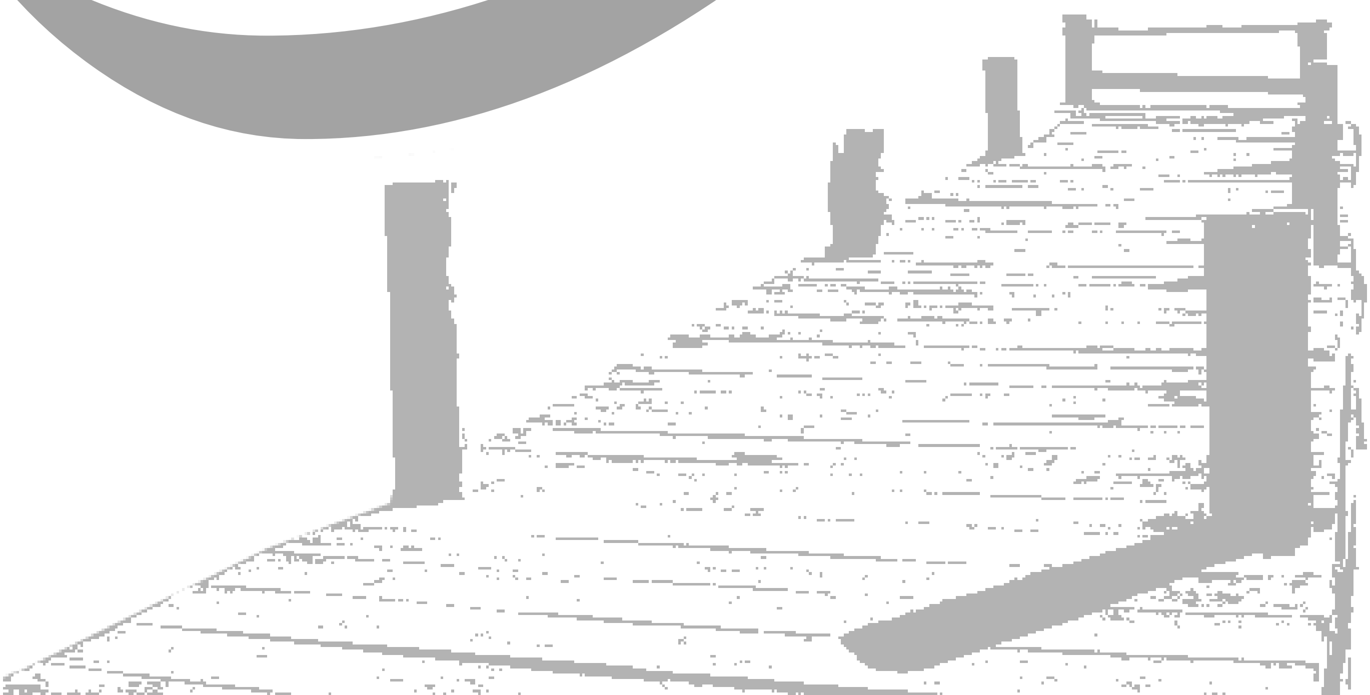
GCE
AS and A Level

Physics A

AS exams 2009 onwards
A2 exams 2010 onwards

Unit 5C: Approved specimen question paper

Version 1.1



Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
2010
Advanced Examination

version 1.1

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS A **PHA5C**
Unit 5C Applied Physics

Section B

SPECIMEN PAPER

Time allowed: 50 minutes

Instructions

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- A *Data and Formula Booklet* is provided as a loose insert.

Information

- The maximum mark for this paper is 35.
- The marks for the questions are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers. You will be assessed on your quality of written communication where indicated in the question.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
Total (Column 1)			
Total (Column 2)			
TOTAL			
Examiner's Initials			

Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

1 Flywheels store energy very efficiently and are being considered as an alternative to battery power.

(a) A flywheel for an energy storage system has a moment of inertia of 0.60 kg m^2 and a maximum safe angular speed of 22 000 rev min^{-1}.

Show that the energy stored in the flywheel when rotating at its maximum safe speed is 1.6 MJ.

(2 marks)

(b) In a test the flywheel was taken up to maximum safe speed then allowed to run freely until it came to rest. The average power dissipated in overcoming friction was 8.7 W.

Calculate

(i) the time taken for the flywheel to come to rest from its maximum speed,

Time taken = ...

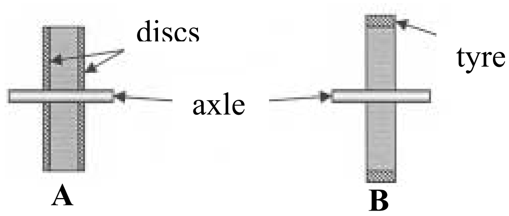
(ii) the average frictional torque acting on the flywheel.

Torque = ...

(3 marks)

(c) The energy storage capacity of the flywheel can be improved by adding solid discs to the flywheel as shown in cross-section **A** in **Figure 1**, or by adding a hoop or tyre to the rim of the flywheel as shown in **B** in **Figure 1**. The same mass of material is added in each case. State, with reasons, which arrangement stores the more energy when rotating at a given angular speed.

Figure 1



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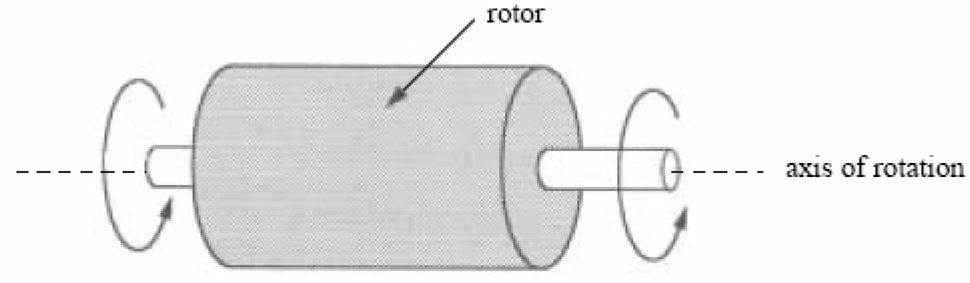
(2 marks)

Total 7 marks

2 'Low inertia' motors are used in applications requiring rapid changes of speed and direction of rotation. These motors are designed so that the rotor has a very low moment of inertia about its axis of rotation.



(a) (i) Explain why a low moment of inertia is desirable when the speed and direction of rotation must be changed quickly.

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(ii) State, giving a reason in each case, **two** features of rotor design which would lead to a low moment of inertia about the axis of rotation.

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(4 marks)

(b) In one application, a rotor of moment of inertia 4.4×10^{-5} kg m^2 about its axis of rotation is required to reverse direction from an angular speed of 120 rad s^{-1} to the same speed in the opposite direction in a time of 50 ms. Assuming that the torque acting is constant throughout the change, calculate

(i) the angular acceleration of the rotor,

....

....

(ii) the torque needed to achieve this acceleration,

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....

(iii) the angle turned through by the rotor in coming to rest momentarily before reversing direction.

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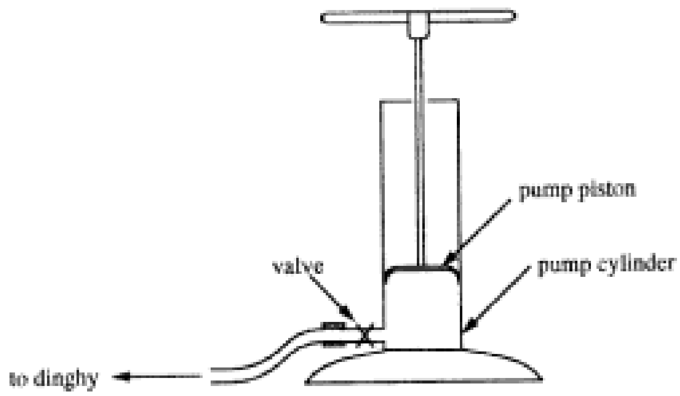
(3 marks)

Total 7 marks

3 **Figure 2** shows a pump used to inflate a rubber dinghy. When the piston is pushed down, the pressure of air in the cylinder increases until it reaches the pressure of the air in the dinghy. At this pressure the valve opens and air flows at almost constant pressure into the dinghy.

Figure 2



(a) The pump is operated quickly so the compression of the air in the cylinder before the valve opens can be considered adiabatic.
At the start of a pump stroke, the pump cylinder contains 4.25×10^{-4} m^3 of air at a pressure of 1.01×10^5 Pa and a temperature of 23ºC. The pressure of air in the dinghy is 1.70×10^5 Pa.

Show that, when the valve is about to open, the volume of air in the pump is 2.93×10^{-4} m^3.

γ for air = 1.4

(2 marks)

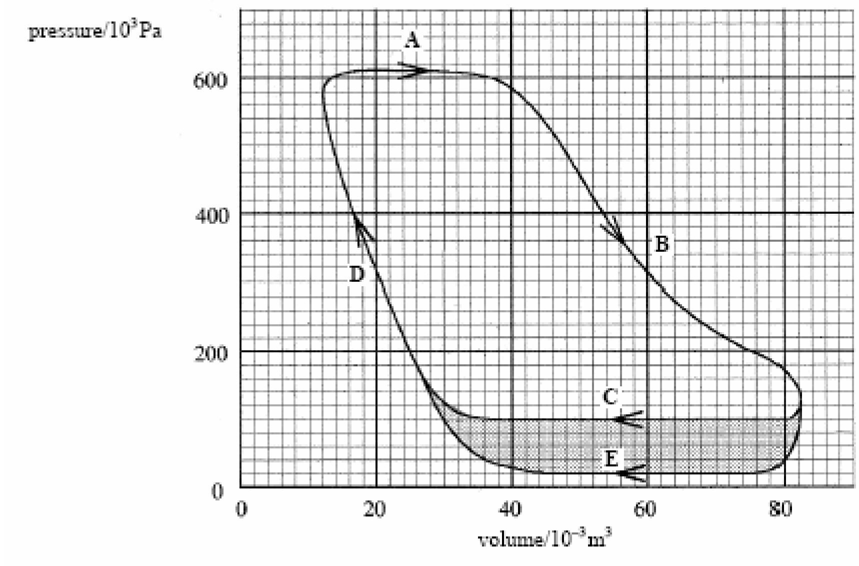
(b) Calculate the temperature of the air in the pump when the valve is about to open.

Temperature = ...

(4 marks)

Total 6 marks

4 The line **ABCD** in the graph below is the indicator diagram for a single cylinder steam engine in which the exhaust steam is released directly into the atmosphere.



(a) (i) Calculate the work done by the engine during the cycle **ABCD**.

Work done = ...

(ii) Calculate the indicated output power of the engine when running at 3 cycles per second.

Indicated output power = ...

(iii) To achieve this output power, fuel of calorific value $34\,\text{MJ}\,\text{kg}^{-1}$ must be burnt at a rate of $2.4 \times 10^{-2}\,\text{kg}\,\text{s}^{-1}$. Calculate the thermal efficiency of the engine.

Thermal efficiency = ...

(6 marks)

(b) The line **ABED** in the graph is the indicator diagram for the same engine after a modification has been made so that the exhaust steam is passed into a condenser, where it is converted to water. The hot water formed is returned to the boiler for reheating.

Without further calculation, compare the performance of the modified engine with that of the original engine when both engines are making the same number of cycles per second. In your comparison you should consider the fuel consumption of the engines, the mass of steam supplied to them, their power outputs and efficiencies.

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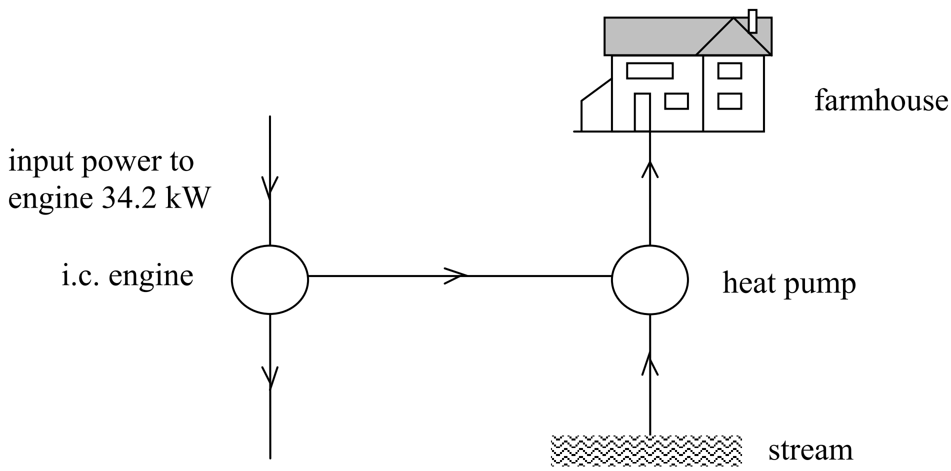
(3 marks)

Total 9 marks

5 Two systems are proposed for heating a remote farmhouse. In the first system bottled gas heats water in a boiler and the hot water is circulated through radiators. The maximum power input to the boiler is 34.2 kW and the maximum boiler output is 28.0 kW.

In the second system the same fuel as in the system described above is burned at the same maximum rate in an internal combustion engine of overall efficiency 36%. The engine drives a heat pump of coefficient of performance 2.5 which extracts energy from a nearby stream. The system is shown schematically is **Figure 3**.

Figure 3



(a) Determine the maximum

(i) power output of the internal combustion engine,

Power output = ...

(ii) rate at which the heat pump supplies energy to the farmhouse

Rate of supply of energy = ...

(iii) rate at which the heat pump extracts energy from the stream.

Rate of extraction of energy = ...

(3 marks)

(b) State which system is cheaper to run, giving **two** reasons for your answer.

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(3 marks)

Total 6 marks