	Centre Number	Candidate Number
Candidate Name ______		

CAMBRIDGE INTERNATIONAL EXAMINATIONS

General Certificate of Education Advanced Level

PHYSICS 9702/6

PAPER 6 Options

MAY/JUNE SESSION 2002

45 minutes

Candidates answer on the question paper.
No additional materials.

TIME 45 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.

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

Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

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.

FOR EXAMINER'S USE

This question paper consists of 20 printed pages.

University of Cambridge Local Examinations Syndicate

Data

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

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,	$p = \rho g h$
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,	$F = Br^2 \rho v^2$

[Turn over

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

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 and 16

Option A

Astrophysics and Cosmology

1 The average diameter of the Earth's orbit around the Sun is 2.99×10^8 km.

(a) Calculate, to three significant figures, the magnitude, in metres, of the astronomical unit (AU).

1 AU = ... m [1]

(b) (i) Define the parsec (pc).

....

....

(ii) Use your answer to **(a)** to calculate the magnitude, in metres, of the parsec.

1 pc = ... m
[5]

For Examiner's Use

2 **(a)** On Fig. 2.1, sketch a graph to show the variation with distance *d* from Earth of the linear speed *v* of galaxies.

[1]

Fig. 2.1

(b) Suggest why your graph implies a finite age for the Universe.

....

....

....[2]

(c) Explain why, although most galaxies appear to be moving away from the Milky Way galaxy, it cannot be assumed that the Universe had its origin somewhere in the Milky Way.

....

....

....[2]

(d) Explain how your graph of Fig. 2.1 may be used to

(i) obtain a value for the Hubble constant,

....

(ii) estimate the age of the Universe.

....

....

[3]

[Turn over

For Examiner's Use

3 Fig. 3.1 shows the variation with the age of the Universe of its mean temperature.

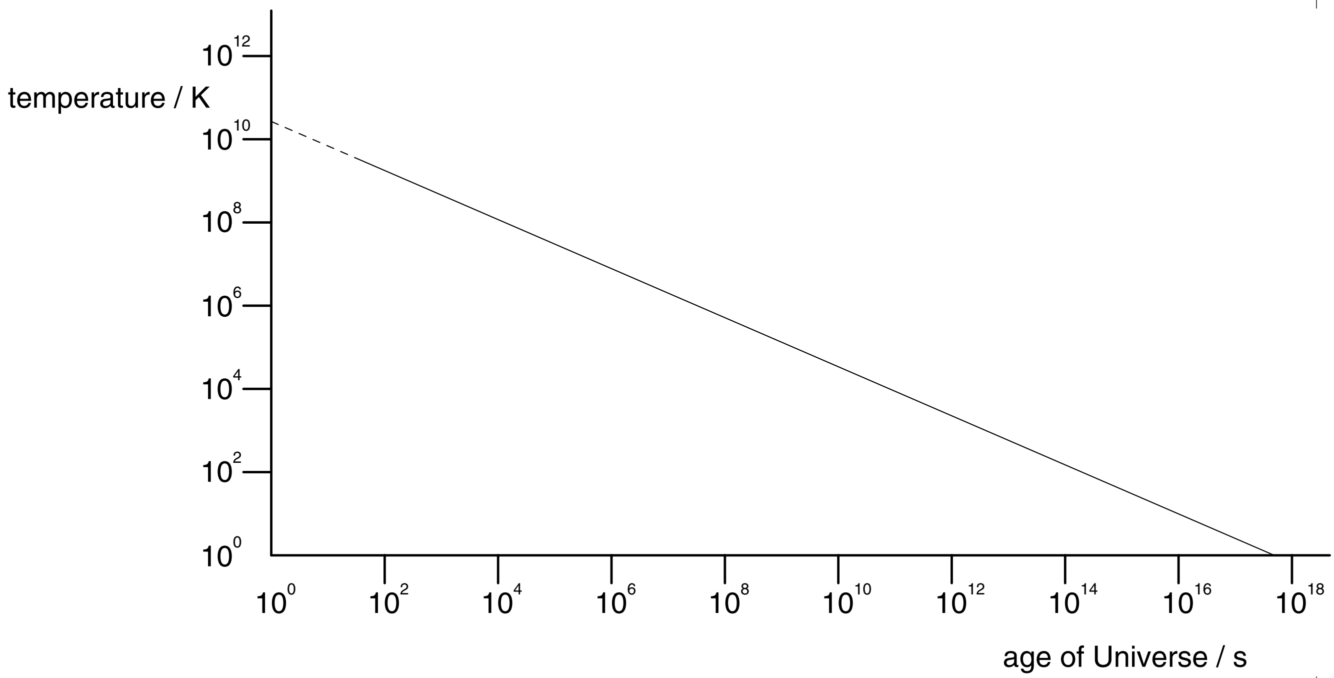

Fig. 3.1

On Fig. 3.1, mark positions at which

(a) light elements were formed (mark this position L), [1]

(b) decoupling of radiation and matter occurred (mark this position D), [1]

(c) the formation of galaxies began (mark this position G). [1]

4 Suggest why the detection of very distant galaxies is a recent development in astronomy.

....

....

....

....[3]

For Examiner's Use

Option F

The Physics of Fluids

5 **(a)** Fig. 5.1 illustrates a cross-section through a ship.

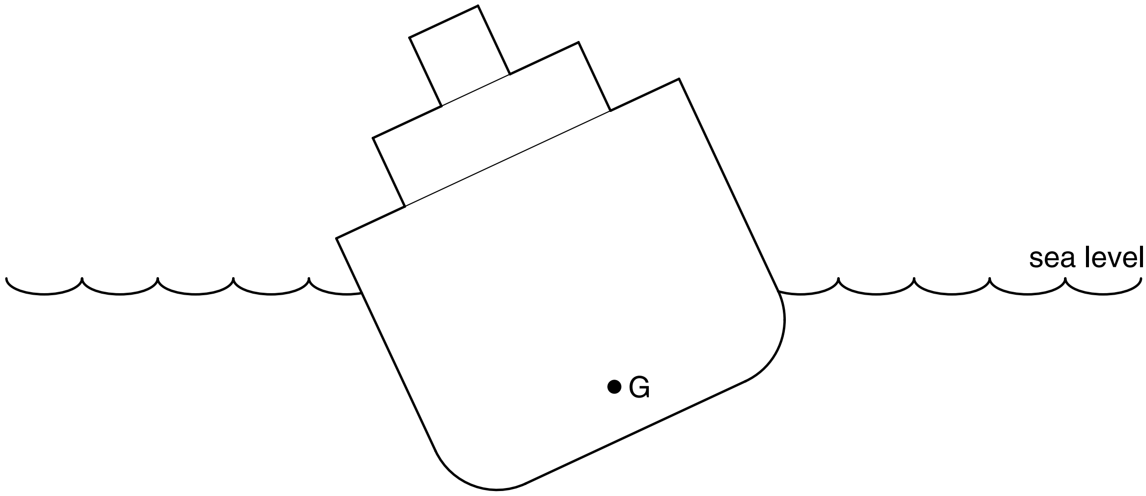

Fig. 5.1

The point G is the centre of gravity. On Fig. 5.1,

(i) mark the approximate position of the centre of buoyancy (label this point B),

(ii) draw lines to show the position of the metacentre (label this point M).

[2]

(b) For stability, the point M must be above the point G. Suggest the effect on the ship of increasing the separation of M and G when the ship is in rough seas.

....

....

....[2]

6 An ideal incompressible fluid of density ρ flows along a pipe as shown in Fig. 6.1.

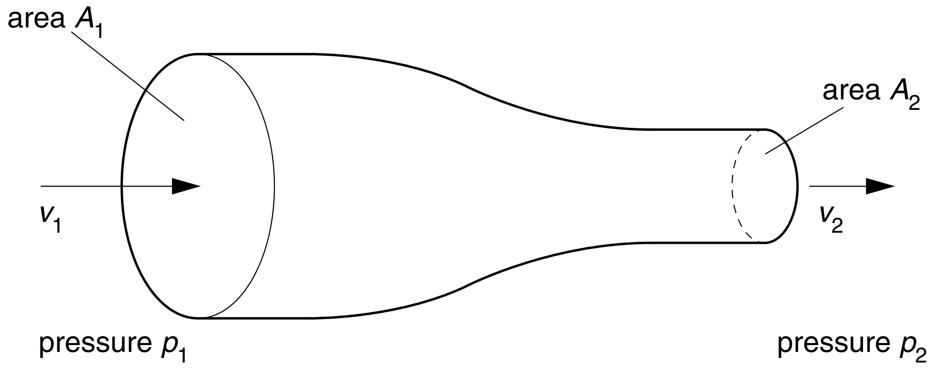

Fig. 6.1

The fluid travels at speed v_1 where the area of cross-section is A_1 and at speed v_2 where the area of cross-section is A_2. The fluid pressure at these points is p_1 and p_2 respectively.

(a) State formulae, in terms of v_1, A_1 and ρ for

(i) the volume of fluid flowing per unit time along the pipe,

....

(ii) the mass flow-rate of the fluid.

....
[2]

(b) Derive formulae, in terms of v_1, v_2, A_1, A_2 and ρ, for

(i) the change in kinetic energy per unit time of the fluid as it flows through the pipe,

(ii) the work done per unit time to force the fluid along the pipe.

[4]

(c) **(i)** Using your answers in **(b)**, derive the Bernoulli equation

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

(ii) State one assumption, other than that of an ideal fluid, which you made in your derivation.

....

....
[3]

7 A metal sphere is held just below the surface in a deep vessel containing oil. It is released from rest at time $t = 0$.

(a) On the axes of Fig. 7.1, sketch a graph to show the variation with time t of the speed v of the sphere.

[2]

Fig. 7.1

(b) By reference to the forces acting on the sphere, describe the motion of the sphere.

....

....

....

....

....

....[5]

For Examiner's Use

Option M

Medical Physics

8 **(a)** Outline the use of ultrasound to obtain diagnostic information about internal body structures.

....

....

....

....

....

....

....

....[5]

(b) The intensity I of a parallel beam of ultrasound is related to its initial intensity I_0 and the thickness x of the medium through which it has travelled by the relation

$$I = I_0 \, e^{-\mu x}$$

where μ is a constant for the medium.

Fig. 8.1 shows the constant μ for different media.

medium	μ/m^{-1}
blood	2
bone	130
muscle	23

Fig. 8.1

(i) Use the information in Fig. 8.1 to suggest why

1. ultrasound is not used to examine structures within bones,

....

....

....

2. bones may be at risk when using high intensities of ultrasound to treat diseased joints.

....

....
[4]

(ii) Determine the ratio

$$\frac{\text{fraction of intensity of ultrasound transmitted through 10 mm of muscle}}{\text{fraction of intensity of ultrasound transmitted through 10 mm of bone}}.$$

ratio = ... [3]

For Examiner's Use

9 A student can only focus clearly on objects which are between 75 cm and 10 cm from his eyes.

(a) Name the eye defect from which the person is suffering.

....[1]

(b) Determine the power of the lenses required so that distant objects may be seen clearly.

power = ... D [2]

(c) Suggest why this student has an advantage over a person with normal vision when a small object, such as the spring in a watch, is to be examined closely.

....

....

....[2]

10 Fig. 10.1 shows the variation with frequency *f* of the minimum intensity level *I.L.* of sound heard by a particular person.

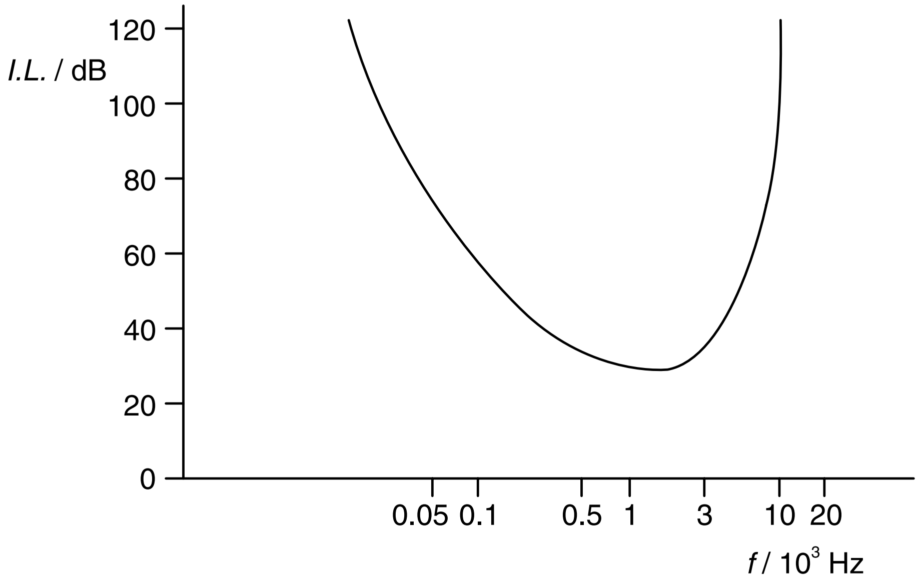

Fig. 10.1

(a) Explain what is meant by *intensity level*.

....

....[1]

(b) Describe, with reference to features of Fig. 10.1, the defects of hearing from which the person is suffering.

....

....

....[2]

Option P

Environmental Physics

11 **(a)** Compare a pumped-water storage scheme and a tidal barrage scheme for the generation of electrical energy. You should include two distinct aspects in your comparison.

1. ....

....

....

2. ....

....

....

....[4]

(b) A pumped-water storage scheme is used both to pump water and to generate electrical energy. It is capable of pumping water at a rate of $77\,m^3\,s^{-1}$ to a height of 180 m. The density of water is $1000\,kg\,m^{-3}$.

(i) Calculate the useful power output of the turbine assembly when it is used as a pump.

power = ... MW

(ii) The same turbine assembly generates 100 MW when the stored water is released at the same rate as when it was being pumped. By reference to your answer in **(i)**, comment on this output power.

....

....

....

[5]

12 A wind generator has blades of length r. Air of density ρ and speed v is incident normally on the plane of the rotating blades.

(a) Show that the kinetic energy E of the wind incident normally per unit time on the plane of the rotating blades is given by

$$E = \tfrac{1}{2}\pi r^2 v^3 \rho.$$

[3]

(b) One particular wind generator has blades of length 12 m. Air of density 1.2 kg m^{-3} and speed 4.5 m s^{-1} is incident normally on the generator. Calculate the power output of the generator given that its overall efficiency is 55%.

power = ... kW [2]

(c) Suggest one problem associated with high wind speeds on such a generator, and how the problem is overcome.

....

....

....[2]

For Examiner's Use

13 (a) Comment on the statement that wind generators are pollution-free.

....

....

....[2]

(b) Suggest why there is controversy over the building of wind farms capable of generating the same output as a nuclear reactor.

....

....

....[2]

For Examiner's Use

Option T

Telecommunications

14 Fig. 14.1 shows the signal received at the aerial of a radio.

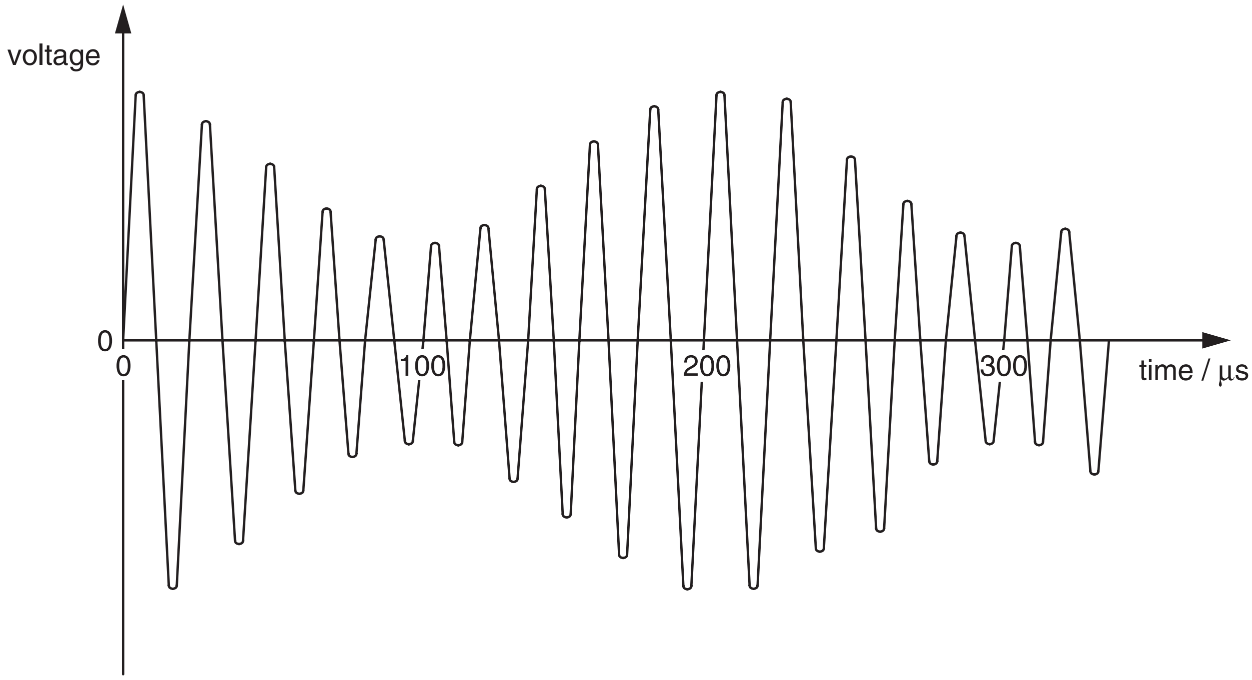

Fig. 14.1

(a) State the form of modulation illustrated in Fig. 14.1.

....[1]

(b) Calculate

(i) the frequency of the transmission,

frequency = ... Hz

(ii) the frequency of the modulating waveform.

frequency = ... Hz
[3]

[Turn over

For Examiner's Use

(c) On Fig. 14.2, draw a graph to show the variation with frequency f of the signal shown in Fig. 14.1. Show appropriate values on the frequency axis.

[3]

Fig. 14.2

For Examiner's Use

15 Railway tracks provide a convenient route for communication cables. However, passing electric trains produce interference (noise) of power 7.3×10^{-5} W in a certain co-axial cable. The signal-to-noise ratio in this cable must not fall below 25 dB for the effective transmission of the signal.

(a) Show that the minimum effective signal power in the cable is 0.023 W. [2]

(b) The cable has a loss of 4.8 dB km^{-1}. Calculate the maximum length of cable which can be used without the need for repeater amplifiers for an input signal of power 5.8 W.

length = ... km [3]

(c) Co-axial cables are being replaced by optic fibres along railway tracks. Suggest two reasons why this is being done.

1. ....

....

2. ....

....[2]

For Examiner's Use

16 (a) State two uses of polar orbiting satellites.

1. ....

....

2. ....

....[2]

(b) State two uses, other than for television transmissions, of geostationary satellites.

1. ....

....

2. ....

....[2]

(c) (i) State a typical wavelength used for satellite communication.

wavelength = ... m

(ii) Explain briefly why the transmission frequency from Earth to a satellite is different from the frequency that the satellite transmits back to Earth.

....

....

[2]