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.

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.

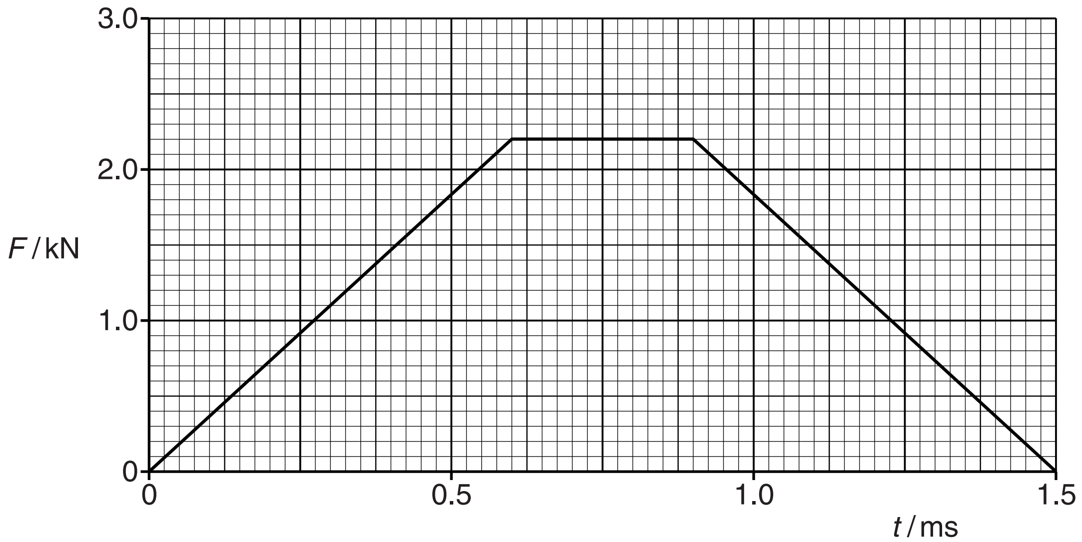

Fig. 1.2

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

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.... **[1]**

(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]

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.

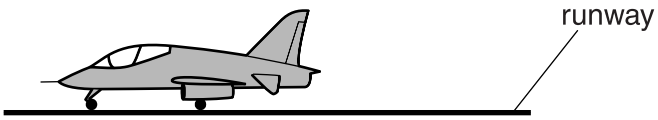

Fig. 2.1

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]**

(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 $86\,\mathrm{m\,s^{-1}}$. 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.

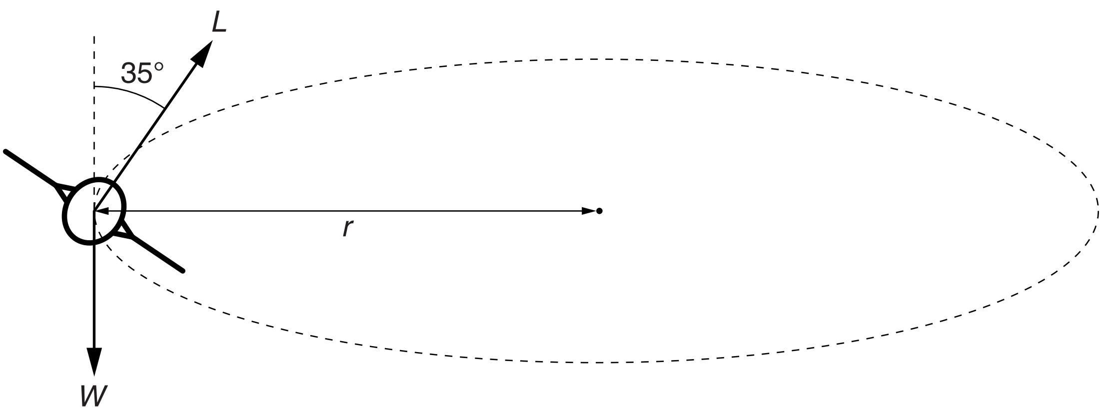

Fig. 2.2

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

[1]

(ii) Calculate the radius r.

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

(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.

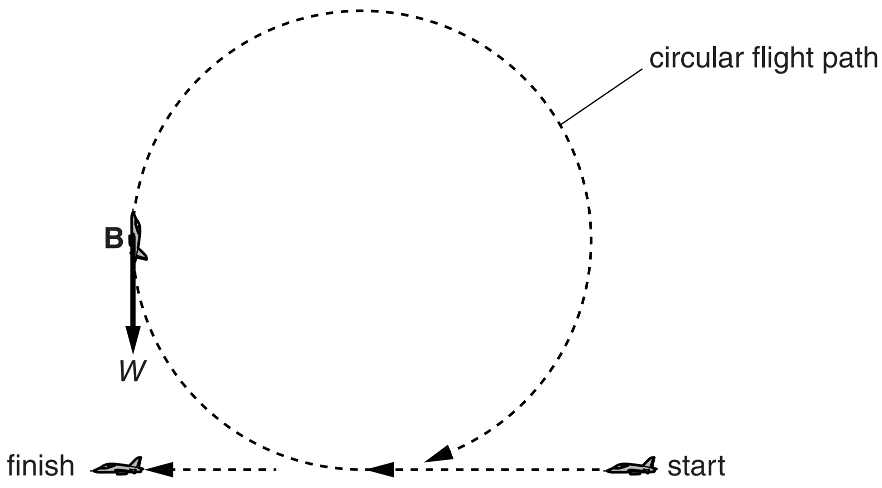

Fig. 2.3

(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 $t = 0$.

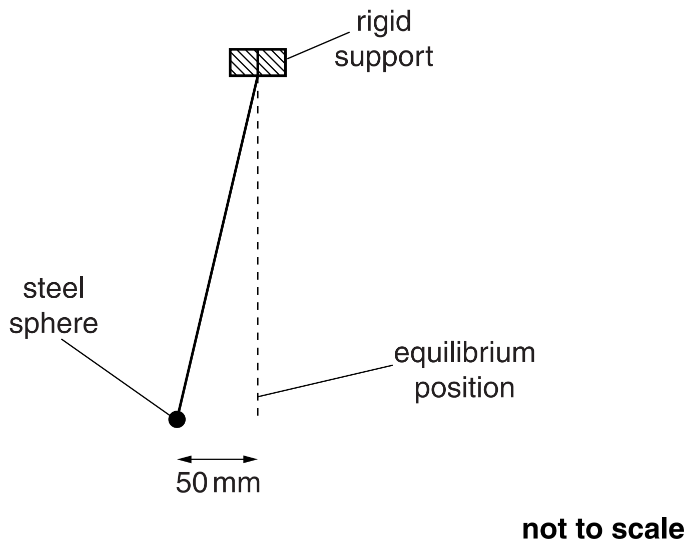

Fig. 3.1

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

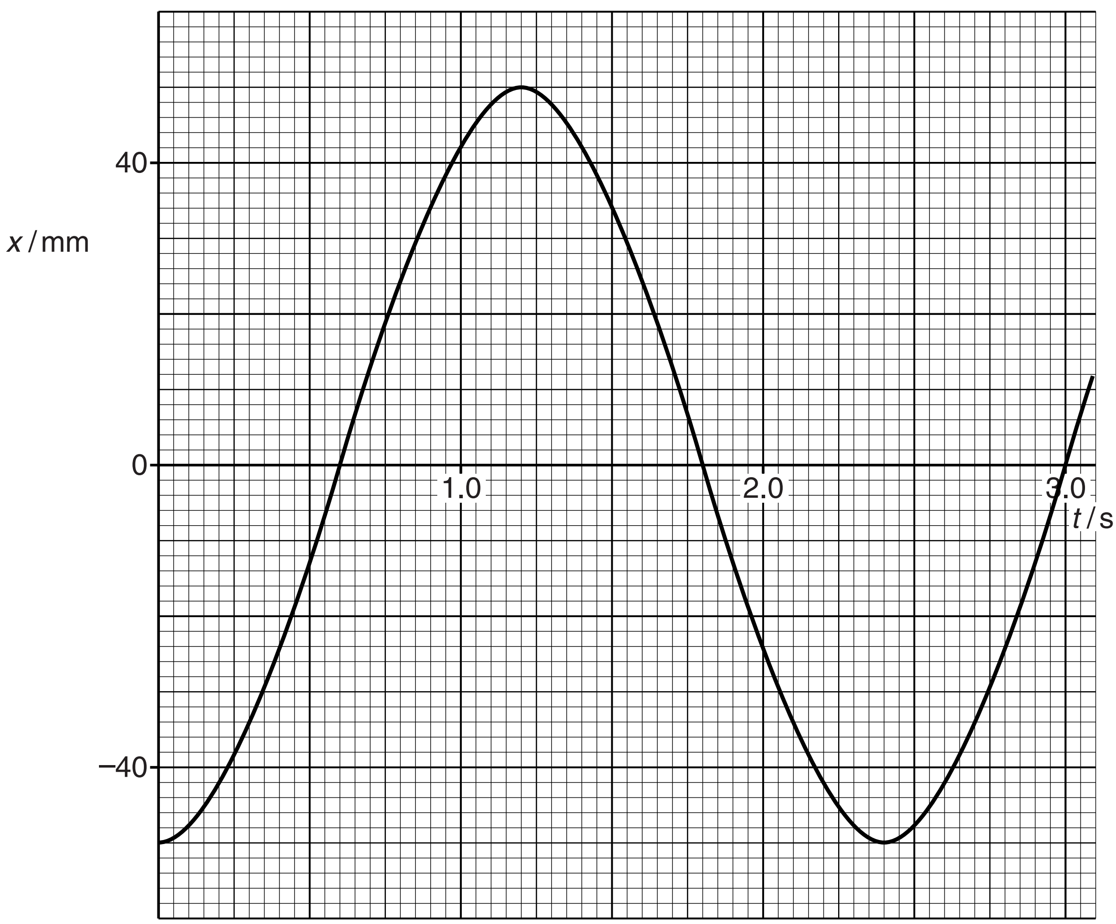

Fig. 3.2

(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

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.... **[1]**

(ii) the maximum kinetic energy of the sphere.

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.... **[2]**

(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.

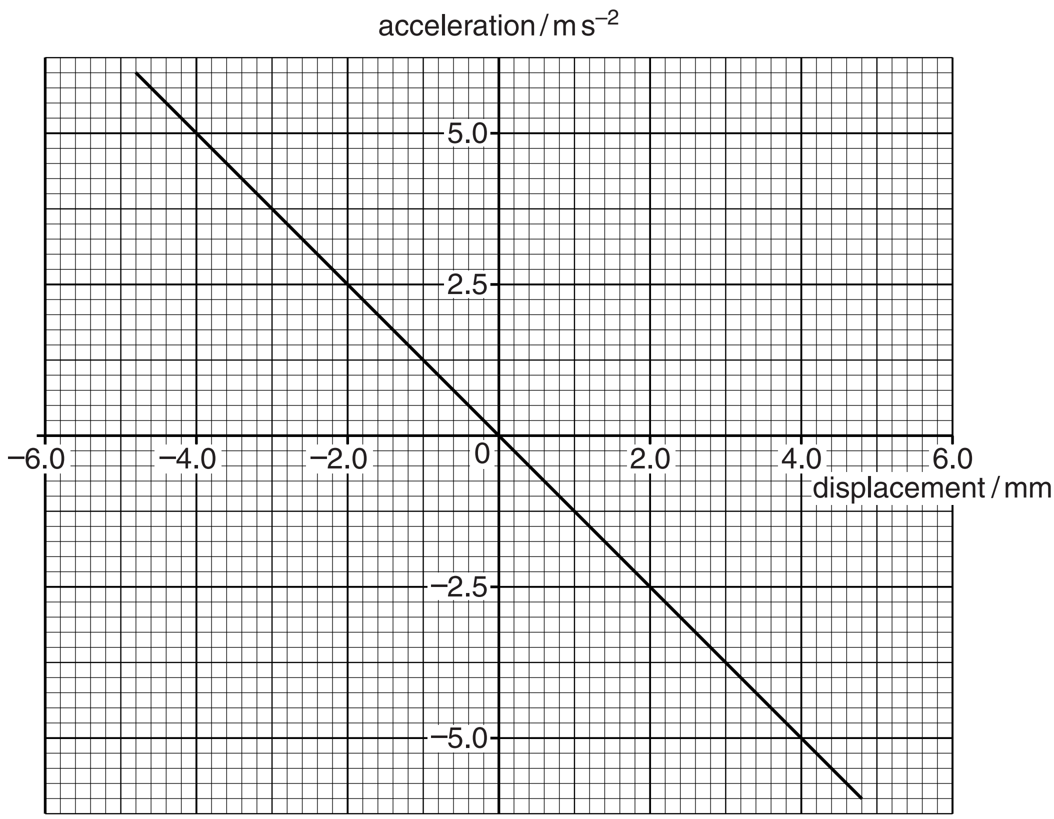

Fig. 3.3

(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]

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

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.... [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]

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

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

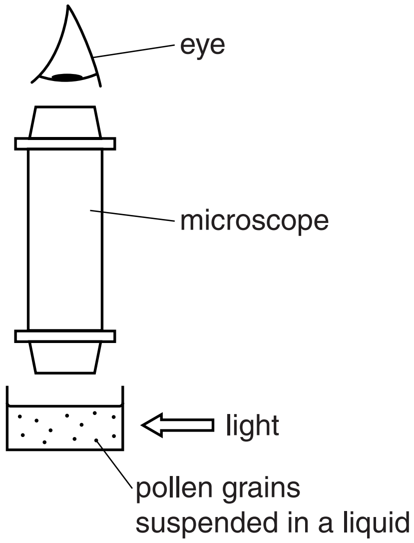

Fig. 6.1

(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]**

(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]

(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]**

(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

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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