OCR A-LEVEL PHYSICS A

PHYSICS



EXAM QUESTION PACK

UNIT G484 OLD SPECIFICATION PAPERS

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OCR
Oxford Cambridge and RSA

Thursday 15 June 2017 – Morning

A2 GCE PHYSICS A

G484/01 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

* G 4 8 4 0 1 *

* 6 8 0 8 5 1 1 7 3 9 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 An alpha-particle is moving in a straight line directly towards a **stationary** strontium nucleus. The alpha-particle and the strontium nucleus are both positively charged particles. The alpha-particle has kinetic energy of 5.2 MeV when it is at a large distance away from the strontium nucleus. The mass of the alpha-particle is 6.6×10^{-27} kg.

(a) Show that the speed of the alpha-particle is about $2 \times 10^{7}\,m\,s^{-1}$.

[2]

(b) Use Newton's laws to describe and explain the motion of the **strontium** nucleus as the alpha-particle approaches the strontium nucleus.

In your answer, you should use appropriate technical terms, spelled correctly.

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..... **[3]**

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(c) Fig. 1 shows the alpha-particle and the strontium nucleus at an instant in time. The alpha-particle is now **stationary** and the strontium nucleus is moving with a speed V.

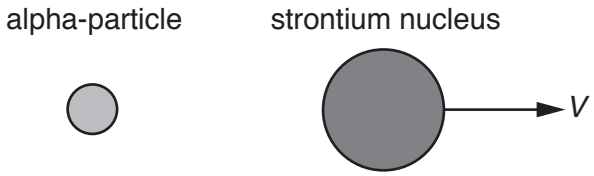


Fig. 1

The mass of the strontium nucleus is 1.3×10^{-25} kg.
Calculate the speed V of the strontium nucleus.

$V =$ ..... $m\,s^{-1}$ **[2]**

(d) The alpha-particle 'bounces' back after its interaction with the strontium nucleus. The final speed of the alpha-particle is the same as its initial speed of approach. The average force experienced by the alpha-particle during the interaction is 4.8 N.
Estimate the time t of the interaction between the alpha-particle and the strontium nucleus.

$t =$ ..... s **[2]**

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2 A cylinder **C** is attached to one end of a spring. The other end of the spring is connected to a block **D** which is fixed at the end of a smooth horizontal **transparent** tube as shown in Fig. 2.1.

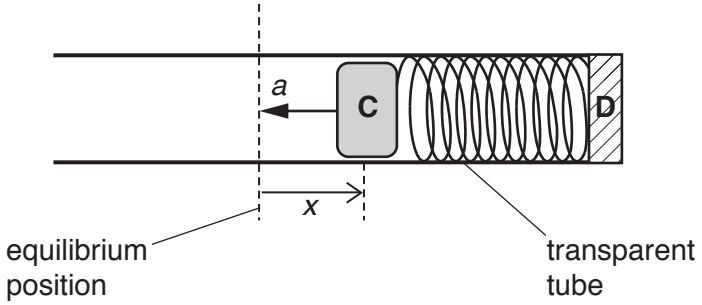


Fig. 2.1

The cylinder **C** is moved to the right, compressing the spring. **C** is then released and it oscillates at its natural frequency about the equilibrium position.
Fig. 2.1 also shows the displacement and acceleration vectors for the cylinder **C** at an instant in time. The magnitude of the displacement is x and the magnitude of the acceleration is a.
Fig. 2.2 shows the variation of a with x.

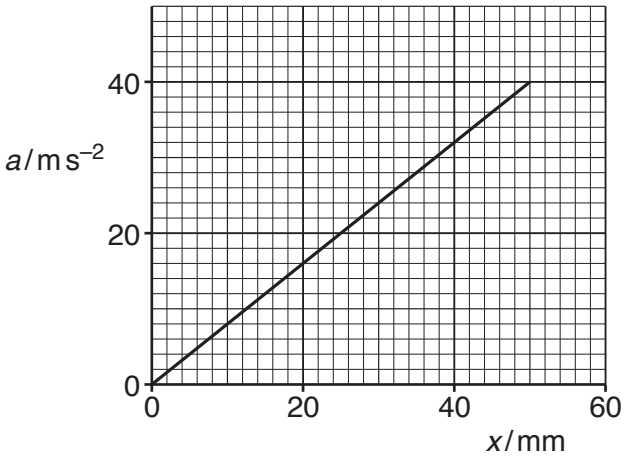


Fig. 2.2

(a) State one feature from Fig. 2.1 and one feature from Fig. 2.2 that suggests that the motion of the cylinder **C** is simple harmonic.

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..... **[2]**

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(b) Use Fig. 2.2 to determine the period T of the oscillations.

$T =$ ..... s **[2]**

(c) The equation for the motion of the cylinder **C** is

$$ma = -kx$$

where m is the mass of the cylinder **C** and k is the force constant of the spring.

(i) Determine the units for k in terms of kg, m and s.

units = ... **[2]**

(ii) Determine a value for $\frac{k}{m}$.

$\frac{k}{m} =$ ..... s^{-2} **[1]**

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(d) Describe and explain how you would expect the oscillations of the cylinder **C** to change, if at all, should a small amount of friction exist between the cylinder **C** and the walls of the tube.

In your answer, you should use appropriate technical terms, spelled correctly.

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..... **[3]**

(e) The point **D** in the arrangement shown in Fig. 2.1 is now attached to the shaft of an electric motor. The tube is rotated in a horizontal circle as shown in Fig. 2.3.

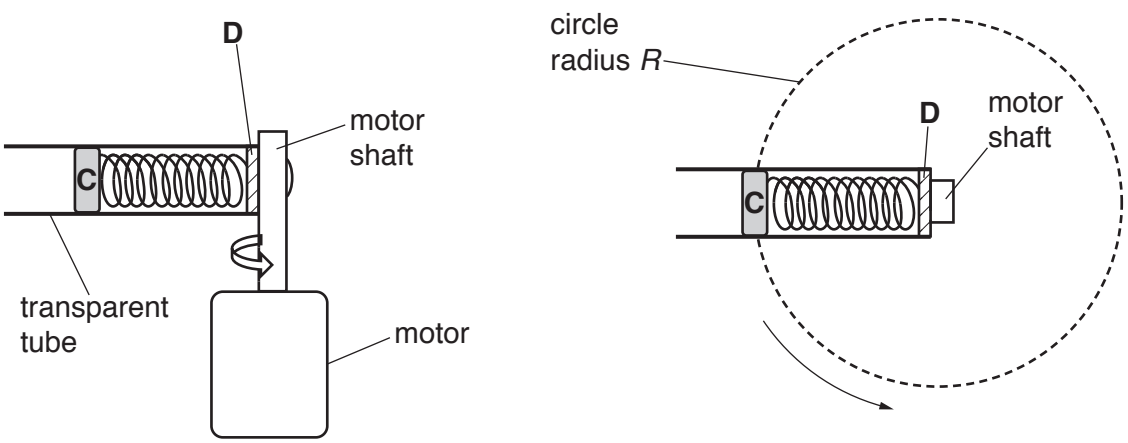


Fig. 2.3

(i) The rotational speed of the cylinder **C** is increased.
Use Newton's laws to explain why the spring stretches and the cylinder **C** moves radially outwards.

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..... **[2]**

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(ii) The apparatus shown in Fig. 2.3 is used by a student to investigate the relationship between the force F acting on the cylinder **C**, its speed v and the radius R of its circular path.
The force constant k of the spring is known.
Describe how the student can use a video camera and a ruler to determine the values of R, F and v.

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..... **[4]**

Question 2(e)(iii) begins on page 8

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(iii) The student has been asked to use their results from **(e)(ii)** to determine the mass of the cylinder **C** by plotting a straight line graph.
This straight line graph is shown in Fig. 2.4.

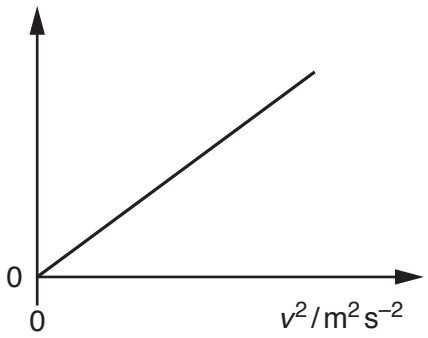


Fig. 2.4

1 Complete Fig. 2.4 by correctly labelling the vertical axis. **[1]**

2 Explain how the mass of the cylinder **C** can be determined from Fig. 2.4.

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..... **[2]**

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Question 3 begins on page 10

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3 The planet Mars has a mean radius 3400 km and has a mass 9.3 times **smaller** than the mass of the Earth. The mean radius of the Earth is 6400 km.

(a) Show that the gravitational field strength g on the surface of Mars is about $4\,N\,kg^{-1}$.

[2]

(b) **(i)** On the surface of Mars a space probe fires a projectile at right angles to the gravitational field.
Explain why this projectile will travel further on the surface of Mars than an identical projectile fired from the same height during tests on the surface of the Earth.

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..... **[2]**

(ii) A second projectile is fired at high speed u vertically upwards from the space probe. A technician calculates the maximum height s reached by the projectile as 2000 km by using the equation of motion $v^2 = u^2 + 2as$, where a is equal to the gravitational field strength from **(a)**.
Discuss the accuracy of this calculation for s.

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..... **[2]**

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(c) As part of the exploration of Mars it has been suggested that two satellites should be placed in orbit around the planet.
The Martian day is 8.9×10^4 s.

(i) The first satellite should orbit the planet so that it remains vertically above one particular location at all times.

1 State **three** conditions that must be satisfied in order to achieve this task.

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..... **[3]**

2 Calculate the radius of the orbit of this satellite.

radius = ... m **[2]**

(ii) The second satellite should be placed in a polar orbit. It will pass over the north and south poles of Mars. This satellite will have a circular orbit at a height of 9000 km **above** the surface of Mars. A camera on board will take one image every 25 s.
Calculate the number of images that can be taken in a single polar orbit of Mars.

number of images = ... **[3]**

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4 A beam of electrons is incident at a metal. Most of the kinetic energy of the electrons is transformed into thermal energy in the metal and some of the kinetic energy of the electrons is transformed into X-ray photons.
The kinetic energy of each electron is 130 keV. The current of the electron beam is 45 mA. The electron beam is switched on for a time of 1.6 s.

(a) Show that the total number of electrons arriving at the metal is about 5×10^{17}.

[1]

(b) The maximum energy of an X-ray photon is equal to the kinetic energy of a single electron. Calculate the minimum wavelength of the X-ray photons.

minimum wavelength = ... m **[2]**

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(c) Water is circulated through the metal to prevent it from melting when it is being bombarded by the high-speed electrons. The water removes 90% of the thermal energy from the metal. The remainder of the thermal energy is lost through conduction and convection.
The water enters the metal at 17 °C and leaves the metal at 27 °C.
The specific heat capacity of water is 4200 J kg^{-1} K^{-1} and the density of water is 1000 kg m^{-3}.

Calculate the rate of flow of water through the metal in m^3 s^{-1}.

rate of flow = ... m^3 s^{-1} **[3]**

Question 5 begins on page 14

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5 **(a)** Fig. 5.1 shows an arrangement used to investigate the properties of a gas.

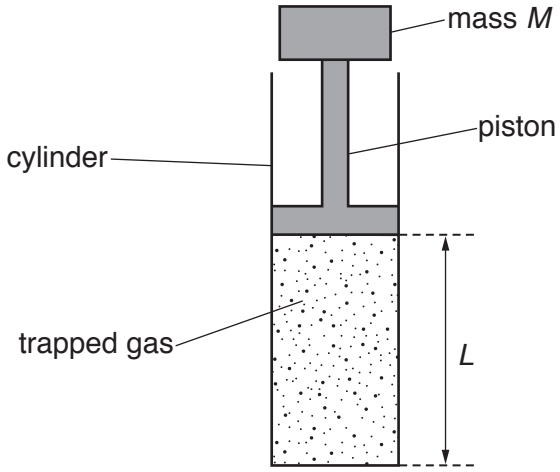


Fig. 5.1

The gas is trapped in a vertical cylinder. The pressure exerted on the gas is changed by placing a different mass on the top of the piston. Fig. 5.2 shows the variation of pressure *p* with volume *V* for the trapped gas.

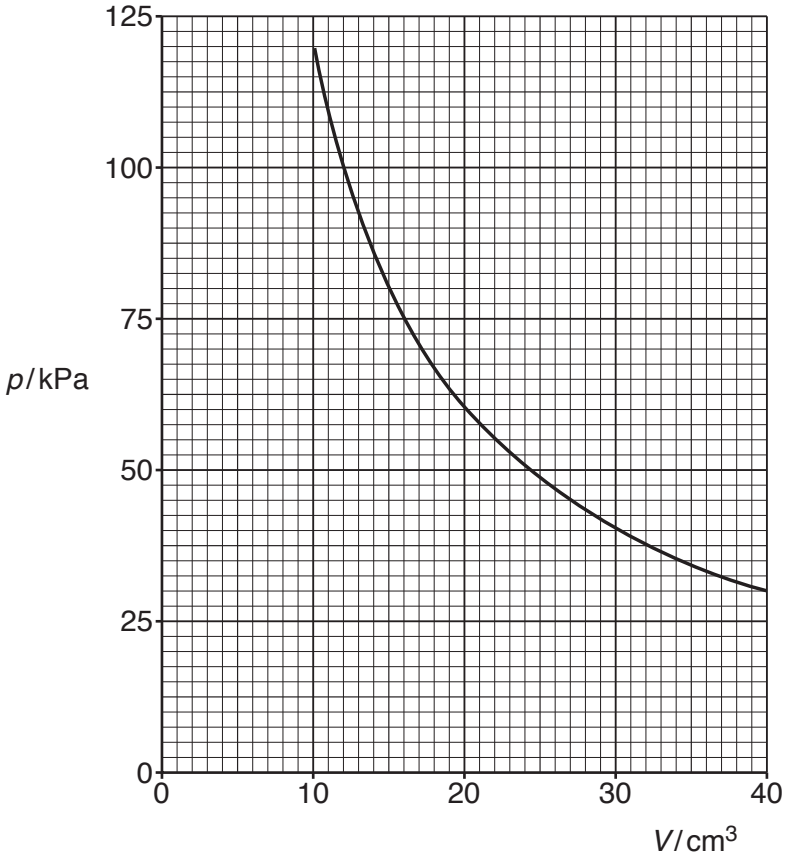


Fig. 5.2

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(i) Use Fig. 5.2 to show that the trapped gas obeys Boyle's law.

[2]

(ii) State **two** conditions which must be met for the gas to obey Boyle's law.

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..... **[2]**

(iii) The cylinder has uniform cross-sectional area. The length of the trapped gas column is L and the mass placed on the piston is M. The piston itself has a small mass.
Sketch a suitable graph on Fig. 5.3.

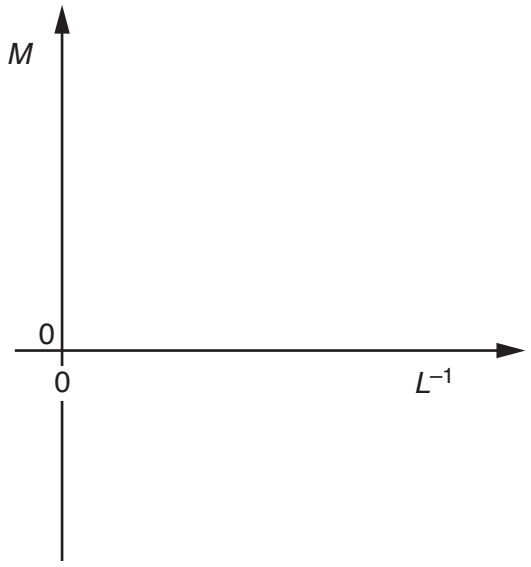


Fig. 5.3

[2]

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(b) A spherical meteorological balloon has diameter of 2.0 m when filled with helium at a pressure of 1.0×10^5 Pa and 17 °C. The balloon expands as it rises until it reaches a specific height when its diameter is 9.0 m and the balloon bursts. The temperature of the atmosphere at this specific height is –33 °C.
The molar mass of helium is 4.0×10^{-3} kg mol^{-1}.

(i) Calculate the initial mass of helium in the balloon.

mass = ... kg **[2]**

(ii) Calculate the pressure exerted by helium when the diameter of the balloon was 9.0 m.

pressure = ... Pa **[2]**

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(iii) Calculate the ratio

$$\frac{\text{internal energy of helium in the balloon of diameter } 9.0\,\text{m}}{\text{internal energy of helium in the balloon of diameter } 2.0\,\text{m}}.$$

ratio = ... **[2]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2017

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Annotations

Annotation	Meaning
BOD	Benefit of doubt given
BP	Blank Page
CON	Contradiction
	Incorrect Response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct Response
AE	Arithmetic error
	Wrong physics or equation

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Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

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Question			Answer	Marks	Guidance
1	a		Energy of ∝ = $5.2 \times 10^6 \times 1.6 \times 10^{-19}$ (= 8.32×10^{-13} (J)) $E = ½ mv^2$ so $v = \sqrt{\frac{2 \times 8.32 \times 10^{-13}}{6.6 \times 10^{-27}}}$ $= 1.6 \times 10^7 \quad (\text{m s}^{-1})$	C1 A1 A0	Must see some working **Allow:** Max 1 mark for 4 x 10^{16} (not converting to J) or 1.6 x 10^4 (not converting MeV to eV) 5.1 x 10^5 (using keV rather than MeV)
	b		Any **three** from • Total **momentum** of system / particles is conserved (as there are no external forces) / Increase in momentum of Sr nucleus equals decrease in momentum of alpha-particle • (Electrostatic) force (of repulsion) acts on (Sr) nucleus • (By Newton's 2nd law Sr) nucleus accelerates (away from alpha particle) • Sr acceleration increases and then decreases (to zero) • Force on Sr nucleus ∝ rate of change of momentum of alpha particle. (AW)	B1 × 3	✎ **momentum / accelerate(s) / acceleration** must be spelled correctly to score corresponding mark
	c		(Momentum is conserved) $6.6 \times 10^{-27} \times 1.6 \times 10^7 = 1.3 \times 10^{-25} \times V$ $V = 8.1 \times 10^5 \quad (\text{m s}^{-1})$	C1 A1	**Possible ECF from (a)** **Allow** full marks for use of 2 x 10^7 for speed of alpha particle giving V = 1.0 x 10^6 (m s^{-1})
	d		$\Delta(mv) = 2 \times 6.6 \times 10^{-27} \times 1.6 \times 10^7$ (= 2.11×10^{-19}) $F\Delta t = 4.8 \times \Delta t = 2.11 \times 10^{-19}$ $\Delta t = 4.4 \times 10^{-20}$ (s)	C1 A1	**Possible ECF from (a)** **Allow** full marks for use of 2 x 10^7 for speed of alpha particle giving Δt = 5.5 x 10^{-20} (s)
			Total	9	

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2	**a**		(Fig. 2.1 shows) *a* and *x* are in opposite directions (Fig. 2.2 shows that magnitude of) *a* is proportional to *x* because graph is a straight line <u>through the origin</u>	**B1** **B1**	**Allow** *a* is towards the equilibrium position Reason must be given
	b		gradient = $\omega^2 = \frac{40}{50\times10^{-3}} = 800$ $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{800}} = 0.22$ (s)	**C1** **A1**	**Allow** : use of equation and one point from graph **Allow:** Max 1 mark for *T* = 7 (s) (not converting mm to m)
	c	**i**	$[k] = \left[\frac{ma}{x}\right] = \frac{\text{kg}\times\text{m s}^{-2}}{\text{m}}$ $[k] = \text{kg s}^{-2}$	**C1** **A1**	**Allow:** C1 mark for any subject
		ii	$\frac{k}{m}$ is gradient $\frac{k}{m} = 800$ (s^{-2})	**A1**	**Possible ECF from (b)** Ignore sign
	d		• The period / frequency of the oscillations would remain the same • Successive **amplitude(s)** would decrease in magnitude • energy is dissipated as heat / thermal energy / work is done against friction (AW)	**B1** **B1** **B1**	✎ **amplitude** must be spelled correctly to score this mark **Allow:** 1 mark for bald statement that motion would be 'damped harmonic ' or suitable sketch.

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2	**e**	**i**	• **C** continues to move in a straight line as the tube rotates (by N1st Law) stretching the spring. • Spring exerts a force on **C** which provides the centripetal acceleration (by Newton's 2nd law) to rotate **C** (in a circle of appropriate radius).	**B1** **B1**	No credit for bald statement of laws. They must be applied to the problem.
		ii	Any **four** from • Measure natural length of spring **OR** Measure mass of **C** with balance/scale(s). • Rotate at <u>constant</u> speed and video apparatus and ruler • Measure *R* from video • Find period *T* from video and speed *v* from $2\pi R/T$ • Measure extension from video **OR** calculate extension, *x*, from *R* and natural length • Use spring constant and $F = kx$ / Hooke's law **OR** substitute *M, v R* into $F = Mv^2/R$ to find force *F*	**B1 x 4**	
		iii1	*FR* / Nm	**B1**	Must have appropriate unit (ignore any prefix)
		iii2	$m = FR / v^2$ [any subject] mass is gradient of graph	**C1** **A1**	**Possible ecf from (iii)1**
			Total	**19**	

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3	a		$g = \frac{GM}{R^2}$ $\frac{g_{Mars}}{g_{Earth}} = \left(\frac{GM_{Mars}}{R^2_{Mars}}\right)\left(\frac{R^2_{Earth}}{GM_{Earth}}\right) = \left(\frac{1}{(3400)^2}\right)\left(\frac{(6400)^2}{9.3}\right)$ $g_{Mars} = 0.38 \times 9.81$ $g_{Mars} = 3.74 \approx 3.7 \quad (N\,kg^{-1})$	**C1** **A1**	**Allow:** use of recalled mass of Earth (~6 x 10^{24} kg) and G from data tables **OR** calculation of mass of Earth from g = 9.81 m s^{-1} **C1** mark is for substitution into appropriate formula **OR** mass of Mars = 6.45 x 10^{23} (kg) Possible **FT** from their mass of Mars
	b	i	• Vertical acceleration on Mars is less than on Earth (AW) • time of fall on Mars is greater than time of fall on Earth (AW) • horizontal distance travelled will be greater on Mars	**B1** **B1** **A0**	
		ii	• Value of max height will be too small • g /a will reduce as height increases / $g \propto 1/r^2$ / SUVAT equations only apply if a is constant	**B1** **B1**	**Allow** 1 out of 2 marks for 'air resistance will reduce the height'

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	c	i1	• orbit must be over equator / equatorial • period must be one Martian day / 8.9 x 10^4 s • direction of rotation must be the same as that of Mars / must travel in orbit parallel to a point on surface of Mars	B1 B1 B1	**Allow** : same <u>angular</u> speed as Mars
		i2	$GM_{Mars} = gR^2 = 3.74 \times (3400 \times 10^3)^2 \quad (= 4.3 \times 10^{13})$ $T^2 = \frac{4\pi^2}{GM_{Mars}} r^3$ $r = \sqrt[3]{\frac{4.3 \times 10^{13} \times (8.9 \times 10^4)^2}{4\pi^2}}$ $r = 2.1 \times 10^7$ (m)	C1 A1	**Possible** ECF for mass of Mars from (a) **Allow: C1** mark for substitution of values into correct equation written with any subject. **Allow:** $r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.45 \times 10^{23} (8.9 \times 10^4)^2}{4\pi^2}}$ $r = 2.1 \times 10^7$ (m)
		ii	$T = \sqrt{\frac{4\pi^2 r^3}{GM_{Mars}}} = \sqrt{\frac{4\pi^2 \times ((3400 + 9000) \times 10^3)^3}{4.3 \times 10^{13}}}$ $T = 4.2 \times 10^4$ (s) number of images $= \frac{4.2 \times 10^4}{25} = 1700$	C1 C1 A1	**Possible ECF from** their GM_{Mars} in c(i)**2** or mass of Mars from (a) **Allow :** Alternative method using $T^2 \propto r^3$ eg $T = \left(\sqrt{\frac{(12400 \times 10^3)^3}{(2.1 \times 10^7)^3}} \right) \times 8.9 \times 10^4$ = 4.2 x 10^4 (s) **Allow:** 2 out of 3 marks for T = 2.6 x 10^4 (s) leading to approximately 1034 images [uses 9000 km as radius of orbit] **Possible FT** from their value of T
			Total	**14**	

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4	a		charge flowing = $I\,\Delta t = 45 \times 10^{-3} \times 1.6 = (72 \times 10^{-3}$ C) number of electrons $= \frac{72\times10^{-3}}{1.6\times10^{-19}} = 4.5\times10^{17}$	A1	
	b		$\lambda = \frac{hc}{eV} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{1.6\times10^{-19}\times130\times10^{3}}$ $\lambda = 9.6\times10^{-12}$ (m)	C1 A1	
	c		electrical power = IV =$130 \times 10^{3} \times 45 \times 10^{-3}$ = 5850 W rate of heat produced = 0.9 x 5850 = 5265 W 5265 = m x 4200 x 10 m = 0.125 (kg s^{-1}) $V = \frac{m}{\rho} = \frac{0.125}{1000} = 1.25\times10^{-4}$ $(m^3\ s^{-1})$	 C1 C1 A1	**Allow:** electrons energy = 4.5 x 10^{17} x 130 x 10^{3} in 1.6 s. $\text{power} = \frac{4.5\text{ x }10^{17}\text{ x }130\text{ x }10^{3}\times1.6\times10^{-19}}{1.6} = 5850\text{ W}$ **Allow:** Full marks for correct use of 5 x 10^{17} electrons. Giving V = 1.4 x 10^{-4} ($m^3\ s^{-1}$)
			Total	**6**	

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5	a	i	Selection of **two or more** points from the curve and calculation of pV for each point or comparison of values hence pV constant / $p \propto 1/V$ / Boyle's law is obeyed	**M1** **A1**	Ignore units in calculation
		ii	• mass of gas / number of molecules must be constant/fixed • Temperature must be constant	**B1** **B1**	**Allow:** system must be closed
		iii	Straight line graph with positive gradient negative intercept on the mass axis (equal to mass of piston)	**B1** **B1**	
	b	i	$n = \frac{pV}{RT} = \frac{1.0\times10^5 \times (4/3)\pi \times 1.0^3}{8.31\times(273+17)} = (174)$ mass $= 4.0\times10^{-3}\times174 = 0.70$ (kg)	**C1** **A1**	**Allow:** 1 mark for mass = 5.6 kg [incorrect radius] **Allow:** 1 mark for mass = 12 kg [incorrect T]
		ii	$p_2 = \frac{p_1V_1T_2}{V_2T_1}$ $= \frac{1.0\times10^5\times1.0^3\times240}{4.5^3\times290}$ $p_2 = 9.1\times10^2$ (Pa)	**C1** **A1**	**Allow:** Use of $p = \frac{nRT}{V}$ with their n from **b(i)** **Allow:** 1 mark for p_2 = 2100 (Pa) [incorrect T]
		iii	Use of internal energy $\propto T$ $\frac{\text{internal energy at max height}}{\text{internal energy at ground}} = \frac{240}{290}$ = 0.83	**C1** **A1**	**Not** ratio = 1.9 [incorrect T]
			Total	**12**	

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Oxford Cambridge and RSA

Monday 20 June 2016 – Morning

A2 GCE PHYSICS A

G484/01 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

* G 4 8 4 0 1 *

* 1 3 2 0 8 1 6 3 6 7 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 A ball is held above level ground. It is then dropped from rest at time $t = 0$.
Fig. 1.1 shows the velocity v against time t graph for this ball bouncing vertically.
Ignore the effect of air resistance.

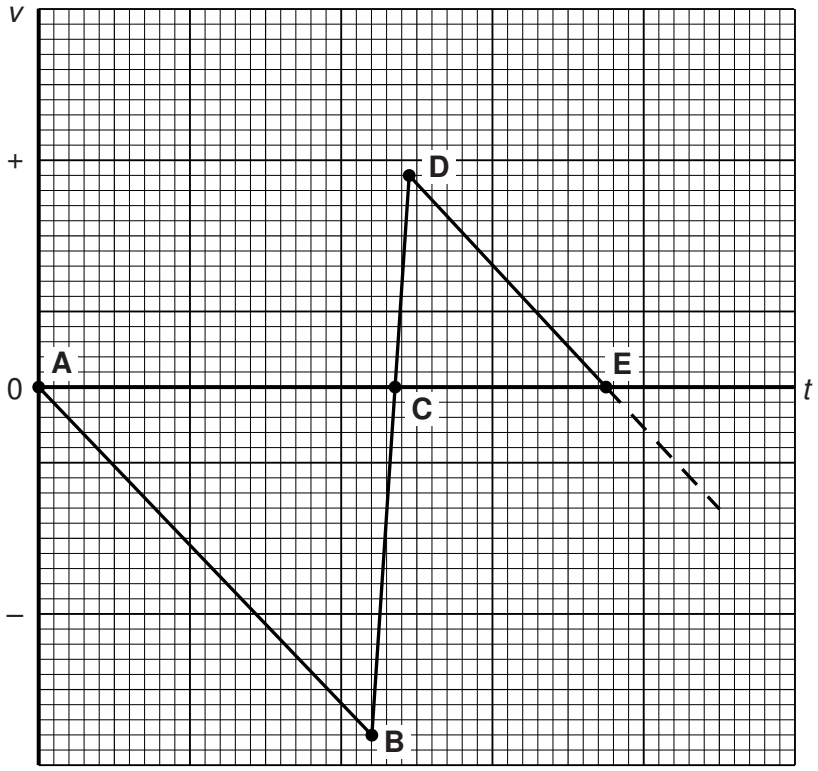


Fig. 1.1

(a) (i) Explain why the gradient of the line **DE** is the same as the gradient of the line **AB**.

In your answer, you should use appropriate technical terms spelled correctly.

.....

..... **[1]**

(ii) Explain why the area of triangle **ABC** is not the same as the area of triangle **CDE**.

.....

.....

.....

..... **[2]**

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(b) The ball, of mass 0.13 kg, was dropped from an initial height of 1.7 m. It remained in contact with the ground for 75 ms while experiencing a mean upward force of 16 N.

Calculate

(i) the speed of the ball immediately before impact with the ground

speed = ... $m\,s^{-1}$ **[1]**

(ii) the speed of the ball immediately at **D**

speed = ... $m\,s^{-1}$ **[2]**

(iii) the maximum height reached after the first bounce.

height = ... m **[1]**

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2 **(a)** State Newton's first law of motion.

.....

.....

..... **[1]**

(b) Newton's third law suggests that forces always occur in pairs when two objects interact.

(i) State **two** ways in which the forces in such a pair are identical.

.....

.....

..... **[2]**

(ii) State **two** ways in which these forces are different.

.....

.....

..... **[2]**

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(c) Fig. 2.1 shows a fireman using a hosepipe held at 55° to the horizontal. The cross-sectional area of the hosepipe nozzle is $3.3 \times 10^{-4}\,m^2$. Water is ejected from the nozzle at $25\,m\,s^{-1}$.

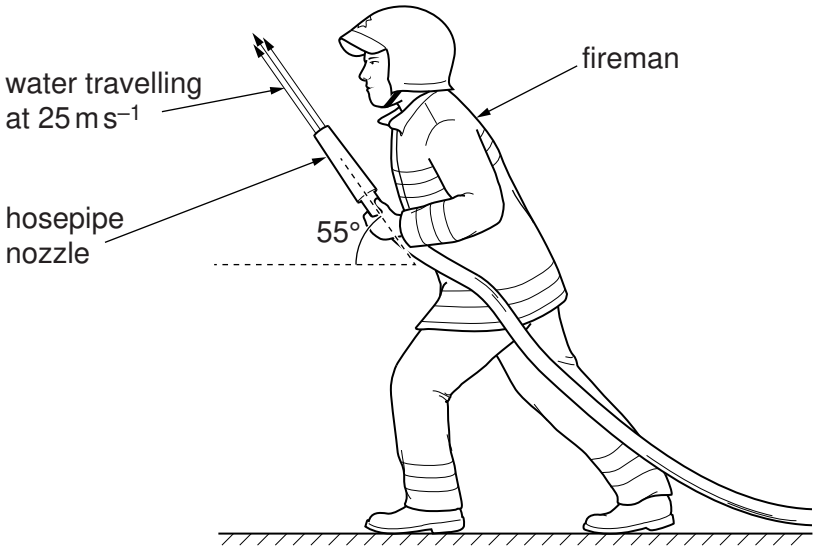


Fig. 2.1

(i) Show that the rate at which water is ejected from the nozzle is about $8.3\,kg\,s^{-1}$.

density of water = $1.0 \times 10^3\,kg\,m^{-3}$

[1]

(ii) The mass of the fireman is 92 kg. Determine the vertical component of the force exerted by the ground on the fireman's feet.

force = ... N **[3]**

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3 **(a)** Fig. 3.1 shows a displacement against time graph of an object undergoing simple harmonic motion. Seven points, **A** to **G**, have been labelled on the graph.

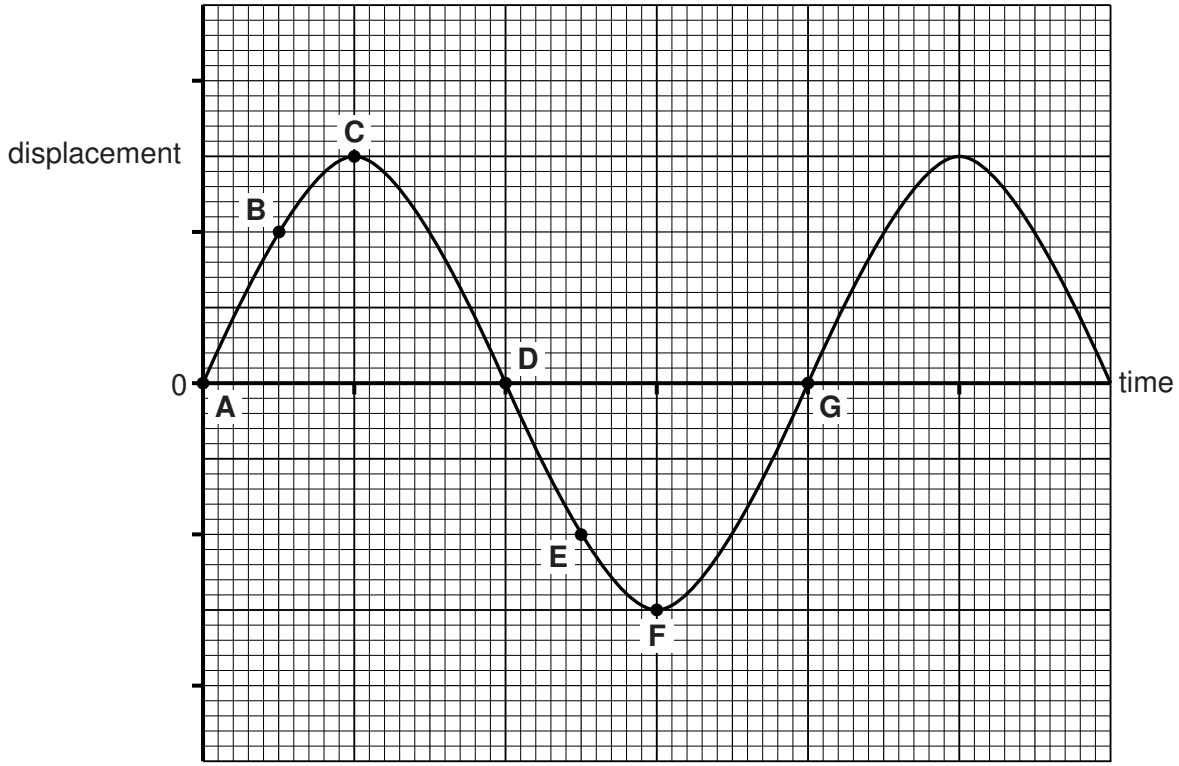


Fig. 3.1

(i) Write down two points that indicate when the object is at its amplitude position.

..... **[1]**

(ii) Write down a point which lags behind **D** by half a period.

..... **[1]**

(iii) Determine the phase difference, in radians, between points **B** and **F**.

phase difference = ... rad **[1]**

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(b) Fig. 3.2 shows an airtrack glider of mass 0.45 kg held in equilibrium by two identical stretched springs. The glider is pulled 5.0 cm to the left. When released, it oscillates without friction. The springs are always in tension.

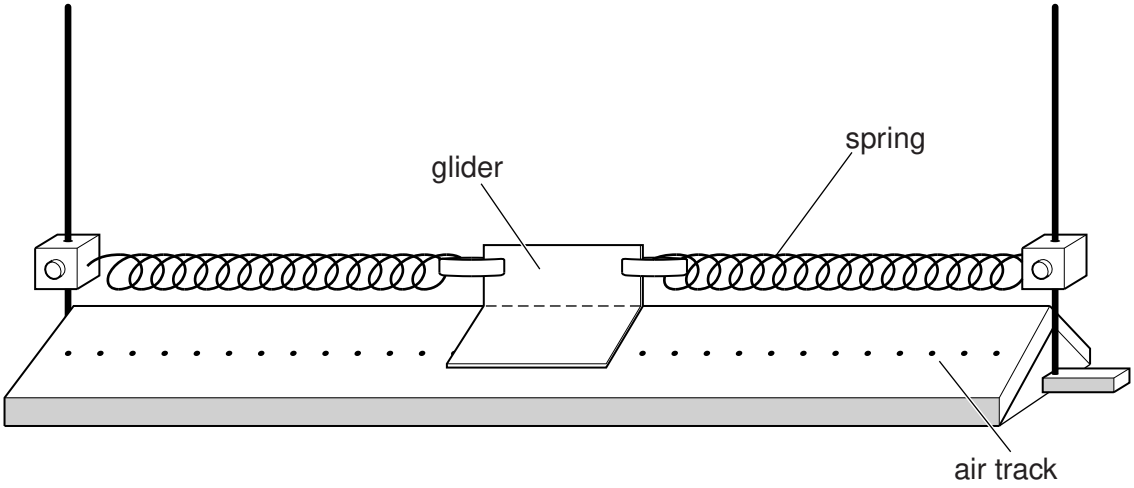


Fig. 3.2

The variation of elastic potential energy stored in the springs with displacement, x, of the glider is shown in Fig. 3.3.

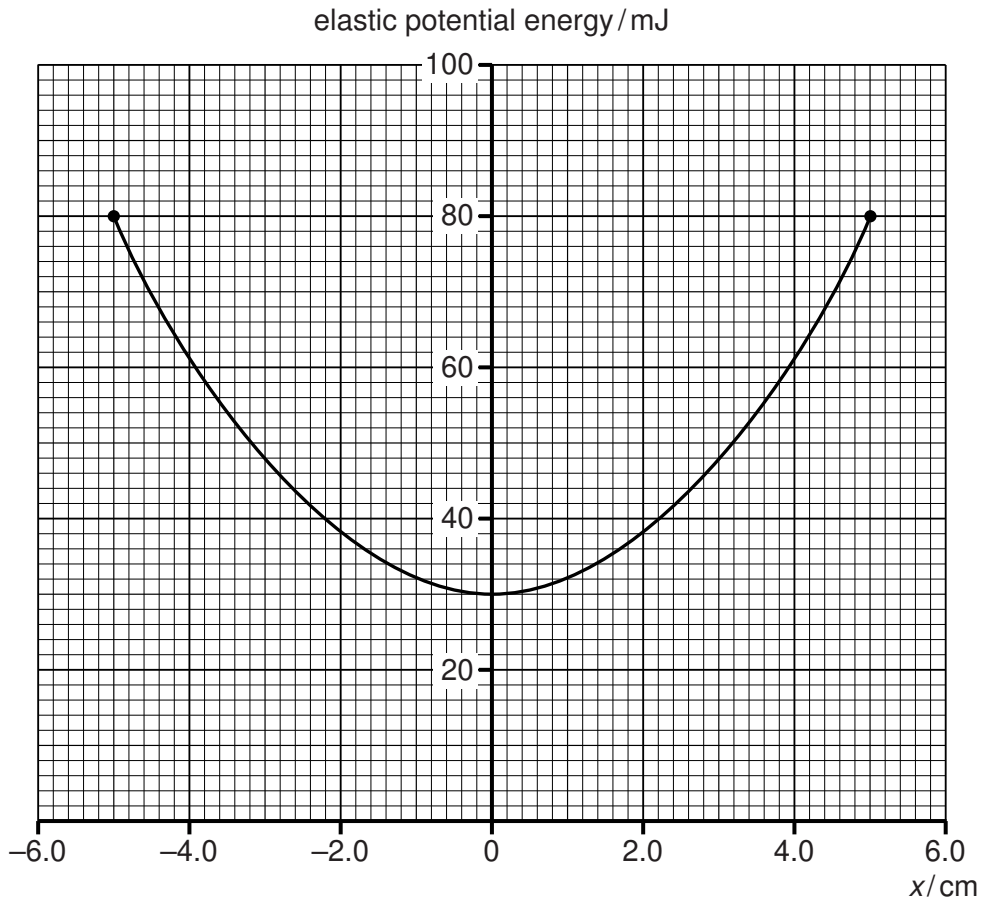


Fig. 3.3

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(i) Draw on Fig. 3.3 a graph to show the variation of kinetic energy with displacement of the glider. **[2]**

(ii) Calculate the maximum speed of the glider.

maximum speed = ... $m\,s^{-1}$ **[1]**

(iii) Determine the period of the oscillations.

period = ... s **[2]**

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4 This question is about Mars and its two moons, Phobos and Deimos.

(a) Calculate

(i) the mass of Mars

gravitational field strength on the surface of Mars is $3.7\,N\,kg^{-1}$
radius of Mars is $3.4 \times 10^3\,km$

mass = ... kg **[2]**

(ii) the gravitational field strength at a height of $3.4 \times 10^3\,km$ **above** the surface of Mars.

gravitational field strength = ... $N\,kg^{-1}$ **[1]**

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(b) (i) State Kepler's third law.

.....

..... **[1]**

(ii) Phobos completes a circular orbit of mean radius 9.4×10^3 km in 7.7 hours. Deimos completes its orbit in 30 hours.
Calculate the mean radius of the orbit of Deimos.

mean radius = ... km **[2]**

(c) Recent observations of Phobos indicate that it is slowly spiralling towards the surface of Mars. State and explain how you would expect this to affect the speed of Phobos.

.....

.....

..... **[1]**

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Question 5 begins on page 12

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5 A binary star consists of two stars that orbit about their common centre of mass **C**, as shown in Fig. 5.1.

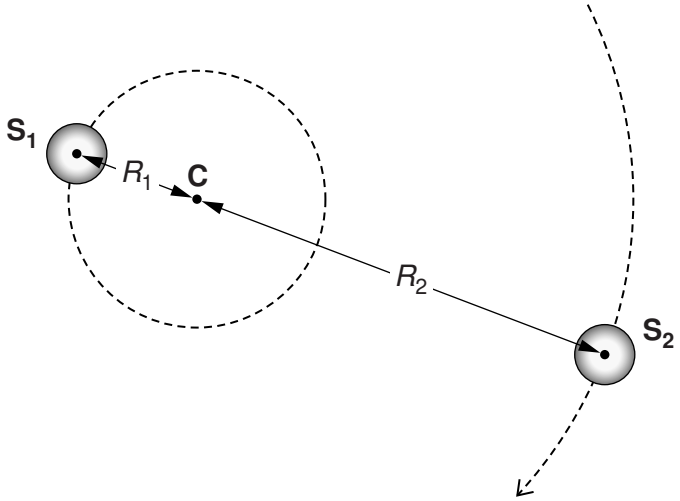


Fig. 5.1

The star $\mathbf{S_1}$ has mass M_1 and orbits in a circle of radius R_1. Star $\mathbf{S_2}$ has mass M_2 and a circular orbit of radius R_2. Both stars have the same orbital period T about **C**.

(a) Using the terms G, M_1, M_2, R_1, R_2 and T write an expression for

(i) the gravitational force F experienced by each star

[1]

(ii) the centripetal force F_1 acting on the star $\mathbf{S_1}$

[1]

(b) Use **(a)(ii)** to show that the ratio of the masses of the stars is given by the expression

$$\frac{M_1}{M_2} = \frac{R_2}{R_1}$$

[2]

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(c) The ratio of the masses, M_1/M_2, is equal to 3.0 and the separation between the stars is 4.8×10^{12} m.
Calculate the radii R_1 and R_2.

R_1 = ... m

R_2 = ... m **[3]**

(d) The orbital period T of each star is 4.0 years.
Calculate the orbital speed of $\mathbf{S_1}$.

speed = ... $m\,s^{-1}$ **[2]**

(e) Calculate the mass of $\mathbf{S_2}$.

mass = ... kg **[3]**

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6 Fig. 6.1 shows a tube containing small pellets of lead. When the tube is inverted the pellets of lead fall freely through a vertical height equal to the length of the tube. The pellets are warm after the tube has been inverted many times.

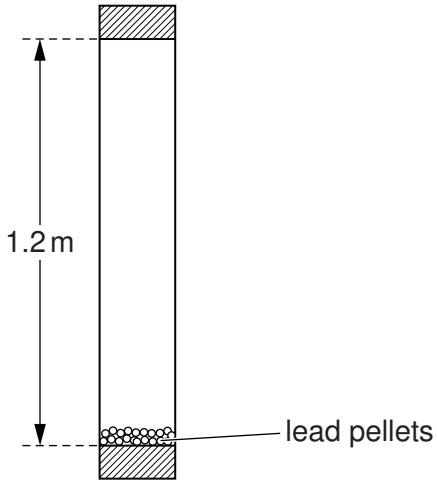


Fig. 6.1

(a) Describe the energy changes that take place to the lead pellets following one inversion of the tube.

.....

.....

..... **[2]**

(b) The tube is used in an experiment to determine the specific heat capacity of lead. The following results are obtained.

total mass of lead pellets = 0.025 kg
number of inversions = 50
length of tube = 1.2 m
change in temperature of the lead = 4.5 °C

Use this information to calculate the specific heat capacity of the lead.

specific heat capacity ..... $J\,kg^{-1}\,K^{-1}$ **[4]**

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(c) State **two** assumptions you have made in your calculation of the specific heat capacity.

.....

.....

.....

..... **[2]**

(d) State and explain the change, if any, you would expect to see in the temperature rise if the mass of the lead pellets is doubled.

.....

.....

.....

..... **[2]**

Question 7 begins on page 16

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7 **(a)** Explain how the *internal energy* of an ideal gas is related to its temperature.



In your answer, you should use appropriate technical terms spelled correctly.

.....

.....

.....

.....

..... **[2]**

(b) A weather balloon is designed to be inflated to a maximum volume of $1.4 \times 10^4\,m^3$. To launch the balloon it is partially inflated with 80 kg of helium at a pressure of 1.0×10^5 Pa and a temperature of 21 °C.

molar mass of helium = $0.004\,kg\,mol^{-1}$

(i) Calculate the volume of the partially inflated balloon.

volume = ... m^3 **[3]**

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(ii) To limit the maximum height that the balloon can reach, helium is allowed to leak out through a control valve.
Determine the number of moles of helium that need to escape for the weather balloon to reach its maximum volume when the pressure is 1.2×10^3 Pa and the temperature is −40 °C.

number of moles = ... mol **[2]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

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GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2016

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
BOD	Benefit of doubt given
BP	Blank Page
CON	Contradiction
	Incorrect Response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct Response
AE	Arithmetic error
	Wrong physics or equation

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Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise **once** only in the entire paper.
Any exception to this rule will be mentioned in the Guidance.
Penalise a rounding error in the second significant figure **once** only in the paper.

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Question			Answer		Mark	Guidance
1	(a)	(i)	Gradient /It is the **acceleration** which is the same (for both) (AW)		B1	**Note:** **acceleration** must be spelled correctly for this mark **Allow**: Gradient /It is the **acceleration** and **acceleration** is free fall/*g*/*9.8 (1)*
		(ii)	Collision is inelastic / kinetic energy is lost (on impact with the ground) Idea that area is height (above ground) / Height (at E) is less (than height of A) (AW)		B1 B1	 **Not** heights are not the same **Allow:** displacement or distance travelled by ball for height
	(b)	(i)	$u^2 = 2\times 9.8(1)\times 1.7 \quad (=33.32)$ $u = 5.8 \ (\text{m s}^{-1})$		B1	**Not** g = 10 **Note** answer to 3 sf is 5.78 (m s^{-1})
		(ii)	**EITHER** $F\Delta t = m(v-u)$ **and** $F\Delta t = 16\times 75\times 10^{-3}$ $16\times 75\times 10^{-3} = 0.13\times[v-(-5.78)]$ $v = 3.5 \quad (\text{ms}^{-1})$	**OR** $a = F/m$ = 16/0.13 (a =123) (upwards positive) v = -5.78 +123 x 75 x 10^{-3} = 3.5 (m s^{-1})	C1 A1	**Allow** ECF from b(i) **Allow** v = $\frac{14}{23}$ x 5.78 (from graph for C1 mark) **Note:** answer to 3 sf is 3.46 (ms^{-1}) Using u = - 5.8 leads to v = 3.4 scores 2/2 Using u = +5.78 leads to v = 15 scores 1/2 Using equation of motion with a = 9.8(1) is WP scores 0/2
		(iii)	$h = \frac{v^2}{2g} = \frac{3.46^2}{2\times 9.8}$ $h = 0.61$ (m)		B1	**NO ECF** **Allow** graphical method using $h \propto v^2$ **Allow** answer in range 0.59 – 0.63 (m)
				Total	**7**	

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Question			Answer	Mark	Guidance
2	(a)		A body will remain at rest or keep travelling at constant velocity unless acted upon by a resultant/net (external) force (AW)	B1	**Allow** 'speed in straight line' for velocity **Allow** 'uniform motion'
	(b)	(i)	They have equal magnitude/ same size They are the same type / nature	B1 B1	**Allow** act for the same time **Allow** have same line of action
		(ii)	Act in opposite directions Act on different bodies	B1 B1	**Not** act in different directions
	(c)	(i)	$\frac{dm}{dt} = \rho A v$ $= 1\times10^{3}\times3.3\times10^{-4}\times25$ $(=8.25\,\text{kg s}^{-1})$	B1	
		(ii)	Weight (of fireman) = 92*g* / *W* = 92 x 9.8(1) (= 903 N) Vertical component of water force = 8.25 x 25 sin 55 (= 169 N) Vertical component of contact force = 169 + 903 = 1100 N	C1 M1 A1	**Allow** use of 8.3 leading to 170 N **Note** answer to 3 sf is 1070 N **Note:** a **bald** $\frac{92g}{\sin 55} = 1100$ is WP scores 0/3
			Total	**9**	

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Question			Answer	Marks	Guidance
3	(a)	(i)	C and F	B1	
		(ii)	G	B1	
		(iii)	$5\pi/4$ (= 1.25 π) or 3.93 (rad)	B1	
	(b)	(i)	Correct shape graph (by eye) Through the points (-5,0) (0,50) and (5,0)	B1 B1	**Note :** Max KE = 80 – 30 = 50 (mJ)
		(ii)	½ (0.45)v_{max}^2 = 50 x 10^{-3} v_{max} = 0.47 (m s^{-1})	A1	**Allow** ECF if max value on y axis from b(i) is used. If max KE = 80 mJ then v_{max} = 0.596 = 0.60 (m s^{-1})
		(iii)	$v_{max} = \frac{2\pi A}{T}$ $T = \frac{2\pi(5.0\times10^{-2})}{0.47}$ $T = 0.67\,(s)$	C1 A1	**Allow** C1 mark for correct frequency =1.5 (Hz) ECF from b(ii) Using v_{max} = 0.60 leads to T = 0.52 (s) and using v_{max} = 0.596 leads to T = 0.53 (s)
			Total	**8**	

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Question			Answer	Marks	Guidance
4	(a)	(i)	$M = \frac{gR^2}{G}$ $M = \frac{3.7 \times (3.4 \times 10^6)^2}{6.67 \times 10^{-11}}$ [any subject] $M = 6.4 \times 10^{23}$ (kg)	C1 A1	If square is omitted from 3.4 x 10^6 score is 0/2. **Allow** 1 mark for M = 6.4 x 10^{17} (Mars radius km not converted to m)
		(ii)	$g_h = \frac{g_s R^2}{(R+h)^2} = \frac{3.7 \times (3.4 \times 10^6)^2}{(6.8 \times 10^6)^2}$ $g_h = 0.93$ (N kg^{-1})	A1	**Allow**: $h = R$ so $g_h = ¼\ g_s$ **Allow** use of $g_h = \frac{GM}{(R+h)^2}$ **Allow** ECF from a(i)
	b	(i)	$T^2 \propto R^3$ with T = period **and** R = orbital radius	B1	**Allow** separation / distance between bodies Do **not** allow bald radius for R
		(ii)	$\left(\frac{R_D}{R_P}\right)^3 = \left(\frac{T_D}{T_P}\right)^2$ $R_D = 9.4 \times 10^3 \times \left(\frac{30}{7.7}\right)^{2/3}$ [any subject] $R_D = 2.3 \times 10^4$ (km)	C1 A1	C1 mark is for correct substitution **Allow** use of $R^3 = \frac{GMT^2}{4\pi^2}$ with possible ECF from a(i) [Note M=6.4 x 10^{17} leads to 2.3 x 10^2 km]
	(c)		Speed will increase Because a decrease in orbital radius results in a decrease in period (by Kepler's law) / Correct reference to centripetal force = gravitational force or $v^2 = Gm/R$	M0 A1	**Allow** GPE decreases so KE increases
			Total	**7**	

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Question			Answer	Marks	Guidance
5	(a)	(i)	$F = \dfrac{GM_1M_2}{(R_1 + R_2)^2}$	B1	Ignore sign
		(ii)	$F_1 = \dfrac{4\pi^2 M_1 R_1}{T^2}$	B1	Allow $F_1 = \left(\dfrac{2\pi}{T}\right)^2 M_1R_1$
	(b)		Centripetal forces on both star are same magnitude / $F_1 = F_2$ / answer to a(ii) equated to similar expression for **S_2** Correct working starting from <u>correct</u> a(ii) forces $\dfrac{M_1}{M_2} = \dfrac{R_2}{R_1}$	M1 A1 A0	Eg $\dfrac{4\pi^2 M_1R_1}{T^2} = \dfrac{4\pi^2 M_2R_2}{T^2}$
	(c)		$\dfrac{R_2}{R_1} = 3 \quad \therefore \quad R_2 = 3R_1$ *and* $R_1 + R_2 = 4.8\times10^{12}$ $R_1 = \dfrac{1}{4}\times 4.8\times10^{12} = 1.2\times10^{12}$ (m) $R_2 = \dfrac{3}{4}\times 4.8\times10^{12} = 3.6\times10^{12}$ (m)	C1 A1 A1	 Allow 2 marks if $R_1 = 3.6 \times 10^{12}$ (m) And $R_2 = 1.2 \times 10^{12}$ (m)
	(d)		$v_1 = \dfrac{2\pi R_1}{T} = \dfrac{2\pi\times1.2\times10^{12}}{4\times3.16\times10^7}$ $v_1 = 6.0\times10^4 \quad (\text{m s}^{-1})$	C1 A1	Possible ECF Mark is for substitution Max 1 mark if T is not converted to seconds (leads to speed = 1.9×10^{12})

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Question			Answer	Marks	Guidance
	(e)		$\frac{M_1 v_1^2}{R_1} = \left(\frac{4\pi^2 R_1 M_1}{T^2}\right) = \frac{GM_1M_2}{(R_1+R_2)^2}$ $M_2 = \frac{(6.0\times10^4)^2 \times (4.8\times10^{12})^2}{6.67\times10^{-11}\times1.2\times10^{12}}$ $M_2 = 1.0\times10^{33}$ (kg)	C1 C1 A1	**Allow ECF** from (c) and (d) **only** if method is correct **Allow** this C1 mark if M_1 has been cancelled **Special case** Use of $T^2 \propto R^3$ will lead to 1.73 x 10^{33} (kg) this scores 1 mark. Do not allow any ECF if this method is used.
			Total	**12**	

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Question			Answer	Marks	Guidance
6	(a)		(Gravitational) potential energy is converted to kinetic energy which is then converted to thermal energy/heat Statement that KE to thermal takes place on impact	B1 B1	Not 'GPE to KE and thermal'
	(b)		GPE converted in one inversion = 0.025 x 9.8 x 1.2 (= 0.294) GPE converted in 50 inversions = 0.294 x 50 = 14.7 (J) (Use of Q =mcΔθ to give) 14.7 = 0.025 x c x 4.5 c = 130 (J kg^{-1} K^{-1})	C1 A1 C1 A1	**Allow** follow through from their total GPE converted **Note** answer to 3 sf = 131 (J kg^{-1} K^{-1})
	(c)		• No heat is absorbed by the tube/ lost (by conduction) through the tube/all heat goes to pellets • All the lead falls through the same height or length of tube/ Lead does not bounce on impact	B1 B1	**Ignore** 'heat lost to surroundings/air'
	(d)		Temperature change is the same (Since mass is doubled) (max) GPE/KE/total energy is doubled **AND** Q is doubled	M1 A1	**Allow** mgh = mcΔθ and m is same **or** m cancels **Alternative answer** **Allow** 2 marks for any sensible practical suggestions why T is **not** the same eg double mass means more lead which will **not** fall full length of tube.
			Total	**10**	

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Question			Answer	Marks	Guidance
7	(a)		An ideal gas has zero/negligible (electrical) PE / All internal energy is (translational) KE (translational) KE $\propto$ absolute/ thermodynamic /kelvin temperature	B1 B1	 **Allow** internal energy $\propto$ absolute/ thermodynamic /kelvin temperature Note: absolute/thermodynamic/kelvin must be used and spelled correctly for second mark
	(b)	(i)	Number of moles of helium = 80/0.004 (= 2×10^4) $V = \frac{nRT}{p} = \frac{2 \times 10^4 \times 8.31 \times 294}{1.0 \times 10^5}$ $V = 490$ (m^3)	C1 C1 A1	**Allow** use of $pV=NkT$ Use of T in ºC is WP giving max 1 out of 3 **Allow** follow through(FT) from an error in n
		(ii)	number of moles remaining $= \frac{pV}{RT} = \frac{1.2 \times 10^3 \times 1.4 \times 10^4}{8.31 \times 233}$ = 8.68 x 10^3 Number of moles escaping = 2 x 10^4 - 8.68 x 10^3 = 1.1 x 10^4	C1 A1	Use of T in ºC is WP 0/2
			Total	**7**	

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OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
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Oxford Cambridge and RSA

Thursday 11 June 2015 – Morning

A2 GCE PHYSICS A

G484/01 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

* G 4 8 4 0 1 *

* 4 8 6 5 8 7 5 5 0 7 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 **(a)** Apollo-11 was the first manned spacecraft to land on the Moon. Fig. 1.1 shows part of the equipment left on the surface by the astronauts and the forces acting upon it.

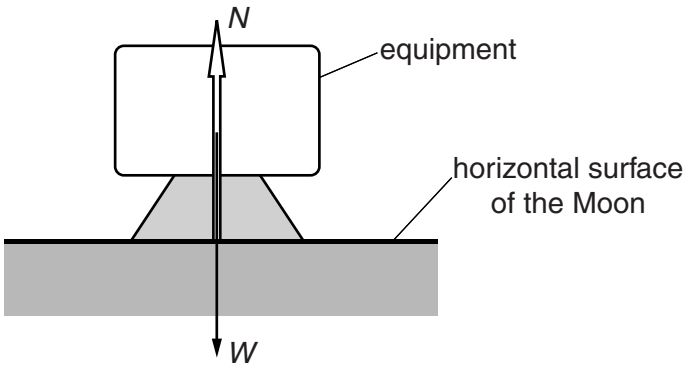


Fig. 1.1

According to Newton's third law interacting forces always occur in pairs. A student states that the normal contact force *N* is equal in magnitude to the weight *W* because of Newton's third law.

(i) Give **two** reasons why the student's statement is incorrect.

.....

.....

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.....

.....

..... **[2]**

(ii) Use Newton's third law to state the magnitude and location of the force pairing up with the weight *W*.

.....

..... **[1]**

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(b) While on the surface of the Moon one of the astronauts hit a golf ball with a club and declared that it went for 'miles and miles'. The ball was given an initial velocity u at a fixed angle θ to the horizontal. Show that the horizontal distance travelled by the ball is directly proportional to u^2.

[3]

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2 **(a)** A solar-powered ion propulsion engine creates and accelerates xenon ions. The ions are ejected at a constant rate from the rear of a spacecraft, as shown in Fig. 2.1.
The ions have a fixed mean speed of $3.2 \times 10^4\,m\,s^{-1}$ relative to the spacecraft.
The initial mass of the spacecraft is $5.2 \times 10^3\,kg$.

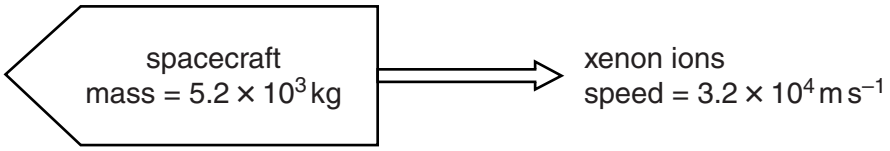


Fig. 2.1

(i) Calculate the mass of one xenon ion.
molar mass of xenon = $0.131\,kg\,mol^{-1}$

mass ..... kg **[1]**

(ii) The engine is designed to eject 9.5×10^{18} xenon ions per second.
Determine the initial acceleration of the spacecraft.

acceleration = ... $m\,s^{-2}$ **[3]**

(iii) State in words the law that you have used to solve **a(ii)**.

In your answer, you should use appropriate technical terms spelled correctly.

.....

.....

..... **[1]**

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(iv) State and explain how you would expect the acceleration of the spacecraft to change, if at all, while the engine is running.

.....

.....

.....

.....

..... **[3]**

(b) A small rocket is used to detach a satellite of mass 180 kg from the spacecraft. Fig. 2.2 shows the variation of the force F created by the rocket on the satellite with time t.

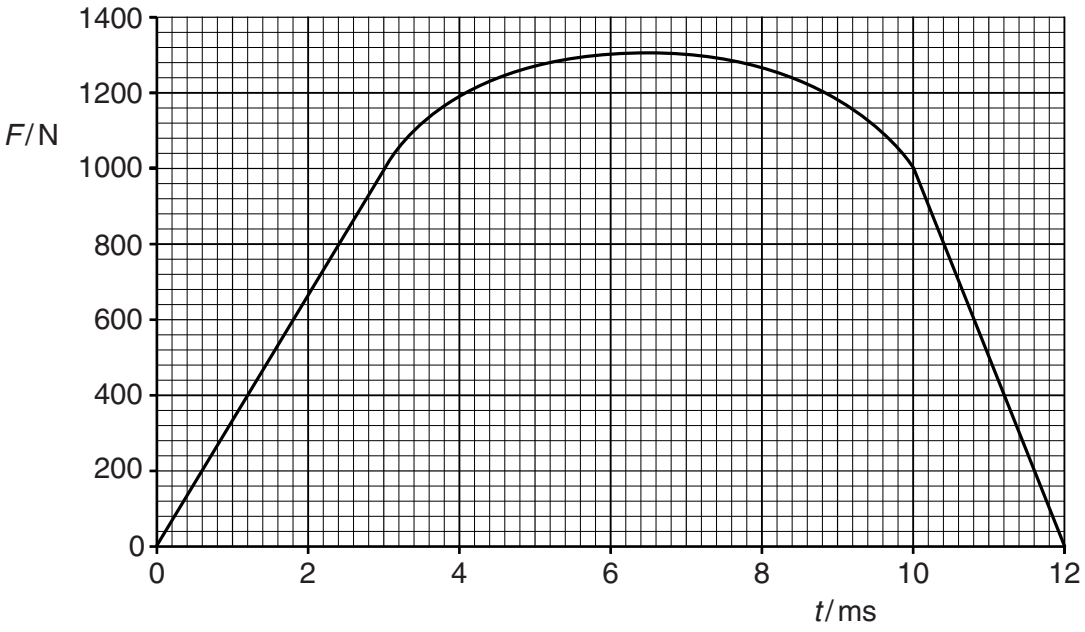


Fig. 2.2

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Use Fig. 2.2 to

(i) determine the change in the velocity of the satellite as a result of the force *F* applied for the period of 12 ms.

change in velocity = ... $m\,s^{-1}$ **[4]**

(ii) describe how the acceleration of the satellite varies between 0 and 10 ms.

.....

.....

.....

.....

..... **[2]**

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3 Fig. 3.1 shows a metal plate attached to the end of a spiral spring. The end **A** of the spring is fixed to a rigid clamp. The plate is pulled down by a small amount and released. The plate performs simple harmonic motion in a vertical plane at a natural frequency of 8 Hz and the spring remains in tension at all times.

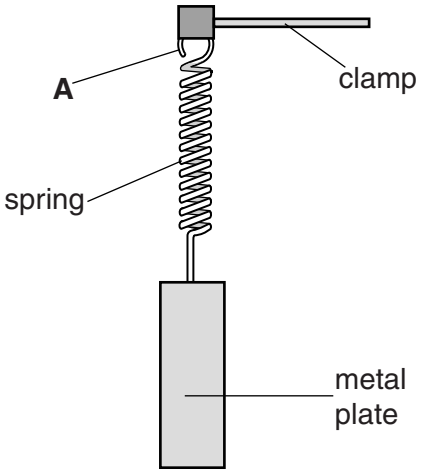


Fig. 3.1

(a) (i) On Fig. 3.2 sketch an acceleration *a* against displacement *x* graph for the motion of the metal plate. You are not required to give values on the axes.

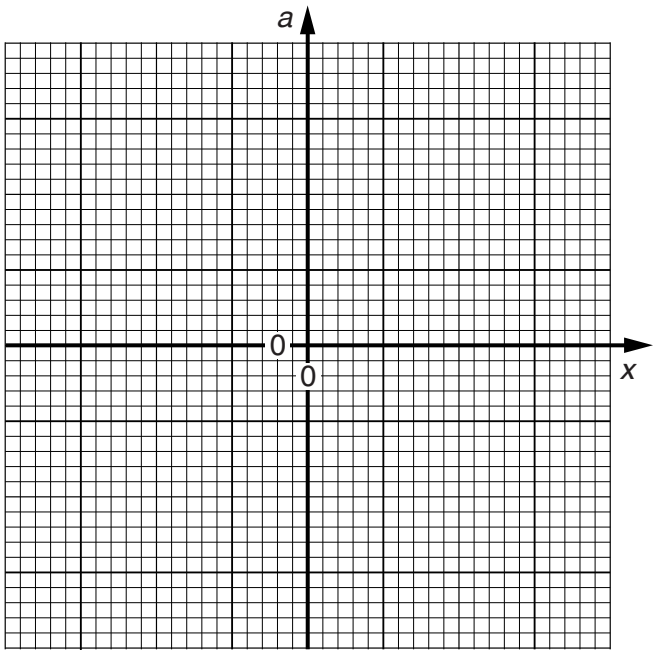


Fig. 3.2

[2]

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(ii) Explain how your graph could be used to determine the frequency of oscillation of the metal plate.

.....

.....

..... **[2]**

(b) Fig. 3.3 shows the variation of the vertical velocity v of the plate with time t at a frequency of 8 Hz.

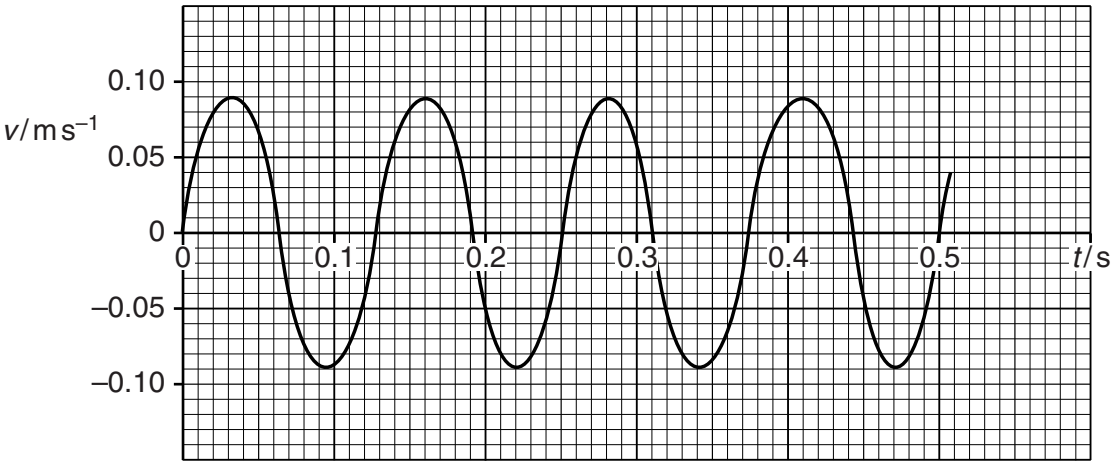


Fig. 3.3

Use the graph to determine

(i) the amplitude of the motion

amplitude = ... m **[2]**

(ii) the maximum vertical acceleration of the plate.

acceleration = ... $m\,s^{-2}$ **[2]**

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(c) The metal plate is now immersed in light oil which provides a constant frictional force to the plate. On Fig. 3.4 draw carefully the graph you would expect to obtain for the variation of the vertical velocity v with time t. As a guide a copy of the graph in Fig. 3.3 is drawn for you.

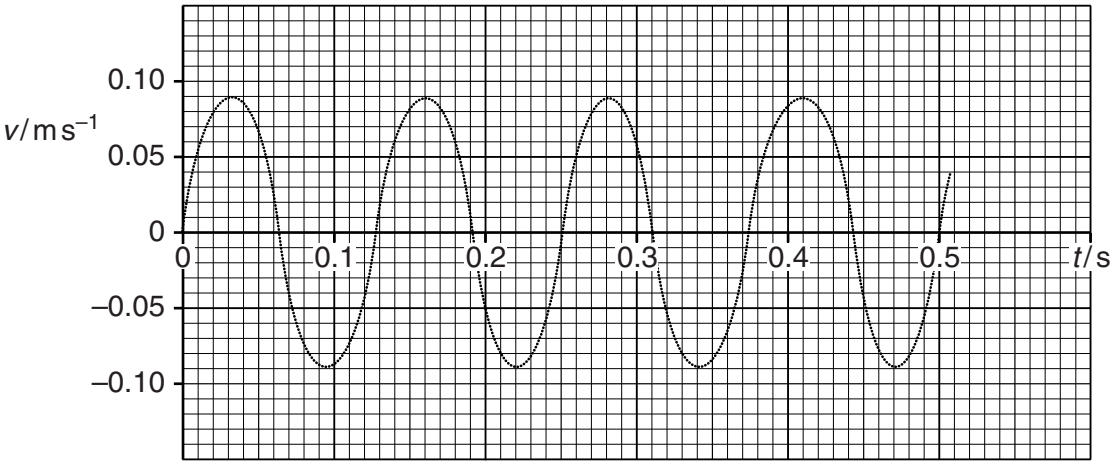


Fig. 3.4

[2]

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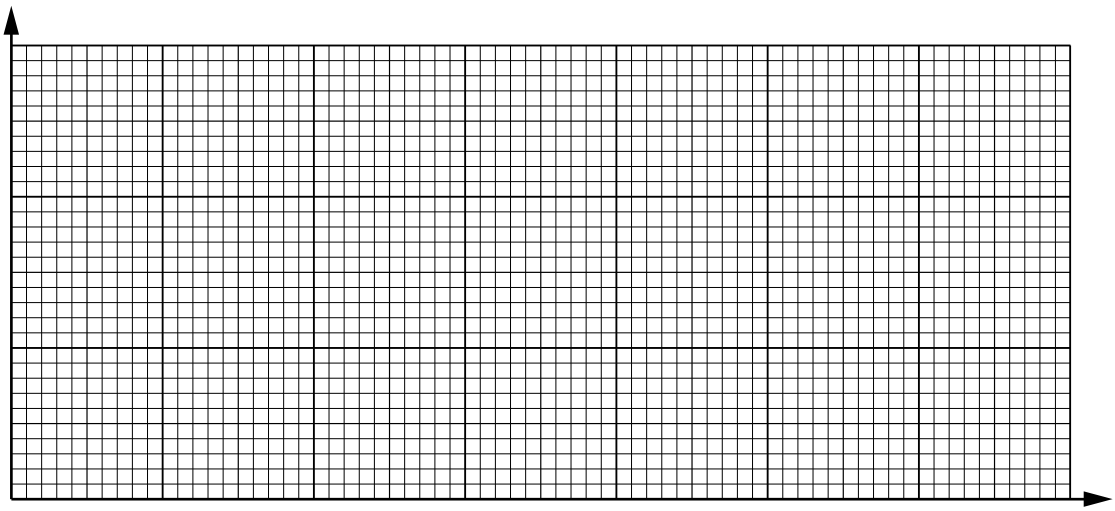
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(d) The plate is now removed from the oil and the point **A** on the spring connected to an oscillator that vibrates vertically with constant amplitude. The frequency of the oscillator is increased slowly from 0 Hz to 12 Hz.

Describe and explain the motion of the metal plate during this procedure.

Sketch a labelled graph to help with your explanation.

In your answer, you should use appropriate technical terms spelled correctly.



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..... **[3]**

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4 **(a)** Write a word equation which states Newton's law of gravitation.

.....

.....

..... **[1]**

(b) A planet of mass *m* moves in a circular orbit of radius *r* about a star of mass *M*. The planet has an orbital period *T*.

Use your knowledge of circular motion and Newton's law of gravitation to derive Kepler's third law.

[4]

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(c) The star HD10180 in the constellation Hydrus is notable for its large planetary system. The period T and the mean orbital radius r for HD10180's planets have been deduced from recent observations. Fig. 4.1 has been constructed using these data.

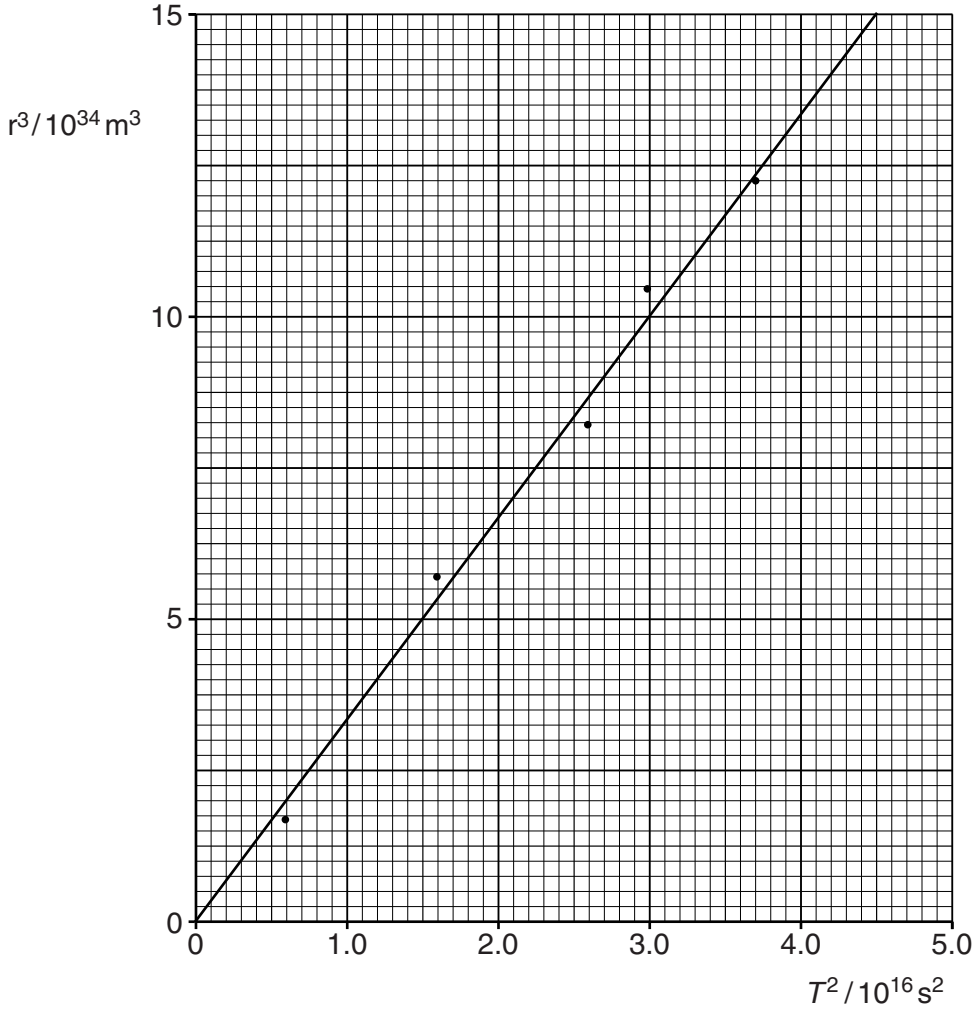


Fig. 4.1

(i) State what features of Fig. 4.1 support the view that Kepler's third law may be applied to this system.

.....

.....

..... **[1]**

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(ii) Use Fig. 4.1 to determine the mass of the star HD10180.

mass = ... kg **[3]**

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5 Lasers are often used to form precision-welded joints in titanium. To form one such joint it is first necessary to increase the temperature of the titanium to its melting point. Fig. 5.1 shows the joint and the volume of titanium to be heated.

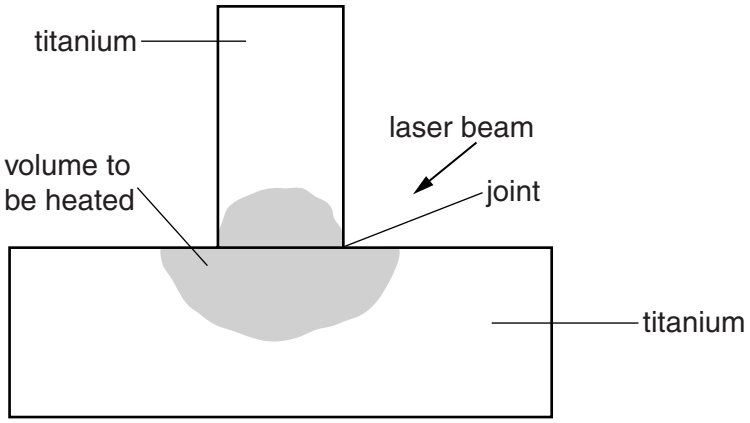


Fig. 5.1

The photon beam from the laser is focused onto the shaded volume of the joint and is converted into thermal energy in the titanium.

(a) The wavelength of the photons is 1.1×10^{-6} m.

Show that the energy of a photon in the beam is 1.8×10^{-19} J.

[1]

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(b) Photons are emitted from the laser at a constant rate of $6.3 \times 10^{19}\,s^{-1}$.

Estimate the time taken to raise the temperature of the shaded volume of titanium shown in Fig. 5.1 to melting point. Use the data below for your calculations.

initial temperature = 20 °C
melting point of titanium = 1700 °C
density of titanium = $4.5 \times 10^{3}\,kg\,m^{-3}$
specific heat capacity of titanium = $520\,J\,kg^{-1}\,K^{-1}$
shaded volume of titanium being heated = $8.1 \times 10^{-12}\,m^{3}$.

time = ... s **[3]**

(c) In practice it takes a longer time to reach the melting point.
State and explain **two** factors that will increase the time taken.

.....

.....

.....

..... **[2]**

(d) To complete the weld more photons must be focused onto the joint. During this final stage the temperature remains constant. Explain why this is to be expected.

.....

.....

..... **[1]**

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6 **(a)** Fig. 6.1 shows how the volume V of a fixed mass of an ideal gas at constant pressure varies with temperature θ from 0 °C to 120 °C.

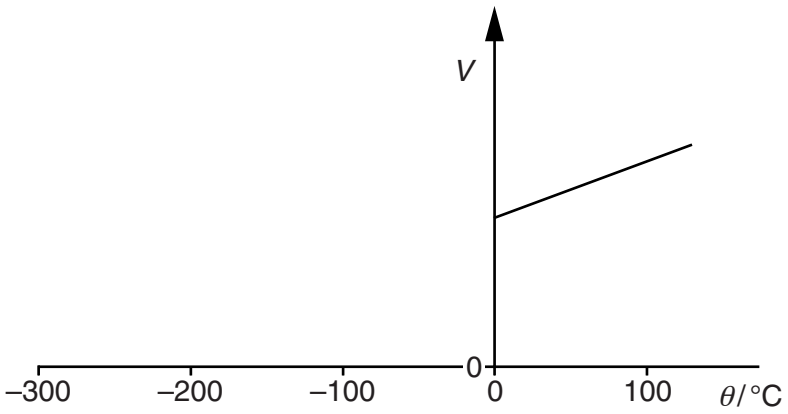


Fig. 6.1

Describe how this graph leads to the concept of an absolute zero of temperature.

.....

.....

.....

..... **[2]**

(b) A mass of gas is enclosed in a tank. The gas is cooled until it becomes a liquid. During this process its internal energy changes.

(i) State what is meant by the *internal energy* of the gas.

.....

.....

..... **[1]**

(ii) Explain why the internal energy of the gas differs from that of its liquid phase.

.....

.....

.....

.....

..... **[2]**

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(c) A scuba diver uses air in which the percentage of nitrogen is reduced by adding helium to form a substance known as Trimix. A $1.2 \times 10^{-2}\,m^3$ rigid steel scuba diving tank contains 45 mol of air at a temperature of 20 °C.

(i) Calculate the pressure in the tank.

pressure = ... Pa **[2]**

(ii) The tank is then connected to a cylinder of volume $2.0 \times 10^{-3}\,m^3$ containing helium at a pressure of 5.0×10^{7} Pa and a temperature of 20 °C as shown in Fig. 6.2.

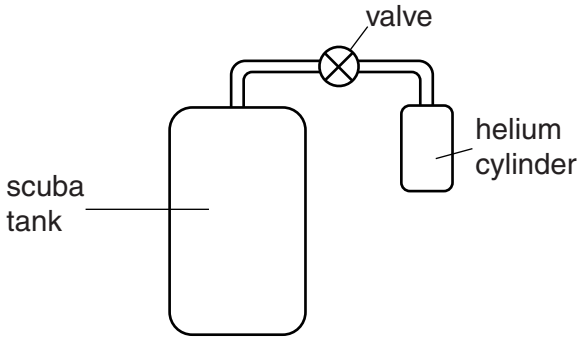


Fig. 6.2

The valve is opened allowing the gases to mix. When mixed the final temperature is 20 °C. Calculate the final pressure of the resulting Trimix in the scuba tank helium cylinder system.

pressure = ... Pa **[3]**

(iii) Explain why you would expect this pressure to decrease when the tank is used by a diver in water where the temperature is 4 °C.

.....

.....

..... **[1]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2015

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect Response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct Response
AE	Arithmetic error
	Wrong physics or equation

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Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance.
Penalise a rounding error in the second significant figure once only in the paper.

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Question			Answer	Mark	Guidance
1	(a)	(i)	*N* & *W* act on the same body / Newton's 3rd Law forces should act on different bodies *N* & *W* are different types (of force) / are not same type	B1 B1	**Allow:** 3rd law pair to W acts on (centre of)Moon 3rd law pair to N acts on surface of Moon **Allow:** *N* is electromagnetic/electrostatic/electrical/contact *W* is gravitational. **Allow:** Paired forces should be of the same type **Ignore** a general statement of Newton's 2nd or 3rd law
		(ii)	Equal to / same as *W* acting on (the centre of) the Moon	B1	Do not allow 'acts on **surface** of Moon Diagram is not sufficient for this mark
	(b)		Clear use of vertical motion with downward acceleration **and** horizontal motion at constant velocity vertically $0 = (u\sin\theta)t - \frac{1}{2}g_M t^2$ $t = \frac{2u\sin\theta}{g_M}$ horizontaly $x = u\cos\theta \times \frac{(2u\sin\theta)}{g_M}$ $x \propto \frac{u^2}{g_M}$	B1 M1 A1 A0	If sin θ and cos θ are confused allow max 1/3. **Allow:** use of *a* for g_m **Allow:** determination of time to max height using $v=u+at$ Then total time = 2 x time to max height (M1) **Allow** use of 9.81 instead of g_m
			Total	**6**	

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Question			Answer	Mark	Guidance
2	(a)	(i)	$m = \frac{0.131}{6.02\times10^{23}}$ $m = 2.18\times10^{-25}$ (kg)	A1	
		(ii)	mass of xenonejected/ s $= m_{Xe} = 2.2\times10^{-25}\times9.5\times10^{18}$ $(= 2.07\times10^{-6})$ $F_{Xe} = \left(m_{Xe}\frac{\Delta v}{\Delta t}\right) = 2.2\times10^{-25}\times9.5\times10^{18}\times3.2\times10^{4}$ $(= 0.06627)$ $a_S = \left(\frac{F_{Xe}}{m_s}\right) = \frac{2.2\times10^{-25}\times9.5\times10^{18}\times3.2\times10^{4}}{5.2\times10^{3}}$ $a_S = 1.3\times10^{-5}$ (m s^{-2})	C1 C1 A1	Possible ECF **Allow:** $5.2\times10^{3}\times\Delta v = 2.07\times10^{-6}\times3.2\times10^{4}$ $\Delta v = 1.3\times10^{-5}$ $a_S = 1.3\times10^{-5}$ (m s^{-2})
		(iii)	Rate of change of **momentum** (of an object) is proportional to the resultant / net (external) force acting upon it. (AW) **OR** statement of law of Conservation **of momentum** in a closed system/no external forces	B1	**Momentum** must be spelled correctly **Allow:** ' equal to' instead of 'proportional to' **Allow:** statement of Newton's 3rd Law provided it is clear the forces act on **different** bodies and **opposite** is spelled correctly
		(iv)	Force (on spacecraft) is constant Mass (of spacecraft) decreases (as xenon is ejected) Acceleration increases	B1 M1 A1	**Not:** Weight (of spacecraft) or 'it is lighter'
	(b)	(i)	Area under graph in range 10.5 to 11.5 (Ns) Area under graph in range 10.8 to 11.2 (Ns) $\Delta v = \frac{\text{impulse}}{m} = \frac{\text{area}}{m}$ $= \frac{11.0}{180}$ $= 6.1\times10^{-2}$ (ms^{-1})	C1 C1 C1 A1	Possible FT for using their area / 180 Use of mass of spacecraft rather than satellite scores 1 out of last 2 marks.
		(ii)	From 0 to 3 (ms) acceleration increases linearly/uniformly/ at constant rate/ at a steady rate. (From 6.5 ms) onwards/later/at end the acceleration decreases	B1 B1	**Allow:** upper limit on time in range 3.0 to 3.5 ms Do not credit use **of 'constantly'** for this mark **Not 'decelerates'**
			Total	**14**	

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Question			Answer	Marks	Guidance
3	(a)	(i)	Straight line <u>through</u> the origin Negative gradient and symmetrical about (0,0) by eye.	M1 A1	
		(ii)	Linking gradient to $[2\pi f]^2$. Frequency $= \frac{\sqrt{\text{gradient}}}{2\pi}$	C1 A1	**Allow:** use of a single data point used in $a = (-)[2\pi f]^2 x$ **Note** frequency must be the subject of this equation
	(b)	(i)	$A = \frac{v_{max}}{2\pi f} = \frac{0.09}{2\pi \times 8.0}$ $A = 1.8 \times 10^{-3}$ (m)	C1 A1	**Allow:** values for T in range 0.125 to 0.13 s
		(ii)	$a_{max} = (2\pi f)^2 A$ $a_{max} = (2\pi \times 8.0)^2 \times 1.8 \times 10^{-3}$ $a_{max} = 4.5 \quad (\text{m s}^{-2})$	C1 A1	Possible ecf from b(i) **Allow:** Tangent drawn on graph at any $v = 0$ point (C1) calculation of gradient (A1)
	(c)		Curve with same frequency /period max velocities decreasing at **three** successive **positive** peaks	B1 B1	**Allow**: ½ small square error on $v = 0$ points
	(d)		Axes labelled and graph showing correct bell shaped curve (amplitude increases then decreases) <u>Maximum/largest</u> amplitude or energy at f=8 Hz / natural frequency When <u>driving/oscillator's frequency</u> is equal to natural frequency / 8 Hz **resonance** occurs (AW).	B1 B1 B1	**Allow** this mark if curves are drawn asymptotically (to 8 Hz) May be scored on diagram or in text '**resonance**'/ '**resonant**' to be spelled correctly for this mark to be scored.
			Total	**13**	

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Question			Answer	Marks	Guidance
4	(a)		(gravitational) force $\propto$ $\frac{\text{[mass 1] [mass 2]}}{\text{[separation (of masses)]}^2}$	B1	**Allow:** equation in symbols if symbols are defined **Allow:** equality **Not** radius
	(b)		Use of $F = \frac{GMm}{R^2}$ AND $F = \frac{mv^2}{R}$ $v = \frac{2\pi R}{T}$ $\frac{GM}{R^2} = \frac{1}{R}\left(\frac{(2\pi R)}{T}\right)^2$ $R^3 = \frac{GM}{4\pi^2}T^2$ OR $R^3 \propto T^2$	B1 B1 B1 A1	**Ignore** signs **Allow:** equation with cancelling shown This mark is for some evidence of substitution and manipulation **Allow:** subject must be either R^3 or T^2 **Allow:** Max 1 mark for bald statement of $R^3 = \frac{GM}{4\pi^2}T^2$ without proof
	(c)	(i)	Graph is a straight line / has constant gradient and passes through the origin	B1	
		(ii)	gradient of graph $= \frac{GM}{4\pi^2} = \frac{15\times10^{34}}{4.5\times10^{16}} = \left(3.3\times10^{18}\right)$ $M = \frac{4\pi^2 \times 3.3\times10^{18}}{6.67\times10^{-11}}$ $M = 1.97\times10^{30}$ (kg)	C1 C1 A1	**Allow:** ± half small square on reading off points on line **Note** 2 possible POT error in this equation would give max 1 out 3 with FT. **Allow:** use of a point read from straight line substituted into Kepler's equation **Allow:** FT from their gradient value. 2.0×10^n where $n \neq 30$ scores **max** 2 out of 3 marks
			Total	**9**	

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Question			Answer	Marks	Guidance
5	(a)		$E = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{1.1\times10^{-6}}$ $E = 1.8\times10^{-19}$ (J)	M1 A0	Values must be substituted Answer to 3sf is 1.81 x 10^{-19} (J)
	(b)		$m = \rho V = 8.1\times10^{-12}\times4.5\times10^{3} = \left(3.645\times10^{-8}\right)$ Thermal energy gained $= (mc\,\Delta\theta) = 3.645\times10^{-8}\times520\times[1700-20]$ $(= 0.0318)$ $1.81\times10^{-19}\times6.3\times10^{19}\times t = 0.0318$ $t = 2.8\times10^{-3}$ (s)	C1 C1 A1	**Allow**: ecf from (a) and mass of titanium
	(c)		Thermal energy is conducted / transferred to the rest of titanium/metal Photons are reflected / scattered from / not absorbed the titanium surface	B1 B1	**Not:** heat lost to surroundings
	(d)		(Photon) energy is converted into potential energy (rather than kinetic energy) OR Energy is used to change solid to liquid / phase (rather than increase kinetic energy) OR Energy provides (specific) latent heat of fusion (rather than increase kinetic energy)	B1	**Allow:** energy is used to overcome the forces between atoms / breakdown the crystal structure of titanium (rather than increase kinetic energy)
			Total	**7**	

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Question			Answer	Marks	Guidance
6	(a)		Idea of extrapolating graph back (to negative temperatures) Volume is zero at absolute zero / negative volumes are impossible	B1 B1	Can be shown on diagram Allow 'negligible volume' rather than zero and use of -273 ºC / 0 K
	(b)	(i)	(Internal energy of a system) is the sum of the random (distribution of) kinetic and potential energies of (all) **atoms/molecules** (in the system)	B1	**Allow :**particles
		(ii)	Any **two** from Comparison of kinetic energies in gas and liquid phases linked to temperature Potential energy of gas phase is greater than PE of liquid phase / energy must be supplied to change liquid into gas phase..	 B1 B1	 **Allow**: potential energy of gas phase is ('close' to) zero
	(c)	(i)	$p = \frac{nRT}{V} = \frac{45 \times 8.31 \times 293}{1.2 \times 10^{-2}}$ $p = 9.1 \times 10^{6}$ (Pa)	C1 A1	**No credit** If temperature is not converted to kelvin
		(ii)	$n_{He} = \frac{5.0 \times 10^{7} \times 2.0 \times 10^{-3}}{8.31 \times 293} = 41$ $p_{trimix} = \frac{[45 + 41] \times 8.31 \times 293}{[1.2 \times 10^{-2} + 2.0 \times 10^{-3}]}$ $p_{trimix} = 1.5 \times 10^{7}$ (Pa)	C1 C1 A1	**Allow:** ECF if temperature is used in ºC only if penalised in (i) Otherwise max mark allowed is 1 out of 3 for n = 602 mol **Allow:** use of partial pressures
		(iii)	Internal / kinetic energy of molecules decreases (as temperature falls) Hence pressure would decrease	M1 A0	**Allow:** $p \propto T$ if (n and) V constant
			Total	**11**	

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Wednesday 11 June 2014 – Afternoon

A2 GCE PHYSICS A

G484/01 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 **(a)** Collisions between two objects can be described as being either *elastic* or *inelastic*. Complete the table shown in Fig. 1.1 by placing a tick (✓) in the relevant column(s) for each statement which is true for that type of collision.

Statement	Elastic collision	Inelastic collision
Total momentum for the objects is conserved.		
Total kinetic energy of the objects is conserved.		
Total energy is conserved.		
Magnitude of the impulse on each object is the same.		

[2]

Fig. 1.1

(b) A snooker ball is at rest on a smooth horizontal table. It is hit by a snooker cue. Fig. 1.2 shows a simplified graph of force F acting on the ball against time t.

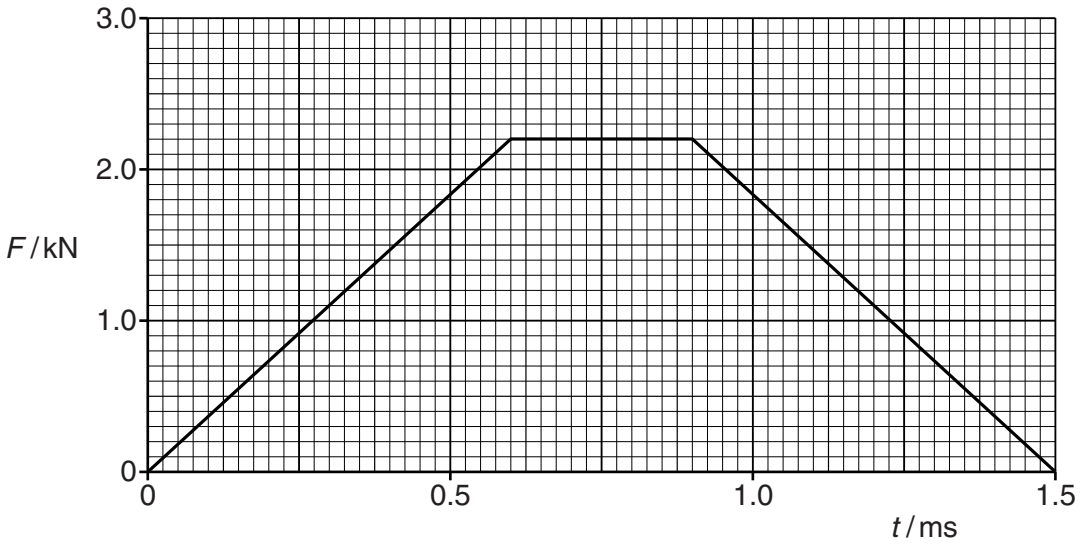


Fig. 1.2

(i) Describe how the velocity of the ball varies between $t = 0.6$ ms and $t = 0.9$ ms.

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..... **[1]**

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(ii) Use Fig. 1.2 to calculate the impulse acting on the ball.

impulse = ... Ns **[2]**

(iii) The mass of the snooker ball is 140 g. Calculate the final speed of the snooker ball as it leaves the cue.

speed = ... $m\,s^{-1}$ **[1]**

[Total: 6]

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2 **(a)** Fig. 2.1 shows a jet aircraft preparing for take-off along a horizontal runway. The engine of the jet is running but the brakes are applied. The jet is not yet moving.

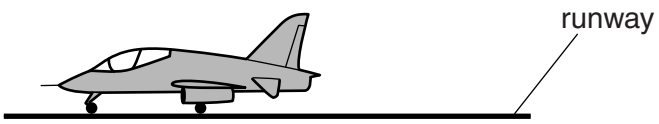


Fig. 2.1

On Fig. 2.1 draw an arrow to show each of the following forces acting on the jet:

(i) the weight of the jet (label this **W**)

(ii) the force produced by the engine (label this **T**)

(iii) the **total** force exerted by the runway on the jet (label this **F**). **[2]**

(b) The brakes are released. The maximum force produced by the engine is 28 kN. The take-off speed of the jet is 56 m s^{-1}. The mass of the jet is 6200 kg.

(i) Calculate the minimum distance the jet travels from rest to the point where it takes off.

distance = ... m **[3]**

(ii) Explain why the runway needs to be longer than the distance calculated in **(i)**.

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..... **[2]**

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(c) The jet is to be used in a flying display in which the pilot will be required to fly the jet in a **horizontal** circle of radius r, at a constant speed of $86\,m\,s^{-1}$. This is achieved by flying the jet with its wings at 35° to the horizontal. With the jet flying in this way, the two forces acting on the jet are the lift L and the weight W, as shown in Fig. 2.2.
Air resistance has negligible effect on the motion of the jet during this manoeuvre.

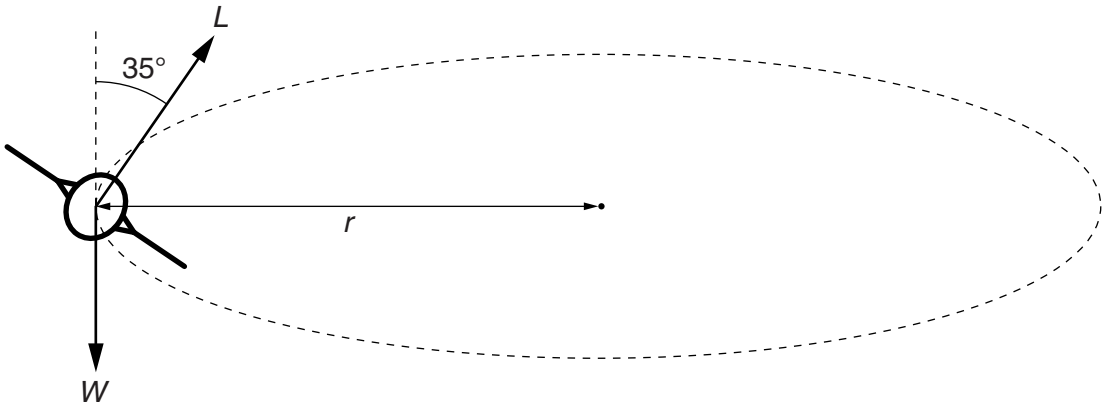


Fig. 2.2

(i) Show that the magnitude of the force L is about 74 kN.

[1]

(ii) Calculate the radius r.

radius = ... m **[3]**

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(d) In a more complex manoeuvre (loop the loop), the pilot is required to fly in a vertical circle at a constant speed as shown in Fig. 2.3.

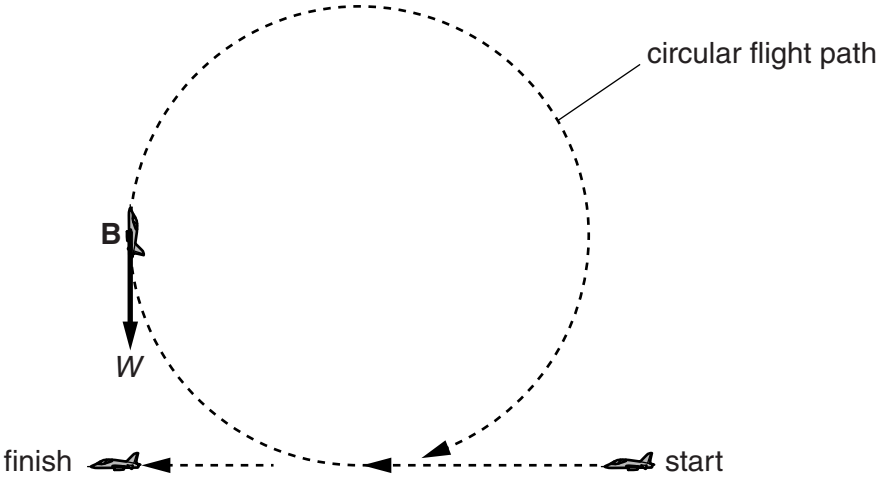


Fig. 2.3

(i) For a certain speed, the pilot can experience a sensation of weightlessness at a particular point along the circular path.

1 On Fig. 2.3, mark with a cross labelled **A**, the point where the pilot experiences the sensation of weightlessness. **[1]**

2 State the magnitude of the vertical component of the contact force exerted by the seat on the pilot at **A**.

force = ... N **[1]**

(ii) In this manoeuvre it is convenient to analyse the motion of the jet in terms of two forces:

- a constant weight *W*
- a variable force *P*.

P is the resultant of the engine thrust, the lift from the wings and air resistance.
At the point **B** in Fig. 2.3 the jet is flying vertically upwards.
Explain why the force *P* is not directed towards the centre of the circular path.

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..... **[1]**

[Total: 14]

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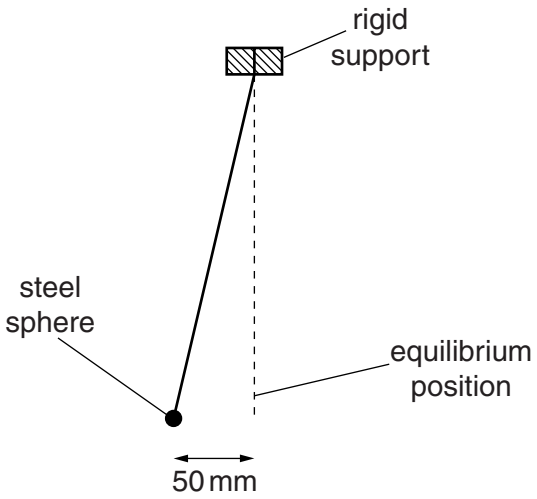
Question 3 begins on page 8

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3 **(a)** Fig. 3.1 shows a simple pendulum consisting of a steel sphere suspended by a light string from a rigid support. The sphere is displaced 50 mm from its vertical equilibrium position and released at time $t = 0$.



not to scale

Fig. 3.1

Fig. 3.2 shows the graph of displacement x of the sphere against time t.

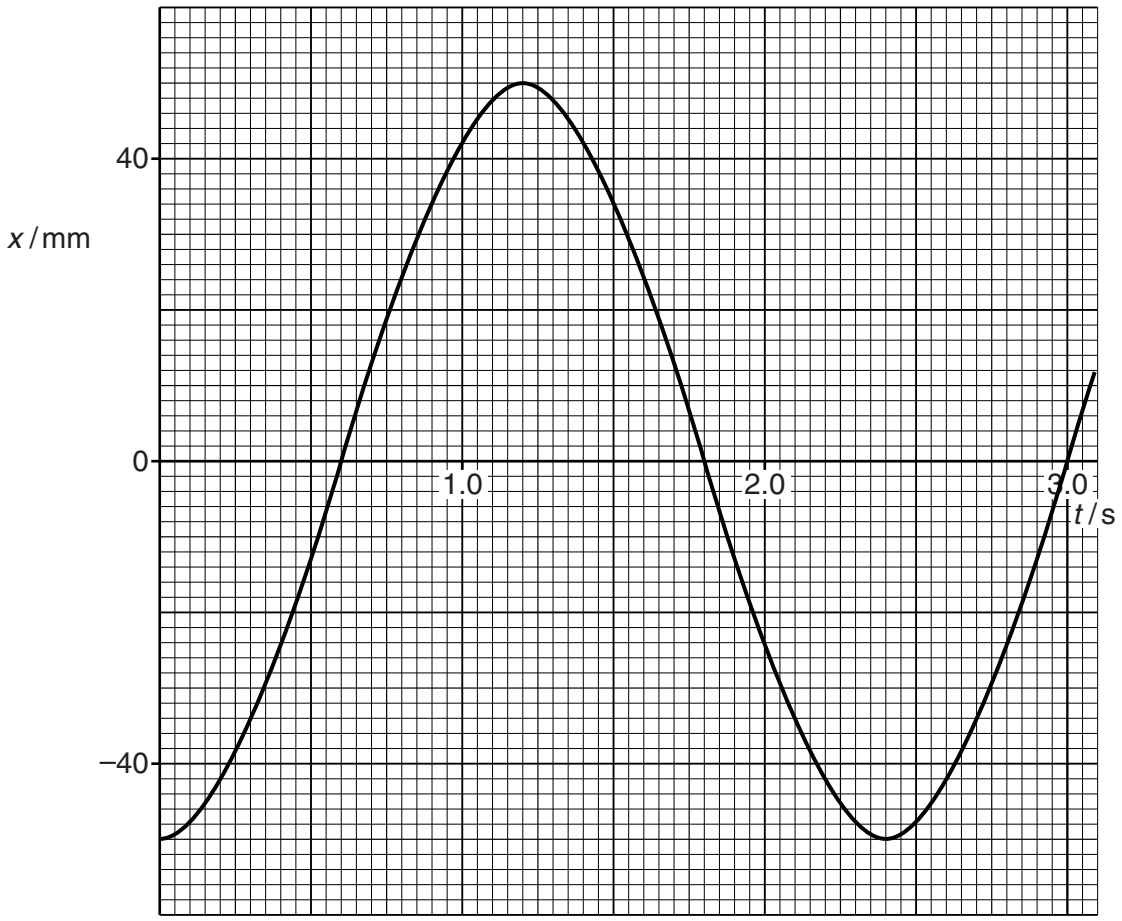


Fig. 3.2

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(i) Use Fig. 3.2 to determine the frequency of oscillation of the pendulum.

frequency = ... Hz **[1]**

(ii) Use Fig. 3.2, or otherwise, to determine the maximum speed of the sphere.
Show your method clearly.

speed = ... $m\,s^{-1}$ **[2]**

(b) The sphere is now released from rest with a displacement $x = 25\,mm$.
State with a reason, the change if any in

(i) the frequency of the oscillations

.....

.....

..... **[1]**

(ii) the maximum kinetic energy of the sphere.

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..... **[2]**

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(c) In turbulent air the wingtip of an aircraft can vibrate vertically. To investigate this effect, the acceleration and the vertical displacement of the wingtip are measured. Fig. 3.3 shows how the acceleration of the wingtip varies with displacement.

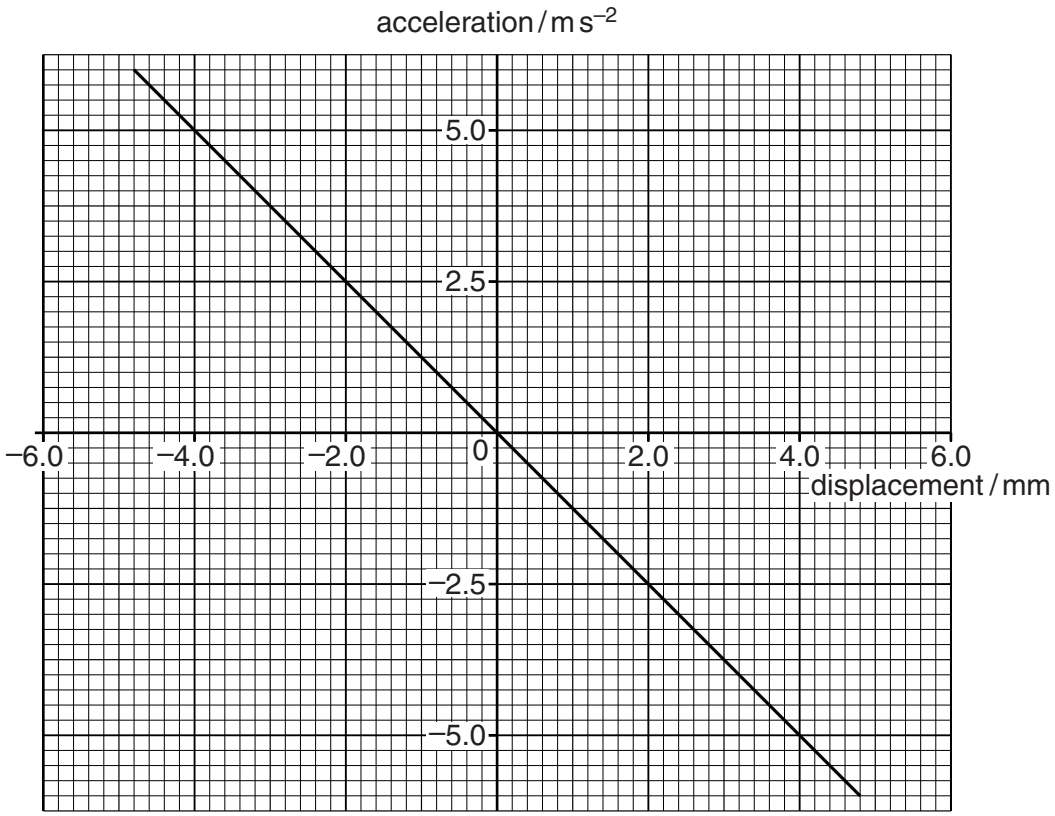


Fig. 3.3

(i) Explain how Fig. 3.3 suggests that the wingtip undergoes simple harmonic motion under the test conditions.

.....

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..... **[2]**

(ii) Use Fig. 3.3 to determine the frequency of the vibration.

frequency = ... Hz **[2]**

[Total: 10]

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4 **(a)** State what is meant by the term *geostationary orbit*.

.....

.....

..... **[1]**

(b) In a science fiction movie, a spaceship approaches a planet called Benzar.
Benzar has a period of rotation of 1.2×10^5 s.
The captain of the spaceship orders the crew to "enter a stationary orbit over the South Pole of Benzar".

(i) Use your knowledge of physics to explain why it is impossible to follow these orders.

.....

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.....

..... **[2]**

(ii) Benzar has mass 8.9×10^{25} kg.
Calculate the radius of the possible stationary orbit for a spaceship circling Benzar.

radius = ... m **[3]**

[Total: 6]

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5 You are provided with a small bottle of cooking oil and standard physics laboratory equipment. With the help of a **labelled** diagram, describe an electrical experiment to determine the specific heat capacity *c* of the oil.
State **two** sources of uncertainty in your measurements and discuss how these could be reduced.

In your answer, you should use appropriate technical terms spelled correctly.

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..... **[6]**

[Total: 6]

Question 6 begins on page 14

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6 Fig. 6.1 shows the apparatus used to observe Brownian motion using pollen grains suspended in a liquid.

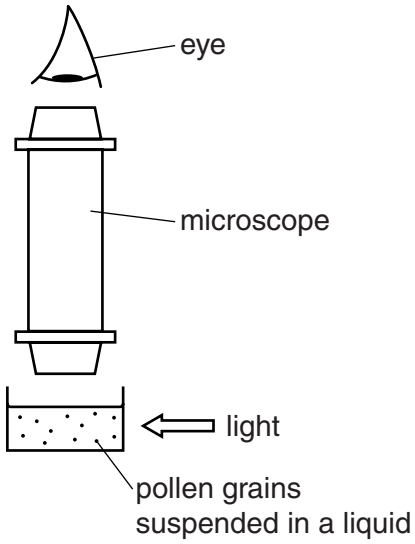


Fig. 6.1

(a) (i) State **two** conclusions that may be deduced about the molecules of the liquid from the motion of the pollen grains observed with the microscope.

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..... **[2]**

(ii) Suggest how the motion of these pollen grains could be increased.

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..... **[1]**

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(b) (i) State **three** assumptions made in the development of the kinetic model of an ideal gas.



In your answer, you should use appropriate technical terms spelled correctly.

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..... **[3]**

(ii) Use the kinetic model of a gas and Newton's laws of motion to explain how a gas exerts a pressure on the walls of its container.

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..... **[4]**

(c) The ideal gas equation is $pV = nRT$.
Show that the pressure p exerted by a fixed mass of gas is given by the equation

$$p = \frac{\rho RT}{M}$$

where ρ is the density of the gas and M is the mass of one mole of gas.

[3]

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(d) The Earth's atmosphere may be treated as an ideal gas whose density, pressure and temperature all decrease with height.
In 1924, Howard Somervell and Edward Norton set a new altitude record when attempting to climb Mount Everest. They managed to climb to a vertical height of 8570 m above sea level by breathing in natural air. At this height, the air pressure was 0.35 times the pressure at sea level and the temperature was −33 °C. At sea level, air has a temperature 20 °C and density 1.3 kg m^{-3}.

(i) Calculate the density of the air at a height of 8570 m at the time the record was set.

density = ... kg m^{-3} **[3]**

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(ii) Determine the ratio

$$\frac{\text{number of air molecules present in Somervell's lungs at the top of his climb}}{\text{number of air molecules present in Somervell's lungs at sea level}}.$$

Assume that the volume of Somervell's lungs remained constant throughout the climb.

ratio = ... **[2]**

[Total: 18]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

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GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2014

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	correct response
	incorrect response
BOD	benefit of the doubt (where professional judgement has been used)
NBOD	benefit of the doubt **not** given
ECF	error carried forward
^	information omitted
CON	contradiction (in cases where candidates contradict themselves in the same response)
FT	follow through
SF	error in number of significant figures
POT	error in the power of 10 in calculation
AE	arithmetic or calculation error
NAQ	not answered question
?	wrong physics
RE	reading error or rounding error

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Abbreviations, annotations and conventions used in the detailed Mark Scheme.

/	=	alternative and acceptable answers for the same marking point
(1)	=	separates marking points
allow	=	answers that can be accepted
not	=	answers which are not worthy of credit
reject	=	answers which are not worthy of credit
ignore	=	statements which are irrelevant
( )	=	words which are not essential to gain credit
__	=	underlined word (or the equivalent) must be present in answer to score a mark
ecf	=	error carried forward
AW	=	alternative wording
ora	=	or reverse argument

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Subject-specific Marking Instructions

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper
If an answer is incorrectly rounded to **2 sf**, then penalise once only in the entire paper.

Any exception to this rule will be mentioned in the Additional Guidance.

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><th>Statement</th><th>Elastic collision</th><th>Inelastic collision</th></tr>
<tr><td>Total momentum for the objects is conserved.</td><td>✓</td><td>✓</td></tr>
<tr><td>Total kinetic energy of the objects is conserved.</td><td>✓</td><td></td></tr>
<tr><td>Total energy is conserved.</td><td>✓</td><td>✓</td></tr>
<tr><td>Magnitude of the impulse on each object is the same.</td><td>✓</td><td>✓</td></tr>
</table>
</td><td>B1

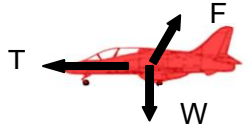
B1</td><td>Allow: Clear notation as alternative to tick.
Award mark only if all responses for elastic collisions are correct.
Award mark only if all responses for inelastic collisions are correct.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>(Velocity) <u>increases</u> at a <u>constant</u> / <u>uniform</u> rate</td><td>B1</td><td>Allow: steady rate.
Allow: (velocity) increases with <u>constant</u> / <u>uniform</u> acceleration.
Do not allow reference to speed.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Impulse = Area under curve
$\text{Area} = \left(\frac{1}{2}\times 0.6\times 10^{-3}\times 2.2\times 10^{3}\right)+\left(0.3\times 10^{-3}\times 2.2\times 10^{3}\right)$
$+\left(\frac{1}{2}\times 0.6\times 10^{-3}\times 2.2\times 10^{3}\right)$
$= 0.66+0.66+0.66$

$\text{Area} = 1.98$ (Ns)</td><td>C1

A1</td><td>Allow: use of trapezium formula.
Allow: counting squares.
If value is in range 780 – 800 small squares and one small square represents 2.5 x 10^{-3} (Ns) or equivalent then max of 2 marks.
If number of squares is outside this range allow max 1 mark

Allow:
Area = 2.0 (N s) but not 2 (sf error)
1 mark for Area = 2.0 x 10^{-3} omitting kN
1 mark for Area = 2000 omitting ms</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>Impulse = $\Delta(mv)$
$v = \frac{1.98}{140\times 10^{-3}} = 14$ (m s^{-1})</td><td>B1</td><td>Possible ecf from b(ii)
Answer to 3 sf = 14.1 (m s^{-1}) [14.3 if using 2.0 N s]</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
</table>

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Question			Answer	Mark	Guidance
2	(a)	(i) (ii)	 Correct direction and labelling for W and T	B1	**Both** forces must be correct to score this mark.
		(iii)	Straight line for F Correct direction **not** horizontal or vertical	B1	**Allow:** Freehand sketch of *F* must lie between 15º and 75º to the horizontal to score this mark.
	(b)	(i)	$a = T / m$ $a = 28 \times 10^3 / 6200$ (= 4.516)	C1	Must substitute to score this mark.
			$v^2 = u^2 + 2as$ $56^2 = 0 + 2 \times 4.516s$ (any subject)	C1	Answer to 3 sf = 347 (m). **Allow:** max 2 marks if v is not squared but correct formula was quoted. [Expect s = 6.2 (m)]
			s = 350 (m)	A1	**Allow:** $Fs = ½ mv^2$ [C1] $28 \times 10^3 \, s = ½ \times 6200 \times 56^2$ [C1] (any subject) s = 350 (m) [A1] **Allow:** $Ft = mv$ t = 12.4 (s) [C1] $s = ½ vt = ½ \times 56 \times 12.4$ [C1] s = 350 (m) [A1]
		(ii)	Air resistance/drag/friction acts on aircraft decreasing **either** the net forward force **or** the acceleration	M1	**Not:** 'slowing the aircraft down'.
			Fs = ΔKE so reduced force must act over a longer distance to produce enough kinetic energy for take-off OR $v^2 = (u^2) + 2as$ so reduced acceleration means longer distance to reach take-off speed.	A1	**Allow** word equation. **Note:** This mark cannot be given if the previous (M1) mark has not been scored.
	(c)	(i)	$L \cos 35^\circ = 6200 \times 9.81$ $L = \frac{6200 \times 9.81}{\cos 35^\circ}$ OR $L = 7.42 \times 10^4$	M1	**Allow:** Use of 9.8
			L = 7.4 x 10^4 (N)	A0	**Note:** There is no mark for the answer as it is given in the question. Marks in 'Show' questions are for the working.

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Question			Answer	Mark	Guidance
		(ii)	$L\sin 35^\circ = mv^2/r$ $r = \dfrac{6200 \times 86^2}{7.4 \times 10^4 \sin 35^\circ}$ r = 1100 (m)	C1 C1 A1	Possible ecf from (c)(i). Correct answer to 3 sf = 1.08 x 10^3 (m). **Allow:** 1 mark for using cos 35º instead of sin 35º. Expect gives an answer of 760 (m). **Allow:** 2 marks for correct working using v = 56 (m s^{-1}) Expect an answer of r = 460 (m). No marks for using tan 35º or for omitting a trig function.
	(d)	(i)1	Indication at 'top' of circle (by eye)	B1	
		(i)2	0 (N)	B1	
		(ii)	P is not the resultant force **OR** Resultant force must be towards centre of circle so *P* must have a component acting vertically upwards, equal in magnitude to *W* (AW)	B1	**Allow:** (Horizontal) component of *P* provides centripetal acceleration and vertical component of *P* is equal to weight. (AW)
			Total	14	

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Question			Answer	Marks	Guidance
3	(a)	(i)	T = 2.4 (s) f = 1/T = 1/2.4 = 0.42 (Hz)	A1	No marks for T = 3 (s) leading to f = 0.33 (Hz).
		(ii)	$v_{max} = 2\pi fA$ $v_{max} = 2\pi \times \frac{1}{2.4} \times 50 \times 10^{-3}$ $v_{max} = 0.13 \quad (m\,s^{-1})$	C1 A1	**Allow:** Tangent drawn on graph at any x = 0 point (C1) calculation of gradient to give value in range 0.12 to 0.14 (m s^{-1}) (A1) Mark is for substitution. Possible ecf from a(i). Answer to 3 sf = 0.131 (m s^{-1}). Expect v_{max} = 0.10 (m s^{-1}) if answer in (i) f = 0.33 Hz (T=3).
	(b)	(i)	frequency is the same / not changed since (in SHM) it is independent of amplitude / (starting) displacement (AW)	B1	**Allow:** ...since length of pendulum is unchanged
		(ii)	(maximum velocity) is reduced because amplitude / (starting) displacement is reduced (AW) (Max) KE is reduced to one quarter / 4 times smaller	B1 B1	**Allow:** (Max) KE is smaller since amplitude/ (starting) displacement is smaller **Allow:** (Max) KE is smaller because GPE is smaller
	(c)	(i)	Straight line through origin means acceleration ∝ displacement Negative gradient means acceleration and displacement are in opposite directions / acceleration directed is towards the midpoint/equilibrium point (AW)	B1 B1	**Allow:** Straight line through origin means a ∝ x **Allow:** 1 mark for straight line through origin and negative gradient means $a \propto -x$ (hence SHM)
		(ii)	(Magnitude) Gradient = $\omega^2 = 5/0.004 = (2\pi f)^2$ $f = 5.6 \quad (Hz)$	C1 A1	C1 mark is for substitution of gradient for ω^2 or $(2\pi f)^2$ Answer to 3 sf = 5.63 (Hz) **Allow:** 1 mark for f = 0.178 (Hz) not converting mm to m
			Total	10	

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Question			Answer	Marks	Guidance
4	(a)		Spaceship is (always vertically) above the same point on (the surface of the Earth/ planet) (AW)	B1	**Allow:** Spaceship must orbit the equator with a period of 24 h/ 1 day **and** must have the same direction of rotation as Earth / planet (AW) **Not :** same point in sky
	(b)	(i)	Centre of spaceship's orbit must coincide with the centre of mass of Benzar **OR** orbit must be equatorial (AW)	B1	S Pole is on axis of rotation (radius of orbit is zero)
			Velocity of spaceship must be parallel to the velocity of a point on the surface of Benzar. **OR** Spaceship must orbit in the same direction as Benzar rotates (AW)	B1	Spacecraft must be stationary /not orbiting planet / spinning on its axis OR Spacecraft will only pass over S Pole once in each orbit
		(ii)	$R^3 = \frac{GT^2M}{4\pi^2}$	C1	Must have R or R³ as subject
			$R^3 = \frac{6.67\times10^{-11}\times(1.2\times10^5)^2\times8.9\times10^{25}}{4\pi^2}$	C1	Mark is for substitution
			$R = 1.3\times10^8$ (m)	A1	Answer to 3 sf is 1.29 x 10^8 (m)
			Total	6	

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Question			Answer	Marks	Guidance
5			**Diagram showing** • Oil in (insulated) container • Electrical heater <u>fully immersed in oil</u> • <u>Thermometer / Temperature sensor</u> **Electrical circuit** • Ammeter in series , voltmeter in parallel with heater / joulemeter in parallel with heater • Power supply /+ & - signs marked on wires **Measurements** • Measure mass of oil /use known mass of oil, • Measure change in temperature / initial and final temperatures • Measure current, pd and (fixed) time / energy **Calculation** $\text{Input Energy} = E = Pt = VIt$ and $c = \frac{E}{m\Delta\vartheta}$ **Uncertainties** Any **two** together with minimising action. • Heat losses (make $\Delta\vartheta$ uncertain) - minimise by using initial ϑ below and final ϑ <u>same amount</u> above, room temperature • Temperature varies throughout oil - minimise by stirring before taking temperature readings • Some energy is required to raise temperature of the container / heater (etc) - allow by including in calculation. • Temperature will continue to rise after heater is turned off – find max temperature.	B1 B1 B1 B1 2 x B1	**Not:** oven or hotplate **Allow:** 'Fully immersed' seen in the body of text **Thermometer /Temperature sensor** must be spelled correctly on diagram All elements should be shown to score these diagram marks. Ignore appropriate additional items Connections to heater should be clear. Must have all elements. **Allow:** Use of symbols **Allow:** Take energy reading from joulemeter **Not:** use given power rating of heater Input energy must be consistent with equipment used. c must be the subject of the equation and temperature **rise** ($\Delta\vartheta$ or ϑ_2 - ϑ_1) must be clear. **Allow**: Draw graph of temperature against time c = VI / [gradient x mass] These points may be scored in the description of method. No credit for other uncertainties including heat lost to surroundings
			Total	6	

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Question			Answer	Marks	Guidance
6	(a)	(i)	Molecules (of the liquid) are in random / haphazard motion (AW) Molecules (of liquid) are smaller than pollen grains	B1 B1	Not zig-zag must compare to pollen grains **Ignore** mass is smaller
		(ii)	Increase the temperature (of the liquid)	B1	**Allow:** Heating the liquid
	(b)	(i)	Any **three** from: • Collisions with the walls/container/sides are elastic • force between molecules is negligible / zero except during collisions • Volume of the molecules is negligible compared to the volume of the container (AW) • Time within a collision is negligible compared to time between collisions **Max 3**	 (B1) (B1) (B1) (B1) B3	**Collision/collides** must be spelled correctly to score the mark Ignore collisions between gas molecules Must refer to comparison to score either of the last two points. Ignore references to incomplete assumptions and assumption not given in expected answer.
		(ii)	Momentum of the molecule changes when it collides with the wall (AW) Force on the molecule is rate of change of momentum (by N 2nd Law) (By N 3rd Law) Force on wall is equal to and opposite to the force on the molecule pressure = **sum** of forces (due to all molecules) / Area of wall	B1 B1 B1 B1	**Allow:** There is an impulse on molecule when it collides with wall.

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Question			Answer	Marks	Guidance
	(c)		$\rho = \frac{m}{V}$ (any subject) $n = \frac{m}{M}$ (any subject) $pV = nRT$ $p\left(\frac{m}{\rho}\right) = \left(\frac{m}{M}\right)RT$ $p = \frac{\rho RT}{M}$	M1 M1 A1 A0	**Allow:** $\rho = \frac{m}{V}$ (M1) A clear statement of "n = 1 then m = M" (M1) **Note:** Both M marks must be scored and the method **must be clear** to score the A1 mark. $pV = nRT$ $p\left(\frac{M}{\rho}\right) = RT$ (A1) $p = \frac{\rho RT}{M}$ (A0)
	(d)	(i)	Use of $p \propto \rho T$ or $\frac{p_T}{p_B} = \frac{\rho_T T_T}{\rho_B T_B}$ $0.35 = \frac{\rho_T \times 240}{1.3 \times 293}$ $\rho_T = \frac{0.35 \times 1.3 \times 293}{240}$ $\rho_T = 0.56$ (kg m^{-3})	C1 C1 A1	**Allow:** any subject **Allow:** any subject **Allow:** Max 1 mark if temperatures are not converted to kelvin. Expect density to be – 0.276 kg m^{-3} Answer to 3 sf is 0.555 (kg m^{-3})
		(ii)	**Correct** use of $N \propto \frac{p}{T}$ or $\frac{N_T}{N_B} = \frac{p_T T_B}{p_B T_T}$ $\frac{N_T}{N_B} = \frac{0.35 \times 293}{240}$ $\frac{N_T}{N_B} = 0.43$	C1 A1	Do not penalise use of °C if already penalised in (i) **Allow:** Alternative approach using $\frac{N_T}{N_B} = \frac{\rho_T}{\rho_B}$ with possible ecf from (i) Answer to 3 sf is 0.427
			Total	18	

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RECOGNISING ACHIEVEMENT

Thursday 20 June 2013 – Morning

A2 GCE PHYSICS A

G484/01 The Newtonian World

G411820613

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

G 4 8 4 0 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 **(a)** **(i)** State in words Newton's second law of motion.

.....

.....

..... **[1]**

(ii) Show how this law leads to the expression $F = ma$ for an object of constant mass.

[2]

(b) The graph in Fig. 1.1 shows the variation with time of a force acting on an object of mass 2.5 kg.
The force is acting in the direction of the object's motion.

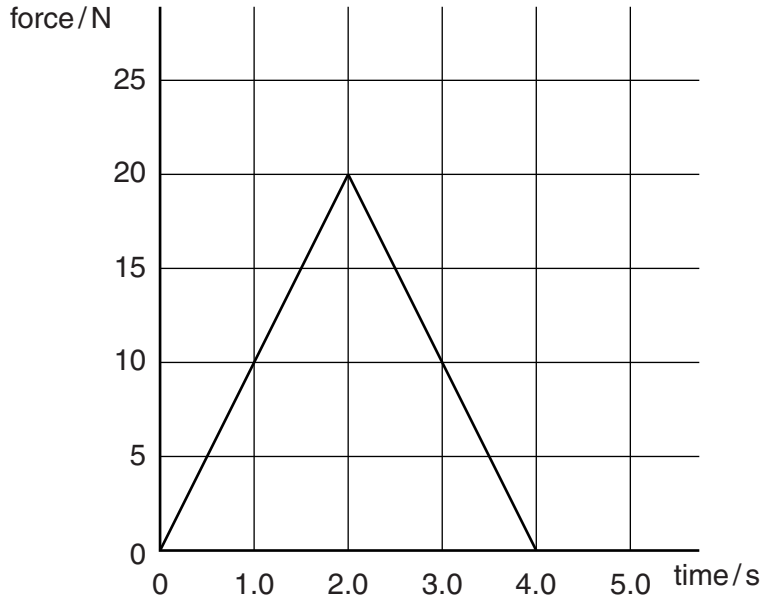


Fig. 1.1

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Use Fig. 1.1 to

(i) determine the change in velocity of the object

change in velocity = ... $m\,s^{-1}$ **[3]**

(ii) calculate the mean acceleration of the object

mean acceleration = ... $m\,s^{-2}$ **[1]**

(iii) describe how the acceleration of the object varies between 0 and 4.0 seconds.

.....

.....

.....

..... **[2]**

[Total: 9]

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2 **(a)** Fig. 2.1 shows the Earth in space.

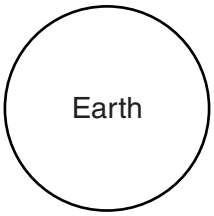


Fig. 2.1

(i) Draw lines on Fig. 2.1 to show the shape and direction of the gravitational field of the Earth. **[1]**

(ii) The gravitational field strength, g, is uniform close to the Earth's surface. Describe the pattern of gravitational field lines close to the surface of the Earth.

In your answer you should use appropriate technical terms spelled correctly.

.....

.....

.....

..... **[2]**

(b) The planet Saturn has mass 5.7×10^{26} kg and radius 6.0×10^{7} m.

(i) Calculate the gravitational field strength g_s at Saturn's surface.

g_s = ... $N\,kg^{-1}$ **[2]**

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(ii) Saturn's second-largest moon, Rhea, has orbital radius 5.3×10^8 m and mass 2.3×10^{21} kg.
Calculate for Rhea

1 its orbital speed v

$v =$ ..... $m\,s^{-1}$ **[3]**

2 its kinetic energy.

kinetic energy = ... J **[1]**

[Total: 9]

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3 **(a)** An object is oscillating with simple harmonic motion. Place a tick (✓) in the box against each true statement that applies to the acceleration of the object.

The acceleration …

… is in the opposite direction to the displacement. ☐

… is directly proportional to the amplitude squared. ☐

… increases as the displacement decreases. ☐

… increases as the speed of the object decreases. ☐

[2]

(b) The graph in Fig. 3.1 shows the variation of the velocity v of the object with time t.

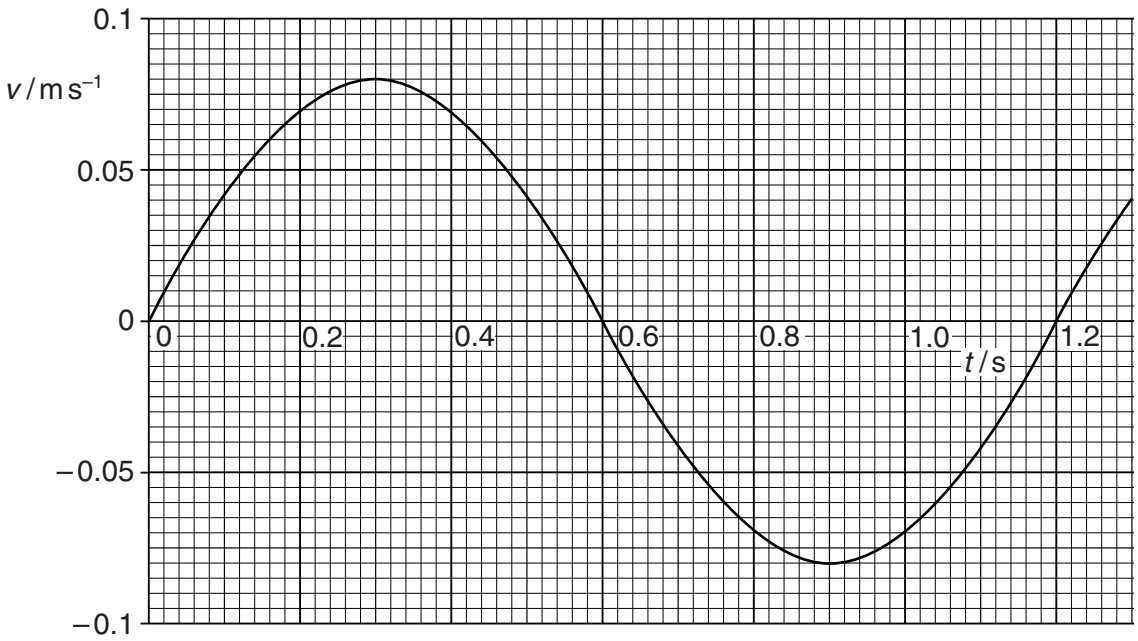


Fig. 3.1

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Using the graph, determine

(i) the frequency of the motion

frequency = ... Hz **[1]**

(ii) the amplitude of the motion

amplitude = ... m **[2]**

(iii) the maximum acceleration of the object.

acceleration = ... $m\,s^{-2}$ **[2]**

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(c) (i) With the help of a suitably labelled graph, explain what is meant by *resonance* of a mechanical system.



.....

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..... **[4]**

(ii) State and explain an everyday example of resonance.

.....

.....

.....

.....

..... **[2]**

[Total: 13]

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4 A room measures 4.5 m × 4.0 m × 2.4 m. The air in the room is heated by a gas-powered heater from 12 °C to 21 °C. The density of the air, assumed to remain constant, is 1.3 kg m^{-3}.

(a) Calculate the thermal energy required to raise the temperature of the air in the room. The specific heat capacity of air is 990 J kg^{-1} K^{-1}.

thermal energy = ... J **[3]**

(b) The heater has an output power of 2.3 kW. The heating gas has a density 0.72 kg m^{-3}. Each cubic metre of heating gas provides 39 MJ of thermal energy.

Use your answer to **(a)** to calculate

(i) the time required to raise the temperature of the air from 12 °C to 21 °C

time = ... s **[2]**

(ii) the mass of heating gas used in this time.

mass = ... kg **[2]**

(c) Suggest **two** reasons why the time required and the mass of heating gas will in practice be greater than the values calculated in **(b)**.

.....

.....

.....

.....

..... **[2]**

[Total: 9]

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5 **(a)** A gas molecule of mass m travelling perpendicular to the wall of a container hits the wall with speed v. Explain why the molecule rebounds with speed v and undergoes a change of momentum of $2mv$.



In your answer you should use appropriate technical terms spelled correctly.

.....

.....

.....

.....

..... **[2]**

(b) A constant mass of gas occupies a container of constant volume. Use the kinetic theory of gases to explain the increase in the force exerted on the walls of the container by the gas when its temperature is raised.

.....

.....

.....

.....

.....

..... **[3]**

(c) **(i)** The pressure of the air in the tyres of a car before a journey is 2.2×10^5 Pa at 18 °C. After travelling some distance, the temperature of the air in the tyres rises to 54 °C. Calculate the new pressure of the air. Assume the volume of air in the tyre stays constant.

pressure = ... Pa **[2]**

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(ii) Assuming that the total mass of the car in **(i)** stays constant at 1200kg, calculate the change in the total area of contact of the tyres with the road as a result of the rise in temperature.

change in area = ... m^2 **[3]**

[Total: 10]

Question 6 begins on page 12

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6 **(a)** **(i)** State, in words, Boyle's law.

.....

.....

..... **[2]**

(ii) Fig. 6.1 is a graph showing the relationship between the quantities involved in Boyle's law. Label the axes appropriately. **[1]**

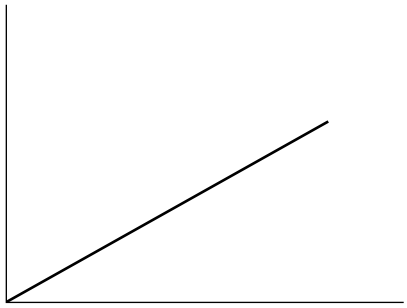


Fig. 6.1

(b) A gas cylinder of internal volume $0.050\,m^3$ contains compressed air at 21 °C and pressure 1.2×10^7 Pa. The molar mass of air is $0.029\,kg\,mol^{-1}$.

(i) Calculate

1 the number of moles of air in the cylinder

number of moles = ...

2 the mass of air in the cylinder.

mass = ... kg
[3]

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(ii) An additional 1.5 m^3 of air at 21 °C and at atmospheric pressure, 1.0×10^5 Pa, is pumped into the cylinder. Calculate the new pressure of air in the cylinder, assuming no change in temperature during the process.

pressure = ... Pa **[4]**

[Total: 10]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question number(s) must be clearly shown in the margins.

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GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for June 2013

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect Response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct Response
AE	Arithmetic error
	Wrong physics or equation

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Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance.
Penalise a rounding error in the second significant figure once only in the paper.

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Question			Answer	Marks	Guidance
1	(a)	(i)	(Resultant) force (acting on an object) is (directly) proportional to the <u>rate of change of momentum</u> (and occurs in the same direction)(AW)	B1	**Allow:** 'equal' instead of proportional, **Allow:** 'change in momentum <u>divided</u> by time taken' **Not:** a definition involving acceleration **Not:** 'change in momentum **over** time taken' **Not:** an equation unless all terms are defined
		(ii)	$F = \frac{\Delta(mv)}{\Delta t}$ $F = m\frac{\Delta(v)}{\Delta t}$ (if m is constant) $F = ma$ $F = \frac{(mv - mu)}{\Delta t}$ $F = \frac{m(v-u)}{\Delta t}$ (if m is constant) $F = ma$	M1 A1 A0	**Allow:** Any subject. **Not:** $\Delta p/\Delta t$ for M mark **Allow:** $F \propto \frac{(mv - mu)}{\Delta t}$ **Allow:** Use of *t* for Δt
	(b)	(i)	(Impulse) $F\Delta t$ = area (under graph) **OR Clear** use of ½ x 4 x 20 in $F\Delta t = m\Delta v$ $\Delta v = \frac{40}{2.5}$ $\Delta v = 16 \quad (\text{m s}^{-1})$	C1 C1 A1	**Note:** Area = 40 (N s) **Allow**: any subject
		(ii)	$a = \frac{(v-u)}{t}$ $a = \frac{16}{4}$ $a = 4.0 \quad (\text{m s}^{-2})$	B1	Possible **ecf** from **(b)(i)** **Allow:** mean force <*F*> = 10 N mean acceleration (= <*F*>/*m*) = 10/2.5 = 4.0 (m s^{-2}) **Allow:** a = 4 (m s^{-2}) as answer is exact.
		(iii)	'acceleration **increases** to 2s **and** then **decreases**' Reference to the rate of change of acceleration being constant / linear change in acceleration / acceleration changes at uniform rate in either section.	M1 A1	No credit for any reference to **deceleration.** **Not:** accelerating constantly / uniform acceleration / constant acceleration / increasing rate of change of acceleration
			Total	**9**	

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Question			Answer	Marks	Guidance
2	(a)	(i)	Diagram showing **at least 4 radial** lines outside Earth, appearing to meet at centre of Earth (as judged by eye – in a square containing letters **a** and **r** of label) **AND** **at least 4 arrows** directed towards the Earth	B1	**Do not** award this mark if any arrow is in wrong direction. **Allow**: line(s) to continue inside the Earth
		(ii)	Any **two** from the following: • Field lines are **parallel** to each other • Field lines are equally/evenly/uniformly/constantly spaced (AW) • Field lines are **perpendicular / vertical** / **right angles** (to surface of the Earth)	B1 B1	**Note: vertical**, **parallel**, **perpendicular** /**right angles** wherever used to be spelled correctly .
	(b)	(i)	$g = \frac{GM}{R^2}$ $g = \frac{6.67\times10^{-11}\times5.7\times10^{26}}{(6\times10^{7})^2}$ $g = 11 \quad (\text{N kg}^{-1})$	C1 A1	**Note:** Mark is for substitution Answer is 10.6 (N kg^{-1}) to 3 sf Ignore sign
		(ii)1	$\frac{mv^2}{r} = \frac{GMm}{r^2}$ or $v^2 = \frac{GM}{r}$ $v^2 = \frac{6.67\times10^{-11}\times5.7\times10^{26}}{5.3\times10^{8}} \quad (= 7.17\times10^{7})$ $v = 8.5\times10^{3} \quad (\text{m s}^{-1})$	C1 C1 A1	Allow $T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$ **and** $v = \frac{2\pi r}{T}$ Expected value for T = 3.93 x 10^5 s **Note:** Mark is for substitution Answer is 8470 (m s^{-1}) to 3 sf **Note:** Using • mass of Rhea (2.3 x 10^{21}) gives v = 17 (m s^{-1}) • g from b(i) in $v = \sqrt{gr}$ gives v = 7.5 x 10^4 [correct value of g at Rhea's orbit is 0.135 N kg^{-1}] Both score max 1 mark for use of correct formula
		(ii)2	$E_k = \frac{1}{2}\times2.3\times10^{21}\times7.17\times10^{7}$ $E_k = 8.2\times10^{28}$ (J)	B1	Possible **ecf** for v from **(ii)1** **Note:** Using v = 17 gives E_k = 3.3 x 10^{23} (J) Using v = 7.5 x 10^4 gives E_k = 6.5 x 10^{30} (J) Using b(ii)1 to 2sf gives E_k = 8.3 x 10^{28} (J)
			Total	**9**	

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Question			Answer	Marks	Guidance
3	(a)		Is in the opposite direction to the displacement Increases as the speed of the object decreases	B1 B1	If more than 2 ticks are given mark all and deduct 1 mark for each error
	(b)	(i)	$f = \frac{1}{T} = \frac{1}{1.2}$ $f = 0.83 \quad (\text{Hz})$	B1	**Allow:** the fraction 5/6 only
		(ii)	$v_{max} = (2\pi f)\ A$ $0.08 = (2\pi \times 0.83)A$ $A = \frac{0.08}{(2\pi \times 0.83)} = 0.015 \quad (\text{m})$	C1 A1	Possible **ecf** from **(b)(i)** **Note:** Mark is for substitution; any subject Answer is 0.0153 (m) to 3 sf
		(iii)	$a_{max} = (2\pi f)^2 A$ $a_{max} = (2\pi \times 0.83)^2 \times 0.015$ $a_{max} = 0.42 \quad (\text{m s}^{-2})$	C1 A1	Possible **ecf** from **(b)(i)** and **(ii)** **Note:** Mark is for substitution **Ignore sign** Expect to see 0.41 if 2 sf values are used **Allow:** tangent used at $v = 0$ (M1) gradient of tangent calculated in range 0.37 to 0.44 (m s^{-2}) to 2sf (A1). Accept gradient of tangent =0.4 (m s^{-2})
	(c)	(i)	Graph(s) tending to single peak with axes labelled in words or appropriate symbols Peak labelled as natural / resonant frequency (of system) or f_o • Resonance occurs when the driving frequency matches natural / resonant frequency (of system) • the amplitude of vibrations / energy (transferred) is then a maximum (AW)	B1 B1 B1 B1	Can be scored even if horizontal axis is not correctly labelled
		(ii)	A valid example of resonance Explanation to include • what does the driving and what is being driven • that this occurs at specific (driver) frequency	B1 B1	**Allow:** Mirror in car, Washing machine, Child on swing, microwave (oven), radio (tuning), Structures (in wind etc) MRI **Not** musical instruments
			Total	**13**	

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Question			Answer	Marks	Guidance
4	(a)		Mass of air = 4.5 x 4 x 2.4 x 1.3 (= 56.2) $Q = mc\Delta\theta$ = 56.2 x 990 x (21 – 12) $Q = 5.0 \times 10^5$ (J)	B1 C1 A1	 **Allow:** follow through (FT) for mass of air **Note:** Max 1 mark out of 3 if temperature **rise** is given as 282 K.
	(b)	(i)	$t = \frac{Q}{P} = \frac{5.0 \times 10^5}{2300}$ $t = 220 \quad (s)$	C1 A1	Possible **ecf** from **(a)** Answer is 217 (s) or 218 (s) to 3 sf depending on accuracy of Q used from (a)
		(ii)	$\text{Volume of gas}, V = \frac{5.0 \times 10^5}{39 \times 10^6}$ $(= 0.0128 \quad (m^3))$ $\text{Mass of gas} = V\rho = 0.0128 \times 0.72$ $\text{Mass} = 9.2 \times 10^{-3} \quad (kg)$	C1 A1	Possible **ecf** from **(a)**
	(c)		Any **two** from the following : • thermal energy/heat is lost through or to walls / ceiling / floor/windows /door of room (AW) • other objects within the room (AW) • warm <u>air</u> may escape from room / cold <u>air</u> or draughts may enter the room	 B1 B1	**Not:** Bald 'Heat lost to surrounding' **Ignore** any references to heater
			Total	**9**	

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Question			Answer	Marks	Guidance
5	(a)		**Kinetic** energy is conserved (when molecule collides) / collision is **elastic** (so velocity after collision is $-v$) Momentum change = $mv - [-mv]$ $= 2mv$	M1 A1 A0	**Note: Kinetic** and **elastic,** wherever used, to be spelled correctly **Allow**: *m[v-(-v)] or –mv – mv* **Allow**: A1 mark if M1 mark has been lost for incorrect spelling
	(b)		Increase in temperature causes an increase in velocity / speed (of molecules) Collisions are more frequent (AW) Greater (rate of) change in momentum (in each collision with the surface) Hence force increases	B1 B1 B1 A0	**Note:** No credit for references to pressure [NAQ]
	(c)	(i)	$\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $p_2 = \frac{2.2 \times 10^5}{(273+18)} \times (273+54)$ $p_2 = 2.5 \times 10^5$ (Pa)	C1 A1	**Note:** Mark is for substitution; any subject No marks if temperatures are not converted to kelvin Answer to 3 sf is 2.47×10^5 (Pa)
		(ii)	Original area $= \frac{W}{p_1} = \frac{1200 \times 9.8}{2.2 \times 10^5}$ $(= 5.35 \times 10^{-2})$ (m^2) Final area $= \frac{W}{p_2} = \frac{1200 \times 9.8}{2.47 \times 10^5}$ $(= 4.77 \times 10^{-2})$ (m^2) Change in area $= (5.35 - 4.77) \times 10^{-2} = 5.8 \times 10^{-3}$ (m^2)	C1 C1 A1	 Possible **ecf** from **(c)(i)** **Allow:** Full credit if 2 sf values are used eg 6.4×10^{-3} (m^2) using $p_2 = 2.5 \times 10^5$
			Total	**10**	

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Question			Answer		Marks	Guidance
6	(a)	(i)	For a fixed / constant mass of gas at constant temperature Pressure is inversely proportional to volume / pressure x volume = constant		B1 B1	
		(ii)	Axes labelled *p* and 1/*V* OR *V* and 1/*p*		B1	**No ecf from a(i)** **Note:** Only one tick
	(b)	(i)1	$pV = nRT$ $n = \frac{pV}{RT} = \frac{1.2\times10^{7}\times0.05}{8.31\times(273+21)}$ $n = 250$		C1 A1	**Allow:** use of $pV = NkT$ leading to $N = 1.48\text{x}10^{26}$ (C1) and $n = N/N_A$ giving $n = 250$ (A1) Mark is for substitution; any subject. No credit if 21ºC is used giving $n = 3438$
		(i)2	mass = *n* x 0.029 = 246 x 0.029 = 7.1 kg	mass = *n* x 0.029 = 250 x 0.029 = 7.3 kg	A1	Possible **ecf** from **(b)(i)1** Allow ecf if *n* = 3438 leads to mass = 99.7 kg

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Question			Answer	Marks	Guidance
6	(b)	(ii)	$n_{air\ added} = \frac{pV}{RT} = \frac{1.0\times10^5\times1.5}{8.31\times(273+21)}$		Possible **ecf** from **(b)(i)1** or **2**
			$n_{air\ added} = 61.4$	C1	**Allow** follow through for incorrect $n_{air\ added}$ value
			$n_{total} = n_{initial} + n_{air\ added} = 246 + 61.4 \quad (= 307)$	C1	Using n =250 from **b(i)1** leads to $n_{total} = 250 + 61.4 \quad (= 311)$
			$p_{final} = n_{total}\left(\frac{RT}{V}\right) = 307\times\left(\frac{8.31\times(273+21)}{0.050}\right)$	C1	Use of T = 21ºC or V =1.55 is wrong physics so can not score last two marks
			$p_{final} = 1.5\times10^7 \quad (\text{Pa})$	A1	**ALTERNATIVE METHOD** Calculates pressure of air pumped in if it were to occupy a volume equal to cylinder $p_2 = \frac{1\times10^5\times1.5}{0.05}$ (C1) $p_2 = 3.0\times10^6$ (C1) When added to air already in cylinder $p_{final} = p_{original} + p_2$ $p_{final} = 1.2\times10^7 + 3.0\times10^6$ (C1) $p_{final} = 1.5\times10^7$ (Pa) (A1) **SPECIAL CASES** Using alternative method but with final volume taken as 1.5 m³ p_2 = 4.0 x 10^5 (Pa) and final pressure is 5.0 x 10^5 (Pa) Scores 2 marks . No credit if final volume taken as 1.55 m³
			Total	**10**	

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OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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OCR
RECOGNISING ACHIEVEMENT

Wednesday 16 January 2013 – Afternoon

A2 GCE PHYSICS A

G484/01 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

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G 4 8 4 0 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

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Turn over

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Answer **all** the questions.

1 **(a)** State, in words, Newton's second law of motion.

In your answer you should use appropriate technical terms spelled correctly.

.....

.....

..... **[2]**

(b) Fig. 1.1 shows the masses and velocities of two objects **A** and **B** moving directly towards each other. **A** and **B** stick together on impact and move with a common velocity *v*.

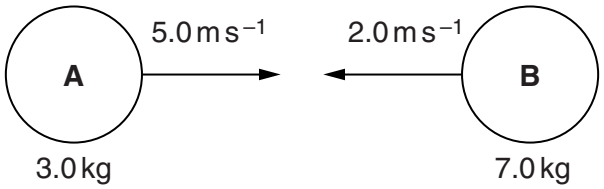


Fig. 1.1

(i) Determine the velocity *v*.

magnitude of velocity = ... $m\,s^{-1}$

direction = ...

[3]

(ii) Determine the impulse of the force experienced by the object **A** and state its direction.

impulse = ... N s

direction = ...

[2]

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(iii) Explain, using Newton's third law of motion, the relationship between the impulse experienced by **A** and the impulse experienced by **B** during the impact.

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..... **[2]**

[Total: 9]

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2 A satellite orbits the Earth in a circular path 800 km above the Earth's **surface**. At the orbit of the satellite the gravitational field strength is 7.7 N kg^{-1}. The radius of the Earth is 6400 km.

(a) Calculate

(i) the orbital speed of the satellite

orbital speed = ... m s^{-1} **[3]**

(ii) the period of the orbit of the satellite.

period = ... s **[2]**

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(b) The orbit of the satellite passes over the Earth's poles.

(i) Show that the satellite makes about 14 orbits around the Earth in 24 hours.

[1]

(ii) The cameras on board the satellite continually photograph a strip of the Earth's surface, of width 3000 km, directly below the satellite. Determine, with an appropriate calculation, whether the satellite can photograph the whole of the Earth's surface in 24 hours. State your conclusion.

.....

.....

..... **[3]**

(c) Suggest a practical use of such a satellite.

.....

..... **[1]**

[Total: 10]

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3 **(a)** State, in words, Newton's law of gravitation.

.....

.....

..... **[1]**

(b) Fig. 3.1 shows the circular orbits of two of Jupiter's moons: Adrastea, **A**, and Megaclite, **M**.

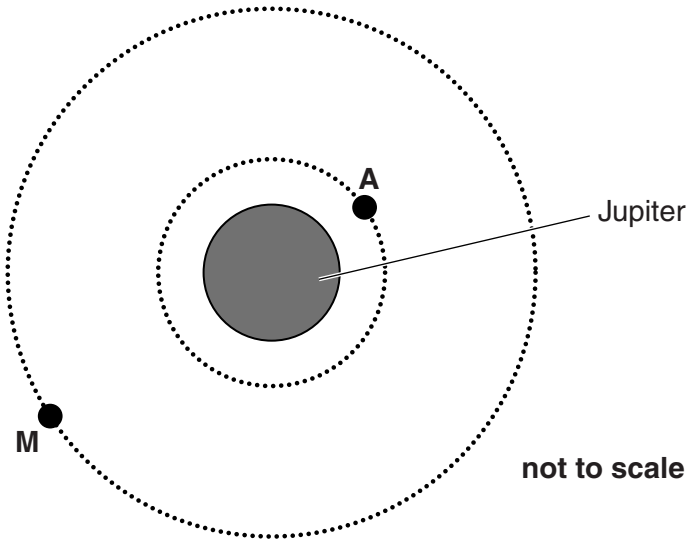


Fig. 3.1

Use the following data in the calculations below.

orbital radius of **A** = 1.3×10^8 m
orbital period of **A** = 7.2 hours
gravitational field strength at orbit of **A** = $7.5\,\text{N kg}^{-1}$
orbital radius of **M** = 2.4×10^{10} m

Calculate

(i) the mass of Jupiter

mass = ... kg **[3]**

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(ii) the gravitational field strength at the orbit of **M**

gravitational field strength = ... $N\,kg^{-1}$ **[2]**

(iii) the orbital period of **M**.

orbital period = ... hours **[3]**

[Total: 9]

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4 Fig. 4.1 shows slotted masses suspended from a spring. The spring is attached to a fixed support at its upper end.

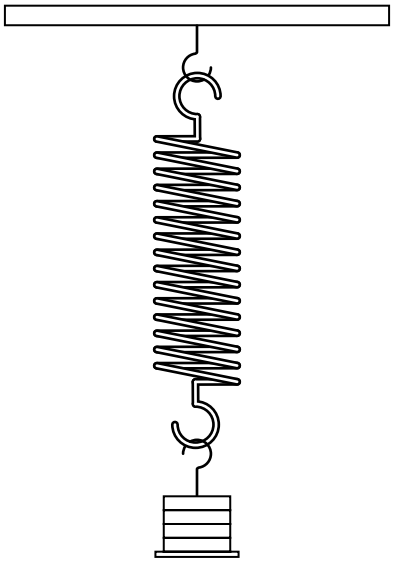


Fig. 4.1

When the masses are pulled down a short distance from the equilibrium position and released they oscillate vertically with simple harmonic motion. The frequency f of these oscillations depends on the mass m of the masses.
Two students make different predictions about the relationship between f and m.
One suggests f is proportional to $1/m$ and the other believes f is proportional to $1/\sqrt{m}$.

(a) Describe how you would test experimentally which prediction is correct.
Include in your answer:

- the measurements you would take, and
- how you would use these measurements to test each prediction.

You should also discuss ways of making the test as reliable as possible.

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..... **[4]**

(b) When the masses hanging on the spring are 400 g in total, they oscillate with an amplitude of 36 mm and a period of 1.2 s. Calculate

(i) the maximum kinetic energy of the masses

maximum kinetic energy = ... J **[3]**

(ii) the maximum acceleration of the masses.

maximum acceleration = ... $m\,s^{-2}$ **[2]**

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(c) List the different types of energy involved in the oscillations of this mass-spring system. Describe the energy changes when the masses move from the lowest point of the oscillation to the highest point.

In your answer you should use appropriate technical terms spelled correctly.

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..... **[4]**

[Total: 13]

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Question 5 begins on page 12

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5 **(a)** **(i)** The pressure p and volume V of a quantity of an ideal gas at absolute temperature T are related by the equations $pV = nRT$ and $pV = NkT$. In these equations identify the symbols n and N.

n .....

N.....

[1]

(ii) Choose one of the equations in **(i)** and show how Boyle's law follows from it.

.....

.....

..... **[2]**

(iii) Show that the product of pV has the same units as work done.

[1]

(b) The graph in Fig. 5.1 shows the variation of pressure, p, with the reciprocal of volume, $1/V$, of 0.050 kg of oxygen behaving as an ideal gas.

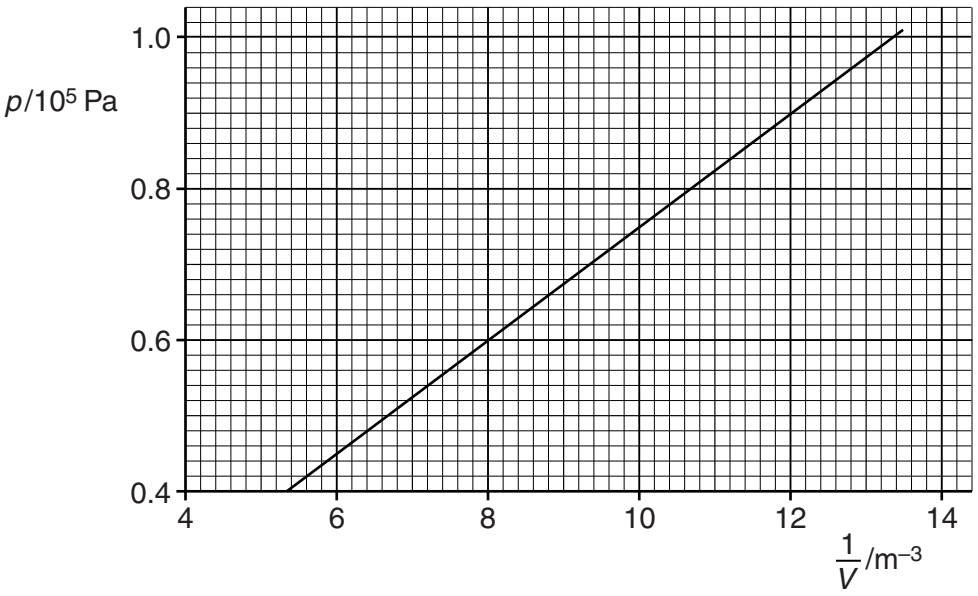


Fig. 5.1

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(i) Use the graph to show that the variation of p with $\frac{1}{V}$ is taking place at constant temperature.

[2]

(ii) The molar mass of oxygen is $0.016\,\text{kg}\,\text{mol}^{-1}$. Calculate the temperature, in °C, of the oxygen in **(i)**.

temperature = ... °C **[3]**

[Total: 9]

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6 **(a)** Describe

(i) the motion of atoms in a solid at a temperature well below its melting point

.....

..... **[1]**

(ii) the effect of a small increase in temperature on the motion of these atoms

.....

..... **[1]**

(iii) the effect on the internal energy and temperature of the solid when it melts.

.....

.....

..... **[2]**

(b) Fig. 6.1 shows the apparatus used to determine the specific heat capacity of a metal. A block made of the metal is heated by an electrical heater that produces a constant power of 48 W. In order to reduce heat loss from the sides, top and bottom of the block, it is covered by a layer of insulating material.

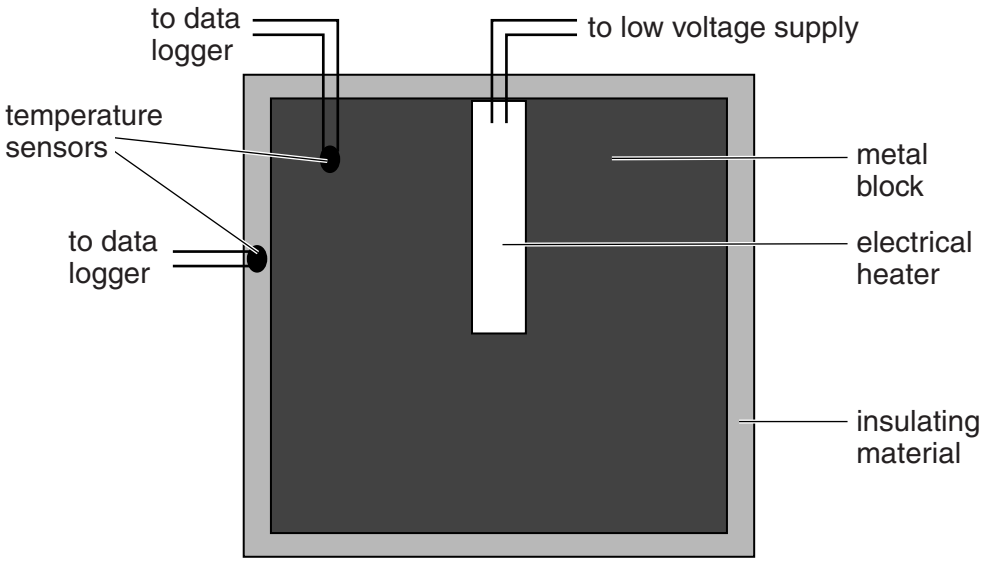


Fig. 6.1

Temperature sensors connected to a data logger show that the block and insulation are initially at the room temperature of 18 °C. The heater is switched on and after 720 seconds the sensors show that the temperature of the block is 54 °C and the average temperature of the insulating material is 38 °C.

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(i) Use the information given above and the data shown below to determine the specific heat capacity of the metal block.

mass of metal block = 0.98 kg
power of heater = 48 W
specific heat capacity of the insulating material = 850 $J\,kg^{-1}\,K^{-1}$
mass of the insulating material = 0.027 kg

specific heat capacity = ... $J\,kg^{-1}\,K^{-1}$ **[4]**

(ii) A second experiment is done without the insulating material and with the block again starting at 18 °C. Discuss whether the value of the specific heat capacity calculated from the second experiment is likely to be lower, the same or higher than the value calculated in **(i)**.

.....

.....

.....

..... **[2]**

[Total: 10]

END OF QUESTION PAPER

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GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

The abbreviations, annotations and conventions used in the detailed Mark Scheme are:

Annotation	Meaning
/	Alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

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Subject-specific Marking Instructions

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance Column.

CATEGORISATION OF MARKS

The mark scheme categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

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Question			Answer	Marks	Guidance
1	(a)		Rate of change of momentum (of a body) is proportional / equal to the (net) force (acting on it) and takes place in the direction of that force.	M1 A1	**Allow:** Force = change in momentum / time (taken) ✎ **Note: momentum** must be spelled correctly to score the mark. **Allow** this mark if the M1 mark is lost for spelling error
	(b)	**(i)**	(3 x 5) – (7 x 2) = 10v v = (15 – 14)/10 = 0.10 (m s^{-1}) to the right (AW)	C1 M1 A1	Signs must be correct for the mark to be scored **Allow** 1 sf answer **Not** forwards/towards **B** but **allow** correct arrow → or east
		(ii)	Impulse = 3(0.1 – 5) (= - 14.7) = (-)15 (Ns) to the left (AW)	M1 A1	**Allow:** ecf from (b)(i) **Ignore** sign **Not** backwards/towards **A** but **allow** correct arrow ← or west
		(iii)	(Newton's 3rd law says) Force on B (due to A) is equal and opposite to force on A (due to B) time (of contact) / t is same for both **AND** Impulse = Ft impulse on A is equal and opposite to impulse on B	M1 A1 A0	**Allow**: use of minus sign to indicate 'opposite' **Not**: Action and reaction are equal and opposite.
			Total	**9**	

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Question			Answer	Marks	Guidance
2	(a)	(i)	$g = \frac{v^2}{r}$ or $v^2 = \frac{GM}{r}$ $v = \sqrt{gr}$ $v = \sqrt{7.7 \times 7.2 \times 10^6}$ $v = 7400$ (m s^{-1})	C1 C1 A1	Correct formula in any form **Allow:** use of *a* for *g* Mark is for substitution (**Note** Mass of Earth is 6.0 x 10^{24} kg) **Any use of r = 800 km is WP scores 0/3** **Note:** Answer to 3 sf is 7450 (m s^{-1})
		(ii)	$T = \frac{2\pi r}{v}$ $T = \frac{2\pi \times 7.2 \times 10^6}{7450}$ = 6100 (s) OR $T^2 = \frac{4\pi^2 r^3}{GM}$ $T^2 = \frac{4\pi^2 (7.2 \times 10^6)^3}{6.67 \times 10^{-11} \times 6 \times 10^{24}}$ T = 6100 (s)	C1 A1	**Allow:** possible ecf for *v* from (a)(i) **No ecf** for use of *r* = 6.4 x 10^6 again or use of r = 800 km Both score 0/2 **Note:** Answer to 3 sf using v = 7400 is 6110 (s) Answer to 3 sf using v = 7450 is 6070 (s)
	(b)	(i)	Number of orbits = $\frac{24 \times 3600}{6080}$ (= 14.2) ≈ 14	B1	**Allow** any correct method **Allow** ora **No ecf** from a(ii)
		(ii)	Circumference = $2\pi r$ $\frac{\text{equatorial circumference}}{\text{width of photograph}} = \frac{2\pi \times 6400}{3000} = 13.4$ (But each orbit crosses the equator twice hence) number of orbits = 6.7 This is fewer than 14 orbits so whole of Earth's surface can be photographed (AW)	C1 C1 A1 A0	**Allow**: Circumference = $2\pi r$ (C1) length of equator covered per orbit = 2π x 6.4 x 10^3/14 (C1) (= 2872) (But each orbit crosses the equator twice hence) min width to be photographed = ½ x 2872 = 1400 km (A1) < 3000 km so all of Earth's surface can be photographed in one day (A0)

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Question			Answer	Marks	Guidance
	(c)		suitable example: eg weather / spy / surveying / mapping / GPS	B1	**Ignore** TV / radio / communications
			Total	**10**	

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Question			Answer	Marks	Guidance
3	(a)		Force is proportional to the product of the masses and inversely proportional to the square of their separation (AW)	B1	**Allow:** $F = \frac{GmM}{r^2}$ with **all** symbols defined.
	(b)	(i)	$mg = \frac{GmM_J}{r^2}$ $M_J \left(= \frac{g r^2}{G} \right) = \frac{7.5 \times (1.3 \times 10^8)^2}{6.67 \times 10^{-11}}$ M_J = 1.9 x 10^{27} (kg)	C1 C1 A1	**Allow:** formula with m cancelled **Allow:** use of $T^2 = \frac{4\pi^2 r^3}{GM_J} \Rightarrow M_J = \frac{4\pi^2 (1.3 \times 10^8)^3}{6.67 \times 10^{-11} \times (7.2 \times 60^2)^2}$ **Note:** mark is for substitution with any subject
		(ii)	$\frac{g_M}{g_A} = \frac{r_A^2}{r_M^2}$ $\frac{g_M}{7.5} = \frac{(1.3 \times 10^8)^2}{(2.4 \times 10^{10})^2}$ g_M = 2.2 x 10^{-4} (N kg^{-1})	C1 A1	**Allow:** use of $g = \frac{GM_J}{r^2}$ with possible ecf for M_J from (b)(i) $g_M = \frac{(6.67 \times 10^{-11}) \times (1.9 \times 10^{27})}{(2.4 \times 10^{10})^2}$ **Note:** mark is for substitution g_M = 2.2 x 10^{-4} (N kg^{-1})
		(iii)	$T^2 \propto r^3$ OR T^2/r^3 = constant (= $4\pi^2/GM_J$) $\frac{T_M^2}{7.2^2} = \frac{(2.4 \times 10^{10})^3}{(1.3 \times 10^8)^3}$ T_M = 1.8 x10^4 (hours)	C1 C1 A1	**Allow:** possible ecf for M_J from b(i) **Allow:** use of other **c**orrect formulae **Note:** mark is for substitution **Note** using times in seconds gives T_M = 6.49 x10^7 (s) scores 2 marks
			Total	**9**	

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Question			Answer	Marks	Guidance
4	(a)		Obtain a set of readings for: mass *m*, time period AND calculate frequency using *f* = 1/*T*. Plot graphs of *f* against 1/*m* AND *f* against 1/√*m* The graph which is a straight line through the origin provides the correct relationship Reference to one method of improving reliability eg counting more than 5 oscillations to find *T* or *f* taking repeat measurements of *T* or *f* (and average values) time oscillations from equilibrium position	B1 B1 B1 B1	**Not** number of oscillations in a set time **Allow:** product method using two or more points (B1) Select the relation which gives a constant product (B1) **Allow:** plot ln *f* against ln *m* (B1) gradient= -1 then $f \propto 1/m$ **or** gradient= -0.5 then $f \propto 1/\sqrt{m}$ (B1)
	(b)	(i)	$v_{max} = 2\pi f A = 2\pi\left(\frac{1}{1.2}\right)\times 36\times 10^{-3}$ $v_{max} = \frac{3\pi}{50} \quad (= 0.188)$ $KE_{max} = \frac{1}{2}\times 0.4\times\left(\frac{3\pi}{50}\right)^2$ $KE_{max} = 7.1\times 10^{-3}$ (J)	C1 C1 A1	**Note:** mark is for substitution
		(ii)	$a_{max} = (2\pi f)^2 A = \left[2\pi\left(\frac{1}{1.2}\right)\right]^2 \times 36\times 10^{-3}$ $a_{max} = 0.99$ (ms^{-2})	C1 A1	**Note:** mark is for correct substitution

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Question			Answer	Marks	Guidance
	(c)		**Reference to** : kinetic energy (of masses and spring), gravitational potential energy (of mass and spring), elastic (potential) energy / strain energy of spring KE: zero (at lowest point), increasing to max at equilibrium point, decreasing to zero (at highest point) GPE: increases (as masses rise from lowest to highest point) (clearly worded ora)(AW) strain / elastic energy: decreases (as masses rise from lowest to highest point) (clearly worded ora) (AW)	B1 B1 B1 B1	**Note:** mark to be awarded only if **all** 3 forms are quoted ✎ **Note: potential** must be spelled correctly throughout to score this mark
			Total	**13**	

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Question			Answer	Marks	Guidance
5	(a)	(i)	*n* = number of moles (in sample) **AND** *N* = number of atoms / molecules (in sample)	B1	**Note: both** definitions are required **Not:** particles / Avogadro's constant
		(ii)	*n* or *N* **AND** T is constant (and R and k are constants) for a fixed mass (of gas), pV = constant / $p \propto 1/V$	M1 A1	nRT or NkT is constant is **not** sufficient
		(iii)	Shows that $Nm^{-2} \times m^3 = Nm$	B1	**Allow:** Use of base units for **both** pV **and** work done
	(b)	(i)	Calculates $p \times (1/V)^{-1}$ at **two** points on the graph values are the same pV = constant / $p \propto 1/V$ / nRT = constant	M1 A1	Expected values for pV are 7500 (Nm) or 0.075 ($\times 10^{-5}$)for most points **Allow:** Correct calculation of gradient (M1) Calculates intercept = 0 hence graph is through the origin and pV = constant / $p \propto 1/V$ (A1)
		(ii)	Number of moles in 0.050 kg = 0.05/0.016 (= 3.125) $T = \frac{pV}{nR} = \frac{7500}{3.125 \times 8.31}$ $= 289$ (K) $T = 16$ (°C)	C1 C1 A1	**Allow:** possible ecf from (b)(i) or error in *n* but apply POT error for use of pV = 0.075 leading to $T = 2.9 \times 10^{-3}$ K **Note:** Mark is for correct conversion of their T (K) value **Note**: Allow full range of marks for other sensible alternative approaches e.g. use of a molecular mass of 0.032 kg/mol giving a temperature of 305°C
			Total	**9**	

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Question			Answer	Marks	Guidance
6	(a)	(i)	vibrate (about their 'fixed' positions)	B1	**Allow:** molecules vibrate
		(ii)	greater amplitude / greater frequency (of vibration)	B1	**Not:** faster / more / bigger /more vigorous (vibrations)
		(iii)	**Either** internal energy increases **Or** potential energy (of molecules) increases and the kinetic energy remains constant temperature remains constant	B1 B1	
	(b)	(i)	$P\,t = m\,c\,\Delta\theta$ 48 x 720 = 0.98 x c x (54 - 18) + 0.027 x 850 x (38-18) c = 970 (J kg^{-1} K^{-1})	C1 C1 C1 A1	**Note:** mark is for correct substitution for total energy input **and** heat gained by **metal** **Note:** mark is for adding a correct substitution for heat gained by insulation into this equation **Note:** answer to 3 sf = 967 Calculation of c = 980 ignoring energy used to heat insulation scores 2 marks
		(ii)	Without the insulation there will be **more** heat lost to the surroundings / air (AW) final temperature will be **lower** **OR** a **lower** temperature rise **OR** more energy will be required to give the **same** temperature rise / final temperature **AND** hence c is **higher** than that calculated in (i)	M1 A1	**Not:** lost to wires / data logger
			Total	**10**	

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Monday 18 June 2012 – Morning

A2 GCE PHYSICS A

G484 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

G411820612

G 4 8 4

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

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Turn over

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Answer **all** the questions.

1 **(a)** State the effect a net force has on the motion of an object.

.....

.....

..... **[1]**

(b) **(i)** Define the *impulse of a force*.

.....

..... **[1]**

(ii) A force *F* is applied to an object. The graph in Fig. 1.1 shows the variation of this force with time *t*.

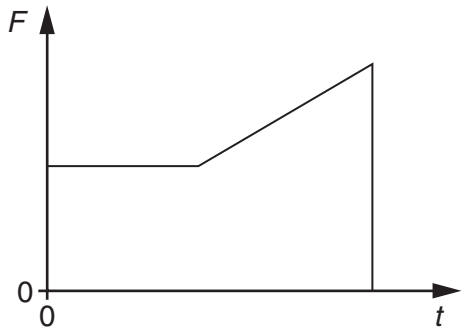


Fig. 1.1

The initial velocity of the object is zero and its mass is known. Explain how this graph can be used to determine the final velocity of the object.

.....

.....

.....

..... **[2]**

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(c) A tennis ball is hit by a racket as shown in Fig. 1.2.

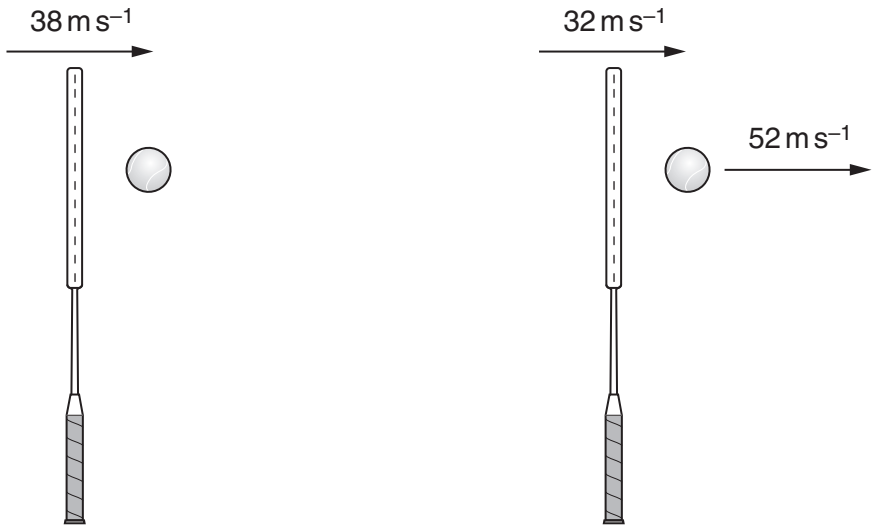


Fig. 1.2a **Fig. 1.2b**

Fig. 1.2

The mass of a tennis ball is 0.058 kg. During a serve the racket head and the ball are in contact for 4.2 ms. Just before contact, the racket head is travelling towards the ball at 38 m s^{-1} and the ball is stationary. Fig.1.2a shows the situation just before contact. Immediately after contact, the racket head is travelling in the same direction at 32 m s^{-1} and the ball is travelling away from the racket at 52 m s^{-1}. This is shown in Fig. 1.2b.

(i) Calculate the mean force provided by the racket on the ball.

mean force = ……N **[2]**

(ii) Estimate the mass of the racket.

mass = …….. kg **[2]**

(iii) Suggest why the value of the mass calculated in **(ii)** will be different from the actual mass of the racket.

.....

..... **[1]**

[Total: 9]

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2 **(a)** A body moves with simple harmonic motion. Define, in words, *simple harmonic motion*.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

.....

..... **[2]**

(b) A horizontal metal plate connected to a vibration generator is oscillating vertically with simple harmonic motion of period 0.080 s and amplitude 1.2 mm. There are dry grains of sand on the plate. Fig. 2.1 shows the arrangement.

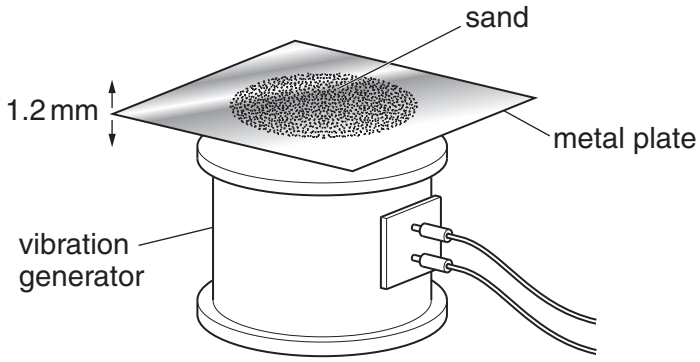


Fig. 2.1

(i) Calculate the maximum speed of the oscillating plate.

maximum speed = ...m s^{-1} **[2]**

(ii) The frequency of the vibrating plate is kept constant and its amplitude is slowly increased from zero. The grains of sand start to lose contact with the plate when the amplitude is A_0. State and explain the necessary conditions when the grains of sand first lose contact with the plate. Hence calculate the value of A_0.

.....

.....

.....

A_0 = ...m **[4]**

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(c) The casing of a poorly designed washing machine vibrates violently when the drum rotates during the spin cycle. Fig. 2.2 shows how the amplitude of vibration of the casing varies with the frequency of rotation of the drum.

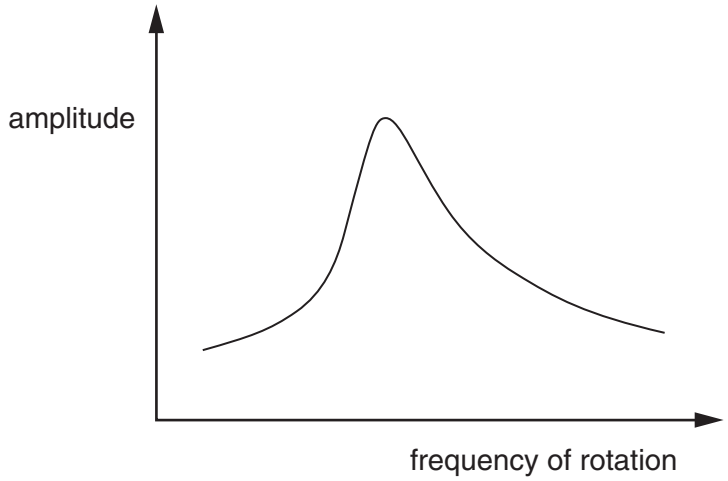


Fig. 2.2

(i) State the name of this effect and describe the conditions under which it occurs.

.....

.....

.....

..... **[2]**

(ii) The design of the washing machine is improved to reduce the effect by adding a damping mechanism to the inside of the machine. Sketch on Fig. 2.2 the new graph of amplitude against frequency of rotation expected for this improved design. **[2]**

[Total: 12]

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3 Fig. 3.1 shows apparatus used to investigate circular motion. The bung is attached by a continuous nylon thread to a weight carrier supporting a number of slotted masses which may be varied. The thread passes through a vertical glass tube. The bung can be made to move in a nearly horizontal circle at a steady high speed by a suitable movement of the hand holding the glass tube. A constant radius *r* of rotation can be maintained by the use of a reference mark on the thread.

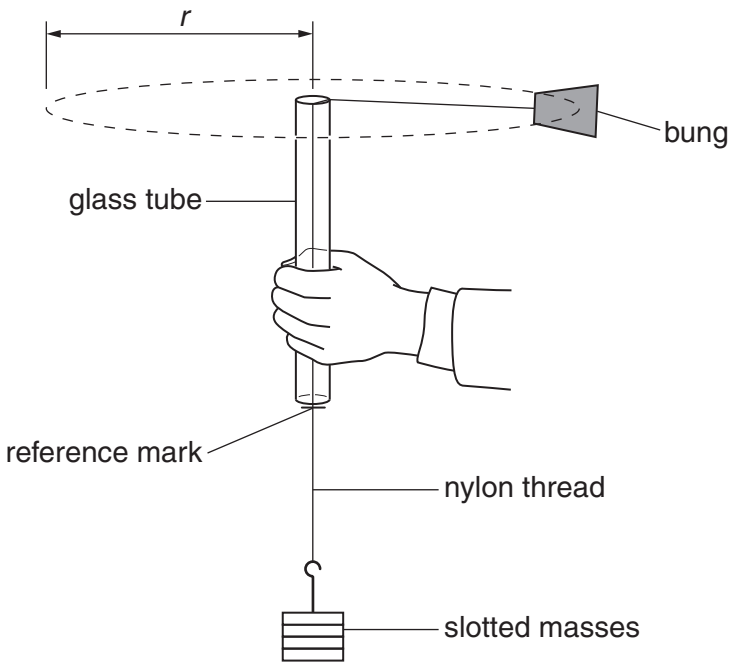


Fig. 3.1

(a) (i) Draw an arrow labelled **F** on Fig. 3.1 to indicate the direction of the resultant force on the bung.

[1]

(ii) Explain how the speed of the bung remains constant even though there is a resultant force *F* acting on it.

.....

.....

.....

.....

..... **[2]**

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(b) (i) Two students carry out an experiment using the apparatus in Fig. 3.1 to investigate the relationship between the force F acting on the bung and its speed v for a constant radius. Describe how they obtain the values of F and v.

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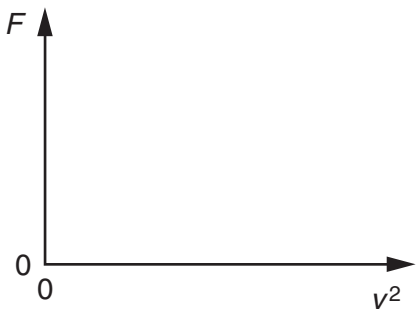
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.....

.....

..... **[5]**

(ii) 1 Sketch, on Fig. 3.2, the expected graph of F against v^2.



[1]

Fig. 3.2

2 Explain how the graph can be used to determine the mass m of the bung.

.....

.....

.....

..... **[2]**

[Total: 11]

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4 **(a)** **(i)** Define *specific heat capacity*.

.....

.....

..... **[1]**

(ii) Describe the difference between the *latent heat of fusion* and the *latent heat of vaporisation*.

.....

.....

..... **[1]**

(b) The graph in Fig. 4.1 shows the variation of temperature with time for a fixed mass of substance when heated by a constant power source. At **A** the substance is a solid; at **E** the substance is a vapour.

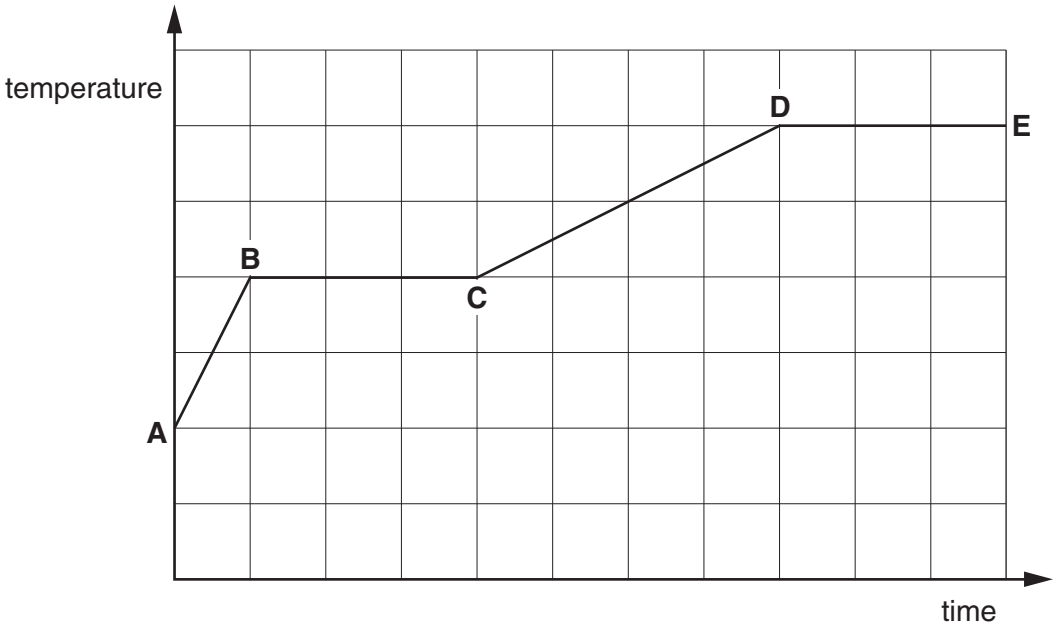


Fig. 4.1

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(i) Describe the changes taking place in the kinetic energy and potential energy of the molecules for the following sections:

A to **B**

.....

.....

.....

B to **C**

.....

.....

..... **[2]**

(ii) State and explain what you can conclude from Fig. 4.1 about the specific heat capacity of the substance in the solid state compared with the specific heat capacity of the substance in the liquid state.

.....

.....

.....

.....

..... **[2]**

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(c) The electric heating element of a bathroom shower has a power rating of 5.0 kW. An attempt is made to test the accuracy of this value by measuring the rate of flow of the water and the temperature of the water before and after passing the element.

The results of the test and other required data are as follows:

temperature of water supply to the shower = 17.4 °C
temperature of water after being heated by the element = 36.7 °C
rate of flow of water = 3.60×10^{-3} m^3 min^{-1}
density of water = 1000 $kg\,m^{-3}$
specific heat capacity of water = 4200 $J\,kg^{-1}\,K^{-1}$

(i) Show that the power of the heating element is approximately 5 kW.

[4]

(ii) State and explain a possible source of uncertainty that might affect the reliability of the test.

.....

.....

..... **[2]**

[Total: 12]

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5 **(a)** State a conclusion about the movement of gas molecules provided by observations of Brownian motion.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

.....

..... **[1]**

(b) Fig. 5.1 shows a gas contained in a cylinder enclosed by a piston. The volume of the gas inside the cylinder is 120 cm^3. The pressure inside the cylinder is 350 kPa.

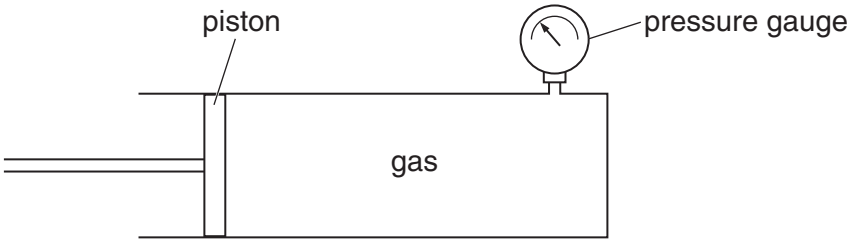


Fig. 5.1

(i) State a necessary condition for Boyle's law to apply to a fixed quantity of gas.

.....

.....

..... **[1]**

(ii) The piston in Fig. 5.1 is moved quickly so that the gas occupies a volume of 55 cm^3. Use Boyle's law to calculate the new pressure of the gas.

pressure = ……kPa **[2]**

(iii) In practice, the quick movement of the piston during compression of the gas causes an increase in the temperature of the gas. Explain this increase in temperature in terms of the **movement of the piston** and **the motion of the gas molecules**.

.....

.....

.....

..... **[2]**

[Total: 6]

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6 **(a)** **(i)** State Newton's law of gravitation.

.....

.....

..... **[2]**

(ii) Define *gravitational field strength, g*.

.....

..... **[1]**

(b) Titan, a moon of Saturn, has a circular orbit of radius 1.2×10^6 km. The orbital period of Titan is 16 Earth days.

(i) Calculate the speed of Titan in its orbit.

speed = ... m s^{-1} **[2]**

(ii) Show that the mass of Saturn is about 5×10^{26} kg.

[3]

(c) Rhea is another moon of Saturn with a smaller orbital radius than Titan.
Determine the ratio

$$\frac{\text{orbital period } T_R \text{ of Rhea}}{\text{orbital period } T_T \text{ of Titan}}$$

in terms of their orbital radii r_R , and r_T .

ratio = ... **[2]**

[Total: 10]

END OF QUESTION PAPER

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ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

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GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for June 2012

Oxford Cambridge and RSA Examinations

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

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The abbreviations, annotations and conventions used in the detailed mark scheme are:

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

Q2a, Q2bii, Q3bi, Q5a should be full annotated on all scripts. Ticks are preferred on **all** questions where credit is given.

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance Column.

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Question			Answer	Marks	Guidance
1	(a)	(i)	Force changes the momentum of / accelerates / decelerates the object	B1	**Allow:** Change of speed / velocity / direction <u>of motion</u>
	(b)	(i)	Force x time <u>for which the force acts</u> / <u>duration of collision</u>	B1	**Allow:** $F\,\Delta t$ with both symbols defined **Not:** change of momentum
		(ii)	Area under graph = impulse OR Area = change in momentum final velocity = Area under graph / mass	B1 B1	**Allow:** Area under graph = mv OR ... = $m(v-u)$ **Note:** v must be the subject to score this mark
	(c)	(i)	mean force on ball x time = increase in momentum of ball mean force = $\frac{0.058 \times 52}{4.2 \times 10^{-3}}$ = 720 (N)	 C1 A1	 Mark for correct substitution **Note:** Answer to 3 sf is 718 (N) Bald 720 (N) scores 2 marks
		(ii)	momentum change of racket = momentum (change) of ball M(38 – 32) = 0.058 x 52 $M = \frac{0.058 \times 52}{6}$ = 0.50 (kg)	 C1 A1	 **Allow:** use of mean force from c(i) and time 4.2ms . Possible ECF from c(i) **Note:** Answer to 3 sf is 0.503 (kg) **Allow:** 0.5 (kg)
		(iii)	The person / hand / arm holding the racket also changes momentum (AW)	B1	**Not:** references to angles or initial speed of ball
			Total	**9**	

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Question			Answer	Marks	Guidance
2	(a)		acceleration proportional to <u>displacement</u> (from the equilibrium position)	B1	**displacement** must be spelled correctly to score the mark. **Allow:** acceleration proportional to distance <u>from equilibrium position</u> with equilibrium spelled correctly for first B1
			and is always acting towards the equilibrium position / the mid-point of the motion (AW)	B1	**Allow:** 'acceleration is in the opposite direction to displacement' for the second B1 mark **Use tick or cross on Scoris**
	(b)	(i)	$v_{max} = 2\pi f A$ $\quad f = 1/0.08 = 12.5$ $v_{max} = 2\pi\left(\frac{1}{0.080}\right) \times 1.2 \times 10^{-3} \left(= 2\pi \times 12.5 \times 1.2 \times 10^{-3}\right)$	C1	If A = 0.6 mm used $v_{max} = 2\pi\left(\frac{1}{0.080}\right) \times 0.6 \times 10^{-3}$ (✓) $v_{max} = 4.7 \times 10^{-2}$ (m s^{-1}) (✓) **Note:** Answer to 3 sf is 9.42 x 10^{-2} (m s^{-1})
			$v_{max} = 9.4 \times 10^{-2}$ (m s^{-1})	A1	**Allow:** 1 mark for 94(.2) (m s^{-1}) not converting mm to m
		(ii)	This occurs at the highest point (top) of the oscillations When acceleration of plate equals/exceeds free fall acceleration /g/ 9.81	B1 B1	
			$g = (2\pi f)^2 A_0$ hence $A_0 = \frac{9.81}{\left(2\pi \times \frac{1}{0.080}\right)^2}$	C1	**Allow:** equation with any subject for this mark
			A_0 = 1.6 x 10^{-3} (m)	A1	**Note:** Answer to 3 sf is 1.59 x 10^{-3} (m)
	(c)	(i)	Resonance Driving / drum frequency matches natural frequency (of casing) (AW)	B1 B1	
		(ii)	Graph with peak amplitude **less than** original peak amplitude Similar shape curve with peak at the **same** or **lower** frequency than given curve Curve is lower than given curve at all frequencies	M0 A1 A1	Must see this before subsequent marks can be scored.
			Total	**12**	

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Question			Answer	Marks	Guidance
3	(a)	(i)	Arrow (labelled F) directed towards centre of circle	B1	**Allow:** arrow drawn parallel to the string
		(ii)	Resultant force (F) acts at 90° to motion / velocity of bung	B1	**Allow:** No component of F acts in the direction of motion (B1)
			so no work done is done by F (hence no change in speed)	B1	hence there is no acceleration in the direction of motion (AW) (B1)
	(b)	(i)	Student tries to rotate bung at constant radius / tries to keep reference mark at end of tube (AW)	B1	**Not:** bald 'constant radius'
			Force F is calculated using $F = Mg$. where M is mass of slotted masses	B1	**Not** : F = weight
			Measure time *t* for n revolutions of the bung (hence calculate T for 1 revolution).	B1	**Not:** 'take time for 1 revolution'
			Measure radius r when stationary	B1	
			Calculate v using $2\pi r\, n\, /t$ (or $2\pi r\, /T$).	B1	
		(ii)	**1** Straight line of positive gradient passing through the origin	B1	
			2 $F = \frac{m}{r} v^2$ hence gradient $= \frac{m}{r}$	B1	Cannot award this mark if graph is curved
			Mass = gradient (of graph) x radius (of orbit)	B1	Can score this mark if graph is curved
			Total	**11**	

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Question			Answer	Marks	Guidance
4	(a)	(i)	Energy required to raise the temperature of a unit mass of a substance by unit temperature rise.	B1	**Allow:** $c = \frac{Q}{m\Delta\theta}$ with all symbols defined.
		(ii)	LH of fusion is energy needed to change (a substance) from solid to liquid LH of vaporisation is energy needed to change (a substance) from liquid to gas/vapour	B1	Allow: a single reference to energy (either statement acceptable)
	(b)	(i)	**A to B**: KE of molecules increases AND PE of molecules (small) increases **B to C**: KE of molecules remain constant AND PE of molecules increases	B1 B1	
		(ii)	c_{solid} is **less than** c_{liquid} Correct reason **Eg** gradient for solid is greater than gradient for liquid AND gradient is inversely proportional to specific heat capacity (AW}	B1 B1	
	(c)	(i)	In one second volume flowing through = (3.6 x 10^{-3} /60) = 6.0 x 10^{-5} mass flowing through = 6.0 x 10^{-5} x 1000 = (6.0 x 10^{-2}) Energy gained by water $E = mc\,\Delta\theta$ = 0.060 x 4200 x (36.7 – 17.4) (= 4864) Power of heater = E / t = 4864 /1 Power of heater = 4.9 x 10^3 ≈ 5 kW	 C1 C1 C1 A1 A0	**Alternative** In one minute volume flowing through = 3.6 x 10^{-3} mass flowing through = 3.6 (C1) Energy gained $E = mc\,\Delta\theta$ = 3.6 x 4200 x (36.7 – 17.4) (C1) (= 2.92 x 10^5 J) Power = E / t = 2.92 x 10^5 /60 (C1) Power of heater = 4.9 x 10^3 (A1) ≈ 5 kW (A0)
		(ii)	EITHER rate of flow of water changes **because** water pressure changes OR Inlet temperature changes **because** ambient temperature changes	 M1 A1	
			Total	**12**	

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Question			Answer	Marks	Guidance
5	(a)		Gas molecules move in **random / erratic / haphazard** motion (AW) :	B1	**Use tick or cross on Scoris** ✎ **random / erratic / haphazard** must be spelled correctly to score the mark.
	(b)	(i)	constant temperature	B1	
		(ii)	$P_1V_1 = P_2V_2$ $350 \times 120 \times (A) = P_2 \times 55 \times (A)$ $P_2 = \frac{350 \times 120}{55}$ = 760 (kPa)	C1 A1	**Note:** Answer to 3 sf is 764 (kPa) **Note**: 7.6×10^5 (kPa) scores 1 mark
		(iii)	When a molecule collides with the (moving) piston it rebounds with higher speed / ke / momentum (Mean) kinetic energy of molecules is <u>proportional / $\propto$</u> to (Kelvin) temperature	B1 B1	Must refer to collisions with piston or rebounds from piston not collisions within gas molecules. Allow: $E_k = 3kT/2$ without definition of terms.
			Total	**6**	

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Question			Answer	Marks	Guidance
6	(a)	(i)	Force between two (point) masses is proportional to the product of masses and inversely proportional to the square of the distance between them	B1 B1	**Not:** radius **Allow:** $F = GMm/r^2$ B1 **All** symbols defined B1
		(ii)	Force per (unit) mass	B1	**Allow:** $g = F/m$ with symbols defined
	(b)	(i)	$v = \frac{2\pi R}{T}$ $v = \frac{2\pi \times 1.2 \times 10^9}{16 \times 86400}$ $v = 5.5 \times 10^3$ (ms^{-1})	C1 A1	**Note:** Answer to 3 sf is 5.45 x 10^3 **Allow:** 1 mark for 4.7 x 10^8 not converting days to s **Allow:** 1 mark for 5.5 not converting km to m
		(ii)	$m_T \frac{v^2}{r} = \frac{GM_S m_T}{r^2}$ $M_S = \frac{v^2 r}{G}$ $M_S = \frac{(5.45 \times 10^3)^2 \times 1.2 \times 10^9}{6.67 \times 10^{-11}}$ $M = 5.3 \times 10^{26}$ (kg)	C1 C1 A1	**Allow:** alternative method using Kepler's third law Possible ECF from b(i) **Note :** An answer of 5.3 x 10^{26} (or 5.4 x 10^{26}) **without substitution shown** scores 2 marks since this is a '**show'** question. **Note:** Use of 5.5 x 10^3 gives 5.4 x 10^{26} (kg)
	(c)		Reference to $T^2 = (4\pi^2/GM)\, r^3$ OR $T^2 \propto r^3$ $\frac{T_R}{T_T} = \sqrt{\frac{r_R^3}{r_T^3}}$ OR $\frac{T_R}{T_T} = \left(\frac{r_R}{r_T}\right)^{\frac{3}{2}}$	B1 B1	**Not:** $\left(\frac{T_R}{T_T}\right)^2 = \left(\frac{r_R}{r_T}\right)^3$
			Total	**10**	

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Tuesday 24 January 2012 – Afternoon

A2 GCE PHYSICS A

G484 The Newtonian World

G411590112

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

G 4 8 4

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **12** pages. Any blank pages are indicated.

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Turn over

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Answer **all** the questions.

1 **(a)** **(i)** Define *linear momentum*.

.....

..... **[1]**

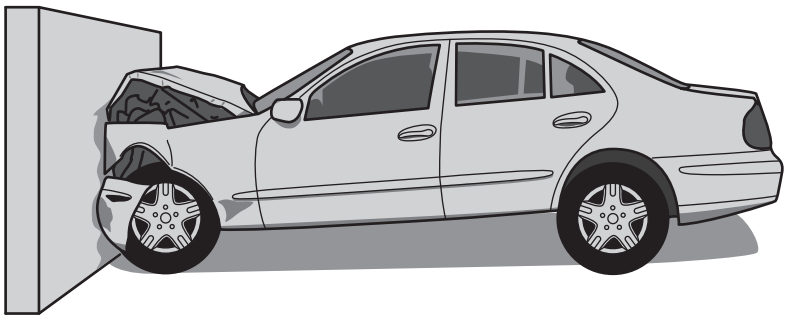
(ii) Linear momentum is a vector quantity. Explain why.

.....

.....

..... **[2]**

(b) The crumple zone of a car is a hollow structure at the front of the car designed to collapse during a collision. In a laboratory road-test, a car of mass 850 kg was driven into a concrete wall. A video recording of the impact showed that the car, initially travelling at 7.5 m s^{-1}, was brought to rest in 0.28 s when it hit the wall.



(i) Calculate

1 the deceleration of the car, assuming it to be uniform

deceleration = ... m s^{-2} **[1]**

2 the average force exerted by the wall on the car.

force = ... N **[2]**

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(ii) The crumple zone of the car is designed to absorb 0.45 MJ of energy before any distortion of the passenger cabin occurs. For this design of crumple zone, calculate the maximum speed of the car at impact.

speed = ... $m\,s^{-1}$ **[2]**

(c) In a different test, another car of mass 850 kg is travelling at a speed of 7.5 $m\,s^{-1}$. It makes a head-on collision with a stationary car of mass 1200 kg. Immediately after the impact, both cars move off together with a common speed *v*. Calculate this speed.

v = ... $m\,s^{-1}$ **[2]**

[Total: 10]

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2 Fig. 2.1 shows a displacement against time graph for an oscillating mass.

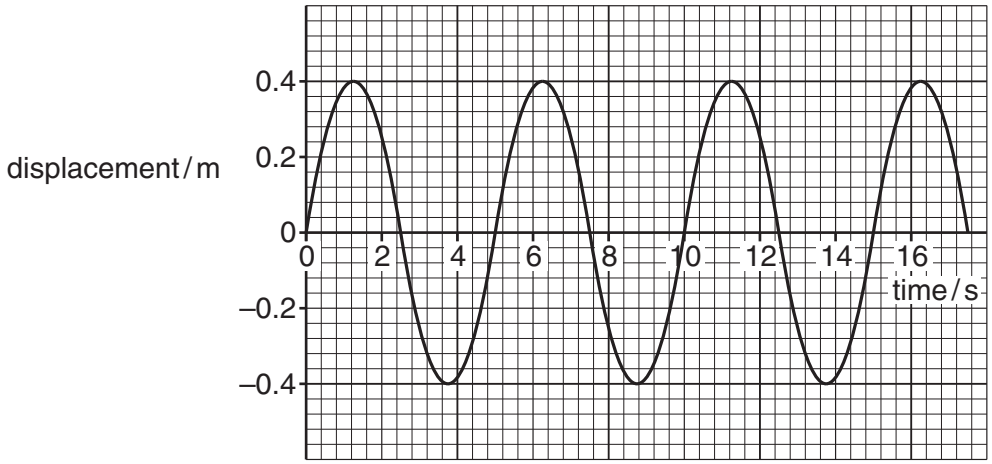


Fig. 2.1

(a) Use Fig. 2.1 to determine, for the oscillations of the mass,

(i) the amplitude and period

amplitude = ... m

period = ... s **[1]**

(ii) the angular frequency, ω.

ω = ... rad s^{-1} **[2]**

(b) Mark with a cross (**X**) on Fig. 2.1, using a different position in each case,

(i) a point where the velocity of the mass is a maximum; label it **V** **[1]**

(ii) a point where the acceleration of the mass is zero; label it **A** **[1]**

(iii) a point where the potential energy of the mass is a minimum; label it **P**. **[1]**

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(c) The cone of a loudspeaker oscillates with simple harmonic motion. It vibrates with a frequency of 2.4 kHz and has an amplitude of 1.8 mm.

(i) Calculate the maximum acceleration of the cone.

acceleration = ... $m\,s^{-2}$ **[3]**

(ii) The cone experiences a mean damping force of 0.25 N. Calculate the average power needed to be supplied to the cone to keep it oscillating with a constant amplitude.

power = ...W **[3]**

[Total: 12]

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3 **(a)** **(i)** State the name given to satellites that orbit the Earth, with a period of 1 day, above the equator.



You should use the appropriate technical term spelled correctly.

..... **[1]**

(ii) Explain why these satellites orbit above the equator.

.....

..... **[1]**

(iii) For companies who provide a satellite TV service, suggest the main advantage of using this type of satellite.

.....

..... **[1]**

(iv) The mass of the Earth is 6.0×10^{24} kg. Show that the radius of the orbit of a satellite with an orbital period of 1 day is about 4×10^{7} m.

[3]

(b) **(i)** State Kepler's third law.

.....

..... **[1]**

(ii) The Moon orbits the Earth with a period of 27.3 days. Use the information given in **(a)(iv)** to calculate the following ratio:

$$\frac{\text{distance of the Moon from the Earth's centre}}{\text{distance of the satellite from the Earth's centre}}$$

ratio = ... **[2]**

[Total: 9]

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4 **(a)** State the term used for the energy required to change a solid into a liquid.



You should use the appropriate technical term spelled correctly.

..... **[1]**

(b) **(i)** Define the *internal energy* of a system.

.....

.....

..... **[2]**

(ii) There is a change in internal energy when a mass of water at 100 °C becomes an equal mass of vapour at 100 °C. Explain why.

.....

.....

..... **[2]**

(c) **(i)** The air in a greenhouse has a volume of $15\,m^3$, a density of $1.2\,kg\,m^{-3}$ and a specific heat capacity of $990\,J\,kg^{-1}\,K^{-1}$. Immediately after sunset, the soil is transferring thermal energy to the air at an average rate of 12 W. Estimate the increase in temperature of the air in the greenhouse one hour after sunset as a result of this energy transfer from the soil.

increase in temperature = ...K **[3]**

(ii) Suggest two possible reasons why the actual increase in temperature of the air is likely to be much lower than this estimate.

.....

.....

..... **[2]**

[Total: 10]

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5 **(a)** **(i)** State what is meant by a *perfectly elastic collision*.

.....

..... **[1]**

(ii) Explain, in terms of the behaviour of **molecules**, how a gas exerts a pressure on the walls of its container.

.....

.....

.....

.....

.....

.....

..... **[4]**

(iii) Explain, in terms of the behaviour of **molecules**, why the pressure of a gas in a container of constant volume increases when the temperature of the gas is increased.

.....

.....

.....

.....

..... **[2]**

(b) A weather balloon is filled with helium gas. Just before take-off the pressure inside the balloon is 105 kPa and its internal volume is $5.0 \times 10^3\,m^3$. The temperature inside the balloon is 20 °C. The pressure, volume and temperature of the helium gas change as the balloon rises into the upper atmosphere.

(i) The balloon expands to a volume of $1.2 \times 10^4\,m^3$ in the upper atmosphere where the temperature inside the balloon is –30° C. Calculate the pressure inside the balloon.

pressure = ... kPa **[3]**

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(ii) Suggest why it is necessary to release helium from the balloon as it continues to rise.

.....

.....

..... **[1]**

[Total: 11]

Question 6 is on page 10.

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6 **(a)** The molar mass of hydrogen gas is $2.02 \times 10^{-3}\,\text{kg mol}^{-1}$. Calculate the mass of a hydrogen molecule.

mass = ... kg **[2]**

(b) The temperature of the Earth's upper atmosphere is about 1100 K. Show that at this temperature the mean kinetic energy of an air molecule is about 2×10^{-20} J.

[2]

(c) Show that the speed of a helium atom of mass 6.6×10^{-27} kg at a temperature of 1100 K is about $2.5\,\text{km s}^{-1}$.

[2]

(d) The *escape velocity* from the Earth is $11\,\text{km s}^{-1}$. The escape velocity is the minimum vertical velocity a particle must have in order to escape from the Earth's gravitational field. Explain why helium atoms still escape from the Earth's atmosphere.

.....

.....

.....

.....

..... **[2]**

[Total: 8]

END OF QUESTION PAPER

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GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for January 2012

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Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Telephone: 0870 770 6622
Facsimile: 01223 552610
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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

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Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

The use of ticks to indicate where marks are awarded is strongly advised in all questions but the following questions **must always** be annotated with ticks.
Q3(a)(i), Q4(a), Q5(a)(ii), Q5(a)(iii)

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more significant figures.

(Significant figures are rigorously assessed in the practical skills.)

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Question			Answer	Marks	Guidance
1	(a)	(i)	(linear momentum =) mass x velocity	B1	**Allow**: momentum = *m v* where *m* is mass and *v* is velocity **Not**: mass x speed
		(ii)	Any **two** from: momentum / vector has magnitude and direction velocity is a vector A product of a scalar and vector is a vector	B1 x 2	
	(b)	(i)1	$a = \Delta v / \Delta t = 7.5 / 0.28$ $a = 27$ (m s^{-2})	A1	Ignore sign
		2	$F = ma$ $F = 850 \times 27$ $= 2.3 \times 10^4$ (N)	C1 A1	Possible ecf from b(i) for acceleration
		(ii)	$E = \frac{1}{2}mv^2$ $0.45 \times 10^6 = ½ \times 850 \times v^2$ $v = \sqrt{(2 \times 0.45 \times 10^6 / 850)}$ $v = 33$ (m s^{-1})	C1 A1	Mark is for correct substitution **Note**: Possible POT error
	(c)		$m_1u = (m_1 + m_2)v$ $850 \times 7.5 = (850 + 1200)\ v$ $v = 850 \times 7.5 / 2050$ $v = 3.1$ (m s^{-1})	C1 A1	Mark is for correct substitution
			Total	**10**	

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Question			Answer	Marks	Guidance
2	(a)	(i)	amplitude = 0.4(0) (m) **and** period = 5.(0) (s)	B1	**Note**: Both values are required. **Allow** 1 sf values
		(ii)	$\omega = (2\pi f) = 2\pi / \tau$ $\omega = 2\pi / 5.0 = (2\pi \times 0.2)$ $\omega = 1.3$ (rad s^{-1})	 C1 A1	Possible ecf from a(i) for period Mark is for correct substitution
	(b)	(i)	V clearly marked at any point where graph crosses time axis	B1	
		(ii)	A clearly marked at any point where graph crosses time axis	B1	
		(iii)	P clearly marked at any point where graph crosses time axis	B1	
	(c)	(i)	Selecting from data sheet $a = -(2\pi f)^2 x$ $a_{max} = (-)(2\pi \times 2.4 \times 10^3)^2 \times 1.8 \times 10^{-3}$ $a_{max} = 4.1 \times 10^5$ (m s^{-2})	C1 C1 A1	**Allow**: $a = (-)\omega^2 x$ **Note**: Ignore sign of a **Allow**: 2 marks for 4.1×10^n, $n \neq 5$ [POT error]
		(ii)	Work done = mean force x distance moved For ¼ oscillation distance moved = 1.8 mm, Work done $= 0.25 \times 1.8 \times 10^{-3}$ ($= 4.5 \times 10^{-4}$ J) Time taken $\Delta t = ¼ T = ¼ (1/2.4 \times 10^3) = 1.04 \times 10^{-4}$ Power = work done / $\Delta t = 0.25 \times 1.8 \times 10^{-3} / 1.04 \times 10^{-4}$ = **4.3 W** Power = 4.3 (W)	 C1 C1 A1	**Allow:** other correct values of distance moved and compatible time taken. Eg 7.2 (mm) and 4.17×10^{-4} (s) for 1 complete oscillation
			Total	**12**	

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Question			Answer	Marks	Guidance
3	(a)	(i)	**geostationary** or **synchronous** ✍**The term geostationary** or **synchronous** **to be included and spelled correctly to gain the B1 mark**	B1	**Must use tick or cross on Scoris to show if the mark is awarded**
		(ii)	So that they stay: above the same point (at all times) at same point in the sky	B1	**Allow**: travel at same (angular) speed / period and same direction as the Earth
		(iii)	Dish can be fixed to point in one (specific) direction/ Dish does not have to track the satellite (across the sky)	B1	**Allow**: Receiver / aerial for dish
		(iv)	Select from data sheet $T^2 = (4\pi^2/GM)r^3$ $r^3 = T^2 (GM/4\pi^2)$ $r^3 = (8.64 \times 10^4)^2 (6.67 \times 10^{-11} \times 6.0 \times 10^{24} / 4\pi^2)$ any subject $(= 7.56 \times 10^{22})$ $r = 4.2 \times 10^7$ (m) $r \approx 4 \times 10^7$ (m)	C1 C1 A1 A0	**Allow**: Full credit if candidate assumes r = 4×10^7 and shows T is approx 1 day. 1 day = 8.64×10^4 s G = 6.67×10^{-11} N m^2 kg^{-2} Mark for radius can only be awarded if suitable working is shown
	(b)	(i)	The cube of the planets distance (from the Sun) divided by the square of the (orbital) period is the same (for all planets) (WTTE)	B1	**Allow**: radius for distance., **Allow:** $T^2 \propto r^3$ or r^3 / T^2 = constant provided T and r are identified
		(ii)	$\text{ratio}^3 = \left(\frac{27.3}{1}\right)^2$ $\text{ratio} = (27.3)^{2/3}$ ratio = 9.1	C1 A1	**Allow:** 1 mark for correct value of distance of Moon from Earth's centre 3.8×10^8(m) **Note**: Full credit for 4×10^7 (m) used from (a)(iv)
			Total	**9**	

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Question			Answer	Marks	Guidance
4	(a)		latent heat of **fusion** ✍**The term fusion to be included and spelled correctly to gain the B1 mark**	B1	**Allow**: Specific latent heat of fusion **Allow**: (Specific) latent energy of fusion **Must use tick or cross on Scoris to show if the mark is awarded**
	(b)	(i)	Total / sum of randomly (distributed) kinetic energy and potential energy of molecules/atoms	B2	**Allow**: 1 mark only if molecules / atoms and/or randomly are omitted
		(ii)	Potential energy of the molecules increases Kinetic energy of molecules is the same for water and steam (since the temperature is the same) / work is done in moving molecules apart	B1 B1	**Allow** : work is done to break the bonds (between molecules)
	(c)	(i)	Mass of air = volume x density = 15 x 1.2 (= 18 kg) Heat energy transferred to air in one hour Q = 12 x 60 x 60 (= 43200 J) $\Delta\theta = Q / mc$ = 12 x 60 x 60 / 18 x 990 Temperature rise in one hour = 2.4 K	C1 C1 A1	**Allow**: any subject Treat a transcription error as one AE. **Allow**: 2 K as question asks for an estimate
		(ii)	Any **two** from • Heat lost to structure of greenhouse / contents • Heat lost through glass / from the greenhouse / surroundings • Average rate of loss of heat reduces (as temperature falls)	B1 x 2	
			Total	**10**	

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Question			Answer	Marks	Guidance
5	(a)	(i)	Collision in which kinetic energy is conserved	B1	**Allow**: no ke lost (wtte)
		(ii)	Any **four** from • Many molecules collide with the walls • A change in momentum occurs when molecule(s) collide with (and rebound from) the walls of container • Force is rate of change of momentum • The force exerted by the molecule(s) on wall is equal to force exerted by the wall on the molecule(s) (by Newton's third law) • pressure (on wall) = (total) force (on wall) / area (of wall)	B1 x 4	Symbols must be defined in formulae
		(iii)	Any **two** from • Molecules move faster/have greater kinetic energy (at higher temperature) • There is an increased rate of collision / more collisions occur per second / collisions occur more often • Each collision involves a greater change in momentum	B1 x 2	**Not**: greater force **Not**: harder collisions
	(b)	(i)	$P_1V_1/T_1 = P_2V_2/T_2$ with T stated in Kelvin or clearly shown in subsequent working $P_2 = 105 \times 5\times10^3 \times (273 - 30)/(273 + 20) \times 1.2 \times 10^4$ $P_2 = 36$ (kPa)	C1 C1 A1	Temperatures must be in kelvin to score this mark. **Allow** : consistent working in pascal
		(ii)	Risk that balloon will burst (with further increase in volume)	B1	**Allow**: pop / explode
			Total	**11**	

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Question			Answer	Marks	Guidance
6	(a)		Mass of one hydrogen molecule = $2.02 \times 10^{-3} / 6.02 \times 10^{23}$	C1	
			Mass = 3.4×10^{-27} (kg)	A1	
	(b)		Mean k.e = $3kT/2$		
			Mean ke = $3/2 \times 1.38 \times 10^{-23} \times 1100$	B1	
			Mean ke = 2.3×10^{-20} (J)	B1	
			Mean ke ≈ 2×10^{-20} (J)	A0	
	(c)		$E_k = ½ mv^2$		**Note**: Full credit to be given for the use of 2×10^{-20} (J) from (b) giving $v = 2.5 \times 10^3$ (ms^{-1})
			$2.3 \times 10^{-20} = ½ \times 6.6 \times 10^{-27} v^2$		
			$v^2 = (2 \times 2.3 \times 10^{-20} / 6.6 \times 10^{-27})$ $v = (2 \times 2.3 \times 10^{-20} / 6.6 \times 10^{-27})^{1/2}$	M1	**Note:** If 3.36×10^{-27} is used from (a) (hydrogen molecules) then speed = 3.68×10^3 m s^{-1} and scores max 1 mark
			$v = 2.6 \times 10^3$ (m s^{-1})	A1	
	(d)		Helium atoms have a range of speeds / kinetic energies	M1	Accept equivalent wording or suitable diagram
			Hence some atoms have a velocity greater than 11 km s^{-1} / escape velocity	A1	.
			Total	**8**	

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OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
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RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

The Newtonian World

G484

Candidates answer on the question paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet

Other materials required:
- Electronic calculator

Monday 27 June 2011
Morning

Duration: 1 hour

G4103406111

G 4 8 4

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **12** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 **(a)** **(i)** State Newton's first law of motion.

.....

.....

..... **[1]**

(ii) Define the *newton*.

.....

..... **[1]**

(b) A jet plane on the deck of an aircraft carrier is accelerated before take-off using a catapult. The mass of the plane is 3.2×10^4 kg and it is accelerated from rest to a velocity of 55 m s^{-1} in a time of 2.2 s. Calculate

(i) the mean acceleration of the plane

mean acceleration = ... m s^{-2} **[2]**

(ii) the distance over which the acceleration takes place

distance = ... m **[2]**

(iii) the mean force producing the acceleration.

mean force = ...N **[1]**

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(c) The jet plane describes a **horizontal** circle of radius 870 m flying at a constant speed of 120 m s^{-1}.

(i) State the direction of the resultant horizontal force acting on the plane.

..... **[1]**

(ii) Calculate the magnitude of this horizontal force.

force = ...N **[2]**

(d) By changing the velocity of the plane it can be made to fly in a **vertical** circle of radius 1500 m. At a particular point in the vertical circle, the contact force between the pilot and his seat may be zero and the pilot experiences "weightlessness".

(i) State and explain at what point in the circle this weightlessness may occur.

.....

.....

.....

..... **[2]**

(ii) Calculate the speed of the plane at which weightlessness occurs.

speed = ... m s^{-1} **[2]**

[Total: 14]

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2 **(a)** Fig. 2.1 shows a mass attached to the end of a spring. The mass is pulled down and then released. The mass performs vertical simple harmonic motion.

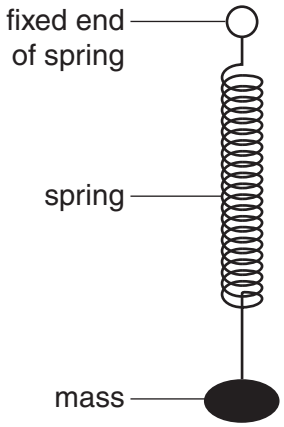


Fig. 2.1

(i) Define *simple harmonic motion*.

.....

.....

.....

..... **[2]**

(ii) Mark the following statements about the oscillating mass-spring system as *true* or *false*. **[2]**

statement	**true/false**
The period of oscillation is constant.	
The net force on the mass is equal to its weight.	
The acceleration of the mass is a maximum at the mid-point of the oscillations.	
The velocity of the mass is proportional to the displacement.	

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(b) A student wishes to investigate whether the period of oscillation of a simple pendulum is constant for all angles of swing. Describe how the student should carry out the investigation. Include the following in your description:

- a sketch of the apparatus with angle of swing labelled
- details of how the measurements would be made
- how these results would be used to form a conclusion
- the major difficulty likely to be encountered and how this might be overcome.

Sketch:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[5]**

[Total: 9]

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3 **(a)** Define *gravitational field strength*.

.....

..... **[1]**

(b) The table shows, in modern units, information that was known to physicists at the time of Isaac Newton.

position	distance r from centre of the Earth / km	gravitational field strength g due to the Earth / N kg^{-1}
surface of Earth	6.4×10^{3}	9.8
Moon's orbit	3.8×10^{5}	2.7×10^{-3}

Use the information provided in the table to

(i) state a relationship between the gravitational field strength g and the distance r and verify this relationship

.....

..... **[3]**

(ii) show that the mass of the Earth is about 6×10^{24} kg

[2]

(iii) determine the mean density of the Earth.

density = ... kg m^{-3} **[2]**

[Total: 8]

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4 **(a)** *In your answer you should use appropriate technical terms spelled correctly.*

State the terms used to describe the thermal energy required to change

(i) a solid into a liquid at a constant temperature

..... **[1]**

(ii) a liquid into a gas at a constant temperature.

..... **[1]**

(b) Most households waste energy by overfilling electric kettles. Assume that, on average, 0.80 kg of water per household per day is unnecessarily boiled.

(i) Estimate the energy required when 0.80 kg of water, initially at 18 °C, is heated in an electric kettle. The kettle switches off automatically when the water is boiling steadily at 100 °C. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

heat energy = ... J **[2]**

(ii) State and explain **two** different reasons why the actual quantity of energy required to warm the water to 100 °C is greater than the estimate in **(i)**.

1. .....

.....

2. .....

..... **[2]**

(iii) Calculate, in kW h, the average annual energy wasted per household by boiling too much water.

energy = ...kW h **[2]**

[Total: 8]

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5 **(a)** One assumption required for the development of the kinetic model of a gas is that molecules undergo perfectly elastic collisions with the walls of their containing vessel and with each other.

(i) Explain what is meant by a *perfectly elastic collision*.

.....

..... **[1]**

(ii) State **three** other assumptions of the kinetic theory of gases.

1. .....

.....

2. .....

.....

3. .....

..... **[3]**

(b) Fig. 5.1 shows a cubical box of side length 0.20 m. The box contains one molecule of mass 4.8×10^{-26} kg moving with a constant speed of 500 m s^{-1}. The molecule collides elastically at right angles with the opposite faces **X** and **Y** of the box.

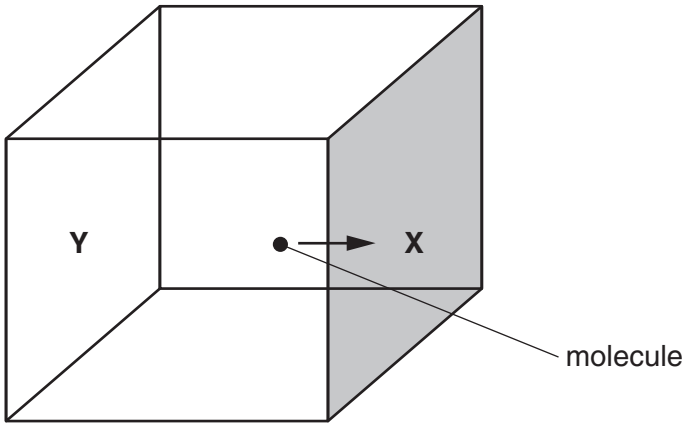


Fig. 5.1

(i) Calculate the change of momentum each time the molecule collides with face **X**.

change of momentum = ...kg m s^{-1} **[2]**

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(ii) Calculate the number of collisions made by the molecule with face **X** in 1.0 s.

number = ... **[1]**

(iii) Calculate the mean force exerted on the molecule by face **X**.

force = ...N **[2]**

(iv) Hence state the force exerted on face **X** by the molecule. Justify your answer.

.....

..... **[1]**

(c) The single molecule in the box in **(b)** is replaced by 3 moles of air at atmospheric pressure.

(i) Calculate the number of air molecules in the box.

number = ... **[1]**

(ii) Suggest why the pressure exerted by the air on each of the six faces of the box is the same.

.....

..... **[1]**

(iii) The temperature of the air inside the box is increased. Explain in terms of the **motion** of the air molecules how the pressure exerted by the air will change.

.....

.....

..... **[2]**

[Total: 14]

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6 **(a)** **(i)** A container has **1 mole** of an ideal gas. The volume of the container is V cubic metres (m^3) and the gas exerts pressure p pascal (Pa). On Fig. 6.1, show the relationship between the product pV and the absolute temperature T of the gas. **[1]**



Fig. 6.1

(ii) State the value of the gradient of this graph.

..... **[1]**

(b) The volume of 1.5 moles of an ideal gas at −40 °C is $2.4 \times 10^{-2}\,m^3$. The gas is now heated at constant pressure p. Calculate

(i) the new volume of the gas at a temperature of 250 °C

volume = ...m^3 **[3]**

(ii) the value of the pressure p.

p = ... Pa **[2]**

[Total: 7]

END OF QUESTION PAPER

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ADDITIONAL PAGE

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ADDITIONAL PAGE

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RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for June 2011

Oxford Cambridge and RSA Examinations

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OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

Q1	Expected Answers	Marks	Additional guidance
(a)(i)	A body will remain at rest or continue to move with constant velocity unless acted upon by a force (WTTE)	B1	Do not allow speed unless "speed in a straight line" is stated. Allow "uniform motion"
(a)(ii)	The force which gives a mass of 1 kg an acceleration of 1 m s^{-2}	B1	**Allow** 1N = 1 kg m s^{-2}
(b)(i)	Use of $v = u + at$ OR $a = (v - u) / t \Rightarrow a = (55 - 0) / 2.2$ $a = 25$ (m s^{-2})	C1 A1	
(b)(ii)	Use of $s = ut + ½ at^2$ e.g. $s = 0 + ½ \times 25 \times 2.2^2$ $s = 60.5$ (m)	C1 A1	**Allow** other valid solutions e.g. using $v^2 = u^2 + 2as$
(b)(iii)	$F = ma = 3.2 \times 10^4 \times 25 = 8.0 \times 10^5$ (N)	A1	**Allow** ecf from (b)(i)
(c)(i)	towards the centre of the circle.	B1	Do not allow a bare "perpendicular to the velocity" Do not allow "in the same direction as the acceleration."
(c)(ii)	use $F = mv^2/r$ e.g. $F = (3.2 \times 10^4 \times 120^2)/870$ $F = 5.3 \times 10^5$ (529655) (N)	C1 A1	If 55 is used instead of 120 for the velocity $F = 1.1 \times 10^5$ ms^{-1} and scores 1 mark
(d)(i)	At top of the circle when the weight provides/equals the required centripetal force	M1 A1	**Allow** "when the resultant force = weight"
(d)(ii)	realisation that acc = g (OR 9.81) AND (hence) $v^2/r = g$ $\{v = \sqrt{(gr)} = \sqrt{(9.81 \times 1500)}\} \Rightarrow v = 120$ (m s^{-1}) (121.3)	M1 A1	**Accept** 121.24 as this corresponds to 9.8, do **not** allow 122.5 since this assumes $g = 10$ ms^{-2}
	Total	**14**	

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Q2	Expected Answers	Marks	Additional guidance
(a)(i)	Force/acceleration is proportional to displacement **(**from equilibrium position**)** (Resultant force) force/acceleration is (always) towards equilibrium position (WTTE, e.g. allow fixed point).	B1 B1	**Allow** force/acceleration is in opposite direction to the displacement. **Allow** acc $\propto x$, provided x is identified as the displacement for 1st mark. 2nd mark only scored if –ve sign used and explained.
(a)(ii)	True; False False; False	B2	-1 for each error stop at zero Assume ✓ means true and X means false Do not credit blank spaces
(b)	***Measurements***: angle measured <u>with protractor</u> stated or shown on the diagram <u>stop-watch/ms timer/data-logger</u> to measure time stated or shown on the diagram ***Conclusion:*** compare periods for different angles stated/implied OR plot period against angle ***major difficulty:*** angle of swing decreases during the timing of the swing ***solution:*** e.g. measure time for ¼, ½ or 1 swing accurately (using electronic timer/datalogger) OR use data logger with motion sensor to record many swings and analyse how the period changes over time OR video the motion with onscreen timer and analyse	 B1 B1 B1 M1 A1	**Allow** ruler used to measure initial and subsequent displacement/amplitude if explained. **Allow** table of results with correct column headings i.e. at least angle and period Do not allow ‘time is short so measure nT and divide by n to reduce (%) error’.(WTTE)
	Total	**9**	

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Q3	Expected Answers	Marks	Additional guidance
(a)	Force per unit mass (at a point in a gravitational field).	B1	Accept $g = F/m$ if F and m are identified
(b)(i)	Recognition that inverse square law needs to be verified: e.g. $g \propto 1/r^2$ hence gr^2 = constant $\Rightarrow$ $9.8 \times 6400^2 = 4.0 \times 10^8$ (or 4×10^{14}) AND $2.7 \times 10^{-3} \times (3.8 \times 10^5)^2 = 3.9 \times 10^8$ (or 3.9×10^{14}) (n.b values in brackets correspond to radius in metres) Any appropriate comment consistent with the calculations e.g. values are close enough (to verify the relationship).	B1 B1 B1	Do not accept a bare $g = GM/r^2$ unless G and M are stated as constants or following calculations shows this. They must use values in table and do both calculations for this mark **Allow** other valid approaches e.g. g ratio compared to $1/r^2$ ratio (3630 and 3530) OR (2.75×10^{-4} , 2.84×10^{-4} ,)
(b)(ii)	($mg = GmM / r^2 \Rightarrow M = gr^2 / G$) $M = 9.81 \times (6.4 \times 10^6)^2 / 6.67 \times 10^{-11}$ $M = 6.024 \times 10^{24}$ kg	 C1 A1	(this formula is given on data sheet) Correct substitution into formula **Allow** 6.018×10^{24} this is for $g = 9.8$ and allow any value between 6.0×10^{24} and 6.03×10^{24} but not 6×10^{24} Also **allow** data for the moon to be used i.e $M_E = 2.7 \times 10^{-3} \times 3.8 \times 10^8 / 6.67 \times 10^{-11}$ = 5.846×10^{24} kg $\approx 6 \times 10^{24}$ kg
(b)(iii)	volume = $(4/3)\pi r^3 = (4/3)\pi (6.4 \times 10^6)^3$ (= 1.10×10^{21} m^3) $\rho = M/V = 6.0 \times 10^{24} / 1.10 \times 10^{21} = 5500$ (5464)(kg m^{-3})	C1 A1	mark for correct substitution e.g. 6.4×10^6 (in m) used and not 6.4×10^3 (km) **allow** ecf from b(ii) for cand's value of M but no ecf for wrong volume formula If $r = 6.4 \times 10^3$ is used $V = 1.1 \times 10^{12} \Rightarrow$ $\rho = 5.5 \times 10^{12}$ and scores 1 mark
	Total	**8**	

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Q4	Expected Answers	Mark	Additional guidance
(a)(i)	Latent heat of <u>fusion</u>.	B1	QWC fusion spelled correctly ignore any reference to specific.
(a)(ii)	Latent heat of <u>vaporisation</u>.	B1	QWC Vaporisation spelled correctly. **Accept** vaporization but not vapourisation.
(b)(i)	E = $mc\Delta\theta$ used correctly e.g. 0.8 x 4200 x 82 = 2.8 x 10^5 (J) (275520)	C1 A1	0.8 x 4200 x (82+273) scores zero
(b)(ii)	Any two from: Some heat/energy used to heat kettle Some heat/energy lost to surroundings/air/environment. Some heat/energy used to boil water before kettle switches off	B1 B1	Do **not allow** "some heat lost" i.e. they must state where/how Do **not allow** "kettle if not 100% efficient". Do not allow "energy lost as sound/light"
(b)(iii)	1 kWh = 1000 x 3600 = 3.6 x 10^6 J Wastage per year = (2.8 x 10^5 x 365) / 3.6 x 10^6 = 28 kWh (27.9)	C1 A1	**Allow** 1 mark for energy lost per year = 1.02 x 10^8 <u>Joules</u> Allow ecf from (b)(i)
	Total	**8**	

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Q5	Expected answers	Mark	Additional guidance
(a)(i)	A collision with no change / loss of kinetic energy.	B1	**Allow** coeff't of restitution = 1
(a)(ii)	Any 3 from Volume of particles negligible compared to volume of vessel OR molecules much smaller than distance between them No intermolecular forces acting (other than during collisions) OR molecules only have kinetic energy (and no PE) Particles travel in straight lines/at uniform velocity between collisions OR force of gravity on molecules is negligible time of collisions much smaller than time between collisions gas consists of a large number of molecules moving randomly (both needed for the mark)	 B1 B1 B1	 do not allow a bare "negligible volume of molecules " Do not allow "collisions between molecules are elastic" because this is given in the question. do not allow a bare "negligible time of collisions" Do not allow a bare "rapid random motion"
(b)(i)	$\Delta p = mv - mu$ $= 4.8 \times 10^{-26} [500 - (-500)] = 4.8 \times 10^{-23}$ kg m s^{-1}	C1 A1	 2.4×10^{-23} scores zero
(b)(ii)	(time between collisions = 0.4 /500 s) . Number of collisions/sec. = 500/0.4 = 1250	A1	Correct answer only
(b)(iii)	(Mean) force = $\Delta p/t$ OR Force = rate of change of momentum OR Impulse = change in momentum Force = $1250 \times 4.8 \times 10^{-23} / 1 = 6.0 \times 10^{-20}$ N	C1 A1	**Allow** ecf from (b)(i) and (b)(ii) e.g. if 2500 is used from (b)(ii) $F = 2500 \times 4.8 \times 10^{-23} = 1.2 \times 10^{-19}$ N and this scores 2 marks
(b)(iv)	Same value as candidate's (b)(iii) due to Newton's third law OR this force acts in opposite direction	B1	 OR –ve sign shown
(c)(i)	$3 \times 6 \times 10^{23} = 1.8 \times 10^{24}$	B1	1.806×10^{24} if 6.02 is used
(c)(ii)	(very) large number of particles that are moving randomly means that at any instant the number of collisions on each face will be the same (WTTE)	B1	Allow no gravitational forces and hence uniform density
(c)(iii)	(mean) KE/speed of molecules increases Increased rate of collisions with wall OR 'harder' collisions with wall	B1 B1	Also **allow** greater change of momentum per collision (WTTE) Not just "more collisions".
	Total	**14**	

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Q6	Expected answers	Mark	Additional guidance
(a)(i)	Straight line (judged by eye)with positive slope AND passing through the origin	B1	correct answer only
(a)(ii)	8.31 (J mol^{-1} K^{-1})	B1	Allow *R* and molar gas constant, but do not allow *pV*/*T* OR *nR*
(b)(i)	-40 ^{o}C = 233 K, AND 250 ^{o}C = 523 K Use of $V_1/T_1 = V_2/T_2$ 2.4 x 10^{-2} / 233 = V_2 / 523 V_2 = 0.053(8) (m^3)	M1 C1 A1	No marks scored if 40° C and/or 250°C are used Accept other correct versions.
(b)(ii)	Use of $p = nRT/V$ = 1.5 x 8.31 x 233 / 2.4 x 10^{-2} = 1.21 x 10^5 (Pa)	C1 A1	Allow *T*= 523 and *V*= 0.053 hence *p* = 1.2 x10^5 Allow ecf from (b)(i)
	Total	**7**	

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ADVANCED GCE
PHYSICS A
The Newtonian World

G484

Candidates answer on the Question Paper

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- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator

Tuesday 29 June 2010
Afternoon

Duration: 1 hour

OCE/23016

G4834

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **12** pages. Any blank pages are indicated.

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Turn over

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Answer **all** the questions.

1 **(a)** A particular collision between two objects is *inelastic*. Place a tick (✓) at the end of each statement that applies to such a collision. **[2]**

Statement	
The magnitude of the impulse on each object is the same.	
Kinetic energy and momentum for the objects are conserved.	
Total energy is conserved.	
After the collision, the objects have the same momentum.	

(b) Fig. 1.1 shows a tennis ball before and after striking a wall at right angles.

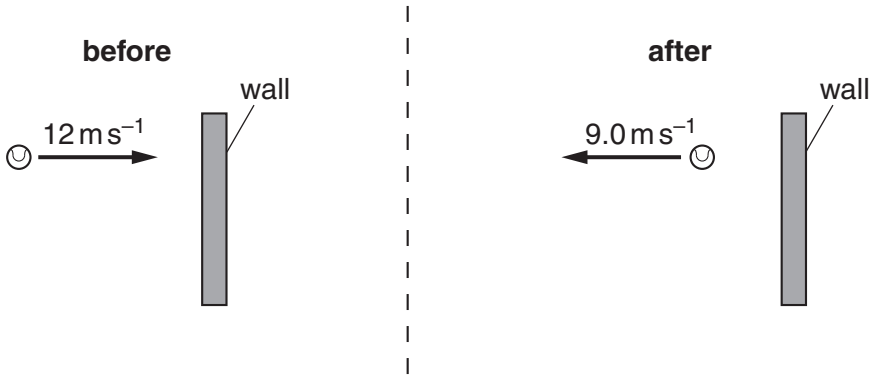


Fig. 1.1

The ball of mass 0.060 kg hits the wall at a speed of 12 m s^{-1}. The ball is in contact with the wall for 0.15 s. It rebounds with a speed of 9.0 m s^{-1}. Calculate

(i) the loss of kinetic energy during the collision

loss of kinetic energy = ... J **[2]**

(ii) the magnitude of the average force exerted on the ball by the wall

average force on ball = ... N **[2]**

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(iii) the magnitude of the average force exerted on the wall by the ball during this collision.

average force on wall = ... N **[1]**

(c) (i) State **three** assumptions of the kinetic model of ideal gases.

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..... **[3]**

(ii) Use the kinetic theory of gases to explain how a gas exerts a pressure.

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..... **[3]**

[Total: 13]

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2 **(a)** Fig. 2.1 shows an aeroplane flying in a horizontal circle at constant speed. The weight of the aeroplane is *W* and *L* is the lift force acting at right angles to the wings.



Fig. 2.1

(i) Explain how the lift force *L* maintains the aeroplane flying in a **horizontal** circle.

.....

.....

.....

..... **[2]**

(ii) The aeroplane of mass 1.2×10^5 kg is flying in a horizontal circle of radius 2.0 km.

The centripetal force acting on the aeroplane is 1.8×10^6 N. Calculate the speed of the aeroplane.

speed = ... $m\,s^{-1}$ **[2]**

(b) Fig. 2.2 shows a satellite orbiting the Earth at a constant speed *v*. The radius of the orbit is *r*.

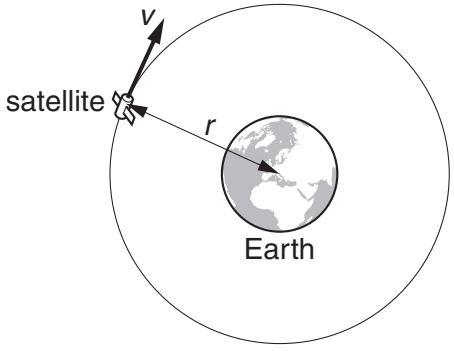


Fig. 2.2

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Show that the orbital period T of the satellite is given by the equation

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where M is the mass of the Earth and G is the gravitational constant.

[3]

(c) The satellites used in television communication systems are usually placed in geostationary orbits.



In your answer, you should use appropriate technical words spelled correctly.

(i) State two features of geostationary orbits.

1. .....

.....

2. .....

..... **[2]**

(ii) Calculate the radius of orbit of a geostationary satellite.

The mass of the Earth is 6.0×10^{24} kg.

radius = ... m **[3]**

[Total: 12]

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3 **(a)** State two conditions concerning the **acceleration** of an oscillating object that must apply for simple harmonic motion.

1. .....

.....

2. .....

.....

..... **[2]**

(b) Fig. 3.1 shows how the potential energy, in mJ, of a simple harmonic oscillator varies with displacement.

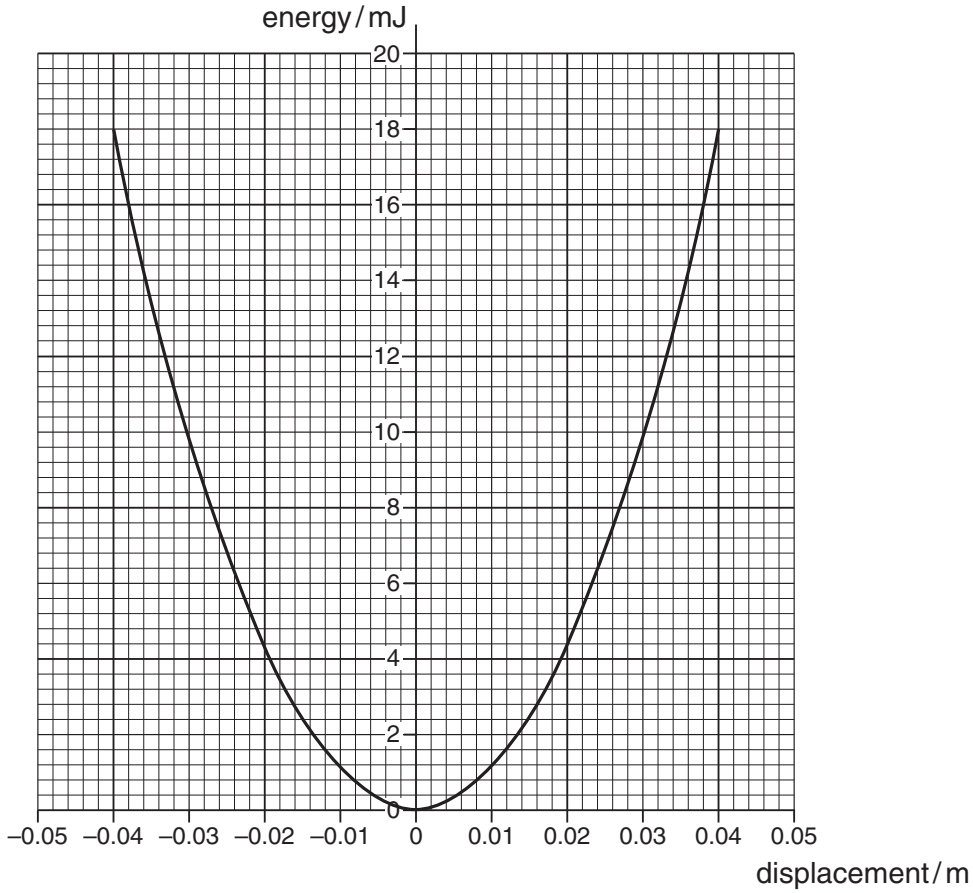


Fig. 3.1

On Fig. 3.1 sketch graphs to show the variation of

(i) kinetic energy of the oscillator with displacement – label this graph **K** **[2]**

(ii) the total energy of the oscillator with displacement – label this graph **T**. **[1]**

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(c) Use Fig. 3.1 to determine

(i) the amplitude of the oscillations

amplitude = ... m **[1]**

(ii) the maximum speed of the oscillator of mass 0.12 kg

maximum speed = ... $m\,s^{-1}$ **[2]**

(iii) the frequency of the oscillations.

frequency = ... Hz **[2]**

(d) Resonance can either be useful or a problem. Describe one example where resonance has a useful application and one example where resonance is a problem or nuisance. For each example identify what is oscillating and what causes these oscillations.

(i) useful application

.....

.....

.....

.....

..... **[2]**

(ii) problem

.....

.....

.....

.....

..... **[2]**

[Total: 14]

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4 Fig. 4.1 shows smoke particles suspended in air. The arrows indicate the directions in which the smoke particles are moving at a particular instant. The lengths of the arrows indicate the different speeds of the particles.

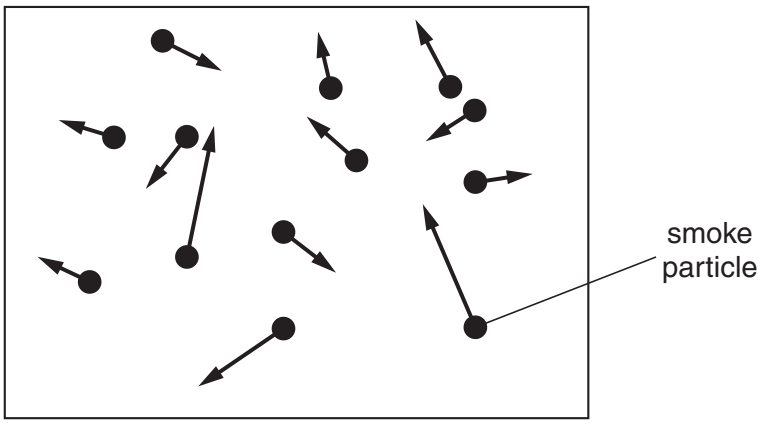


Fig. 4.1

(a) (i) State the name given to this type of random motion of smoke particles in air.

In your answer, you should use appropriate technical terms spelled correctly.

.....

..... **[1]**

(ii) State **two** conclusions about the air molecules that may be deduced from the observed motion of the smoke particles.

.....

.....

.....

..... **[2]**

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(b) (i) The radius of an inflated football is 0.11 m. The temperature of the air inside the ball is 17 °C. Calculate the mass of air in the ball when the pressure inside it is 2.6×10^5 Pa.

The mass of one mole of air is 0.028 kg.

mass of air = ... kg **[4]**

(ii) The football is left in a room at a temperature of 0 °C until it reaches thermal equilibrium.

1 Explain the term *thermal equilibrium*.

.....

.....

..... **[1]**

2 Calculate the pressure exerted by the air inside the football when the temperature drops to 0 °C.

pressure = ... Pa **[2]**

[Total: 10]

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5 A car of mass 970 kg is travelling at 27 m s^{-1} when the brakes are applied. The car is brought to rest in a distance of 40 m.

(a) **(i)** Calculate the kinetic energy of the car when it is travelling at 27 m s^{-1}.

kinetic energy = ... J **[1]**

(ii) Hence calculate the average braking force on the car stating any assumption that you make.

average braking force = ... N

assumption .....

..... **[3]**

(b) The car has four brake discs each of mass 1.2 kg. The material from which the discs are made has a specific heat capacity of 520 J kg^{-1} K^{-1}.

(i) Calculate the temperature rise of each disc after braking from a speed of 27 m s^{-1}. Assume all the kinetic energy of the car is converted into internal energy of the brake discs equally during braking.

temperature rise = ... °C **[2]**

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(ii) State and explain **two** reasons why the actual temperature rise will be different.

.....

.....

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.....

..... **[4]**

(iii) Suggest one modification to the design of the disc braking system that could reduce the temperature rise of the discs.

.....

.....

..... **[1]**

[Total: 11]

END OF QUESTION PAPER

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GCE

Physics A

Advanced GCE **G484**

The Newtonian World

Mark Scheme for June 2010

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Question	Expected Answers	Marks	Additional guidance
1(a)	The magnitude of the impulse on each object is the same Total energy is conserved	B1 B1	For 3 or 4 ticks mark and deduct 1 mark for each error.
(b) (i)	Correct use of ½ mv^2 Loss of KE = 0.03(144-81) = **1.9** (or 1.89) **J**	C1 A1	0.27 J scores 1st mark Do not allow 1.8
(b) (ii)	Change in momentum = (0.06x12)+(0.06x9) = 1.26 (Ns) Average force=rate of change of momentum = 1.26/0.15 = **8.4** (or 8) **N**	C1 A1	Award 1 mark for 1.2 N ignore minus signs
(b) (iii)	**8.4 N** (or - 8.4)	B1	Allow ecf from (ii)
(c) (i)	ANY 3 of the following particles move with <u>rapid, random</u> motion (WTTE) elastic collisions negligible (or zero) volume of atoms (compared with volume of container) no intermolecular forces (except during collisions)/all internal energy is KE collision time negligible (compared to time between collision).	 B1 B1 B1	Allow " gravitational force on molecules is negligible" Do not allow a bare "large number of particles".
(c) (ii)	molecules make <u>collisions with walls/surface</u> (WTTE) (hence) exerts a force on the wall (or each collision has a change of momentum) Pressure = force/area	B1 B1 B1	Do not allow a bare "molecules collide with each other"
	Total	13	

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Question	Expected Answers	Marks	Additional guidance
2 (a) (i)	Horizontal <u>component</u> of **L** provides the centripetal force (WTTE) Vertical <u>component</u> of **L** balances the weight (WTTE)	B1 B1	
(a) (ii)	$F = mv^2/r$ correct rearranged into $v = \sqrt{(Fr/m)}$ $v = \sqrt{(1.8\text{x}10^6 \text{ x}2000/1.2\text{x}10^5)} =$ **173** m s^{-1} (or 170)	C1 A1	Allow correct substitution of values into $F = mv^2/r$ for C1 mark
(b)	$mv^2/r = GMm/r^2$ $T = 2\pi r/v$ Correct manipulation of equations to give $T^2 = \frac{4\pi^2 r^3}{GM}$	B1 M1 A1	Do not allow a bare $v^2 = GM/r$ for the first mark – we need to see where this has come from.
(c) (i)	**Equatorial** orbit (WTTE) (<u>QWC mark</u>) Period is 24h/1day/same as Earth **OR** moves from West to East (WTTE)	B1 B1	QWC <u>equatorial</u> or <u>equator</u> must be spelled correctly
(c) (ii)	Correct rearrangement of $T^2 = (4\pi^2 r^3/GM)$ to give $r^3 = T^2GM/4\pi^2$ correct sub. $r^3 = \{6.67\text{ x}10^{-11} \text{ x } 6.0 \text{ x } 10^{24} \text{ x } (8.64\text{x}10^4)^2\}/4\pi^2 = 7.57\text{x}10^{22}$ r = **$4.23 \text{ x } 10^7$ m** (or 4.2 or 4.3 x 10^7)	C1 C1 A1	(1 day = 8.64 x10^4s is given on the data sheet). For those who use $g = GM/r^2$ with g = 9.81 award 1 mark for r= 6.4 x 10^6 m.
	Total	12	

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Question	Expected Answers	Marks	Additional guidance
3(a)	Acceleration is (directly) proportional to the displacement/distance (from the equilibrium position/central pt) Acceleration is always directed towards the equilibrium position/central point.	B1 B1	Allow "fixed point" or "point" Allow acc. is in opposite direction to displacement (WTTE) If formula is used: allow a $\propto$ -x for 1st mark and 2nd mark if x is stated as displacement.
(b) (i)	Curve symmetrical about energy axis with maximum at 18 zero at +0.04 and – 0.04	B1 B1	Ignore points where graphs cross Give bod if not labelled **K** but correct
(b) (ii)	Horizontal straight line passing 18	B1	Give bod if not labelled **T** but correct
(c) (i)	0.04 m	B1	
(c) (ii)	$\frac{1}{2}m(v_{max})^2 = 0.018$ $v_{max} = \sqrt{(2x0.018/0.12)} =$ **0.55** ms^{-1} (0.548)	C1 A1	Many will use 18 instead of 0.018. This results in 17.3 and scores 1 mark. Allow ecf for cand's value of max KE. Do not allow 0.54 for second mark.
(c) (iii)	correct use of $v_{max} = 2\pi fA$ $f = (0.55/0.04x2\pi) =$ **2.2** (or 2.19 or 2.18)Hz	C1 A1	Allow ecf for cand's values from (c)(i) and/or (c) (ii). E.g for 17.3 f = 68.8 Hz. This scores 2 marks e.c.f. Do not allow 2.1
(d)	Award first mark for stating the **'driver'** of the oscillations and the second mark for stating what is **'driven'** i.e. oscillating useful applications: e.g. Cooking: **micro waves** cause **water molecules** to resonate Woodwind: **reed** causes **air column** to resonate Brass: **lips** cause **air column** to resonate MRI: **radio waves** (in a magnetic field) cause **nuclei/proton** to resonate Radios: **radio waves** cause **electrons/current** to resonate Person on swing: **intermittent pushes** cause **swing** to resonate problem: Bridges: **wind/walkers** causes **bridge** to resonate Vehicles: **engine vibrations** cause **panels/mirrors** to resonate Earthquakes: **ground vibrating** causes **buildings** to resonate	B1 B1 B1 B1	No marks to be awarded for a bare statement of the example e.g MRI. Please allow any other valid examples.
	Total	14	

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Question	Expected Answers	Marks	Additional guidance
4 (a) (i)	**Brownian** (motion) (QWC mark)	B1	QWC Brownian spelled correctly
(a) (ii)	ANY two from the following three: air molecules are moving in different directions/randomly with different speeds mass/size of air molecules is smaller than smoke particles	 B1 B1	Answers that refer to smoke particles only cannot score the marks.
(b) (i)	vol = (4/3) πr^3 = 5.58 x 10^{-3} correct sub into pV = nRT i.e. with T as 290K n = (2.6x10^5x 5.58x10^{-3})/8.31x290 = 0.602 moles mass = n x 0.028 = **0.0169** kg (0.016856)	C1 C1 A1 A1	Allow ecf for wrong volume Allow use of pV = NkT and n = N/N_A Allow ecf for cand's value for n If 17° C used allow maximum of 2 marks for n = 10.3 moles and m = 0.29 kg
(b) (ii) 1	no net heat flow between objects (WTTE)	B1	Allow "they are at the same temp."
(b) (ii) 2	correct use of P/T = constant: e.g. P = (273/290) x 2.6 x 10^5 P = **2.45 x 10^5** (or 2.4 x 10^5 or 2.5 x 10^5)Pa	C1 A1	Allow correct use of pV=nRT
	Total	10	

Question	Expected Answers	Marks	Additional guidance
5(a) (i)	Initial KE of car = 0.5x970x27^2 = **3.5 x 10^5 J** (353565J)	B1	
(a) (ii)	Work done = Av Force x distance moved Av Force = 3.5 x 10^5 J/40 = **8.8 x 10^3 N** (or 8750 N) (or 353565/40 = 8836.7 N) Assumption: **no air resistance**	C1 A1 B1	If $v^2 = u^2 + 2as$ is used. accept a = 0-27^2/(2x40) = 9.113 ms^{-2} C1 F = ma = 970x9.11 = 8.84 x 10^3 N A1 Allow air friction or drag
(b) (i)	correct use of E = mc$\Delta\theta$: 3.5 x 10^5/4 = 1.2x520x$\Delta\theta$ $\Delta\theta$ = **140°C** (if 353565 is used $\Delta\theta$ = 142°C)	C1 A1	If cand. forgets to divide by 4 allow any value between 560 and 570 for 1 mark.
(b) (ii)	Air resistance will be acting (slowing down the car) (hence) reducing the KE of the car (WTTE) The discs are hotter than the surroundings (hence) energy/heat will be lost from discs/brakes (WTTE)	M1 A1 B1 B1	Do not allow sound since only a tiny proportion of energy is lost in this way. Allow other valid comments as alternative ways of scoring one or both of the 'B' marks: e.g. 'hot spots' on discs; discs are different. Try to credit a well argued case based upon correct physics- e.g. wheels locking.
(b) (iii)	Any valid suggestion: e.g. use a material with a higher s.h.c use a disc with a higher heat capacity Use discs of greater mass put holes in the discs (to increase air flow)	 B1	Confusion between shc and heat capacity should not be penalised.
	Total	11	

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Centre Number						Candidate Number				

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

ADVANCED GCE

G484

PHYSICS A

The Newtonian World

THURSDAY 28 JANUARY 2010: Afternoon
DURATION: 1 hour

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

Candidates answer on the Question Paper

OCR SUPPLIED MATERIALS:
Data, Formulae and Relationships Booklet

OTHER MATERIALS REQUIRED:
Electronic calculator

READ INSTRUCTIONS OVERLEAF

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INSTRUCTIONS TO CANDIDATES

- **Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes on the first page.**
- **Use black ink. Pencil may be used for graphs and diagrams only.**
- **Read each question carefully and make sure that you know what you have to do before starting your answer.**
- **Answer ALL the questions.**
- **Write your answer to each question in the space provided, however additional paper may be used if necessary.**

INFORMATION FOR CANDIDATES

- **The number of marks is given in brackets [ ] at the end of each question or part question.**
- **The total number of marks for this paper is 60.**
- **You may use an electronic calculator.**
- **You are advised to show all the steps in any calculations.**
-  **Where you see this icon you will be awarded marks for the quality of written communication in your answer.**

  This means for example you should:

  - **ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;**
  - **organise information clearly and coherently, using specialist vocabulary when appropriate.**

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Answer ALL the questions.

1 (a) State Newton's second and third laws of motion.



In your answer, you should use appropriate technical terms spelled correctly.

(i) second law

_____

_____

_____ **[1]**

(ii) third law

_____

_____

_____ **[1]**

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(b) A golfer uses a golf club to hit a stationary golf ball off the ground. Fig. 1.1 shows how the force *F* on the golf ball varies with time *t* when the club is in contact with the ball.

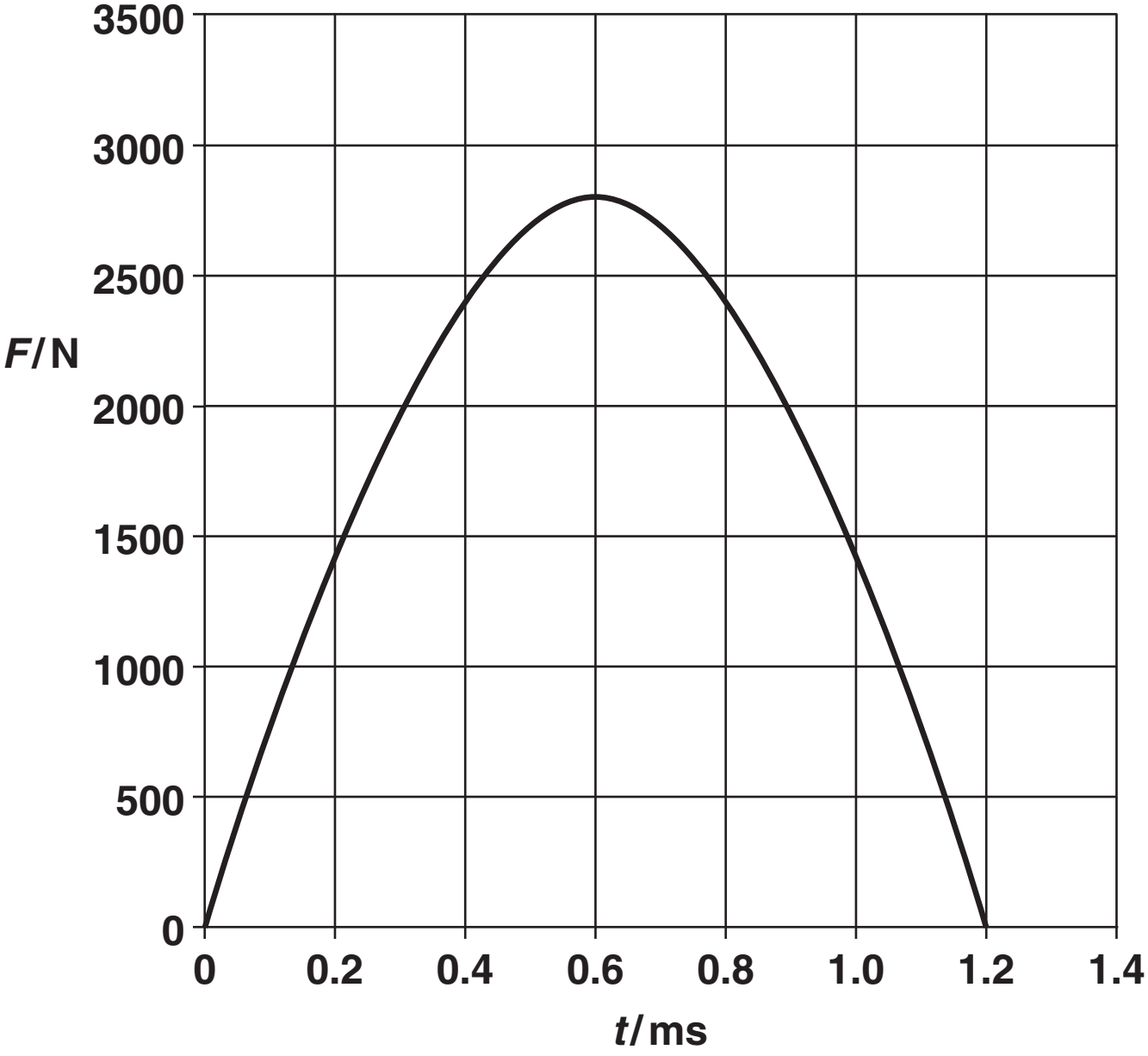


Fig. 1.1

(i) Estimate the area under the graph.

area = _____ Ns [2]

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(ii) Name the physical quantity represented by the area under the graph in (i).



In your answer, you should use appropriate technical terms spelled correctly.

_____ **[1]**

(iii) Show that the speed of a golf ball, of mass 0.046 kg, as it leaves the golf club is about 50 m s^{-1}.

speed = _____ **m s^{-1} [2]**

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(iv) **The ground is level. The ball leaves the ground at a velocity of 50 m s^{-1} at an angle of 42° to the horizontal. Determine the horizontal distance travelled by the ball before it hits the ground.**

State <u>ONE</u> assumption that you make in your calculations.

distance = _____ m

assumption _____

_____ [5]

[Total: 12]

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2 (a) Fig. 2.1 shows the London Eye.

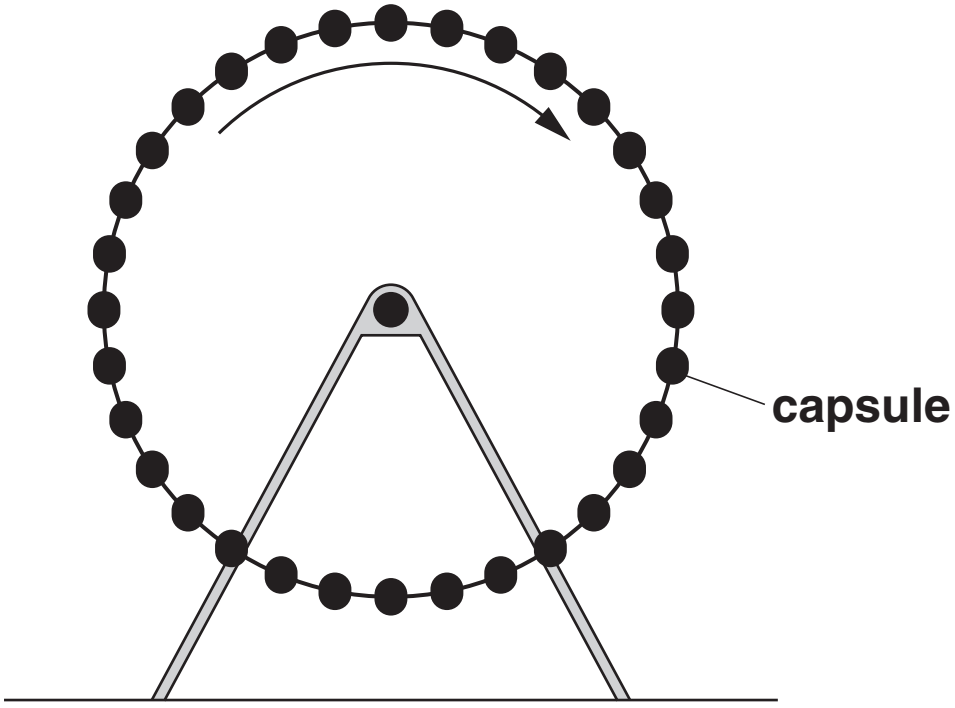


Fig. 2.1

It has 32 capsules equally spaced around the edge of a large vertical wheel of radius 60 m. The wheel rotates about a horizontal axis such that each capsule has a constant speed of 0.26 m s^{-1}.

(i) Calculate the time taken for the wheel to make one complete rotation.

time = _____ s [1]

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(ii) **Each capsule has a mass of 9.7×10^3 kg. Calculate the centripetal force which must act on the capsule to make it rotate with the wheel.**

centripetal force = _____ N [2]

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(b) Fig. 2.2 shows the drum of a spin-dryer as it rotates. A dry sock S is shown on the inside surface of the side of the rotating drum.

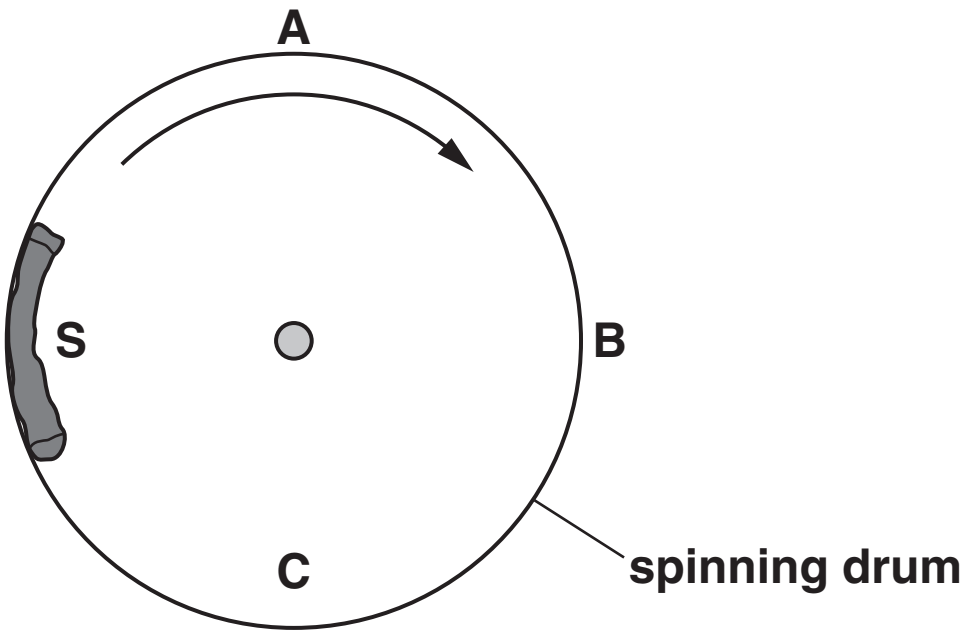


Fig. 2.2

(i) Draw arrows on Fig. 2.2 to show the direction of the centripetal force acting on S when it is at points A, B and C. [1]

(ii) State and explain at which position, A, B or C the normal contact force between the sock and the drum will be

1 the greatest

_____

_____

_____

_____ **[2]**

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2 the least.

_____

_____

_____ [1]

[Total: 7]

3 Fig. 3.1 represents the planet Jupiter. The centre of the planet is labelled as O.

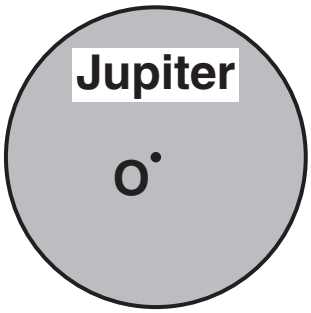


Fig. 3.1

(a) Draw gravitational field lines on Fig. 3.1 to represent Jupiter's gravitational field. [2]

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(b) Jupiter has a radius of 7.14×10^7 m and the gravitational field strength at its surface is $24.9\,N\,kg^{-1}$.

(i) Show that the mass of Jupiter is about 2×10^{27} kg.

[3]

(ii) Calculate the average density of Jupiter.

density = _____ $kg\,m^{-3}$ [2]

[Total: 7]

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4 Fig. 4.1 shows a mass suspended from a spring.

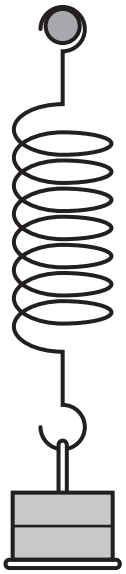


Fig. 4.1

(a) The mass is in equilibrium. By referring to the forces acting on the mass, explain what is meant by *equilibrium*.

_____

_____

_____ **[2]**

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(b) The mass in (a) is pulled down a vertical distance of 12 mm from its equilibrium position. It is then released and oscillates with simple harmonic motion.

(i) Explain what is meant by *simple harmonic motion*.

_____

_____

_____

_____ **[2]**

(ii) The displacement x, in mm, at a time t seconds after release is given by

$$x = 12\cos(7.85t).$$

Use this equation to show that the frequency of oscillation is 1.25 Hz.

[2]

(iii) Calculate the maximum speed V_{max} of the mass.

V_{max} = _____ m s^{-1} **[2]**

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(c) Fig. 4.2 shows how the displacement *x* of the mass varies with time *t*.

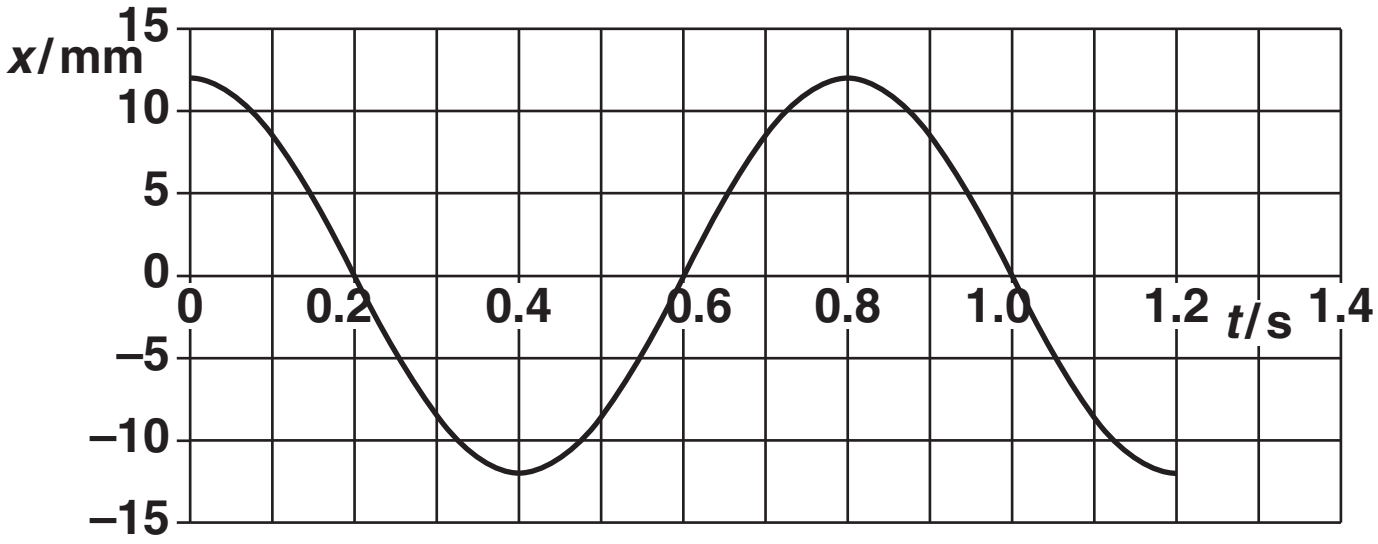


Fig. 4.2

Sketch on Fig. 4.3 the graph of velocity against time for the oscillating mass.

Put a suitable scale on the velocity axis. [3]

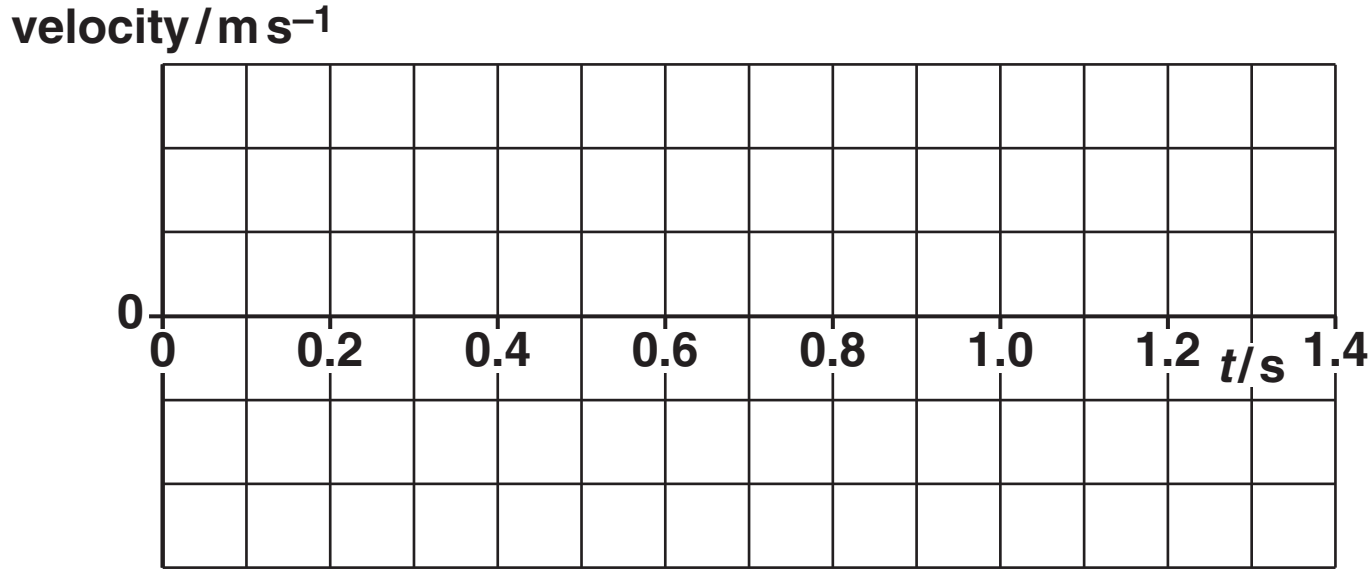


Fig. 4.3

[Total: 11]

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5 (a) The table shows the specific heat capacities c of alcohol and water.

	c / J kg^{-1} K^{-1}
alcohol	2460
water	4180

(i) An alcohol thermometer is placed in 80 g of water at 20 °C. The mass of alcohol in the thermometer is 0.050 g. The water is then heated from 20 °C to 60 °C.

Calculate the ratio

$$\frac{\text{energy required to warm the water from 20 °C to 60°C}}{\text{energy required to warm the alcohol from 20 °C to 60 °C}}$$.

ratio = _____ [2]

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(ii) State and explain a situation in which the very high value of specific heat capacity for water is useful.

_____

_____

_____

_____

_____ **[2]**

(b) Describe an electrical experiment to determine the specific heat capacity *c* of a liquid.

Include in your answer:

- **a labelled diagram of the arrangement**
- **a list of the measurements to be taken**
- **an explanation of how the value of *c* would be determined from your results**
- **possible sources of uncertainty in your measurements and how these could be reduced.**

[8]

[Total: 12]

6 (a) The ideal gas equation may be written as

$$pV = nRT.$$

State the meaning of the terms n and T.

n _____

T _____ [2]

(b) Fig. 6.1 shows a cylinder that contains a fixed amount of an ideal gas. The cylinder is fitted with a piston that moves freely. The gas is at a temperature of 20 °C and the initial volume is $1.2 \times 10^{-4}\,m^3$. Fig. 6.2 shows the cylinder after the gas has been heated to a temperature of 90 °C under constant pressure.

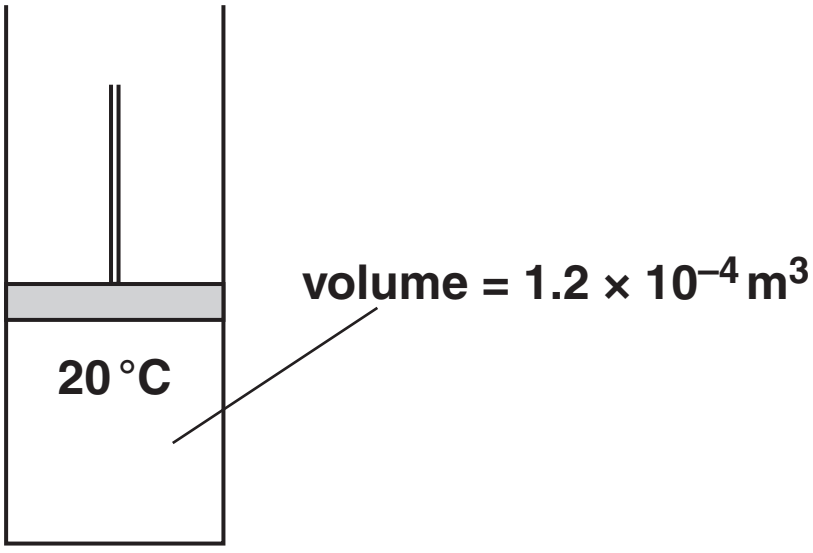


Fig. 6.1

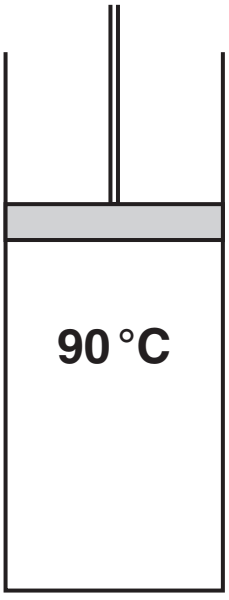


Fig. 6.2

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(i) Explain in terms of the motion of the molecules of the gas why the volume of the gas must increase if the pressure is to remain constant as the gas is heated.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ **[4]**

(ii) Calculate the volume of the gas at 90 °C.

volume = _____ **m^3 [2]**

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(c) The mass of each gas molecule is 4.7×10^{-26} kg. Estimate the average speed of the gas molecules at 90 °C.

speed = _____ $m\,s^{-1}$ [3]

[Total: 11]

END OF QUESTION PAPER

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G484 The Newtonian World

Question			Expected Answers	Marks	Additional guidance
1	a	i	Force is proportional to the rate of change of **momentum** *(QWC This mark can only be scored if momentum is spelled correctly)*	B1	Allow "equal" instead of proportional, allow "change in momentum over time" (WTTE) Do not allow F = ma or in words
		ii	When one body exerts a force on another the other body exerts an equal (in magnitude) and opposite (in direction) force on the first body (WTTE)	B1	Must refer to two bodies. Do not allow a bare "Action and reaction are equal and opposite".
	b	i	*area*: number of squares correctly counted: 20 - 24 (500 – 600) = **2.2** Ns {allow 2.0 to 2.4}	C1 A1	First mark for correct number of squares Second mark for correct conversion to Ns If 2 Δs assumed, area = 1.68 Ns and scores 1 mark 1680 scores 0 (2 errors) but 2200 scores 1 mark
		ii	**Impulse** QWC must be spelled correctly	B1	No not allow change of momentum.
		iii	recall of Impulse = change in momentum OR I = mv OR mv –mu (mv = 2.2 hence v = 2.2/0.046) v = **47.8** ms^{-1} (hence about 50) (2.0 gives 43.5, 2.1 45.7, 2.3 50, 2.4 52.2)	C1 A1	Allow 'Area = mv' Allow ecf from cand's value for (b)(i): e.g. mv = 1.68 v = 36.5 ms^{-1} and scores 2 marks mv = 2200 v = 47800 ms^{-1} also scores 2marks! (ecf)
		iv	initial horizontal velocity = 50cos42 = (37.2 ms^{-1}) initial vertical velocity = 50sin42 = (33.5 ms^{-1}) time taken to reach maximum height = 33.5/9.8 (= 3.41 s) total time to reach ground = 2x 3.41 = 6.82 s hence distance = 50cos42xtotal time = 37.2x6.82 = **253** m any valid assumption: eg no air resistance / horizontal velocity is constant/ acceleration due to gravity is 9.8 (or 10) ms^{-2} / ball follows a parabolic or symmetrical path (WTTE).	C1 C1 C1 A1 B1	Allow 1 mark for correct identification of cosine and sine components of v, without substitution. Allow ecf for cand's value of v throughout e.g if 47.8 is used for v, distance = **232** m and this scores four marks. if 47800 is used distance = 2.32 x 10^8 m! Also allow "only the gravitational force is acting" "no friction" "only gravity"
			Total	**12**	

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Question			Expected Answers	Marks	Additional guidance
2	a	i	(v = 2πr/t) t = 2π60/0.26 = **1450** s	B1	Correct answer is 1449.96 hence allow 1.4 X 10^3 Do not allow a bare 1.5 x10^3
		ii	(ii) correct substitution into F =mv^2/r: eg F = ($9.7x10^3x0.26^2$)/60 F = **10.9** N	C1 A1	Allow 11 N
	b	i	THREE correct arrows at A, B and C **all** pointing towards the centre (judged by eye)	B1	Ignore starting point of arrow
		ii	1. Greatest reaction force is at **C** because it supports weight of sock AND provides the required upward resultant (centripetal) force (WTTE) 2. Least at **A** because sock's weight provides part of the required downward resultant (centripetal) force (WTTE)	**M1** A1 B1	This is a mandatory M mark. The second mark cannot be gained unless this is scored. Any indication that candidates think that the centripetal force is a **third** force loses this second and possibly the next mark. They must make correct reference to the resultant force that provides the required centripetal force/acceleration. Allow answers using the equation F =mv^2/r such as N_C - mg (at C) = centripetal force OR mv^2/r OR mg +N_A (at A) = centripetal force OR mv^2/r
			Total	**7**	

Question			Expected Answers	Marks	Additional guidance
3	a		arrows (at least one) indicating direction is **towards** the planet. All lines looking as though they would meet at the centre judged by eye	B1 B1	 At least 4 drawn and care taken Some of the lines must be outside the planet.
	b	i	(mg = GMm/r^2 and hence) **M = gr^2/G** correct substitution M = 24.9x(7.14 x 10^7)^2/6.67x10^{-11} = **1.9 x 10^{27}** Kg (i.e about **2x10^{27}**)	C1 **M1** A1	Equation needs to be rearranged as shown for C1 mark
		ii	correct substitution into V=(4/3)πr^3 = (4/3)π(7.14x10^7)^3 {= 1.52 x 10^{24} m^3} density = mass/volume = 1.9 x10^{27}/1.52 x 10^{24} = **1250** kg m^{-3}	C1 A1	If m= 2 x 10^{27} kg is used d = 1312 scores 2 marks
			Total	**7**	

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Question			Expected Answers	Marks	Additional guidance
4	a		The resultant force is zero (WTTE) Forces are weight and force from the spring (allow tension)	B1 B1	For the first mark allow - sum of forces is zero, - upward force = downward force, - forces cancel each other BUT do not allow forces are balanced Allow force of gravity for weight
	b	i	acceleration is (directly) proportional to displacement and is directed in the opposite direction to the displacement. (WTTE)	M1 A1	allow a=-$(2\pi f)^2$ x, provided a and x are identified and –ve sign must be explained. Do not allow "acceleration is prop to negative displacement for second mark. Allow always towards the equilibrium position
		ii	x= a$\cos 2\pi ft \Rightarrow 2\pi f = 7.85$ (expressed in any form) f = (7.85/2π) = 1.25 (1.249Hz)	**M1** A1	Do not allow use of Fig 4.2 to show T= 0.8s and hence f=1.25 Hz. This scores 0.
		iii	correct subst^n in $V_{max} = (2\pi f)A \Rightarrow V_{max} = 2\pi$x1.25x0.012 V_{max} = **0.094** ms^{-1}	C1 A1	Many will forget to change 12 mm into 0.012m and have v = 94 ms^{-1} this scores 1 mark.
	c		roughly **sinusoidal** graph of correct period ie **0.8s** 90° out of phase with displacement graph (i.e. starts at origin with -ve initial gradient) maximum velocity correctly shown as 0.094 {allow ecf from (iii)}	B1 B1 B1	
			Total	**11**	

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Question			Expected Answers	Marks	Additional guidance
5	a	i	correct substitution in E = mcΔθ: eg E = 0.08x4180x40 ratio = 0.08x4180x40/5 x 10^{-5} x2460x40 = **2.7(2) x 10^{3}**	C1 A1	Allow 80x4180/0.05x2460 (13376/4.92) for this C1 mark. 1: 2700 does not score the second mark.
		ii	*Any valid advantage: eg* car cooling systems because it absorbs large amounts of heat for a small rise in temp OR ideal fluid for central heating systems because it releases large amounts of heat for a small drop in temp. OR helps to maintain constant body temperature since body is mainly water which absorbs lots of heat for small temp rise	 B1 B1	 First mark for valid situation Second mark for correct explanation of why the high value of the shc is helpful.
	b		***labelled diagram (2 marks)*:** liquid in vessel with electrical heater (submerged) and thermometer ammeter connected in series between supply and heater AND voltmeter connected across heater. ***list of measurements (3 marks):*** mass of liquid, initial and final temperature/change of temp (of the liquid) I, V and t values OR energy meter readings OR power and time ***explanation (1 mark):*** E = mcΔθ rearranged to c = E/mΔθ ***uncertainties (2 marks) each stated with explanation of remedy:*** e.g. - heat losses (makes E or Δθ uncertain) *(solved by)* insulating beaker/use lid - false temp reading *(solved by)* stir the liquid - temp continues to rise after heater switched off measure highest value - thermal capacity of vessel (*solved by*) take this into account in calculation	 B1 B1 B1 B1 B1 B1 B1 B1 max 2	 Allow use of joule meter if convincingly connected to heater and power supply i.e. 2 wires from power supply two wires to heater Allow such things as “find mass”, “known mass”, “10K temp rise”, “time for 2 minutes” “known power”, etc. Allow ItV/mΔθ. Do not allow “repeat the experiment”. Give credit for valid suggestions if mentioned anywhere in the description of the experiment.
			Total	**12**	

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Question			Expected Answers	Marks	Additional guidance
6	a		(n) number of **moles** (T) **absolute** temperature OR thermodynamic temp OR temp measured in **Kelvin**	B1 B1	 Accept **K** for Kelvin
	b	i	(When gas is heated) molecules gain KE/move faster this would cause more collisions/sec (with the walls) collisions exert more force/greater change in momentum per collision For constant pressure fewer collisions/sec are required Constant pressure is achieved by the increase in volume OR with a bigger volume there are fewer collisions/sec	B1 B1 B1 B1 B1 *max 4*	If no reference to rate of collisions, max of 3 marks This must be explained fully but can be done with reference to $P = (1/3)\rho \langle c^2 \rangle$
		ii	correct substitution in pV/T = constant: OR V/T = constant e.g. 1.2×10^{-4} /**293** = V/**363** $V = (363/293) \times 1.2 \times 10^{-4} =$ **1.49×10^{-4}** m^3.	 C1 A1	 Both temps must be in Kelvin. Allow 1.5×10^{-4} m^3
	c		Use of $1/2m\langle c^2 \rangle = 3/2\ kT$ Correct substitution: $\sqrt{\langle c^2 \rangle} = \sqrt{(3kT/m)} = \sqrt{(3 \times 1.38 \times 10^{-23} \times 363 / 4.7 \times 10^{-26})}$ $\sqrt{\langle c^2 \rangle} =$ **565** ms^{-1}	C1 C1 A1	If 90^0 C is used $\sqrt{\langle c^2 \rangle} = 282\ ms^{-1}$ and scores 2 marks Allow 570 ms^{-1} If they do not square root, they get 319225 ms^{-1} and score 2 marks
			Total	**11**	

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