Surname

Other Names

Candidate Signature

AQA

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.

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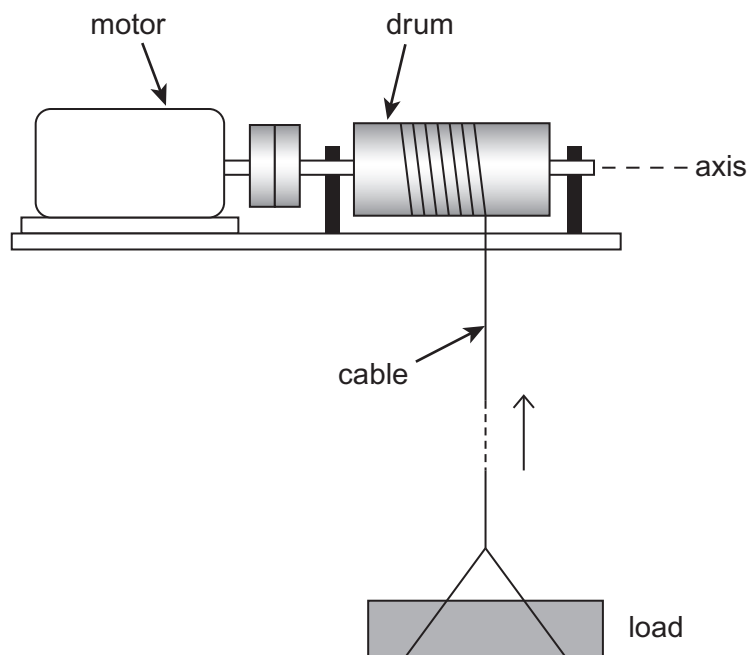
The drum, axle and other rotating parts have a moment of inertia about the axis of rotation of $7.4 \, \text{kg} \, \text{m}^2$, and the mass of the load is $85 \, \text{kg}$. The drum has a radius of $0.088 \, \text{m}$.

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]

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

Turn over ▶

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

[2 marks]

maximum power .... W

10

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

Turn over ▶

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

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

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

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

Figure 2
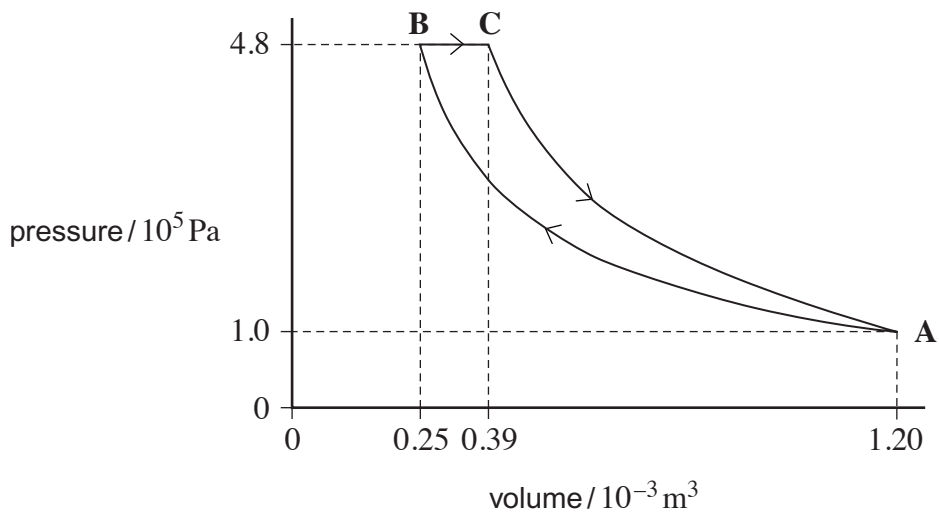
3 (a) (i)   Show that process $A \rightarrow B$ is isothermal.

[2 marks]

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

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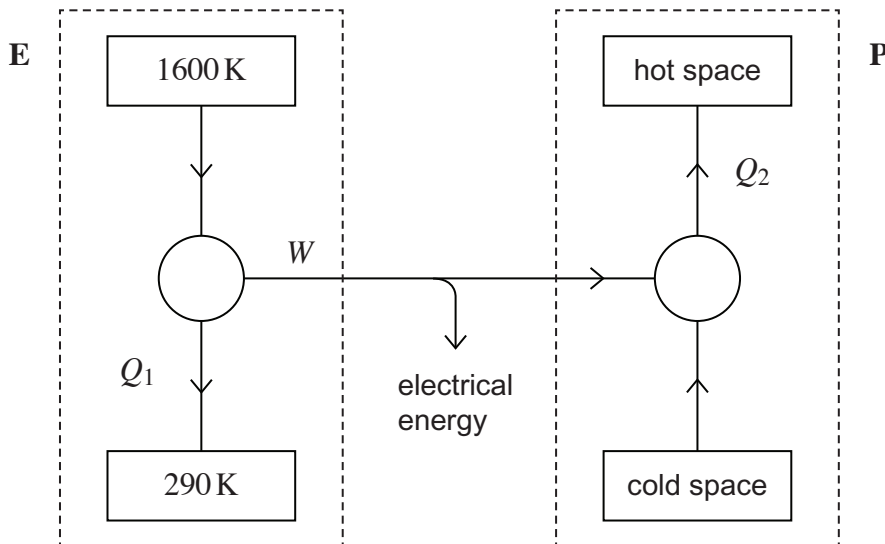
4 (b) The box labelled **E** in **Figure 3** shows a diagram of a combined heat and power scheme. The scheme provides electrical energy W from an engine-driven generator and heat Q_1 for buildings situated near to the generator.

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 $80\,\text{kW}$.

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