| Centre Number | | | | | | Candidate Number | | | | |
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| Other Names | | | | | | | | | | |
| Candidate Signature | | | | | | | | | | |

| For Examiner's Use | |
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| Examiner's Initials | |
| Question | Mark |
| 1 | |
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| TOTAL | |

General Certificate of Education
Advanced Level Examination
June 2013

# Physics A PHYA5/2C

## Unit 5C Applied Physics
## Section B

**Thursday 20 June 2013 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** The turntable of a microwave oven has a moment of inertia of $8.2 \times 10^{-3}$ kg m$^2$ about its vertical axis of rotation.

**1 (a)** With the drive disconnected, the turntable is set spinning. Starting at an angular speed of 6.4 rad s$^{-1}$ it makes 8.3 revolutions before coming to rest.

**1 (a) (i)** Calculate the angular deceleration of the turntable, assuming that the deceleration is uniform. State an appropriate unit for your answer.

angular deceleration ............................................ unit ...........................

*(4 marks)*

**1 (a) (ii)** Calculate the magnitude of the frictional torque acting at the turntable bearings.

torque ..................................... N m

*(1 mark)*

**1 (b)** The turntable drive is reconnected. A circular pie is placed centrally on the turntable. The power input to the microwave oven is 900 W, and to cook the pie the oven is switched on for 270 seconds. The turntable reaches its operating speed of 0.78 rad s$^{-1}$ almost immediately, and the friction torque is the same as in part (a)(ii).

**1 (b) (i)** Calculate the work done to keep the turntable rotating for 270 s at a constant angular speed of 0.78 rad s$^{-1}$ as the pie cooks.

work done .......................................... J

*(2 marks)*

Do not write outside the box

**1 (b) (ii)** Show that the ratio

$$\frac{\text{energy supplied to oven}}{\text{work done to drive turntable}}$$

is of the order of $10^5$.

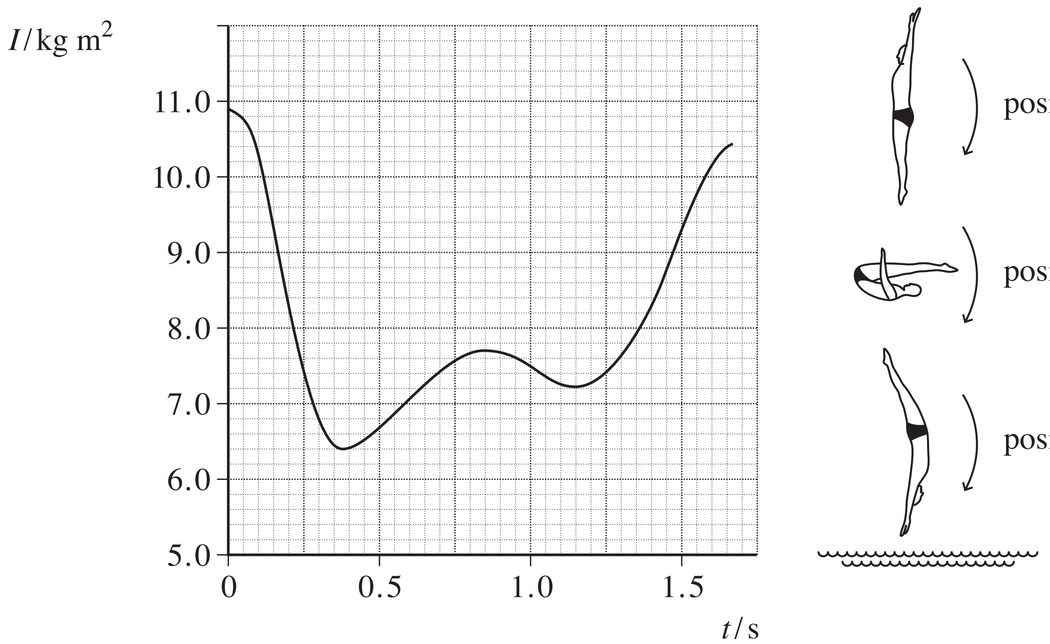
*(2 marks)*

9

**Turn over for the next question**

**2** **Figure 1** shows how the moment of inertia $I$ of a diver performing a reverse dive varies with time $t$ from just after he has left the springboard until he enters the water.

**Figure 1**




The diver starts with his arms extended above his head (position 1), and then brings his legs towards his chest as he rotates (position 2). After somersaulting in mid-air, he extends his arms and legs before entering the water (position 3).

**2 (a)** Explain how moving the legs towards the chest causes the moment of inertia of the diver about the axis of rotation to decrease.

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*(2 marks)*

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**2 (b) (i)** Explain in terms of angular momentum why the angular velocity of the diver varies during the dive.

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*(2 marks)*

**2 (b) (ii)** Describe how the angular velocity of the diver varies throughout the dive.

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*(1 mark)*

**2 (c)** At time $t = 0$ the angular velocity of the diver is 4.4 rad $s^{-1}$ and his moment of inertia about the axis of rotation is 10.9 kg $m^2$.

With reference to **Figure 1** calculate the maximum angular velocity of the diver during the dive.

angular velocity ................................. rad $s^{-1}$

*(3 marks)*

8

**Turn over ▶**

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**ANSWER IN THE SPACES PROVIDED**

**3 (a)** Explain why the compression stroke of a diesel engine is considered to be an adiabatic change.

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*(2 marks)*

**3 (b)** **Figure 2** shows the cylinder of a diesel engine. The pressure of the air at the start of the compression stroke is $1.0 \times 10^5$ Pa and the volume above the piston is $4.5 \times 10^{-4}$ m$^3$.

**Figure 2**

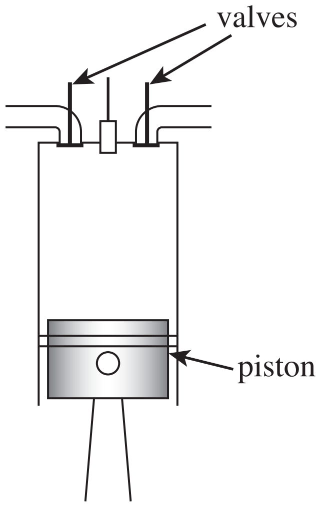


**Figure 3**

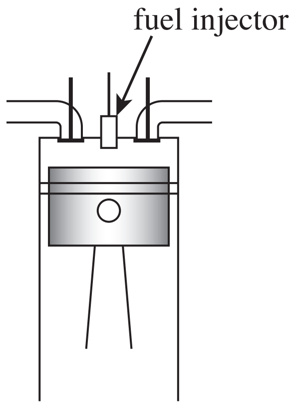


**Figure 3** shows the same cylinder at the instant just before the fuel is injected. The pressure above the piston is now $6.2 \times 10^6$ Pa. The compression is adiabatic with no leakage of air past the piston or valves.

adiabatic index $\gamma$ for air = 1.4

**3 (b) (i)** Calculate the volume above the piston at the instant just before the fuel is injected. Give your answer to an appropriate number of significant figures.

volume ......................................... m$^3$

*(3 marks)*

**Turn over ▶**

**3 (b) (ii)** The temperature of the air in the cylinder at the start of the compression stroke is 297 K. Calculate the temperature of the air at the instant just before the fuel is injected.

temperature ........................................ K
*(2 marks)*

**3 (b) (iii)** Explain why, in a diesel engine, the fuel starts to be injected into the cylinder slightly before the piston reaches its highest point in the cylinder.

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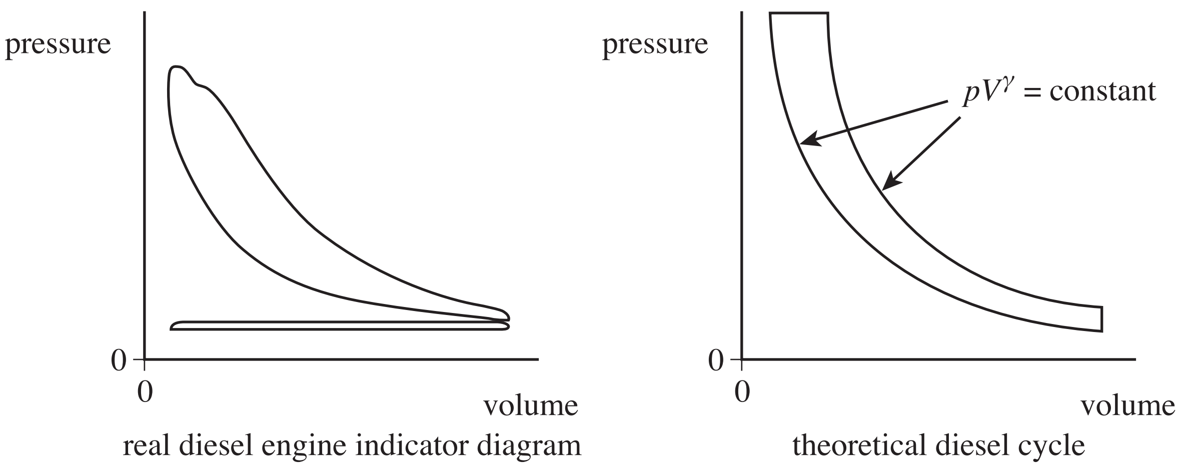
*(1 mark)*

**3 (c)** **Figure 4** shows the indicator ($p - V$) diagram for a real diesel engine compared to the $p - V$ diagram for a theoretical diesel cycle of the same maximum and minimum volumes and fuel injection cut-off.

**Figure 4**




Compare the real engine cycle with the theoretical cycle. In your account you should:

- discuss the important differences between the cycles
- explain why the overall efficiency of the real engine is less than that predicted by an analysis of the theoretical cycle.

The quality of your written communication will be assessed in your answer.

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(6 marks)

14

Turn over ▶

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**4 (a)** Explain what is meant by a reversed heat engine.

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*(2 marks)*

**4 (b)** Explain why the coefficient of performance of a reversed heat engine when operating as a heat pump is always greater than the coefficient of performance of the same reversed heat engine when operating as a refrigerator.

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*(2 marks)*

4

**END OF QUESTIONS**

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