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

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.

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 $2 \times 10^{7}\,\mathrm{m\,s^{-1}}$.

[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]**

(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*.

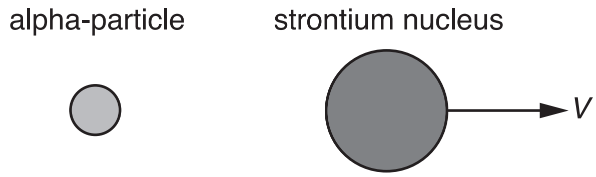

Fig. 1

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]**

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.

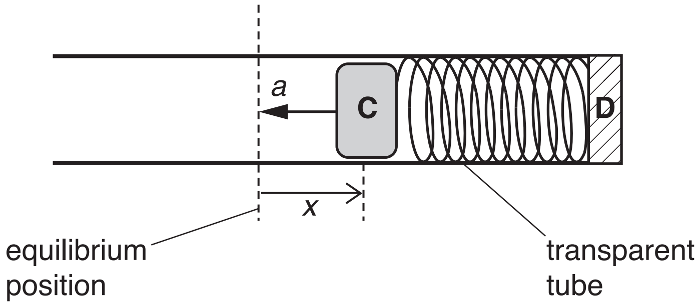

Fig. 2.1

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.

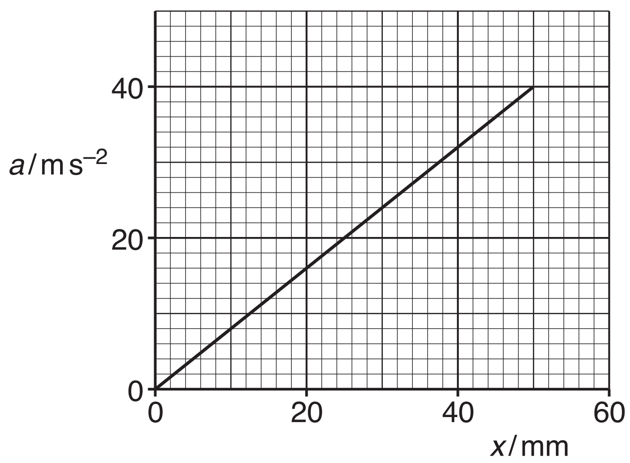

Fig. 2.2

(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]**

(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]**

(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.

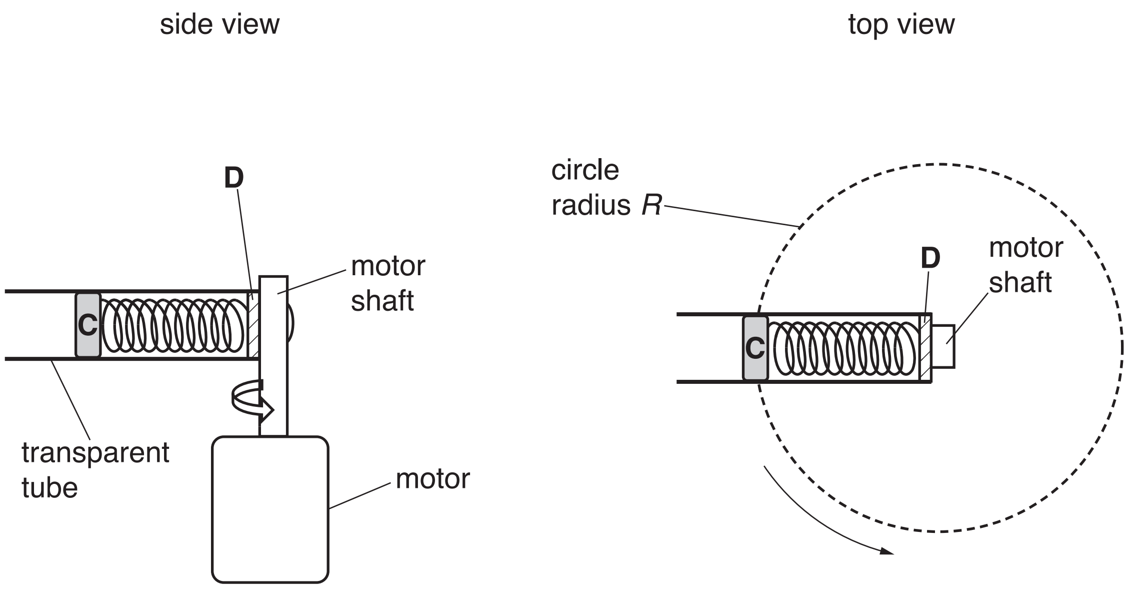

Fig. 2.3

(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]**

(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

(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.

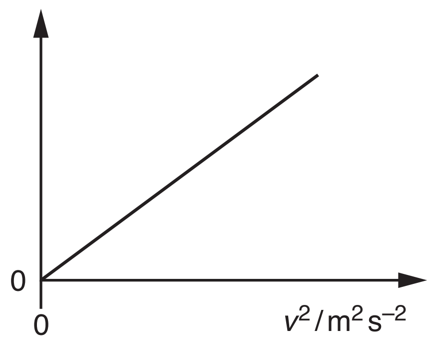

Fig. 2.4

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 $4\,\mathrm{N\,kg^{-1}}$.

[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]**

(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]**

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]**

(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

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

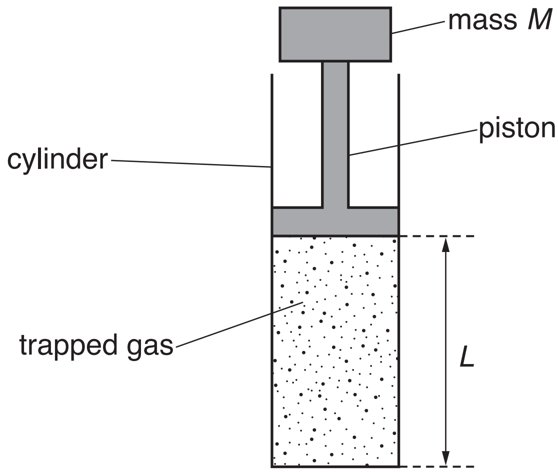

Fig. 5.1

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.

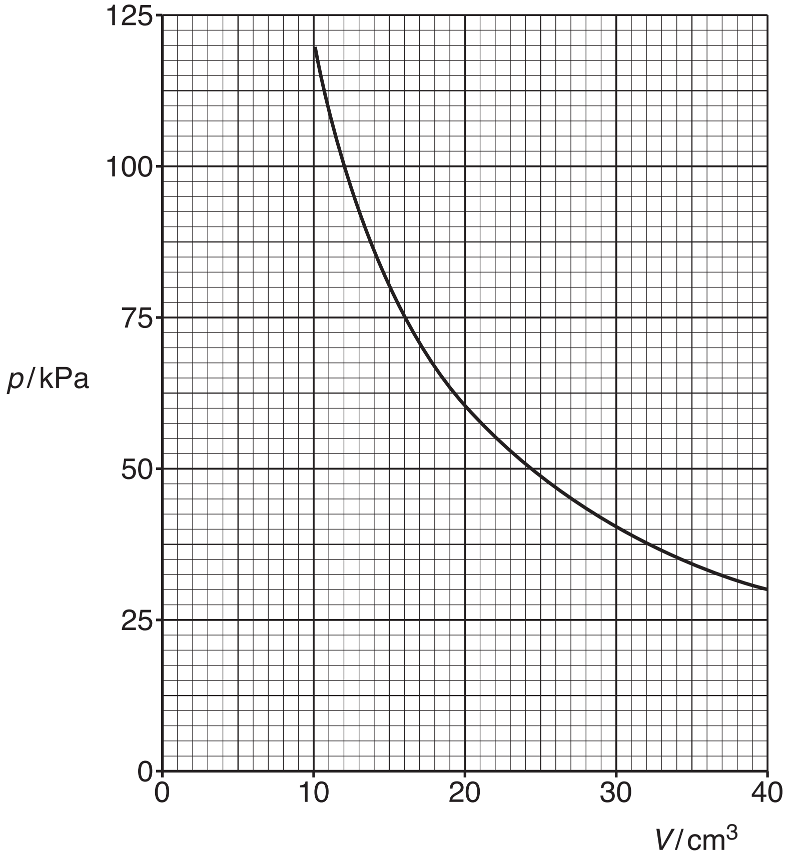

Fig. 5.2

(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.

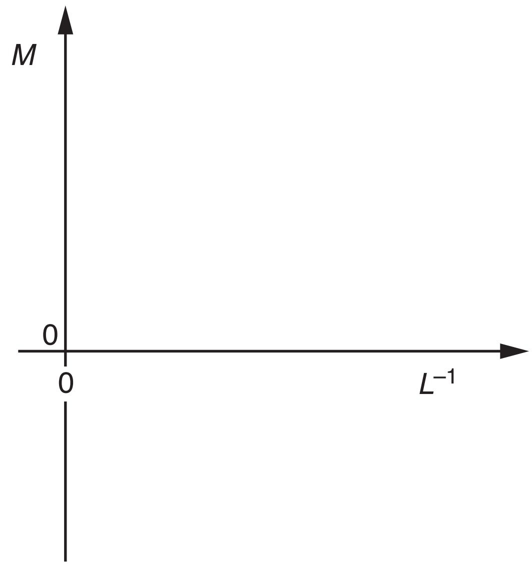

Fig. 5.3

[2]

(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]**

(iii) Calculate the ratio

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

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

END OF QUESTION PAPER

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).