Surname	Centre Number	Candidate Number
Other Names		2

GCE A level

1324/01

PHYSICS – PH4
Oscillations and Fields

P.M. MONDAY, 20 January 2014

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**8**	
3.	**16**	
4.	**14**	
5.	**11**	
6.	**13**	
7.	**10**	
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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Answer all questions.

1. *(a)* State the principle of conservation of momentum. [2]

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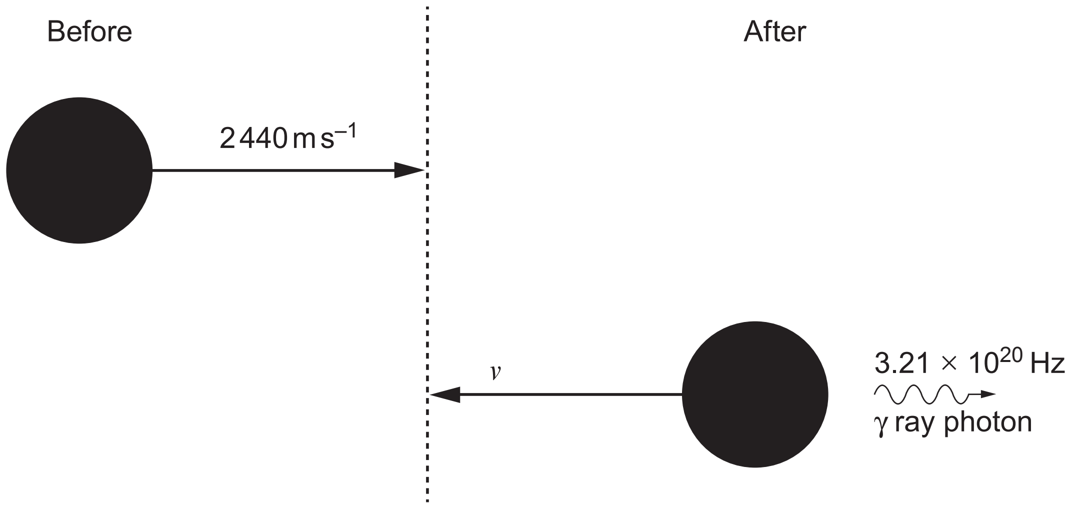
A nickel nucleus emits a γ ray photon as shown.



(b) Show that the γ ray photon has a momentum of approximately 7×10^{-22} kg m s^{-1}. [3]

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(c) Calculate the final speed *(v)* of the nickel nucleus ($m_{nickel} = 9.95 \times 10^{-26}$ kg). [3]

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2. *(a)* Using the equations:

$$p = \frac{1}{3}\rho\overline{c^2}$$

$$pV = nRT$$

show that the mean kinetic energy of an individual (monatomic) gas particle of mass m is given by: [3]

$$\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$$

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(b) (i) Calculate the temperature at which argon atoms have a rms speed of 630 m s^{-1}. (Relative molecular mass of argon = 38.) [3]

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(ii) Calculate the rms speed of argon atoms when this temperature is doubled. [2]

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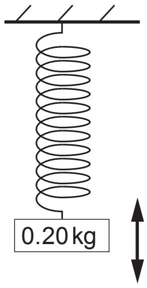
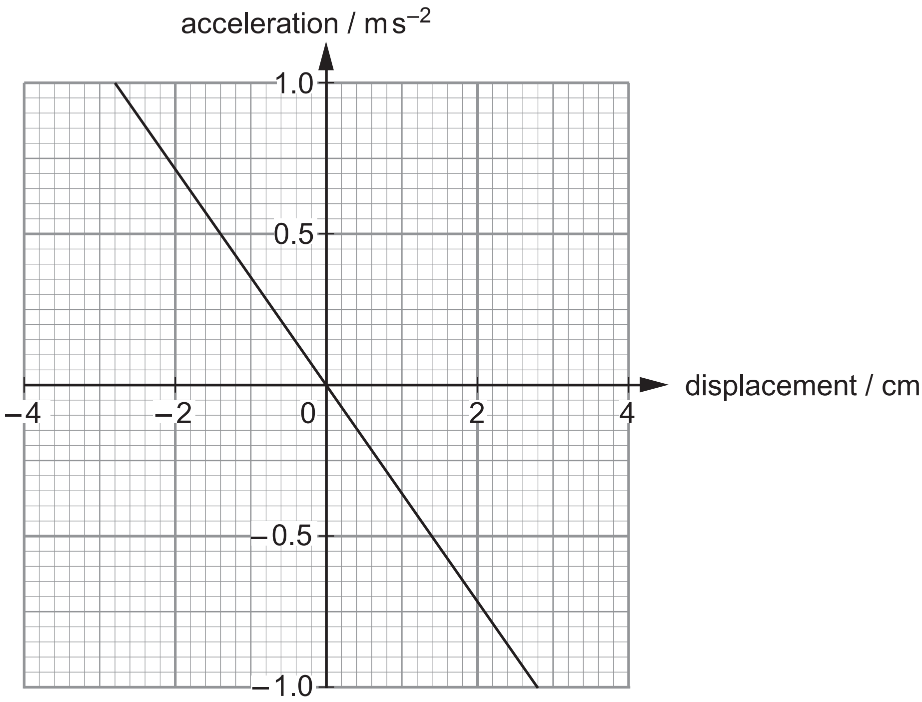
3. A mass oscillates vertically on a spring as shown.



(a) The graph below shows the variation of acceleration with displacement of the mass on the spring.



(i) Explain how the graph verifies that the mass will perform simple harmonic motion. [2]

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(ii) Use the graph to show that the frequency of oscillation of the mass on the spring is approximately 1 Hz. [3]

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Turn over.

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(iii) The amplitude of oscillation of the mass on the spring is 2.8 cm. Write down (or calculate) the maximum acceleration of the mass. [1]

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(iv) Calculate the maximum kinetic energy of the 0.20 kg mass. [3]

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(v) If the mass is moving upwards at its maximum speed when $t = 0$ s, calculate the first time that the mass moves upwards with a speed of 0.100 m s^{-1}. [3]

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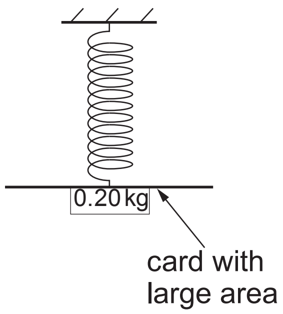
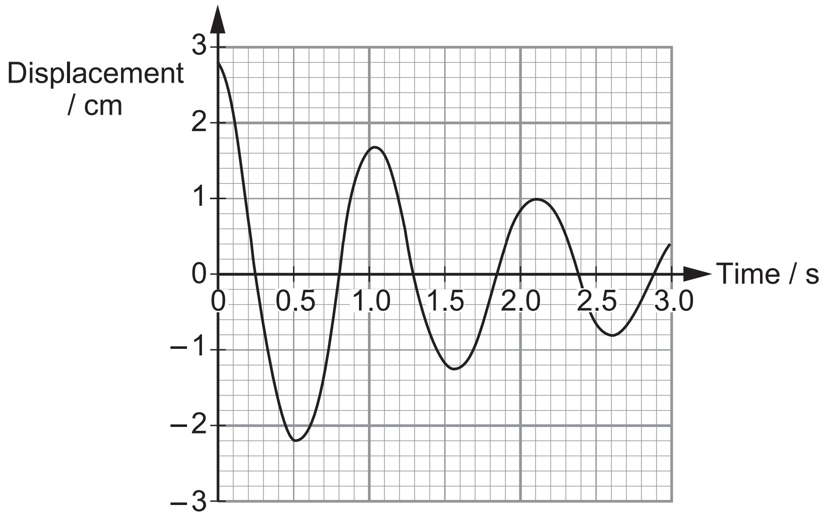
(b) When damping is introduced the following graph of displacement against time is obtained. Explain how the principle of conservation of energy applies during the cycles shown. [4]





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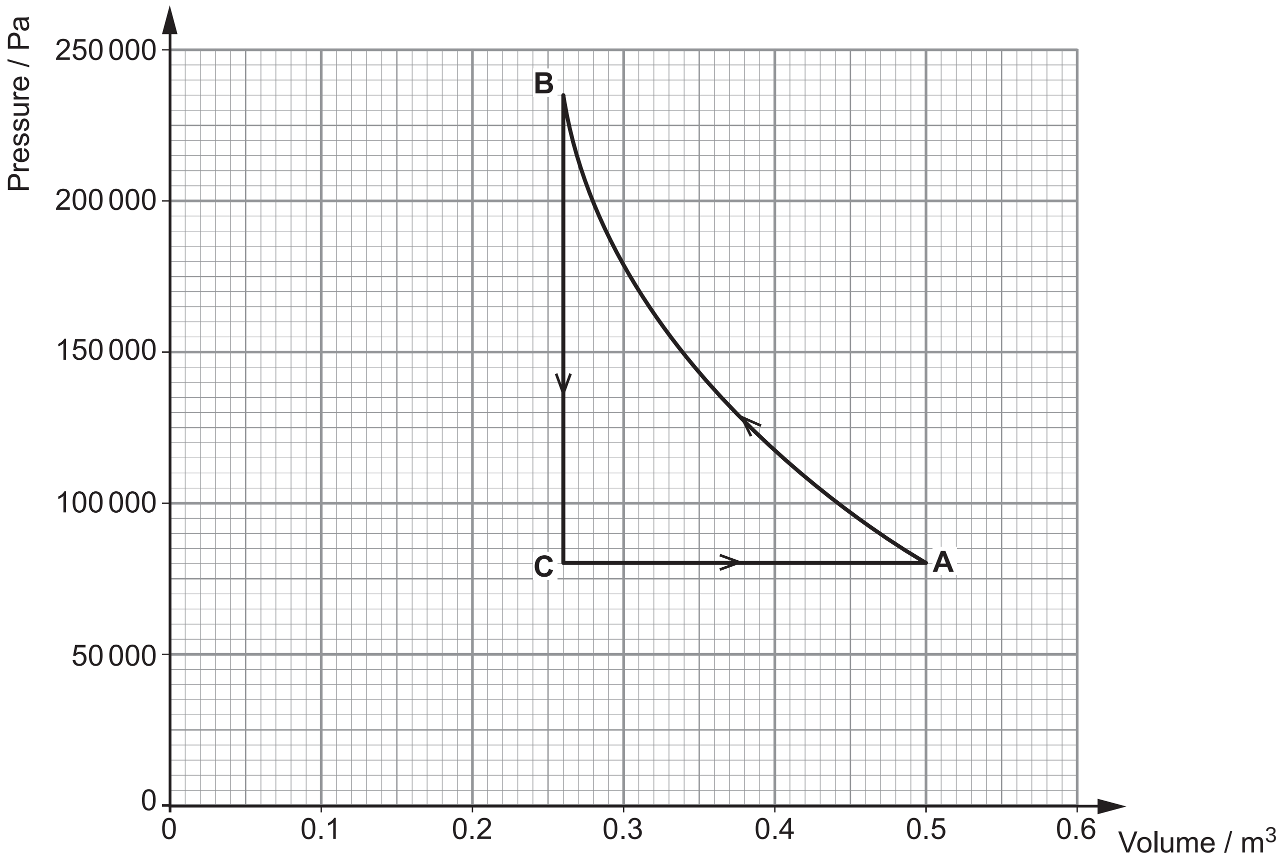
4. An ideal monatomic gas is taken through the closed cycle ABCA as shown.



(a) There are 15.6 mol of gas. Show that the temperatures of points **A**, **B** and **C** are 309 K, 471 K and 160 K respectively. [3]

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(b) Calculate the **change** in internal energy for the three processes. [3]

(i) **AB** ....

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(ii) **BC** ....

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(iii) **CA** ....

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(c) Calculate the work done by the gas for each of the three processes.

(i) **AB** (one mark is available for the accuracy of your estimate) [3]

(ii) **BC** [1]

(iii) **CA** [1]

(d) (i) Calculate the heat supplied to the gas for process **AB**. [2]

(ii) Process **AB** is in fact a very rapid compression. Explain why the answer to *(d)*(i) should be a low value. [1]

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5. *(a)* The mass of the planet Mercury is 3.30×10^{23} kg and its radius is 2440 km.

(i) Calculate the gravitational field strength on the surface of Mercury. [2]

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(ii) Calculate the gravitational potential on the surface of Mercury. [2]

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(iii) Explain briefly why the potential is negative. [1]

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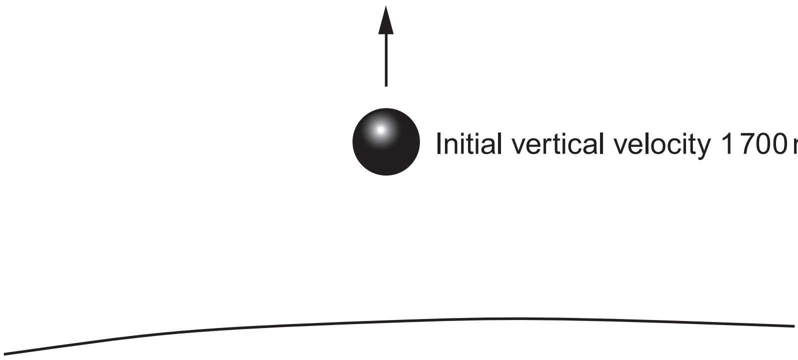
(b) A projectile of mass 0.454 kg is fired upwards from Mercury's surface with an initial vertical velocity of 1 700 m s^{-1}.



Initial vertical velocity 1 700 m s^{-1}

(i) Calculate the total energy of the projectile as it is being launched. [3]

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(ii) Use the principle of conservation of energy to calculate the maximum height that the projectile reaches (Mercury has no atmosphere so that air resistance is negligible). [3]

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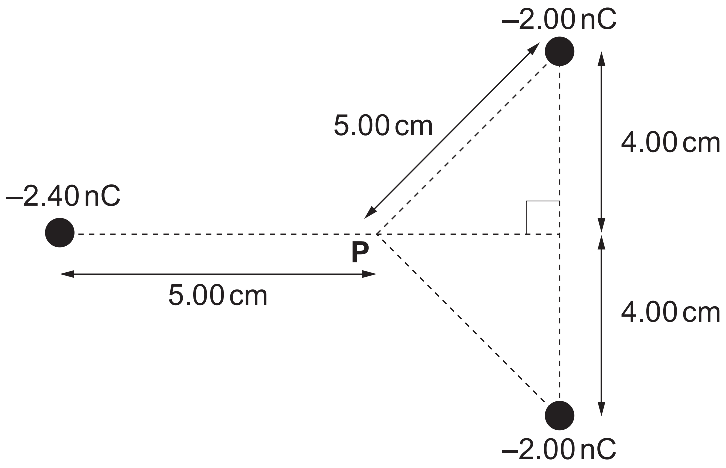
6. Three negative charges are arranged as shown.

(a) **Draw arrows at P** to represent the three electric fields due to the three charges. [2]



(b) Show that the resultant electric field at **P** is zero.

(You may like to use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{F}^{-1}\,\text{m}$.) [5]

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(c) Calculate the electric potential at **P**. [3]

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(d) An electron starts to accelerate from rest from point **P** (in a direction out of the plane of the paper). Calculate its speed when it arrives at another point where the potential is –200 V. [3]

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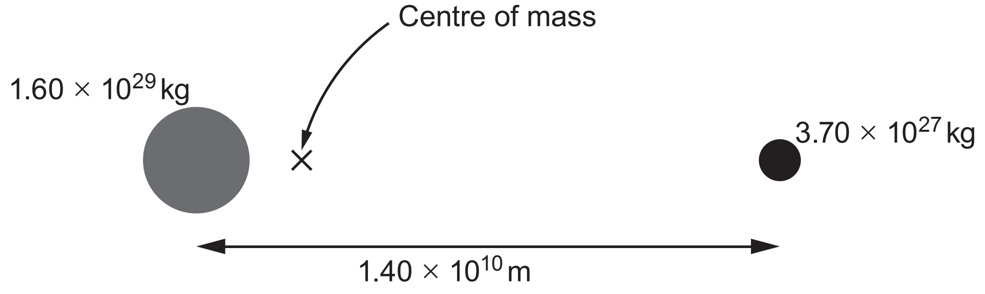
7. A star and planet travel in circular orbits about their mutual centre of mass.



(a) Calculate the period of orbit of the planet-star system and convert your answer to days (your answer will need to be accurate to 3 significant figures for full marks). [3]

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(b) Calculate the radius of: [3]

(i) the orbit of the star;

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(ii) the orbit of the planet.

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(c) (i) Show that the orbital speed of the star is around 600 m s^{-1}. [2]

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(ii) Calculate the Doppler shift for a wavelength of 1.875 μm due to the orbital speed of the star (assuming that the system is viewed edge-on). [2]

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END OF PAPER