| Centre Number | Candidate Number | Name |
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CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

**PHYSICS** **9702/06**

Paper 6 Options

October/November 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 | |

This document consists of **19** printed pages and **1** blank page.

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[Turn over

**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, $p = \rho g h$

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, $Av =$ 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 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)** The Andromeda Galaxy (M31) covers an area of the sky approximately five times larger than the full Moon. Suggest why, when looking from the Earth's surface in the direction of M31, the galaxy is not a prominent feature of the night sky.

.....

.....

.....

.....

..... [4]

**(b)** The centre of the galaxy M31 is $6.9 \times 10^5$ pc from Earth. Calculate the distance, in light-years, at the centre of M31 that subtends an angle of 1.0 arc second at the surface of the Earth.

distance = ..... light-year [3]

**2** **(a)** State Olbers' paradox.

.....

.....

.....

..... [3]

**(b)** Explain the significance of Olbers' paradox for the Big Bang model of the Universe.

.....

.....

..... [2]

**3** **(a)** Explain

**(i)** what is meant by *3 K microwave background radiation*,

.....

.....

..... [2]

**(ii)** the significance of this radiation.

.....

.....

.....

..... [3]

**(b)** Observation of the radiation emitted by carbon clouds in distant galaxies indicates a background radiation temperature of approximately 7 K. Suggest an explanation for this observation.

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.....

.....

..... [3]

For Examiner's Use

## Option F

## The Physics of Fluids

**4** **(a)** Explain what is meant by the metacentre of a floating body.

.....

.....

..... [2]

**(b)** Suggest why the stability of a submarine may change as it surfaces.

.....

.....

.....

..... [3]

For Examiner's Use

**5** An ideal incompressible fluid of density 990 kg m$^{-3}$ flows through a pipe of circular cross-section of diameter 2.4 cm. In order to measure the speed $v$ of the fluid at point A in the pipe, one section of the pipe is made narrower, as illustrated in Fig. 5.1.

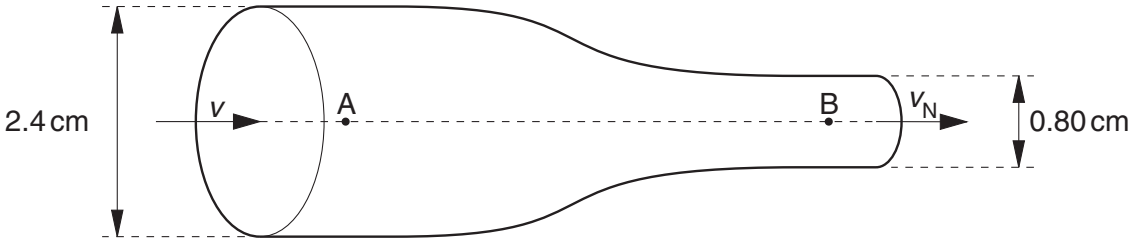


**Fig. 5.1**

The narrow section has a diameter of 0.80 cm and the speed of the fluid in this section is $v_N$. The flow of fluid is streamline in both sections.

The difference in fluid pressure between points A and B on the wide and narrow sections respectively of the tube is found to be 740 Pa.

**(a)** State, with a reason, which point, A or B, is at the higher fluid pressure.

.....

.....

..... [2]

**(b)** Show that the ratio $\frac{v_N}{v}$ of the two speeds is 9.0. [2]

**(c)** Use the Bernoulli equation to calculate the speed $v$ of the fluid in the pipe of diameter 2.4 cm.

speed = ..... m s$^{-1}$ [3]



**[Turn over**

For Examiner's Use

**6** A small sphere of radius $r$ and density $\rho_s$ is falling with speed $v$ in a fluid of density $\rho_f$ and viscosity $\eta$.

The flow of fluid around the sphere is streamline.

**(a)** Write down expressions for

**(i)** the upthrust on the sphere,

.....

**(ii)** the resultant downward force on the sphere.

.....

[2]

**(b)** The drag force $F$ on a sphere in streamline flow is given by the expression

$$F = 6\pi r\eta v.$$

Show that the terminal speed $v_t$ of the sphere is given by

$$v_t = kr^2,$$

where $k$ is a constant. [2]

**(c)** A student determines the viscosity of oil by measuring the terminal speed of a steel sphere as it falls through the oil contained in a wide vertical tube. Suggest

**(i)** how it can be checked that the sphere is falling at terminal speed when measurements are taken,

.....

.....

.....

**(ii)** why the tube should have a diameter at least ten times that of the steel sphere.

.....

.....

.....

[4]

For Examiner's Use

## Option M

## Medical Physics

**7** Outline the means by which magnetic resonance is used to obtain diagnostic information about internal structures.

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.....

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.....

..... [6]



[Turn over

**8** The eye of a person may be assumed to be a single convex lens with a distance of 17 mm between the centre of the lens and the retina.

**(a)** Calculate the power of the eye so that the image of an object is clearly focused on the retina for an object

**(i)** at a distance 10 cm from the eye,

power = ..... D

**(ii)** placed at the normal reading distance from the eye.

power = ..... D
[5]

**(b)** **(i)** Use your answers in **(a)** to determine the change in the power of the lens when the eye is first focused on an object at the normal reading distance and then at a distance of 10 cm.

change in power = ..... D

**(ii)** Hence determine the focal length and the type of lens required so that a person with normal vision may see clearly objects that are 10 cm from the eye.

focal length = ..... cm

type of lens .....
[3]

**9** Fig. 9.1 indicates the variation with frequency of the intensity of sound at the ear for the threshold of normal hearing.

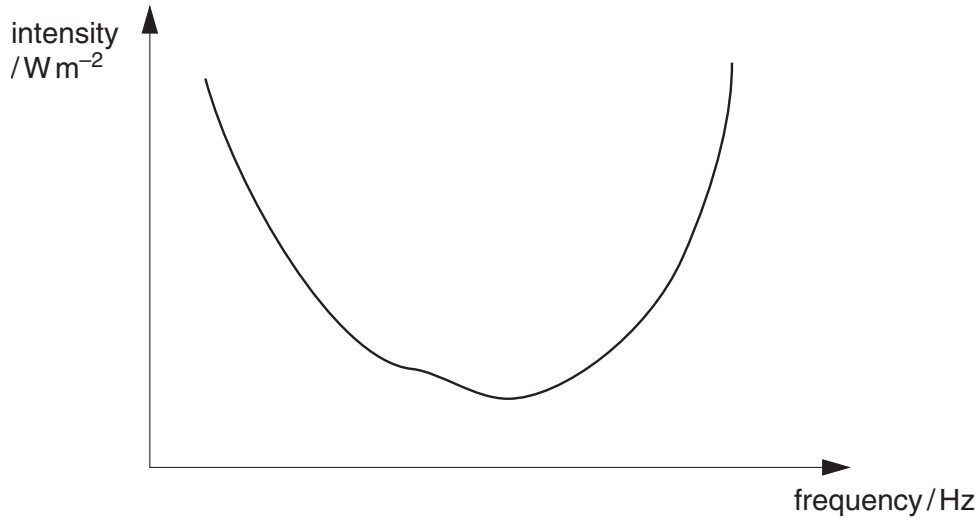


**Fig. 9.1**

**(a)** On Fig. 9.1, mark suitable values on the scales to indicate

**(i)** the audible range of frequencies,

**(ii)** the threshold intensity.

[4]

**(b)** A person suffers from deafness brought about by excessive noise. On Fig. 9.1, draw a line to show the likely variation with frequency of the intensity of sound for this person's threshold of hearing. [2]

## Option P

## Environmental Physics

**10** **(a)** State what is meant by a *fuel*.

.....

.....[1]

**(b)** Give three reasons why alternatives to fossil fuels are being developed and utilised.

1. .....

.....

2. .....

.....

3. .....

..... [3]

**11 (a)** Outline a tidal barrage scheme for the generation of electrical energy.

.....

.....

.....

.....

..... [4]

**(b)** In one particular barrage scheme, the average tidal range $R$ is 8.0 m and the enclosed area is 200 $km^2$. The average height of the water above the turbine is $\frac{1}{2}R$ for a period of 3.0 hours between high tides. The density of water is 1000 $kg\,m^{-3}$.

Calculate the average power input to the turbine during the time that the scheme can operate.

power = ..... W [3]

**(c)** State two environmental problems associated with tidal barrage schemes.

1. .....

.....

2. .....

..... [2]

**12** **(a)** Complete Fig. 12.1 to show the state (open or closed) of the inlet and the exhaust valves during the four strokes of a four-stroke petrol engine. [2]

| stroke | inlet valve | exhaust valve |
|---|---|---|
| induction | ..... | ..... |
| compression | ..... | ..... |
| power | ..... | ..... |
| exhaust | ..... | ..... |

**Fig. 12.1**

**(b)** State the stages in the cycle of the engine at which

**(i)** the fuel-air mixture is ignited,

.....

**(ii)** the exhaust gases are removed.

.....

.....
[3]

**(c)** Suggest why, when the fuel is introduced into the cylinder, it is in the form of a vapour or very fine droplets.

.....

.....

.....[2]

## Option T

## Telecommunications

**13** Fig. 13.1 illustrates a ray of light entering a step-index optic fibre.

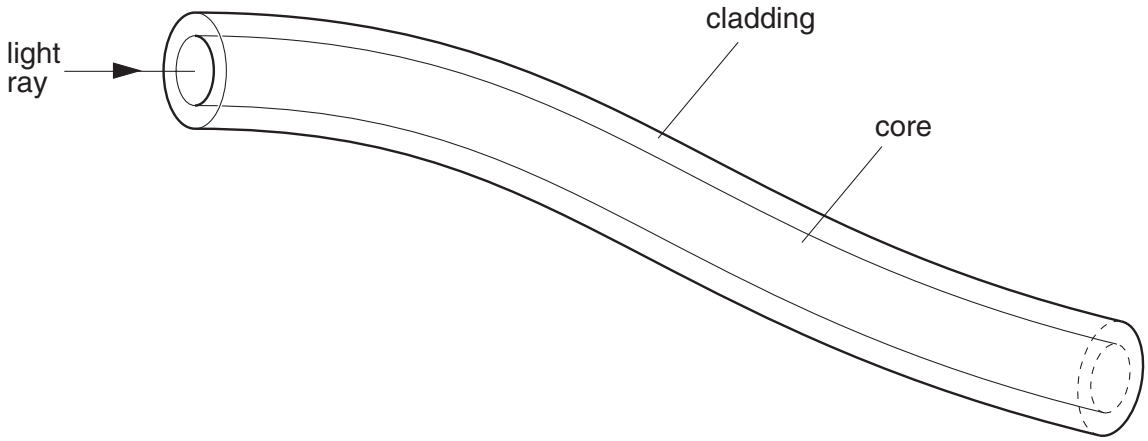


**Fig. 13.1**

**(a)** On Fig. 13.1, complete the path of the ray of light along the fibre. [1]

**(b)** Suggest why the core of the fibre is made as narrow as possible.

.....

..... [1]

**(c)** State three advantages, other than smaller attenuation allowing much greater uninterrupted transmission lengths, that optic fibres have compared with co-axial cables.

1. .....

.....

2. .....

.....

3. .....

..... [3]

**14** A sinusoidal wave of frequency 75 kHz is to be amplitude modulated by a wave of frequency 5.0 kHz.

**(a)** Explain what is meant by amplitude modulation.

.....

.....

..... [2]

**(b)** On the axes of Fig. 14.1, sketch a graph to show the variation with frequency *f* of the power *P* of the modulated wave. Give labelled values on the frequency axis. [3]

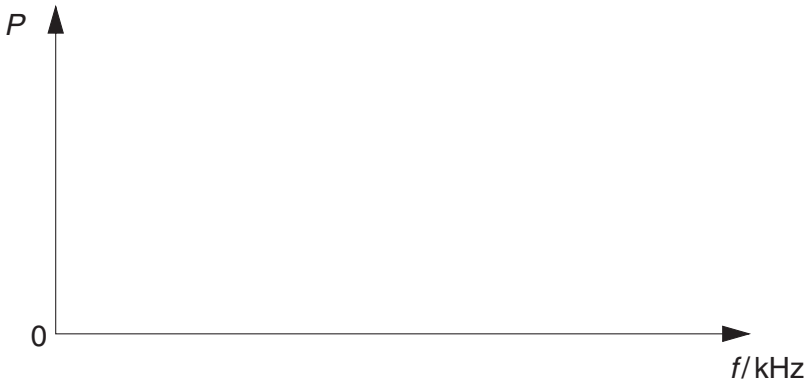


**Fig. 14.1**

**(c)** State the bandwidth of the modulated wave.

bandwidth = ..... kHz [1]

**15** Fig. 15.1 shows a microphone connected directly to an amplifier having a gain of 63 dB.

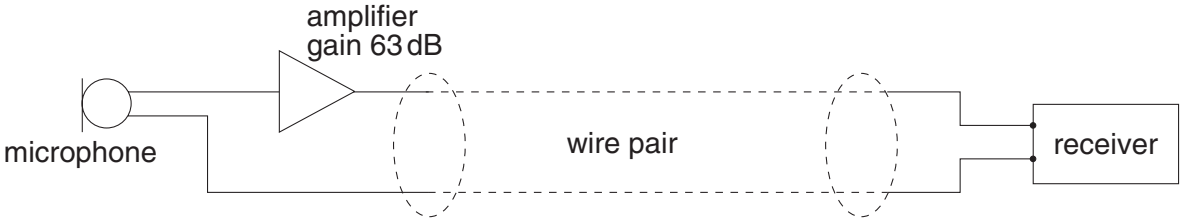


**Fig. 15.1**

The microphone and amplifier are connected to a receiver by means of a wire pair having an attenuation of 12 dB per kilometre length. The output signal from the microphone is 2.5 μW and there is a constant noise power in the wire pair of 0.035 μW.

**(a)** Explain what is meant by

**(i)** *attenuation*,

.....

.....

**(ii)** *noise*.

.....

.....

[3]

**(b)** Calculate the power output of the amplifier.

power output = ..... W [3]

**(c)** Calculate the length of the wire pair for the signal power to be reduced to the level of the noise power.

length = ..... km [3]

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