UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

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| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | | |

*4835727641*

**PHYSICS** **9702/22**

Paper 2 AS Structured Questions **May/June 2013**

**1 hour**

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 pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
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 | |
|---|---|
| 1 | |
| 2 | |
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| 4 | |
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| 6 | |
| 7 | |
| Total | |

This document consists of **14** printed pages and **2** blank pages.


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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, $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$

$$\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \cdot\ 10^{9}\ \text{m F}^{-1}\right)$$

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, $\phi = -\frac{Gm}{r}$

hydrostatic pressure, $p = \rho gh$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

simple harmonic motion, $a = -\omega^2 x$

velocity of particle in s.h.m., $v = v_0 \cos \omega t$
$v = \pm \omega \sqrt{(x_0^2 - x^2)}$

electric potential, $V = \frac{Q}{4\pi\varepsilon_0 r}$

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, $W = \frac{1}{2}QV$

resistors in series, $R = R_1 + R_2 + \ldots$

resistors in parallel, $1/R = 1/R_1 + 1/R_2 + \ldots$

alternating current/voltage, $x = x_0 \sin \omega t$

radioactive decay, $x = x_0 \exp(-\lambda t)$

decay constant, $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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**[Turn over**

Answer **all** the questions in the spaces provided.

**1** **(a)** Determine the SI base units of power.

SI base units of power ..... [3]

**(b)** Fig. 1.1 shows a turbine that is used to generate electrical power from the wind.

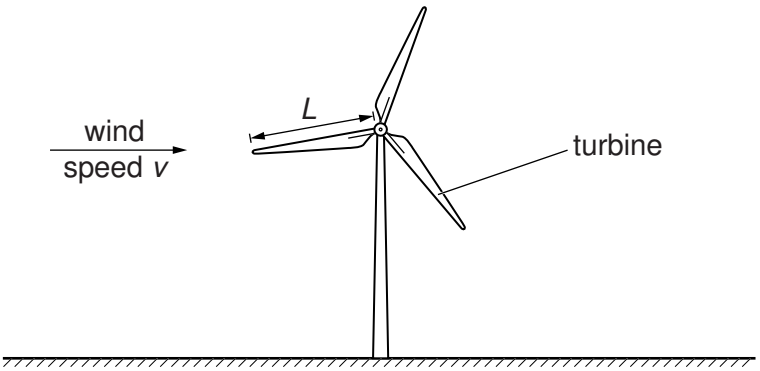


**Fig. 1.1**

The power $P$ available from the wind is given by

$$P = CL^2\rho v^3$$

where $L$ is the length of each blade of the turbine,
$\rho$ is the density of air,
$v$ is the wind speed,
$C$ is a constant.

**(i)** Show that $C$ has no units.

[3]

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**(ii)** The length $L$ of each blade of the turbine is 25.0 m and the density $\rho$ of air is 1.30 in SI units. The constant $C$ is 0.931.
The efficiency of the turbine is 55% and the electric power output $P$ is $3.50 \times 10^5$ W.

Calculate the wind speed.

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

**(iii)** Suggest two reasons why the electrical power output of the turbine is less than the power available from the wind.

1. .....

.....

2. .....

.....
[2]

**2** **(a)** Define *force*.

..... [1]

**(b)** A resultant force $F$ acts on an object of mass 2.4 kg. The variation with time $t$ of $F$ is shown in Fig. 2.1.

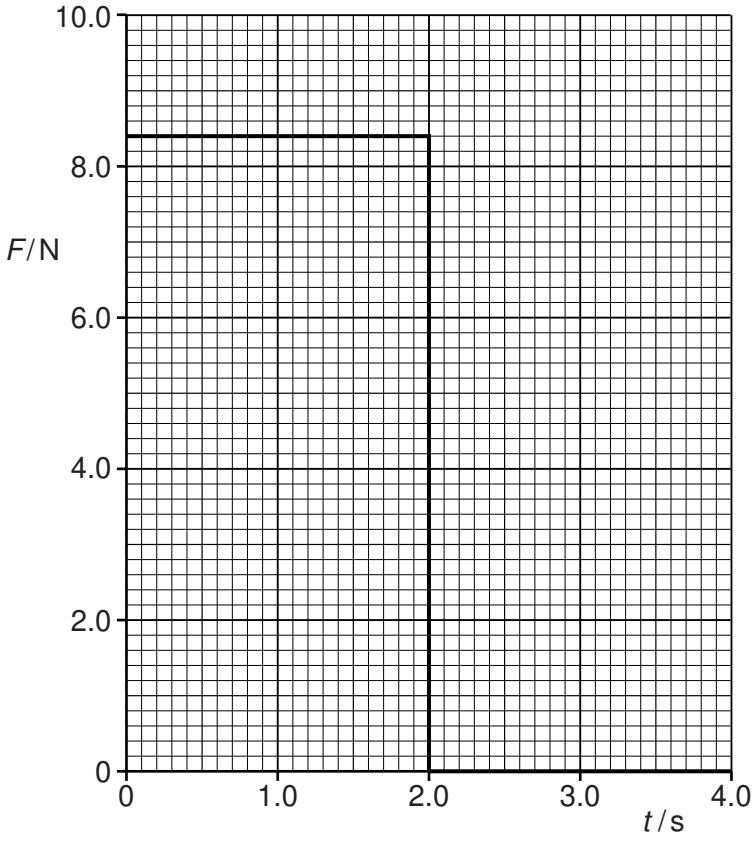


**Fig. 2.1**

The object starts from rest.

**(i)** On Fig. 2.2, show quantitatively the variation with $t$ of the acceleration $a$ of the object. Include appropriate values on the $y$-axis.

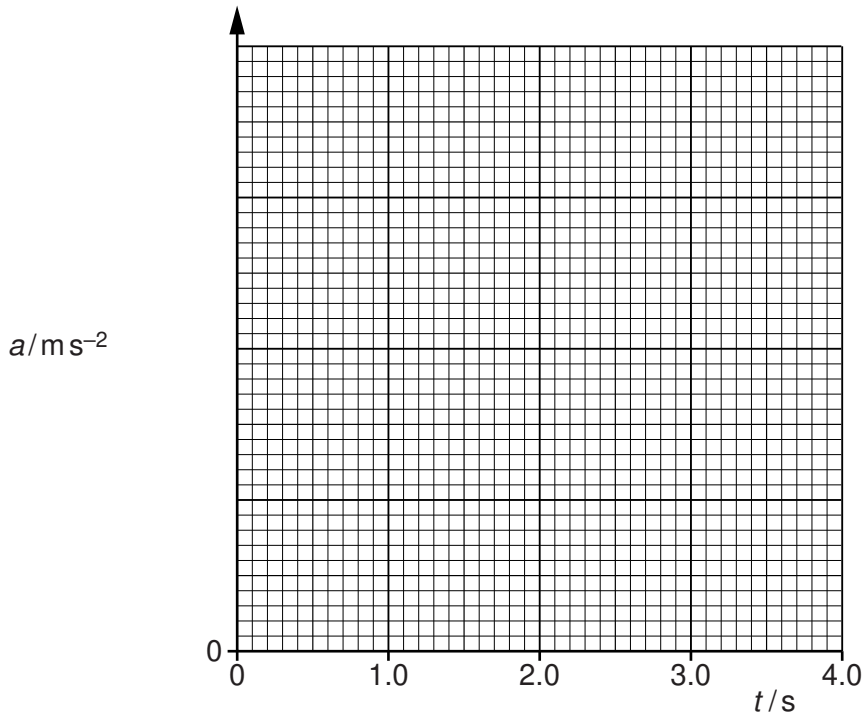


**Fig. 2.2**

[4]

**(ii)** On Fig. 2.3, show quantitatively the variation with $t$ of the momentum $p$ of the object. Include appropriate values on the $y$-axis.

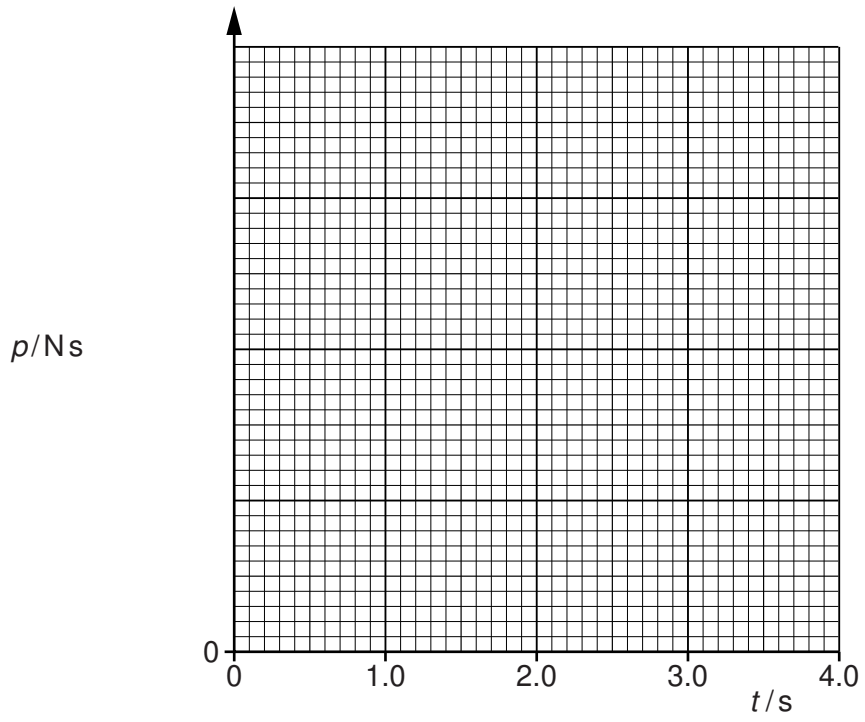


**Fig. 2.3**

[5]

**3** **(a)** Define *centre of gravity*.

.....

.....[2]

**(b)** A uniform rod AB is attached to a vertical wall at A. The rod is held horizontally by a string attached at B and to point C, as shown in Fig. 3.1.

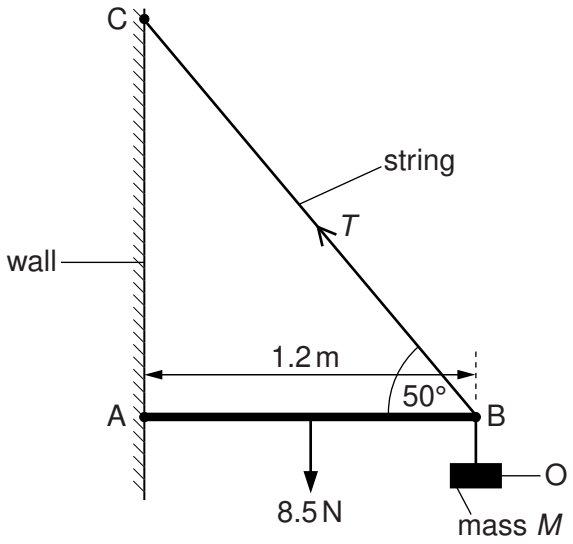


**Fig. 3.1**

The angle between the rod and the string at B is 50°. The rod has length 1.2 m and weight 8.5 N. An object O of mass *M* is hung from the rod at B. The tension *T* in the string is 30 N.

**(i)** Use the resolution of forces to calculate the vertical component of *T*.

vertical component of *T* = ..... N [1]

**(ii)** State the *principle of moments*.

.....

.....[1]

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**(iii)** Use the principle of moments and take moments about A to show that the weight of the object O is 19 N.

[3]

**(iv)** Hence determine the mass *M* of the object O.

*M* = ..... kg [1]

**(c)** Use the concept of equilibrium to explain why a force must act on the rod at A.

.....

.....

.....[2]

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**4** **(a)** Describe apparatus that demonstrates Brownian motion. Include a diagram.

.....

.....

.....

.....

.....[2]

**(b)** Describe the observations made using the apparatus in **(a)**.

.....

.....

.....[2]

**(c)** State and explain two conclusions about the properties of molecules of a gas that follow from the observations in **(b)**.

1. .....

.....

2. .....

.....

[2]

**5** Fig. 5.1 shows a string stretched between two fixed points P and Q.

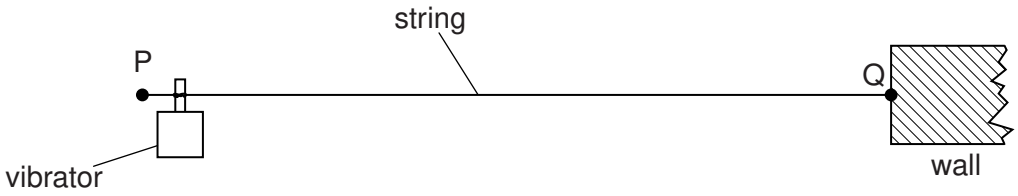


**Fig. 5.1**

A vibrator is attached near end P of the string. End Q is fixed to a wall. The vibrator has a frequency of 50 Hz and causes a transverse wave to travel along the string at a speed of $40\,m\,s^{-1}$.

**(a) (i)** Calculate the wavelength of the transverse wave on the string.

wavelength = ..... m [2]

**(ii)** Explain how this arrangement may produce a stationary wave on the string.

.....

.....

.....[2]

**(b)** The stationary wave produced on PQ at one instant of time *t* is shown on Fig. 5.2. Each point on the string is at its maximum displacement.

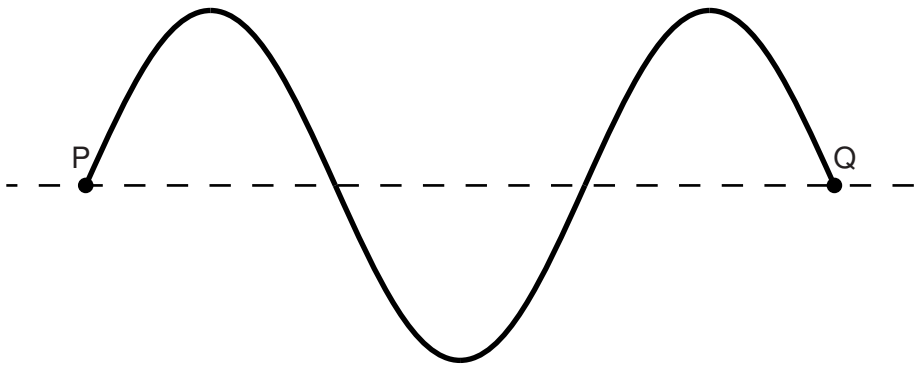


**Fig. 5.2** (not to scale)

**(i)** On Fig. 5.2, label all the nodes with the letter **N** and all the antinodes with the letter **A**. [2]

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**(ii)** Use your answer in **(a)(i)** to calculate the length of string PQ.

length = ..... m [1]

**(iii)** On Fig. 5.2, draw the stationary wave at time ($t$ + 5.0 ms). Explain your answer.

.....[3]

**6** **(a)** Define *charge*.

.....[1]

**(b)** A heater is made from a wire of resistance 18.0 Ω and is connected to a power supply of 240 V. The heater is switched on for 2.60 Ms.

Calculate

**(i)** the power transformed in the heater,

power = ..... W [2]

**(ii)** the current in the heater,

current = ..... A [1]

**(iii)** the charge passing through the heater in this time,

charge = ..... C [2]

**(iv)** the number of electrons per second passing a given point in the heater.

number = ..... $s^{-1}$ [2]

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**7** A polonium nucleus $^{210}_{84}Po$ is radioactive and decays with the emission of an $\alpha$-particle. The nuclear reaction for this decay is given by

$$^{210}_{84}Po \rightarrow {}^{W}_{X}Q + {}^{Y}_{Z}\alpha.$$

**(a) (i)** State the values of $W$ .....

$X$ .....

$Y$ .....

$Z$ .....

[2]

**(ii)** Explain why mass seems not to be conserved in the reaction.

.....

.....[2]

**(b)** The reaction is spontaneous. Explain the meaning of *spontaneous*.

.....

.....[1]

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