CAMBRIDGE
INTERNATIONAL EXAMINATIONS

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the November 2003 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 discussions or correspondence in connection with these mark schemes.

CIE is publishing the mark schemes for the November 2003 question papers for most IGCSE and GCE Advanced Level syllabuses.

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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))

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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))

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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) (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 $45 = 0.12 \times T$ C1
$T = 375$ N ..... A1 [4]

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

(i)2 wavelength = 7.5×10^{-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 $v = f\lambda$
$= 4400 \times 7.5 \times 10^{-2}$ 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 sinθ = $n\lambda$ (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) ½L = 1.5 tan20.1 ..... 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) Ek = ½mv^2
$7.2 \times 10^{-17} = ½ \times 9.1 \times 10^{-31} \times v^2$ 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 $\times 1.67 \times 10^{-27}$ 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 = 48Ω ..... A1 [4]

(b) **(i)** p.d. = (5.0 x 4.0 =) 20 V A1

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

(iii) P = (20 x 5.0 =) 100 W ..... A1 [3]

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

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November 2003

GCE ADVANCED SUBSIDIARY LEVEL AND ADVANCED LEVEL

MARK SCHEME

MAXIMUM MARK: 25

SYLLABUS/COMPONENT: 9702/03

PHYSICS
Paper 3 (Practical (AS))

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(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 m s^{-2} < g < 10.3 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.

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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

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
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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)

CAMBRIDGE
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November 2003

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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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.).

(e_2) 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.

(e_3) 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.

(e_4) 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.

(e_5) *y*-intercept **1**
The value may be read from the *y*-axis or calculated from a point on the line using $y = mx + c$.

(f_1) e/kT = gradient **1**
Can be implied in the working.

(f_2) 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 … x 10^{-19} or … x 10^{-20}.

(f_3) Value for I_O **1**
Working must be checked (i.e. $I_o = e^{y\text{-intercept}}$)

(f_4) Units of both correct *e* and I_o **1**
(i.e. a unit of charge and a unit of current)

(f_5) 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; change 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 workable 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 Valid method 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.

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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
Local Examinations Syndicate

Categorisation of marks

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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 x 10^5 pc corresponds to 6.9 x 10^5 AU C1
1 ly = 6.3 ($\pm$0.3) x 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 formation ..... B1 [3]

(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 in tanks B1
centre of mass and 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) $p_1 - p_2 = \Delta p = \frac{1}{2}\rho(v_2^2 = v_1^2)$ 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 x $\pi r^3 \rho_F g$ B1

(ii) resultant downward force = 4/3 x $\pi r^3 (\rho_S - \rho_F)g$
or 4/3 x $\pi r^3 (\rho_S - \rho_F)g$ – *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 across 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 x 200 x 10^6 x 1000 kg C1
change in p.e = 1.6 x 10^{12} x 9.8 x 4
= 6.27 x 10^{13} J C1
power = 6.27 x 10^{13}/(3 x 3600)
= 5.8 x 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]

(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 x 10^{-6}) C1
P_{OUT} = 5.0 W .... A1 [3]

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