

Centre Number						Candidate Number				
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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 2014

Physics A

PHYA5/2C

Unit 5C Applied Physics
Section B

Thursday 19 June 2014 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.



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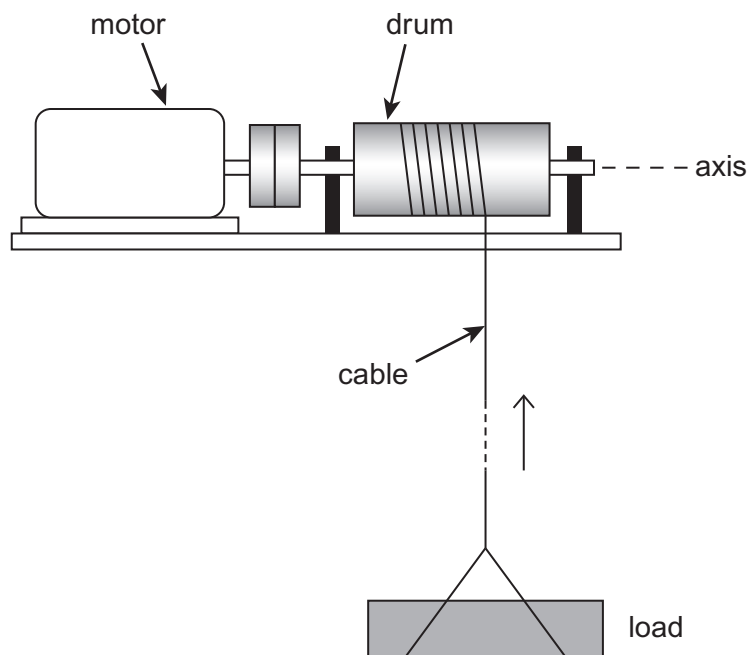
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PHYA5/2C

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 motor-driven winch for raising loads on a building site. As the motor turns the cable is wound around the drum, raising the load.

Figure 1

The drum, axle and other rotating parts have a moment of inertia about the axis of rotation of 7.4 kg m^2 , and the mass of the load is 85 kg . The drum has a radius of 0.088 m .

The load is accelerated uniformly from rest to a speed of 2.2 m s^{-1} . When it is accelerating it rises through a height of 3.5 m . It then continues at the constant speed of 2.2 m s^{-1} .

- 1 (a) Show that the drum turns through 40 rad as the load accelerates.

[1 mark]

- 1 (b)** Calculate the angular speed of the drum when the load is moving at 2.2 m s^{-1} . **[1 mark]**

angular speed rad s^{-1}

- 1 (c) (i)** Show that for the time that the load is accelerating the total increase in energy of the load and the rotating parts is about 5400 J. **[3 marks]**

- 1 (c) (ii)** A constant frictional torque of 5.2 N m acts at the bearings of the winch.

Calculate the total work done by the motor to accelerate the load.

Give your answer to an appropriate number of significant figures.

[3 marks]

total work done J

Question 1 continues on the next page

Turn over ►



1 (d) Calculate the **maximum** power developed by the motor.

[2 marks]

maximum power W

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Turn to page 6 for the next question



Turn over for the next question

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



2 In the sport of sprint cycling rapid acceleration is required.

Discuss the importance of moment of inertia in the design of sport cycle wheels. In your account you should:

- explain why it is desirable for the wheels to have a **low** moment of inertia when the cycle is required to accelerate rapidly
- explain the basic features of wheel design which would lead to a **low** moment of inertia about the axis of rotation.

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

[6 marks]

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Turn over for the next question

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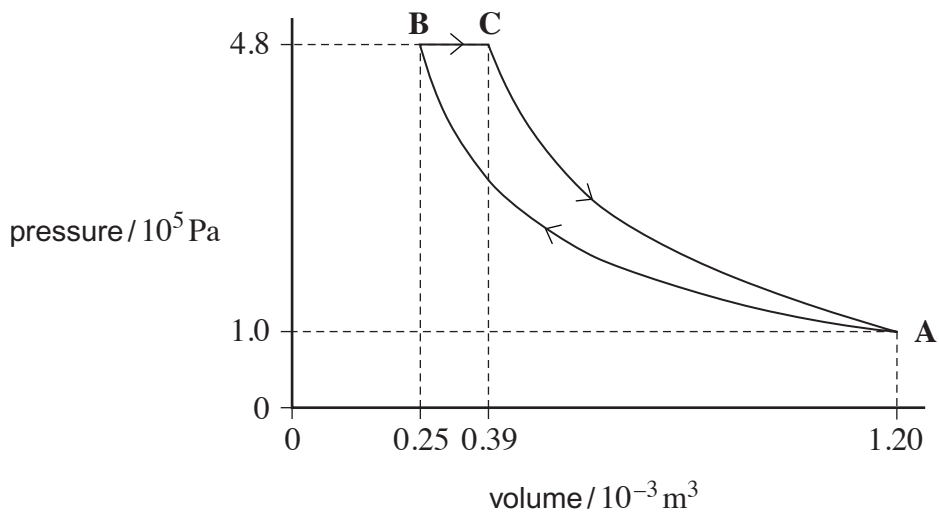
3 **Figure 2** shows a theoretical engine cycle in which a fixed mass of ideal gas is taken through the following processes in turn:

A → **B**: isothermal compression from volume $1.20 \times 10^{-3} \text{ m}^3$ and pressure $1.0 \times 10^5 \text{ Pa}$ to a volume $0.25 \times 10^{-3} \text{ m}^3$ and maximum pressure of $4.8 \times 10^5 \text{ Pa}$.

B → **C**: expansion at constant pressure with heat addition of 235 J

C → **A**: adiabatic expansion to the initial pressure and volume at **A**.

Figure 2



3 (a) (i) Show that process **A** → **B** is isothermal.

[2 marks]

3 (a) (ii) Calculate the work done by the gas in process **B** → **C**.

[1 mark]

work done J



3 (b) Complete **Table 1**. Apply the first law of thermodynamics to determine values of Q , W and ΔU for each process and for the whole cycle. Use a consistent sign convention. **[3 marks]**

Table 1

	Q / J	W / J	$\Delta U / J$
process A \rightarrow B		-188	
process B \rightarrow C	+235		
process C \rightarrow A		+168	
whole cycle		+47	0

3 (c) The overall efficiency of an engine is defined as

$$\frac{\text{net work output in one cycle}}{\text{energy supplied by heating from an external source in one cycle}}$$

Calculate the overall efficiency of the cycle.

[1 mark]

overall efficiency

3 (d) Describe **two** problems that would be encountered in trying to design a real engine based on this cycle.

[2 marks]

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4 (a) Explain what is meant by the coefficient of performance of a heat pump. [1 mark]

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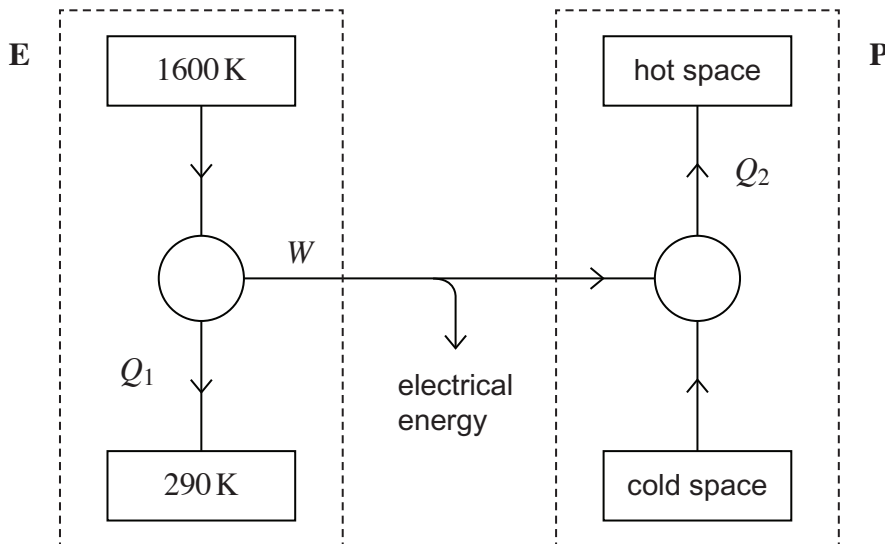
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4 (b) The box labelled **E** in **Figure 3** shows a diagram of a combined heat and power scheme. The scheme provides electrical energy W from an engine-driven generator and heat Q_1 for buildings situated near to the generator.

Some of the electrical energy is used to drive the heat pump shown in the box labelled **P**. Output Q_2 is also used to heat the buildings.

Figure 3



You may assume that the engine runs at its maximum theoretical efficiency and that the electrical generator is 100% efficient. The output power of the engine-driven generator is 80 kW.



- 4 (b) (i) The fuel used in the engine (**E**) is propane of calorific value 49 MJ kg^{-1} . Calculate the rate of flow of propane into the engine. State an appropriate unit.

[4 marks]

rate of flow unit

- 4 (b) (ii) The heat pump has a coefficient of performance of 2.6.
The power supplied by the electrical generator to the heat pump (**P**) is 16 kW.
Calculate the total rate at which energy is available for heating from both the engine and heat pump.

[3 marks]

rate at which energy is available W

Question 4 continues on the next page

Turn over ►



4 (b) (iii) The conversion of electrical energy to heat is nearly 100% efficient. Explain why the designer has proposed installing a heat pump rather than an electrical heater to provide the additional heat Q_2 .

[2 marks]

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END OF QUESTIONS

