Candidate Name	Centre Number	Candidate Number

GCE A level

1324/01

PHYSICS

ASSESSMENT UNIT PH4: OSCILLATIONS AND FIELDS

A.M. FRIDAY, 18 June 2010

1½ hours

For Examiner's use only.		
1.	9	
2.	13	
3.	14	
4.	10	
5.	12	
6.	11	
7.	11	
Total	80	

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

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.

1324 01 01

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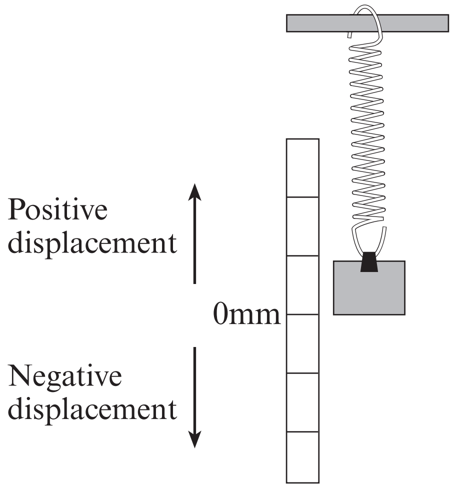
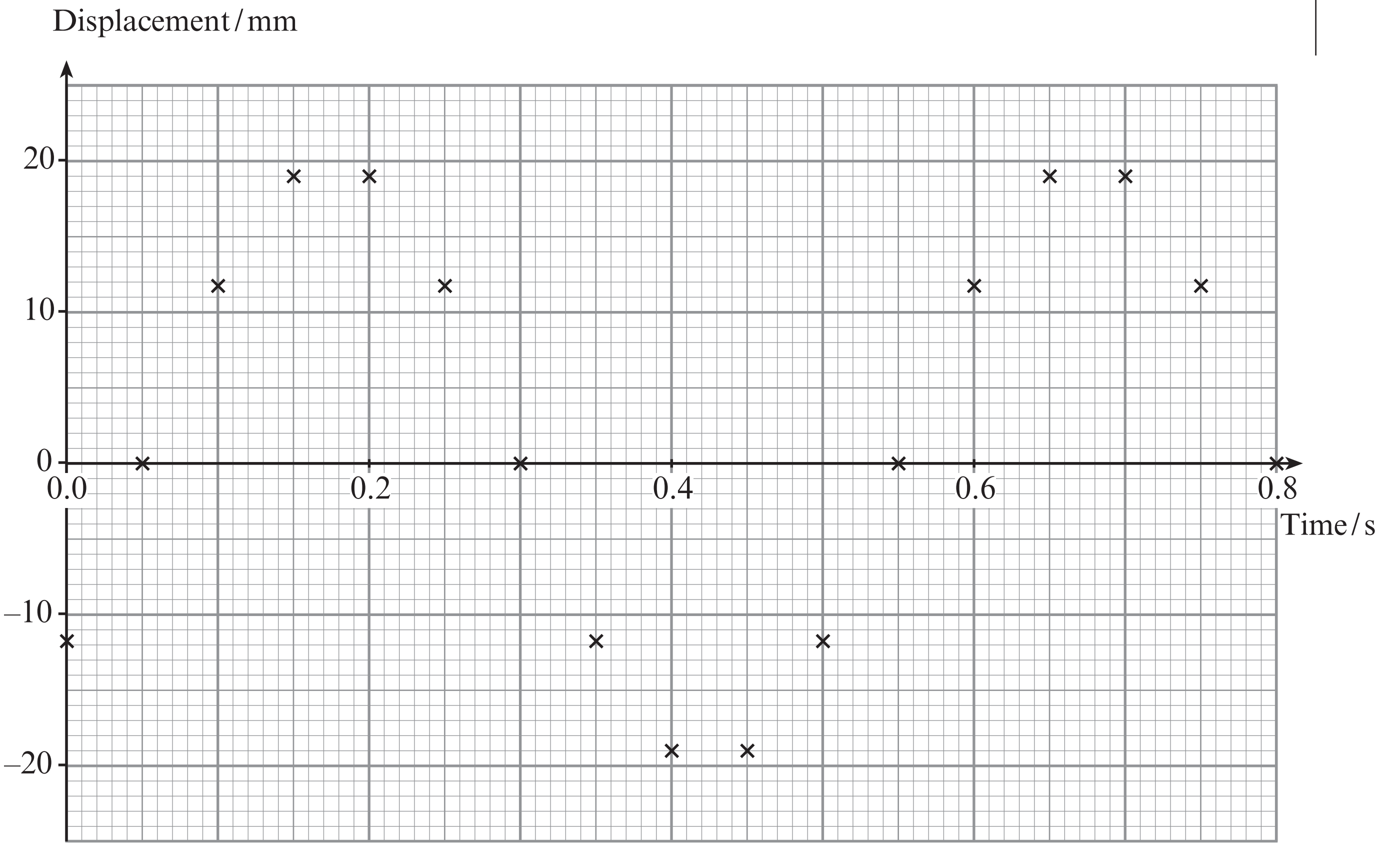
1. In a laboratory experiment a block with a mass of 0.04 kg is suspended from a vertical spring. The diagram shows the block in its equilibrium position. When it is pulled down and released it oscillates with simple harmonic motion (SHM).

The motion is recorded by a high speed video camera, and the displacement of the bottom of the block at regular times is shown on the graph.





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(a) Define simple harmonic motion (SHM).

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[2]

(b) On the graph, plot carefully a curve through the points that shows how the displacement varies with time. [1]

(c) Show that the angular frequency, ω, of the oscillation is 12.57 rad s^{-1}.

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[1]

(d) Calculate the maximum speed of the block.

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[2]

(e) Find the stiffness, k, of the spring (force per unit extension).

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[3]

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2. The air in a room of dimensions 6.0 m × 5.0 m and height 3.0 m is at atmospheric pressure, 1.01×10^5 Pa, and a temperature of 293 K.

(a) Write two assumptions of the kinetic theory of gases.

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(b) Calculate the number of air molecules in the room.

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.... [2]

(c) At some instant three of the molecules in the room have respectively speeds of 350 m s^{-1}, 420 m s^{-1} and 550 m s^{-1}. Calculate the root-mean-square (r.m.s.) speed of these three molecules at this instant.

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(d) Show that the r.m.s. speed of all the molecules in the room is approximately 500 m s^{-1}. (Mean relative molecular mass of air = 29)

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(e) Scent is sprayed in one corner of the room.

(i) Use the r.m.s. speed in part *(d)* to estimate a time of travel of a molecule from the spray to the far corner of the room.

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.... [1]

(ii) Is this a reasonable estimate of the delay between the spraying of the scent and its detection at the far corner of the room? Explain your answer.

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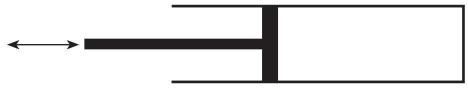
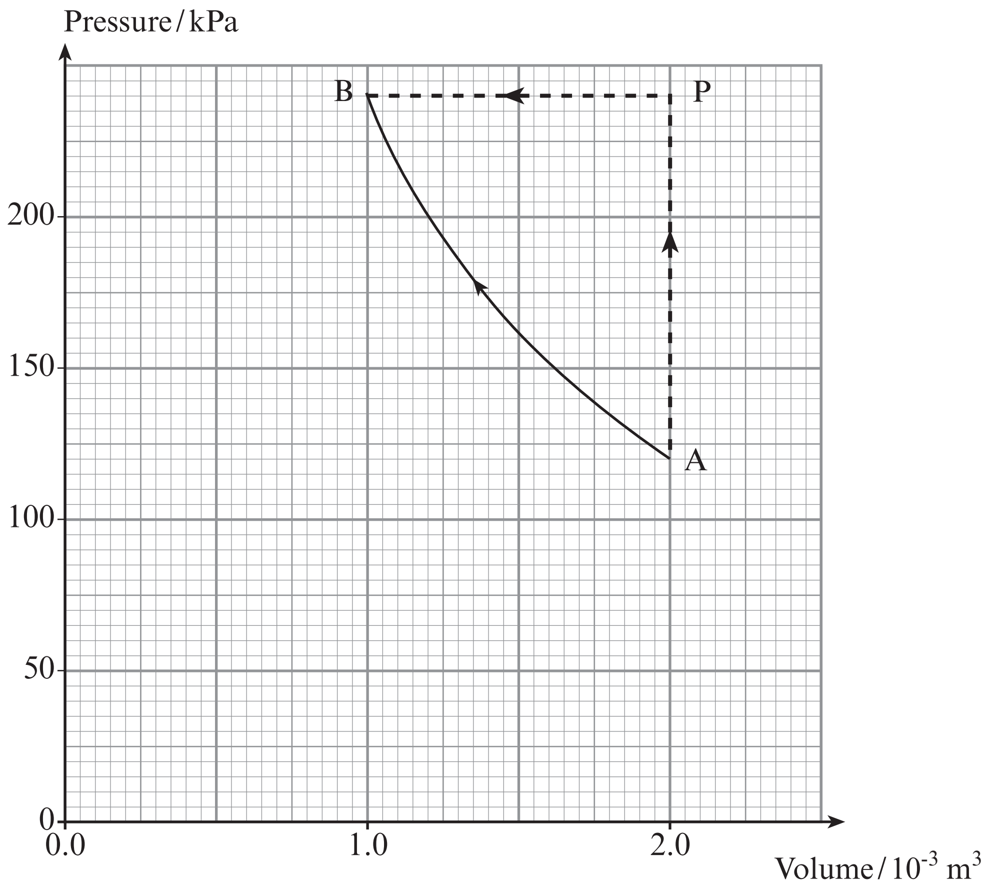
1324 01 05

3. A gas is contained in a metal cylinder with a leak-proof piston at one end



The pressure and volume of the gas during an experiment are shown on the graph below.



(a) The first law of thermodynamics may be written.

$$\Delta U = Q - W$$

By referring to the gas in the cylinder, explain the meaning of

(i) ΔU .... [1]

(ii) Q .... [1]

(iii) W .... [1]

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(b) If the cylinder contains 0.1 mol of gas and the initial conditions are given by point A on the graph, show that the initial temperature of the gas is approximately 290 K.

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.... [3]

(c) The gas is compressed along the curved path AB at a constant temperature of 290 K. Show that the total work done along this path is approximately 170 J.

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(d) In an alternative process for changing the state, the gas follows path APB.

(i) Explain why no work is done on or by the gas along the path AP.

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.... [2]

(ii) Estimate the total work done along path PB, **indicating clearly** whether the work is done on or by the gas.

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.... [2]

(e) Use the first law of thermodynamics to explain why the heat flowing out of the gas system along path APB is different from the heat flowing out along path AB. A calculation is not required.

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1324 01 07

4. *(a)* The diagram shows a positively charged particle at rest. Draw and label the electric field on the diagram – include electric field lines and equipotential surfaces.

[2]

(b) (i) An alpha particle (helium nucleus) of charge 3.2×10^{-19} C and mass 6.6×10^{-27} kg travels with a speed of $5.0 \times 10^{6}\,\mathrm{m\,s^{-1}}$. Calculate its kinetic energy.

[1]

(ii) If the alpha particle travels head-on towards a stationary copper nucleus of charge 4.6×10^{-18} C in thin copper foil, find their distance of closest approach.

[4]

(iii) Describe in terms of energy what happens to the alpha particle after it has reached the point of closest approach.

[2]

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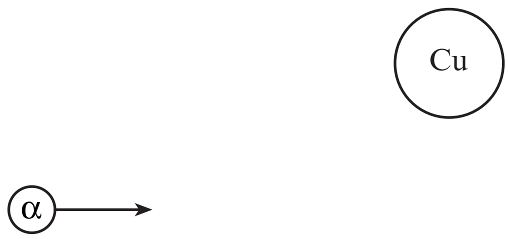
(iv) Complete the sketch below by showing the path of the alpha particle (α) if it was not travelling head-on towards the copper nucleus (Cu).



[1]

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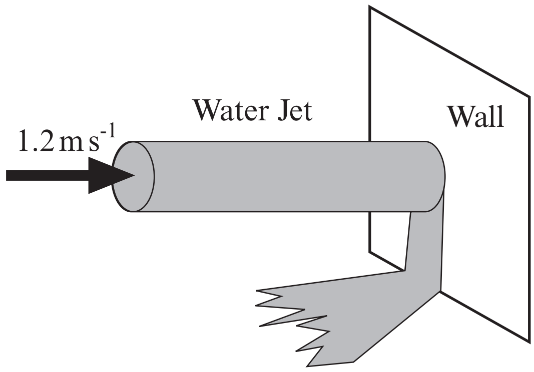
5. *(a)* A horizontal jet of water strikes a vertical wall perpendicularly. The speed of the water is $1.2\,\text{m s}^{-1}$ and the cross-sectional area of the jet is $2.0 \times 10^{-4}\,\text{m}^2$. After striking the wall the water runs down the wall.
(Density of water = $1.00 \times 10^3\,\text{kg m}^{-3}$)



(i) Pressure = Force / Area. State the SI unit for pressure.

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[1]

(ii) Show that the mass of water that strikes the wall in 1.0 s is 0.24 kg.

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[1]

(iii) Show clearly that the decrease in the horizontal momentum of the water each second is approximately $0.3\,\text{kg m s}^{-1}$.

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[1]

(iv) Find the pressure exerted on the wall.

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[2]

Examiner only

(b) A beam of light with wavelength 660 nm from a laser of output power 1 mW is incident normally on a screen where it is totally absorbed.

(i) Determine the momentum of a single photon in the beam.

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.... [3]

(ii) If the beam is incident on an area of $1.0 \times 10^{-6}\,m^2$ determine the pressure exerted by the light on the screen.

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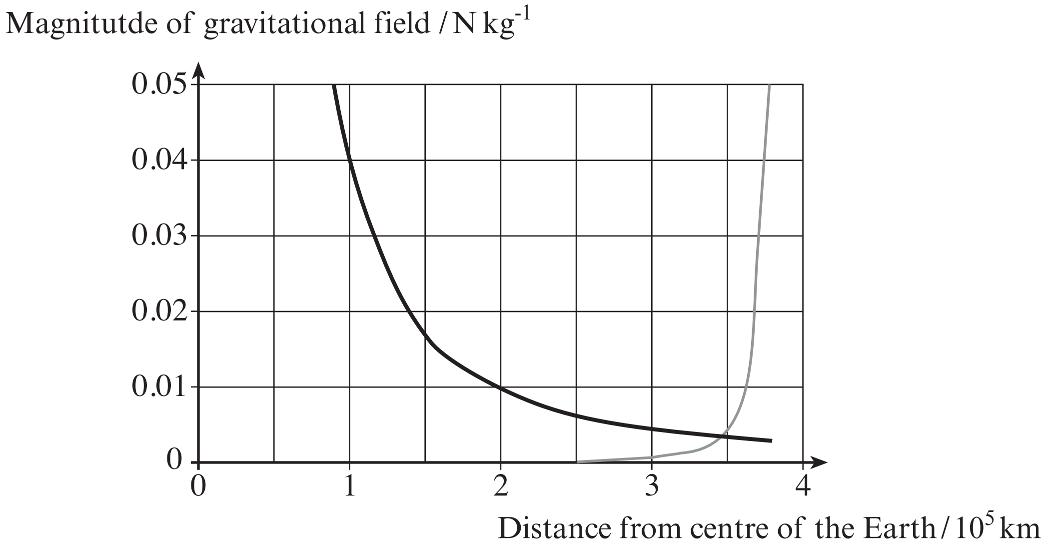
Turn over.

6. The graph below shows the **magnitudes** of the gravitational fields of the Earth (thick curve) and of the Moon (thin curve) along the line connecting the centre of the Earth to the centre of the Moon. Fields in excess of 0.05 N kg^{-1} are beyond the scale of the graph and are not plotted.



(a) Show by calculation that the gravitational field due to the Earth at a distance 1.0×10^5 km agrees with the graph. (Mass of the Earth = 6.0×10^{24} kg).

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[3]

(b) Explain why the Moon's gravitational field near the Earth is significantly less than the Earth's field near the Moon.

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[1]

Examiner only

(c) Estimate the distance of the point of intersection of the two curves from the centre of the Earth. Explain the significance of this point of intersection.

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(d) A spacecraft is launched directly **towards the Earth** from the equator of the Moon. Discuss the forces due to gravity that it experiences during its journey to Earth, mentioning their relative magnitudes.

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(e) A second spacecraft is launched on the far-side of the Moon so that it travels directly away from the Earth. Would it require more or less energy than the first spacecraft to escape from the Moon? Explain your answer.

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Examiner only

7. A star of mass 2.2×10^{30} kg has a companion planet. The star and planet orbit a common centre of mass with an orbital period of 1090 days.

(a) If the star's orbital speed is 45.5 m s^{-1}, determine the radius of the star's orbit.

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[3]

(b) (i) Show that the distance from the planet to the star is approximately 3.2×10^{11} m. The mass of the planet is very much smaller than the mass of the star.

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[4]

(ii) Hence, estimate the mass of the planet.

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[2]

Examiner only

(c) Suggest how the orbital speed of the star may have been measured.

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[2]

Examiner only