Centre Number						Candidate Number				
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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.

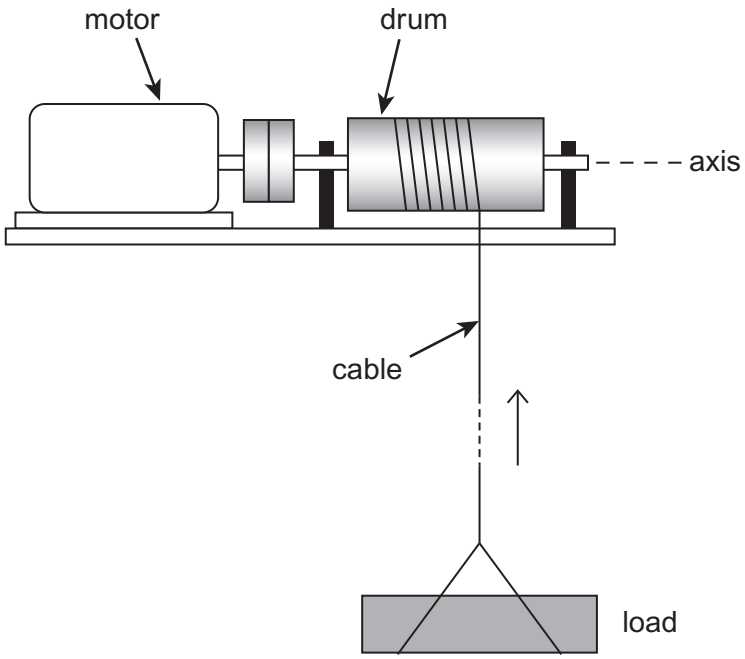
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Section B

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 $7.4\,\text{kg}\,\text{m}^2$, and the mass of the load is $85\,\text{kg}$. The drum has a radius of $0.088\,\text{m}$.

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

1 (a) Show that the drum turns through $40\,\text{rad}$ as the load accelerates.

[1 mark]

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1 (b) Calculate the angular speed of the drum when the load is moving at $2.2\,\mathrm{m\,s^{-1}}$.

[1 mark]

angular speed ..... $\mathrm{rad\,s^{-1}}$

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 $5400\,\mathrm{J}$.

[3 marks]

1 (c) (ii) A constant frictional torque of $5.2\,\mathrm{N\,m}$ 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

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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

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ANSWER IN THE SPACES PROVIDED

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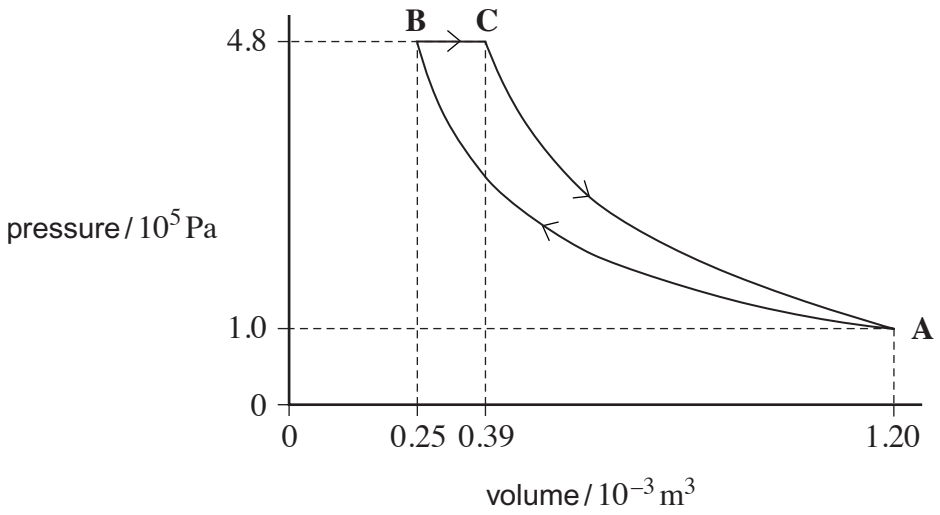
3 **Figure 2** shows a theoretical engine cycle in which a fixed mass of ideal gas is taken through the following processes in turn:

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

$\mathbf{B} \rightarrow \mathbf{C}$: expansion at constant pressure with heat addition of $235\ \mathrm{J}$

$\mathbf{C} \rightarrow \mathbf{A}$: adiabatic expansion to the initial pressure and volume at **A**.

Figure 2



3 (a) (i) Show that process $\mathbf{A} \rightarrow \mathbf{B}$ is isothermal.

[2 marks]

3 (a) (ii) Calculate the work done by the gas in process $\mathbf{B} \rightarrow \mathbf{C}$.

[1 mark]

work done ..... J

Do not write outside the box

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	ΔU / J
process A → B		–188	
process B → C	+235		
process C → 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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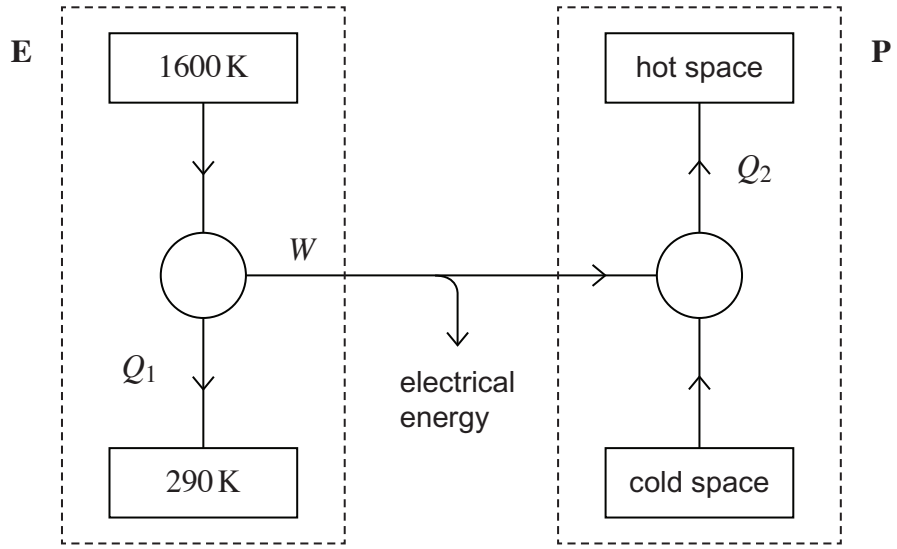
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4 (b) The box labelled **E** in **Figure 3** shows a diagram of a combined heat and power scheme. The scheme provides electrical energy W from an engine-driven generator and heat Q_1 for buildings situated near to the generator.

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 $80\,\text{kW}$.

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4 (b) (i) The fuel used in the engine (**E**) is propane of calorific value $49\,\text{MJ}\,\text{kg}^{-1}$. 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

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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

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