**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 | |
| | | $V = 2.6 \times 10^{-3}\ \text{m}^3$ | | 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 $= 4/3\ \pi r^3\ (\rho - \rho_w)$g | C1 | |
| | | | $= 4/3 \times \pi \times (4.5 \times 10^{-7})^3 \times (2.9 \times 10^3) \times 9.8$ | | |
| | | | $= 1.08(5) \times 10^{-14}$ N | C1 | |
| | | | $1.085 \times 10^{-14} = 6 \times \pi \times (4.5 \times 10^{-7}) \times 9.5 \times 10^{-4} \times v$ | C1 | |
| | | | $v = 1.35 \times 10^{-6}$ m s$^{-1}$ | A1 | [4] |
| | | (ii) | in 1.0 hours, particles move 1.35 x 10-6 x 3600 (= $4.85 \times 10^{-3}$ 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 = $1450 \times 0.4 \times 10 \times 10^{-6}$ | | |
| | | | $= 5.8 \times 10^{-3}$ 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 ± 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/cos$\theta$, with $\theta$ 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 = $p\Delta V$ | C1 | |
| | | | = 55 x $10^5$ x (150 – 40) x $10^{-6}$ | 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 x $10^8$ = 50 x $10^3$ x $\lambda$ | 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<br>aerials point is fixed direction/no tracking required<br>(any sensible suggestion, 1 mark) | B1 | |
| | | | disadvantage: e.g. noticeable time delay in messages<br>reception difficult at Poles<br>(any sensible suggestion, 1 mark) | B1 | [2] |
| | | | **Total** | | [7] |