AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS A

Unit 5C Applied Physics
Section B

Tuesday 28 June 2016 Morning

Time allowed: The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:
- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

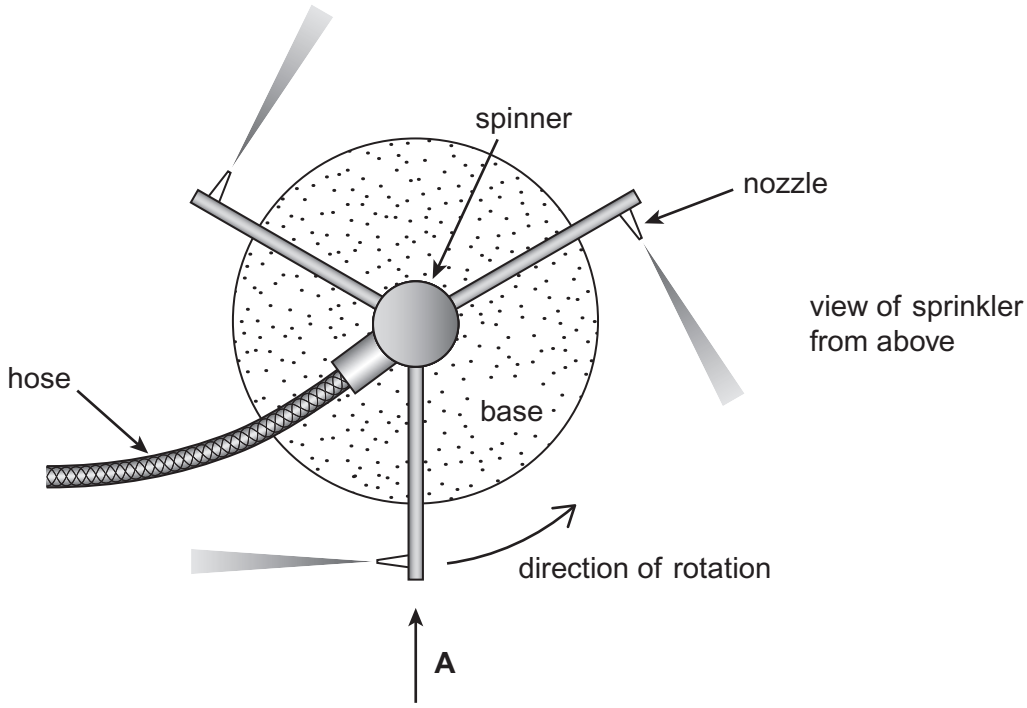
Do not write outside the box

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

1 A garden sprinkler consists of a fixed base and a rotating spinner having three arms as shown in **Figure 1**.

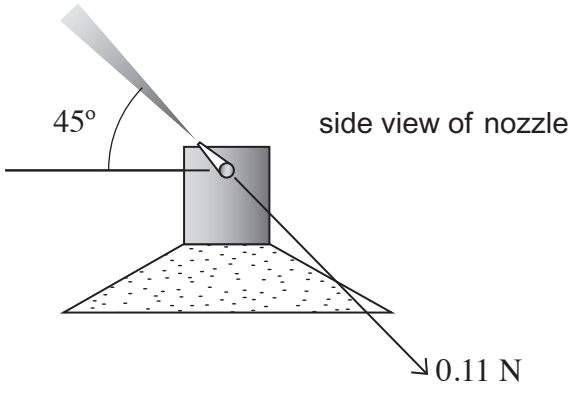
Figure 1



At the end of each arm is a nozzle at 90^{o} to the arm and inclined at 45^{o} to the horizontal. Water flows in jets at a constant rate from these nozzles when the hose water tap is turned on.

Figure 2 shows a side view of one of the nozzles viewed in the direction of arrow **A** in **Figure 1**.

Figure 2



Do not write outside the box

The water jets produce reaction forces that act on the arms which cause the spinner to rotate. The base remains fixed in position. In operation, the spinner rotates at a constant rate of 240 rev min^{-1}. The nozzles rotate in a horizontal circle of radius 120 mm.

1 (a) Each water jet exerts a constant force of 0.11 N on its arm at 45° to the horizontal.

Show that the torque exerted on the spinner by the jets of water is about $3 \times 10^{-2} \text{ N m}$.

[2 marks]

1 (b) (i) Explain why, when the water tap is turned on, the spinner accelerates initially but then reaches a constant angular speed.
Assume that, when the tap is turned on, the flow-rate of the water from the jets is constant.

[2 marks]

1 (b) (ii) Calculate the power dissipated by the frictional torque acting between the spinner and the fixed base when the sprinkler is rotating at 240 rev min^{-1}.

[2 marks]

power = _____ W

Do not write outside the box

1 (c) When the water is suddenly turned off all the kinetic energy of the spinner and arms is dissipated as heat due to work done by the frictional torque and the spinner makes a further 13 rotations before coming to rest. Assume uniform deceleration.

1 (c) (i) Calculate the time taken for the spinner to come to rest.

[2 marks]

time = _____ s

1 (c) (ii) Show that the kinetic energy of the spinner when rotating at its operating speed is about 2 J.

[1 mark]

1 (c) (iii) Determine the moment of inertia of the spinner about its axis of rotation.

[1 mark]

moment of inertia = _____ kg m^2

10

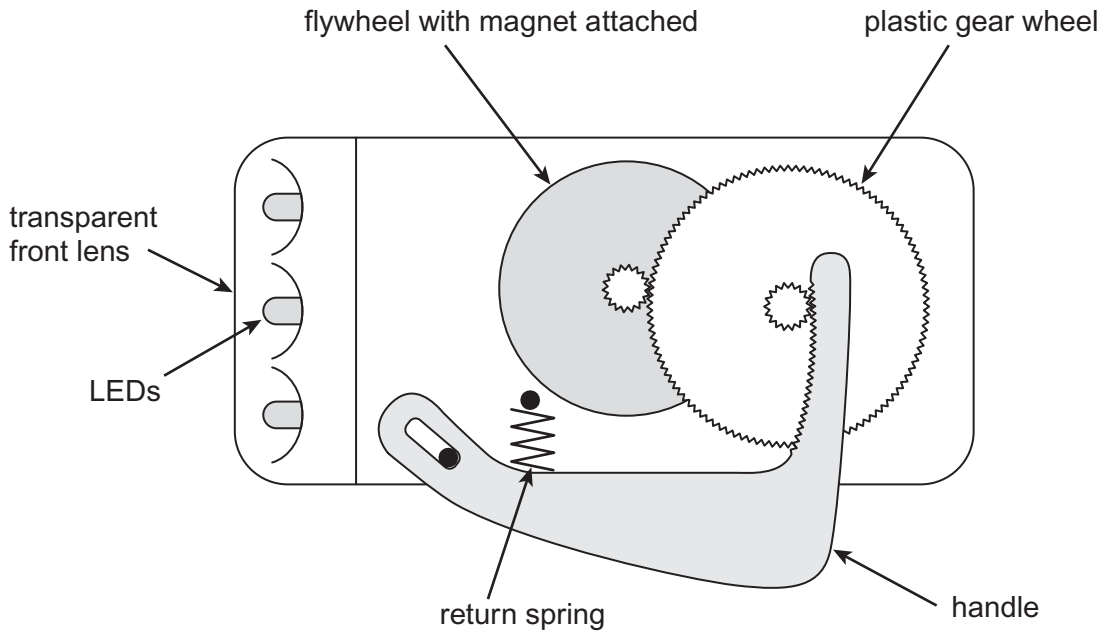
Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

2 **Figure 3** shows the mechanism of a dynamo torch for providing light without the use of batteries. When the handle is squeezed the gears rotate the flywheel increasing the kinetic energy stored in the flywheel. On the same axle as the flywheel is a magnet which generates an emf in surrounding coils as it rotates. The magnet, coils and electrical connections are not shown.

Figure 3



When the handle is released the mechanism disengages and a spring returns the handle to its original position. During this time the gears continue to turn. The energy of the flywheel enables it to continue to rotate for several seconds.

A designer wishes to enable the flywheel to store more energy and thus rotate for longer after the handle has been released.
The radius of the flywheel is limited by the overall size of the torch and cannot be increased.

Describe and explain other changes that can be made to the mechanism and flywheel to store more energy. Your answer should include consideration of:

- the flywheel's shape
- the material from which it is made
- changes to the mechanism.

The quality of your written communication will be assessed in your answer.

[6 marks]

Do not write outside the box

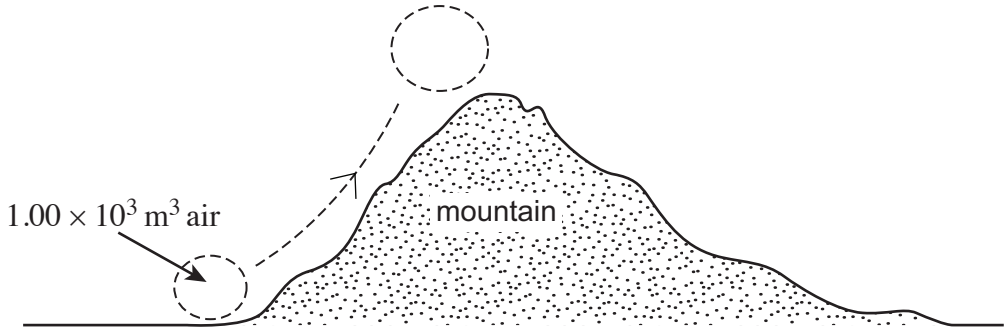
6

Do not write outside the box

3 This question is about a group of a fixed number of air molecules that remain together called an air pocket.

Figure 4 shows an air pocket of volume 1.00×10^3 m^3 near the base of a mountain where the temperature is 25 °C and atmospheric pressure is 1.01×10^5 Pa. The air pocket expands adiabatically as it rises to the top of the mountain where the air pressure is lower.

Figure 4



3 (a) Calculate the new volume of the air pocket when it reaches the top of the mountain, where the pressure is 8.25×10^4 Pa.
Give your answer to an appropriate number of significant figures.

[3 marks]

adiabatic index γ for air = 1.40

volume = _____ m^3

Do not write outside the box

3 (b) Meteorologists use the term adiabatic lapse rate for the temperature change per km when air rises as it expands adiabatically.

Calculate the temperature of the air pocket when it has reached the top of the mountain, and hence estimate the height of the mountain assuming the adiabatic lapse rate is $9.8\ \text{K km}^{-1}$.

[3 marks]

temperature = _____ °C

height = _____ km

3 (c) Work is done by the air pocket as it expands against the surrounding air.
Explain, with reference to the first law of thermodynamics, why the temperature of the air decreases as the air pocket rises.

[3 marks]

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

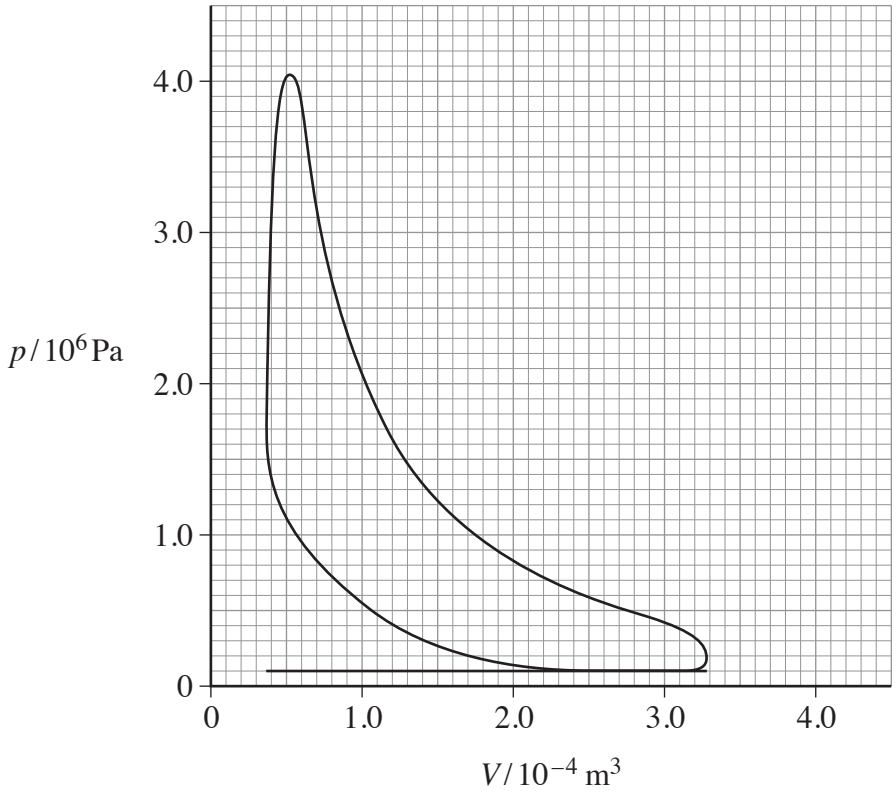
9

Do not write outside the box

4 (a) Explain the **basic** differences in operation between a petrol engine and a diesel engine.
[2 marks]

4 (b) **Figure 5** shows the indicator diagram taken during a test from one cylinder of a four cylinder four-stroke petrol engine.

Figure 5



Data from the test are as follows:

engine speed:	2000 rev min^{-1}
calorific value of fuel:	44.0 MJ kg^{-1}
fuel consumption:	1.1×10^{-3} kg s^{-1}

Do not write outside the box

4 (b) (i) Draw an **X** on **Figure 5** to show where in the cycle the spark would occur.

[1 mark]

4 (b) (ii) Calculate the indicated power of the engine.

[4 marks]

power = _____ W

4 (b) (iii) Calculate the thermal efficiency of the engine.

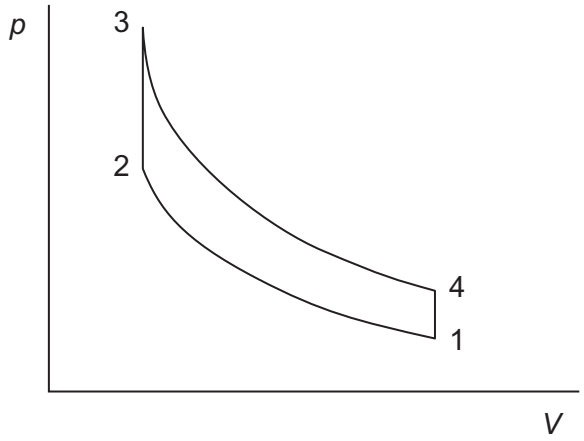
[2 marks]

thermal efficiency = _____

Do not write outside the box

4 (c) **Figure 6** shows the *p* - *V* diagram for a theoretical or ideal petrol engine (Otto) cycle.

Figure 6



Which **one** of the following lines in the table best represents what is occurring in different parts of the ideal cycle of **Figure 6**?
Place a tick (✓) in the right-hand column to show the correct answer.

[1 mark]

1 → 2	**2 → 3**	**3 → 4**	**4 → 1**	✓ if correct
induction	compression	expansion	exhaust	
compression	heating	expansion	cooling	
induction	heating	cooling	exhaust	
cooling	compression	heating	expansion	

10

END OF QUESTIONS

Copyright Information

For confidentiality purposes, from the November 2015 examination series, acknowledgements of third party copyright material will be published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.aqa.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2016 AQA and its licensors. All rights reserved.