Surname	Centre Number	Candidate Number
Other Names		2

GCE A level

1324/01

PHYSICS
PH4: OSCILLATIONS AND FIELDS

P.M. TUESDAY, 24 January 2012

1½ hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**14**	
3.	**7**	
4.	**13**	
5.	**12**	
6.	**14**	
7.	**12**	
Total	**80**	

1324 010001

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

BLANK PAGE

Examiner only

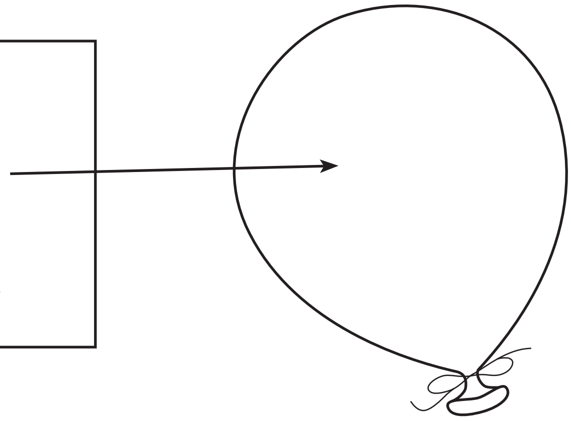
1. A toy balloon contains gas for which data are given.

pressure = 1.10×10^5 Pa

density = $1.25\,\text{kg}\,\text{m}^{-3}$

total mass of air (M) = 3.75 g

number of particles = 8.06×10^{22}



(a) Calculate the rms speed of the molecules inside the balloon. [2]

(b) Show that the molar mass of the gas inside the balloon is approximately 28. [2]

(c) (i) Calculate the momentum of a gas molecule of mass 4.65×10^{-26} kg travelling at a speed of $460\,\text{m}\,\text{s}^{-1}$. [2]

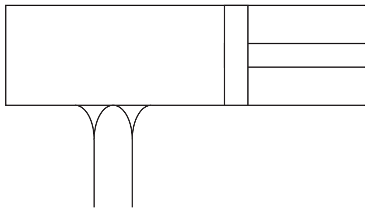
(ii) Calculate the wavelength of a photon of light that has the same momentum as this gas molecule. [2]

1324 010003

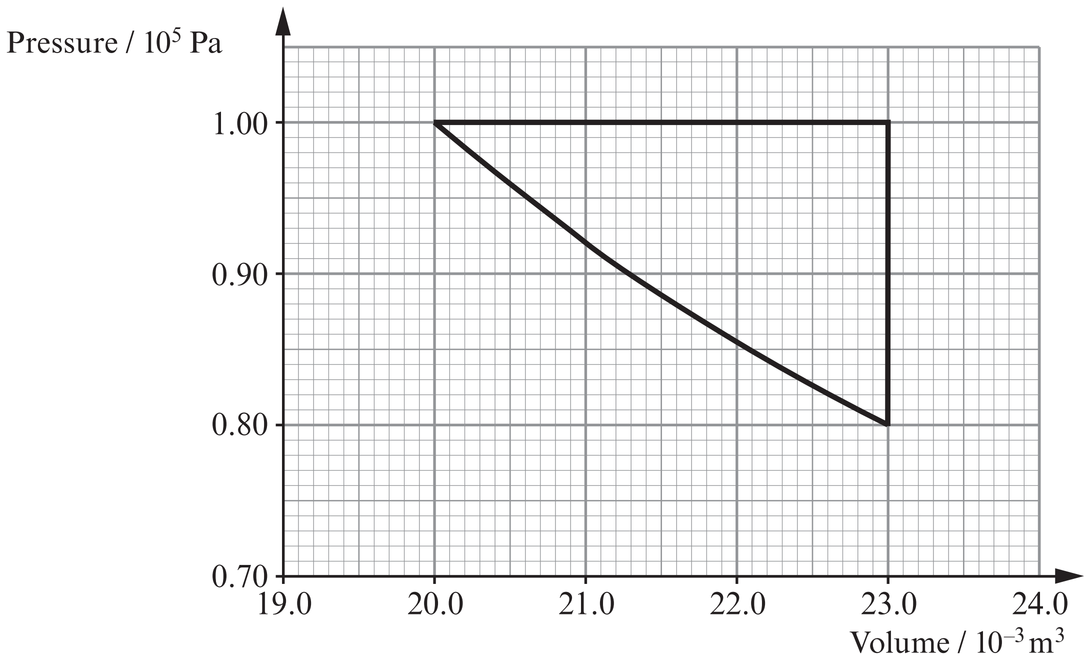
Turn over.

Examiner only

2. *(a)* (i) Gas inside a cylinder is heated using a Bunsen burner.



The gas expands at constant pressure.
Label the start of this expansion **A** and the end **B** on the p-V graph below. [1]



(ii) The gas is now cooled at constant volume from **B**.
Label the end point of this process **C**. [1]

(b) When the gas is at a pressure of 1.00×10^5 Pa and has a volume 20.0×10^{-3} m^3, its temperature is 323 K.

(i) Calculate the total number of moles of gas. [2]

....

....

....

(ii) Calculate the total number of molecules of gas. [1]

....

....

....

Examiner only

(iii) Calculate the temperatures of the gas at **B** and **C**. [2]

....

....

....

(c) For **BC**, the gas was cooled by pouring 0.125 kg of cold water over the piston. The amount of heat that flowed out of the gas was 715 J. Calculate the increase in temperature of the cold water given that the specific heat capacity of water is 4200 J kg^{-1} K^{-1}. [2]

....

....

....

(d) Estimate the total work done by the gas for the whole cycle **ABCA**. [3]

....

....

....

....

....

(e) Explain why your answer to *(d)* is also the heat flowing into the gas during the cycle **ABCA**. [2]

....

....

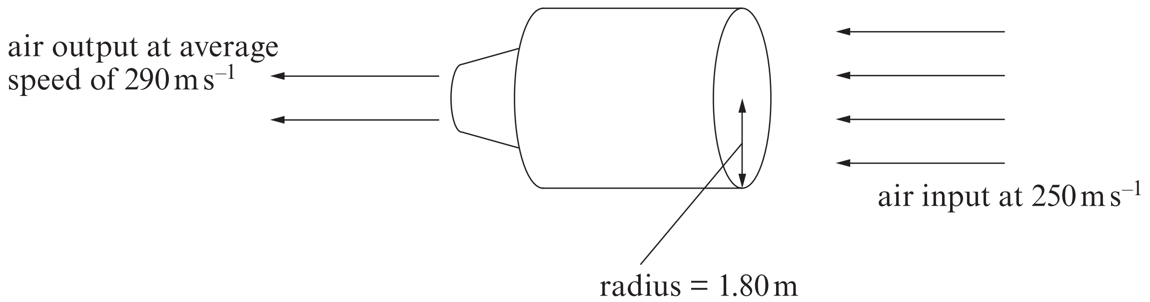
....

1324 010005

Turn over.

Examiner only

3. A Rolls Royce jet engine operates by collecting air into the jet engine at a speed of $250\,\text{m}\,\text{s}^{-1}$ and ejecting it with an average speed of $290\,\text{m}\,\text{s}^{-1}$.



(a) The radius of the jet engine is 1.80 m as shown and the density of air entering it is $0.4\,\text{kg}\,\text{m}^{-3}$. Show that the mass of air entering the jet engine per second is approximately 1 000 kg. [3]

....

....

....

....

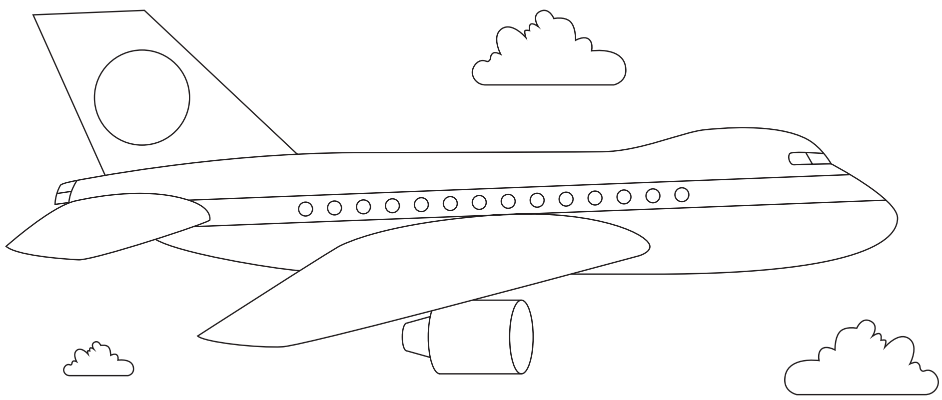
....

(b) Calculate the forward thrust produced by this jet engine. [2]

....

....

....



(c) Explain how the principle of conservation of momentum applies to the air - aeroplane system when the aeroplane is travelling at a **constant** velocity of $250\,\text{m}\,\text{s}^{-1}$. [2]

....

....

....

Examiner only

4. The first step in deriving the relationship between the height of a satellite above the Earth's surface, h, and the period of its orbit around the Earth is to note that the centripetal force is provided by the gravitational force:

$$\frac{Gm_1m_2}{r^2} = m_2\omega^2 r$$

(a) Explain briefly the meaning of each term in the equation. [4]

m_1 ....

m_2 ....

r ....

ω ....

(b) Use the above equation to derive the relationship between the height, h, of a satellite above the Earth's surface and its orbital period, T, [4]

$$h + R_E = \sqrt[3]{\frac{Gm_1T^2}{4\pi^2}}$$

where R_E is the radius of the Earth.

....

....

....

....

....

....

(c) The mass of the Earth is 6.0×10^{24} kg and its radius is 6.4×10^6 m. Calculate the height of a geostationary satellite above the Earth's surface. [2]

....

....

....

....

(d) The mass of the satellite is 850 kg. Calculate the increase in its potential energy when it was initially moved from the Earth's surface to the geostationary orbit. [3]

....

....

....

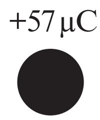
....

....

1324
010007

Examiner only

5. The diagram shows an isolated positive charge (+57 μC).



(a) Sketch and label electric field lines and equipotential surfaces for the positive charge. [3]

(b) State **one** difference between this diagram and the equivalent diagram of the gravitational field due to a spherical mass. [1]

(c) Calculate the magnitude of the electric field strength 15.8 cm from the centre of the +57 μC charge. [2]

(d) (i) Calculate the potential 15.8 cm from the centre of the +57 μC charge. [2]

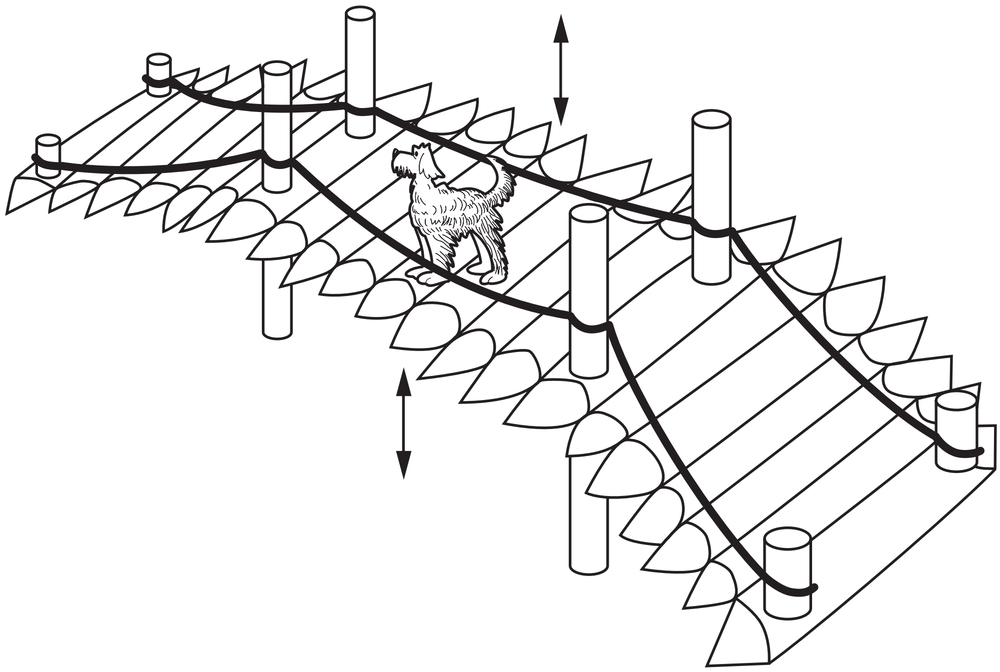
(ii) State the potential a large (infinite) distance away from the +57 μC charge. [1]

(e) A 2.45 μC point charge is placed 15.8 cm away from the +57 μC charge and then released. Use your answers to *(d)* to calculate the final kinetic energy of the point charge when it has travelled a large distance away from the +57 μC charge. [3]

BLANK PAGE

Examiner only

6. A poorly-designed bridge oscillates up and down at its natural period of 0.81 s.



(a) Calculate the natural frequency of oscillation. [2]

....

....

(b) Show that the angular velocity of the oscillations is approximately 7.8 rad s^{-1}. [2]

....

....

(c) When people walk across this bridge, oscillations of large amplitude occur. Explain the cause of the large-amplitude oscillations and the possible consequences. [3]

....

....

....

....

....

....

Examiner only

(d) A dog standing in the middle of the bridge moves up and down with simple harmonic motion with an amplitude of 10.4 cm (and period 0.81 s). At time t = 0 s, the dog is at the centre of its motion moving upwards. Calculate the displacement of the dog at time t = 1.40 s. [2]

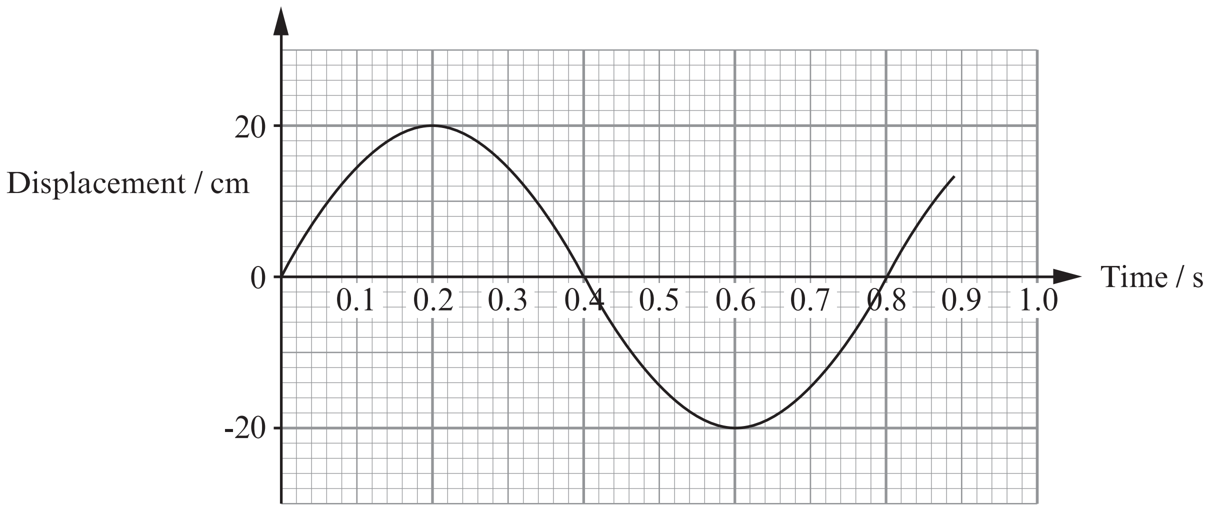
....

....

....

....

(e) The amplitude of oscillation is increased and is now so great that the dog temporarily loses contact with the bridge. The displacement of the bridge where the dog is standing varies as shown.



(i) Calculate the dog's displacement when it loses contact with the bridge. [Hint: The downward acceleration of the dog cannot be greater than g.] [3]

....

....

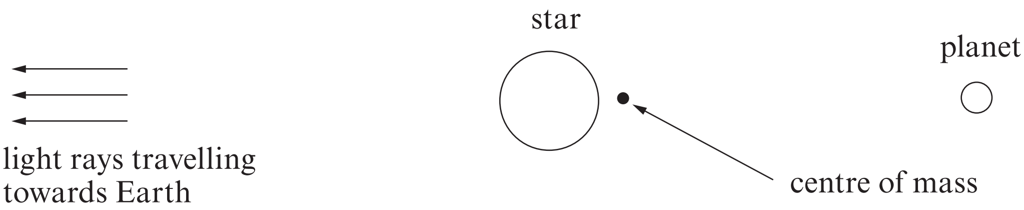
....

....

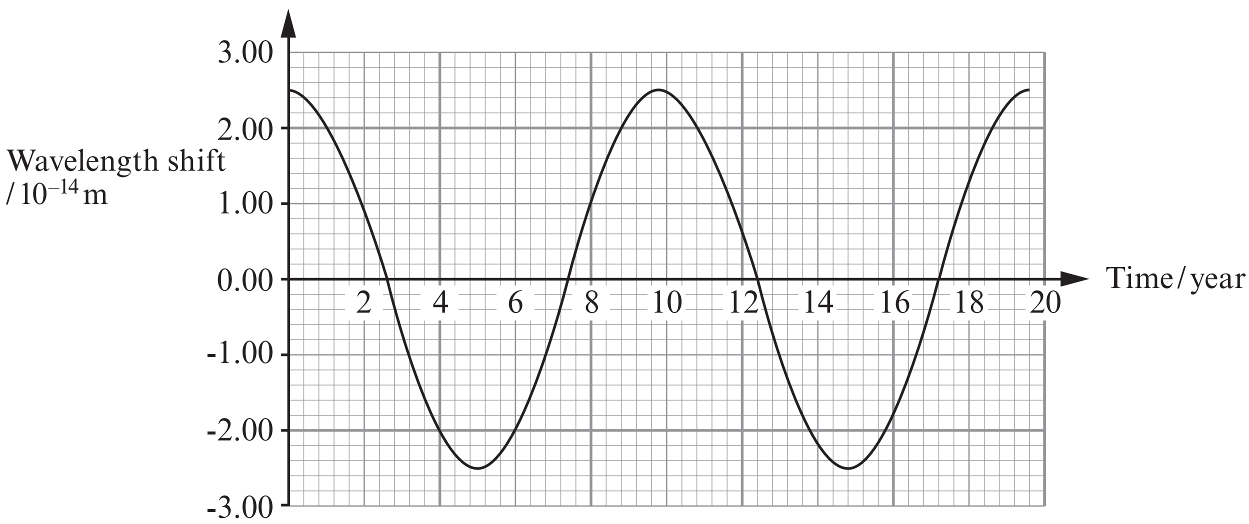
(ii) **Without further calculation** indicate, on the graph above, the point at which the dog loses contact with the bridge and the **approximate point** at which it makes contact with the bridge again. [2]

Examiner only

7. Light from a distant star arrives at the Earth. The star and a planet are revolving about the centre of mass of the star-planet system (see diagram).



A scientist analyses the light and draws the following graph of results.



(a) Use an appropriate value from the graph to show that the orbital speed of the star about the centre of mass is approximately $12\,\text{m}\,\text{s}^{-1}$.
[The wavelength of light used is 650 nm] [2]

....

....

....

....

(b) Use the period of orbit of the star to calculate the radius of the star's orbit. [3]

....

....

....

Examiner only

(c) The mass of the star is 2×10^{31} kg. Show that the distance between the star and the planet is approximately 1.5×10^{12} m. [Show your working clearly and state any approximation that you make]. [3]

....

....

....

....

....

....

(d) Calculate the mass of the planet. [2]

....

....

....

(e) The luminosity (radiation power output) of the star is 3000 times greater than our Sun. However, the planet is ten times further away from the star than the Earth is from the Sun. Explain briefly whether or not the temperature of this planet is similar to that of the Earth. [2]

....

....

....