 2 s.f.)*			A1	**[3]**
		2	$E = mc^2$			C1	
			$m = (3.04 \times 10^{-11})/3.0 \times 10^8)^2 = 3.38 \times 10^{-28}$ kg (ignore s.f.)			A1	**[2]**
		(iii)	e.g. neutrons are single particles,				
			neutrons have no binding energy per nucleon			B1	**[1]**
					Total		**[8]**

June 2004

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 30

SYLLABUS/COMPONENT: 9702/05

PHYSICS
Paper 5 (Practical (A2))

UNIVERSITY of CAMBRIDGE
International Examinations

Question 1

(a) (v) Sensible use of fiducial marker placed at centre of oscillation/mean position/ equilibrium position **1**

(a) (vi) Measurements **3**
6 sets scores one 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 values for T^2d & d^2. Tick if correct.
One mark each. If incorrect, write in correct values. Ignore small rounding errors.
Impossible values of d or t, -1. Misread stopwatch –1.
Minor help from the Supervisor, -1. Major help, then -2.

Repeats **1**
Expect to see at least two sets of readings of raw times.

At least half the raw times > 20 s **1**

Column heading for T^2d **1**
The column heading must contain a quantity and a unit (e.g. s^2 m or s^2 cm).
There must be some distinguishing mark between the quantity and the unit.

Consistency **1**
Apply to d (all values of d must be given to the nearest millimetre).

SF in d^2 **1**
Check by row in the table; compare with raw values of d.
The number of significant figures in d^2 must be the same as, or one better than, the number of significant figures in d.

(a) (vii) Justification of sf in d^2 **1**
Answer must relate the number of sf in d.
Do not allow answers in terms of decimal places.

(b) (i) Axes **1**
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, 8:10 etc.).
If axes reversed (i.e. d^2 against T^2d) then zero and ecf.

Plotting of points **1**
All the observations must be plotted.
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 score zero. Allow errors up to and including half a small square.

Line of best fit **1**
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.

Quality of results **1**
Judge by scatter of points about the line of best fit.
5 trend plots can score this mark. Curved trend scores zero.
This mark can only be scored if a graph of d^2 against T^2d or T^2d against d^2 has been plotted.

(b) (iii) Gradient **1**
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.

y-intercept **1**
The value must be read to the nearest half square.
Allow calculation from $y = mx + c$

(c) *k* = gradient of line of best fit **1**
A numerical value is expected. Substitution method scores zero.

A = candidate's value for the *y*-intercept **1**
A numerical value is expected. Substitution method scores zero.

Unit of *A* correct and consistent with value (e.g. s^2 m or s^2 cm) **1**
If incorrect allow ecf from column heading in table.

(d) Value of *T* when *d* = 1.0 cm **1**
Must be in range 3 – 8 s.
A power of ten error anywhere in the working will result in this mark not being scored.
Working must be checked. Bald answer scores zero.

20 marks in total

Question 2

A1 Sensible choice of equipment and basic idea OK **1**
Source/magnetic field/detector
Inappropriate choice of apparatus cannot score this mark.
Ignore lead or aluminium plates at this stage.

A2 Method of measuring angle of deflection **1**
(e.g. detector at edge of large protractor/lengths & trig ratio used)
Do not allow vague 'use a protractor'.
This mark can be awarded even if the detector has not been specified.

A3 Use Hall probe/search coil/current balance to measure field strength **1**
Allow Helmholtz coils expression if Helmholtz coils used.
Allow a current or voltage measurement as indication of field strength (as I α B)

B1 Method of removing α radiation or statement that α radiation almost undeflected **1**
Use paper or distance to detector > few cm/air to absorb alpha
Could be shown on the diagram. Do not allow lead/aluminium plate.
Allow α to be shown deflecting in the opposite direction to β on the diagram.

B2 γ -radiation undeflected/deflect beta particles using electric field **1**
Can be shown on diagram. Do not allow 'absorb gamma with lead plate'.

B3 Workable procedure for uniform fields **1**
Measure deflection and field strength; change current in coils and repeat.

C1/2 Any two safety precautions **2**
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
place lead sheet at 'end of experiment' to absorb unwanted rays

D1/2 Any good/further detail. Examples of creditworthy points might be: **2**
Type of detector (GM tube/film/screen/scintillation counter). N/a cloud chamber/CRO
Repeat readings to allow for randomness of activity
Correct deflection of beta on diagram/left hand rule ideas (diagram or written)
Separation of coils = radius of coils for uniform field
Discussion of count rate (and not just count)
Plane of semiconductor slice is perpendicular to field lines
Calibrate Hall probe
Detail of calibration
Collimation ideas
Allow other valid points. Any two, one mark each.
B1 = B2 = B3 = 0 if lead or aluminium plate is placed in front of the source. Allow thin (less than 1 mm) sheet or foil

10 marks in total.

June 2004

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 40

SYLLABUS/COMPONENT: 9702/06

PHYSICS
Paper 6 (Options (A2))

UNIVERSITY of CAMBRIDGE
International Examinations

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.

Option A – Astrophysics and Cosmology

1	**(a)**	In an infinite and static Universe		M1	
		every line of sight should end on a star		M1	
		(or spherical shells argument)			
		so sky at night should be bright		A1	**[3]**
	(b)	For expanding Universe			
		finite age limits size	(1)		
		light from distant galaxies is red-shifted out of visible	(1)		
		light from distant young stars not yet reached Earth	(1)		
		Any two points, maximum 2		B2	**[2]**
			Total		**[5]**
2	**(a)**	1 pc = 3.26 ly (allow 3.3 ly)		C1	
		distance = 16/3.26 = 4.9 pc		A1	**[2]**
	(b)	base line is 2 AU		C1	
		angle = 2 x 1/4.9			
		= 0.41 arc sec		B1	**[2]**
			Total		**[4]**
3	**(a)**	Universe is same everywhere/homogeneous/isotropic		M1	
		when considered on a sufficiently large scale		A1	**[2]**
	(b)	characteristic of (black body) 3 K radiation		B1	
		CMB is highly isotropic/same from all directions		M1	
		This indicates that the Universe is highly uniform		A1	**[3]**
			Total		**[5]**
4	**(a)**	e.g. planet observed by reflected light		B1	
		this is too faint (against the starlight)		B1	
		e.g. physically too small		B1	
		to be resolved (at such great distances)		B1	**[4]**
		(any sensible suggestion (B1) with some further comment (B1) – max 4)			
	(b)	e.g. change in intensity of starlight		M1	
		as the star is eclipsed		A2	**[2]**
		e.g. wobble in position of star (M1)			
		as planet orbits star (A1)			
		(any sensible suggestion plus some further comment – max 2)			
			Total		**[6]**

Option F – The Physics of Fluids

5	**(a)**	force = upthrust – weight of polystyrene in air		C1	
		25 = V x (1000 – 15) x 9.8		C1	
		$V = 2.6 \times 10^{-3}$ m^3		A1	**[3]**
	(b)	boat will tend to right itself/float higher in the water		M1	
		if at positions B		A1	**[2]**
			Total		**[5]**
6	**(a)**	if air is streamline		B1	
		air above car moves faster than air below		M1	
		so (by Bernoulli) pressure above is lower than below		M1	
		and car experiences an upward force		A1	**[4]**
	(b)	the spoiler causes turbulence		M1	
		turbulence prevents the lift force from developing		A1	**[2]**
			Total		**[6]**

7	**(a)**	symmetrical pattern on above/below sphere	M1

			lines closer near top and bottom of sphere	A1	**[2]**
	(b)	**(i)**	force on particle = 4/3 πr^3 ($\rho - \rho_w$)g	C1	
			= 4/3 x π x $(4.5 \times 10^{-7})^3$ x (2.9×10^3) x 9.8		
			= 1.08(5) x 10^{-14} N	C1	
			1.085 x 10^{-14} = 6 x π x (4.5×10^{-7}) x 9.5 x 10^{-4} x v	C1	
			v = 1.35 x 10^{-6} m s^{-1}	A1	**[4]**
		(ii)	in 1.0 hours, particles move 1.35 x 10-6 x 3600 (= 4.85 x 10^{-3} m)	B1	
			fraction = (8.0 – 4.85)/8.0	C1	
			= 0.39	A1	**[3]**
			(allow 2/3 for answer of 0.61)		
				Total	**[9]**

Option M – Medical Physics

8	**(a)**		piezo-electric/quartz crystal	B1	
			across which is applied an <u>alternating</u> voltage	B1	
			crystal vibrates	B1	
			at its resonant frequency	B1	**[4]**
	(b)	**(i)**	trace length = 4.0 mm	C1	
			distance = speed x time = 1450 x 0.4 x 10 x 10^{-6}		
			= 5.8 x 10^{-3} m	C1	
			thickness = 0.29 cm	A1	**[3]**
		(ii)	trace length = 5.2 cm	C1	
			thickness = 4.1 cm	A1	**[2]**
				Total	**[9]**
9	**(a)**		ability of eye to form focused images	M1	
			of objects at different distances from the eye	A1	**[2]**
	(b)	**(i)**	25 cm (allow $\pm$ 5 cm) to infinity	B1	**[1]**
		(ii)	(for close-up vision), power = 1/0.25 – 1/1.2	C1	
			= 3.17 D	A1	
			(for distance vision), power = -0.25D	A1	**[3]**
		(iii)	use bifocal lenses	B1	
			further detail e.g. region of lens identified	B1	**[2]**
				Total	**[8]**
10			loss of hearing at higher frequencies	B1	
			loss of sensitivity (at about 3 kHz)	B1	
			further comment on either e.g. upper limit should be about 15 kHz, at 3 kHz, I.L. should be about 10 dB (or less)	B1	**[3]**
				Total	**[3]**

Option P – Environmental Physics

11	**(a)**	**(i)**	Sun's energy incident per unit time per unit area	M1	
			on the cross-sectional area of the Earth	A1	**[2]**
		(ii)	solar constant = $(3.9 \times 10^{26})/(4\pi \times \{1.5 \times 10^{11}\}^2)$	C1	
			= 1380 W m^{-2}	A1	**[2]**
	(b)		at C, greater thickness of atmosphere so more absorption	B1	
			also larger area (for beam of a particular width)	B1	
			explanation of 'larger area' (e.g. diagram or 1/cosθ, with θ clear)	B1	**[3]**
				Total	**[7]**
12	**(a)**		e.g. daily variations as industry opens up/closes down daily variations with TV programmes, cooking meals, lighting seasonal variations with heating/AC, length of day		
			(any reasonable response, 1 for daily, 1 for seasonal plus 1 more)		
			1 each, max 3	B3	**[3]**
	(b)		power demand may change <u>suddenly</u>	B1	
			pumped water scheme can be brought onto full load in a short time	B1	
			can use surplus energy at times of low demand to pump water 'back up'	B1	**[3]**
				Total	**[6]**

13	**(a)**	**(i)**	work done	$= \rho \Delta V$	C1		
				$= 55 \times 10^5 \times (150 - 40) \times 10^{-6}$	M1		
				$= 605$ J	A0		
		(ii)	energy wasted	$= (2500 + 400) - (1020 + 605) = 1275$ J	A1		
		(iii)	efficiency	$= 1625/2900$	C1		
				$= 0.56$ or 56%	A1		**[5]**
	(b)		similarity:	e.g. compression/expansion are both adiabatic	B1		
			difference:	e.g. in petrol engine, energy input at constant volume	B1		**[2]**
				Total			**[7]**

Option T - Telecommunications

14	**(a)**		$10 \lg(P_1/P_2)$ or $10 \lg(P_2/P_1)$		B1		**[1]**
	(b)		$10 \lg(25.4/1.0) = 14$ dB		A1		
			above the reference level		A1		**[2]**
	(c)	**(i)**	loss of signal power/energy		B1		
		(ii)	length	$= 14/3.2$	C1		
				$= 4.4$ km	A1		**[3]**
				Total			**[6]**
15	**(a)**		amplitude of the carrier wave varies		M1		
			in synchrony with the displacement of the information signal		A1		**[2]**
	(b)	**(i)**	broadcast frequency = 50 kHz		C1		
			$3.0 \times 10^8 = 50 \times 10^3 \times \lambda$		C1		
			$\lambda = 6000$ m		A1		
		(ii)	bandwidth = 7.0 kHz		A1		
		(iii)	maximum frequency = 3.5 kHz		A1		**[5]**
				Total			**[7]**
16	**(a)**		period (or orbit) is 24 hours		B1		
			equatorial (orbit)		B1		
			(satellite orbits) from west to east		B1		**[3]**
	(b)	**(i)**	allow 2 GHz → 40 GHz		B1		
		(ii)	prevent swamping of the (low power) signal received from Earth		B1		**[2]**
	(c)		advantage: e.g.	fewer satellites required aerials point is fixed direction/no tracking required (any sensible suggestion, 1 mark)	B1		
			disadvantage: e.g.	noticeable time delay in messages reception difficult at Poles (any sensible suggestion, 1 mark)	B1		**[2]**
				Total			**[7]**