Candidate Name _____ Centre Number | | | Candidate

CAMBRIDGE INTERNATIONAL EXAMINATIONS

General Certificate of Education Advanced Level

PHYSICS 9702/6

PAPER 6 Options

OCTOBER/NOVEMBER 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** of 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 18 printed pages and 2 blank pages.

University of Cambridge Local Examinations Syndicate

[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, $Av = \text{constant}$

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 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 Give an estimate of the time for light to travel

(a) from the Sun to Earth,

time = ... [1]

(b) from the nearest stars (other than the Sun) to Earth,

time = ... [1]

(c) across the Milky Way galaxy.

time = ... [1]

2 **(a)** Explain what is meant by *redshift*.

.....

.....

.....

.....[3]

(b) Suggest why line spectra, rather than continuous spectra, are used to study redshift.

.....

.....

.....[2]

(c) Outline three problems associated with observations of electromagnetic radiation at the Earth's surface.

1. .....

.....

2. .....

.....

3. .....

.....[3]

3 **(a)** Estimate the critical mean density of matter in the Universe, giving your answer as the average number of nucleons per cubic metre of space. The age of the Universe is about 4.1×10^{17} s.

number density = ... m^{-3} [5]

(b) Current observations suggest that the actual mean density of matter gives rise to a 'flat' Universe.

(i) Explain why the amount of matter in the Universe is not known with any accuracy.

.....

.....

.....

(ii) Describe the likely fate of the Universe if the actual mean density is greater than is currently suggested.

.....

.....

.....

[4]

Option F

The Physics of Fluids

4 When a body is immersed in a fluid, it experiences an upthrust equal to the weight of fluid displaced. Explain

(a) what is meant by an *upthrust*,

.....

.....[1]

(b) the origin of the upthrust,

.....

.....

.....[2]

(c) two conditions for the upthrust to be independent of the depth of immersion.

1. .....

.....

2. .....

.....[3]

[Turn over

5 Fluid flow is sometimes illustrated by means of streamlines.

(a) Explain

(i) what is meant by a *streamline*,

.....

.....

(ii) what is meant by a *tube of flow*,

.....

.....

(iii) why fluid in a tube of flow cannot pass out through its sides.

.....

.....

[3]

(b) **(i)** On Fig. 5.1, draw streamlines to illustrate laminar flow round the object shown.

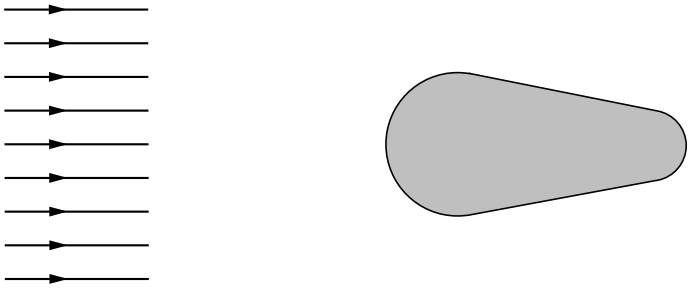

Fig. 5.1

(ii) On Fig. 5.2, draw streamlines to illustrate turbulent flow round the object.

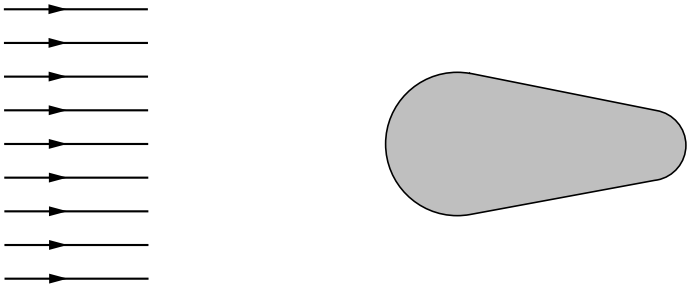

Fig. 5.2

(iii) Suggest one change which could have occurred for the flow to become turbulent, rather than laminar.

.....

[4]

6 The arrows in Fig. 6.1 represent the velocity of fluid moving down a pipe.

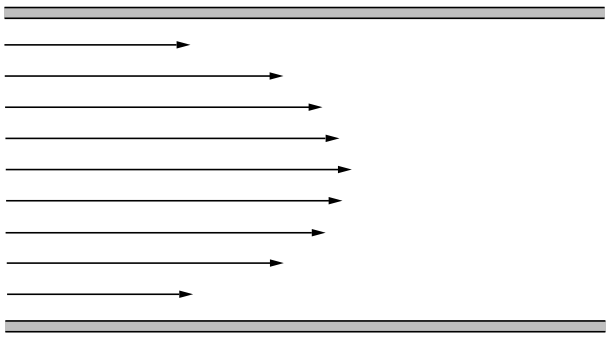

Fig. 6.1

(a) (i) Suggest why the arrows are not all the same length.

.....

.....

.....

(ii) Hence explain what is meant by a *velocity gradient* in the fluid.

.....

.....

.....

[4]

(b) The magnitude F of tangential forces between two parallel layers of fluid of area A, distance Δx apart and moving with a relative speed Δv, is given by

$$F = \eta A\,(\Delta v/\Delta x),$$

where η is a constant known as the viscosity.

A block of glass of weight 1.5 N has a face of area $9.0 \times 10^{-4}\,m^2$ in contact with a flat vertical surface, as illustrated in Fig. 6.2.

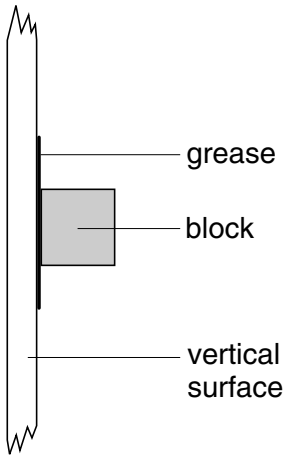

Fig. 6.2

The block is held against the surface by a layer of grease of thickness 2.2×10^{-6} m. It is found that, after seven days, the glass block has slid down the vertical surface by a distance of 3.0 mm. Using the equation above, calculate the viscosity of the grease.

viscosity = ... Pa s [3]

Option M

Medical Physics

7 **(a)** The quality of an image produced using X-rays depends on sharpness and contrast. State what is meant by, and briefly explain the causes of,

(i) sharpness, ...

.....

.....

(ii) contrast. .....

.....

.....

[4]

(b) A parallel beam of X-ray photons is produced by an X-ray tube with 80 keV across it. The beam has its intensity reduced to one half of its original value when it passes through a thickness of 1.0 mm of copper.

(i) Describe the energies of the X-ray photons in the beam.

.....

.....[2]

(ii) Determine the linear absorption coefficient μ of the X-ray photons in copper.

μ = ... mm^{-1} [2]

(iii) Suggest, with a reason, the effect on the linear absorption coefficient if the beam is comprised of 100 keV photons.

.....

.....[2]

8 **(a)** With reference to the eye, explain what is meant by *accommodation*.

.....

.....

.....[2]

(b) Estimate the change in power of the optical system of an eye when viewing a star and then when reading a book.

change in power = ...D [3]

9 Explain why the intensity level of a sound may provide a measure of loudness, but care must be taken in the interpretation of such measurements.

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.....

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.....

.....[5]

Option P

Environmental Physics

10 (a) Distinguish between the functions of a solar cell and a solar panel.

solar cell: .....

.....

solar panel: .....

.....[2]

(b) (i) State one practical use of solar cells.

.....

(ii) Explain, giving numerical values where appropriate, why it is not feasible to replace nuclear reactors with solar cells for the generation of electrical power.

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.....

[4]

11 Fig. 11.1 is an idealised indicator diagram for one cycle of a four-stroke petrol engine.

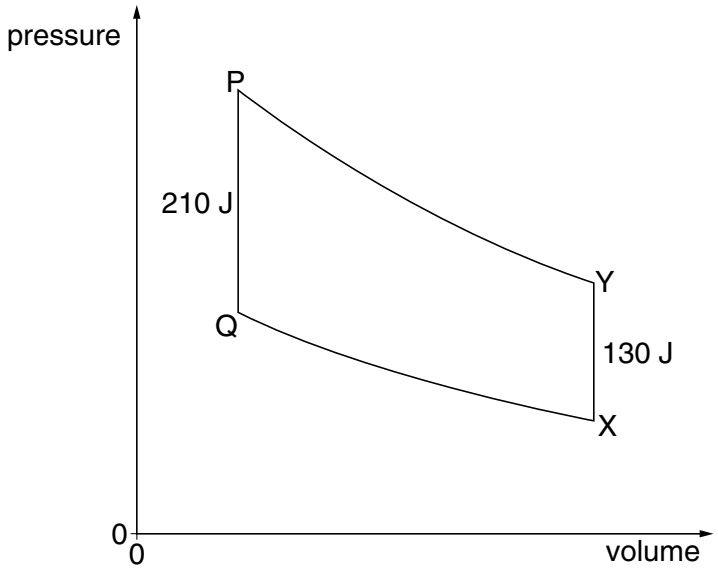


Fig. 11.1

In the changes PQ and XY, the energies involved are 210 J and 130 J respectively.

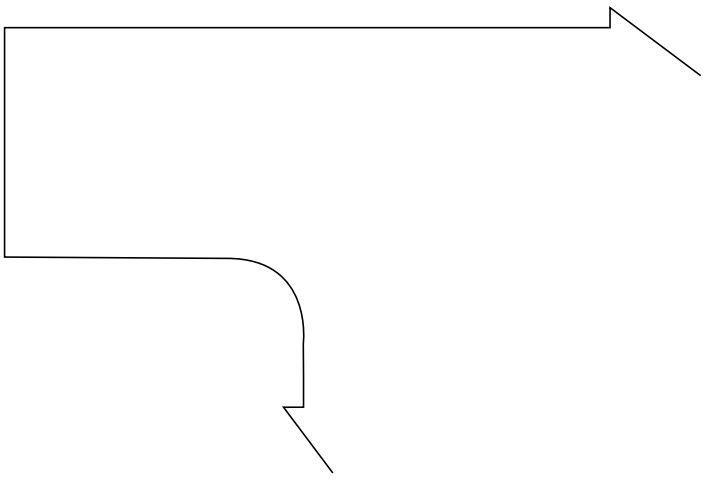
(a) On Fig. 11.1,

(i) mark with arrows the directions of the changes PQ, QX, XY and YP,

(ii) mark the directions of the transfers of energy.

[2]

(b) Complete the Sankey diagram of Fig. 11.2 for one cycle of the engine.



[3]

Fig. 11.2

(c) (i) Calculate the efficiency of the engine.

efficiency = ... %

(ii) By reference to the second law of thermodynamics, suggest why no engine can achieve 100% efficiency.

.....

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.....
[5]

12 A student stated that all cars should be driven by electric motors rather than petrol or diesel engines so that pollution would be reduced. Comment on this statement.

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.....

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.....[4]

Option T

Telecommunications

13 **(a)** Explain what is meant by a *digital* signal.

.....

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.....[2]

(b) Music can be recorded and stored digitally on a compact disc (CD). The music is sampled at a frequency of 44.1 kHz, and each sample consists of two 16-bit words, corresponding to the left and right stereo channels.

Calculate the total number of bits stored on this CD if its playing time is 1.0 hour.

number = ... [2]

(c) State one advantage and one disadvantage of storing and transmitting music in digital rather than analogue form.

advantage: .....

.....

disadvantage: .....

.....[2]

14 Fig. 14.1 shows the variation with time t of the power of a pulse of light on entering and on leaving an optic fibre.

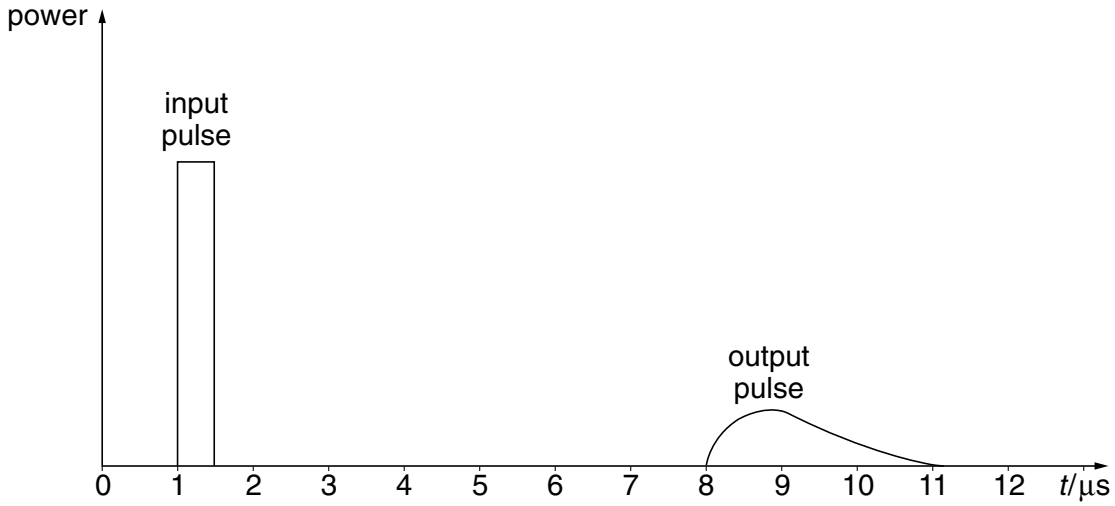

Fig. 14.1

(a) Suggest why

(i) the output pulse has a smaller area on the graph than the input pulse,

.....

.....

(ii) the output pulse lasts for a longer time than the input pulse.

.....

.....

[4]

(b) The length of the optic fibre is 1400 m. Use Fig. 14.1 to determine a value for the speed of light in the fibre. Explain your working.

speed = ... $m\,s^{-1}$ [4]

15 **(a)** State a typical value of wavelength for

(i) sky waves,

wavelength = ... m

(ii) space waves.

wavelength = ... m
[2]

(b) Explain why radio communication via satellite is more reliable than communication using sky waves.

.....

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.....

.....[4]

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