Candidate Name	Centre Number	Candidate Number

GCE A level

1324/01

PHYSICS

ASSESSMENT UNIT PH4: OSCILLATIONS AND FIELDS

A.M. TUESDAY, 21 June 2011

1½ hours

For Examiner's use only.		
1.	10	
2.	16	
3.	20	
4.	18	
5.	16	
Total	80	

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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.

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1. *(a)* State the *Principle of Conservation of Momentum.* [2]

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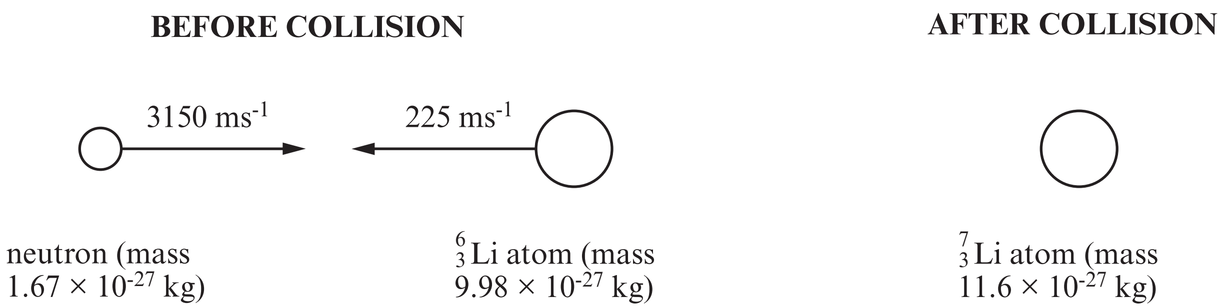
(b) (i) A head-on inelastic collision occurs between a neutron and a lithium atom, $^{6}_{3}$Li.

The nucleus of the atom absorbs the neutron, to form the heavier isotope $^{7}_{3}$Li. Using the data in the diagram, calculate the *velocity* of the $^{7}_{3}$Li atom, adding an arrow to the (right hand) diagram, to show its direction of motion. [4]



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(ii) By calculating *energies* confirm that the collision is inelastic. [2]

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(c) The nucleus of the $^{7}_{3}Li$ atom is formed in an excited state and loses excess energy by emitting a gamma ray photon of wavelength 1.71×10^{-13} m. Calculate the recoil velocity of the $^{7}_{3}Li$ atom, **treating its initial velocity as negligible.** [2]

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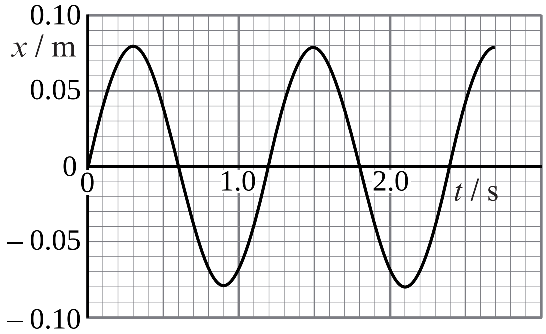
2. A steel ball of mass 0.40 kg hangs by a spring from a fixed support. The ball is displaced vertically from its equilibrium position and then released. A graph of **upward** displacement *(x)* from the equilibrium position against time *(t)* is plotted from readings obtained using a video camera.



(a) (i) How can you tell that $t = 0$ is not the time when the ball was released? [1]

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(ii) Write down the values of

(I) the *amplitude* of the oscillations. [1]

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(II) the *periodic time*. [1]

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(b) Calculate the *stiffness, k* (the force per unit extension), of the spring. [2]

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(c) (i) Show that the maximum speed of the ball is approximately 0.4 ms^{-1}. [2]

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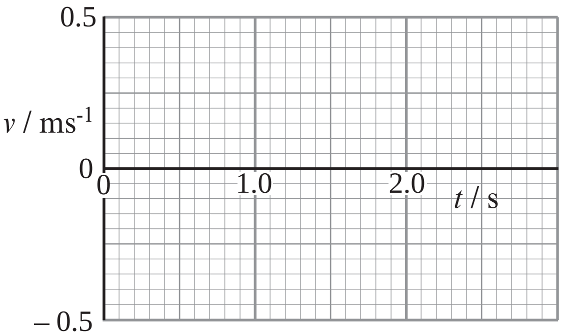
(ii) Sketch a graph of velocity *(v)* against time on the grid alongside. The maximum, minimum and zero values should be plotted carefully.



[2]

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(d) (i) Calculate the changes in *kinetic energy* and *gravitational potential energy* of the ball which occur between $t = 0.60\,\text{s}$ and $t = 0.90\,\text{s}$. State whether each is an increase or decrease.

(I) change in kinetic energy [2]

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(II) change in gravitational potential energy [1]

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(ii) Explain, without further calculation, how the *Principle of Conservation of Energy* applies over this interval. [1]

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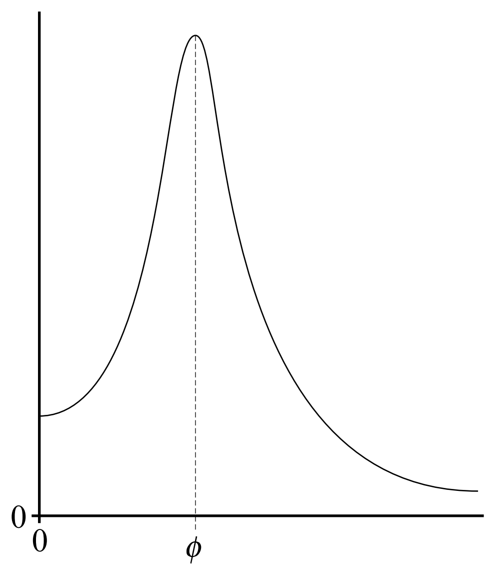
(e) The spring with its suspended steel ball is now hung from the pin of a vibration generator. This is connected to a signal generator so that the pin moves up and down. Using this apparatus, readings can be taken for a *resonance curve*. The curve is sketched alongside.



(i) Label the graph axes with the physical quantities plotted. [1]

(ii) Determine the expected value of ϕ, explaining your reasoning. [2]

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3. A cylinder fitted with a leak-proof piston contains 2.4×10^{-3} kg of argon gas at a pressure of 100 kPa. The volume of the gas is 1.5×10^{-3} m^3.

(a) (i) (I) Calculate the rms speed of the molecules. [3]

(II) At any instant some of the molecules will have speeds much greater than the rms speed of all the molecules. How could they have acquired such speeds? [1]

(III) Three of the molecules have speeds 935 ms^{-1}, 743 ms^{-1}, and 312 ms^{-1}. Calculate the rms speed of these three molecules. [3]

(ii) There are 0.0600 moles of argon gas in the cylinder.

(I) Show that the temperature of the gas is approximately 300 K. [2]

(II) Calculate the number of molecules of argon in the cylinder. [1]

(III) Calculate the relative molecular mass of argon. [2]

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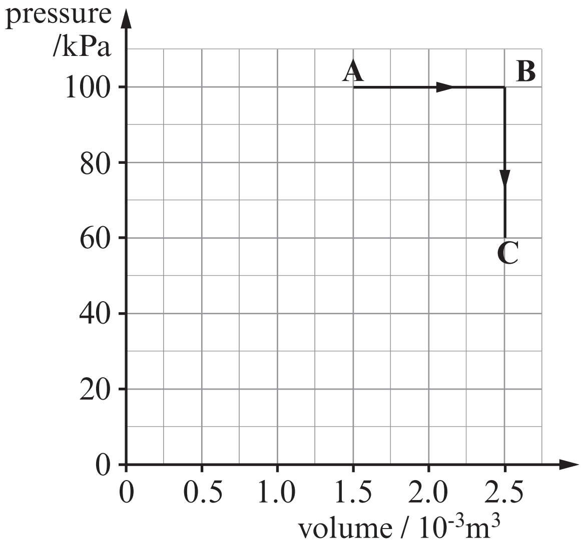
(b) The cylinder is now heated and the gas allowed to expand at constant pressure, pushing out the piston. The change is shown as **AB** on the graph.



(i) Calculate the *work* done by the gas for the change **AB**. [2]

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(ii) The *internal energy* of the argon gas is given by $U = \frac{3}{2}nRT$. [n = 0.0600 mole.]

Calculate the **increase** in internal energy of the gas for **AB**. [3]

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(iii) Calculate the heat taken in by the gas for **AB**. [1]

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(iv) The gas is now allowed to cool at constant volume to its original temperature. The change is shown as **BC** on the graph. How much heat is given off by the gas for **BC**? **Explain your reasoning**. [2]

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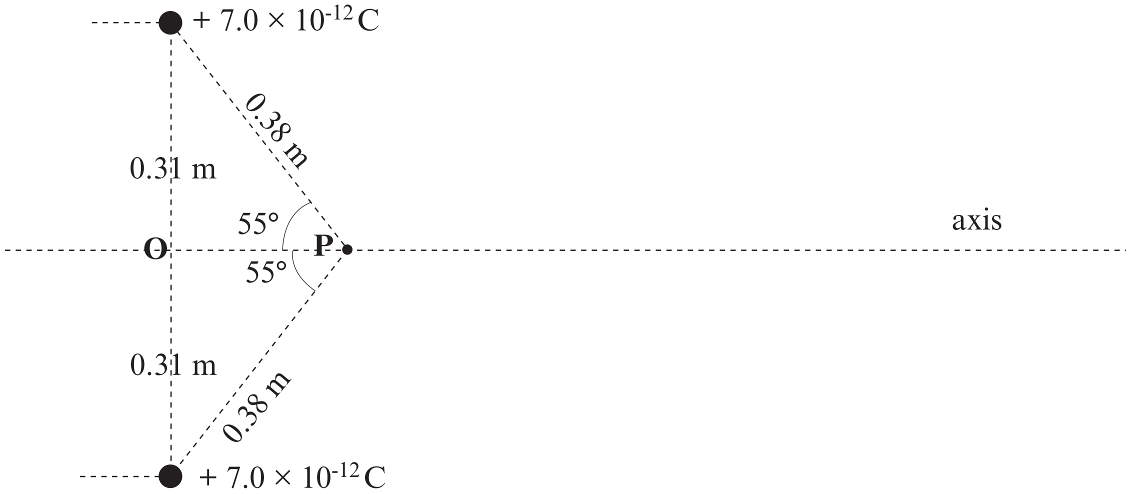
4. Two small positive charges are placed in empty space as shown.



(a) (i) Put arrows at point **P** to show the directions of the *electric fields* at **P** due to each charge. [1]

(ii) Calculate the **resultant** electric field strength at point **P**. [4]

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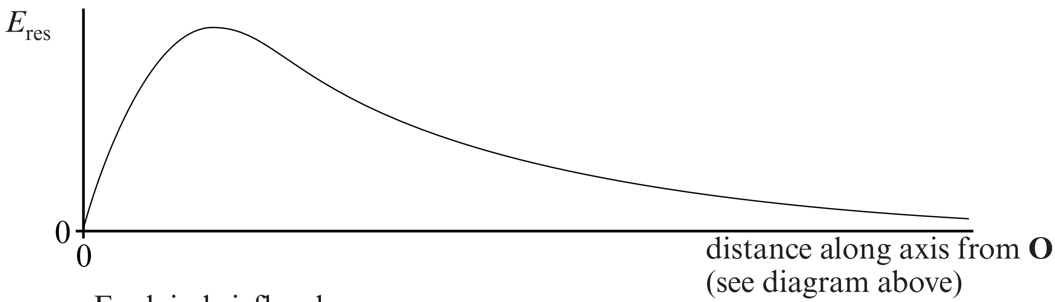
(iii) The graph shows how the resultant electric field strength, E_{res}, varies with distance along the axis from point **O**.



Explain briefly why

(I) E_{res} is zero at **O**. [1]

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(II) E_{res} decreases with distance along the axis, at large distances from **O**. [1]

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(b) A positive ion with a charge of 4.8×10^{-19} C and mass 4.5×10^{-26} kg enters the region shown in the diagram, travelling along the axis. At point **O** the ion is moving to the right with a speed of 2000 m s^{-1}. Gravitational and resistive forces are negligible.

(i) Calculate the *acceleration* of the ion as it passes through point **P**. [Make use of your answer from *(a)*(ii).] [2]

(ii) Describe how the *speed* of the ion changes as it travels along the axis from **O** until it is well beyond P. [2]

(iii) Calculate the *total energy* (kinetic energy + electrical potential energy) of the ion as it passes through point **O**. [See diagram.] [4]

(iv) Hence find the maximum speed eventually reached by the ion. [3]

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5. *(a)* Two planets, P and Q, orbit a star of mass M. The planets' masses are very much less than M.

(i) P's orbit is **non**-circular. Use Kepler's laws to describe with words and **diagrams**

(I) the path the planet takes, [2]

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(II) the variation in the planet's speed. [2]

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(ii) (I) Q's orbit is a circle of radius r. Show that Q's speed is given by $v = \sqrt{\frac{GM}{r}}$. [1]

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(II) Explain why this reasoning would be invalid if Q's mass were not very small compared with M. [2]

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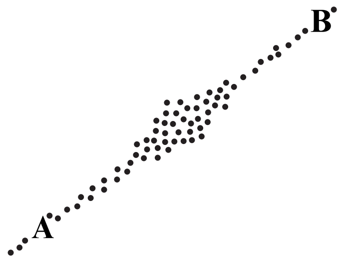
(b) (i) A galaxy is seen edge-on from the Earth. Light emitted from hydrogen atoms in the regions **A** and **B** is examined. [**A** and **B** are equal distances from the centre of the galaxy.] A line of wavelength 656.28 nm in the hydrogen spectrum is seen to be red-shifted to 658.36 nm in light from **A** and to 657.44 nm in light from **B**.



Calculate

(I) the radial velocities of **A** and **B**, that is their velocity components away from us. [2]

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(II) the mean radial velocity of the galaxy, [1]

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(III) the speed due to the rotation of **A** or **B** around the centre of the galaxy. [1]

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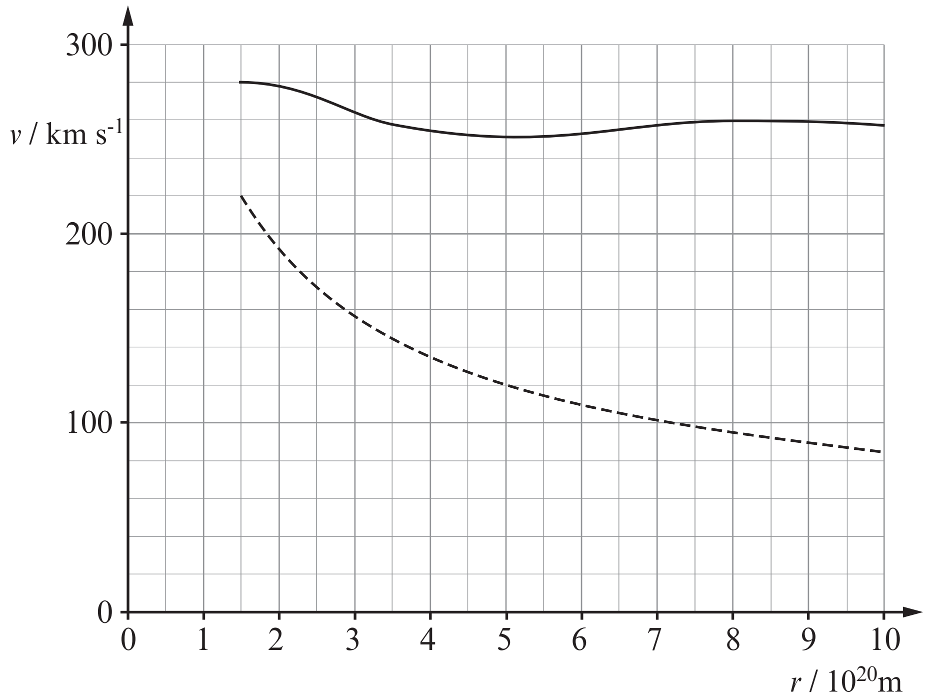
(ii) The **broken** line on the graph shows how the rotation speeds, *v,* of bodies in the outer regions of the galaxy depend on their distances, *r,* from the centre of the galaxy, according to the equation

$$v = \sqrt{\frac{GM}{r}}.$$

[*M* is an estimate of the galaxy's mass, based on the radiation emitted by the galaxy.]



(I) Calculate *M*. [3]

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(II) The full line on the graph is drawn using the rotation speeds actually observed. What does it tell us about the *actual* mass of the galaxy and its distribution within the galaxy compared with the mass and distribution on which the broken line is based? [2]

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