UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2006 question paper

9702 PHYSICS

9702/06 Paper 6

Maximum raw mark 40

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which Examiners were initially instructed to award marks. It does 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*.

The minimum marks in these components needed for various grades were previously published with these mark schemes, but are now instead included in the Report on the Examination for this session.

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UNIVERSITY of CAMBRIDGE
International Examinations

Option A - Astrophysics and Cosmology

1 Planet: almost circular orbits **B1**
all in nearly the same plane **B1**

Comet: highly elliptical orbits **B1**
in many different planes **B1** **[4]**

2 **(a)** (mean) density **M1**
of matter in the Universe **A1** **[2]**

(b) **(i)** symmetrical curve below given line **M1**
touching given line at 'present time' **A1** **[2]**

(ii) H_0 not known with any certainty **B1**
mass of matter in the Universe not known **B1**
extent of Universe unknown **B1** **[3]**
(*allow 1 of the last 2 marks for ρ_0 not known*)

3 1 light-year = 0.306 pc (allow 0.3 pc) **C1**
1.3×10^{10} light-years = 3.98×10^3 Mpc **C1**
$v = H_0 d$ **C1**
speed = $60 \times 3.98 \times 10^3 = 2.39 \times 10^5$ km s^{-1}
ratio = $(2.39 \times 10^5 \text{ x } 10^3)/(3.0 \times 10^8)$
= 0.8 **A1** **[4]**

4 e.g. vast expense **(M1)**
money could be spent on humanitarian aid **(A1)**

observations possible that cannot be made on Earth **(M1)**
since atmosphere limits observations **(A1)**

technological/scientific developments on Earth **(M1)**
greater understanding of Universe **(M1)**
leads to 'spin off' benefits for individuals **(A1)**

Any sensible comments, 1 each to max 5 **B5** **[5]**

Option F - The Physics of Fluids

5 **(a)** conservation of volume/mass/density or incompressible **B1** **[1]**

(b) conservation of energy **B1** **[1]**

6 **(a)** air near jet is moving at speed OR water in jet is moving at speed **B1**
higher speed air has a lower pressure OR high-speed water has lower pressure **B1**
(because) air is dragged along by water jet OR air is drawn into water jet **B1**
air (outside pump) is not moving OR loss of air reduces pressure **B1** **[4]**

(b) **(i)** air/water in pump has a higher speed **M1**
so greater pressure difference **A1** **[2]**

(ii) no change in speed of air OR reference to greater ρ in Bernoulli eqn **M1**
so no change in pressure difference OR greater pressure difference **A1** **[2]**

(*allow any logical argument based on liquid causing more/less drag on air*)

7 **(a)** eddy currents have kinetic energy OR cause extra drag **M1**
eddy currents caused by movement of the car OR energy required to overcome drag **A1**
extra energy (of eddy currents) is derived from car's fuel **A1** **[3]**

(b) **(i)** power = force × speed **B1**
so power = $\frac{1}{2}C_D A\rho v^2 \times v$ and A and ρ are constants **B1** **[2]**

(ii) $84 \times 10^3 = \frac{1}{2} \times 0.34 \times 1.8 \times 1.1 \times v_{max}^3$ **C1**
v_{max} = 63 m s^{-1} **A1** **[2]**

(iii) $P = \frac{1}{2} \times 0.34 \times 1.8 \times 1.1 \times (63 + 9)^3$ **C1**
P = 126 kW **C1**
ratio = 126 / 84 = 1.5 **A1** **[3]**

Option M - Medical Physics

8 **(a)** alternating voltage **B1**
applied across (piezo-electric) crystal **B1**
causes crystal to vibrate **B1**
crystal dimensions such as to give resonance (in US range) **B1** **[4]**

(b) wavelength at 1 MHz is shorter **B1**
so greater detail is possible **B1** **[2]**

9 e.g. used as a scalpel (1)
further detail: causes (explosive) vaporisation of intracellular water (1)
CO_2 laser (1)
IR radiation strongly absorbed by water (1)
laser beam focused to give high power density (1)
no/very little bleeding (1)
accurate guidance (1)

e.g. repair of retina (1)
further detail: focused laser beam onto retina (1)
melts tissue and forms a weld (1)
(pulsed) ruby or argon laser (1)

any two examples: named (1) plus further detail (2) **B6** **[6]**

(*allow up to two marks for each diagnostic technique*)

10 **(a)** minimum intensity (of sound) detected **M1**
where intensity = (sound) power per unit area at a stated frequency **A1**
value is 1×10^{-12} W m^{-2} **B1**
at 3 kHz (*allow 2 kHz → 3 kHz*) **B1** **[4]**

(b) (i) intensity = $(0.14 \times 10^{-6})/(54 \times 10^{-6}) = 2.6 \times 10^{-3}$ W m^{-2} **C1**

$IL = 10 \lg (2.6 \times 10^{-3})/(1 \times 10^{-12})$ **C1**

$= 94$ dB **A1** **[3]**

(ii) comment e.g. would be perceived as being loud
could cause tinnitus over a short period of time
could cause deafness over a long period of time
higher level than is acceptable in the workplace

any appropriate comment, 1 mark **B1** **[1]**

Option P - Environmental Physics

11 (a) at times of low usage of electrical power **B1**
water pumped from low-level to high-level reservoir **B1**
at times of high/sudden demand for electrical power **B1**
water released to pass through turbines **B1** **[4]**

(b) electrical energy generated = $78 \times 10^6 \times 4.0 \times 3600 = 1.12 \times 10^{12}$ J **C1**

energy to be stored = $(1.12 \times 10^{12})/0.75 = 1.5 \times 10^{12}$ J **C1**

$1.5 \times 10^{12} = \rho Vgh$ **C1**

$= 1.0 \times 10^3 \times V \times 9.8 \times 95$

$V = 1.6 \times 10^6$ m^3 **A1** **[4]**

12 (a) law: it is impossible to convert all of a given amount of thermal energy into work **B1**
(that is) $W < Q_H$ **B1**
($Q_H - W$) is energy rejected at temperature T_L **B1** **[3]**

(b) $W/Q_H = 1 - T_L/T_H$ **B1** **[1]**

(c) efficiency $= 1 - 313/393$ **C1**

$= 0.20$ **A1** **[2]**

13 (a) (i) e.g. industry setting up
people preparing to go to work
starting to cook breakfast

(*allow any two sensible suggestions, 1 each*) **B2** **[2]**

(ii) e.g. change in temperature with use of heaters/air conditioning
holiday or workday with more power used by industry when not on holiday

(*allow any two sensible suggestions, 1 each*) **B2** **[2]**

(b) (i) sudden increase in demand (as appliances are used) **B1**

(ii) increased demand in the afternoon **B1** **[2]**

(*allow any two sensible suggestions in **(i)** and **(ii)***)

Option T - Telecommunications

14 (a) (instantaneous) displacement of information signal **M1**
determines the frequency of the carrier wave **A1** **[2]**

(b) (i) 12 V **B1** **[1]**

(ii) 650 kHz **B1** **[1]**

(iii) 550 kHz **B1** **[1]**

(iv) 3000 **B1** **[1]**

15 (a) analogue-to-digital converter (*do not allow ADC*) **B1** **[1]**

(b) controls the time at which samples are taken **B1** **[1]**

(c) enables higher frequency components in signal to be 'detected' **B1** **[1]**

16 (a) electromagnetic shielding for the inner conductor **B1**
the braid is earthed **B1** **[2]**

(b) increased bandwidth means more information can be carried **B1**
so more calls can be transmitted simultaneously **B1**
fewer links are required **B1** **[3]**

17 (a) e.g. cross-talk/cross-linking
interference/picking up atmospherics/picking up man-made radiation
white noise associated with vibrating atoms

(*any two, 1 each*) **B2** **[2]**

(b) (i) number of dB = 10 lg (P_2/P_1)
35 = 10 lg ($P/\{7.6 \times 10^{-6}\}$) **C1**
P = 0.024 W **A1** **[2]**

(ii) number of dB = 10 lg (2.6/0.024) = 20.3 **C1**
length = 20.3/5.8 = 3.5 km **A1** **[2]**