Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/06**

Paper 6

October/November 2005

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.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** of the questions in any **two** options.
You may use a soft pencil for any diagrams, graphs or rough working.
You may lose marks if you do not show your working or if you do not use appropriate units.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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,	$g = 9.81\ \text{m s}^{-2}$

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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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[Turn over

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

Answer the questions in the spaces provided on the Question Paper.

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 **(a)** Define

(i) the astronomical unit (AU),

.....

.....[1]

(ii) the parsec (pc).

.....

.....

.....[2]

(b) Calculate the magnitude, in metres, of the parsec given that 1.0 AU = 1.5×10^{11} m.

1.0 parsec = ... m [3]

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2 One model of the Universe is based on the 'hot big bang' and another is based on the 'infinite and static' concept.

(a) State two pieces of experimental evidence in support of a 'hot big bang' model.

1. .....

.....

2. .....

.....[2]

(b) State Olbers' paradox.

.....

.....

.....

.....[3]

(c) Explain why the 'hot big bang' model does not necessarily imply that the Universe will expand indefinitely.

.....

.....

.....

.....[3]

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[Turn over

3 A telescope that will detect infra-red radiation has recently been put into Earth-orbit.

(a) State two reasons why such a telescope is likely to operate more successfully in Earth-orbit than on the Earth's surface.

1. .....

.....

2. .....

.....[2]

(b) Suggest, with a reason in each case, two types of object that are likely to be observed more effectively in the infra-red region of the spectrum than in the visible region.

1. .....

.....

.....

2. .....

.....

.....[4]

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Option F

The Physics of Fluids

4 The Bernoulli equation for fluid flow may be expressed in the form

$$p_1 + \tfrac{1}{2}\rho v_1^2 = p_2 + \tfrac{1}{2}\rho v_2^2.$$

(a) State three conditions for this equation to apply.

1. .....

.....

2. .....

.....

3. .....

.....[3]

(b) An aerofoil has an effective area of $25\,m^2$. Air of density $1.2\,kg\,m^{-3}$ flows over the aerofoil at a speed of $85\,m\,s^{-1}$ and under the aerofoil at $75\,m\,s^{-1}$. Calculate the lift force on the aerofoil.

lift force = ... N [3]

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[Turn over

5 A glass tube of uniform cross-sectional area is sealed at one end and contains some sand. The tube floats upright in water as illustrated in Fig. 5.1.

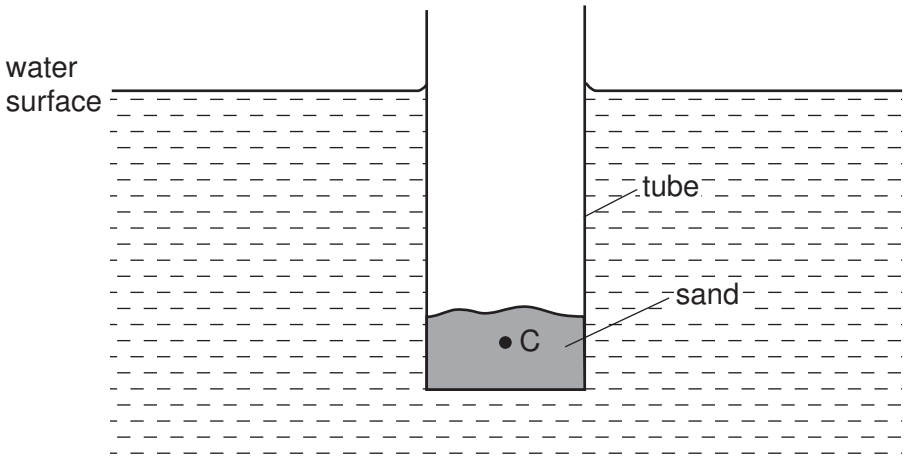

Fig. 5.1

The centre of mass of the tube and its contents is at C.

(a) (i) State what is meant by the *centre of buoyancy*.

.....

.....[1]

(ii) On Fig. 5.1, mark the position of the centre of buoyancy of the floating tube. Label this point B. [1]

(iii) The tube is displaced slightly from the vertical. Explain why the tube returns to the vertical position when released.

.....

.....

.....

.....[3]

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(b) Sand is gradually removed from the tube. State what change, if any, occurs in

(i) the depth of immersion of the tube,

.....[1]

(ii) the distance between the base of the tube and the centre of buoyancy B,

.....[1]

(iii) the distance between the base of the tube and the centre of mass C of the tube and its contents.

.....[1]

(c) For one particular mass of sand in the tube, the tube no longer stays floating vertically. State and explain the relative positions of C and of B for this to occur.

.....

.....

.....[2]

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6 **(a)** State what is meant by *turbulent flow*.

.....

.....[1]

(b) By reference to energy principles, explain why an increase in turbulence behind a car will increase the drag force on the car.

.....

.....

.....

.....[3]

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Option M

Medical Physics

7 **(a)** Outline the principles of production of X-rays in an X-ray tube. The detailed structure and operation of an X-ray tube are **not** required.

.....

.....

.....

.....

.....

.....

.....

.....

.....[6]

(b) The quality of the image on an X-ray plate depends on the sharpness and on the contrast.
Explain what is meant by

(i) *sharpness*,

.....

.....[1]

(ii) *contrast*.

.....

.....[1]

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8 Fig. 8.1 shows parallel rays of light refracted by a defective eye.

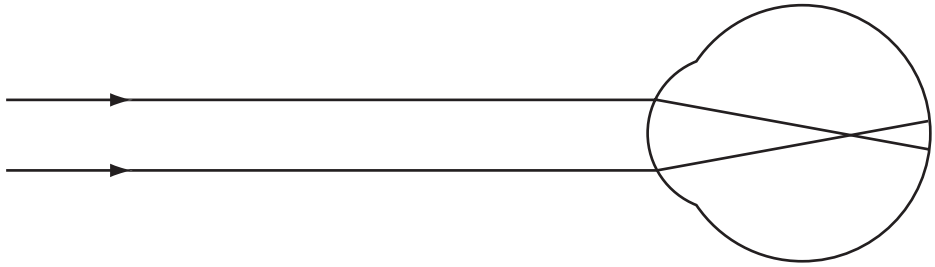

Fig. 8.1

It is assumed that all the refraction of the light takes place at the front surface of the eye.

(a) State the defect of this eye.

.....[1]

(b) **(i)** In position AB on Fig. 8.2, draw a lens that could be used to correct the defect. [1]

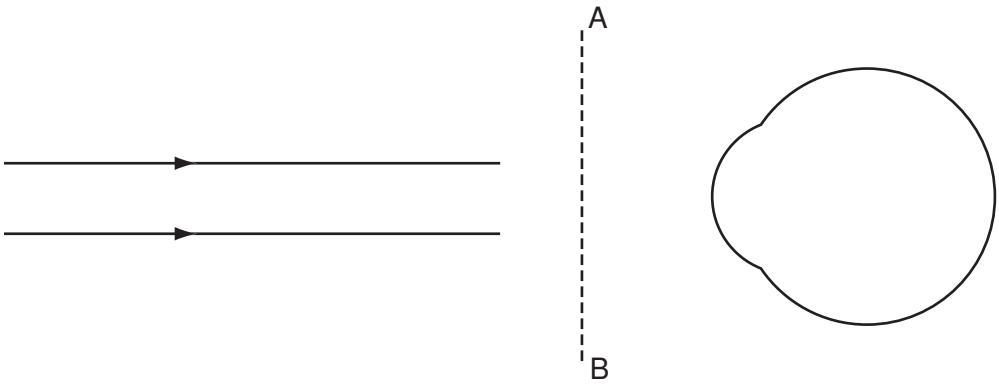

Fig. 8.2

(ii) Complete Fig. 8.2 by drawing the light rays through the lens and into the eye. [2]

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9 **(a)** **(i)** Distinguish between the *intensity* of a sound consisting of one frequency and its *loudness*.

.....

.....

.....

.....[2]

(ii) State what is meant by the *sensitivity* of the ear.

.....

.....[1]

(b) The minimum change in intensity level (*I.L.*) that can be detected by a certain person is 3 dB when the intensity level is 89 dB.
Calculate the ratio

$$\frac{\text{intensity of sound at intensity level 89 dB}}{\text{increase in intensity corresponding to 3 dB increase in intensity level at 89 dB}}$$

ratio = ... [5]

Option P

Environmental Physics

10 (a) Draw a labelled diagram to show the main features of a solar panel. [3]

(b) Suggest why, when installing a solar panel in the southern hemisphere, the panel should face northwards at noon.

.....

.....[1]

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(c) Fig. 10.1 shows the variation with time of the Sun's power incident per unit area of the Earth's surface at one position in the southern hemisphere.

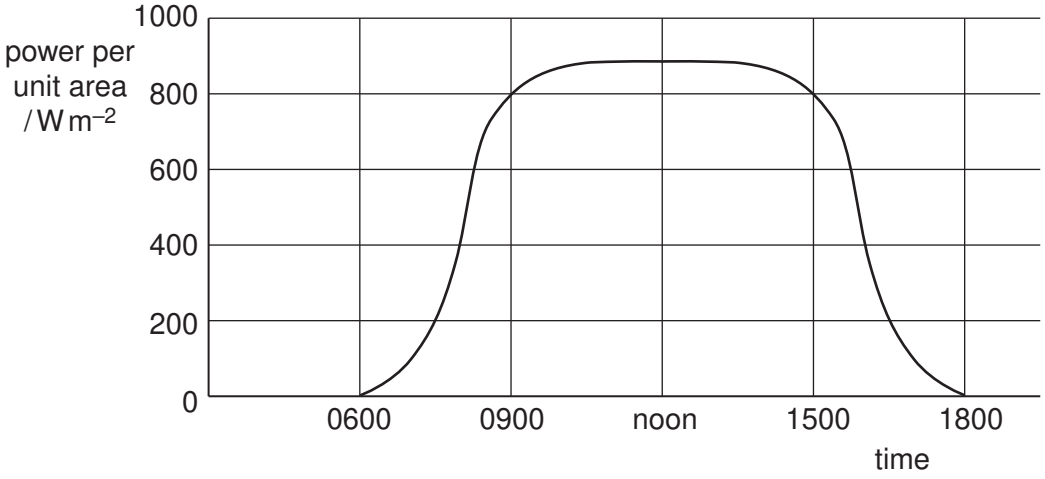

Fig. 10.1

A solar panel has an area of 1.4 m^2 and is to be used to raise the temperature of water by a minimum of 15 K.
The efficiency of energy collection by the panel is 35% and the specific heat capacity of water is 4200 $J\,kg^{-1}\,K^{-1}$.
Use data from Fig. 10.1 to determine the maximum rate of flow of water through the panel so that the water may be heated for six hours each day.

rate of flow = ... $kg\,s^{-1}$ [3]

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11 (a) (i) State what is meant by an *adiabatic change*.

.....

.....

.....[2]

(ii) Suggest why, during the compression stroke of a petrol engine, the change is said to be adiabatic.

.....

.....

.....[2]

(b) Fig. 11.1 represents one cycle of a four-stroke petrol engine.

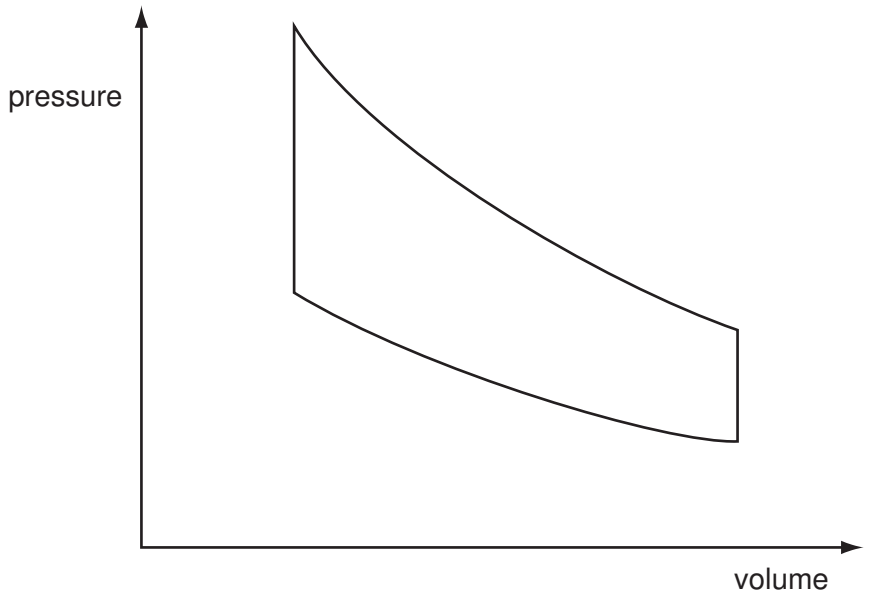

Fig. 11.1

On Fig. 11.1,

(i) mark with arrows the direction of the changes in the cycle, [1]

(ii) label with the letter E the section of the cycle during which the fuel is burned. [1]

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12 **(a)** Suggest why, in some countries, the use of unleaded fuel, rather than leaded fuel, has been introduced.

.....

.....

.....[2]

(b) State two forms of pollution, other than air pollution, associated with the use of cars.

1. .....

.....

2. .....

.....[2]

(c) The use of wind generators for the production of electrical energy is said, by some, to be a renewable pollution-free alternative to generation using fossil fuels.

(i) Suggest what is meant by *renewable*.

.....

.....[1]

(ii) Discuss briefly the respects in which wind turbines can be considered to be 'pollution-free'.

.....

.....

.....

.....[2]

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Option T

Telecommunications

13 **(a)** Explain what is meant by *fibre-optic transmission* of a signal.

.....

.....

.....

.....[3]

(b) Give two technological and two social advantages of fibre-optic transmission when compared with metal cable transmission.

technological

1. .....

.....

2. .....

.....

social

1. .....

.....

2. .....

.....[4]

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14 The input signal to a metal cable of length 75 m has a power of 0.60 W. The output signal from the cable is 0.55 W.

(a) (i) Suggest the main cause of this loss of power (attenuation) in the cable.

.....

.....[1]

(ii) Calculate the signal attenuation, in $dB\,km^{-1}$, of the metal cable.

attenuation = ... $dB\,km^{-1}$ [4]

(b) The maximum uninterrupted length of cable for the transmission of a signal is limited not only by attenuation but also by noise.

(i) Explain what is meant by *noise*.

.....

.....[1]

(ii) Suggest two sources of noise in metal cables.

1. .....

.....

2. .....

.....[2]

15 Discuss briefly the effects on society of the change to the transmission of signals in digital, rather than analogue, form.

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.....[5]

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