

WJEC A-LEVEL PHYSICS

PHYSICS



EXAM QUESTION PACK

UNIT PH4 OLD SPECIFICATION PAPERS

STEMUP

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Surname	Centre Number	Candidate Number
Other Names		2



GCE A level

1324/01



S16-1324-01

PHYSICS – PH4

Oscillations and Fields

A.M. MONDAY, 20 June 2016

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	13	
2.	12	
3.	9	
4.	11	
5.	11	
6.	10	
7.	14	
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.

Answer all questions.

1. (a) State:

(i) Newton's second law of motion;

[2]

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(ii) the principle of conservation of momentum.

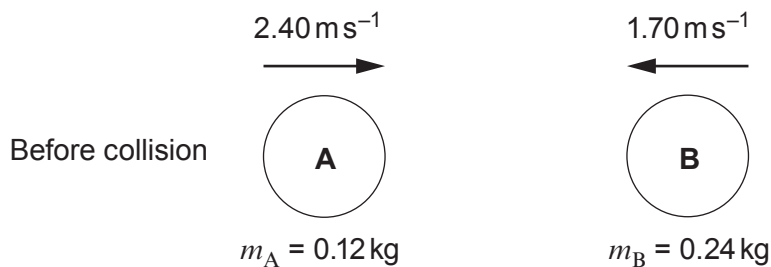
[2]

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- (b) Two discs **A** and **B** of masses $m_A = 0.12 \text{ kg}$ and $m_B = 0.24 \text{ kg}$ on a frictionless horizontal surface slide directly towards each other and collide head-on. Before the collision the speed of disc **A** is 2.40 ms^{-1} and the speed of disc **B** is 1.70 ms^{-1} .



- (i) After the collision the direction of disc **A** is reversed. Its speed is 2.24 ms^{-1} . Determine the speed of disc **B** after collision.

[3]

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- (ii) Calculate the total kinetic energy lost during the collision.

[3]

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- (iii) The collision duration is 0.30s. Calculate the mean force on disc **A** and state its direction.

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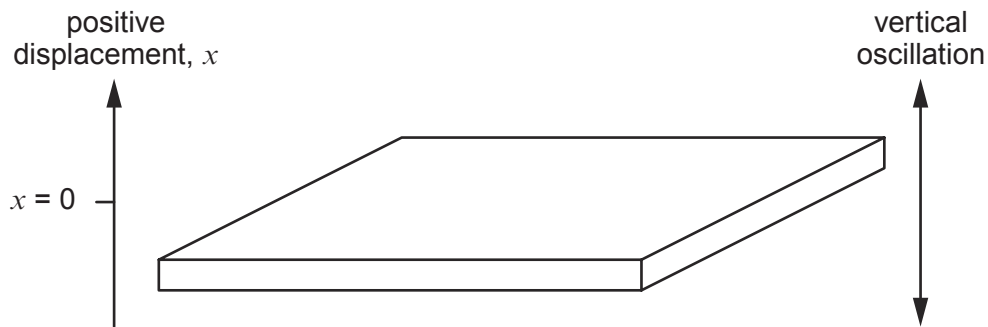
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2. A horizontal platform oscillates vertically with Simple Harmonic Motion (shm).



- (a) The amplitude, A , of oscillation is 0.030 m. The frequency, f , is 0.50 Hz. State what is meant by:

(i) amplitude, A ;

[1]

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(ii) frequency, f .

[1]

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- (b) Taking the platform to be at the centre of oscillation ($x = 0$) when time, $t = 0$ calculate:

(i) the maximum velocity of the platform;

[2]

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(ii) the velocity of the platform at a displacement of $x = + 0.020$ m;

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- (iii) the maximum acceleration of the platform.

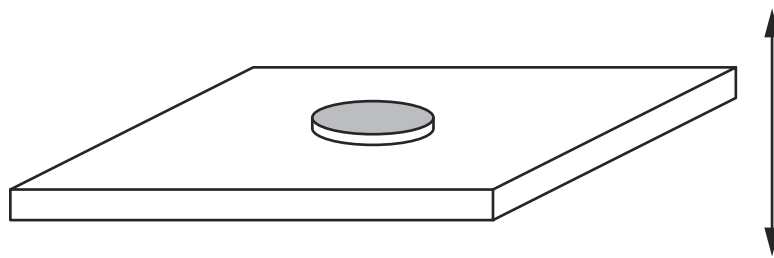
[2]

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- (c) In an experiment a small coin is placed on the platform.



The platform now oscillates at a frequency of 1.00 Hz. The frequency of oscillation is then increased in equal steps of 0.50 Hz, keeping the amplitude constant at 0.030 m. Determine the **lowest** frequency at which the coin loses contact with the platform. Explain your reasoning clearly.

[3]

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3. Helium gas is contained in a closed cylinder with a leak-proof moveable piston at one end. Initially the volume is $1.2 \times 10^{-3} \text{ m}^3$, the pressure is $3.0 \times 10^5 \text{ Pa}$ and the temperature is 275 K . (Relative molecular mass of helium = 4.0.)



- (a) (i) Calculate the mass of the gas in the cylinder. [2]

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- (ii) Calculate the rms speed of the molecules. [2]

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- (b) The volume of the gas is increased to $1.8 \times 10^{-3} \text{ m}^3$ at constant pressure. Calculate:

- (i) the work done by the gas; [2]

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(ii) the heat supplied to the gas.

[3]

Examiner
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- (a) Explain what is meant by thermal equilibrium.

[2]

- (b) Vegetables of mass 1.1 kg and temperature 17°C are placed in the water, and the system is left to reach thermal equilibrium once again. Describe in terms of heat flows how thermal equilibrium is reached between the saucepan, water and vegetables. (*Calculations are not required.*) [3]

[3]

- (c) Calculate the final temperature of the saucepan, water and vegetables given the specific heat capacities below. [4]

[4]

	Specific heat capacity / J kg ⁻¹ °C ⁻¹
Water	4 200
Saucepan	500
Vegetables	3 500

- (d) Explain what will happen to the final temperature if the system is not completely isolated from the surroundings. [2]

Examiner
only

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- (a) Calculate the gravitational field strength at the surface of the Moon. [2]

- (b) A mass, m , is fired vertically from the surface of the Moon at a speed of 400 m s^{-1} . Show that the greatest height above the surface reached by the mass is 51 km. (Hint: use the conservation of energy and $V_g = \frac{-GM}{r}$) [4]

- (c) In many applications an approximate value for the height reached by an object is obtained by neglecting the variation in the gravitational field strength with height. Determine the value for the height reached by the object in part (b) assuming a gravitational field strength equal to that at the surface of the Moon. [2]

- (d) Hence determine the difference in the heights obtained in parts (b) and (c) as a percentage of the height given in part (b). [2]

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- (e) Discuss whether the use of the approximation in part (c) is appropriate in this case. [1]

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6. A small sphere has a charge $q = + 1.11 \times 10^{-6} \text{C}$.

(a) How many electrons have been removed from the sphere?

[2]

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(b) On the grids below sketch curves between distances 0.5 m and 2.0 m from the centre of the sphere for:

(i) the electric field strength (first grid);

(ii) the electric potential (second grid).

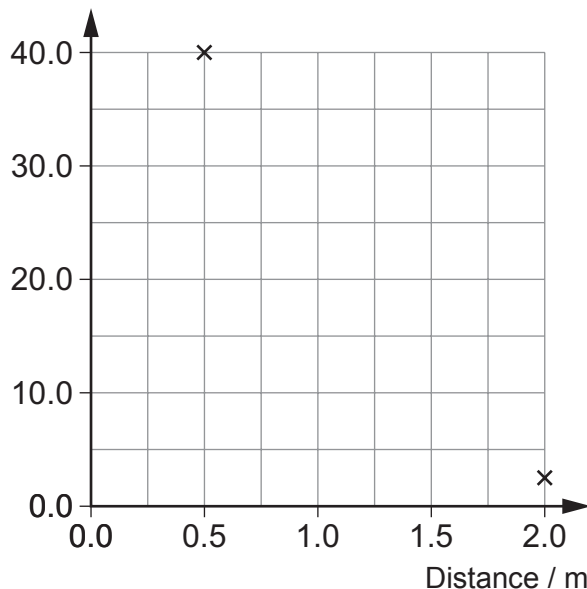
The points at 0.5 m and 2.0 m are already shown.

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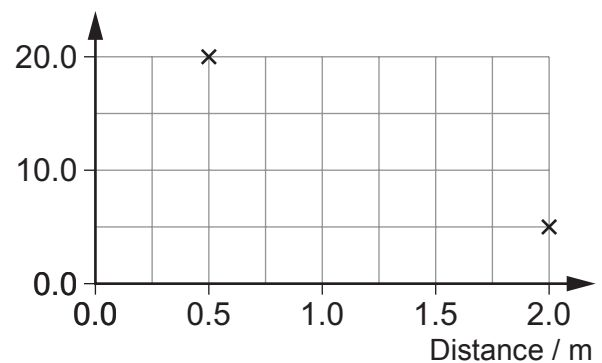
You may wish to use the approximation: $\frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1} \text{ m}$.

Space for calculations if needed:

Electric field strength / $\times 10^3 \text{ N C}^{-1}$



Electric potential / $\times 10^3 \text{ V}$



- (c) (i) A second identical sphere also has a charge of $+ 1.11 \times 10^{-6} \text{ C}$. It is brought from a distant point to a distance 1.2 m from the first sphere. Determine the work required to do this. [2]



- (ii) Determine the magnitude of the electric field strength at the point between the two spheres that is 0.7 m from the left-hand side sphere. Show the direction of the field at this point. [3]

7. A star and its companion planet are in mutual orbit about a common centre of mass. The observed spectrum of the star reveals an orbital speed of 56.0 ms^{-1} and an orbital period of 4.23 day.

(a) Describe how the spectrum was used to determine the orbital speed **and** orbital period. [4]

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(b) Calculate the distance between the star and the planet given that the mass of the star is $2.21 \times 10^{30} \text{ kg}$. Assume that the mass of the planet is very much smaller than the mass of the star. [5]

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(c) Calculate the distance of the star from the centre of mass of the system.

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(d) Use your answers in parts (b) and (c) to determine the mass of the planet.

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END OF PAPER



GCE MARKING SCHEME

SUMMER 2016

**PHYSICS PH4
1324/01**

INTRODUCTION

This marking scheme was used by WJEC for the 2016 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

**GCE PHYSICS PH4
SUMMER 2016 MARK SCHEME**

Question			Marking details	Marks Available
1	(a)	(i)	The rate of change of momentum of an object is (directly) proportional to the <u>resultant / net / total / overall</u> (1) force acting on it (1) [and is in the direction of that force] Award 1 mark for stating $F = ma$ with all terms correctly identified	2
		(ii)	The [vector sum of the] momenta of bodies in a system stays constant (1) [even if forces act between the bodies], <i>provided there is no [net] external [resultant] force / isolated system</i> (1)	2
	(b)	(i)	Conservation of momentum: idea of (1) $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ $(0.12)(2.40) + (0.24)(-1.70) = (0.12)(-2.24) + (0.24)v_B$ correct substitution (1) $(0.24)v_B = 0.1488$ $v_B = 0.62 \text{ [m s}^{-1}\text{]} (1)$	3
		(ii)	Energy considerations Energy lost = Initial kinetic energy – Final kinetic energy $= \left(\frac{1}{2} m_A u_A^2 + \frac{1}{2} m_B u_B^2 \right) - \left(\frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2 \right)$ idea and formulation of energy lost (1) $= \frac{1}{2} (0.12 \times 2.40^2 + 0.24 \times 1.70^2)$ $\quad - \frac{1}{2} (0.12 \times 2.24^2 + 0.24 \times 0.62^2)$ correct substitution, allow ecf from (i) (1) $= 0.6924 - 0.3472$ $= 0.3452 \text{ [J]} (1)$	3
		(iii)	Consider mass m_A Force $\times \Delta t$ = change of momentum idea (1) Force $\times (0.3) = \text{final momentum} - \text{initial momentum}$ Force $\times (0.3) = m_A(-2.24 - 2.40)$ Force $= \frac{(0.12)(-4.64)}{0.3} = -1.856 \text{ N}$ Force of 1.86 [N] (1) to the left accept – sign or arrow (1)	3
Question 1 Total			[13]	

Question			Marking details	Marks Available
2	(a)	(i)	The maximum value of the platform's displacement [from its equilibrium (central) position]. Don't accept reference to height	1
		(ii)	The number of cycles / oscillations / vibrations [completed by the platform] per second / rate.	1
	(b)	(i)	$v = \omega A = (2\pi f)A = (2\pi(0.5))0.03$ substitution (1) $v = 0.094 \text{ [m s}^{-1}\text{]}$ (1)	2
		(ii)	$x = A\sin(2\pi ft)$ use of $\omega = 2\pi f$ $0.02 = 0.03\sin(2\pi(0.5)t)$ substitution (1) $t = 0.232 \text{ [s]}$ or 0.768 [s] (1) $v = (2\pi f)A\cos(2\pi ft)$ $v = (2\pi(0.5))(0.03)\cos(2\pi(0.5)(0.232))$ $v = 0.070 \text{ [m s}^{-1}\text{]}$ or $-0.070 \text{ [m s}^{-1}\text{]}$ (1)	3
	(c)	(iii)	max acceleration = $(2\pi f)^2 A = (2\pi(0.5))^2(0.03)$ subs (1) $= 0.30 \text{ [m s}^{-2}\text{]}$ (1)	2
			Contact will be lost when the maximum downward acceleration is equal (or greater) to the acceleration due to gravity, g i.e. when acceleration at top of oscillation = g explanation (1) $g = (2\pi f)^2 A$ (implies 1 st mark) $9.81 = (2\pi f)^2(0.03)$ $f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{9.81}{0.03}} = 2.88 \text{ [Hz]}$ (1) As frequency is incrementally increased, contact will be lost at $f = 3.00 \text{ [Hz]}$ answer (1)	3
			[Alternatively for the 2 nd and 3 rd marks, substitute values and find acceleration for different frequencies. Indicate 2.50 Hz is on lower side of g (1) and 3.00 Hz on higher side.(1)]	
Question 2 Total				[12]

Question			Marking details	Marks Available
3	(a)	(i)	$pV = nRT$ $n = \frac{pV}{RT} = \frac{(3 \times 10^5)(1.2 \times 10^{-3})}{(8.31)(275)} = 0.1575 \text{ mol} \quad (1)$ mass, $m_n = n \times M_r \times 10^{-3} = (0.1575)(4 \times 10^{-3})$ $= 6.30 \times 10^{-4} \text{ kg}$ or 0.63 g (1) unit mark	2
		(ii)	density $\rho = \frac{m_n}{V} = \frac{6.30 \times 10^{-4}}{1.2 \times 10^{-3}} = 0.525 \text{ kg m}^{-3} \quad (1)$ $p = \frac{1}{3} \rho \overline{c^2}$ $\text{rms } \sqrt{\overline{c^2}} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3(3 \times 10^5)}{(0.525)}} = 1\,309 \text{ [m s}^{-1}] \quad (1)$ Allow 1 mark for 41.4 [m s ⁻¹] and allow ecf from (i). [Alternatively $\frac{1}{2} m \overline{c^2} = \frac{3}{2} kT$ where $m = \frac{M_r \times 10^{-3}}{N_A} = \frac{4 \times 10^{-3}}{6.02 \times 10^{23}} \quad (1)$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3(1.38 \times 10^{-23})(275)(6.02 \times 10^{23})}{(4 \times 10^{-3})}} = 1\,309 \text{ [m s}^{-1}] \quad (1)]$	2
	(b)	(i)	Increase in volume $\Delta V = (1.8 - 1.2) \times 10^{-3} = 6 \times 10^{-4} \text{ m}^3 \quad (1)$ Work done by gas = $p \Delta V = (3 \times 10^5)(6 \times 10^{-4}) = 180 \text{ [J]} \quad (1)$	2
		(ii)	Final temperature $T_f = \frac{p V_f}{n R} = \frac{(3 \times 10^5)(1.8 \times 10^{-3})}{(0.1575)(8.31)} = 412.584 \text{ K} \quad (1)$ Increase in internal energy of gas $\Delta U = \frac{3}{2} n R \Delta T = \frac{3}{2} (0.1575)(8.31)(412.584 - 275.0) = 270.110 \text{ J} \quad (1)$ Heat flowing into gas $Q = \Delta U + W = 270.110 + 180 = 450 \text{ [J]} \quad (1)$ Allow ecf from part (i)	3
		Question 3 Total		[9]

Question			Marking details	Marks Available
4	(a)		If two (or more) systems are in thermal equilibrium then the <i>systems are in thermal contact</i> (1) but there is <i>no (net) heat flowing between them</i> (1). Alternative No heat flow between the systems (1) because they are at the same temperature (1)	2
	(b)		[Saucepan and water initially at higher temperature than vegetables], so net heat will flow from the saucepan to the water (1) and from the water to the vegetables (1) Accept heat flows from the saucepan to the vegetables (1) and from the water to the vegetables (1) Eventually heat transfer will stop and all three (saucepan, water and vegetables) will be in thermal equilibrium / be at the same temperature (1).	3
	(c)		Heat lost by saucepan = $(0.9)(92 - T)(500)$ Heat lost by water = $(1.6)(92 - T)(4\,200)$ heat lost (1) Heat gained by vegetables = $(1.1)(T - 17)(3\,500)$ (1) Heat lost is equal to the heat gained: understanding of this (1) $((0.9)(92 - T)(500)) + ((1.6)(92 - T)(4\,200))$ $= (1.1)(T - 17)(3\,500)$ $T((3\,500)(1.1) + (500)(0.9) + (4\,200)(1.6))$ $= ((3\,500)(1.1)(17)) + ((500)(0.9)(92))$ $+ ((4\,200)(1.6)(92))$ $T(11\,020) = 725\,090$ $T = 65.80\,^{\circ}\text{C}$ (1)	4
	(d)		Lower final temperature (or eventually temperature of surroundings) (1) Heat will be lost to the surroundings from the system [as the temperature of the surroundings is lower] (or temperature gradient between saucepan-water-vegetable system and surroundings is driving transfer of heat) (1)	2
	Question 4 Total			[11]

Question			Marking details	Marks Available
5	(a)		$g_M = \frac{GM}{R_M^2} = \frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})}{(1.74 \times 10^6)^2} = 1.62 \text{ [N kg}^{-1}\text{]}$ substitution (1); answer (1)	2
	(b)		Total energy at surface = $-\frac{GMm}{R_M} + \frac{1}{2}mv^2$ m: mass of projectile $= -\frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})m}{(1.74 \times 10^6)} + \frac{1}{2}m(400)^2 \quad (1)$ Total energy at highest altitude = $-\frac{GMm}{r_M}$ $= -\frac{GMm}{r_M} = -\frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})m}{r_M} \quad (1)$ Conservation of energy: application (1) $-\frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})m}{(1.74 \times 10^6)} + \frac{1}{2}m(400)^2 = -\frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})m}{r_M}$ $-\frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})}{(1.74 \times 10^6)} + \frac{1}{2}(400)^2 = -\frac{(6.67 \times 10^{-11})(7.34 \times 10^{22})}{r_M}$ $-2\,813\,666.667 + 80\,000 = -\frac{4.89578 \times 10^{12}}{r_M}$ $-2\,733\,666.667 r_M = -4.89578 \times 10^{12}$ $r_M = \frac{(4.89578 \times 10^{12})}{2\,733\,666.667} = 1\,790.921 \times 10^3 \text{ m}$ above surface $h = 1\,790.921 - 1\,740 = 50.9 \text{ [km]} \quad (1)$ [with rounding: $-2.814 \times 10^6 + 80\,000 = -\frac{4.896 \times 10^{12}}{r_M}$ $r_M = \frac{4.896 \times 10^{12}}{2.734 \times 10^6} = 1\,790.8 \times 10^3 \text{ m}$ from surface $h = 1\,790.8 - 1\,740 = 50.8 \text{ km]}$	4
	(c)		$\frac{1}{2}mv^2 = mg_M h \quad (1)$ $h = \frac{v^2}{2g_M} = \frac{400^2}{2(1.62)} = 49\,382.716 \text{ m} = 49.4 \text{ [km]} \quad (1)$	2
	(d)		percentage difference = $\frac{(51 - 49.4)}{51} \times 100\% = 3\%$ formula for percentage error (1), result (1)	2
	(e)		Yes, as it is likely that the percentage difference is less than the uncertainty because of the measurement of the velocity or suitable alternative. ecf for consistency Answer to (e) must be consistent with answer to (d)	1
Question 5 Total				[11]

Question			Marking details	Marks Available															
6	(a)		Number of electrons removed = $\frac{1.11 \times 10^{-6}}{1.6 \times 10^{-19}}$ (1) $= 6.94 \times 10^{12}$ (1)	2															
	(b)		Values for graph: <table border="1"><thead><tr><th>distance /m</th><th>0.5</th><th>1.0</th><th>1.5</th><th>2.0</th></tr></thead><tbody><tr><td>$E \times 10^3 \text{ N C}^{-1}$</td><td>39.96</td><td>9.99</td><td>4.44</td><td>2.50</td></tr><tr><td>$V \times 10^3 \text{ V}$</td><td>19.98</td><td>9.99</td><td>6.66</td><td>5.00</td></tr></tbody></table> Point (or implied from curve) for E approx. (1) Point (or implied from curve) for V approx. (1) Shape of <u>both curves</u> i.e. curves with decreasing magnitudes with increasing distance, [E decreasing faster with distance than V and both curves passing through 10]. (1)		distance /m	0.5	1.0	1.5	2.0	$E \times 10^3 \text{ N C}^{-1}$	39.96	9.99	4.44	2.50	$V \times 10^3 \text{ V}$	19.98	9.99	6.66	5.00
	distance /m	0.5	1.0	1.5	2.0														
	$E \times 10^3 \text{ N C}^{-1}$	39.96	9.99	4.44	2.50														
	$V \times 10^3 \text{ V}$	19.98	9.99	6.66	5.00														
(c)	(i)	Work = $q \Delta V = \frac{q^2}{4\pi\epsilon_0} \left(\frac{1}{1.2} - 0 \right) =$ $(1.11 \times 10^{-6})^2 (9.0 \times 10^9) (0.833)$ substitution (1) $9.24 \times 10^{-3} \text{ [J]}$ (1)	2																
	(ii)	$E \text{ field} = \frac{q}{4\pi\epsilon_0} \left(\frac{1}{0.5^2} - \frac{1}{0.7^2} \right)$ $= (1.11 \times 10^{-6}) (9.0 \times 10^9) \left(\frac{1}{0.5^2} - \frac{1}{0.7^2} \right)$ formula and substitution (1) $= 1.96 \times 10^4 \text{ V m}^{-1}$ or equivalent (1) unit mark Direction: to the left accept – sign or arrow (1)		3															
Question 6 Total					[10]														

Question			Marking details	Marks Available
7	(a)		Star (and companion planet) will both orbit the common centre of mass. Observe star spectral line from Earth. Measure Doppler shift in spectral line. Max wavelength corresponds to star moving away from Earth. Min wavelength corresponds to star moving towards Earth. Doppler shift accept red shift (1) in spectral line (1) Doppler shift ($\Delta\lambda$) – at max or min - can be used to determine orbital speed (v) as: $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ (1) Orbital period is determined from one cycle of Doppler shift e.g. from one max to the next max. (1)	4
	(b)		Change units $T = 4.23 \text{ days} = 4.23 \times 24 \times 60 \times 60 \text{ seconds} = [365\,472] \text{ s}$ (1) $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$ Approximation $M_{\text{star}} \gg M_{\text{planet}}$ (1) so $T = 2\pi \sqrt{\frac{d^3}{GM_{\text{star}}}}$ $d = \sqrt[3]{GM_{\text{star}} \left(\frac{T}{2\pi}\right)^2} \text{ rearrange(1)}$ $d = \sqrt[3]{(6.67 \times 10^{-11})(2.21 \times 10^{30}) \left(\frac{365472}{2\pi}\right)^2} \text{ substitution (1)}$ $d = 7.93 \times 10^9 \text{ [m]} \quad (1)$	5
	(c)		use of $v = \omega r$ or equivalent (1) $r_{\text{star}} = \frac{v}{\omega} = \frac{vT}{2\pi} = \frac{(56.0)(365472)}{2\pi}$ $= 3.26 \times 10^6 \text{ [m]} \quad (1)$	2
	(d)		use of $r_1 = \frac{M_2}{M_1 + M_2} d$ or approximation (1) $r_{\text{star}} = \frac{M_{\text{planet}}}{M_{\text{star}} + M_{\text{planet}}} d$ $(M_{\text{star}} + M_{\text{planet}})r_{\text{star}} = M_{\text{planet}}d$ $(d - r_{\text{star}})M_{\text{planet}} = r_{\text{star}}M_{\text{star}}$ $M_{\text{planet}} = \frac{r_{\text{star}}M_{\text{star}}}{(d - r_{\text{star}})}$ $M_{\text{planet}} = \frac{(3.26 \times 10^6)(2.21 \times 10^{30})}{(7.93 \times 10^9 - 3.26 \times 10^6)} \text{ substitution (1)}$ $= 9.09 \times 10^{26} \text{ [kg]} \quad (1) \text{ ecf}$	3
	Question 7 Total			[14]

Surname	Centre Number	Candidate Number
Other Names		2



GCE A level

1324/01



S15-1324-01

PHYSICS – PH4

Oscillations and Fields

A.M. THURSDAY, 11 June 2015

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	13	
2.	15	
3.	11	
4.	13	
5.	9	
6.	9	
7.	10	
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.

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- (b) A container of volume 0.7 m^3 holds oxygen gas at a pressure of $4.0 \times 10^5\text{ Pa}$ and a temperature of 288 K . (Relative molecular mass of oxygen gas = 32.)

Calculate:

- (i) the number of moles of oxygen gas in the container; [2]

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- (ii) the rms speed of the molecules. [3]

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- (c) In practice oxygen is not an ideal gas. Give one reason for this. [1]

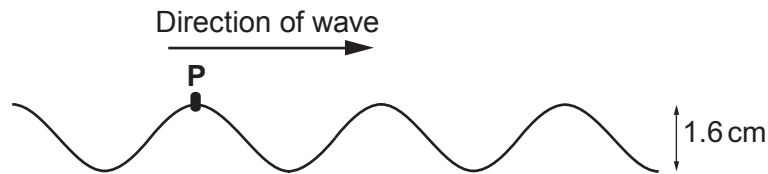
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2. A cork, **P**, floats on the surface of a pond. When a wave travels over the surface the cork oscillates vertically with Simple Harmonic Motion (SHM). The cork completes 20 oscillations in 24 s and has a total vertical range of 1.6 cm.



- (a) Define *Simple Harmonic Motion*.

[2]

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- (b) Calculate the period of oscillation.

[1]

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- (c) Show that the angular velocity, ω , of oscillation is approximately 5 rad s^{-1} .

[2]

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- (d) If the cork is at its highest point when $t = 0$, complete the expression for the upward displacement of the cork, x , by inserting numerical values into the boxes.

[3]

$$x = \boxed{} \sin \left(\boxed{} t + \boxed{} \right) \text{ cm}$$

- (e) Determine the time it takes for the cork to move directly downward from 0.4 cm above the centre of oscillation to 0.3 cm below the centre. [3]

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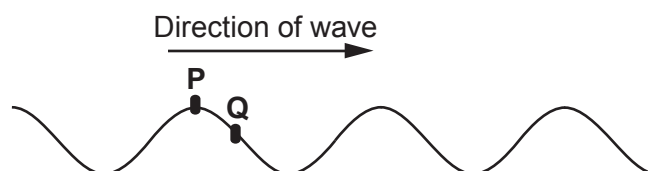
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- (f) A second cork, **Q**, also oscillates on the surface at a **quarter of a wavelength** from **P** as shown in the diagram.



Sketch the vertical displacements of the two corks during the time interval $t = 0$ to $t = 2.4$ s. Use the same axes for both curves and label both curves clearly for cork **P** and cork **Q**. [3]

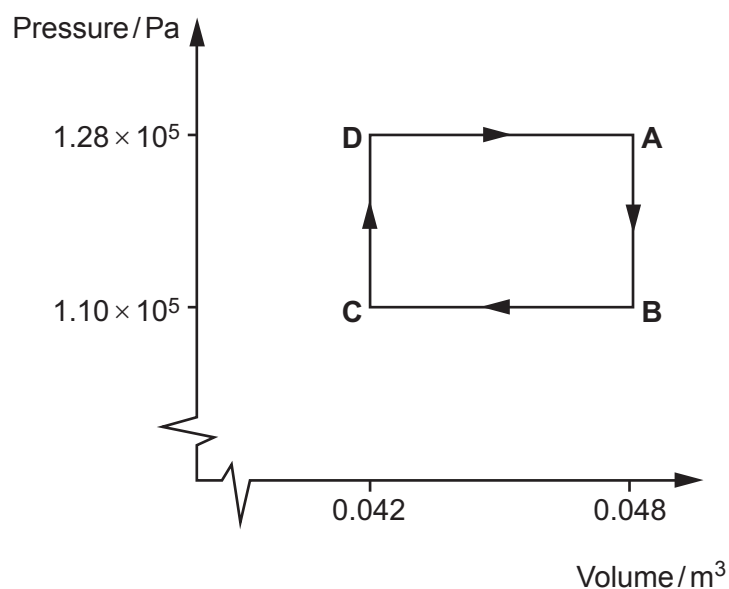


- (g) Hence write an expression for the upward displacement of cork **Q** in terms of t . [1]

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3. A heat engine has a cylinder with a leak-proof moveable piston which contains 2.00 mol of ideal monatomic gas. The gas is taken around the 4-stage cycle **A**→**B**→**C**→**D**→**A** as shown in the diagram.



- (a) Complete the table indicating the temperature and internal energy of the gas in state **C**.

[2]

State	Temperature T/K	Internal energy U/J
A	369.7	9 217
B	317.7	7 920
C		
D	323.5	8 065

Space for calculations.

(b) Determine the work done (W) **by** the gas for each of the following:

[4]

(i) $A \rightarrow B$;

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(ii) $B \rightarrow C$;

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(iii) $C \rightarrow D$;

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(iv) $D \rightarrow A$;

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(v) $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$ (net work done by the gas during the whole cycle).

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(c) Determine the stages of the cycle in which heat is **absorbed by** (supplied to) the gas. Show that the total heat absorbed in these stages is approximately 3 000 J. (*Hint: Use the first law of thermodynamics for each stage.*) [3]

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(d) A heat engine absorbs heat and does work. The efficiency of a heat engine is given by:

$$\text{efficiency} = \left(\frac{\text{net work done by the engine}}{\text{heat absorbed by the engine}} \right) \times 100\%$$

Calculate the efficiency of the gas heat engine.

[2]

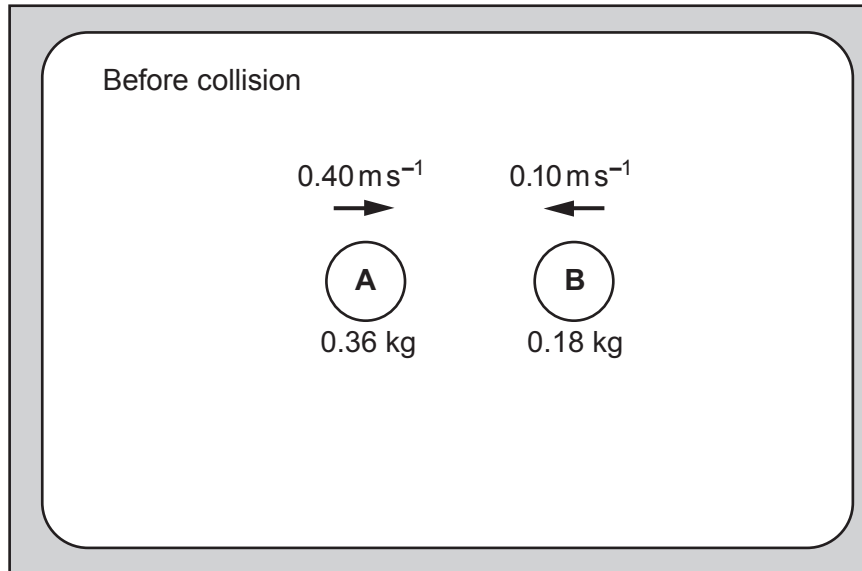
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4. (a) Two discs, **A** and **B**, on a frictionless air table collide head-on. Disc **A** has a mass of 0.36 kg and disc **B** a mass of 0.18 kg. Before colliding, disc **A** has a velocity of 0.40 m s^{-1} and disc **B** a velocity of 0.10 m s^{-1} in the opposite direction. On colliding they stick together.



Calculate:

- (i) the velocity of the discs after the collision;

[3]

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- (ii) the kinetic energy **lost** during the collision expressed as a percentage of the initial kinetic energy.

[3]

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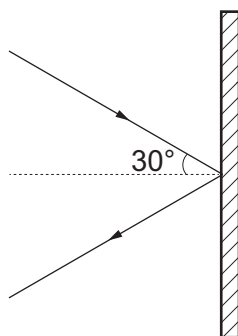
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- (b) A red laser beam of power 1 mW and wavelength 633 nm is incident at an angle of 30° on a **perfectly reflecting** mirror.



Determine:

- (i) the energy of a single photon of this wavelength; [2]

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- (ii) the number of photons incident on the mirror per second; [2]

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- (iii) the component of the momentum of an individual incident photon perpendicular to the mirror; [1]

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- (iv) the force exerted by the photons on the mirror. [2]

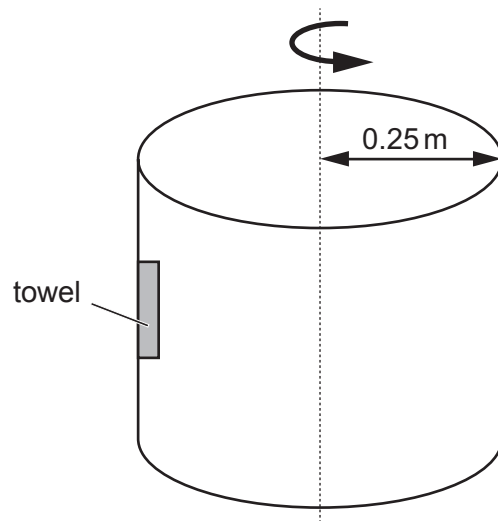
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5. (a) The drum of a top-loading washing machine spins around a vertical axis. The drum has a radius of 0.25 m and spins at a rate of 1 200 revolutions per **minute**.



Determine the centripetal force on a damp towel, of mass 0.8 kg, on the inner wall of the drum. [4]

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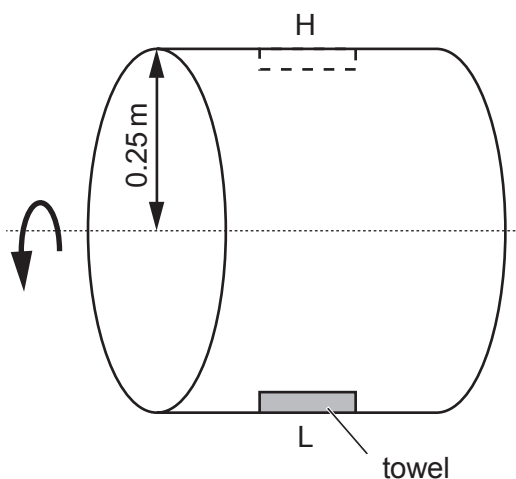
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- (b) The drum of a front-loading washing machine also has a radius of 0.25 m and spins at the same rate of 1 200 revolutions per minute.



By considering the forces on the towel, determine the force exerted by the wall of the drum on the towel when the towel is at its:

- (i) lowest point in the rotation (L);

[2]

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- (ii) highest point in the rotation (H).

[1]

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- (c) As the drum spins, the lid of a nearby saucepan is heard to vibrate. The vibration reduces when the spinning rate decreases. Explain both of these effects.

[2]

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6. (a) The diagram shows an isolated electron. On the diagram, sketch and label:

- (i) the electric field lines and direction (label as E);
- (ii) the equipotential surfaces (label as V).

[2]



(b) Determine the electric potential at a distance of 2.00 mm from the electron.

[2]

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(c) A second electron is located at a distance of 2.00 mm from the first electron shown above. Determine the work required to bring this second electron from this distance of 2.00 mm to a point 1.20 mm away from the first electron, where the potential is -1.20×10^{-6} V. [2]

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- (d) Compare the magnitude **and** direction of the electrostatic forces that the electrons, separated by a distance of 1.20 mm, exert on each other with the gravitational forces that they exert at this separation. Support your answer with calculations. [3]

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7. The Moon has an orbital period of about 27.3 days. The mass of the Earth is 6.00×10^{24} kg and the mass of the Moon is 7.34×10^{22} kg.

(a) Show that the distance between the Moon and the Earth is approximately 385 000 km.

[3]

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- (b) (i) Determine the distance of the centre of mass of the Earth-Moon system from the centre of the Earth.

[2]

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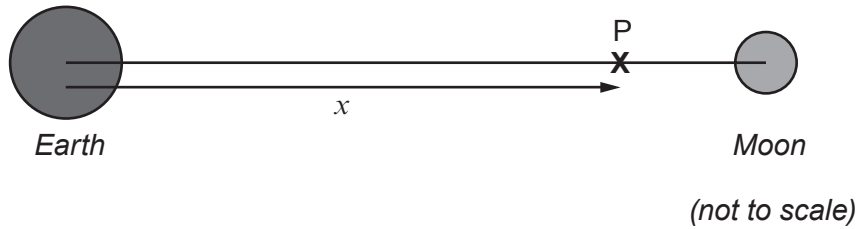
- (ii) Comment on your answer to (b)(i) given that the radius of the Earth is approximately 6 370 km.

[1]

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- (c) Calculate the distance, x , from the centre of the Earth along the Earth-Moon line to the point P where the net gravitational field strength due to the Earth and Moon is zero. [4]



END OF PAPER



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2015

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2015 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

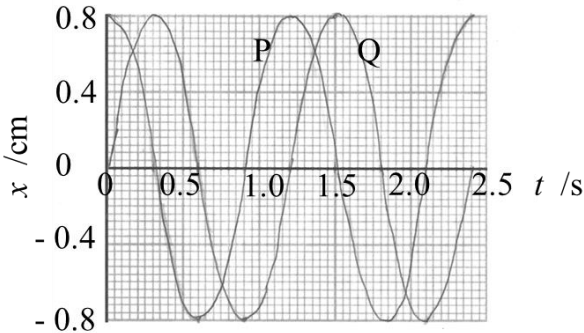
It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
PH1	1
PH2	7
PH3	12
PH4	17
PH5	24
PH6	39

PH4

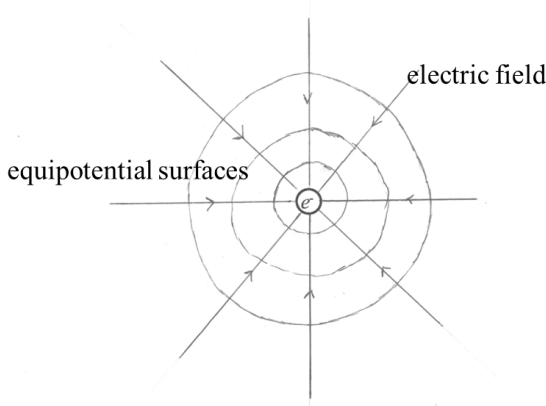
Question			Marking details	Marks Available
1	(a)	(i)	Any 4 from the following (1 mark for each): - the oxygen molecules move at random / in all directions - the molecules strike [the walls of] the container [and rebound] - rate of change of momentum of the molecules when they strike the wall is equal to the <u>force exerted by the wall on the molecules</u> (Newton's second law of motion). - force on the wall is equal and opposite to the force on the molecules (Newton's third law of motion). - pressure is the force per unit area on the walls of the container. Award a maximum of 2 marks if no reference made to Newton's laws	4
		(ii)	I. N : number of molecules [in the container] (1) II. m : mass of <u>one</u> molecule (1) III. $\overline{c^2}$: mean square speed [of the molecules] (1)	3
		(b)	(i) $n = \frac{pV}{RT} = \frac{(4 \times 10^5)(0.7)}{(8.31)(288)}$ (substitution (1)) = 117 [mol] (1)	2
	(c)	(ii)	$pV = \frac{1}{3} Nm\overline{c^2}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3pV}{Nm}}$ (rearrange (1)) $\sqrt{\overline{c^2}} = \sqrt{\frac{3pV}{n(32 \times 10^{-3})}}$ correct incorporation of relative mol. mass (1) $\sqrt{\overline{c^2}} = \sqrt{\frac{3(4 \times 10^5)(0.7)}{(117)(32 \times 10^{-3})}} = 473.7 \text{ m s}^{-1}$ (1) UNIT mark	3
			One of the following (or equivalent)(1): Volume of molecules not negligible. Force exerted on walls less due to the attraction by other molecules. Intermolecular forces not negligible. Accept: oxygen diatomic / density too high Collisions not elastic PE not zero	1
Question 1 Total				[13]

Question		Marking details	Marks Available
2	(a)	Acceleration is - [directly] proportional to the displacement [from a fixed point] (1) - directed towards the fixed point (1)	2
	(b)	$T = \frac{24}{20} = 1.2 \text{ [s]}$	1
	(c)	$\omega = 2\pi f = 2\pi \left(\frac{20}{24}\right)$ (formula and subs. ecf from (b)(1)) $= 5.2 \text{ [rad s}^{-1}\text{]} (1)$	2
	(d)	$x = 0.8 \text{ (amplitude (1))} \sin \left(5.2 (\omega (1))t + \frac{\pi}{2} \text{ (phase (1))} \right) \text{ cm}$ [or use $\omega = 5 \text{ rad s}^{-1}$ or phase $= 90^\circ$]	3
	(e)	$0.4 = 0.8 \sin \left(5.2t_1 + \frac{\pi}{2} \right) \quad -0.3 = 0.8 \sin \left(5.2t_2 + \frac{\pi}{2} \right)$ $t_1 = [-]0.201 \text{ [s]} (1) \quad t_2 = [-]0.376 \text{ [s]} (1)$ $\Delta t = t_2 - t_1 = 0.376 - 0.201 = 0.175 \text{ [s]} (1) \text{ ecf from (d)}$ [If using $\omega = 5 \text{ rad s}^{-1}$, $t_1 = 0.209 \text{ [s]} (1) \quad t_2 = 0.391 \text{ [s]} (1)$ $\Delta t = t_2 - t_1 = 0.391 - 0.209 = 0.182 \text{ [s]} (1) \text{]}$	3
	(f)	 Curve for P (1) Curve for Q relative to P (1) Axes labelled with units and scales (1) ecf for A, phase and T	3
	(g)	$x = 0.8 \sin 5.2t \text{ [cm]} \quad \text{(or equivalent)}$ Allow ecf if curve in (f) is incorrect, but consistent with (g)	1
Question 2 Total			[15]

Question			Marking details	Marks Available															
3	(a)		<table><tr><td></td><td>Temperature T /K</td><td>Internal Energy U /J</td></tr><tr><td>A</td><td>369.7</td><td>9 217</td></tr><tr><td>B</td><td>317.7</td><td>7 920</td></tr><tr><td>C</td><td>278.[0]</td><td>6 931/ 6 930</td></tr><tr><td>D</td><td>323.5</td><td>8 065</td></tr></table>		Temperature T /K	Internal Energy U /J	A	369.7	9 217	B	317.7	7 920	C	278.[0]	6 931/ 6 930	D	323.5	8 065	
			Temperature T /K	Internal Energy U /J															
	A	369.7	9 217																
	B	317.7	7 920																
	C	278.[0]	6 931/ 6 930																
	D	323.5	8 065																
		(1 for value of T ; 1 for value of U) ecf for U if T incorrect	2																
	(b)	(i)	Work done by gas A→B = 0																
		(ii)	Work done by gas B→C = -660 [J]																
		(iii)	Work done by gas C→D = 0																
(iv)		Work done by gas D→A = 768 [J]																	
(v)		Work done by gas A→B→C→D→A (net work done during cycle) = 768 – 660 = 108 [J] ecf																	
	1 mark each for (ii), (iv) and (v); 1 mark for both (i) and (iii)	4																	
(c)		$\Delta U = Q - W$ i.e. application of equation for the first law of thermodynamics (1)																	
		C→D 8 065 – 6 931 = $Q_{CD} - 0$ $Q_{CD} = 1\,134$ [J] / 1 135 D→A 9 217 – 8 065 = $Q_{DA} - 768$ $Q_{DA} = 1\,920$ [J] Either of these two lines correct (1)																	
		Heat absorbed = 1 134 + 1 920 = 3 054 [J] / 3 055 (1)	3																
(d)		Efficiency = $\frac{108}{3054} \times 100\%$ (substitution (1)) = 3.54[%] (1) ecf on 108																	
		[If using heat absorbed = 3 000 J; Efficiency = 3.60%]	2																
		Question 3 Total	[11]																

Question			Marking details	Marks Available
4	(a)	(i)	Application of conservation of momentum (1) $(0.36 + 0.18)v = (0.36 \times 0.40) + (0.18 \times (-0.10))$ correct eqn(1) $0.54v = 0.126$ $v = 0.23 \text{ [m s}^{-1}\text{]}$ to the right (1) – direction may be by implication	3
		(ii)	Initial KE = $\frac{1}{2}(0.36)(0.4)^2 + \frac{1}{2}(0.18)(-0.10)^2 = 0.0297 \text{ [J]}$ (1) Final KE = $\frac{1}{2}(0.36 + 0.18)(0.23)^2 = 0.0143 \text{ [J]}$ (1) KE lost = $0.0297 - 0.0143 = 0.0154 \text{ [J]}$ as percentage: $\frac{0.0154}{0.0297} \times 100\% = 51.85\%$ (1)	3
	(b)	(i)	$hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{(633 \times 10^{-9})}$ (subs. (1)) = $3.14 \times 10^{-19} \text{ [J]}$ (1)	2
		(ii)	$N = \frac{(1 \times 10^{-3})}{(3.14 \times 10^{-19})}$ (substitution (1)) = 3.18×10^{15} (1)	2
		(iii)	component of momentum = $\frac{h}{\lambda} \cos 30^\circ$ $= \frac{(6.63 \times 10^{-34})}{(633 \times 10^{-9})} \cos 30^\circ = 9.07 \times 10^{-28} \text{ kg m s}^{-1}$ or N s UNIT mark	1
		(iv)	$-N \frac{h}{\lambda} \cos 30^\circ - \left(N \frac{h}{\lambda} \cos 30^\circ\right) = F \times 1$ (application of N 2 nd law (1)) $F = -2(3.18 \times 10^{15})(9.07 \times 10^{-28}) = -5.8 \times 10^{-12} \text{ N}$ Force on photon = $5.8 \times 10^{-12} \text{ [N]}$ (1)	
			Allow ecf from (b) (iii) for the component of momentum	2
			Question 4 Total	[13]

Question			Marking details	Marks Available
5	(a)		$\omega = \frac{2\pi(1200)}{60} \text{ (conversion of units (1))} = 125.7 \text{ [rad s}^{-1}\text{]} \text{ (1)}$ $F = m\omega^2 r = (0.80)(125.7)^2(0.25) \text{ (subs (1))} = 3160.1 \text{ [N]} \text{ (1)}$	4
	(b)	(i)	$R - mg = 3160.1 \text{ (1)}$ $R = 3160.1 + (0.8)(9.81) = 3168 \text{ [N]} \text{ (1) ecf from (a)}$	
		(ii)	$R + mg = 3160.1$ $R = 3160.1 - (0.8)(9.81) = 3152 \text{ [N]} \text{ (1) ecf from (a)}$	3
	(c)		Resonance – frequency of rotation matches the natural / resonant frequency of vibration of the saucepan [lid] (1) [When the spin rate decreases,] the frequencies no longer match / so no resonance (1)	2
			Question 5 Total	[9]

Question		Marking details	Marks Available
6	(a)	 (i) Correct diagram – 2 or more circles and 3 or more roughly symmetrical lines (1) (ii) Correct arrows and labels (1)	2
	(b)	$V = -\frac{1}{4\pi\epsilon_0} \frac{q}{r} = -\frac{1}{4\pi(8.85 \times 10^{-12})} \frac{1.60 \times 10^{-19}}{2.00 \times 10^{-3}} \text{ (subs. (1))}$ $= -7.19 \times 10^{-7} \text{ [V] (1)}$	2
	(c)	Use of $W = q\Delta V$ (1) $= (-1.60 \times 10^{-19})(-1.20 \times 10^{-6} - (-7.19 \times 10^{-7}))$ $= 7.70 \times 10^{-26} \text{ [J] (1)}$	2
	(d)	$F_C = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2} = \frac{1}{4\pi(8.85 \times 10^{-12})} \frac{(1.60 \times 10^{-19})^2}{(1.20 \times 10^{-3})^2}$ $= 1.60 \times 10^{-22} \text{ [N]}$ $F_G = G \frac{m^2}{r^2} = (6.67 \times 10^{-11}) \frac{(9.11 \times 10^{-31})^2}{(1.20 \times 10^{-3})^2} = 3.84 \times 10^{-65} \text{ [N]}$ Both F_C and F_G (1) (or by implication) Gravitational force much less [by factor $\sim \frac{3.84 \times 10^{-65}}{1.60 \times 10^{-22}} = 2.40 \times 10^{-43}$] (or equivalent quantitative comparison or qualitative comparison such as much larger, much smaller) (1) Electrostatic force repels. Gravitational force attracts. (1) Both need to be mentioned for comparison (or equivalent statement).	3
Question 6 Total			[9]

Question			Marking details	Marks Available
7	(a)		$27.3 \times 24 \times 60 \times 60 = 2.36 \times 10^6 \text{ [s]} \quad (1)$ $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$ $d = \sqrt[3]{\left(\frac{T}{2\pi}\right)^2 G(M_1 + M_2)} \quad \text{rearrange (1)}$ $d = \sqrt[3]{\left(\frac{2.36 \times 10^6}{2\pi}\right)^2 (6.67 \times 10^{-11})(6.00 \times 10^{24} + 7.34 \times 10^{22})}$ (accept 7.34×10^{22} ignored in formula) substitution (1)	3
	(b)	(i)	$x_{cm} = \frac{M_2}{M_1 + M_2} d$ $= \frac{7.34 \times 10^{22}}{(6.00 \times 10^{24} + 7.34 \times 10^{22})} \times 3.85 \times 10^8 \text{ (substitution (1))}$ $= 4.65 \times 10^6 \text{ [m]} \quad (1) \quad (\sim 4\,650 \text{ k[m]})$	2
		(ii)	The centre of mass is within the Earth ecf (~1 710 km below the surface of the Earth)	1
	(c)		$G \frac{M_1}{x^2} = G \frac{M_2}{(d-x)^2} \quad (1) - \text{equality of the two fields in terms of } x$ $\left(\frac{x}{d-x}\right)^2 = \frac{M_1}{M_2}$ $x = \left(\frac{M_1}{M_2}\right)^{1/2} (d-x)$ $x = \left(\frac{6.00 \times 10^{24}}{7.34 \times 10^{22}}\right)^{1/2} (3.85 \times 10^8 - x) \quad \text{substitution (1)}$ $x = \left(\frac{(9.04) \times (3.85 \times 10^8)}{10.04}\right) \quad \text{rearrange (1)}$ $x = 3.47 \times 10^8 \text{ [m from the Earth]} \quad (1)$	4
			Question 7 Total	[10]

Surname	Centre Number	Candidate Number
Other Names		2



GCE A level

1324/01

PHYSICS – PH4

Oscillations and Fields

P.M. WEDNESDAY, 11 June 2014

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	12	
2.	8	
3.	5	
4.	12	
5.	10	
6.	12	
7.	10	
8	11	
Total	80	

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.

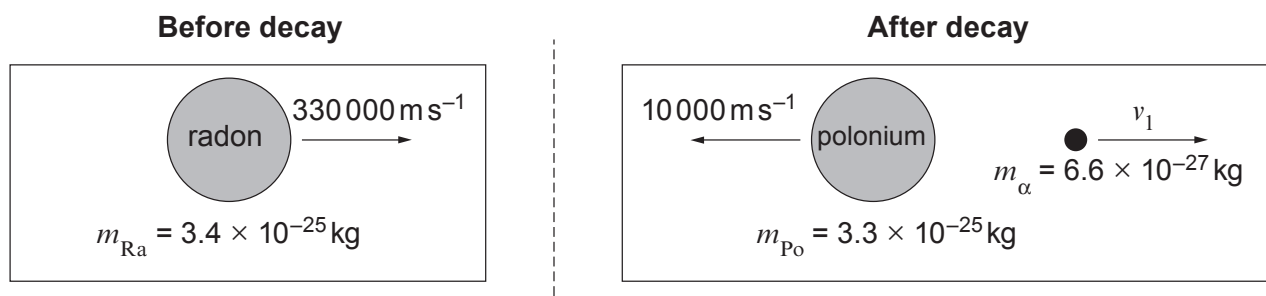
The number of marks is given in brackets at the end of each question or part question.

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.

Answer all questions.

1. A radon nucleus travelling at $330\,000\text{ m s}^{-1}$ decays to produce a polonium nucleus and an alpha particle as shown.



- (a) Use the principle of conservation of momentum to calculate the velocity (v_1) of the alpha particle. [3]

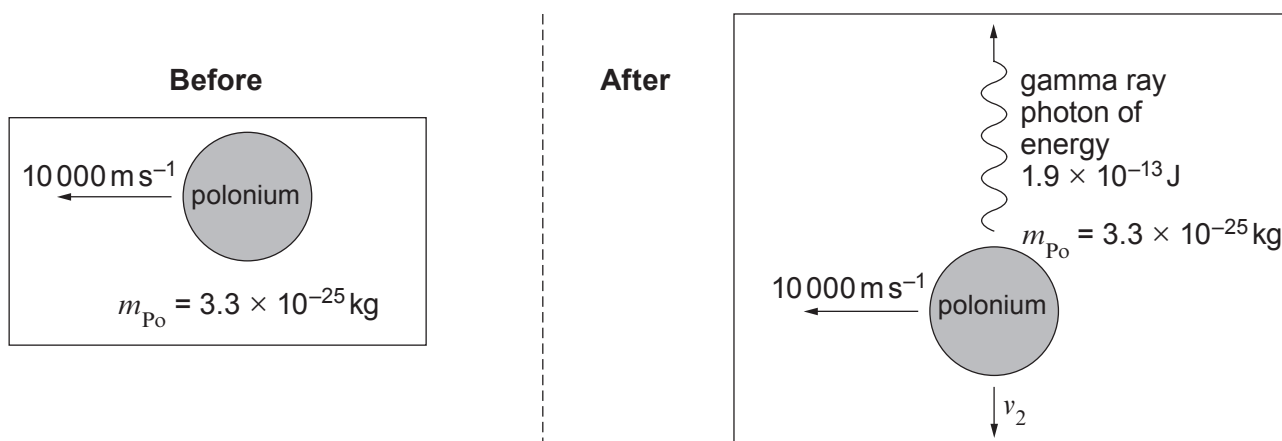
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- (b) The polonium nucleus then emits a gamma ray **perpendicular** to its direction of motion as shown.



- (i) Explain why the horizontal velocity component ($10\,000\text{ m s}^{-1}$) of the polonium nucleus is unchanged. [1]

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- (ii) Show that the downward velocity component (v_2) of the polonium nucleus after emitting the gamma ray photon is approximately 2000 m s^{-1} . [4]

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- (iii) Calculate the final resultant velocity (magnitude and direction) of the polonium nucleus. [4]

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2. (a) A helium weather balloon is to be released.

volume = 0.113 m^3
 temperature = 293 K
 pressure = $1.02 \times 10^5 \text{ Pa}$



- (i) Show that the density of the helium in the balloon is approximately 0.17 kg m^{-3} . (The molar mass of helium is $4.00 \times 10^{-3} \text{ kg mol}^{-1}$.) [3]

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- (ii) Calculate the rms speed of helium molecules in the balloon. [2]

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- (b) The balloon is released and rises to a height where the pressure inside it decreases to $4.5 \times 10^4 \text{ Pa}$ and its volume increases to 0.212 m^3 . Calculate the new rms speed of the helium molecules in the balloon (assume no helium molecules have escaped). [3]

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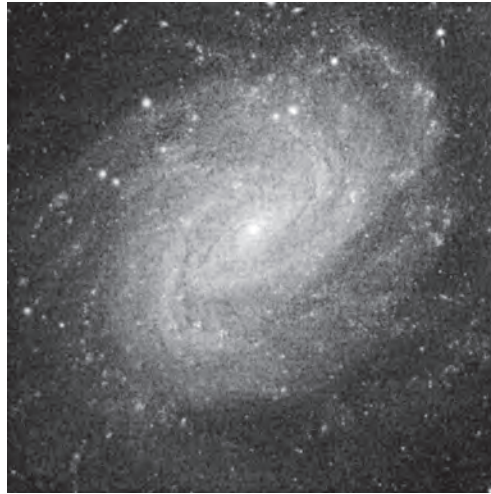
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3. A spiral galaxy is analysed and its mass is estimated as 3.5×10^{41} kg.



- (a) Use the equation $v = \sqrt{\frac{GM}{r}}$ to **estimate** the orbital speed of dust particles at a distance of 9.3×10^{20} m from the centre of the galaxy. [2]

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- (b) The **measured** velocity of the dust particles is different. Explain how dark matter is thought to be responsible for the difference between the **measured** and the **estimated** velocities. [3]

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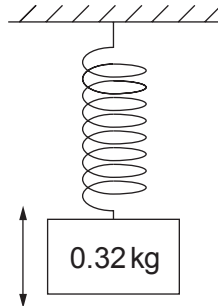
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4. A mass of 0.32 kg oscillates with simple harmonic motion vertically on a spring with a frequency of 3.47 Hz.



- (a) Calculate the spring constant of the spring.

[3]

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- (b) Show that the angular velocity, ω , of the oscillations is 21.8 rad s^{-1} .

[1]

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- (c) The amplitude of oscillation of the spring is 8.5 cm. Calculate:

- (i) the maximum kinetic energy of the mass;

[3]

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- (ii) the maximum resultant force acting on the mass.

[2]

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- (d) The displacement of the mass is given by the equation $x = A \sin(\omega t + \varepsilon)$. Calculate a valid value for ε given that the displacement of the mass is -1.4 cm at time $t = 0.100$ s. [3]

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5. (a) Define:

(i) the gravitational field strength at a point;

[1]

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(ii) the gravitational potential at a point.

[1]

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(b) Charon is the moon of Pluto; it has a mass of 1.5×10^{21} kg and its radius is 600 km.

(i) Calculate the gravitational force exerted by Charon on an object of mass 82 kg on its surface. [2]

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(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

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- (c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

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- (d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]

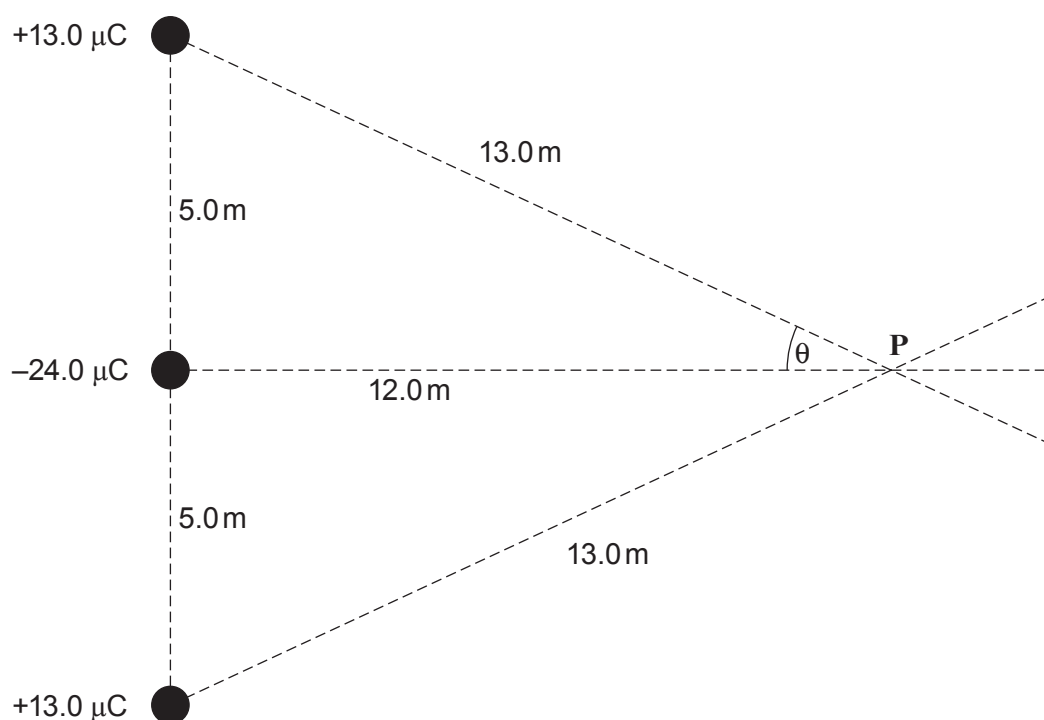
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6. Three charges are arranged as shown.



- (a) **Draw three arrows at P** to represent the electric fields due to **each** of the three charges. [2]
- (b) Calculate the electric field strength at **P** due to the $-24.0 \mu\text{C}$ charge only (you may use the approximation $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ F}^{-1} \text{ m}$). [2]

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- (c) Calculate the resultant electric field strength at **P** (you may use the approximation $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ F}^{-1} \text{ m}$). [3]

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- (d) Show that the electric potential at **P** is zero. [2]

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- (e) A negative charge is released from rest at point **P** and encounters **no resistive forces**. Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]

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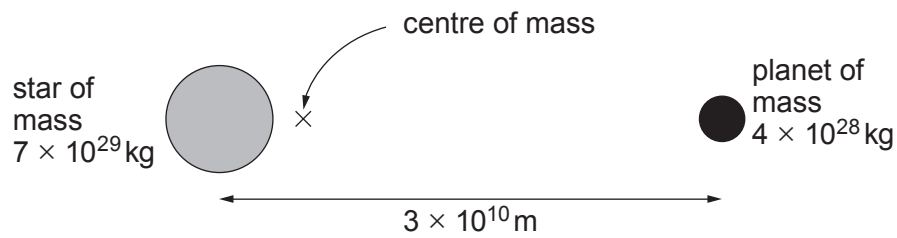
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7.



A star and planet orbit their mutual centre of mass.

(a) Calculate the period of orbit.

[2]

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(b) Calculate the distance of the centre of mass from the centre of the star.

[2]

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(c) Calculate the maximum red shift (or blue shift) measured by a distant observer when light of wavelength 656 nm from this star is analysed. (The centre of mass of the star-planet system is at rest relative to the observer and the system is viewed edge-on.)

[4]

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- (d) The planet is 5 times closer to the star than the Earth is to the Sun but the star emits $\frac{1}{20}$ of the electromagnetic radiation of the Sun. Discuss whether or not this planet is hotter or colder than the Earth. [2]

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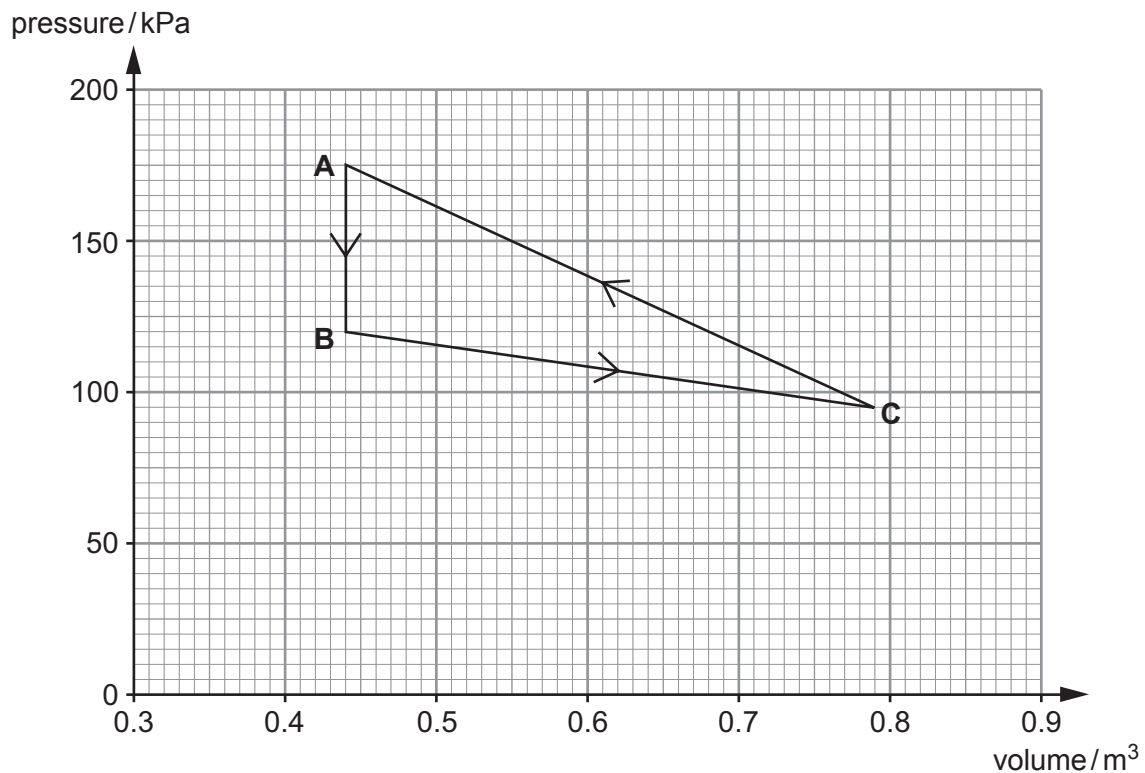
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8. A sample of an ideal monatomic gas is taken through the closed cycle **ABCA** as shown.



- (a) There are **28.9 mol** of gas. The temperatures of points **A** and **B** are 321 K and 220 K respectively.

(i) Show that the temperature of **C** is 313 K.

[2]

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(ii) Calculate the change in internal energy, ΔU , for **AB**.

[2]

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(b) Determine the work done **by** the gas, W , for:

(i) **AB**;

[1]

(ii) **CA**.

[2]

(c) For **each** of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

	Process			
	AB	BC	CA	ABCA
W		37.6 kJ		
ΔU		33.5 kJ	2.9 kJ	
Q				

Space for calculations:

END OF PAPER



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2014 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

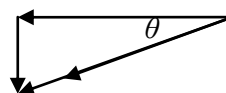
It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
PH1	1
PH2	6
PH3	10
PH4	13
PH5	20
PH6	36

PH4

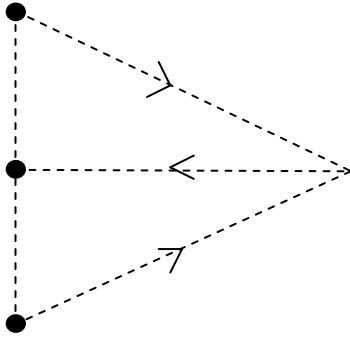
Question			Marking details	Marks Available
1	(a)		Reasonable attempt at conservation of momentum (1) e.g. $330\,000m = \pm 10\,000m + 6.6 \times 10^{-27} \times v_1$ conservation of momentum applied correctly and values substituted (1) e.g. $330\,000 \times 3.4 \times 10^{-25} = -10\,000 \times 3.3 \times 10^{-25} + 6.6 \times 10^{-27} \times v_1$ correct answer = $1.75 \times 10^7 \text{ [ms}^{-1}\text{]}$ (no ecf) (1)	3
	(b)	(i)	Any valid answer e.g. impulse (or force or acceleration or change in momentum) is vertical, gamma has no momentum in horizontal direction, perpendicular directions are independent etc. Accept: no horizontal force	1
		(ii)	Attempt at using $p = \frac{h}{\lambda}$ (1) $E = hf$ and $c = f\lambda$ quoted (or equivalent $E = \frac{hc}{\lambda}$) (1) N.B. $p = \frac{E}{c}$ gains 2 marks Correct momentum = 6.33×10^{-22} (1) Answer = $= \frac{6.33 \times 10^{-22}}{3.3 \times 10^{-25}}$ [1 920 m s ⁻¹] (1)	4
		(iii)	Method i.e. $\sqrt{10000^2 + 2000^2}$ (1) Answer = 10 200 [m s ⁻¹] ecf on v from (b)(ii) (1) Method and correct indication of angle e.g. $\tan^{-1}\left(\frac{2000}{10000}\right)$ (1) Answer = 11.5° or 0.2 [rad] (or 90-11.5 for other angle if indicated etc.) (1)	4
			Question 1 Total	[12]



Question			Marking details	Marks Available
2	(a)	(i)	(Number of moles) $n = 4.73$ (1) Mass = 4×4.73 or 0.004×4.73 (or implied) (1) Density = $0.004 \times 4.73 / 0.113$ [= 0.167] (1)	3
		(ii)	Either $p = \frac{1}{3} \rho c^2$ used or equivalent e.g. $\frac{3}{2} nRT = \frac{1}{2} M \overline{c^2}$ (1) $1\,350 \text{ [m s}^{-1}\text{]}$ (1)	2
	(b)		Density = $0.004 \times 4.73 / 0.212$ or $T = \frac{45000 \times 0.212}{4.73 \times 8.31}$ ecf (1) $p = \frac{1}{3} \rho c^2$ used or $\frac{3}{2} nRT = \frac{1}{2} M \overline{c^2}$ used or equivalent (1) Answer = $1\,230 \text{ [m s}^{-1}\text{]}$ (1)	3
			Question 2 Total	[8]
3	(a)		Substitution into $v = \sqrt{\frac{GM}{r}}$ (1) Answer = $158\,000 \text{ [m s}^{-1}\text{]}$ (1)	2
	(b)		Measured velocity is greater (1) Which implies that the mass is greater (1) Suggests the existence of dark matter (1)	3
			Question 3 Total	[5]

Question			Marking details	Marks Available
4	(a)		Mass substituted into $T = 2\pi\sqrt{\frac{m}{k}}$ (1) $T = \frac{1}{f}$ used or implied (1) Answer = 152 N m ⁻¹ UNIT mark (1)	3
	(b)		$3.47 \times 2\pi [= 21.803]$	1
	(c)	(i)	$v = \omega A [= 1.853]$ or max PE = max KE (1) $KE = \frac{1}{2}mv^2$ used or $= \frac{1}{2}kx^2$ (1) Answer = 0.55 [J] (1)	3
		(ii)	Acceleration = $\omega^2 A$ or $F = kA$ Accept $F = kA - mg$ (1) Answer = 12.9 [N] (1)	2
	(d)		Substitution of values e.g. $-1.4 = 8.5\sin(21.8 \times 0.1 + \varepsilon)$ (1) $\sin^{-1}\left(\frac{-1.4}{8.5}\right) = -0.165$ (1) $\varepsilon = -2.35$ or equivalent in degree (-135°) or other quadrant (-5.16) ecf on minus sign (1) Question 4 total	3 [12]

Question			Marking details	Marks Available
5	(a)	(i)	Force per unit mass (this minimalist answer is acceptable unless some contradiction)	1
		(ii)	Work done per unit mass <u>from infinity</u> (this minimalist answer is acceptable unless some contradiction)	1
	(b)	(i)	$F = \frac{GMm}{r^2}$ used (1) Answer = 22.8 [N] (1)	2
		(ii)	$PE = [-] \frac{GMm}{r}$ used or equivalent (1) Answer = - 13.7 M[J] (1)	2
	(c)		$PE = [-] \frac{GMm}{r}$ used or equivalent (1) Answer = - 61.8 M[J] (ecf on – sign) (1)	2
	(d)		Difference in PE attempted (1) Correct answer = 48.1 M[J] ((b)(ii) – (c)) ecf (1) Answer must be consistent with their signs	2
			Question 5 Total	[10]

Question			Marking details	Marks Available
6	(a)		All arrows correct ✓✓ Directions in line with dotted lines but some (or all) directions inverted ✓ 	2
	(b)		$E = \frac{Q}{4\pi\epsilon_0 r^2}$ used (1) Answer = 1 500 V m⁻¹ or NC⁻¹ or equivalent UNIT mark (1)	2
	(c)		<u>Field of</u> 13 µC ×2 and ×12/13 (1) Answer = 222 [V m⁻¹] (1) To the left or implied clearly in the calculation (1)	3
	(d)		$V = \frac{Q}{4\pi\epsilon_0 r}$ used for 3 charges with $r = 12$ or 13 (1) $V = \frac{1}{4\pi\epsilon_0} \left(2 \frac{13}{13} - \frac{24}{12} \right)$ as shown or equivalent (cm perfectly valid) (1)	2
	(e)		Any 3 (×1) from: - initial total energy is zero / initial and final PE is zero - final total energy is zero / initial and final KE is zero - initial force is to the right (has to be linked to the field and the negative charge) - later the force is to the left (but not a resistive force) Question 6 Total	3
				[12]

Question			Marking details	Marks Available
7	(a)		$T = 2\pi \sqrt{\frac{(3 \times 10^{10})^3}{6.67 \times 10^{-11} \times (7 \times 10^{29} + 4 \times 10^{28})}} \quad (1)$ Answer = 4.65×10^6 [s] (1) $(4.78 \times 10^6 \text{ s scores } 1/2 \text{ marks})$	2
	(b)		$r_1 = \frac{M_1}{M_1 + M_2} d \quad \text{used or } M_1 r_1 = M_2 r_2 \quad \text{used (1)}$ Star orbit radius = 0.162×10^{10} [m] (1) (0.171×10^{10} scores 1/2 marks)	2
	(c)		$v = \frac{2\pi r}{T} \quad \text{or } v = \omega r \quad \text{and } \omega = 2\pi f \quad \text{ecf on } T \text{ and } r \text{ (1)}$ $v = \frac{2\pi \times 0.162 \times 10^{10}}{4.65 \times 10^6} [= 2191] \text{ (1)}$ $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \quad \text{attempted or rearranged ecf on } v \text{ (1)}$ Answer = 4.8×10^{-12} [m] (1)	4
	(d)		Hotter or the Earth is cooler or equivalent (1) Due to higher intensity [of e-m radiation] (1) Accept because $5^2 > 20$ or similar	2
	Question 7 Total			[10]

Question			Marking details	Marks Available																													
8	(a)	(i)	$T = \frac{pV}{nR}$ seen or equivalent or implied (1) $T = \frac{95000 \times 0.79}{28.9 \times 8.31}$ (= 312.5 K) (1)	2																													
		(ii)	$U = \frac{3}{2}nRT$ used or $3/2 pV$ (1) AB = -36 400[J] (1)	2																													
	(b)	(i)	0	1																													
		(ii)	Valid method either stated or clearly implied (1) Accept area under the graph Answer = - 47 250 [J] (1)	2																													
			(c)	<table><tr><td></td><td>AB</td><td>BC</td><td>CA</td><td>ABCA</td></tr><tr><td>W</td><td>0</td><td>37.6 kJ</td><td>-47.3 kJ</td><td>-9.7 kJ</td></tr><tr><td>ΔU</td><td>-36.4 kJ</td><td>33.5 kJ</td><td>2.9 kJ</td><td>0</td></tr><tr><td>Q</td><td>-36.4 kJ</td><td>71.1 kJ</td><td>-44.4 kJ</td><td>-9.7 kJ</td></tr><tr><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td></td><td>ecf on ΔU</td><td>no ecf</td><td>ecf on W</td><td>ecf on all if $\Delta U \approx 0$ but must make sense</td></tr></table>		AB	BC	CA	ABCA	W	0	37.6 kJ	-47.3 kJ	-9.7 kJ	ΔU	-36.4 kJ	33.5 kJ	2.9 kJ	0	Q	-36.4 kJ	71.1 kJ	-44.4 kJ	-9.7 kJ		✓	✓	✓	✓		ecf on ΔU	no ecf	ecf on W
		AB	BC	CA	ABCA																												
	W	0	37.6 kJ	-47.3 kJ	-9.7 kJ																												
	ΔU	-36.4 kJ	33.5 kJ	2.9 kJ	0																												
	Q	-36.4 kJ	71.1 kJ	-44.4 kJ	-9.7 kJ																												
		✓	✓	✓	✓																												
	ecf on ΔU	no ecf	ecf on W	ecf on all if $\Delta U \approx 0$ but must make sense																													
Question 8 Total			[11]																														

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	

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.

Answer all questions.

1. (a) State the principle of conservation of momentum.

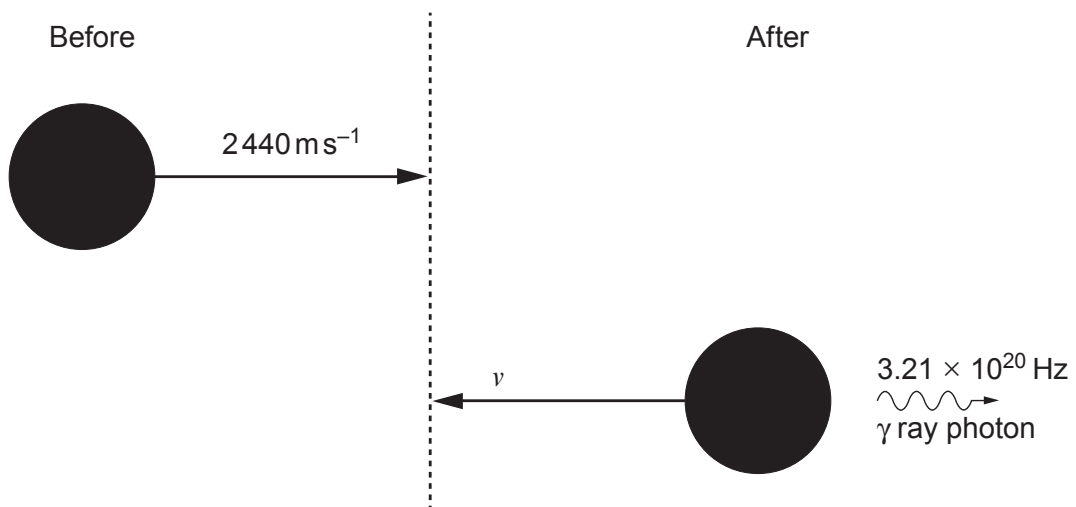
[2]

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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 $7 \times 10^{-22} \text{ kg m s}^{-1}$.

[3]

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

[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]

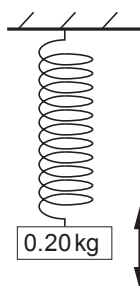
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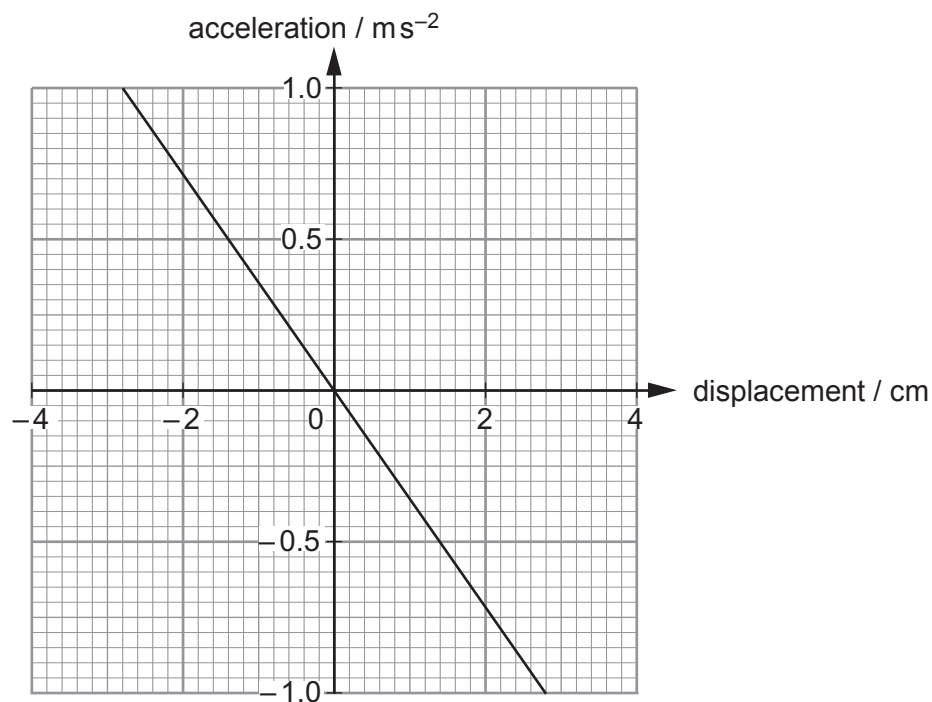
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3. A mass oscillates vertically on a spring as shown.



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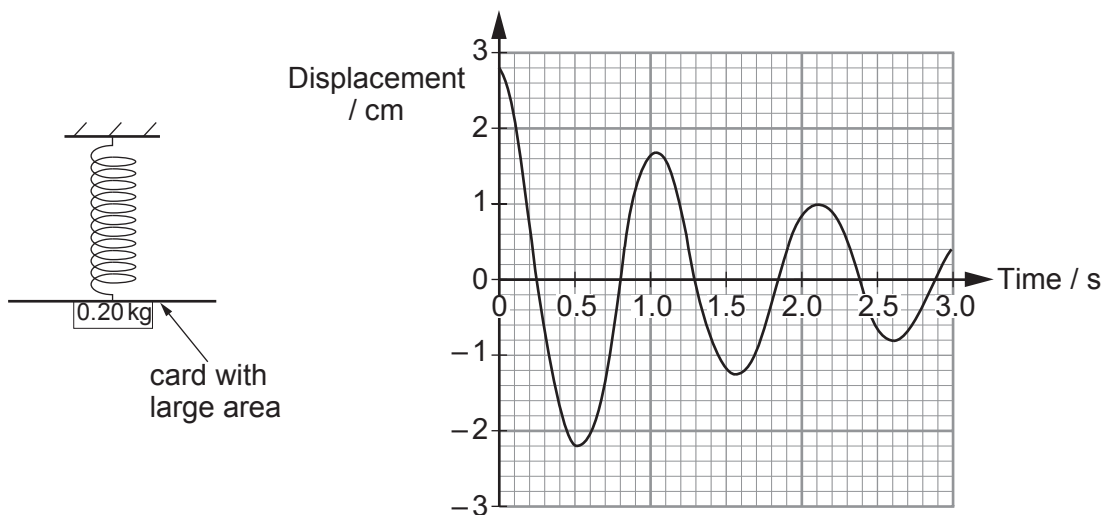
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- (b) When damping is introduced the following graph of displacement against time is obtained. Explain how the principle of conservation of energy applies during the cycles shown. [4]



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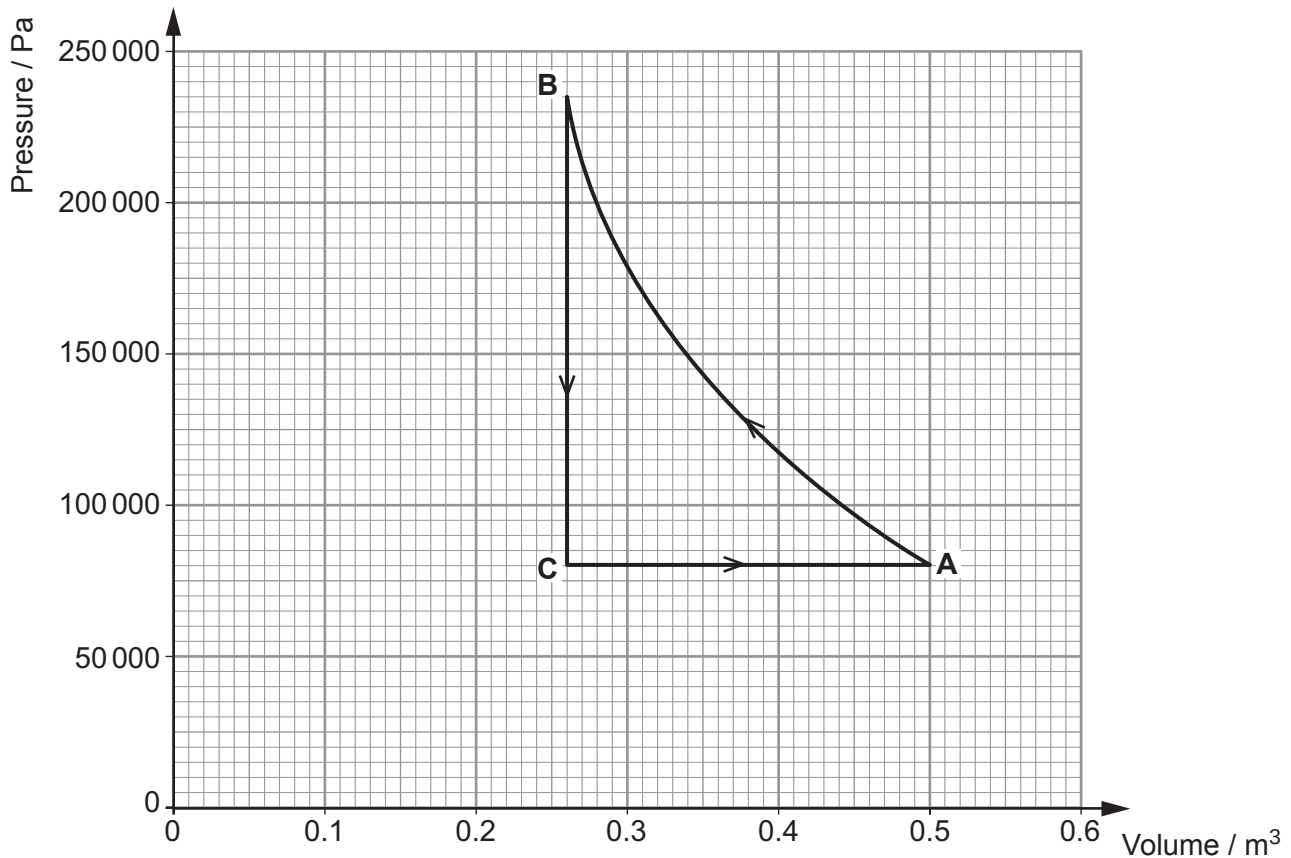
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4. An ideal monatomic gas is taken through the closed cycle ABCA as shown.



- (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]

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(ii) **BC**

[1]

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(iii) **CA**

[1]

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

[2]

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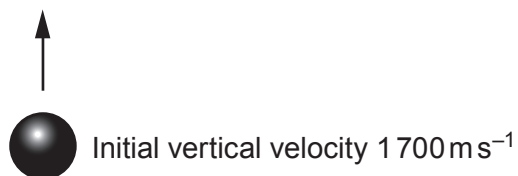
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(iii) Explain briefly why the potential is negative. [1]

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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 1700 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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- (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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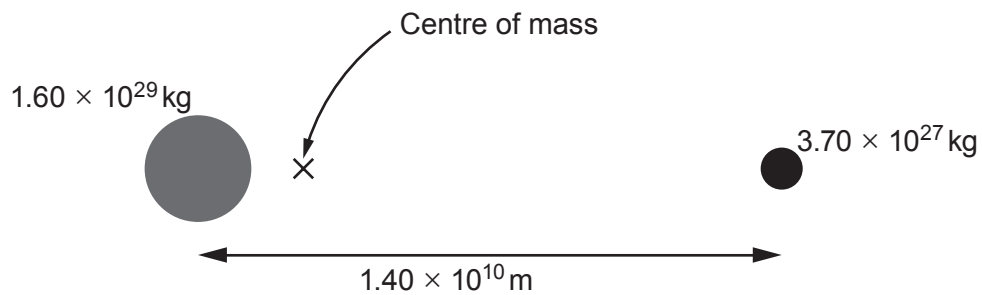
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7. A star and planet travel in circular orbits about their mutual centre of mass.



- (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 $1.875 \mu\text{m}$ due to the orbital speed of the star (assuming that the system is viewed edge-on).

[2]

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END OF PAPER



GCE MARKING SCHEME

PHYSICS AS/Advanced

JANUARY 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2014 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

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PH4

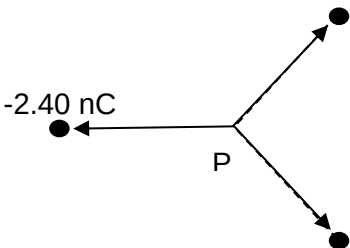
Question				Marking details	Marks Available
1	(a)			The total momentum (of a system) is constant (must have total, sum, vector sum etc.) (1) Provided no <u>external</u> [resultant] force (1) e.g. - The momentum before and after a collision is the same - 0 When two particles collide the sum of momentum stays the same as long as no forces are involved - 1	2
	(b)			$\lambda = \frac{c}{f}$ i.e. rearranged or $E = hf = 2.13 \times 10^{-13}$ [J] (1) $p = \frac{h}{\lambda}$ used or $p = \frac{E}{c}$ quoted (1) Final evidence $p = \frac{6.63 \times 10^{-34}}{9.35 \times 10^{-13}}$ or $p = \frac{2.128 \times 10^{-13}}{3 \times 10^8}$ (= 7.09 x 10⁻²²) (1)	3
	(c)			Reasonable attempt at cons of mom e.g. initial p of Ni = final p of Ni $\pm$ p of photon (1) $2\,440 \times 9.95 \times 10^{-26} = 7 \times 10^{-22} - 9.95 \times 10^{-26} v$ (1) Answer = 4 700 [m s⁻¹] or slightly different dependent on (b) (1) ecf on p	3
	Question 1 Total				[8]

Question				Marking details	Marks Available
2	(a)			$\frac{1}{3}\rho\overline{c^2}V = nRT$ i.e. some sort of combining both equations (1) Realising $\rho = \frac{Nm}{V}$ (any mistakes in N and m means max of 1/3) (1) (or equivalent steps) Clear algebra with no mistakes leading to $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ or $\frac{1}{2}m\overline{c^2} = \frac{3}{2}\frac{R}{N_A}T$ (if it's difficult to follow don't award the mark - needs to be clear) (1)	3
	(b)	(i)		Mass of argon molecule = $6.3(08)\times 10^{-26}$ (1) Algebra or equivalent method $T = \frac{m\overline{c^2}}{3k}$ or $T = \frac{N_A m\overline{c^2}}{3R}$ (1) Answer = 605 [K] (1) ecf	3
		(ii)		$\sqrt{\overline{c^2}} \propto \sqrt{T}$ or correct substitution of 1 210 K (ecf) and algebra (1) Answer = $630 \times \sqrt{2}$ or 891 [m s^{-1}] (1)	2
	Question 2 Total				[8]

Question				Marking details	Marks Available
3	(a)	(i)		Graph is straight line through origin [hence proportional] (1) (accept acceleration is proportional to displacement) Negative gradient [hence direction ok] (1)	2
		(ii)		Gradient calculated correctly i.e. $\frac{1}{0.028}$ or 36 (or k calculated from $ma = kx$ i.e. 7.14 N m^{-1}) (1) Gradient = angular velocity squared i.e. method explained Or $f = \left(2\pi \sqrt{\frac{m}{k}}\right)^{-1}$ i.e. equation for T and $f = 1/T(1)$ Answer = $\frac{5.98}{2\pi} = 0.95 \text{ [Hz]}$ (1)	3
		(iii)		1 m s^{-2} read off graph Or $6^2 \times 0.028 = 1 \text{ [m s}^{-2}\text{]} \text{etc.}$	1
		(iv)		Max speed = ωA or implied (= 0.167) (1) $\text{KE} = \frac{1}{2}mv^2$ or implied (1) Answer = 2.8 [mJ] (1) ecf	3
		(v)		$v = A\omega \cos \omega t$ used or $\varepsilon = 0$ stated (1) Rearrangement e.g. $\omega t = \cos^{-1} \frac{v}{A\omega}$ or implied (1) Correct answer = 0.156 [s] (1) ecf	3
	(b)			KE to PE or PE to KE (1) PE is both GPE and EPE (1) Energy gradually lost due to friction or air resistance or internal energy of spring/air etc. Not sound, not heat by itself - needs more e.g. lost as heat to the air ok (1) Detail of energy loss e.g. internal energy of air, KE of air particles	4
				Question 3 total	[16]

Question				Marking details	Marks Available
4	(a)			$T = \frac{pV}{nR}$ seen or implied (1) Evidence of 1 correct substitution (1) Evidence of all 3 substituted correctly (1) A - $(0.500 \pm 0.002, 80\,000 \pm 2\,000)$ B - $(0.260 \pm 0.002, 235\,000 \pm 2\,000)$ C - $(0.260 \pm 0.002, 80\,000 \pm 2\,000)$	3
		(b)		$U = \frac{3}{2}nRT$ used (1) Evidence of ΔT being used or differences in U being calculated (once) (1) AB = 31 500 [J], BC = - 60 500 [J], CA = 29 000 [J] (1)	3
		(c)	(i)	AB approximated as a trapezium (accept triangle gives 19 000 J) (1) AB = - 38 000 [J] (1) AB $\approx$ (- 32 000 $\pm$ 3 000) J due to better method ✓✓✓ e.g. two trapezia or 2 triangles or square counting, or any attempt at integrating pV (unlikely) etc. (i.e. 2 marks for good method 1 mark for correct answer) (1)	3
		(ii)		BC = 0 (independent)	1
		(iii)		CA = 19 200 [J]	1
	(d)	(i)		$Q = \Delta U + W$ i.e. equation used (1) Correct answer with their figures e.g. $31\,500 - 38\,000 = -6\,500$ (also ecf possible for $31\,500 + 38\,000 = 69\,500$) (1)	2
		(ii)		No time for heat transfer	1
				Question 4 Total	[14]

Question				Marking details	Marks Available
5	(a)	(i)		$g = \frac{GM}{r^2}$ used (1) Answer = 3.7 m s^{-2} or N kg^{-1} or equivalent (1) UNIT MARK	2
		(ii)		$V_g = -\frac{GM}{r}$ used (1) Answer = $\pm 9.02 \text{ [MJ kg}^{-1}\text{]}$ (1) ecf on km conversion	2
		(iii)		Negative amount of work bringing mass from ∞ (accept no work done bringing from ∞ or system will do work or work is done in the other direction etc.)	1
	(b)	(i)		$PE = V_g \times m$ or implied (1) $KE = \frac{1}{2}mv^2$ used (1) Answer = $656 \text{ kJ} - 4.1 \text{ MJ} = -3.44 \text{ [MJ]}$ (1)	3
		(ii)		$-\frac{GMm}{r} = -3.44 \text{ MJ}$ (1) $r = 2905 \text{ km}$ (1) Height = 465 [km] (1) ecf	3
				Question 5 Total	[11]

Question				Marking details	Marks Available
6	(a)			Arrows pointing towards charges similar to shown ✓✓ Arrows pointing away from charges similar to shown ✓ 	2
	(b)			$E = \frac{Q}{4\pi\epsilon_0 r^2}$ used (1) The 2 vertical components cancel or no field into or out of page (1) Pythagoras or trig e.g. $\sqrt{5^2 - 4^2} = 3$ or recognising 3,4,5 triangle (equivalent is to realise $\cos \theta = 3/5$ or $\theta = 53^\circ$ etc.) (1) 2 nC charge field x2 and x3/5 ecf (for horizontal components) (1) Calculations all ok e.g. $8\,640 = 7\,200 \times 2 \times 3/5$ or equivalent shown (1)	5
	(c)			$V = \frac{Q}{4\pi\epsilon_0 r}$ used (1) Attempt at adding all 3 potentials (1) - 360 -360 - 432 = - 1 152 V or J C^{-1} or equivalent (1) UNIT MARK	3
	(d)			Use of $\text{PE} = q\Delta V$ must be a change (1) Rearrangement i.e. $v^2 = \frac{2 \times \text{PE}}{m}$ allow ecf on V (1) Answer = $18.3 \times 10^6 \text{ [m s}^{-1}\text{]}$ (ecf only if a ΔV used) (1)	3
				Question 6 Total	[13]

Question				Marking details	Marks Available
7	(a)			$T = 2\pi \sqrt{\frac{(1.4 \times 10^{10})^3}{6.67 \times 10^{-11} \times (1.6 \times 10^{29} + 3.7 \times 10^{27})}} \quad (1)$ Answer = 3.15×10^6 [s] or implied (3.19×10^6 s if M_2 omitted) (1) 36.5 [days] (1) (36.9 if M_2 omitted gets 2/3)	3
	(b)	(i)&(ii)		$r_1 = \frac{M_2}{M_1 + M_2} d \quad \text{used or } M_1 r_1 = M_2 r_2 \quad \text{used} \quad (1)$ Star orbit radius = 0.032×10^{10} [m] (1) Planet orbit radius = 1.37×10^{10} [m] (1)	3
	(c)	(i)		$v = \frac{2\pi r}{T} \quad \text{or } v = \omega r \quad \text{and } \omega = 2\pi f \quad (1)$ $v = \frac{2\pi \times 0.032 \times 10^{10}}{3.15 \times 10^6} (= 631) \quad (1) \quad \text{ecf}$	2
		(ii)		$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \quad \text{values substituted or not possible} \quad (1)$ Answer = 3.9 [pm] because mean radial speed unknown (1) Don't penalise using $2 \times v$ if explained	2
	Question 7 Total				[10]

Surname	Centre Number	Candidate Number
Other Names		2



GCE A level

1324/01

PHYSICS

ASSESSMENT UNIT PH4: Oscillations and Fields

P.M. THURSDAY, 13 June 2013

1½ hours

For Examiner's use only		
1.	11	
2.	11	
3.	11	
4.	18	
5.	8	
6.	11	
7.	10	
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.

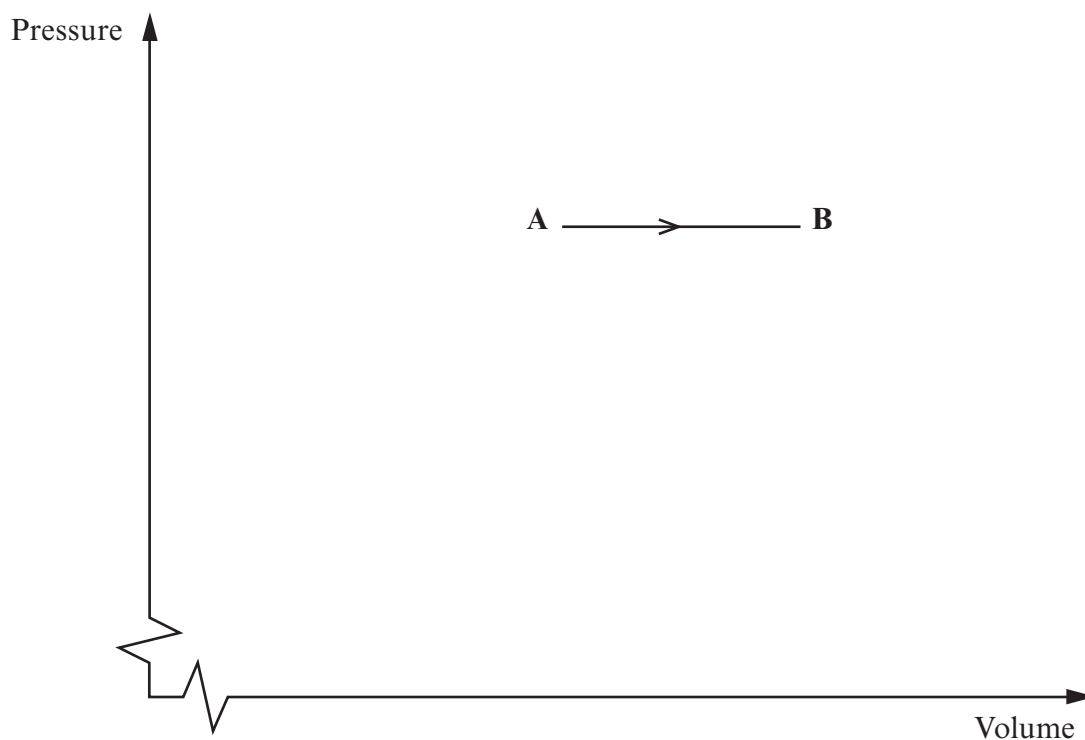
1. A container fitted with a leak-proof moveable piston at one end contains 0.06 mol of a monatomic ideal gas. The gas is initially at a pressure 8.5×10^4 Pa and temperature 250 K.



The gas is taken from this initial state **A** through a cycle (**A**→**B**→**C**→**A**) in three stages.

Stage	Process
A → B	Constant pressure expansion to temperature 355 K.
B → C	Constant temperature expansion to pressure 7.0×10^4 Pa.
C → A	Compression where the pressure increases linearly with decreasing volume to return to the initial state.

- (a) Draw the cycle on the axes below showing each stage clearly and indicating the **direction** of each stage. The first stage **A**→**B** is already done for you. (No *numerical* values are needed.) [3]



(b) Calculate the volume of the gas at:

[3]

(i) **A**;

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.....

(ii) **B**;

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.....

.....

(iii) **C**.

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(c) Show that the work done by the gas during:

[3]

(i) Stage **A→B** is approximately +52 J;

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(ii) Stage **C→A** is approximately –82 J.

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(d) Complete the table below.

[2]

Stage	ΔU /J	W /J	Q /J
A→B	+79	+52	
B→C	0	+34	
C→A		–82	

2. A container made of insulating material contains $1.7 \times 10^{-3} \text{ m}^3$ of water. The water is heated by a 3 kW electric immersion heater. A student records the water temperature at 0.5 minute intervals.

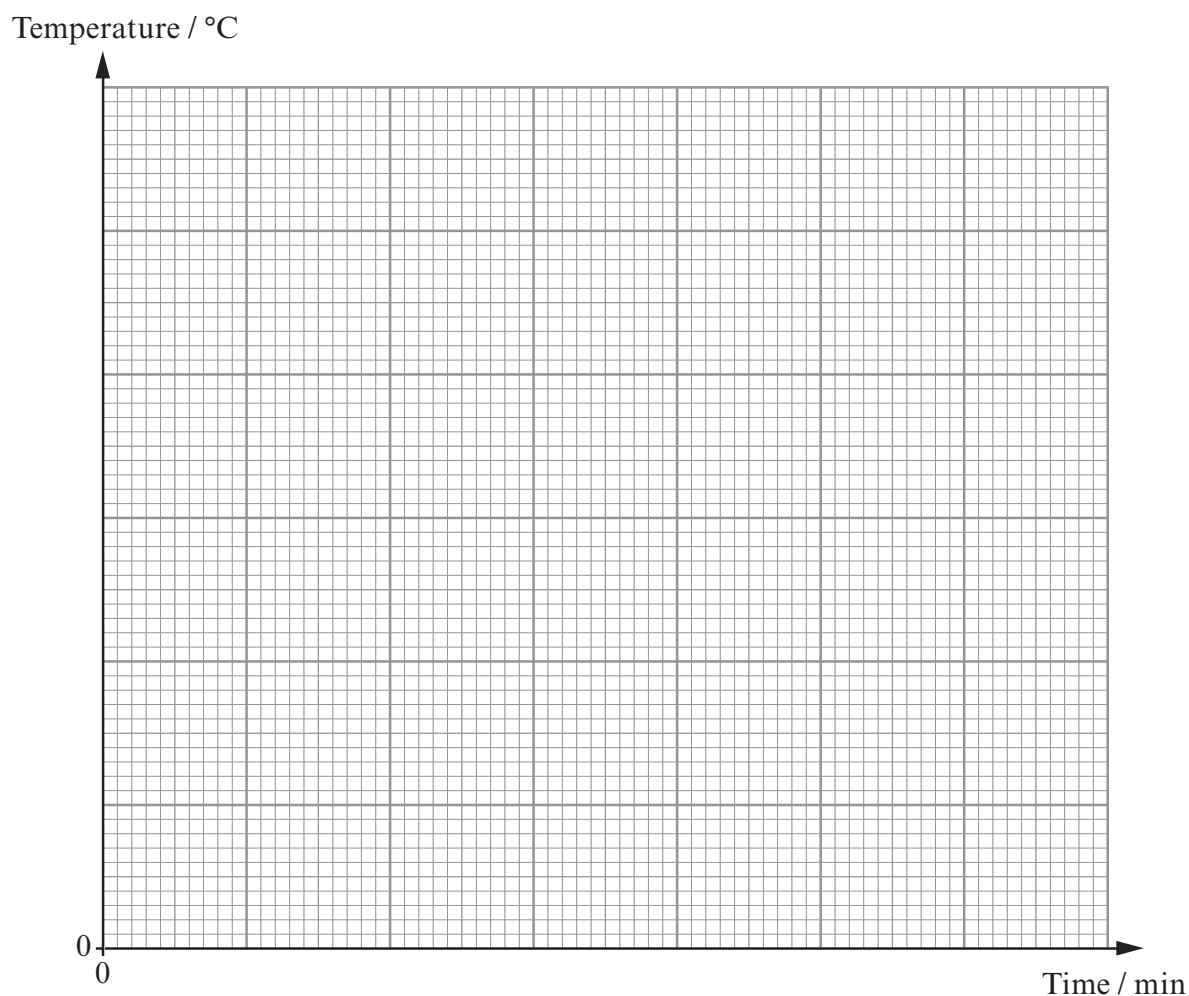
Time / min	Temperature of water / °C
0.5	32.5
1.0	45.0
1.5	57.5
2.0	70.5
2.5	83.0
3.0	95.5

- (a) The density of water is $1.0 \times 10^3 \text{ kg m}^{-3}$. Calculate the mass of the water. [1]

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- (b) Plot a graph of the water temperature against time in minutes. [2]



(c) Estimate the original temperature of the water. [1]

(d) If the heating continues, how long after the start of heating will the water boil? [1]

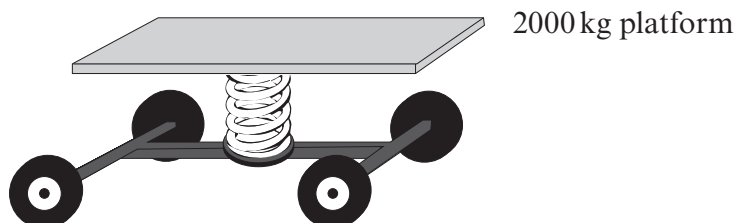
(e) The power of the heater is 3 kW. Determine a value for the specific heat capacity of the water in the insulating container. [3]

(f) The student repeats the experiment but uses a container that is not such a good insulator. Readings are obtained at the same time intervals as before. State what happens to the:

- (i) values of temperature;
- (ii) gradient of the graph;
- (iii) value obtained for the specific heat capacity.

Calculations are not required. [3]

3. A car suspension is modelled as a 2000 kg platform supported on a spring resting on a wheel base. When supporting the platform the spring is compressed 15.0 cm from its natural length.



- (a) Calculate the spring constant. [2]

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- (b) Two passengers, of masses 75 kg and 85 kg, sit on the platform.

- (i) Calculate the additional compression of the spring. [2]

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- (ii) Determine the period of the natural oscillation of the system. [2]

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- (iii) The car travels over a series of speed humps. This results in a driving force of frequency 1.24 Hz. Explain what happens to the oscillation of the platform in the suspension system. [2]

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(c) Explain the purpose of damping in a car suspension system.

[3]

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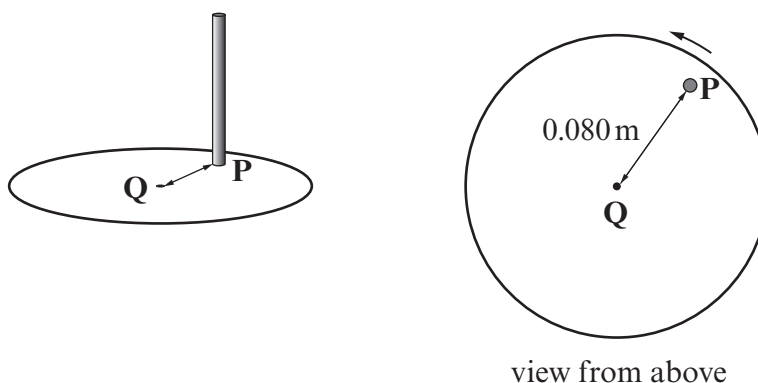
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4. A rod is attached vertically to a horizontal turntable at point **P**, 0.080 m from the centre **Q**.



- (a) (i) The turntable rotates around **Q** at 45 rotations per minute. Show that its angular speed ω is 4.71 rad s^{-1} . [2]

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- (ii) Calculate the speed v of the rod. [2]

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- (iii) Calculate the acceleration of the rod. [2]

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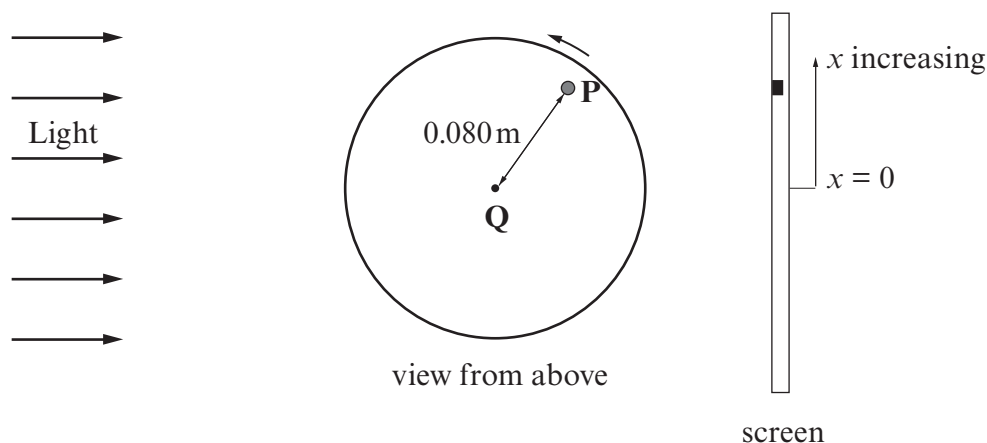
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- (iv) State the direction of the acceleration of the rod. [1]

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- (b) When the rod is illuminated from the side its shadow on a screen oscillates with Simple Harmonic Motion (SHM).



The displacement x in metres of the centre of the shadow from the centre of oscillation and the acceleration a of the shadow may be written

$$x = A \sin(\omega t) \quad \text{and} \quad a = -\omega^2 A \sin(\omega t)$$

where t is time in seconds, A is the amplitude of oscillation and $\omega = 4.71 \text{ rad s}^{-1}$.

- (i) Write the value of A [1]

- (ii) Calculate the value of the period of oscillation. [1]

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- (iii) Calculate the acceleration of the shadow at time $t = 0.20 \text{ s}$. [2]

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(iv) State what is meant by *Simple Harmonic Motion* (SHM).

[2]

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(v) Show clearly that the expressions for x and a agree with the definition of SHM.

[2]

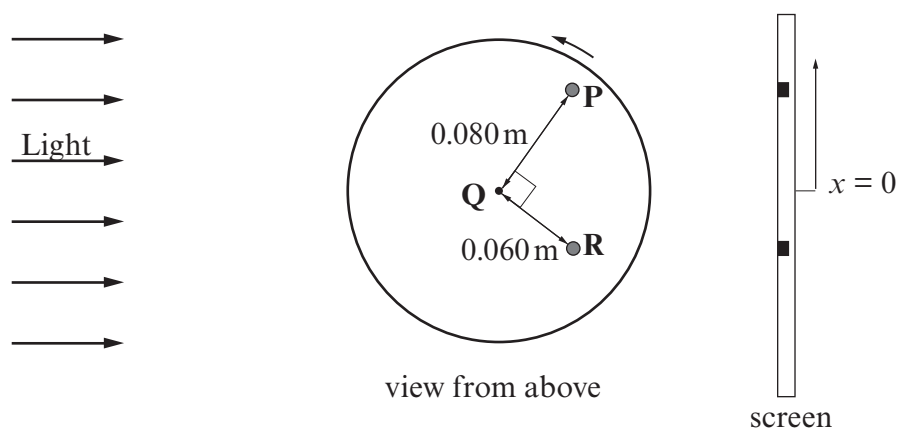
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(c) A second rod is now attached vertically to the turntable at point **R**, 0.060 m from centre **Q**, such that angle **PQR** is a right angle.

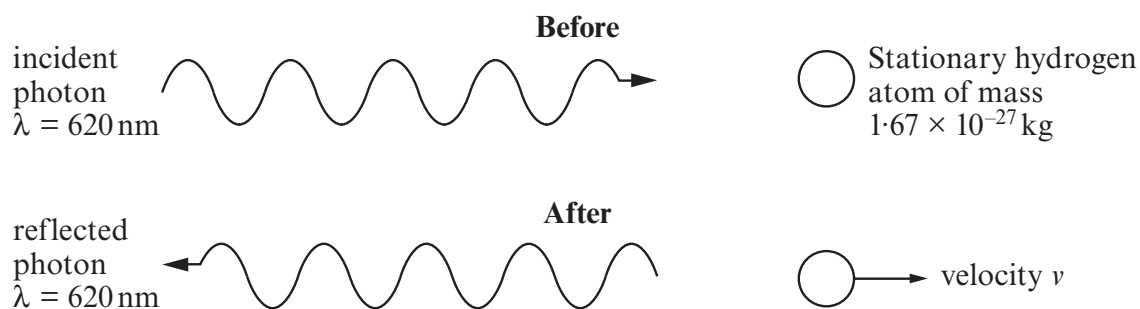


Complete the expression for the displacement of the shadow of the second rod at time t seconds by inserting numerical values in the boxes.

[3]

$$x_R = \boxed{} \sin \left[\boxed{} t - \boxed{} \right]$$

5.



- (a) A photon of wavelength 620 nm strikes a stationary hydrogen atom head-on and rebounds directly backwards. Assume that the wavelength of the photon is unchanged.

- (i) State the principle of *conservation of momentum*. [2]

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- (ii) Show that the speed of the hydrogen atom immediately after impact is 1.28 m s^{-1} . [2]

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- (iii) Calculate the energy of the photon. [1]

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- (b) (i) Determine the wavelength of a photon that has the same momentum as a hydrogen atom moving with the speed of 1.28 m s^{-1} . [2]

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- (ii) Identify the type of electromagnetic radiation of **this** photon. [1]

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6. Information about the Earth, Jupiter and the Sun is given in the table:

	Radius / m	Mass / kg	Distance from the Sun / m
Earth	6.37×10^6	5.97×10^{24}	1.50×10^{11}
Jupiter	6.99×10^7	1.90×10^{27}	7.79×10^{11}
Sun	6.96×10^8	1.99×10^{30}	—

(a) Determine the following at the position of the Earth.

(i) The gravitational field strength of the Sun.

[2]

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(ii) The gravitational potential due to the Sun.

[2]

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(b) (i) Show clearly that the centre of mass of the Sun-Jupiter system lies outside the Sun.

[3]

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(ii) Estimate the speed of the Sun's core around this centre of mass.

[4]

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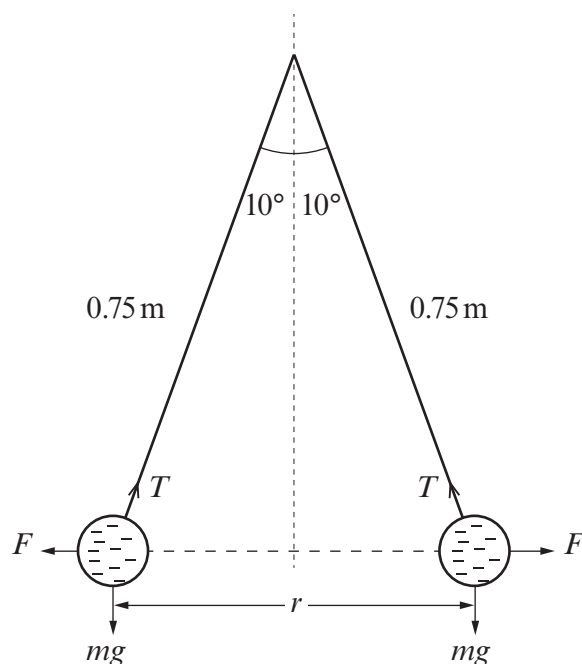
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7. Two spherical balloons each of mass m carry equal numbers of excess electrons distributed uniformly over their surfaces. The total excess charge on each balloon is $-2.55 \times 10^{-7} \text{ C}$.

When both balloons are hung from the same point by light strings of lengths 0.75 m , each string makes an angle of 10° with the vertical.



The weight mg of each balloon, the electrostatic forces F acting on each balloon and the tensions T in the strings are shown in the diagram.

- (a) (i) Use the information in the diagram to show that the separation r of the centres of the balloons is approximately 0.26 m . [2]

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- (ii) Calculate the electrostatic force F on each balloon. [2]

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- (iii) Show that the electrostatic potential energy of the system is $2.25 \times 10^{-3} \text{ J}$. [2]

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- (b) (i) Use the answer to (a)(ii) to show that the tension T in each string is 0.050 N . [3]

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- (ii) Hence calculate the mass of each balloon. [1]

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END OF PAPER



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2013

INTRODUCTION

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GCE Physics - PH4

Question			Marking details	Marks Available
1.	(a)		Curve for 1 st step <u>and</u> line for 2 nd step (1) Direction on both steps (1) Labelling of state C (1)	3
	(b)	(i)	$V_A = \frac{(0.06)(8.31)(250)}{(8.5 \times 10^4)} = 1.47 \times 10^{-3} [\text{m}^3]$	1
		(ii)	$V_B = \frac{(0.06)(8.31)(355)}{(8.5 \times 10^4)} = 2.08 \times 10^{-3} [\text{m}^3]$	1
		(iii)	$V_C = \frac{(0.06)(8.31)(355)}{(7.0 \times 10^4)} = 2.53 \times 10^{-3} [\text{m}^3]$ (alternatively use $\frac{V_B}{V_A} = \frac{T_B}{T_A}$ and $\frac{V_C}{V_B} = \frac{P_B}{P_C}$ allowing ecf)	1
	(c)	(i)	Work done = $p\Delta V = (8.5 \times 10^4)(2.08 - 1.47) \times 10^{-3} \cong 52 [\text{J}]$ ecf Convincing, correct method.	1
		(ii)	Work done = $-\frac{1}{2}(8.5 + 7.0) \times 10^4 (2.53 - 1.47) \times 10^{-3} \cong -82 [\text{J}]$ ecf 1 for: Evidence for “finding area”. 1 for: Convincing algebra.	2
	(d)		1 for: Remaining block in column 1: C to A = -79 1 for: All of column 3: A to B = +131; B to C = +34; C to A = -161	2
Question 1 Total				[11]

Questions			Marking details	Marks Available
2.	(a)		$m = \rho V = 10^3(1.7 \times 10^{-3}) = 1.7 \text{ [kg]}$	1
	(b)		All points plotted correctly ($\pm$ half small square division) and straight line (1) Sensible scales on both axes (1)	2
	(c)		$20 \pm 1 \text{ [}^\circ\text{C]}$	1
	(d)		$3.20 \pm 0.05 \text{ [min]}$ (or $192 \pm 3 \text{ s}$)	1
	(e)		Heat supplied to water in e.g. 2.5 min (Q) $= (3 \times 10^3)(2.5 \times 60) = 4.5 \times 10^5 \text{ [J]}$ (1) e.g. $\Delta\theta = 95.5 - 32.5 = 63 \text{ [}^\circ\text{C]}$ (1) (or equivalent for second and third marks provided consistent for substitution that follows) Rearranging formula for $c = \frac{Q}{m\Delta\theta}$ Substitution of values and result (1) $c = \frac{4.5 \times 10^5}{(1.7)(63)} = 4.2 \times 10^3 \text{ [J kg}^{-1} \text{ }^\circ\text{C}^{-1}] \quad (\pm 0.1 \times 10^3)$	3
	(f)	(i)	[All] temperature measurements lower [because heat taken by container (heat lost) i.e. some reference to heat going elsewhere or lost] (1)	3
		(ii)	Gradient of graph shallower or $\Delta\theta$ smaller (1)	
		(iii)	c larger (overestimated) (1) No ecf within this question part.	
Question 2 Total				[11]

Question		Marking details	Marks Available
3.	(a)	Rearranging Hooke's Law $k = \frac{F}{e} = \frac{mg}{e}$ (1) Substitution and correct result with UNIT $\frac{(2000)(9.81)}{(0.15)} = 1.31 \times 10^5 \text{ N m}^{-1} \text{ (1)}$	2
	(b)	(i) $e = \frac{(75 + 85)g}{(1.31 \times 10^5)} = 0.012 \text{ [m]} = 1.2 \text{ [cm]}$ (allow ecf for k). Correct method. (1) Correct result. (1)	2
		(ii) $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{2160}{1.31 \times 10^5}} = 0.81 \text{ [s]}$ Substitution into formula. (1) Correct result. (1) Award 2 marks for answer of 0.78 [s]	2
		(iii) Natural frequency of system is $\frac{1}{0.81} \cong 1.24 \text{ [Hz]}$; the frequency of driving force is essentially equal to this; so resonance occurs. (1) (need all three points) Accept 1.28 [Hz]. Amplitude of oscillation becomes large/maximum (1)	2
	(c)	Any 3x(1): - return quickly to equilibrium - critical damping - avoid resonance / large amplitude - reduce oscillations - dissipating energy Accept: - comfortable ride - braking better on rough surfaces	3
Question 3 Total			[11]

Question			Marking details	Marks Available
4.	(a)	(i)	$\omega = \frac{45(2\pi)}{60} = 4.71 \text{ [rad s}^{-1}\text{]}$ Conversion from rotations to radians, with the '45'. (1) Conversion from minutes to seconds and convincing working. (1)	2
		(ii)	$\text{velocity} = \omega r = (4.71)(0.08) = 0.38 \text{ [m s}^{-1}\text{]}$ Formula and substitution. (1) Result. (1)	2
		(iii)	$\text{acceleration} = \omega^2 r = (4.71)^2 (0.08) = 1.77 \text{ [m s}^{-2}\text{]}$ Formula and substitution. (1) Result (1)	2
		(iv)	Towards point Q, or towards centre of circle.	1
	(b)	(i)	$A = 0.080 \text{ [m]}$	1
		(ii)	$T = \frac{2\pi}{\omega} = \frac{2\pi}{4.71} = 1.33 \text{ [s]}$	1
		(iii)	$a = -1.77 \sin(4.71 \times 0.20) = -1.43 \text{ [m s}^{-2}\text{]}$ Substitution of time (1). Result with minus sign (1)	2
		(iv)	A body moves with SHM if its acceleration - is directly proportional to its displacement from a fixed point - is always directed towards that [fixed] point 1 for: each statement	2
		(v)	$a = -\omega^2 A \sin(\omega t);$ $x = A \sin \omega t$ so substitution gives: $a = -\omega^2 x$ convincing manipulation. (1) final expression linking to SHM.(1)	2
	(c)		$x = 0.06 \sin\left(4.71t - \frac{\pi}{2}\right).$ 1 for: each correct parameter inserted.	3
	Question 4 total			[18]

Question			Marking details	Marks Available
5.	(a)	(i)	The [vector] sum of the momenta of bodies [in a system] stays constant [even if forces act between the bodies] provided there is no external [resultant] force.	2
		(ii)	Idea of conservation of momentum i.e. expression or statement of $p_i = p_f + m_e v$ (1) No need to specify here that momentum of the hydrogen atom is initially zero. Substitution of values and convincing manipulation. (1) $\frac{6.63 \times 10^{-34}}{620 \times 10^{-9}} = -\frac{6.63 \times 10^{-34}}{620 \times 10^{-9}} + (1.67 \times 10^{-27})v$ $v = 1.28 [\text{m s}^{-1}]$	2
		(iii)	$E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{620 \times 10^{-9}} = 3.2 \times 10^{-19} [\text{J}]$	1
	(b)	(i)	Equating momenta, rearranging and substitution (1) $mv = \frac{h}{\lambda}$ $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(1.67 \times 10^{-27})(1.28)} = 3.10 \times 10^{-7} [\text{m}] (= 310 \text{ nm})$ Correct value of wavelength (1) (allow ecf if substitution incorrect but calculation consistent)	2
		(ii)	Ultraviolet. ecf	1
Question 5 total				[8]

Question			Marking details	Marks Available
6.	(a)	(i)	$\frac{F}{m} = -\frac{GM}{r^2} = -\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{(1.50 \times 10^{11})^2} = [-]5.90 \times 10^{-3} \text{ N kg}^{-1}$ formula and substitution (1) result with UNIT (1).	2
		(ii)	$-\frac{GM}{r} = -\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{(1.50 \times 10^{11})} = -8.85 \times 10^8 \text{ [J kg}^{-1}\text{]}$ formula and substitution (1) result with sign (1) ecf	2
	(b)	(i)	$r_1 = \left(\frac{M_2}{M_1 + M_2}\right)d = \left(\frac{1.90 \times 10^{27}}{1.99 \times 10^{30} + 1.90 \times 10^{27}}\right)(7.79 \times 10^{11})$ or with approximation (1) $= 7.43 \times 10^8 \text{ [m]} (1).$ $7.43 \times 10^8 > 6.96 \times 10^8$ (so centre of mass outside Sun) (1)	3
		(ii)	use of formula and substitution (1) (or with approximation) $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}} =$ result from the substitution (1)	4
			$2\pi \sqrt{\frac{(7.79 \times 10^{11})^3}{(6.67 \times 10^{-11})(1.99 \times 10^{30} + 1.90 \times 10^{27})}} = 3.75 \times 10^8 \text{ [s]}$ or with approximation.	
			$\omega = \frac{2\pi}{T} = 1.68 \times 10^{-8} \text{ [rad s}^{-1}\text{]} \text{ (allow ecf). (1)}$ $\text{speed} = \omega r_1 = (1.68 \times 10^{-8})(7.43 \times 10^8) = 12.5 \text{ [m s}^{-1}\text{]} (1)$	
Question 6 Total			[11]	

Question			Marking details	Marks Available
7.	(a)	(i)	$separation = 2(0.75)\sin 10^\circ = 0.26 \text{ [m]}$ Factor 2 (1) Formula with substitution for one string. (1)	2
		(ii)	$F = \frac{1}{4\pi\epsilon_o} \frac{(2.55 \times 10^{-7})^2}{(0.26)^2} = 8.65 \times 10^{-3} \text{ [N]}$ Substitution into formula. (1) Result.(1)	2
		(iii)	Method. $PotentialE nergy = \left(-\frac{1}{4\pi\epsilon_o} \frac{q}{(0.26)} \right) (-q)(1)$ Convincing substitution (1) $= \frac{(2.55 \times 10^{-7})^2}{4\pi(8.85 \times 10^{-12})(0.26)} = 2.25 \times 10^{-3} \text{ [J]}$	2
	(b)	(i)	$F = T \sin 10^\circ (1)$ Rearranging to $T = \frac{F}{\sin 10^\circ} (1)$ Substitution and result. $T = \frac{8.65 \times 10^{-3}}{\sin 10^\circ} = 0.050 \text{ [N]} (1)$ (allow ecf for force).	3
		(ii)	Convincing use of $mg = T \cos 10^\circ$ to obtain $m = 5.0 \times 10^{-3} \text{ [kg]}$	1
Question 7 Total				[10]

Surname	Centre Number	Candidate Number
Other Names		2



GCE A level

1324/01

PHYSICS – PH4
Oscillations and Fields

P.M. WEDNESDAY, 16 January 2013

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	17	
2.	7	
3.	10	
4.	13	
5.	10	
6.	10	
7.	13	
Total	80	

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.

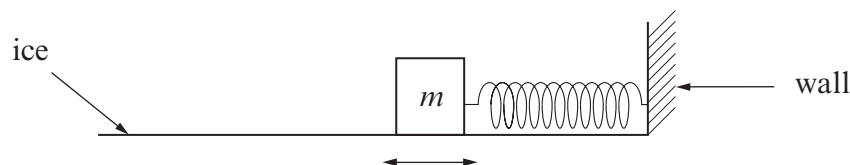
The number of marks is given in brackets at the end of each question or part question.

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.

1324
010001

1. (a) A mass, m , is attached to a spring and oscillates horizontally with simple harmonic motion on the floor of an ice rink. Its frequency of oscillation is 0.625 Hz and the spring constant of the spring is 2640 N m^{-1} .



- (i) Show that the mass, m , is approximately 170 kg . [3]

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- (ii) The maximum kinetic energy of the mass is 2.15 kJ . Calculate its maximum speed. [2]

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- (iii) State the maximum potential energy stored in the spring and explain your reasoning. [2]

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- (iv) Calculate the amplitude of oscillation. [2]

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- (v) At time $t = 0$, the displacement of the mass is zero. Calculate the **acceleration** of the mass at time $t = 1.40$ s. [3]

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- (b) Explain briefly, why pushing the mass every 1.60 s would result in large amplitude oscillations. [2]

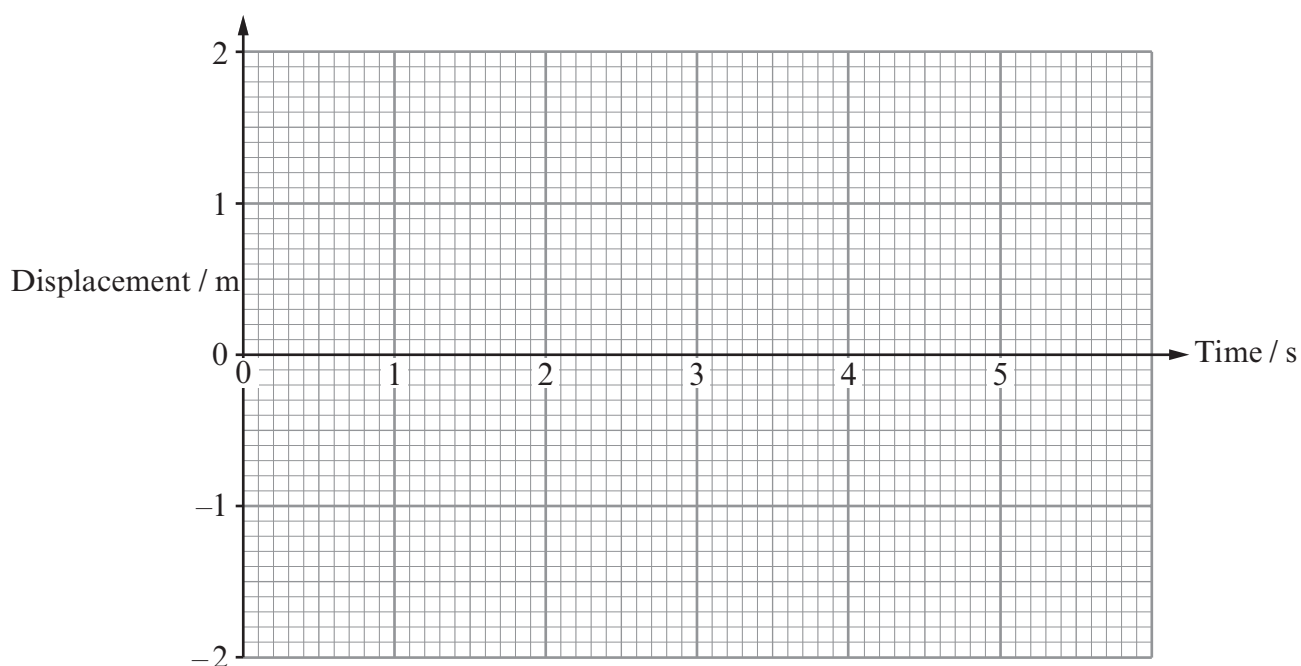
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- (c) Later, when the mass is released from its maximum displacement of 2.00 m an observer starts a stopwatch. After 5.0 s, the amplitude of oscillation has decreased to 1.40 m. Sketch a displacement-time graph of the damped oscillations on the grid below. [3]



2. (a) The following equation relates to ideal gases.

$$N \times \frac{1}{2} m \overline{c^2} = \frac{3}{2} nRT$$

In terms of **energy**, explain the meaning of:

$$\frac{1}{2} m \overline{c^2}$$

[1]

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$$\frac{3}{2} nRT$$

[1]

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- (b) (i) By applying the above equation to one mole of helium gas (or otherwise), calculate the rms speed of helium molecules at 20°C (the mass of a helium molecule is 6.64×10^{-27} kg). [3]

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- (ii) Use your answer to (b)(i) to calculate the pressure of helium gas at 20°C and density 0.19 kg m^{-3} . [2]

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3. (a) State the *Principle of Conservation of Momentum*.

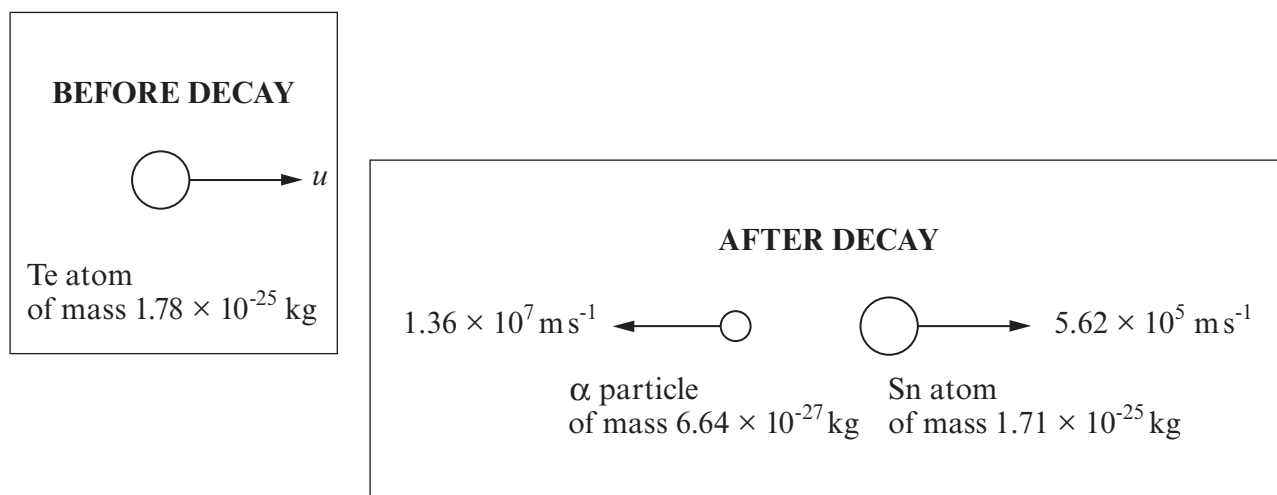
[2]

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- (b) A tellurium (Te) atom undergoes alpha (α) decay into tin (Sn) as shown below.



- (i) Calculate the initial speed, u , of the tellurium (Te) atom.

[3]

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- (ii) Show that the momentum, p , of a photon is related to its energy, E , by the equation

[2]

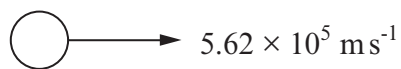
$$E = pc$$

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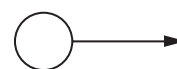
- (iii) Use the equation $E = pc$ to calculate the **percentage** change in the momentum of the tin (Sn) atom when it emits a gamma ray photon of energy 1.30 MeV as shown. [3]

BEFORE

Sn atom
of mass $1.71 \times 10^{-25} \text{ kg}$

AFTER

1.30 MeV photon



Sn atom

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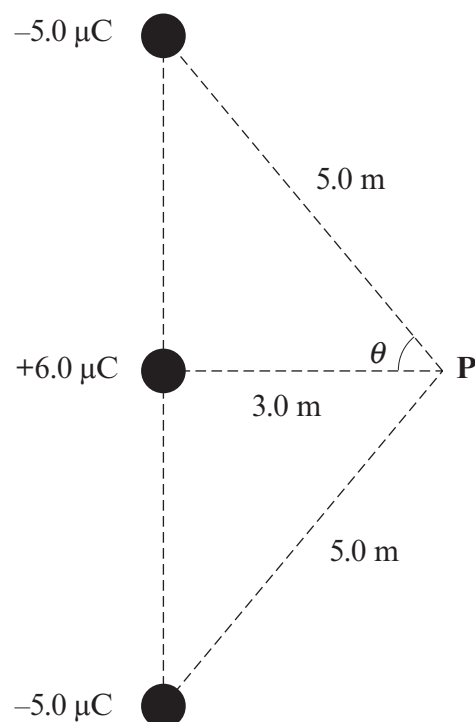
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4. Three charges are placed in a line as shown.

[use the approximation $\frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1} \text{ m}$]



- (a) Draw **three arrows** at **P** representing the electric fields due to **each** of the three charges. [2]
- (b) Calculate the electric field at **P** due to the $+6.0 \mu\text{C}$ charge only. [2]

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- (c) Calculate the resultant electric field at **P** (hint: $\cos \theta = 0.6$). [3]

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- (d) (i) Show that the total electric potential at **P** is zero.

[3]

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- (ii) A positive charge is released from rest at point **P** and encounters **no resistive forces**. Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges.

[3]

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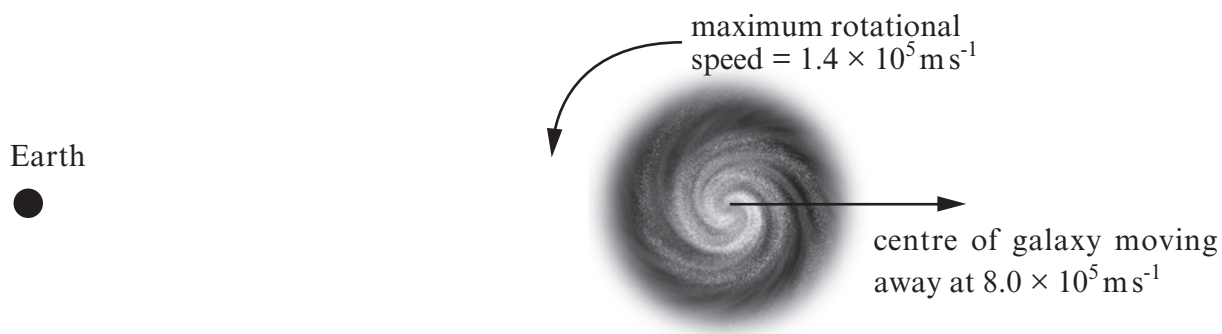
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5. A spiral galaxy is moving away from the Earth and rotating as shown.



- (a) Calculate the maximum and minimum red shift measured by an Earth observer when light of wavelength 656 nm is analysed from this spiral galaxy. [3]

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- (b) The mass of the spiral galaxy is estimated to be 8.0×10^{39} kg (based upon the amount of light that it emits). Use this figure to calculate the gravitational force exerted on a unit mass at a distance of 1.5×10^{20} m from the centre of the spiral galaxy. [2]

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- (c) (i) Show that, for an object in a circular orbit of radius, r , about a body of mass, M , the orbital speed v is given by $v = \sqrt{\frac{GM}{r}}$. [2]

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- (ii) For this galaxy, the maximum rotational speed is $1.4 \times 10^5 \text{ m s}^{-1}$ and this was measured at a radius of $1.5 \times 10^{20} \text{ m}$. Use the equation $v = \sqrt{\frac{GM}{r}}$ to investigate whether dark matter might exist in this spiral galaxy. [3]

Examiner
only

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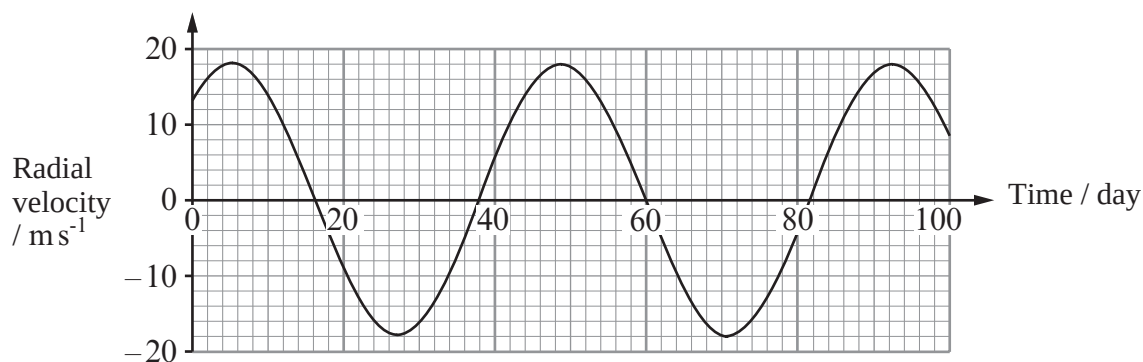
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6. The light spectrum from a star 41 light years from Earth was analysed. It was found that this light was Doppler shifted due to the star orbiting the mutual centre of mass of the star and a nearby planet. The following graph is derived from the data obtained.



- (a) From the graph, calculate the period of the orbit in **seconds**. [2]

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- (b) Show that the radius of orbit of the star about the centre of mass is approximately 1.1×10^7 m. [2]

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- (c) The mass of the star is 1.9×10^{30} kg. Calculate the distance between the star and the planet, ensuring that you state any approximation that you make. [3]

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- (d) Using the centre of mass equation, or otherwise, estimate the mass of the planet and compare its mass with that of the Earth ($M_E = 5.9 \times 10^{24} \text{ kg}$). [3]

Examiner
only

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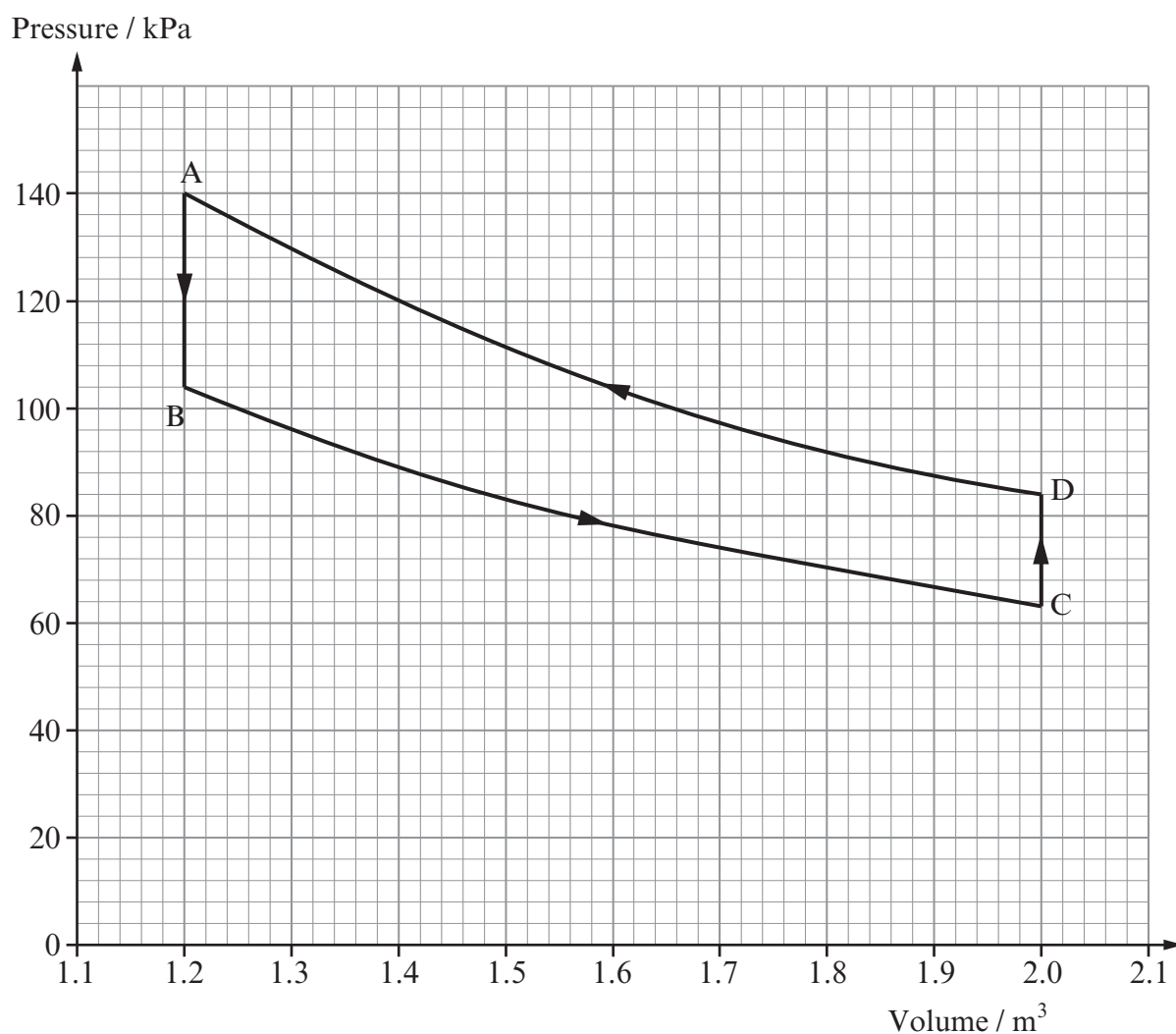
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7. An ideal monatomic gas undergoes the cycle ABCDA shown below.



BC and DA are isotherms (the temperature along each of BC and DA is constant) and there are **49.3 mol** of ideal gas.

- (a) By considering one point on BC and one on DA, show that the temperature of BC is approximately 300 K and that of DA is approximately 400 K. [2]

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- (b) (i) Calculate the internal energy of the gas for BC, [1]

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(ii) and DA.

[1]

(c) Explain why the work is zero for both AB and CD.

[1]

(d) Explain why the change in internal energy is zero for both BC and DA.

[1]

(e) (i) Show that the work done by the gas for DA is approximately -90 kJ .

[2]

(ii) Estimate the work done for BC.

[1]

(f) For **each** of the processes AB, BC, CD, DA and the whole cycle ABCDA, write the values of W (the work done by the gas), ΔU (the **change** in internal energy of the gas) and Q (the heat supplied to the gas). [4]

	Process				
	AB	BC	CD	DA	ABCDA
W	0		0	-90 kJ	
ΔU		0		0	
Q				-90 kJ	

THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.



GCE MARKING SCHEME

**PHYSICS
AS/Advanced**

JANUARY 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2013 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

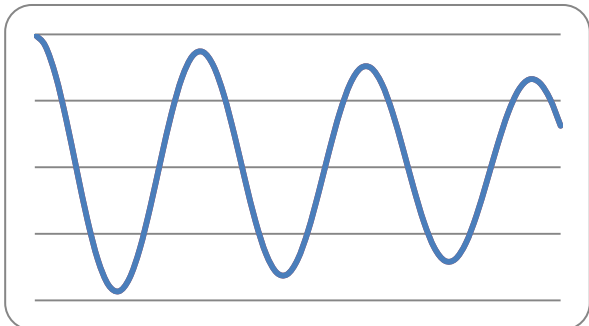
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Unit	Page
PH1	1
PH2	5
PH4	12

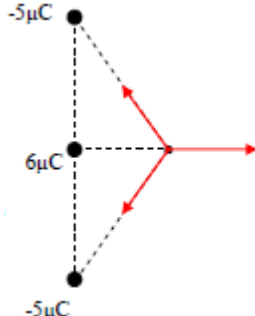
GCE Physics - PH4

January 2013 - Markscheme

Question			Marking details	Marks Available
1	(a)	(i)	$T = \frac{1}{f} = 1.6$ or $\omega^2 = \frac{k}{m}$ (1) algebra i.e. $m = \frac{T^2 k}{4\pi^2}$ or $\omega = 2\pi f$ (1) $m = \frac{1.6^2 \times 2640}{4\pi^2}$ (1) = [171 kg]	[3]
		(ii)	$\frac{1}{2}mv^2 = 2150$ (1) $v = 5.01 [\text{ms}^{-1}]$ (1) ecf on m	[2]
		(iii)	$2.15 [\text{kJ}]$ (1) conservation of energy stated or implied / all KE transferred to PE (1) (accept energy cannot be created or destroyed)	[2]
		(iv)	$v = \omega A$ (1) or suitable alternative $A = 1.28 [\text{m}]$ (1) ecf	[2]
		(v)	$x = \pm A \sin(2\pi ft)$ (1) For 1 st mark ω must be substituted. $a = -\omega^2 x$ used (1) $13.9 [\text{ms}^{-2}]$ (1) ecf	[3]
	(b)		Resonance / maximum amplitude (1) since natural frequency /	[2]
			$\frac{1}{0.625} = 1.6$ (1)	

Question			Marking details	Marks Available
	(c)		Basic shape (decreasing to 1.4 m with a cos or –cos shape) (1) period = 1.6 s (accept 1.5 – 1.7 s) (1) period constant (1)  Question 1 total	[3] [17]
2	(a)		$\frac{1}{2} m \overline{c^2}$ KE of a particle/atom/molecule (1) $\frac{3}{2} nRT$ internal energy (accept total KE) (1)	[1] [1]
	(b)	(i)	$N_A \times \frac{1}{2} m \overline{c^2} = \frac{3}{2} \times 1 \times RT$ (1) (or equivalent) e.g. $\frac{1}{2} m \overline{c^2} = \frac{3}{2} kT$ $\overline{c^2} = \frac{3RT}{mN_A}$ (1) (i.e. algebra) rms speed = 1350 [m s⁻¹] (1)	[3]
		(ii)	$p = \frac{1}{3} \rho \overline{c^2}$ (1) $p = 1.16 \times 10^5 \text{ Pa / Nm}^{-2}$ (1) ecf UNIT mark Or suitable alternative method Question 2 total	[2] [7]

Question			Marking details	Marks Available
3	(a)		The [vector] sum of the momenta [of bodies in a system] stays constant [even if forces act between the bodies], (1) provided there is no external [resultant] force. (1)	[2]
	(b)	(i)	$1.78 \times 10^{-25} \times u = 5.62 \times 10^5 \times 1.71 \times 10^{-25} \pm 1.36 \times 10^7 \times 6.64 \times 10^{-27}$ (1) i.e. attempt at conservation of momentum $u = \{5.62 \times 10^5 \times 1.71 \times 10^{-25} - 1.36 \times 10^7 \times 6.64 \times 10^{-27}\} / 1.78 \times 10^{-25}$ i.e. correct algebra and sign (1) $u = 32\,600 \text{ m s}^{-1}$ (1)	[3]
		(ii)	$E = \frac{hc}{\lambda}$ {or $E = hf$ and $c = f\lambda$ } (1) Algebra and $p = \frac{h}{\lambda}$ (1) (Use of both $E = mc^2$ and $p = mc$ award 1 mark only.)	[2]
		(iii)	$p = \frac{E}{c}$ attempted (1) $5.62 \times 10^5 \times 1.71 \times 10^{-25}$ used as a denominator (1) $\frac{6.93 \times 10^{-22}}{5.62 \times 10^5 \times 1.71 \times 10^{-25}} \times 100 = 0.72\%$ (1) (accept: $4.5 \times 10^{18}\%$)	[3]
			Question 3 Total	[10]

Question		Marking details	Marks Available
4	(a)	horizontal arrow to right at P (1) both other arrows correct direction (1) 	[2]
	(b)	$E = \frac{Q}{4\pi\epsilon_0 r^2} \text{ used (1) e.g. } \frac{6 \times 9 \times 10^9}{3^2}$ $E = 6000 \text{ N C}^{-1} \text{ (1) UNIT mark}$	[2]
	(c)	$E = \frac{Q}{4\pi\epsilon_0 r^2} \text{ used for negative charge (1) (answer = 1800)}$ e.g. $\frac{5 \times 9 \times 10^9}{5^2}$ but not $\frac{5 \times 9 \times 10^9}{3^2}$ x 2 and x cosθ (1) [= 2160] resultant = 3840 [N C⁻¹] [to the right] (1) ecf on arrows	[3]
	(d) (i)	correct equation used (1) e.g. $\frac{5 \times 9 \times 10^9}{5}$ Attempt at adding 3 potentials (1) e.g. $\frac{(6-5-5) \times 9 \times 10^9}{5}$ $\frac{1}{4\pi\epsilon_0} \left\{ \frac{6}{3} - \frac{5}{5} - \frac{5}{5} \right\}$ (1) or equivalent obviously giving zero	[3]
	(ii)	(Energy) - final total energy must be zero or final potential is also zero (1) (any implied dissipation of energy loses this mark) Initially (resultant) <u>force / field</u> is to the right (1) Then (resultant) force / field is to the left or deceleration (1)	[3]
		Question 4 Total	[13]

Question			Marking details	Marks Available
5	(a)		$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \text{ used (1)}$ $\Delta\lambda = \frac{9.4 \times 10^5}{3 \times 10^8} \times 656 = 2.06 \text{ [nm] (1)}$ $\Delta\lambda = \frac{6.6 \times 10^5}{3 \times 10^8} \times 656 = 1.44 \text{ [nm] (1)}$	[3]
	(b)		$F = \frac{GMm}{r^2} \text{ used or } g = \frac{GM}{r^2} \text{ (1)}$ $F = 2.37 \times 10^{-11} \text{ [N] (1)}$	[2]
	(c)	(i)	$\frac{mv^2}{r} = \frac{GMm}{r^2} \text{ (1)}$ convincing algebra (1)	[2]
		(ii)	$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.67 \times 10^{-11} \times 10^{39}}{1.5 \times 10^{20}}}$ <u>or</u> calculating M using v (1st mark algebra) (1) $v = 60\,000 \text{ [ms}^{-1}\text{]} \text{ or } M = 4.4 \times 10^{40} \text{ or } G = 3.675 \times 10^{-10} \text{ (1)}$ Comment: (1) allow ecf If v - suggests dark matter since actual v is greater If M – yes If G – yes because larger G or stronger gravity	[3]
Question 5 Total				[10]

Question			Marking details	Marks Available
6	(a)		period = 44 [days] $\pm$ 2 days (1) correct conversion to seconds (allow ecf) (1) (= 3.83x10⁶ s)	[2]
	(b)		$v = \frac{2\pi r}{T}$ or equivalent e.g. $v = \omega r$ and $\omega = \frac{2\pi}{T}$ (1) $r = \frac{vT}{2\pi} = \frac{18xa}{2\pi}$ (1) (=1.097 x 10⁷) ecf on T	[2]
	(c)		$d^3 = \frac{T^2 G(M_1 + M_2)}{4\pi^2}$ i.e. algebra nearly complete (1) $(M_1 + M_2) \approx M_1$ either written or worded (1) $d = 3.6 \times 10^{10}$ [m] (1) ecf	[3]
	(d)		Values substituted correctly into a correct equation (1) $M_2 = 5.9 \times 10^{26}$ [kg] (1) ecf on d and r i.e. 100 times / [much] larger than the Earth (1) (allow ecf on M) Question 6 Total	[3]
				[10]

Question			Marking details	Marks Available																													
7	(a)		$T = \frac{pV}{nR}$ or implied (1) $T = \frac{84000 \times 2}{49.3 \times 8.31} = 410 \text{ [K]}$ and $T = \frac{104000 \times 1.2}{49.3 \times 8.31} = 305 \text{ [K]}$ (1)	[2]																													
	(b)	(i)	$U = 190 \text{ [kJ]}$ allow ecf	[1]																													
		(ii)	$U = 250 \text{ [kJ]}$ allow ecf	[1]																													
	(c)		no area under graph or no change in volume	[1]																													
	(d)		temp constant / internal energy only depends on temperature / because they are isotherms	[1]																													
	(e)	(i)	A clear valid method (remember show that...) e.g. trapezium (1) (counting squares ok) $DA = \frac{1}{2} (140\,000 + 84\,000) \times 0.8 = 89.6 \text{ [kJ]}$ (1) or better $\frac{1}{2} (140\,000 + 105\,000) \times 0.4$ (no penalty for mysterious -ve sign or +ve sign) $+ \frac{1}{2} (105\,000 + 84\,000) \times 0.4 = \pm 86.8 \text{ [kJ]}$	[2]																													
		(ii)	$BC = \frac{1}{2} (104\,000 + 64\,000) \times 0.8 = 67.2 \text{ [kJ]}$ (1) or better $\frac{1}{2} (104\,000 + 78\,000) \times 0.4$ (sign penalised here!) $\frac{1}{2} (78\,000 + 64\,000) \times 0.4 = 64.8 \text{ [kJ]}$	[1]																													
(f)		Allow ecf <table><tr><td></td><td>AB</td><td>BC</td><td>CD</td><td>DA</td><td>ABCD A</td></tr><tr><td>W</td><td>0</td><td>67[kJ]</td><td>0</td><td>-90 kJ</td><td>-23[kJ]</td></tr><tr><td>ΔU</td><td>-60 [kJ]</td><td>0</td><td>60 [kJ]</td><td>0</td><td>0</td></tr><tr><td>Q</td><td>-60 [kJ]</td><td>67[kJ]</td><td>60 [kJ]</td><td>-90 kJ</td><td>-23[kJ]</td></tr><tr><td></td><td>(1)</td><td>(1)</td><td>(1)</td><td></td><td>(1)</td></tr></table> Question 7 Total		AB	BC	CD	DA	ABCD A	W	0	67[kJ]	0	-90 kJ	-23[kJ]	ΔU	-60 [kJ]	0	60 [kJ]	0	0	Q	-60 [kJ]	67[kJ]	60 [kJ]	-90 kJ	-23[kJ]		(1)	(1)	(1)		(1)	[4] <
	AB	BC	CD	DA	ABCD A																												
W	0	67[kJ]	0	-90 kJ	-23[kJ]																												
ΔU	-60 [kJ]	0	60 [kJ]	0	0																												
Q	-60 [kJ]	67[kJ]	60 [kJ]	-90 kJ	-23[kJ]																												
	(1)	(1)	(1)		(1)																												



1324
010001

Surname	Centre Number	Candidate Number
Other Names		



GCE A level

1324/01

PHYSICS

ASSESSMENT UNIT PH4: OSCILLATIONS AND FIELDS

P.M. MONDAY, 11 June 2012

1½ hours

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.

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

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.

1. (a) The first law of thermodynamics may be written $\Delta U = Q - W$.

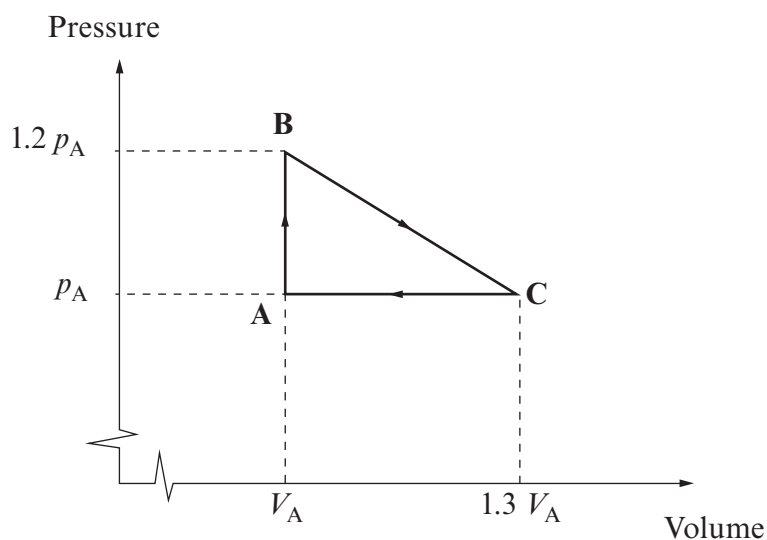
Explain carefully the terms

(i) ΔU [1]

(ii) Q [1]

(iii) W [1]

- (b) A sealed container with a leak-proof piston at one end contains 0.40 mole of an ideal gas. The gas is taken around a cycle (**ABCA**). The pressure and volume of the gas are shown on the graph where $p_A = 1.01 \times 10^5$ Pa and $V_A = 1.00 \times 10^{-2} \text{ m}^3$.



Calculate the temperature at point C. [2]

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- (c) Determine the work done (if any) along the following paths, indicating clearly if it is done **on** or **by** the gas. [4]

(i) CA

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(ii) AB

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(iii) BC

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- (d) Determine the total heat transferred if the gas is taken around the cycle **three** times, stating clearly whether it flows in or out of the gas. [3]

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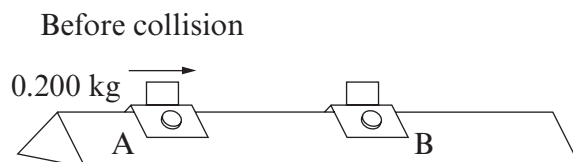
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2. (a) In a laboratory experiment two gliders A and B lie on a linear air track (friction-free). Glider A, of mass 0.200 kg, is accelerated from rest by a force of 3.00 N acting for 0.150 s.



- (i) Show that the velocity of glider A after acceleration is 2.25 m s^{-1} to the right. [1]

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- (ii) Glider A then collides with a stationary glider B. They stick together and move with a velocity of 1.20 m s^{-1} to the right. Show that the mass of glider B is 0.175 kg. [2]

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- (iii) A second demonstration is used to show an elastic collision. The initial conditions for the acceleration of glider A are exactly the same as in part (i). If the velocities of gliders A and B after the collision are 0.15 m s^{-1} and 2.40 m s^{-1} respectively to the right, show that the collision is elastic. [3]

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- (b) A scientist investigates the possibility of using a **totally reflecting** solar sail to power a small spacecraft. Sunlight of typical wavelength 500 nm and intensity 1500 W m^{-2} falls on a sail of area 100 m^2 .

(i) Calculate the energy of a photon of wavelength 500 nm. [2]

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(ii) Determine the number of photons arriving at the sail each second. [1]

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(iii) Calculate the force exerted by the sunlight on this totally reflecting sail. [3]

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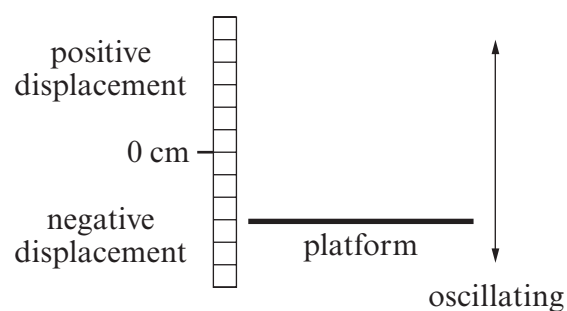
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3. A horizontal platform oscillates vertically with simple harmonic motion around a central position with a period 0.40 s and amplitude 5.0 cm.



- (a) Define simple harmonic motion.

[2]

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- (b) Determine

- (i) the maximum velocity of the platform;

[2]

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- (ii) the maximum acceleration of the platform.

[2]

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- (c) The platform is at its lowest position at time $t = 0$.
The displacement x of the platform at later times is given by the equation:

$$x = A \sin(\omega t + \varepsilon)$$

Rewrite the equation giving correct numerical values for A , ω and ε .

[3]

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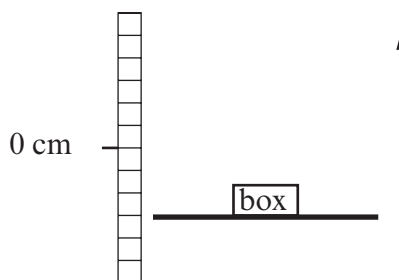
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(d)



A small box is carefully placed on the platform when it is at its lowest position. Before the platform reaches its highest position, the box loses contact. Find the displacement at which contact is lost.

[2]

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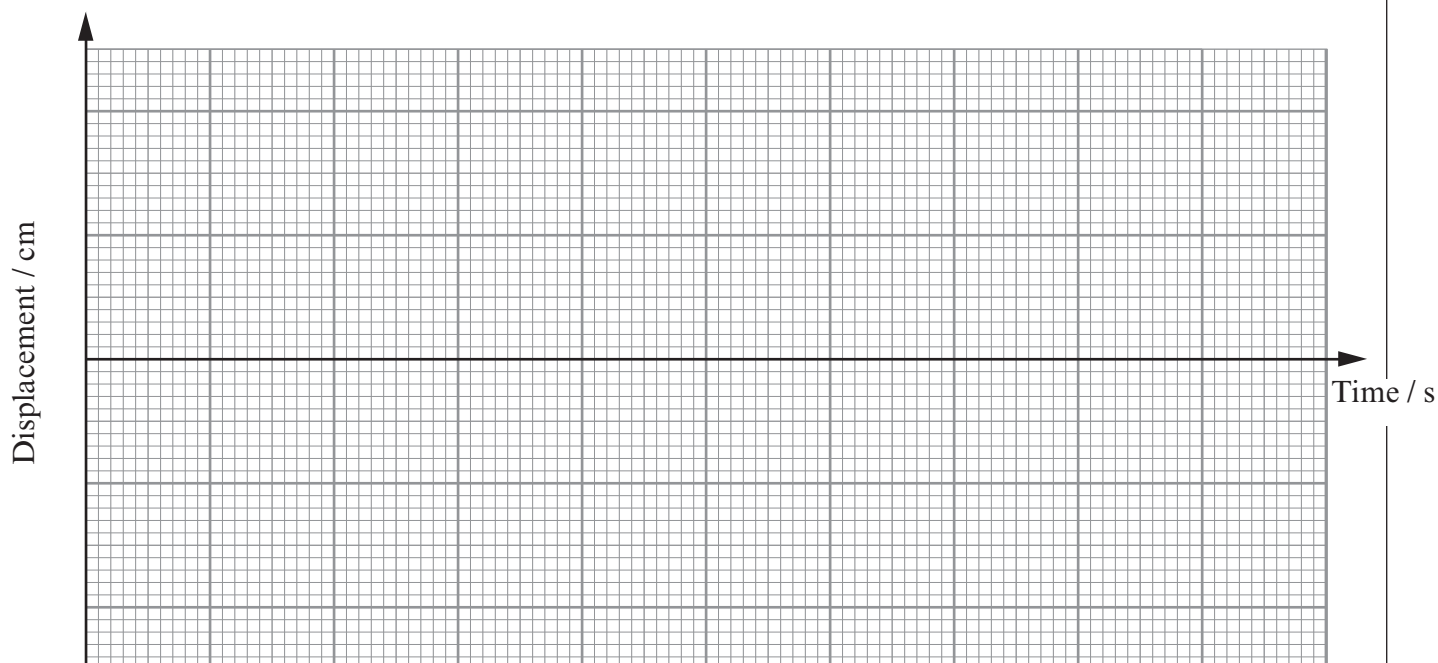
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4. (a) In a laboratory experiment, a load of mass m is supported in equilibrium at the lower end of a spring. The load is raised 2.0 cm from its equilibrium position, and is then released from rest so that it oscillates vertically with a period of 0.50 s. The amplitude then decreases to 1.0 cm after 5 oscillations.

(i) Sketch a displacement–time graph for these 5 oscillations. [3]



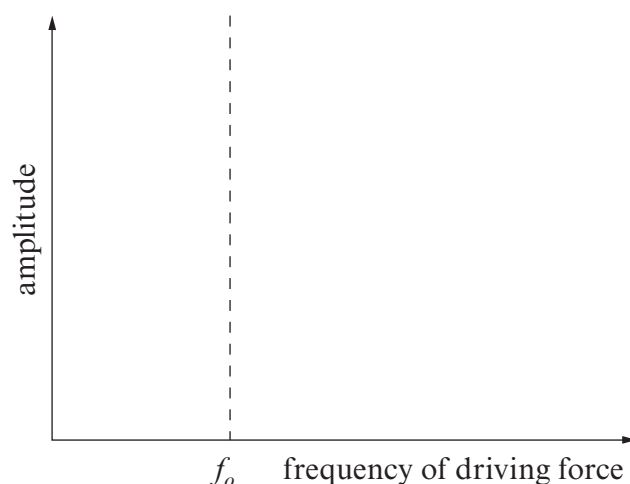
(ii) Suggest a cause for the observed damping. [1]

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(b) A driving force of frequency f is now applied to the top end of the spring. The frequency of the driver can be varied from zero to a frequency well beyond the natural frequency f_o of the spring system.

- (i) Sketch the variation of the amplitude of the motion of the load with the frequency of the driving force on the axes below. Label the curve as A. [1]



- (ii) If the damping on the system is increased slightly, sketch the variation of the amplitude with frequency on the same axes. Label this curve as B. [1]
- (iii) Explain what is meant by *resonance*. [1]

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- (iv) Give a practical example of resonance. Identify the driving force of the system and the responding oscillator. [3]

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5. A canister of volume 0.025 m^3 contains helium gas at a pressure of $3.04 \times 10^5 \text{ Pa}$ and a temperature of 280 K . (Relative molecular mass of helium = 4.0)

(a) Calculate:

- (i) the number of moles of the gas in the canister; [1]

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- (ii) the number of helium molecules in the canister; [1]

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- (iii) the density of the gas; [2]

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- (iv) the rms speed of the helium molecules. [2]

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- (b) The product of the pressure and volume of an ideal gas may be expressed as

$$pV = nRT.$$

The product may also be written in terms of the mean square speed of the molecules as

$$pV = \frac{1}{3}Nm\overline{c^2}.$$

- (i) Derive in clear steps a formula that shows how the internal energy of the ideal gas depends on the temperature of the gas. [4]

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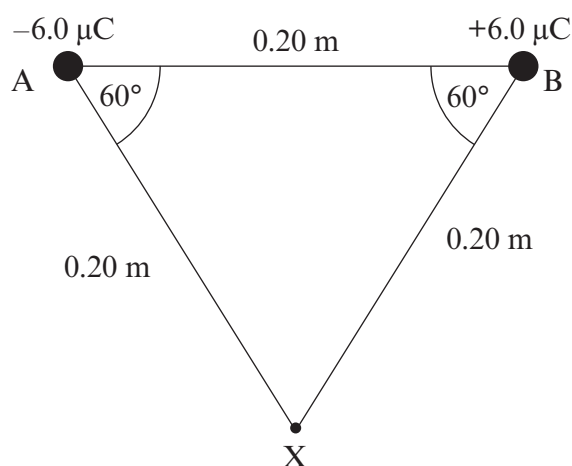
- (ii) Calculate the internal energy of the helium gas in the canister. [1]

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6. Two point charges of $-6.0\ \mu\text{C}$ and $+6.0\ \mu\text{C}$ are arranged at points A and B respectively as in the diagram. Point X lies as shown, with ABX being an equilateral triangle.



- (a) Indicate clearly on the diagram the directions of
- (i) the electric field at X due to the charge at A (label it E_A), [1]
 - (ii) the electric field at X due to the charge at B (label it E_B), [1]
 - (iii) the resultant (net) electric field at X due to the charges at A and B (label it E_R). [1]
- (b) Calculate the magnitude of the resultant electric field at X, showing your working clearly. [3]

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- (c) Point Y is at a distance 0.40 m to the right of B.



- (i) Determine the electric potential at Y.

[3]

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- (ii) Calculate the work required to bring a small charge of $+2.0 \mu\text{C}$ from a distant point to Y.

[2]

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- (iii) The small charge has a mass of $5.0 \times 10^{-3} \text{ kg}$. If it is released from rest at point Y, determine its speed when it returns to a distant point.

[2]

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7.

	Mean radius of planetary orbit / m	Orbital period / year
Earth	149.6×10^9	1.00
Jupiter	778.6×10^9	11.86

(a) State Kepler's three laws of planetary motion.

[3]

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(b) Show that the data above are consistent with Kepler's third law.

[3]

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(c) Explain what is meant by centripetal acceleration.

[1]

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(d) Calculate the mass of the Sun.

[4]

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**THERE ARE NO MORE QUESTIONS
IN THE EXAMINATION**



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2012

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2012 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

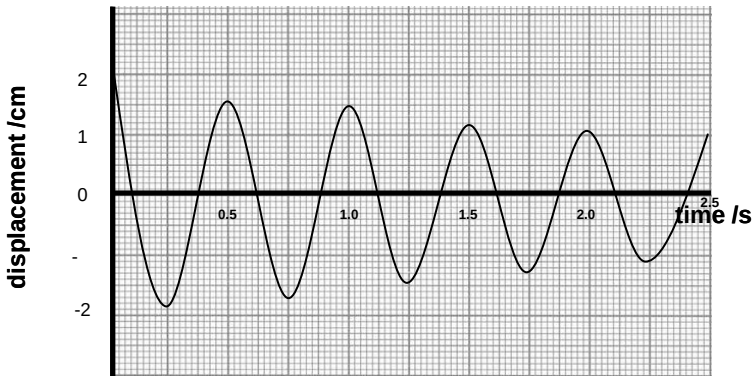
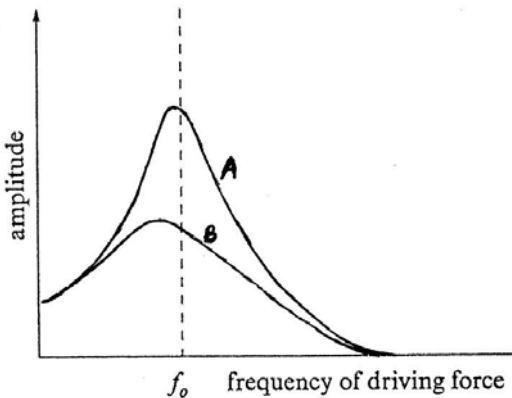
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

PH4

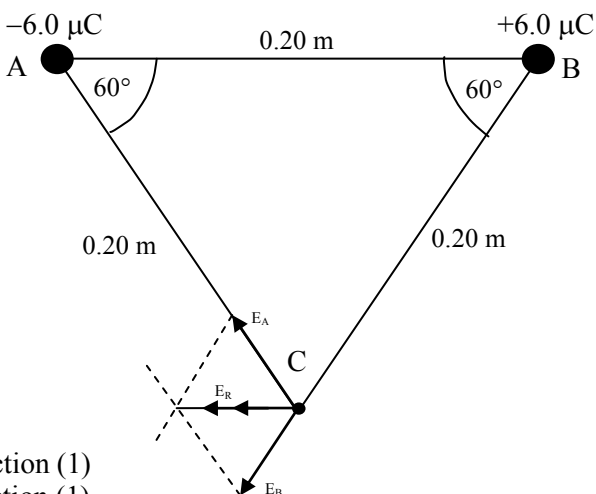
Question			Marking details	Marks Available
1	(a)	(i)	Increase (change) in the internal energy [of the system]	1
		(ii)	Heat supplied to (flowing into) [the system]	1
		(iii)	Work done by the system	1
	(b)		$PV = nRT$	
			$T = \frac{PV}{nR} \text{ (1)} = \frac{(1.01 \times 10^5) (1.3 \times 1.00 \times 10^{-2})}{(0.4) (8.31)} = 395 \text{ K (1) unit mark}$	2
	(c)	(i)	$(1.01 \times 10^5) (0.3 \times 1.00 \times 10^{-2}) = 303 \text{ [J] on gas (1)}$	
		(ii)	0 / No work (1)	
		(iii)	$\frac{1}{2} (0.3 \times 1.00 \times 10^{-2}) (0.2 \times 1.01 \times 10^5) + (0.3 \times 1.00 \times 10^{-2}) (1.01 \times 10^5)$ $= 30 + 303$ $= 333 \text{ [J] (1) by gas ecf from (c)(i) (1)}$	4
	(d)		Convincing evidence of multiplication by 3 for the 3 cycles (1)	
			$\Delta U = 0 \text{ (1)}$	
			$Q = \Delta U + W = 0 + 90 = 90 \text{ [J] into gas (1) ecf from (c)(iii)}$	3
	Question 1 total			[12]

Question			Marking details	Marks Available
2	(a)	(i)	$Ft = \Delta(mv) \quad \therefore 3(0.15) = 0.200 v \quad v = 2.25 \text{ [m s}^{-1}\text{]}$ Or equivalent but clear method must be shown	1
		(ii)	$(0.200)(2.25) = (0.200 + m_B)(1.20)$ (attempting to use conservation of momentum) (1) $m_B = \frac{(0.200)(2.25) - (0.200)(1.20)}{1.20} \quad (1) = 0.175 \text{ [kg]}$	2
		(iii)	KE before collision = $\frac{1}{2}(0.200)(2.25)^2 = 0.506 \text{ [J]} \quad (1)$ KE after collision = $\frac{1}{2}(0.200)(0.15)^2 + \frac{1}{2}(0.175)(2.40)^2 = 0.506 \text{ [J]} \quad (1)$ KE before collision = KE after collision [so collision is elastic] (1)	3
	(b)	(i)	$E = hf = \frac{hc}{\lambda} \quad (1) = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{500 \times 10^{-9}} = 3.98 \times 10^{-19} \text{ [J]} \quad (1)$	2
		(ii)	$N^\circ \text{ arriving each second} = \frac{(1500)(100)}{(3.98 \times 10^{-19})} = 3.77 \times 10^{23}$ allow ecf for E from (i)	1
		(iii)	Momentum of 1 photon $= \frac{h}{\lambda} = \frac{(6.63 \times 10^{-34})}{(500 \times 10^{-9})} \quad (1) = 1.33 \times 10^{-27} \text{ [kg m s}^{-1}\text{]}$ Change of momentum of 1 photon $2(1) \times 1.33 \times 10^{-27} = 2.65 \times 10^{-27} \text{ [kg m s}^{-1}\text{]}$ Total change of momentum of photon in 1 s $= (2.65 \times 10^{-27})(3.77 \times 10^{23}) = 9.99 \times 10^{-4} \text{ [kg m s}^{-1}\text{]} \quad (1)$ Allow ecfs from (b)(i) and (ii) Force = Change of momentum per second = $9.99 \times 10^{-4} = 1.0 \times 10^{-3} \text{ [N]}$ (force on sail is equal and opposite to force on photons)	3
		Question 2 total		[12]

Question			Marking details	Marks Available
3	(a)		Acceleration $\propto$ displacement from central (fixed) point (1) is directed towards the central (fixed) point (1)	2
	(b)	(i)	$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.40} = 15.7 \text{ [rad s}^{-1}\text{]} (1)$	2
			$v_{\max} = \omega A = (15.7)(0.05) = 0.79 \text{ [m s}^{-1}\text{]} (1)$	2
		(ii)	$a_{\max} = \omega^2 A (1) = (15.7)^2 (0.05) = 12.3 \text{ [m s}^{-2}\text{]} (1)$	
	(c)		$x = 0.05 \sin \left(15.7t - \frac{\pi}{2} \right) \text{ [m]}$ 0.05 (1) 15.7 (1) $-\frac{\pi}{2}$ (1) or accept -90°	3
	(d)		Loses contact when $a = -g (1)$ $-\omega^2 x = -g$ $x = \frac{9.81}{(15.7)^2} = 0.04 \text{ [m]} (1)$ Question 3 total	2 [11]

Question			Marking details	Marks Available
4	(a)	(i)	 Scales on both axes (1) Period and shape (1) Amplitude (1)	3
		(ii)	e.g. air resistance magnetic damping friction by itself is not enough - needs either reference or implication to air resistance	1
	(b)	(i)		1
		(ii)	Smaller values than A with peak not to the right and correct shape	1
		(iii)	At a <u>certain</u> driving <u>frequency</u> there is a <u>maximum</u> (peak) in the <u>amplitude</u> of the oscillating load. At this frequency the system is at resonance.	1
		(iv)	e.g. microwave cooking (1) driving force : by microwave radiation (1) responding oscillator : water molecules (1)	3
		Question 4 Total		[10]

Question			Marking details	Marks Available
5	(a)	(i)	$PV = nRT$ $n = \frac{PV}{RT} = \frac{(3.04 \times 10^5)(0.025)}{(8.31)(280)} = 3.27[\text{mol}]$	1
		(ii)	$N = n N_A = (3.27)(6.02 \times 10^{23}) = 1.97 \times 10^{24}$ allow ecf from (i)	1
		(iii)	$\rho = \frac{(m_r \times 10^{-3})n}{V} = \frac{(4 \times 10^{-3})(3.27)}{0.025} = 0.52[\text{kg m}^{-3}] \quad (1)$ formula with m_r (1)	2
		(iv)	$P = \frac{1}{3} \rho \overline{c^2}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3(3.04 \times 10^5)}{0.52}} = 1324[\text{ms}^{-1}] \quad (1) \text{ allow ecf from (iii)}$ Rearrange equation (1)	2
		(b)		
	(b)	(i)	(Combining of the two given equations to give) $\frac{1}{3} N \overline{mc^2} = nRT \quad (1)$ KE of gas (i.e. of the N molecules) = $\frac{1}{2} N \overline{mc^2}$ [= number of atoms x $\frac{1}{2} \overline{mc^2}$] (1) (can award for K.E. of one molecule i.e. K.E. = $\frac{1}{2} \overline{mc^2}$ only if it is clearly noted that it is for one molecule) $\therefore$ KE of gas [$\frac{1}{2} N \overline{mc^2}$] = $\frac{3}{2} nRT$ manipulation mark (1) Internal energy of gas (U) = KE + PE and PE = 0 (for ideal gas) (1) [or internal energy is only the KE] (so $U = \frac{3}{2} nRT$)	4
		(ii)	$U = \frac{3}{2} nRT = \frac{3}{2} (3.27)(8.31)(280) = 11\,413 \text{ [J]}$	1
			Question 5 Total	[11]

Question			Marking details	Marks Available
6	(a)	(i)	 E_A – direction (1) E_B – direction (1) E_R – “horizontal” and to the left (1) ecf from (i) & (ii)	1 1 1
		(ii)		
		(iii)		
	(b)		$E = 2 \frac{1}{4\pi\epsilon_0} \frac{6 \times 10^{-6}}{(0.2)^2} \cos 60^\circ$ $E = 2 \frac{1}{4\pi 8.85 \times 10^{-12}} \frac{6 \times 10^{-6}}{(0.2)^2} \cdot \frac{1}{2} = 1.35 \times 10^6 \text{ N C}^{-1}$ Substitution of Q and r (1) factor of 2 (1) answer with unit (1) Allow ecf from (a)	3
	(c)	(i)	$V = -\frac{1}{4\pi\epsilon_0} \frac{6 \times 10^{-6}}{(0.6)} (1) + \frac{1}{4\pi\epsilon_0} \frac{6 \times 10^{-6}}{(0.4)} (1) = -8.99 \times 10^4 + 13.49 \times 10^4$ $= 4.5 \times 10^4 \text{ [V]} (1)$	3
	(ii)	$W = q \Delta V = (2 \times 10^{-6}) (4.5 \times 10^4) = 0.09 \text{ [J]} (1) \text{ ecf from (c)(i)}$ formula and substitution (1)	2	
	(iii)	$\frac{1}{2} m v^2 = 0.09 (1) \quad (\text{PE} \rightarrow \text{KE}) \quad \text{allow ecf from (c)(ii)}$ $v = \sqrt{\frac{2 (0.09)}{5 \times 10^{-3}}} = 6 \text{ [m s}^{-1}\text{]} (1)$	2	
Question 6 Total				[13]

Question		Marking details	Marks Available
7	(a)	1. Planets move in elliptical orbits with the Sun at one focus (1) 2. Line joining a planet to the Sun sweeps out equal areas in equal time[intervals]. (1) 3. $r^3 \propto T^2$ r - semi major axis (or accept radius), T - period of orbit (1)	3
	(b)	Consider $\frac{r^3}{T^2}$, For Earth $\frac{(149.6 \times 10^9)^3}{(1.00 \times 365.25 \times 24 \times 60 \times 60)^2} = 3.36 \times 10^{18} \text{ [m}^3 \text{ s}^{-2}]$ (1) For Jupiter $\frac{(778.6 \times 10^9)^3}{(11.86 \times 365.25 \times 24 \times 60 \times 60)^2} = 3.37 \times 10^{18} \text{ [m}^3 \text{ s}^{-2}]$ (1) Both essentially equal so data consistent with Kepler's third law. (1) (accept answers in other units e.g. $\text{m}^3 \text{ yr}^{-2}$)	3
	(c)	A body moving in a <u>circular motion</u> experiences an <u>acceleration towards the centre</u> of the circle. This is known as centripetal acceleration.	1
	(d)	$\frac{GM_s m}{r^2} = \frac{mv^2}{r}$ (1) m : mass of planet or equivalent method $v^2 = \frac{GM_s}{r}$ also $v = \frac{2\pi r}{T}$ (1) Combine $\left(\frac{2\pi r}{T}\right)^2 = \frac{GM_s}{r}$ (1) $\frac{4\pi^2 r^2}{T^2} = \frac{GM_s}{r}$ $M_s = \frac{4\pi^2}{G} \frac{r^3}{T^2} = \frac{4\pi^2}{(6.67 \times 10^{-11})} (3.36 \times 10^{18}) = 2 \times 10^{30} \text{ [kg]}$ (1)	4
		Question 7 Total	[11]



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	

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

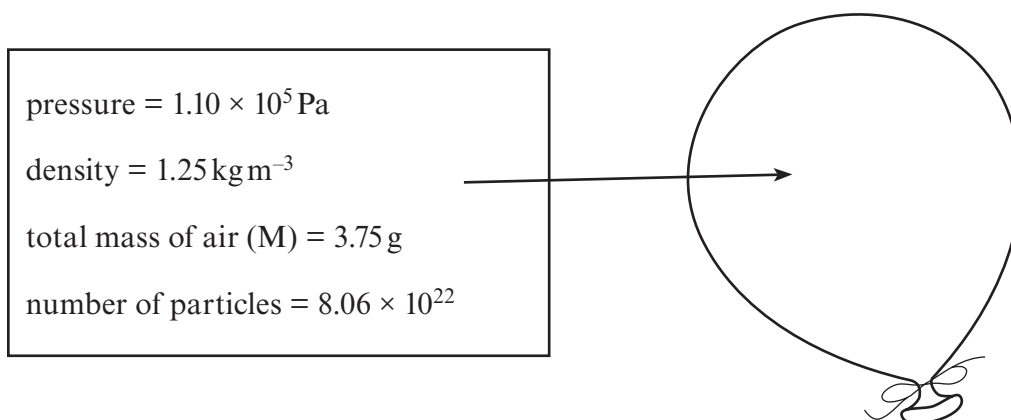
- Use black ink or black ball-point pen.
- Write your name, centre number and candidate number in the spaces at the top of this page.
- Answer **all** questions.
- Write your answers in the spaces provided in this booklet.

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 toy balloon contains gas for which data are given.



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

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

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

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

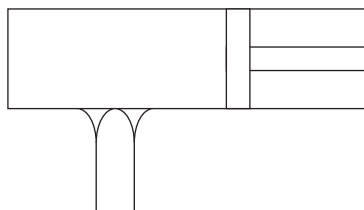
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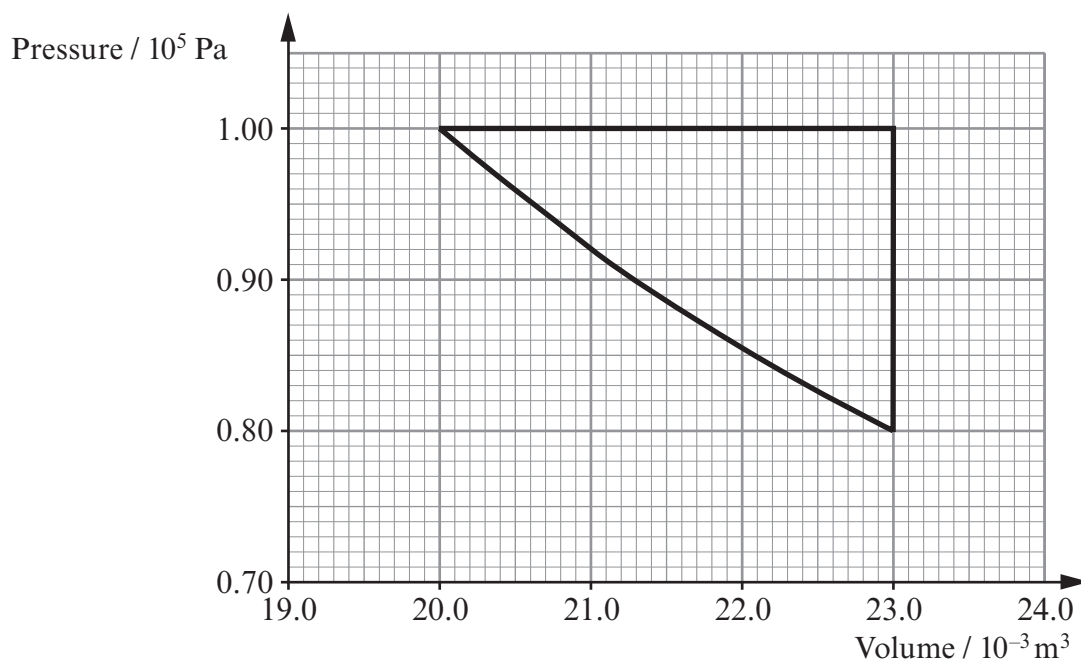
2. (a) (i) Gas inside a cylinder is heated using a Bunsen burner.



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 $20.0 \times 10^{-3} \text{ m}^3$, its temperature is 323 K.

- (i) Calculate the total number of moles of gas.

[2]

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- (ii) Calculate the total number of molecules of gas.

[1]

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- (iii) Calculate the temperatures of the gas at **B** and **C**.

[2]

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- (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 $4200 \text{ J kg}^{-1} \text{ K}^{-1}$.

[2]

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

[3]

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

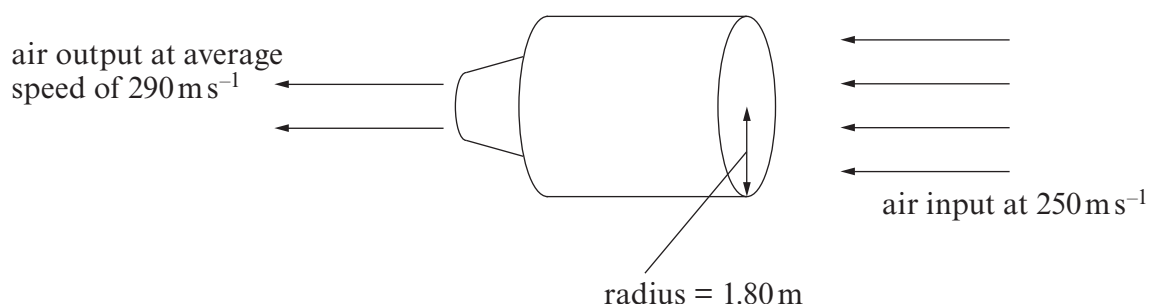
[2]

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3. A Rolls Royce jet engine operates by collecting air into the jet engine at a speed of 250 m s^{-1} and ejecting it with an average speed of 290 m 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 kg m^{-3} . Show that the mass of air entering the jet engine per second is approximately 1 000 kg. [3]

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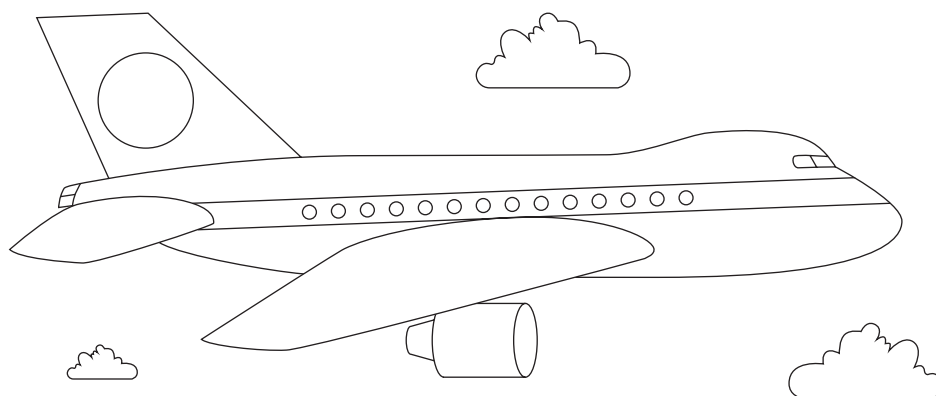
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- (b) Calculate the forward thrust produced by this jet engine. [2]

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- (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 m s^{-1} . [2]

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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:

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

- (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.

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- (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]

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- (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]

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5. The diagram shows an isolated positive charge ($+57\mu\text{C}$).

$+57\mu\text{C}$



- (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 $+57\mu\text{C}$ charge. [2]

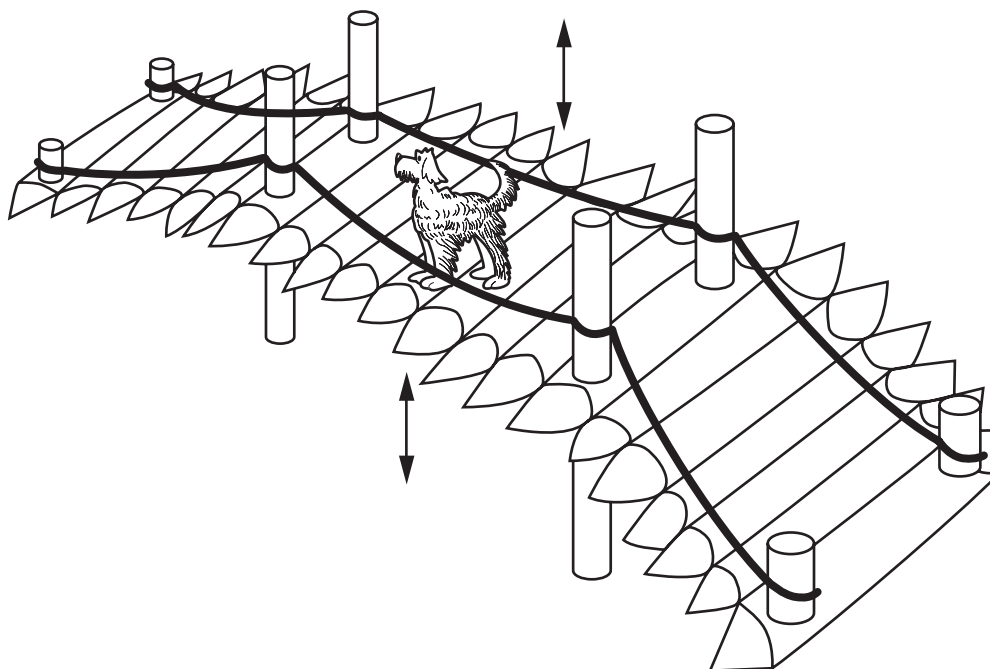
- (d) (i) Calculate the potential 15.8 cm from the centre of the $+57\mu\text{C}$ charge. [2]

- (ii) State the potential a large (infinite) distance away from the $+57\mu\text{C}$ charge. [1]

- (e) A $2.45\mu\text{C}$ point charge is placed 15.8 cm away from the $+57\mu\text{C}$ 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 $+57\mu\text{C}$ charge. [3]

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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]

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

[2]

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- (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]

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- (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]

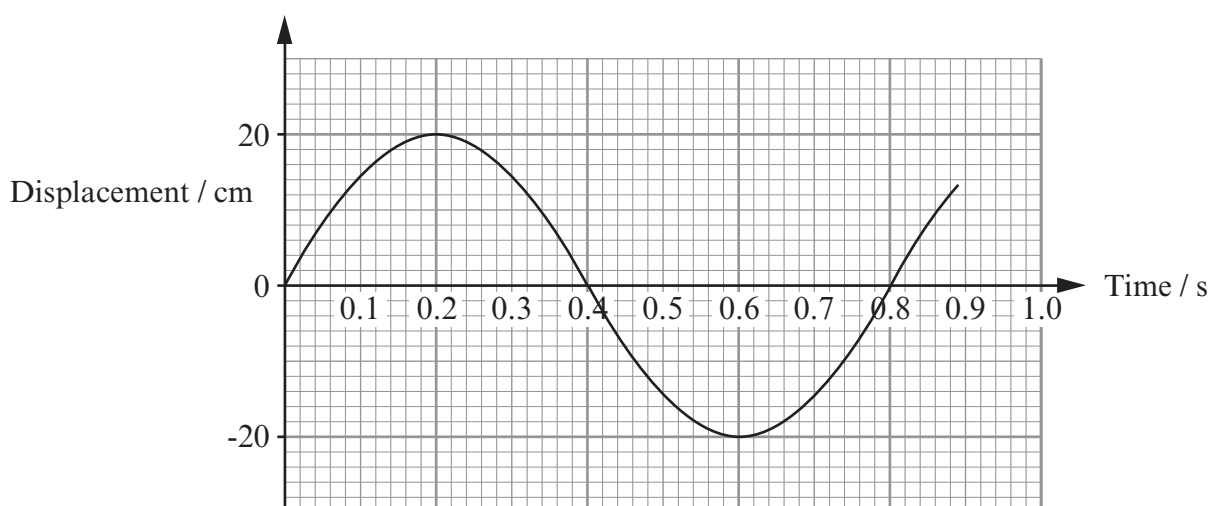
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- (e) The amplitude of oscillation is increased and is now so great that the dog temporarily loses contact with the bridge. The displacement of the bridge where the dog is standing varies as shown.



- (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]

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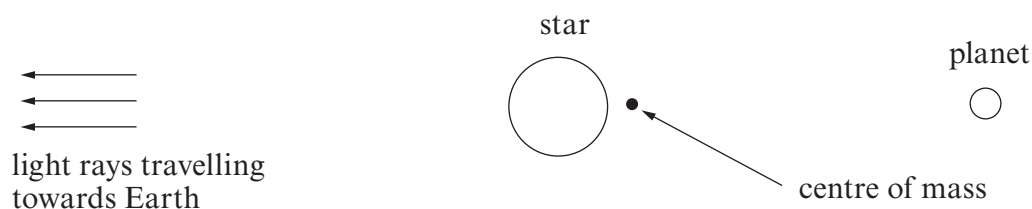
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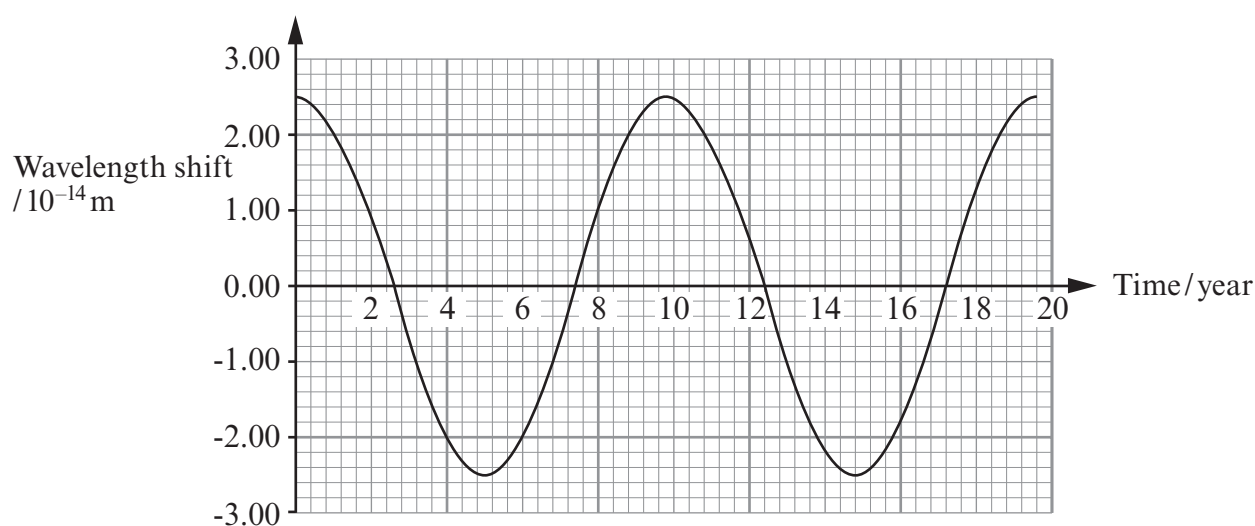
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- (ii) **Without further calculation** indicate, on the graph above, the point at which the dog loses contact with the bridge and the **approximate point** at which it makes contact with the bridge again. [2]

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 m s^{-1} .
[The wavelength of light used is 650 nm] [2]

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

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- (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]

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

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- (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]

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GCE MARKING SCHEME

PHYSICS
AS/Advanced

JANUARY 2012

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2012 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

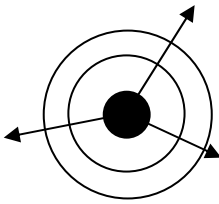
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Unit	Page
PH1	1
PH2	5
PH4	10

PH4

Question			Marking details	Marks Available
1	(a)		$p = \frac{1}{3} \rho \overline{c^2}$ rearranged e.g. $\overline{c^2} = \frac{3p}{\rho}$ (1) $c_{\text{rms}} = 514 \text{ [m s}^{-1}\text{]} (1)$	2
	(b)	(i)	Mass of particle = $\frac{3.75}{8.06 \times 10^{22}} \text{ g} (1) [4.63 \times 10^{-26} \text{ kg}] = 27.9 \text{ u} (1) [\text{so molar mass} = 27.9 \text{ [g mol}^{-1}\text{]} [\sim 28 \text{ g mol}^{-1}]$ Or: Amount of gas = $\frac{8.06 \times 10^{22}}{6.02 \times 10^{23}} \text{ mol} (1) [= 0.134 \text{ mol}]$ So molar mass = $\frac{3.75 \text{ g}}{0.134 \text{ mol}} [= 28 \text{ g mol}^{-1}]$	2
	(c)	(i)	$p = mv$ used, e.g. $p = 460m$ (1) $p = 2.14 \times 10^{-23} \text{ kg m s}^{-1} / \text{N s} ((\text{UNIT mark})) (1)$	2
		(ii)	$\lambda = \frac{h}{p} (1) [\text{manipulation: } p = \frac{h}{\lambda} \text{ by itself is not enough}]$ [or by impl.] $\lambda = 3.1 \times 10^{-11} \text{ m} (1) \text{ Allow e.c.f.}$	2
	Question 1 total			[8]
2	(a)	(i)	(20.0, 1.00) labelled A and (23.0, 1.00) labelled B	1
		(ii)	(23.0, 0.80) labelled C	1
	(b)	(i)	$n = \frac{pV}{RT} (1)$ [manipulation – or by impl.] = 0.745 [mol] (1)	2
		(ii)	$[N = nN_A =] 4.5 \times 10^{23}$ Allow e.c.f.	1
		(iii)	$T = \frac{pV}{nR}$ [or by impl.]; (or $V/T = \text{constant}$ or $P/T = \text{constant}$) $T_B = 371 \text{ [K]} \text{ and } T_C = 297 \text{ [K]} (1) \text{ e.c.f.}$	2
	(c)		at least two values substituted into $E = mc\Delta\theta$ (1) $\Delta\theta = 1.36 \text{ [K or } ^\circ\text{C]} (1)$	2
	(d)		Area under graph = work or by clear implication (1) detail, e.g. $\frac{1}{2} \times 0.21 \times 10^5 \times 3 \times 10^{-3}$ (1) [square counting ok] $31.5 \text{ [J]} \text{ or } 30 \text{ [J]} (\text{ans}) (1)$	3
	(e)		$\Delta U = Q - W$ quoted or by clear implication or 1 st law quoted (1); and $\Delta U = 0 (1)$	2
Question 2 total				[14]

Question			Marking details	Marks Available
3	(a)		$A = \pi \times 1.8^2$ or implied in numbers (1) Volume per second = $\pi r^2 v$ [or by some method e.g. $m = \rho v$] (1) Mass flow rate = $\pi \times 1.8^2 \times 250 \times 0.4$ [= 1018 kg s ⁻¹] (1)	3
	(b)		Thrust = Mass / sec $\times \Delta v$ (1) [or equiv.][i.e. $(a) \times \Delta v$] [or by impl.] = 40 [kN] (1)	2
	(c)		Aeroplane momentum is constant (1) [this mark is implied if the candidates imply or state that the exhaust air speed = 250 m s ⁻¹] No (overall) change in air momentum (1) Or (Δ) momentum of air forwards (due to drag etc.) (1) is balanced by (Δ) momentum of exhaust air backwards (1) Or equivalents if candidate states momentum of aeroplane is decreasing (due to small decrease in mass i.e. kerosene loss) e.g. momentum of aeroplane is decreasing <u>due to decreasing mass</u> (1) so overall transfer of momentum to air to the right (1)	2
			Question 3 Total	[7]
4	(a)		m_1 Earth's mass (1) m_2 satellite mass (1) r radius of <u>orbit</u> or distance between masses (1) ω angular velocity or angular speed [accept: pulsance] [of satellite] (1)	4
	(b)		m_2 clearly cancelled and r collected or by implication (1) e.g. $\frac{Gm_1 m_2}{r^3} = m_2 \omega^2$ $\omega = \frac{2\pi}{T}$ substituted or quoted (1) clear algebra leading to $r = \sqrt[3]{\frac{Gm_1 T^2}{4\pi^2}}$ (1) but $r = h + R_E$ (1)	4
	(c)		period of orbit, $T = 24 \times 60 \times 60$ s or 86400 s (1) $h = 35.9 \times 10^6$ m (1)	2
	(d)		$\Delta V = \pm \frac{Gm}{r} \pm \frac{Gm}{r}$ (i.e. attempt at combining potentials) P.E. = $m\Delta V$ used (1) i.e. 850 $\times$ any change in potential [N.B. $\Delta PE = \pm \frac{Gm}{r} \pm \frac{Gm}{r}$ ✓✓] $\Delta PE = 4.51 \times 10^{10}$ J (UNIT mark) (1) Allow e.c.f.	3
			Question 4 Total	[13]

Question			Marking details	Marks Available
5	(a)		concentric rings: minimum 2 (1) arrows out: minimum 2 (1) correct labelling (1) 	3
	(b)		field inward [or equivalent e.g. opposite]	1
	(c)		values substituted into $E = \frac{Q}{4\pi\epsilon_0 r^2}$ (1) [or by impl.] $E = 2.05 \times 10^7 \text{ V m}^{-1}$ or N C^{-1} [or equivalent] ((UN IT mark))(1)	2
	(d)	(i)	values substituted into $V = \frac{Q}{4\pi\epsilon_0 r}$ (1) [or by impl.] $V = 3.24 \times 10^6 \text{ [V]}$ (1)	2
		(ii)	zero	1
	(e)		$\Delta V = 3.24 \times 10^6 \text{ [V]}$ [or by impl.] Allow e.c.f. (1) $\Delta PE = q\Delta V$ (1) $E_k = 7.94 \text{ [J]}$ (1)	3
			Question 5 Total	[12]
6	(a)		$f = \frac{1}{T}$ (1); $f = 1.23 \text{ [Hz]}$ (1)	2
	(b)		$\omega = 2\pi f$ or $\frac{2\pi}{T}$ (1) $= 2\pi \times 1.23$ (allow e.c.f.) or $2\pi/0.81 = (7.76 \text{ rad s}^{-1})$	2
	(c)		natural frequency (period) close to walking frequency (period) (1) resonance occurs (1) which could break (or damage) bridge (1)	3
	(d)		A and ω subbed into $y = A \sin \omega t$ (1) $y = -10.3 \text{ cm}$ (1) [N.B. $y \sim 2.0 \text{ cm}$ if calculators set to degrees - 1 mark only]	2
	(e)	(i)	$a = \omega^2 x$ or $\omega^2 A \sin \omega t$ (1) $\omega^2 x = 9.81 \text{ m s}^{-2}$ (1) $x = 16.1 \text{ [cm]}$ [16.3 if $\omega = 7.76 \text{ rad s}^{-1}$ used] (1)	3
		(ii)	Point indicated at $\sim 0.12 \text{ s}$ ecf (1) and 2 nd point anywhere $> 0.28 \text{ s}$ (1)	2
			Question 6 Total	[14]

Question			Marking details	Marks Available
7	(a)		$\Delta\lambda = 2.50 [\pm 0.05] \times 10^{-14} \text{ m (1)}$ $v = \frac{\Delta\lambda}{650 \times 10^{-9}} \times 3.00 \times 10^8 \text{ (1) [= 11.54 m s}^{-1} \text{ if } 2.5 \times 10^{-14} \text{ m used]}$	2
	(b)		period = 12.4 - 2.6 [= 9.8 years] allow $9.8 \pm 0.1 \text{ years (1)}$ $v = \frac{2\pi r}{T}$ or equiv [e.g. $v = \omega r$ and $\omega = \frac{2\pi}{T}$] (1) radius = $5.68 \times 10^8 \text{ [m] (1)}$ Allow e.c.f on T [$r = 5.90 \times 10^8 \text{ m}$ if $v = 12 \text{ m s}^{-1}$ used]	3
	(c)		$d^3 = \frac{T^2 G(M_1 + M_2)}{4\pi^2}$ [i.e. algebra nearly complete] (1) $M_1 + M_2 \approx M_1$ stated [or in words] (1) $d = \sqrt[3]{\frac{(9.81 \times 24 \times 365 \times 3600)^2 \times 6.67 \times 10^{-11} \times 2 \times 10^{31}}{4\pi^2}} \text{ (1)}$ [= $1.48 \times 10^{12} \text{ m}$] Allow e.c.f.	3
	(d)		$r_1 \approx \frac{M_2}{M_1} d$ or similar (1) $M_2 = 7.7 \times 10^{27} \text{ kg (1)}$ Allow e.c.f.	2
	(e)		The temperature of the planet is greater than that of the Earth [or equiv.] (1) Because of factors of 3000 and 10^2 [or $3000/10^2$ seen] (1) [Accept 30 times hotter]	2
	Question 7 Total			[12]

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

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.

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

1324
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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, ${}^6_3\text{Li}$.

The nucleus of the atom absorbs the neutron, to form the heavier isotope ${}^7_3\text{Li}$. Using the data in the diagram, calculate the *velocity* of the ${}^7_3\text{Li}$ atom, adding an arrow to the (right hand) diagram, to show its direction of motion. [4]

BEFORE COLLISION



neutron (mass
 $1.67 \times 10^{-27} \text{ kg}$)

${}^6_3\text{Li}$ atom (mass
 $9.98 \times 10^{-27} \text{ kg}$)

AFTER COLLISION



${}^7_3\text{Li}$ atom (mass
 $11.6 \times 10^{-27} \text{ kg}$)

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

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- (c) The nucleus of the ${}^7_3\text{Li}$ 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 ${}^7_3\text{Li}$ atom, **treating its initial velocity as negligible.** [2]

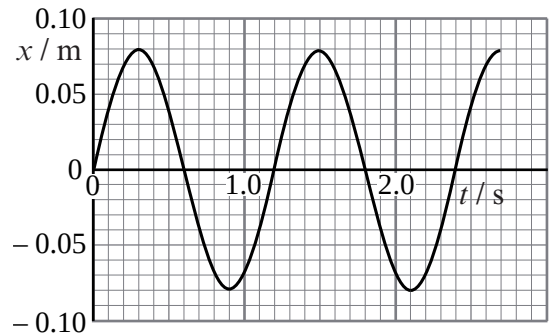
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2. A steel ball of mass 0.40 kg hangs by a spring from a fixed support. The ball is displaced vertically from its equilibrium position and then released. A graph of **upward** displacement (x) from the equilibrium position against time (t) is plotted 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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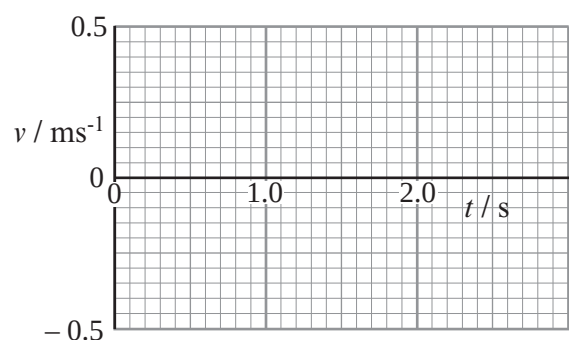
- (c) (i) Show that the maximum speed of the ball is approximately 0.4 ms^{-1} . [2]

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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]

- (d) (i) Calculate the changes in *kinetic energy* and *gravitational potential energy* of the ball which occur between $t = 0.60$ s and $t = 0.90$ 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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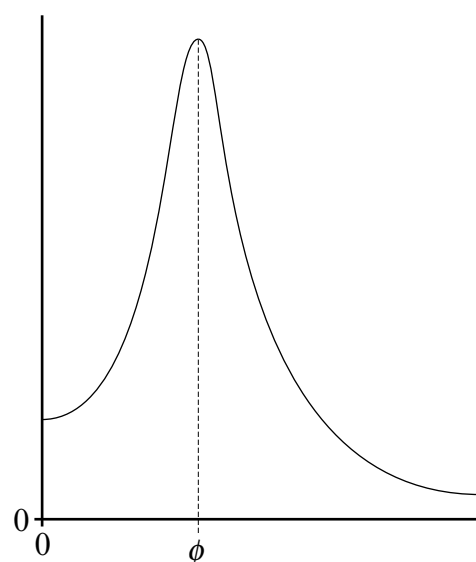
- (ii) Explain, without further calculation, how the *Principle of Conservation of Energy* applies over this interval.

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

[1]

[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} m³.

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

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(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]

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(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]

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(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]

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

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

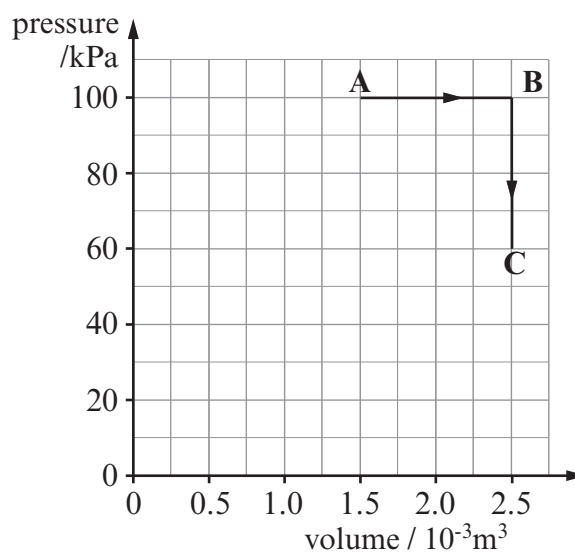
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- (b) The cylinder is now heated and the gas allowed to expand at constant pressure, pushing out the piston. The change is shown as **AB** on the graph.



- (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]

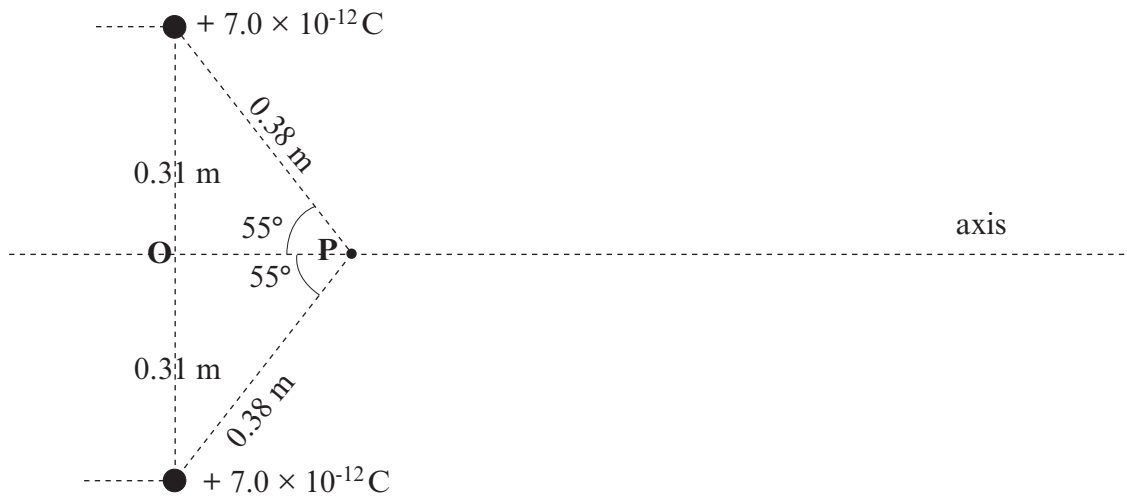
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4. Two small positive charges are placed in empty space as shown.



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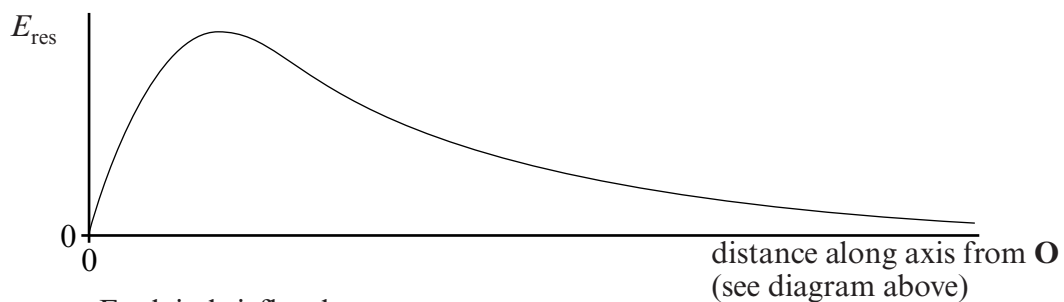
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- (iii) The graph shows how the resultant electric field strength, E_{res} , varies with distance along the axis from point **O**.



Explain briefly why

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

- (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 $4.8 \times 10^{-19} \text{ C}$ and mass $4.5 \times 10^{-26} \text{ kg}$ 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]

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

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

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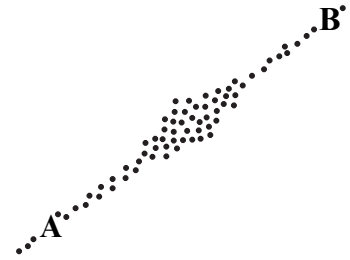
(II) Explain why this reasoning would be invalid if Q's mass were not very small compared with M . [2]

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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]

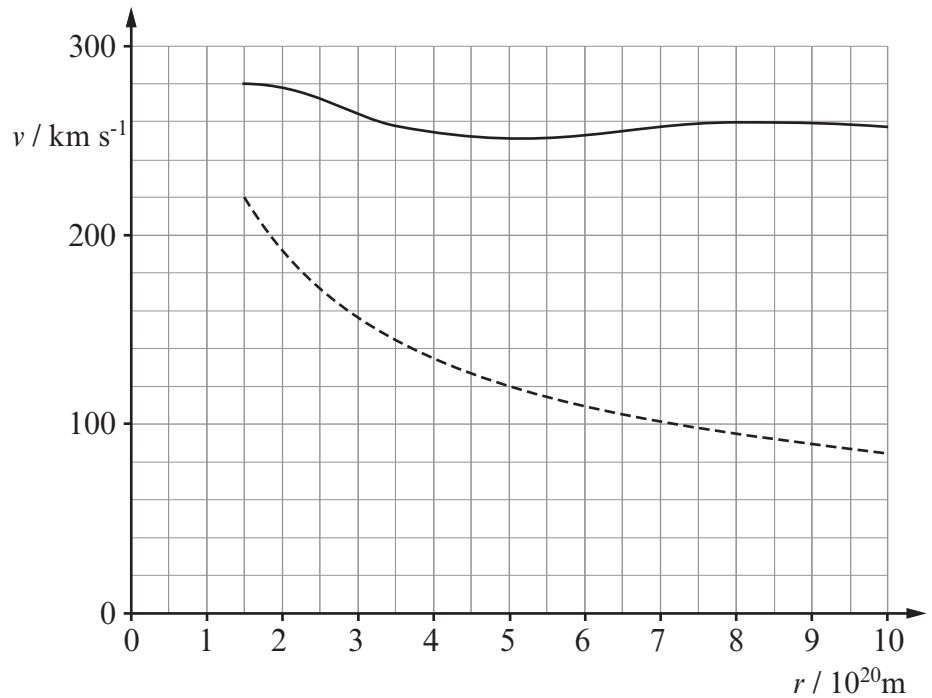
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- (ii) The **broken** line on the graph shows how the rotation speeds, v , of bodies in the outer regions of the galaxy depend on their distances, r , from the centre of the galaxy, according to the equation

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

[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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Candidate Name	Centre Number	Candidate Number



GCE A level

1324/01

PHYSICS

ASSESSMENT UNIT PH4:

OSCILLATIONS AND FIELDS

P.M. THURSDAY, 27 January 2011

1½ hours

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or 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.

For Examiner's use only.		
1.	10	
2.	10	
3.	4	
4.	11	
5.	18	
6.	6	
7.	9	
8.	12	
Total	80	

1324
010001

1. A bubble of krypton (Kr) gas is formed underwater. The bubble has a volume of $2.14 \times 10^{-6} \text{ m}^3$ and contains 1.70×10^{20} krypton molecules each of mass $1.39 \times 10^{-25} \text{ kg}$. The pressure of the gas inside the bubble is 300 kPa.



Kr bubble
 volume = $2.14 \times 10^{-6} \text{ m}^3$
 pressure = 300 kPa
 No. of molecules = 1.70×10^{20}
 mass of a Kr molecule = $1.39 \times 10^{-25} \text{ kg}$

(a) Calculate:

- (i) the rms speed of the Kr molecules in the bubble; [3]

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- (ii) the relative molecular mass of Kr; [2]

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- (iii) the temperature of the gas inside the bubble. [3]

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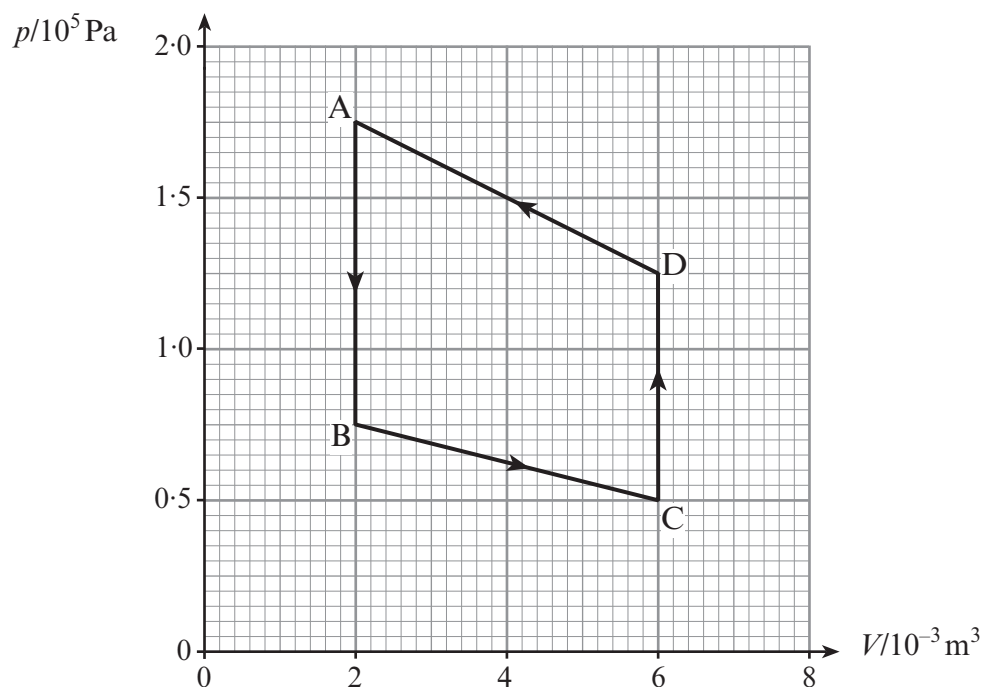
- (b) The bubble is initially 20 m below the surface of the water. Explain, giving your reasoning, what happens to the size of the bubble as it rises. [2]

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2. A gas undergoes the cycle ABCDA as shown in the p - V graph below.



- (a) Explain very briefly why no work is done during AB or CD. [1]

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- (b) Calculate the work done by the gas during process DA. [3]

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- (c) The first law of thermodynamics is usually written

$$\Delta U = Q - W$$

State the meaning of each term. [3]

ΔU

Q

W

- (d) Calculate the heat flow out of the gas during the cycle ABCDA. [3]

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3. Describe an everyday circumstance where resonance occurs. Your example of resonance may be useful or it may be an example where resonance should be avoided. You should explain what is your oscillating system, what provides the driving force and what is the result of the resonance. A diagram may (or may not) assist your answer. [4]

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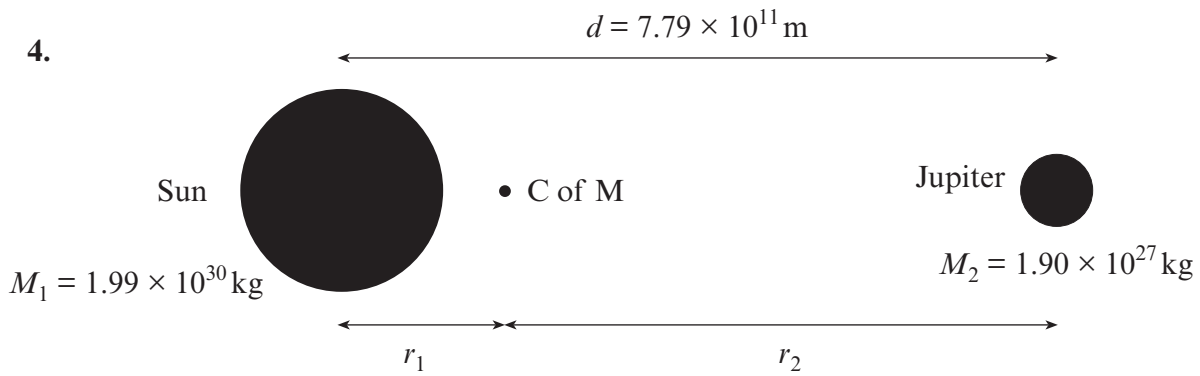


Diagram not to scale

- (a) Calculate r_1 , the distance from the centre of the Sun to the centre of mass (C of M) of the Sun-Jupiter system. [2]

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- (b) Show that the period of orbit of Jupiter is nearly 12 years. [3]

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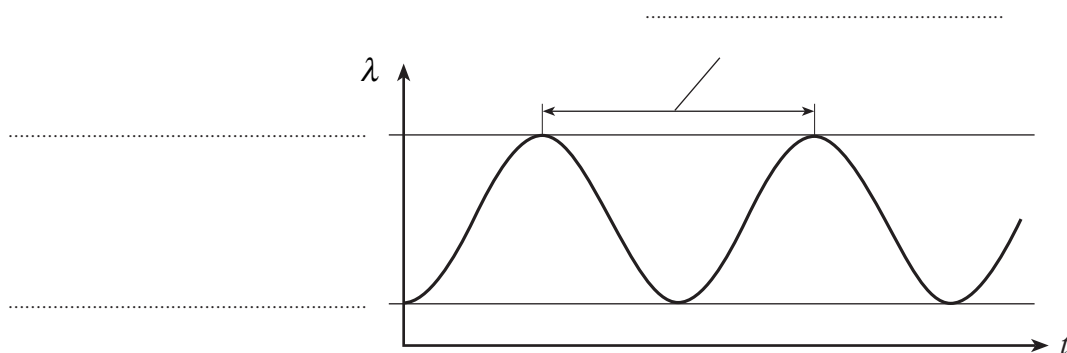
- (c) Show that the orbital speed of the Sun is around 12.5 m s^{-1} . [2]

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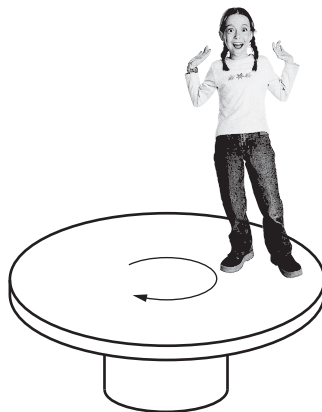
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- (d) An alien outside the Solar System analyses light from the Sun and finds that sunlight is Doppler shifted due to the Sun's orbital speed of 12.5 m s^{-1} . An absorption line of wavelength $1.28 \mu\text{m}$ is used to measure the Doppler shift. The graph shows the variation of wavelength of the $1.28 \mu\text{m}$ line as observed by the alien. Place the correct values on the dotted lines (you will need to calculate Doppler shift values for full marks). [4]



5. A child stands on a park roundabout as it rotates with a constant angular speed of 1.40 rad s^{-1} .



The child's mass is 32.5 kg and she stands a distance r from the centre of the roundabout.

- (a) Show that the frictional force exerted on the child is given by $F = 63.7r$, where F is in newtons and r is in metres. [3]

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- (b) The maximum possible value of the frictional force is 114 N . Explain briefly why the child cannot stand further than about 1.80 m from the centre of the roundabout. [2]

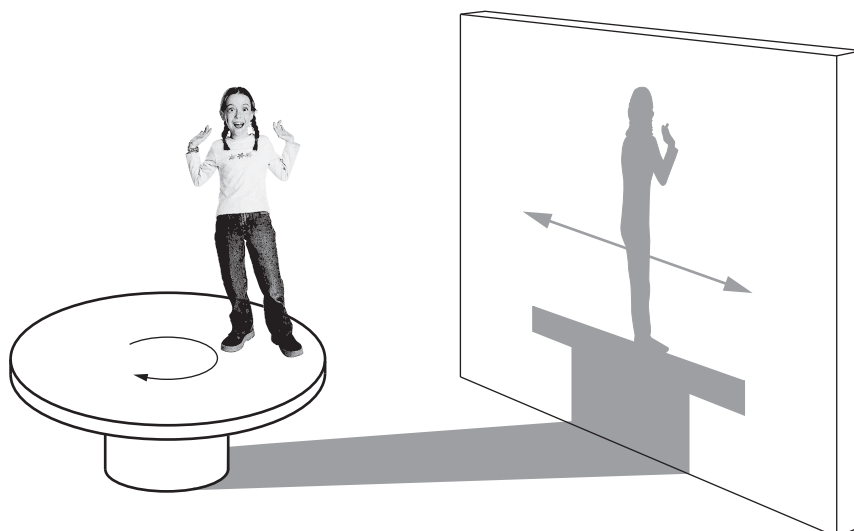
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As the Sun sets, the girl's shadow is cast on a wall. The shadow now performs simple harmonic motion with an amplitude of 1.80 m with $\omega = 1.40 \text{ rad s}^{-1}$.

light from the Sun



(c) Calculate the period of oscillation.

[2]

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(d) Calculate the maximum speed of the shadow.

[2]

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(e) Calculate the maximum acceleration of the shadow and state where this occurs.

[3]

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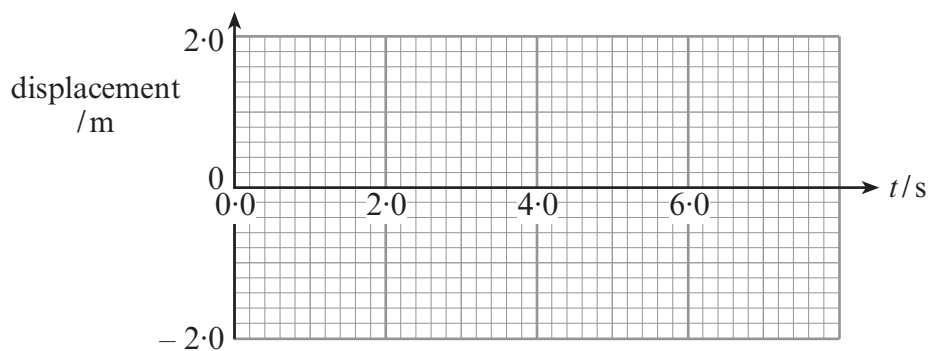
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(f) At time $t = 0$, the shadow is at the centre of its motion and moving in the positive x -direction. Sketch a graph of the shadow's displacement against time on the grid below.

[2]



(g) Calculate, using an appropriate equation, **two** values of t within the first six seconds when the displacement of the shadow is -1.00 m.

[4]

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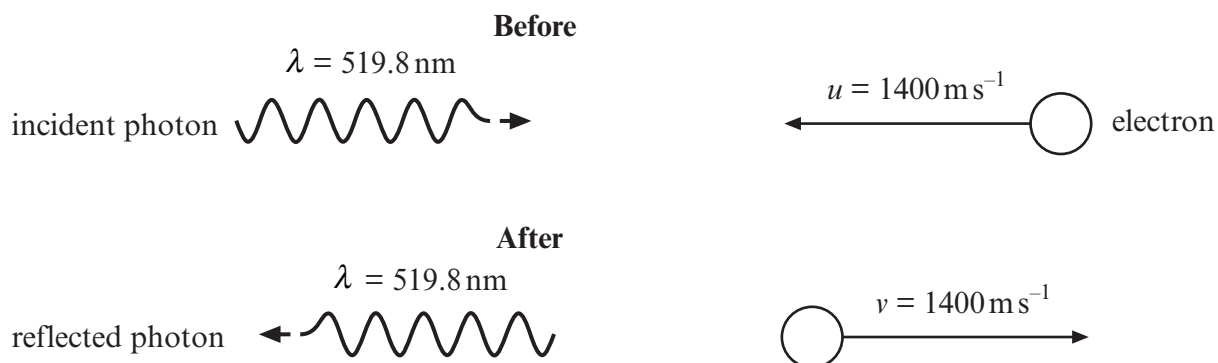
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6. A photon collides with an electron and rebounds as shown below.



- (a) Calculate the momentum of the photon. [1]

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- (b) Show that the combined momentum of the system before the collision is $0.00 \times 10^{-27} \text{ kg m s}^{-1}$ (i.e. nearly zero). [2]

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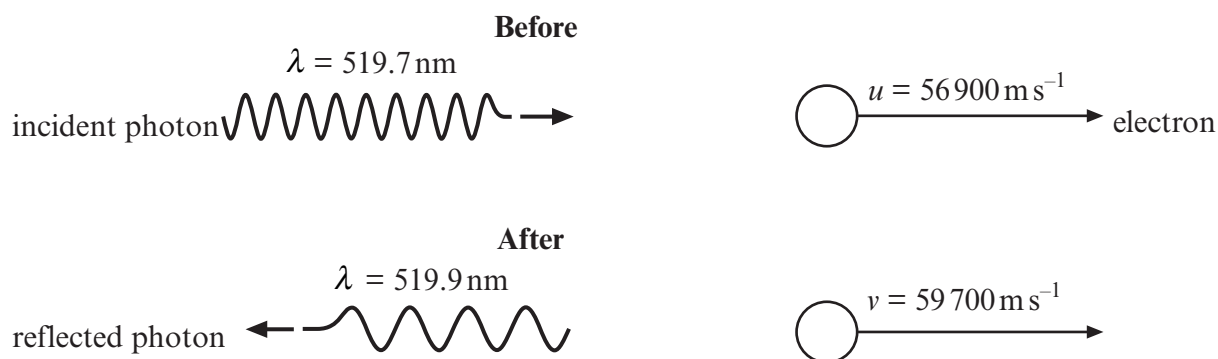
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- (c) Explain briefly whether or not momentum is conserved in the collision. [1]

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- (d) The same collision is witnessed by an observer moving very quickly to the left.

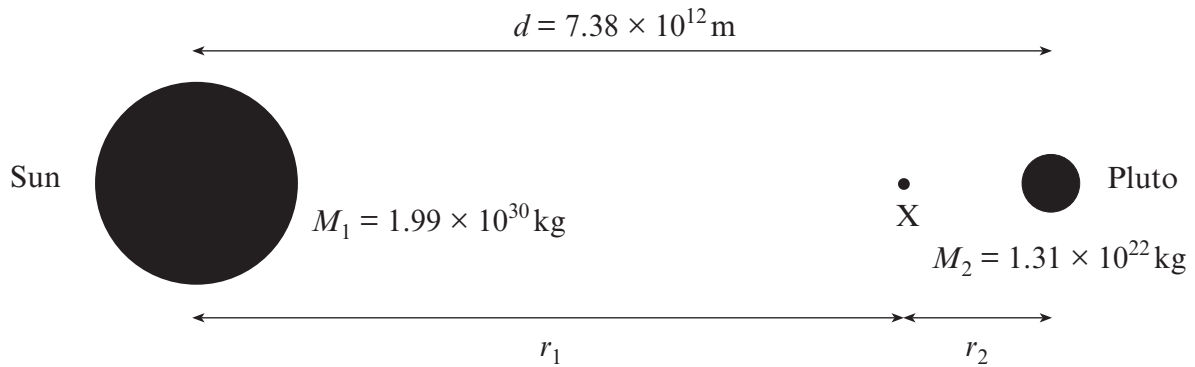


Without further calculations, explain how conservation of **energy** still applies to this collision. [2]

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7.

*Diagram not drawn to scale.*

- (a) Calculate the gravitational force of attraction between the Sun and Pluto. [2]

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- (b) At point X, the resultant gravitational field is zero.

By equating the gravitational fields due to the Sun and due to Pluto, calculate the ratio $\frac{r_2}{r_1}$ and hence r_2 . [4]

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- (c) The distance between Pluto and the Sun decreases from $7.38 \times 10^{12} \text{ m}$ to $4.44 \times 10^{12} \text{ m}$ due to its elliptical orbit.

Apply the principle of conservation of energy to calculate the corresponding increase in kinetic energy of the system. [3]

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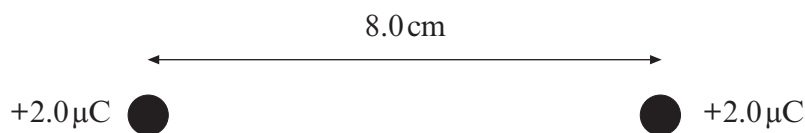
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8. The diagram shows an isolated negative charge ($-Q$).



- (a) Sketch electric field lines and equipotential surfaces for the negative charge. [3]
- (b) Two point charges are placed a distance 8.0 cm apart as shown in the diagram below.



- (i) Calculate the force between the two charges. [2]

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- (ii) One of the two $+2.0\ \mu\text{C}$ charges is released from rest while the other is held stationary. Use the concept of potential or potential energy to calculate the maximum kinetic energy that the charge will eventually acquire. [3]

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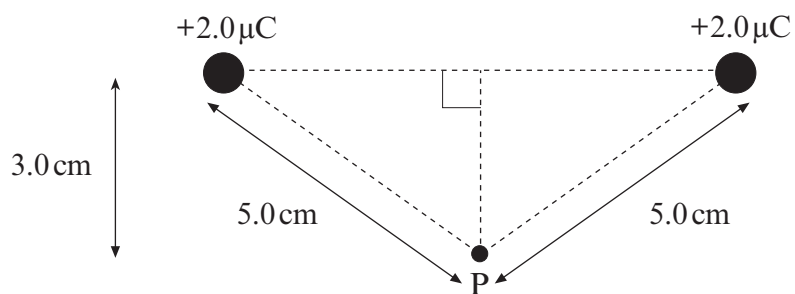
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(c) Calculate the resultant electric field at P in the setup shown below.

[4]



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