Centre Number						Candidate Number				
Surname										
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 2011

Physics A PHYA5/2C

Unit 5C Applied Physics
Section B

Monday 27 June 2011 9.00am to 10.45am

For this paper you must have:
- a calculator
- a ruler
- a Data and Formulae Booklet.

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.

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.

J U N 1 1 P H Y A 5 2 C 0 1
WMP/Jun11/PHYA5/2C

Section B

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

1 (a) State the law of conservation of angular momentum.

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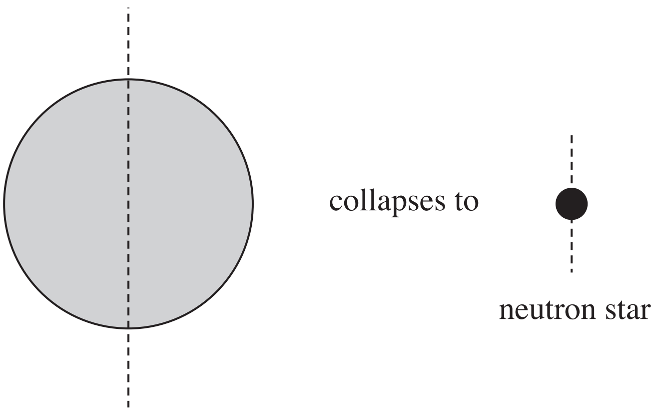
(1 mark)

1 (b) When a star undergoes a supernova explosion, the star's core collapses into a very much smaller diameter forming an extremely dense *neutron star* as shown in **Figure 1**.

Figure 1



A star has a period of rotation about an axis through its centre of 44 days (3.8×10^6 s) and a core of radius 4.1×10^7 m. The star undergoes a supernova explosion and the core collapses into a neutron star of radius 1.2×10^4 m.
You may assume that during the collapse no mass is lost from the core and that the star remains spherical.

Moment of inertia of a sphere of uniform mass m and radius R about an axis through its centre = $0.40mR^2$

1 (b) (i) Explain why the period of rotation of the star decreases as it becomes a neutron star.

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(2 marks)

Do not write outside the box

1 (b) (ii) Determine the period of rotation of the neutron star. Give your answer to an appropriate number of significant figures.

answer = ... s
(4 marks)

7

Turn over for the next question

2 Some motor racing cars are fitted with a kinetic energy recovery system (KERS). In this system, as the car brakes approaching a bend, instead of all the lost kinetic energy being dissipated as heat, some of the energy is used to accelerate a flywheel. When the car needs to accelerate out of the bend, the energy in the flywheel assists the engine in providing extra power.

2 (a) Describe and explain some of the design features of a flywheel in order for it to store maximum energy. Your answer should include consideration of the flywheel's shape, the material from which it is made and its design for high angular speeds.

The quality of your written communication will be assessed in this question.

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(6 marks)

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2 (b) A KERS flywheel has a moment of inertia of 0.036 $kg\,m^2$ and rotates at its maximum angular speed of 6400 $rad\,s^{-1}$. When the flywheel is used to help accelerate the car, the flywheel's speed reduces uniformly to 3100 $rad\,s^{-1}$ in a time of 6.6 s. You may assume that frictional losses in the drive mechanism are negligible.

2 (b) (i) Calculate the energy transferred from the flywheel to the car.

answer = ... J

(1 mark)

2 (b) (ii) Calculate the average power produced by the decelerating flywheel.

answer = ... W

(1 mark)

2 (b) (iii) Calculate the decelerating torque on the flywheel, stating an appropriate unit.

answer = ...

(2 marks)

2 (b) (iv) Calculate the number of revolutions made by the flywheel in the time of 6.6 s.

answer = ... revolutions

(2 marks)

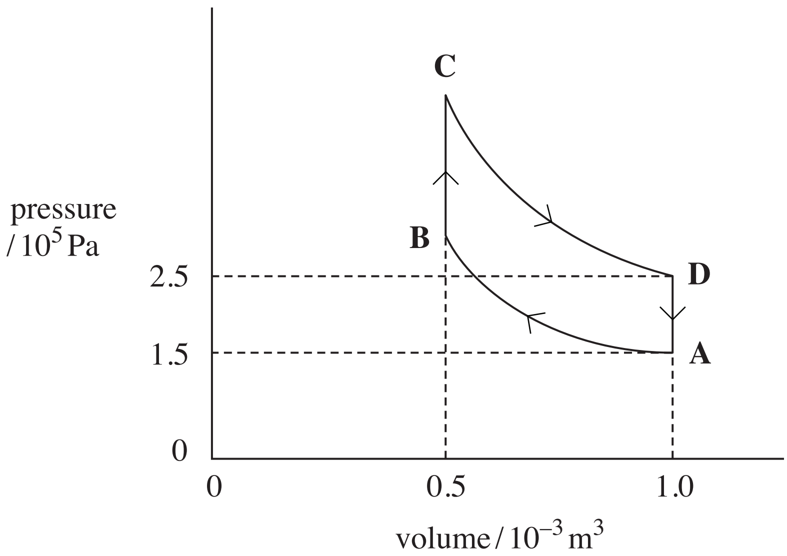
12

3 In an ideal 'hot air' engine, a fixed mass of air is continuously taken through the following four processes:

A → B isothermal compression at a temperature of 300 K. The work done on the air is 104 J.
B → C heating at constant volume.
C → D isothermal expansion. The work done by the expanding air is 173 J.
D → A cooling at constant volume.

The cycle is shown in **Figure 2.**

Figure 2



3 (a) (i) Show that the temperature of the air at point D is 500 K.

(2 marks)

3 (a) (ii) Apply the first law of thermodynamics to calculate the energy supplied by heat transfer in process C → D.

answer = ... J
(2 marks)

3 (b) The engine contains a device called a regenerator which stores **all** the energy rejected by cooling in process D → A and gives up **all** this energy to the air again in process B → C. This means that energy must be supplied to the air by heat transfer from an external source **only** in process C → D.

3 (b) (i) Calculate the net work done during the cycle.

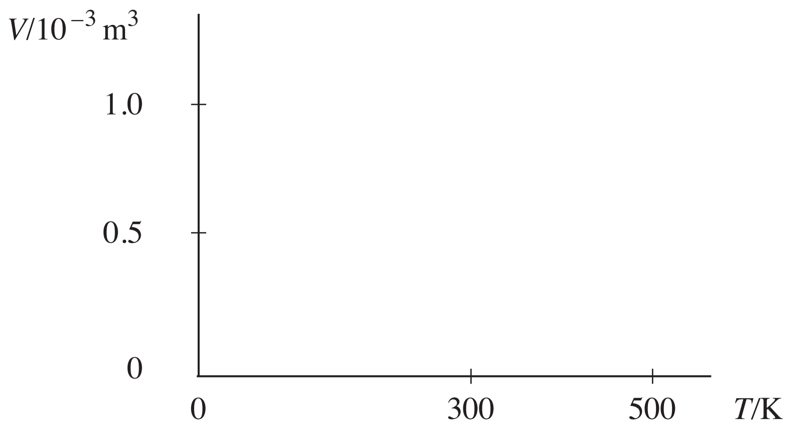
answer = ... J

(1 mark)

3 (b) (ii) Show that the efficiency of the cycle is the same as the maximum possible efficiency of any heat engine operating between the same highest and lowest temperatures in the cycle.

(2 marks)

3 (c) On the axes below, sketch the cycle on a graph of volume V against temperature T. Label the points A, B, C and D.



(2 marks)

Question 3 continues on the next page

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3 (d) Several inventors have tried to build an engine that works on this cycle. Give **two** reasons why they have been unsuccessful.

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(2 marks)

11

4 A heat pump is used for heating a small workshop. The heat pump extracts energy from a patch of ground outside the workshop. The coefficient of performance of the heat pump is 3.2 and the average electrical power input is 780 W.

4 (a) (i) Calculate the rate at which energy is delivered to the workshop.

answer = ... W

(1 mark)

4 (a) (ii) Calculate the rate at which energy is extracted from the ground.

answer = ... W

(1 mark)

4 (b) A student claims: "A heat pump delivers more energy than is supplied to it". Discuss this statement and explain why a heat pump does not contradict the law of conservation of energy or the second law of thermodynamics.

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(3 marks)

5

END OF QUESTIONS

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