

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



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.

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



J U N 1 4 P H Y A 5 2 C 0 1

WMP/Jun14/PHYA5/2C/E5

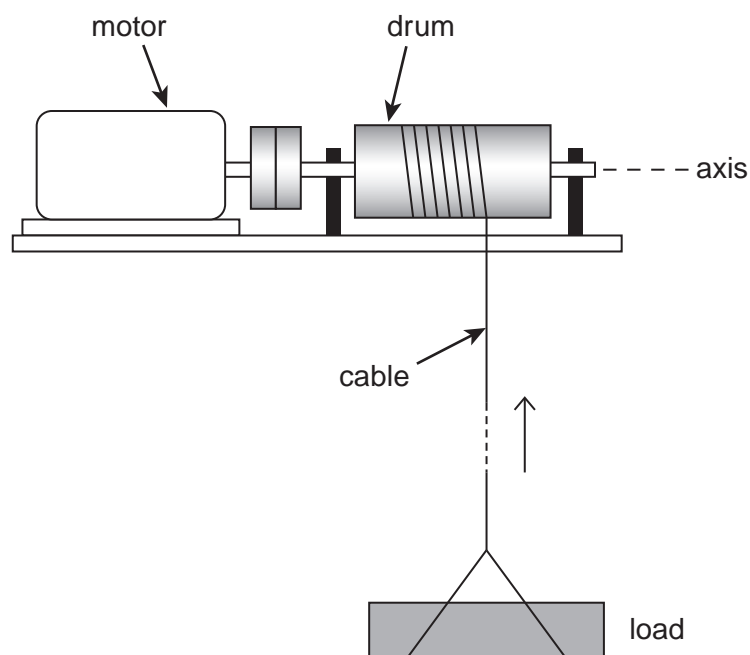
## PHYA5/2C

## 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  $7.4 \text{ kg m}^2$ , 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  $2.2 \text{ m s}^{-1}$ . When it is accelerating it rises through a height of  $3.5 \text{ m}$ . It then continues at the constant speed of  $2.2 \text{ m s}^{-1}$ .

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

**[1 mark]**



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

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

- 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  $5.2 \text{ N m}$  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**

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**[6 marks]**

[illegible]

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Turn over for the next question

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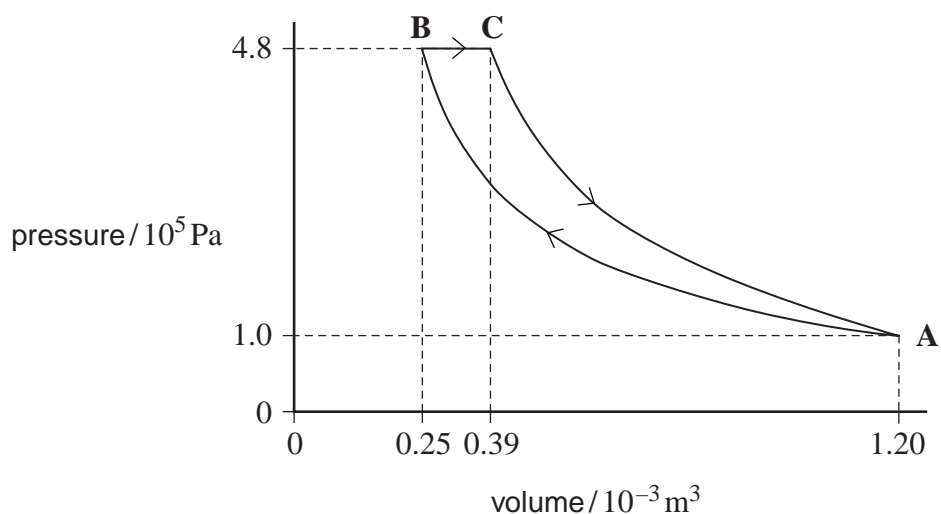
**3** **Figure 2** shows a theoretical engine cycle in which a fixed mass of ideal gas is taken through the following processes in turn:

**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  $235 \text{ J}$

**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  $\Delta U$  for each process and for the whole cycle. Use a consistent sign convention. **[3 marks]**

**Table 1**

	$Q / \text{J}$	$W / \text{J}$	$\Delta U / \text{J}$
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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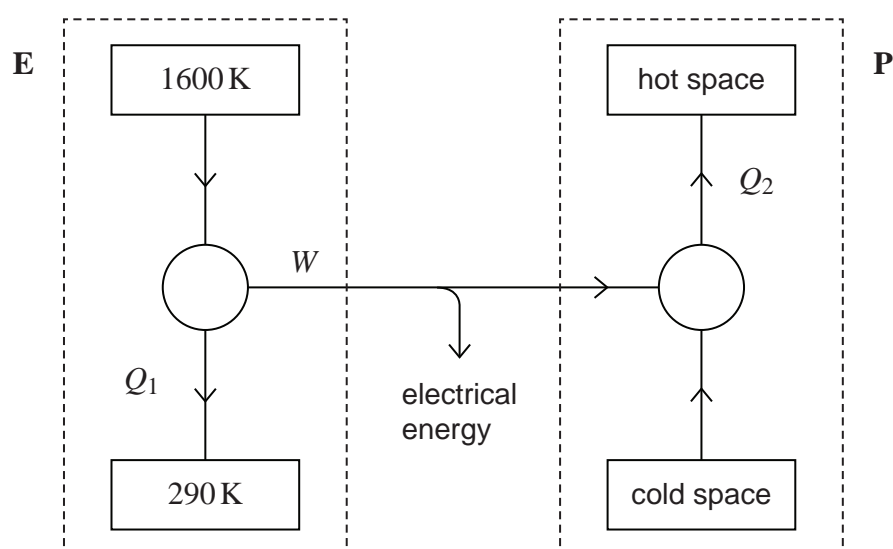
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- 4 (b) The box labelled **E** in **Figure 3** shows a diagram of a combined heat and power scheme. The scheme provides electrical energy  $W$  from an engine-driven generator and heat  $Q_1$  for buildings situated near to the generator.

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  $49 \text{ MJ kg}^{-1}$ . 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

