Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2012

Physics A PHYA5/2C

Unit 5C Applied Physics
Section B

Monday 18 June 2012 9.00 am to 10.45 am

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

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.

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 **Figure 1** shows a child's 'pop' gun in which a piston is pushed quickly along the barrel, compressing the air in the barrel. When the pressure is high enough, the cork is expelled at high speed from the end of the barrel.

Figure 1

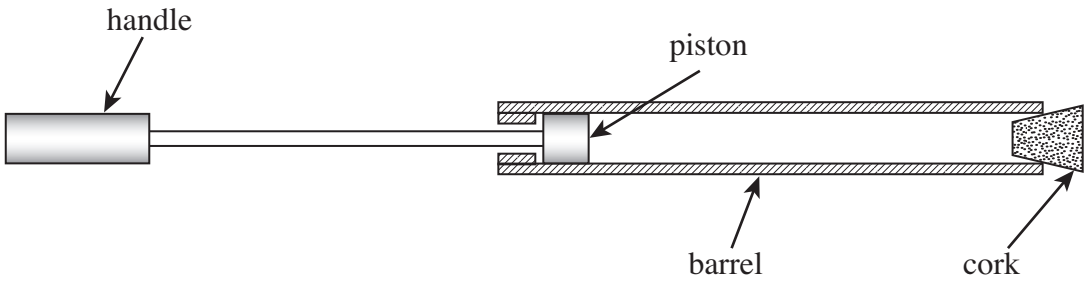


Figure 1 shows the gun before it is 'fired'. The air in the barrel is at a pressure of 1.0×10^5 Pa, a temperature of 290 K and the volume is 2.1×10^{-5} m^3.

1 (a) (i) The volume of air in the barrel at the instant the cork is expelled is 1.2×10^{-5} m^3. Calculate the pressure of the air in the barrel at the instant the cork is expelled. Assume that the air is compressed adiabatically.

adiabatic index, γ, for air = 1.4

answer = ... Pa

(2 marks)

1 (a) (ii) Calculate the maximum temperature reached by the air in the gun. Give your answer to an appropriate number of significant figures.

answer = ... K

(3 marks)

Do not write outside the box

1 (b) The work needed to compress the air adiabatically from $2.1 \times 10^{-5}\ m^3$ to $1.2 \times 10^{-5}\ m^3$ is 1.4 J. Use the first law of thermodynamics to determine the change in internal energy of the air during the compression. Explain how you arrived at your answer.

answer = ... J

(2 marks)

1 (c) Explain, giving your reasons, whether the volume of air in the barrel at the point when the cork leaves the gun would be less than, equal to, or greater than $1.2 \times 10^{-5}\ m^3$ if the handle of the gun had been pushed in slowly. Assume there is no leakage of air past the cork or piston. You may find it helpful to sketch a $p - V$ diagram of the compression.

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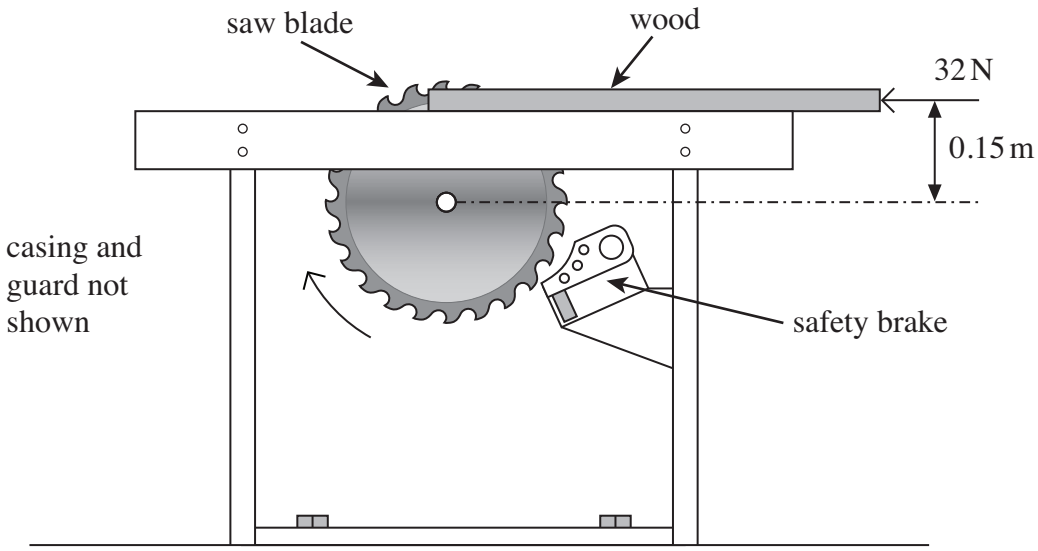
(3 marks)

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2 **Figure 2** shows a type of circular saw. The blade is driven by an electric motor and rotates at 2600 rev min^{-1} when cutting a piece of wood. A constant frictional torque of 1.2 N m acts at the bearings of the motor and axle.

Figure 2



A horizontal force of 32 N is needed to push a piece of wood into the saw. The force acts on the blade at an effective radius of 0.15 m.

2 (a) (i) Calculate the torque on the saw blade resulting from the horizontal force on the wood.

answer = ... N m

(1 mark)

2 (a) (ii) Calculate the output power of the motor when the saw is cutting the wood.

answer = ... W

(3 marks)

Do not write outside the box

2 (b) Immediately after cutting the wood the motor is switched off. The time taken for the saw blade to come to rest is 8.5 s. Calculate the moment of inertia of the rotating parts (i.e. the motor rotor, axle and blade). State an appropriate unit.

answer = ... unit = ...

(3 marks)

2 (c) If the blade is accidentally touched when it is rotating, an electronic safety brake stops the blade in 5.0 ms. This is fast enough to prevent serious injury. The safety brake works by forcing a block of aluminium into the saw teeth.

Estimate the rate at which the rotational kinetic energy is dissipated as heat and in deforming the aluminium when the brake operates.

answer = ... W

(2 marks)

9

Turn over for the next question

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3 **Figure 3** shows a model steam engine used in a school to demonstrate energy transfers. The steam engine drives a dynamo which requires a constant torque.
By means of valves, high pressure steam is applied to one side of the piston on the outward stroke (as shown) and to the other side of the piston on the inward stroke. The motion of the piston is converted to rotary motion by a connecting rod and crank. A flywheel (not shown) is fitted to the crankshaft.

Figure 3

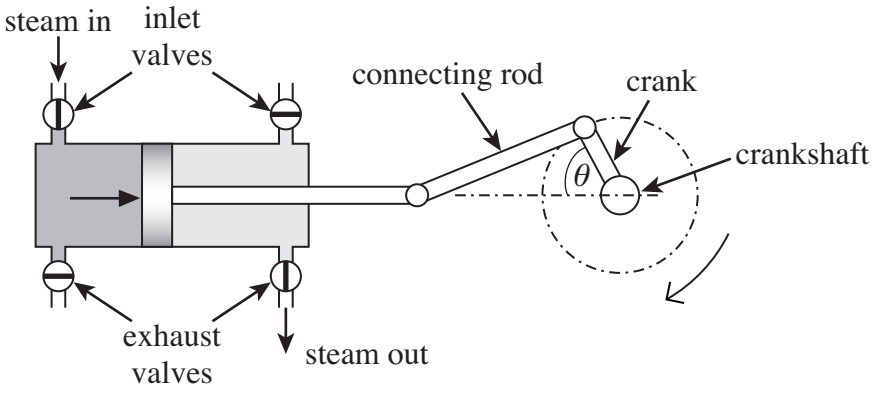
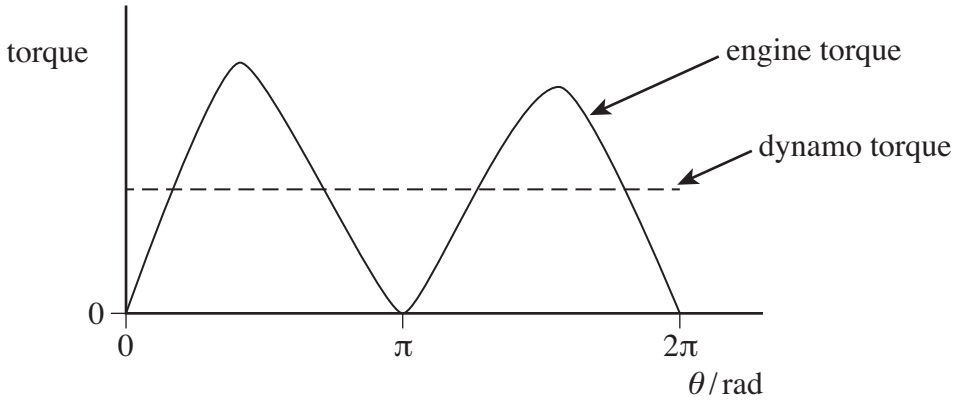


Figure 4 shows how the torque on the crankshaft due to the engine varies with the crankshaft angle θ for one rotation of the crankshaft. The broken line shows the constant dynamo torque required from the output.

Figure 4



3 (a) State and explain how you could use **Figure 4** to determine the work done by the engine in one revolution of the crankshaft.

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(1 mark)

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3 (b) The dynamo has a low moment of inertia.

- Explain why the engine torque varies over a cycle.
- Explain why, in terms of kinetic energy or angular momentum, it is necessary to fit a flywheel to the crankshaft of the engine.
- Discuss how the motion of the crankshaft is influenced by the value of the moment of inertia of the flywheel.

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

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(6 marks)

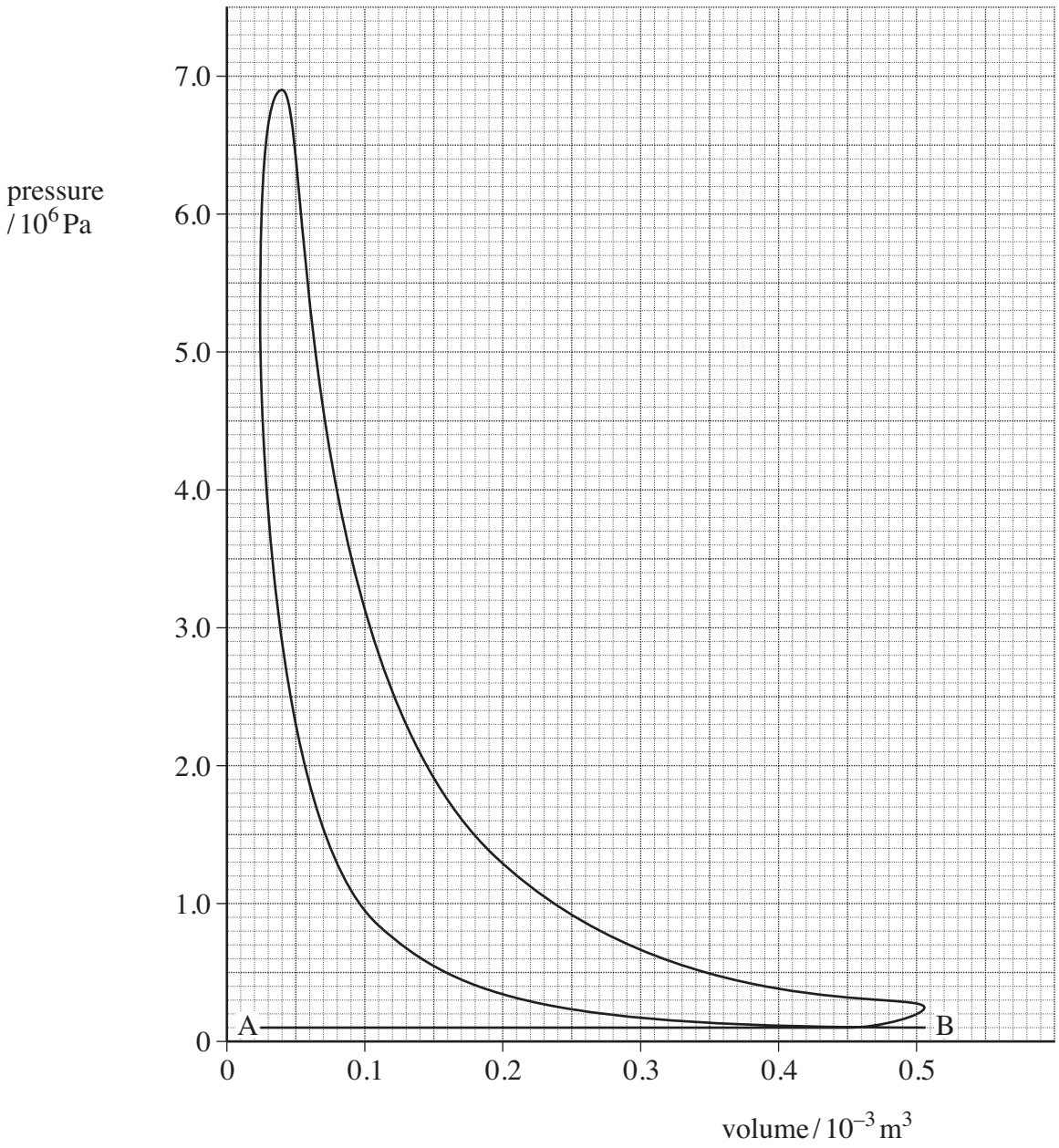
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4 A four-stroke diesel engine with four cylinders is running at constant speed on a test bed. An indicator diagram for **one cylinder** is shown in **Figure 5** and other test data are given below:

measured output power of engine (brake power)	= 55.0 kW
fuel used in 100 seconds	= 0.376 litre
calorific value of fuel	= 38.6 MJ litre^{-1}
engine speed	= 4100 rev min^{-1}

Figure 5



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4 (a) (i) Determine the indicated power of the engine, assuming all cylinders give the same power.

answer = ... kW

(4 marks)

4 (a) (ii) Calculate the overall efficiency of the engine.

answer = ...

(3 marks)

4 (b) Account for the difference between the indicated power and brake power.

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(1 mark)

4 (c) What is represented by the line AB on **Figure 5**?

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(1 mark)

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END OF QUESTIONS

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