Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/06**

Paper 6

May/June 2006

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.
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.
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, $p = \rho g h$

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, 3 and 4
Option F	The Physics of Fluids	questions 5, 6 and 7
Option M	Medical Physics	questions 8, 9 and 10
Option P	Environmental Physics	questions 11, 12 and 13
Option T	Telecommunications	questions 14, 15, 16 and 17

Option A

Astrophysics and Cosmology

1 State, by reference to their orbits, two differences between planets and comets in the Solar System.

1. .....

.....

.....

2. .....

.....

..... [4]

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2 The Universe may be described as 'open', 'flat' or 'closed'.

(a) State clearly the factor on which the ultimate fate of the Universe depends.

.....

..... [2]

(b) Fig. 2.1 illustrates the variation with time of the extent of a 'flat' Universe.

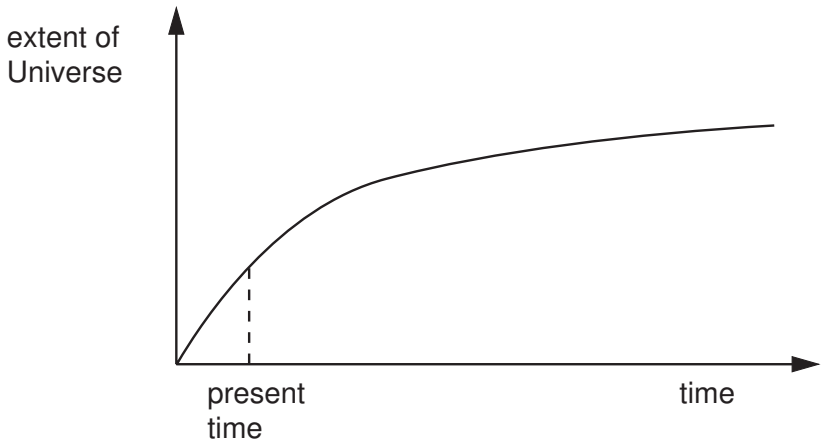

Fig. 2.1

(i) On Fig. 2.1, draw a line to show the variation with time of the extent of a closed Universe. [2]

(ii) Suggest three reasons why the ultimate fate of the Universe is not known.

1. .....

.....

2. .....

.....

3. .....

..... [3]

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3 A galaxy has been discovered that is 1.3×10^{10} light-years from Earth.

Given that the Hubble constant is $60\,\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$, calculate the ratio

$$\frac{\text{speed of galaxy}}{\text{speed of light in free space}} .$$

ratio = ... [4]

4 The Hubble Space Telescope is a telescope that was put into Earth orbit.

State and explain reasons for and against the development of such telescopes.

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..... [5]

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Option F

The Physics of Fluids

5 State the principle on which each of the following is based.

(a) the equation of continuity, $Av = constant$

..... [1]

(b) the Bernoulli equation

..... [1]

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[Turn over

6 Fig. 6.1 illustrates one form of filter pump.

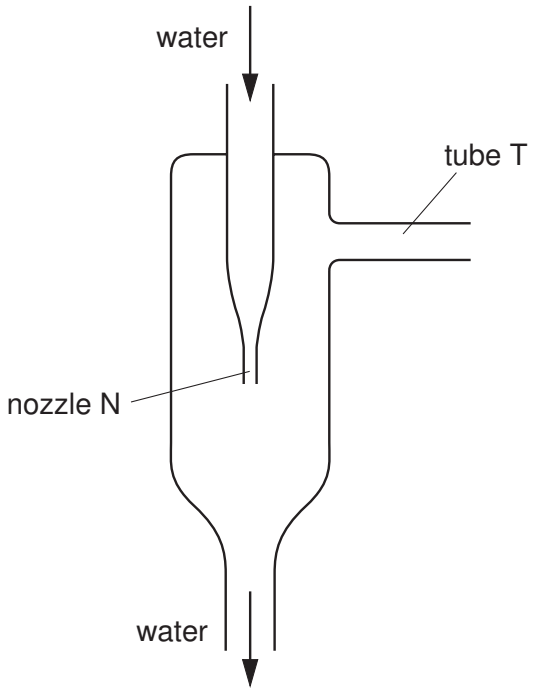

Fig. 6.1

Water is forced through the nozzle N.

(a) With reference to the Bernoulli principle, explain why the air pressure in tube T is below atmospheric pressure.

.....

.....

.....

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..... [4]

(b) Suggest with a reason the change, if any, in the pressure difference produced by the pump when

(i) higher speed water emerges from the nozzle,

.....

.....

..... [2]

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(ii) the water is replaced by another liquid of higher density emerging from the nozzle at the same speed.

.....

.....

..... [2]

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[Turn over

7 A car is moving along a straight horizontal road at constant speed.

(a) Explain why the production of eddy currents behind the car results in an increase in fuel consumption.

.....

.....

.....

..... [3]

(b) A car having a frontal area A is moving through still air of density ρ with speed v. The drag force F acting on the car is given by the expression

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

where C_D is a constant for the car.

(i) Show that the power output P of the car's engine that is required to overcome drag is given by

$$P = kv^3,$$

where k is a constant.

[2]

(ii) One particular car has a frontal area A of $1.8\,m^2$ and a constant C_D of 0.34.

The power available to overcome drag in still air of density $1.1\,kg\,m^{-3}$ is 84 kW. Calculate the maximum speed v_{max} of the car.

v_{max} = ... $m\,s^{-1}$ [2]

(iii) The car in **(ii)** now moves against a current of air of speed $9.0\,m\,s^{-1}$, measured relative to the ground. The air has density $1.1\,kg\,m^{-3}$.

Calculate the ratio

$$\frac{\text{power output to maintain speed } v_{max} \text{ against air current of speed } 9.0\,m\,s^{-1}}{\text{power output to maintain speed } v_{max} \text{ in still air}}\ .$$

ratio = ... [3]

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Option M

Medical Physics

8 **(a)** Outline the principles of the *generation* of ultrasonic waves using piezo-electric transducers.

.....

.....

.....

.....

..... [4]

(b) Suggest and explain one advantage of the use of ultrasound of frequency 1 MHz, rather than 100 kHz, for medical diagnosis.

.....

.....

..... [2]

9 Describe and explain two uses of a laser in clinical therapy.

1. .....

.....

.....

.....

.....

.....

2. .....

.....

.....

.....

.....

..... [6]

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10 (a) Explain what is meant by the *threshold of hearing*. State its value for a person with normal hearing.

.....

.....

.....

.....

..... [4]

(b) A person has an eardrum of area 54 mm^2. When listening to music using an earphone, the earphone produces 0.14 μW of sound power at the eardrum.

(i) Calculate the sound intensity level (*I.L.*) at the eardrum.

I.L. = ... dB [3]

(ii) Comment on the value you have calculated in **(i)**.

.....

.....[1]

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Option P

Environmental Physics

11 (a) Outline the main principles of a pumped-water storage scheme.

.....

.....

.....

.....

.....

..... [4]

(b) A reservoir for a pumped-water storage scheme is to be built such that the mean height of the water, of density 1.0×10^3 kg m^{-3}, above the turbines is 95 m. The scheme has an overall efficiency of 75 % and is to provide 78 MW of electrical power for a period of 4.0 hours.

Calculate the minimum volume of water that must be stored in the reservoir.

volume = ... m^3 [4]

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12 A machine operates between temperatures of T_H and T_L. A quantity Q_H of thermal energy is absorbed at temperature T_H and as a result, the machine does a quantity W of mechanical work, as indicated in Fig. 12.1.

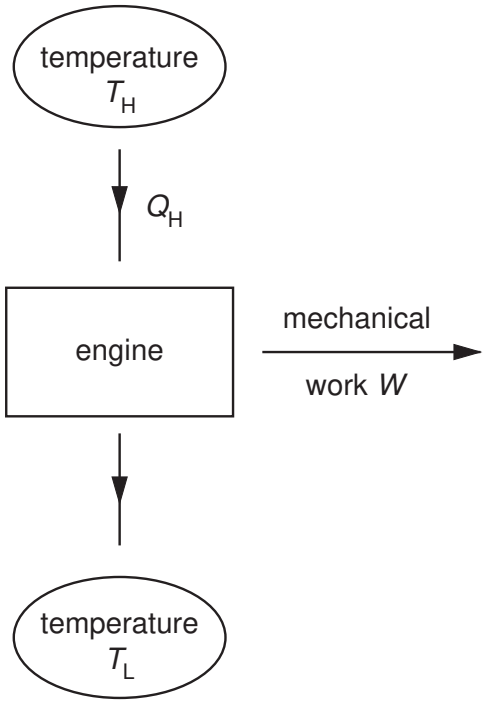

Fig. 12.1

(a) By reference to the second law of thermodynamics, explain why some thermal energy must be rejected at temperature T_L.

.....

.....

.....

..... [3]

(b) State an expression relating T_H, T_L, Q_H and W.

..... [1]

(c) A steam engine operates between the temperatures of 120 °C and 40 °C. Calculate the maximum theoretical efficiency of the engine.

efficiency = ... [2]

13 Fig. 13.1 shows the variation with time of the electric power demands of a city on two different days, several months apart.

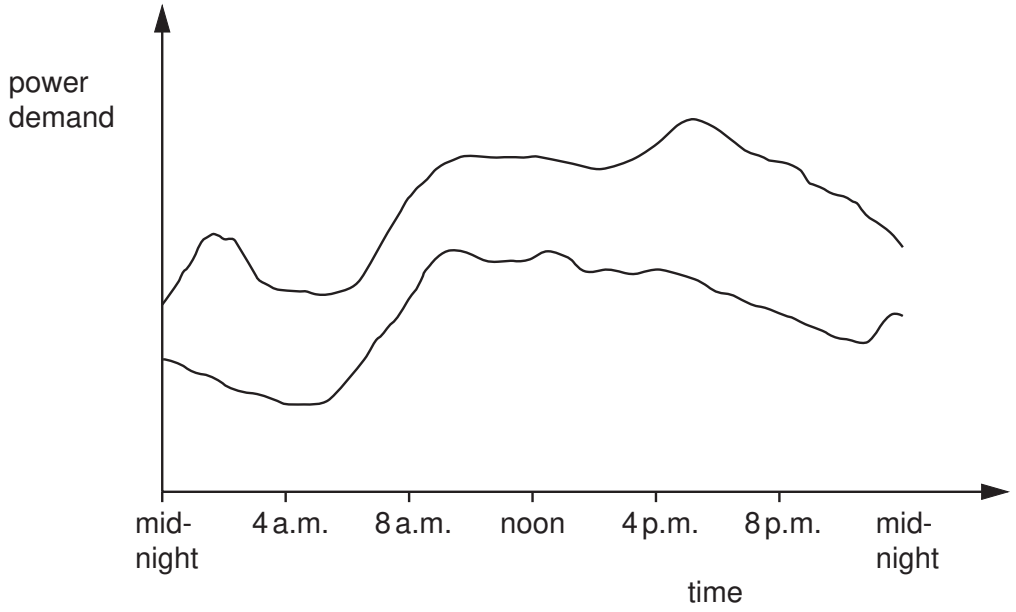

Fig. 13.1

(a) Give two possible explanations for

(i) the increase in demand between 6 a.m. and 10 a.m.,

1. .....

2. ..... [2]

(ii) the different average levels of demand on the two days.

1. .....

2. ..... [2]

(b) Suggest the effect on the graph of Fig.13.1. if

(i) a popular hour-long television programme ends at 8 p.m.,

.....

..... [1]

(ii) there is an exceptionally hot day.

.....

..... [1]

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Option T

Telecommunications

14 **(a)** Explain what is meant by *frequency modulation* (FM).

.....

.....

..... [2]

(b) A sinusoidal carrier wave has amplitude 12 V and frequency 600 kHz. The frequency of the carrier wave changes by 25 kHz per volt.

The carrier wave is used for the transmission of a signal of frequency 3.0 kHz and amplitude 2.0 V.

For the frequency modulated carrier wave, state

(i) the amplitude,

amplitude = ... V [1]

(ii) the maximum frequency,

maximum frequency = ... kHz [1]

(iii) the minimum frequency,

minimum frequency = ... kHz [1]

(iv) the number of times per second that the frequency of the carrier wave changes from the maximum value, to the minimum value and then back to the maximum value.

number = ... [1]

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15 Fig. 15.1 shows a block diagram of a circuit used for the encoding of an analogue signal and its transmission in digital form.

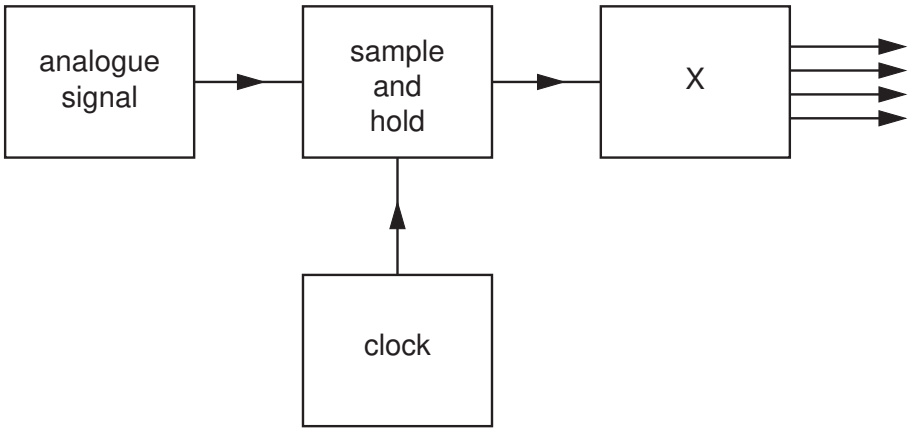

Fig. 15.1

(a) State the name of the block labelled X (do **not** use an abbreviation).

..... [1]

(b) Suggest the function of the clock.

.....

..... [1]

(c) Suggest one advantage of using a high-frequency clock.

.....

..... [1]

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16 Before the development of microwave links and optic fibres, co-axial cables were used widely for telephone communication.

(a) Fig. 16.1 shows one type of co-axial cable.

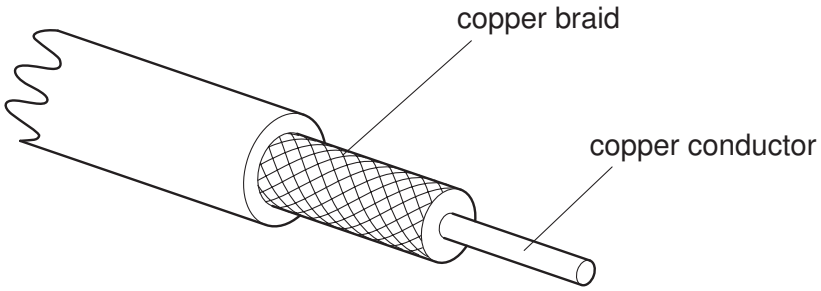

Fig. 16.1

State the purpose of the copper braid and how this purpose is achieved.

.....

.....

..... [2]

(b) One advantage over co-axial cables of microwave links and of optic fibres is increased bandwidth.

Explain why increased bandwidth has led to a reduction in the cost of telephone calls.

.....

.....

.....

..... [3]

Question 17 is on page 20

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[Turn over

17 **(a)** State two sources of noise associated with metal cables.

1. .....

.....

2. .....

..... [2]

(b) A metal cable has a signal attenuation of 5.8 dB km^{-1} and the noise power in the cable is 7.6 μW.

An input signal to the cable has a power of 2.6 W and the minimum acceptable signal-to-noise ratio is 35 dB.

Calculate

(i) the minimum acceptable signal power in the cable,

power = ... W [2]

(ii) the maximum uninterrupted length of cable for the transmission of this signal.

length = ... km [2]

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