CAMBRIDGE
INTERNATIONAL EXAMINATIONS

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

CAMBRIDGE
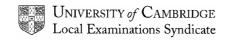## INTERNATIONAL EXAMINATIONS

November 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 60

SYLLABUS/COMPONENT: 9702/02

PHYSICS
Paper 2 (Structured Questions (AS))

Categorisation of marks

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

B marks: These are awarded as <u>independent</u> 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 <u>method</u> 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 <u>compensatory</u> 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 <u>answer</u> 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) (i) acceleration (allow a definition of acceleration)............................ B1

(ii) the velocity is decreasing or force/acceleration is in negative
direction – accept 'body is decelerating'/'slowing down' .... B1   [2]

(b) (i) e.g. separation of dots becomes constant/does not continue to
increase (must make a reference to the diagram) B1

(ii)1 distance = 132 cm.. B1

(ii)2 at constant speed, distance travelled in 0.1 s = 25 cm
(allow ± 1 cm)... C1
distance = 132 + (4 x 25)
= 232 cm .... A1   [4]

(c) $s = ut + \frac{1}{2}at^2$
$1.6 = \frac{1}{2} \times 9.8 \times t^2$ (allow $g = 10$ m s^{-2} C1
$t = 0.57$ s.. C1
hence 6 photographs ('bald' answer scores 2 marks only)........... A1   [3]

2 (a) mass: measure of body's resistance/inertia to changes in
velocity/motion B1
weight: effect of gravitational field on mass or force of gravity B1
any further comment e.g. mass constant, weight varies/
weight = mg/scalar and vector .... B1   [3]

(b) e.g. where gravitational field strength changes
(change) in fluid surrounding body…. *1 each, max 2* .... B2   [2]

3 (a) force x perpendicular distance M1
(of the force) from the pivot... A1   [2]

(b) no resultant force (in any direction)... B1
no resultant moment (about any point).. B1   [2]

(c) (i) correct direction in both.. B1   [1]

(ii)1 moment = 150 x 0.3 = 45 N m (1 sig. fig. -1) A1

(ii)2 torque = 45 N m i.e. same is (i) A1

(ii)3 45 = 0.12 x T.. C1
T = 375 N .... A1   [4]

4 (a) (i)1 amplitude = 0.4(0) mm A1

(i)2 wavelength = 7.5 x 10^{-2} m
(1 sig. fig. -1 unless already penalised)....................................... A1

(i)3 period = 0.225 ms C1
frequency = 1/T = 4400 Hz.. A1

(i)4 $v = f\lambda$
= 4400 x 7.5 x 10^{-2} C1
= 330 m s^{-1}.. A1   [6]

(a) **(ii)** reasonable shape, same amplitude and wavelength doubled ...... B1 [1]

(b) **(i)** 1.7(2) μm A1

(ii) $d \sin\theta = n\lambda$ (double slit formula scores 0/2)
$1.72 \times 10^{-6} \times \sin\theta = 590 \times 10^{-9}$ C1
$\theta = 20.1°$ (allow 20°) A1

(iii) $\frac{1}{2}L = 1.5 \tan 20.1$ C1
$L = 1.1$ m .... A1 [5]

5 (a) **(i)** arrow from B towards A.. B1

(ii) $E = V/d$
$= 450/(9.0 \times 10^{-2})$ C1
$= 5.0 \times 10^{3}$ N C^{-1} (accept 1 sig. fig) .... A1 [3]

(b) **(i)** energy $= qV$ or Eqd C1
$= 1.6 \times 10^{-19} \times 450$ A1
$= 7.2 \times 10^{-17}$ J A0

(ii) $E_k = \frac{1}{2}mv^2$
$7.2 \times 10^{-17} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$ C1
$v = 1.26 \times 10^{7}$ m s^{-1} .... A1 [4]

(c) line from origin, curved in correct direction but not 'level out' .... B1 [1]

6 (a) **(i)** 26 protons... B1

(ii) 30 neutrons.. B1 [2]

(b) **(i)** mass $= 56 \times 1.66 \times 10^{-27}$ C1
(allow x 1.67×10^{-27} but 0/2 for use of 26 or 30)
$= 9.3 \times 10^{-26}$ kg... A1

(ii) density $=$ mass/volume where volume $= 4/3 \times \pi \times r^3$................... C1
$= (9.3 \times 10^{-26})/(4/3 \times \pi \times \{5.7 \times 10^{-15}\}^3)$
$= 1.2 \times 10^{17}$ kg m^{-3} .... A1 [4]

(c) nucleus occupies only very small fraction of <u>volume of atom</u>
or 'lot of empty space inside atom' B1
(do not allow spacing between atoms)
any further good physics e.g. nuclear material is very dense .... B1 [2]

7 (a) **(i)** $P = Vi$ C1
$1200 = 240 \times i$ M1
$i = 5.0$ A A0

(ii) $V = iR$
$240 = 5.0 \times R$ C1
$R = 48\Omega$ .... A1 [4]

(b) **(i)** p.d. $= (5.0 \times 4.0 =)$ 20 V A1

(ii) mains voltage $= (240 + 20 =)$ 260 V A1

(iii) $P = (20 \times 5.0 =)$ 100 W... A1 [3]

(c) power input $= 1200 + 100 = 1300$ W C1
efficiency $= 1200/1300 = 0.92$ .... A1 [2]

CAMBRIDGE
INTERNATIONAL EXAMINATIONS

November 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 25

SYLLABUS/COMPONENT: 9702/03

PHYSICS
Paper 3 (Practical (AS))

(c) (ii) Percentage uncertainty in first value of *d*   **2/1/0**
Uncertainty = 1 mm or 2 mm scores 1 mark.
Ratio idea correct scores 1 mark.

(e) (i) Readings   **3/2/1/0**
6 sets of values for *d*/*T* scores 1 mark.
Check a value for *T*. Underline checked value. Tick if correct and score 1 mark.
Ignore rounding errors. If incorrect, write in correct value and do not award the mark.
If there is no record of the number of oscillations then do not award this mark.
If there are no raw times do not award this mark.
If *t* for *T* then do not award this mark and ecf into the calculation for *d*/*T*.
Check a value for *d*/*T*. Underline this value. Tick if correct and score 1 mark.
Ignore rounding errors.
If incorrect, write in correct value and do not award the mark. ecf for *T*.
Help given by Supervisor, then -1. Excessive help then -2.
Misread stopwatch –1.

(e) (i) Repeated readings   **1**
For each value of *d* there must be at least two values of *t*.
Do not award this mark if all of the repeats are identical.

(e) (i) Reasonable time used for oscillations   **1**
At least half of the raw times must be greater than 20 s.
If there are no raw times do not award this mark.

(e) (i) Quality of results   **2/1/0**
Judge by scatter of points about the line of best fit.
6 trend plots with little scatter scores 2 marks.
5 trend plots with little scatter scores 1 mark.
Wrong trend of plots cannot score these marks (i.e. *t* increases as *d* increases)

(e) (i) Column headings   **1**
Apply to *d*/*T* only.

(e) (i) Consistency   **1**
Apply to *d* only. All the values of *d* must be given to the nearest millimetre.

(e) (i) Significant figures   **1**
Apply to *d*/*T* only.
d/*T* must be given to the same number, or one more than, the number of
significant figures as the least accurate data. Check each value by row.

(e) (ii) Justification for sf in *d*/*T*   **2/1/0**
Answer must relate sf in *d* (and *t*) to sf in *d*/*T*.
Do not allow answers in terms of decimal places.
'Raw data' ideas or reference to *T* instead of *t* can score 1/2 marks.

(f) (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. Scales must be labelled with the quantities plotted.
Do not allow awkward scales (e.g. 3:10, 6:10, 7:10 etc.). Ignore unit.
Do not allow large gaps in the scale (i.e. 4 large squares or more).

(f) (i) Plotting of points   **1**
Count the number of plots and write as a ringed number on the grid.
All observations must be plotted. There must be at least 5 plots on the grid.
Check a suspect plot. Circle and tick if correct. If incorrect, show correct position
with arrow, and do not award the mark. Work to half a small square.

(f) (i)   Line of best fit   **1**
There must be a reasonable balance of points about the line of best fit.
Only a straight line drawn through a linear trend is allowable.

(f) (ii)   Determination of gradient   **1**
Δ used must be greater than half the length of the drawn line.
$\Delta x/\Delta y$ scores zero. The value must be negative (if the line has a negative gradient).
Check the read-offs. Work to half a small square.

(f) (ii) y-intercept   **1**
The value may be read directly or calculated using $y = mx + c$ and a point on the line.

(g$_1$)   Gradient equated with $-\pi^2/g$ **1**

(g$_2$)   Value of g   **1**
Accept $9.3 \text{ m s}^{-2} < g < 10.3 \text{ m s}^{-2}$.
This mark can only be scored if the gradient has been used.

(g$_3$)   Unit of g **1**
Must be consistent with the working.

(g$_4$)   Intercept equated with T_O **1**
A numerical value is expected. Allow ecf from candidate's value in **(f) (ii)**.

(g$_5$)   Unit of T_O **1**

(h)   Suggested improvement; e.g.   **1**
Measure the time for a greater number of oscillations: Use a thinner rod/knife edge
for the stop: Use a fiducial marker/projection on screen: Use an electronic
timing method (e.g. light gates & timer/datalogger & motion sensor/laser & timer)
Use larger values of d. Do not allow 'repeat readings', 'more sensitive stopwatch',
'do the experiment in a vacuum', switch the fans off', 'use heavier bob', 'avoid
parallax error' or 'use a computer'.

25 marks in total.

November 2003

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 <u>independent</u> 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 <u>method</u> 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 <u>compensatory</u> 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 <u>answer</u> 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) (i) radial lines... B1
pointing inwards B1

(ii) no difference OR lines closer near surface of smaller sphere ...... B1 [3]

(b) (i) $F_G = GMm/R^2$.. C1
  $= (6.67 \times 10^{-11} \times 5.98 \times 10^{24})/(6380 \times 10^3)^2$
  $= 9.80$ N A1

(ii) $F_C = mR\omega^2$ C1
$\omega = 2\pi/T$ C1
$F_C = (4\pi^2 \times 6380 \times 10^3)/8.64 \times 10^4)^2$
  $= 0.0337$ N A1

(iii) $F_G - F_C = 9.77$ N.. A1 [6]

(c) because acceleration (of free fall) is (resultant) force per unit
mass B1
acceleration $= 9.77$ m s^{-2} .... B1 [2]

2 (a) (i) a, ω and x identified ....(-1 each error or omission) B2

(ii) (-)ve because a and x in opposite directions
OR a directed towards mean position/centre................................ B1 [3]

(b) (i) forces in springs are $k(e + x)$ and $k(e - x)$ C1
resultant $= k(e + x) - k(e - x)$ M1
  $= 2kx$ .... A0 [2]

(ii) $F = ma$ B1
$a = -2kx/m$ A0
(-)ve sign explained... B1 [2]

(iii) $\omega^2 = 2k/m$ C1
$(2\pi f)^2 = (2 \times 120)/0.90$ C1
$f = 2.6$ Hz .... A1 [3]

(c) atom held in position by attractive forces
atom oscillates,
not just two forces OR 3D not 1D
force not proportional to x
any two relevant points, 1 each, max 2 .... B2 [2]

3 (a) pV/T = constant.. C1
$T = (6.5 \times 10^6 \times 30 \times 300)/(1.1 \times 10^5 \times 540)$................................ C1
  $= 985$ K... A1 [3]
(if uses °C, allow 1/3 marks for clear formula)

3 (b) (i) $\Delta U = q + w$
symbols identified correctly M1
directions correct.. A1 [2]

(ii) q is zero B1
w is positive OR $\Delta U = w$ and U increases B1
ΔU is rise in kinetic energy of <u>atoms</u> M1
and mean kinetic energy $\propto T$ .... A1 [4]
(allow one of the last two marks if states 'U increases so T rises')

4 (a) single diode..M1

in series with R *OR* in series with a.c. supply ....A1   [2]

(b) (i)1 5.4 V (allow ± 0.1 V)... A1

(i)2 $V = iR$

$I = 5.4/1.5 \times 10^3$ C1

$= 3.6 \times 10^{-3}$ A A1

(i)3 time = 0.027 s .... A1   [4]

(ii)1 $Q = it$

$= 3.6 \times 10^{-3} \times 0.027$ C1

$= 9.72 \times 10^{-5}$ C A1

(ii)2 $C = \Delta Q/\Delta V$ (allow C – Q/V for this mark) C1

$= (9.72 \times 10^{-5})/1.2$

$= 8.1 \times 10^{-5}$ F .... A1   [4]

(c) line: reasonable shape with less ripple.............................. B1   [1]

5 (a) field producing force of 1.0 N m^{-1} on wire *OR* $B = F/IL\sin\theta$...........M1

carrying current of 1.0 A normal to field *OR* symbols explained ... A1   [2]

(b) (i) $\phi = BA$

$= 1.8 \times 10^{-4} \times 0.60 \times 0.85$ C1

$= 9.18 \times 10^{-5}$ Wb .... A1   [2]

(ii)1 $\Delta\phi = 9.18 \times 10^{-5}$ Wb.. A1

(ii)2 $e = (N\Delta\phi)/\Delta t$

$= (9.18 \times 10^{-5})/0.20$ C1

$= 4.59 \times 10^{-4}$ V .... A1   [3]

(iii) there is an e.m.f. and a complete circuit

OR no resultant e.m.f. from other three sides

OR no e.m.f. in AB   so yes.. B1   [1]

6 (a) packet/quantum of energy..M1

energy = hf..A1   [2]

(b) e.g. threshold frequency outlined

max. k.e. independent of intensity

max. k.e. dependent on frequency (n.b. NOT proportional)

photoelectric current depends on intensity

instantaneous emission …. (*1 each, max 3*)........................ B3   [3]

(c) (i) photons have same energy so E_{max} unchanged

intensity *OR* number of photons per unit time is halved,

so ½n *OR* n reduced B1

(allow 1 mark for statement that E_{max} unchanged and *n* reduced)

(ii) photons have higher energy so E_{max} increases............................ B1

but fewer photons per unit time so *n* decreases .... B1   [4]

(allow 1 mark for statement that E_{max} increases and n reduced)

(allow any argument based on increased efficiency)

© University of Cambridge Local Examinations Syndicate 2003

CAMBRIDGE
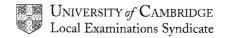## INTERNATIONAL EXAMINATIONS

November 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 30

SYLLABUS/COMPONENT: 9702/05

PHYSICS
Paper 5 (Practical (A2))

Question 1

(b) Temperature of ice/water mixture (-1 to +2°C; ignore unit and sf) **1**

(d$_1$) Readings **3/2/1/0**
6 values of ln I 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 a value for ln(I/A). Tick if correct and score one mark.
If incorrect, write in correct value and do not award the mark.
Ignore small rounding errors.
No help from Supervisor scores one mark. Minor help zero. Major help –1.
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.

(d$_2$) Quality of results **2**
Judge by scatter of points about the line of best fit.
6 trend scores 2 marks; 5 trend scores one mark; no trend scores zero.
Allow very shallow curve.
If an incorrect graph has been plotted these marks cannot be awarded.
Allow quality marks if the negative signs of ln I have been omitted.

(d$_3$) Column headings **1**
Each column heading must contain a quantity and a unit.
There must be some distinguishing feature between the quantity and the unit.
Ignore unit with column heading for ln I.

(d$_4$) Consistency of raw readings **2**
All the raw readings of V should be given to the same number of d.p.
All the raw readings of I should be given to the same number of d.p.
One mark each. Do not allow 'added zeros'.

(e$_1$) Axes **1**
The axes must be labelled with ln I and V.
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.).

(e₂) Plotting of points   1
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 do not award the mark. Allow errors up to and
including half a small square.

(e₃) 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.
Allow this mark if the trend of plots is a very shallow curve.

(e₄) 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.

(e₅) *y*-intercept   1
The value may be read from the *y*-axis or calculated from a point on the line
using $y = mx + c$.

(f₁) e/kT = gradient   1
Can be implied in the working.

(f₂) Value for *e*   1
A numerical value is expected. Method of working must be correct.
1.6×10^{-19} C with no working scores zero.
Gradient and kelvin must be used and the value of *e* must be … $\times 10^{-19}$ or … $\times 10^{-20}$.

(f₃) Value for I_O 1
Working must be checked (i.e. $I_o = e^{y\text{-intercept}}$)

(f₄) Units of both correct *e* and I_o 1
(i.e. a unit of charge and a unit of current)

(f₅) SF in *e*   1
Allow 2 of 3 sf only

(g) Correct working to give *I* when *V* = 1.0 V and *T* = 373 K   1
Method of working must be correct. Ignore unit and sf.
Do not allow gradient value to be substituted.

20 marks in total.

Question 2

A1   Procedure OK (i.e. find m_B and acc^n of A or B; <u>change</u> m_B and repeat).   **1**
An experiment must have been described for this mark to be awarded.
This mark can be scored even if the method is unworkable.

A2   Diagram of <u>workable</u> arrangement to find acceleration   **1**
(e.g. object falls between two markers/light gates/smart pulley at top)
If the diagram is not very detailed refer to text.

A3   Measurement of mass m_B (e.g. using balance/Newton meter/calibrations on masses)   **1**

B1   <u>Valid</u> <u>method</u> of measuring time   **1**
Accept stopwatch; ticker-tape; light gates; motion sensors and
dataloggers; smart pulley etc..
Unworkable methods will not score this mark.

B2   Correct measurements taken to find acceleration   **1**
(e.g.   measure a distance and $u = 0$ (if distance/time method used)
        spacing of successive dots on ticker-tape
        some detail of sampling rate if motion sensor/datalogger used)

B3   Use of results to calculate acceleration   **1**
(e.g.   substitute into $s = ut + \frac{1}{2}at^2$; $a = 25(x_2 - x_1)$ etc..)
If motion sensor used then acceleration obtained from monitor.

C1   Any one safety precaution   **1**
(e.g.   Catch falling mass in bucket of sand
        Care needed to prevent mass B from coming over the top of the pulley
        Whiplash from breaking wires etc.
        Clamp retort stand to prevent it from falling over.
        Do not allow vague 'safety goggles'. Insist on a reason being given.

D1/2/3 Any further good design features   **3**
Some of these might be:
Method of supporting the pulley
Mention of friction in the pulley/oil pulley/smooth pulley
Use large distance (to reduce percentage uncertainty)
Limitations of stopwatch methods
Vary s and measure t; use graph to find a
Repeat the experiment to find values of a for each value of m_B
Some detail about the timing circuit (e.g. stop terminals on timer connected to double pole
switch and electromagnet).

10 marks in total.

CAMBRIDGE
INTERNATIONAL EXAMINATIONS

November 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 40

SYLLABUS/COMPONENT: 9702/06

PHYSICS
Paper 6 (Options (A2))

Categorisation of marks

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

B marks: These are awarded as <u>independent</u> 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 <u>method</u> 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 <u>compensatory</u> 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 <u>answer</u> marks which either depend on an M-mark, or allow a C-mark to be scored.

<u>Conventions within the marking scheme</u>

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) galaxy very distant
light (reaching Earth) very faint
light absorption in Earth's atmosphere (do not allow refraction)
light pollution
light scattered……………… (*1 each, any 4*)................................ B4   [4]

(b) 1 arc sec at 6.9×10^5 pc corresponds to 6.9×10^5 AU C1
1 ly = $6.3 (\pm 0.3) \times 10^4$ AU or other valid conversion C1
hence distance = 11 light-years .... A1   [3]

2 (a) If Universe is (static and) infinite B1
every line of sight would end on a star M1
entire sky would be equally bright .... A1   [3]

(b) shows infinite (static) Universe to be incorrect
(allow back-credit to (a) for initial supposition B1
does not 'prove' Big Bang model .... B1   [2]

3 (a) (i) electromagnetic radiation.. B1
either characteristic of black body at 3 K *or* isotropic .... B1   [2]

(ii) finite age for Universe.. B1
indicated by cooling Universe B1
any further detail e.g. irregularities required for galaxy   [3]
formation B1

(b) radiation takes millions of years to reach Earth.......................... B1
provides evidence for higher temperature in the past.................... B1
(Universe is cooling) as it expands .... B1   [3]

Option F – The Physics of Fluids

4 (a) point where line of action of the upthrust or vertical line through
centre of buoyancy meets centre line of ship .... B1   [2]

(b) (when submarine surfaces), water replaced by air <u>in tanks</u> B1
centre of mass <u>and</u> centre of buoyancy will move........................ M1
causing change in separation of these points .... A1   [3]

5 (a) (Bernoulli:) higher speed, lower pressure.................................... M1
so A at higher pressure.. A1   [2]

(b) $Av = A_N v_N$ or statement (e.g. incompressible) B1
$v_N/v (= A/A_N) = 2.4^2/0.8^2$ or other correct substitution B1
ratio = 9.0 .... A0   [2]

(c) $p_1 - p_2 = \Delta p = \frac{1}{2}p(v_2{}^2 = v_1{}^2)$................................... C1
$740 = \frac{1}{2} \times 990 \times (81v^2 - v^2)$.. C1
$v = 0.14$ m s^{-1} .... A1   [3]

6 (a) (i) upthrust = $4/3 \times \pi r^3 \rho_F g$... B1

(ii) resultant downward force = $4/3 \times \pi r^3 (\rho_S - \rho_F)g$
or $4/3 \times \pi r^3 (\rho_S - \rho_F)g - viscous\ force$..... B1   [2]

(b) $6\pi r\eta v_t = 4/3 \times \pi r^3 (\rho_S - \rho_F)g$... M1

        hence, $v_t = kr^2$ A0

        constant k discussed .... A1   [2]

(c)   **(i)**   e.g.   find speed near 'top' and near 'bottom' of tube M1

                using equally spaced markers (or other detail).................... A1

     (ii)   oil flowing past wall of tube B1

          would cause extra drag... B1   [4]

Option M – Medical Physics

7   large uniform magnetic field... B1

          with superimposed non-uniform field.. B1

          r.f. pulse applied B1

          r.f. pulse (from atoms) detected and processed B1

          plus any two (one each) from

          hydrogen atoms

          nuclei have spin and behave as tiny magnets

          atoms precess around magnetic field

          resonant (Lamour) frequency depends on B-field

          de-excitation detected

          r.f. pulse detected and processed .... B1   [6]

8 (a)   **(i)** $1/u + 1/v = 1/f$ = power C1

          power = $1/0.10 + 1/(17 \times 10^{-3})$.. C1

          power = 68.8 D A1

     (ii)   least distance of distinct vision = 25 cm (allow 20 cm → 50 cm).. C1

          power = $1/0.25 + 1/(17 \times 10^{-3})$

          power = 62.8 D .... A1   [5]

(b)   **(i)**   change = 6.0 D N.b. answer is (i) – (ii)... B1

     (ii)   focal length = 16.7 cm.. B1

          convex/converging lens .... B1   [3]

9 (a)   **(i)**   lower limit of frequency range correct (15 to 40 Hz)..................... B1

          upper limit of frequency range correct (13 to 20 kHz) B1

     (ii)   intensity 1.0×10^{-12} W m^{-2} B1

          at about 2 kHz (allow 1 kHz → 3 kHz).. B1   [4]

(b)   line 'above' that already drawn B1

          both frequency limits showing more limited range....................... B1   [2]

Option P – Environmental Physics

10 (a)   source of (useful) energy .... B1   [1]

(b)   e.g. less pollution
         finite reserves
         chemical feedstock etc ………(*1 each, max 3*)....................... B3   [3]

11 (a)   dam <u>across</u> river mouth/estuary... B1
         water retained as tide goes out.. B1
         at low tide, water is released... B1
         through turbines... .... B1   [4]

(b)   mass of water $= 8.0 \times 200 \times 10^6 \times 1000$ kg C1
         change in p.e $= 1.6 \times 10^{12} \times 9.8 \times 4$
                           $= 6.27 \times 10^{13}$ J C1
         power $= 6.27 \times 10^{13}/(3 \times 3600)$
                  $= 5.8 \times 10^9$ W .... A1   [3]

(c)   e.g. silting up
         feeding grounds of birds etc ……(1 each, max 2)................... B2   [2]

12 (a)   open   closed
         closed   closed
         closed   closed
         closed   open……………(*-1 each error or omission*)........ B2   [2]

(b) (i)   at end of compression stroke or at beginning of power stroke B1

      (ii)   at moment when exhaust valve opens B1
               (and during) exhaust stroke .... B1   [3]

(c)   efficient mixing with air or increase surface area......................... B1
         faster burning   .... B1   [2]

Option T – Telecommunications

13 (a)   multiple reflections with $i = r$ .... B1   [1]

(b)   all rays to have same path length/prevent (multipath) dispersion
         OR easier to store/handle .... B1   [1]

(c)   e.g.   greater bandwidth
             no cross-talk or reduced noise
             smaller size and weight
             cheaper
             security
             suited to digital transmission…….. (*1 each, max 3*)............... A3   [3]

14 (a)   amplitude of carrier wave varies.. M1
         in synchrony with (displacement of information) signal .... A1   [2]

(b)   three vertical lines B1
         symmetrical with smaller sidebands.. B1
         at frequencies 70, 75 and 80 kHz... B1   [3]

© University of Cambridge Local Examinations Syndicate 2003

(c)   bandwidth = 10 kHz B1

15 (a) (i)   loss of power/energy/amplitude (not signal) B1

        (ii)   unwanted energy/power B1
              that is random or that covers whole spectrum .... B1   [3]

    (b)   number of dB = $10 \lg(P_{OUT}/P_{IN})$ C1
            $63 = 10 \lg (P_{OUT} /(2.5 \times 10^{-6})$ C1
            P_{OUT} = 5.0 W .... A1   [3]

    (c)   attenuation   = $10 \lg(5/3.5 \times 10^{-8})$ C1
                        = 81.5 dB C1
            length = 81.5/12 = 6.8 km .... A1   [3]