Centre Number	Candidate Number	Name

CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/06**

Paper 6 Options

May/June 2003

45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** of the questions in any **two** options.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

For Examiner's Use	
A	
F	
M	
P	
T	
Total	

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Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant,	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
acceleration of free fall,	$g = 9.81\ \text{m s}^{-2}$

Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

work done on/by a gas, $W = p\Delta V$

gravitational potential, $\phi = -\frac{Gm}{r}$

simple harmonic motion, $a = -\omega^2 x$

velocity of particle in s.h.m., $v = v_0 \cos \omega t$
$v = \pm \omega \sqrt{(x_0^2 - x^2)}$

resistors in series, $R = R_1 + R_2 + \ldots$

resistors in parallel, $1/R = 1/R_1 + 1/R_2 + \ldots$

electric potential, $V = \frac{Q}{4\pi\epsilon_0 r}$

capacitors in series, $1/C = 1/C_1 + 1/C_2 + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

energy of charged capacitor, $W = \frac{1}{2}QV$

alternating current/voltage, $x = x_0 \sin \omega t$

hydrostatic pressure, $p = \rho gh$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 \exp(-\lambda t)$

decay constant, $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

equation of continuity, $Av = \text{constant}$

Bernoulli equation (simplified), $p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$

Stokes' law, $F = Ar\eta v$

Reynolds' number, $R_e = \frac{\rho v r}{\eta}$

drag force in turbulent flow, $F = Br^2\rho v^2$

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For Examiner's Use

Answer **all** of the questions in any **two** Options.

The Options are as follows:

Option A	Astrophysics and Cosmology	questions 1, 2 and 3
Option F	The Physics of Fluids	questions 4, 5 and 6
Option M	Medical Physics	questions 7, 8 and 9
Option P	Environmental Physics	questions 10, 11 and 12
Option T	Telecommunications	questions 13, 14 and 15

Option A

Astrophysics and Cosmology

1 Explain briefly what is meant by

(a) a star,

.....

.....

..... [3]

(b) a galaxy,

.....

.....

..... [2]

(c) a planet.

.....

.....

..... [3]

2 Outline how the speed, relative to Earth, of a galaxy may be estimated.

.....

.....

.....

..... [3]

For Examiner's Use

3 **(a)** A galaxy in the constellation Corona Borealis is estimated to be 430 Mpc away from Earth and receding at a speed of 1.8×10^4 km s^{-1}. Calculate a value for the Hubble constant H_0.

H_0 = ... km s^{-1} Mpc^{-1} [2]

(b) Use your answer in **(a)** to estimate

(i) the age, based on the Big Bang model, of the Universe,

age = ... s

(ii) the speed at which the Moon is receding from the Earth.

speed = ... m s^{-1}
[5]

(c) Galaxies close to the Milky Way galaxy have been shown to be moving towards the Milky Way galaxy. Suggest whether this observation contradicts the Big Bang model of the Universe.

.....

.....

..... [2]

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For Examiner's Use

Option F

The Physics of Fluids

4 A lump of pure ice floats on pure water in a beaker, as shown in Fig. 4.1.

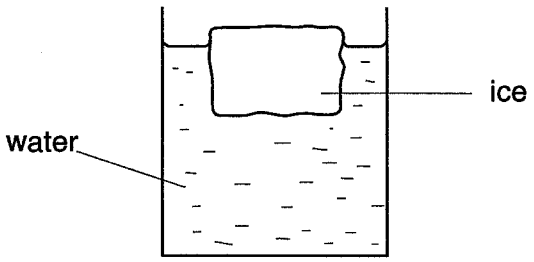

Fig. 4.1

(a) State, qualitatively, the relation between

(i) the mass of the ice and the mass of the displaced water,

.....

(ii) the density of ice and the density of water.

.....

[2]

(b) A student marks the level of the water surface in the beaker and then observes the level as the ice melts. State and explain qualitatively the change, if any, in this level during the melting.

.....

.....

.....

..... [3]

For Examiner's Use

5 **(a)** A simplified form of the Bernoulli equation may be written as

$$p + \frac{1}{2}\rho v^2 = \text{constant}.$$

State **three** conditions that must apply to the fluid for this equation to be valid.

1. .....

2. .....

3. ..... [3]

(b) High-speed trains sometimes pass through stations close to a platform where passengers are standing. In such circumstances, a line may be painted on the platform at some distance from the edge, as illustrated in Fig. 5.1.

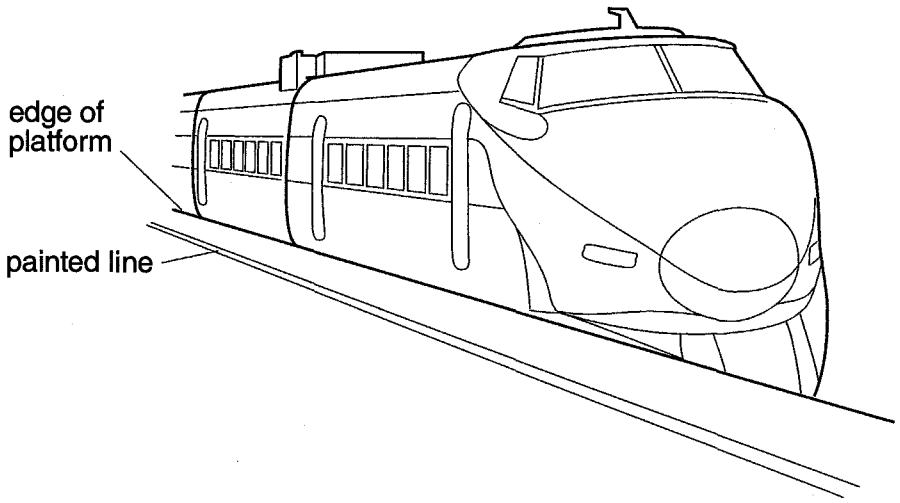

Fig. 5.1

Passengers are warned to keep the line between themselves and the platform's edge. The line is much further from the edge than is required to prevent the passengers being hit by the train.

Suggest why this increased distance is necessary.

.....

.....

.....

.....

..... [4]

[Turn over

For Examiner's Use

6 **(a)** **(i)** Explain what is meant by *turbulence*.

.....

.....

.....

(ii) State and explain why cars are built to reduce turbulence to a minimum.

.....

.....

.....

[4]

(b) The drag force F acting on a car when travelling at speed v in turbulent conditions is given by the expression

$$F = \frac{1}{2} C_D \rho A v^2,$$

where ρ is the density of air and A is the car's frontal area.

(i) Identify the symbol C_D.

.....

(ii) Show that the power P required to overcome this drag force is given by

$$P = \frac{1}{2} C_D \rho A v^3.$$

(iii) For one particular car, C_D is 0.30 and the frontal area A is 2.5 m^2. The power P delivered to overcome drag forces is 120 kW. Calculate the maximum speed of the car in air of density 1.2 kg m^{-3}.

speed = ... $m\,s^{-1}$

[4]

For Examiner's Use

Option M

Medical Physics

7 **(a)** Briefly explain the principles of the production of an X-ray beam.

.....

.....

.....

.....

.....

.....

..... [5]

(b) State how, in an X-ray tube,

(i) the intensity of the X-ray beam may be increased,

.....

(ii) the X-ray beam may be made more penetrating,

.....

(iii) the unwanted 'soft' X-rays may be removed from the beam.

.....

[3]

(c) The intensity of a parallel X-ray beam is reduced to one half of its initial intensity when it passes through bone of thickness 0.40 cm. Calculate the thickness of bone necessary to reduce the beam intensity to one tenth of its initial value.

thickness = ... cm [3]

[Turn over

8 Suggest why, when using a laser as a scalpel,

(a) the laser beam is focused using a short focal length convex lens,

.....

.....

..... [2]

(b) less bleeding is caused than when using a knife.

.....

.....

..... [2]

9 **(a)** Explain what is meant by the *sensitivity* of the ear.

.....

.....

..... [2]

(b) A person stands in a room where the intensity of the background noise due to a party is 4.5×10^{-5} W m^{-2}. The smallest change in intensity level of sound that can be detected by the person is 3.0 dB.

Calculate the change in intensity of sound necessary for the person to hear someone else speak above the background noise.

change = ... W m^{-2} [3]

For Examiner's Use

Option P

Environmental Physics

10 **(a)** Explain what is meant by a *fossil fuel.*

.....

.....

..... [2]

(b) By reference to the Earth's fossil fuels, distinguish between resources and reserves.

resources: .....

.....

reserves: .....

..... [2]

11 **(a)** Describe the nuclear fission process.

.....

.....

.....

.....

..... [4]

(b) Explain the role, in a nuclear reactor, of

(i) the moderator,

.....

(ii) the control rods,

.....

(iii) the reactor vessel.

.....

.....

[4]

[Turn over

For Examiner's Use

12 In a coal-fired generating station, steam from the boiler enters the turbine at 540 °C and leaves at 40 °C, as illustrated in Fig. 12.1.

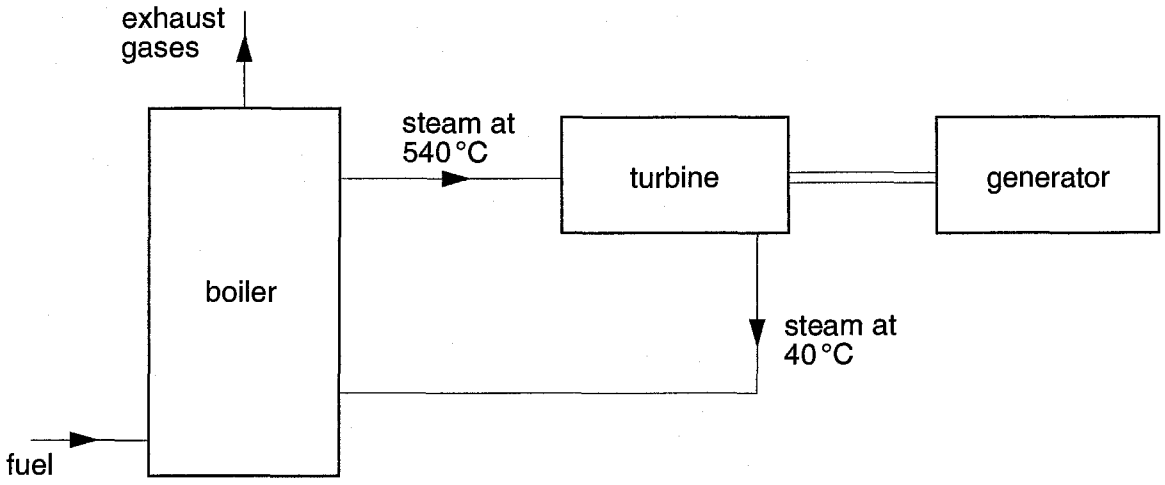

Fig. 12.1

(a) Calculate the maximum efficiency of the turbine.

efficiency = ... [3]

(b) The overall efficiency of the generation of electrical energy in the generating station is 30%.

(i) Suggest one significant source of loss of energy.

.....

.....

(ii) State **two** means by which efficiency is improved.

1. .....

.....

2. .....

.....

[3]

(c) Identify **two** forms of pollution, other than exhaust gases, associated with coal-fired generating stations.

1. .....

2. ..... [2]

Option T

Telecommunications

13 Fig. 13.1 shows the variation with time t of part of the signal voltage V produced by a microphone.

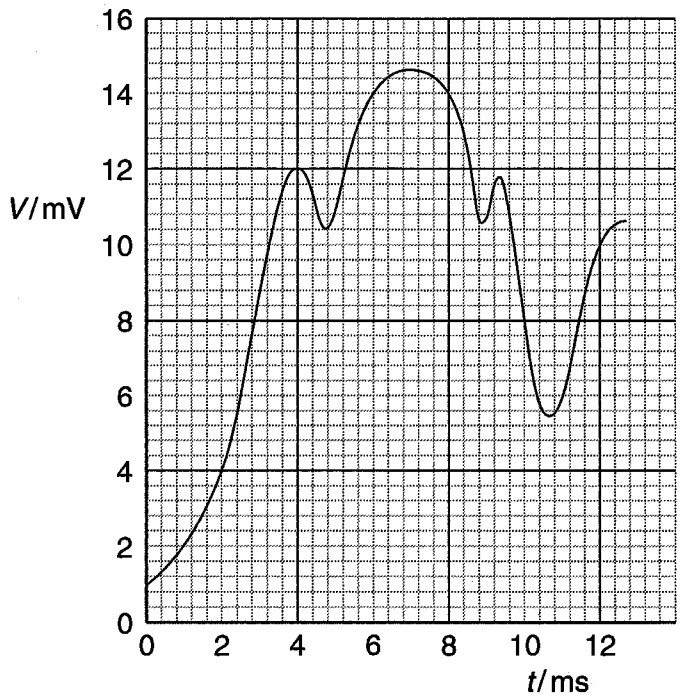

Fig. 13.1

The signal voltage is to be digitised using a 4-bit analogue-to-digital converter (ADC), sampling at 2.0 ms intervals.

(a) The first sample is taken at time $t = 0$. Complete Fig. 13.2 to show the signal voltage and the corresponding binary number at the sampling times shown. [4]

sampling time / ms	signal voltage / mV	binary number
0	1.0	0001
2	.....	.....
4	.....	.....
6	.....	.....
8	.....	.....
10	.....	.....
12	.....	.....

Fig. 13.2

(b) The digitised signal voltage is transmitted and then converted back to an analogue signal using a digital-to-analogue converter (DAC). On Fig. 13.3, draw the variation with time t of the received analogue signal V_r. [2]

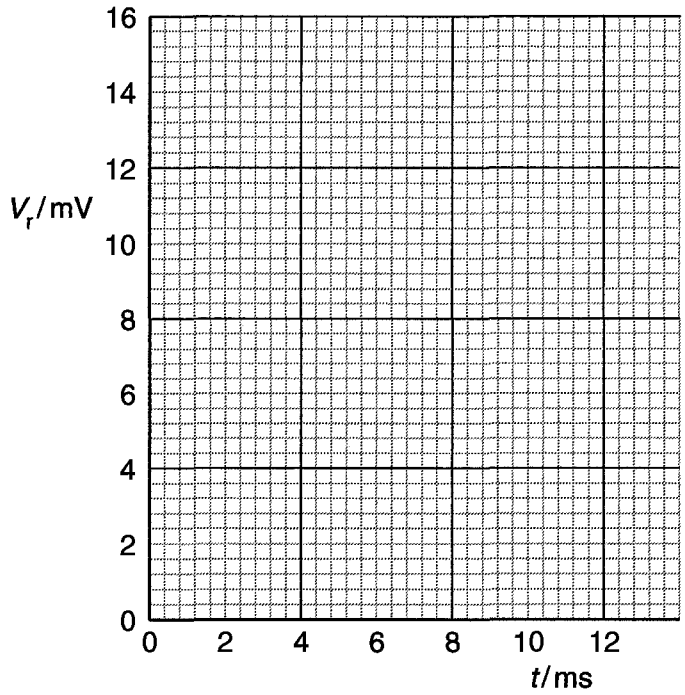

Fig. 13.3

(c) State **two** changes, giving a reason for each, that can be made so as to improve the quality of the received analogue signal.

1. .....

.....

.....

2. .....

.....

..... [4]

14 **(a)** Draw a labelled diagram of a section through a coaxial cable. [2]

(b) State **three** advantages of a coaxial cable compared with a wire pair for the transmission of an electrical signal.

1. .....

2. .....

3. .....[3]

15 A radio signal may be transmitted between a transmitter and a receiving aerial by means of sky waves, ground (surface) waves or space waves. Complete Fig. 15.1 by giving a typical wavelength and the maximum transmission range for each type of wave. [5]

type	wavelength / m	range
sky wave	.....	.....
ground (surface) wave	.....	.....
space wave	.....	.....

Fig. 15.1