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| Other Names | | | | | | | | | | |
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| For Examiner's Use | |
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| Examiner's Initials | |
| Question | Mark |
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General Certificate of Education
Advanced Level Examination
June 2015

# Physics A PHYA5/2C

**Unit 5C Applied Physics**
**Section B**

Thursday 18 June 2015 9.00 am to 10.45 am

**For this paper you must have:**
- a calculator
- a pencil and 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.

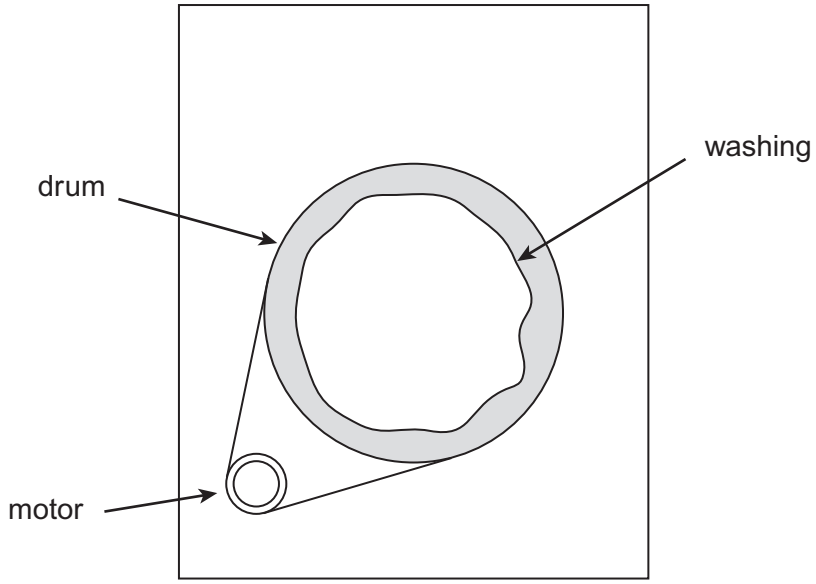
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## Section B

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

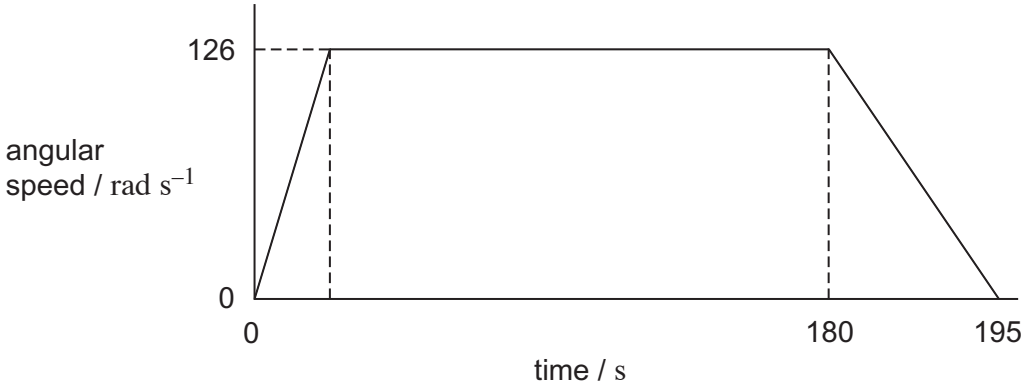
**1** During the spin part of a washing machine programme the maximum rotational speed is $126\ \text{rad s}^{-1}$ ($1200\ \text{rev min}^{-1}$). The moment of inertia of the drum and washing at the start of the spin part of the cycle is $0.565\ \text{kg m}^2$. Assume that the wet washing is evenly distributed around the drum as shown in **Figure 1**.

**Figure 1**




**1 (a)** **Figure 2** shows the variation of angular speed with time for the spin part of the cycle. The graph is not drawn to scale.

**Figure 2**



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The motor provides a torque of $8.80\ \text{N m}$ to accelerate the drum to $126\ \text{rad s}^{-1}$. The drum rotates at $126\ \text{rad s}^{-1}$ until near the end of the spin cycle, when the drum decelerates uniformly to zero angular speed in $15$ seconds. Friction at the bearings may be neglected. Assume that during acceleration the moment of inertia of the drum and washing remains constant.

**1 (a) (i)** Show that the drum accelerates for about $8\ \text{s}$.

**[2 marks]**

**1 (a) (ii)** Calculate the total number of revolutions made by the drum during the $195\ \text{s}$ shown in **Figure 2**.

**[3 marks]**

number of revolutions = .....

**1 (b) (i)** In practice, at the start of the cycle the acceleration will not remain constant. Draw on **Figure 2** a line to show how the initial part of the graph will change.

**[1 mark]**

**1 (b) (ii)** Explain your reasons for the line you have drawn.

**[2 marks]**

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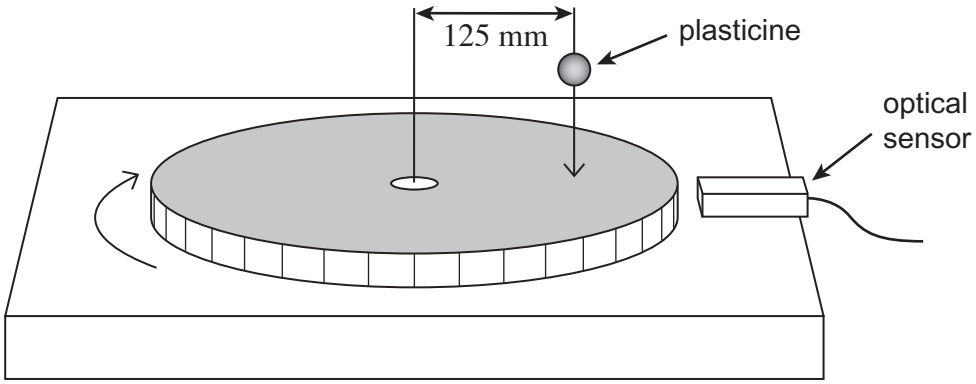
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**Turn over ▶**

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**2** A student carries out an experiment to determine the moment of inertia of a turntable. **Figure 3** shows the turntable with a small lump of plasticine held above it. An optical sensor connected to a data recorder measures the angular speed of the turntable.

**Figure 3**




The turntable is made to rotate and then it rotates freely. The lump of plasticine is dropped from a small height above the turntable and sticks to it. Results from the experiment are as follows.

mass of plasticine = 16.0 g
radius at which plasticine sticks to the turntable = 125 mm
angular speed of turntable immediately before plasticine is dropped = 3.46 rad $s^{-1}$
angular speed of turntable immediately after plasticine is dropped = 3.31 rad $s^{-1}$

The student treats the plasticine as a point mass.

**2 (a)** Explain why the turntable speed decreases when the plasticine sticks to it.

**[3 marks]**

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**2 (b)** Use the results of the experiment to determine the moment of inertia of the turntable.

Give your answer to an appropriate number of significant figures.

**[3 marks]**

moment of inertia ..... kg $m^2$

**2 (c) (i)** Calculate the change in rotational kinetic energy of the turntable and plasticine from the instant before the plasticine is dropped until immediately after it sticks to the turntable.

**[2 marks]**

change in kinetic energy ..... J

**2 (c) (ii)** Explain the change in rotational kinetic energy.

**[1 mark]**

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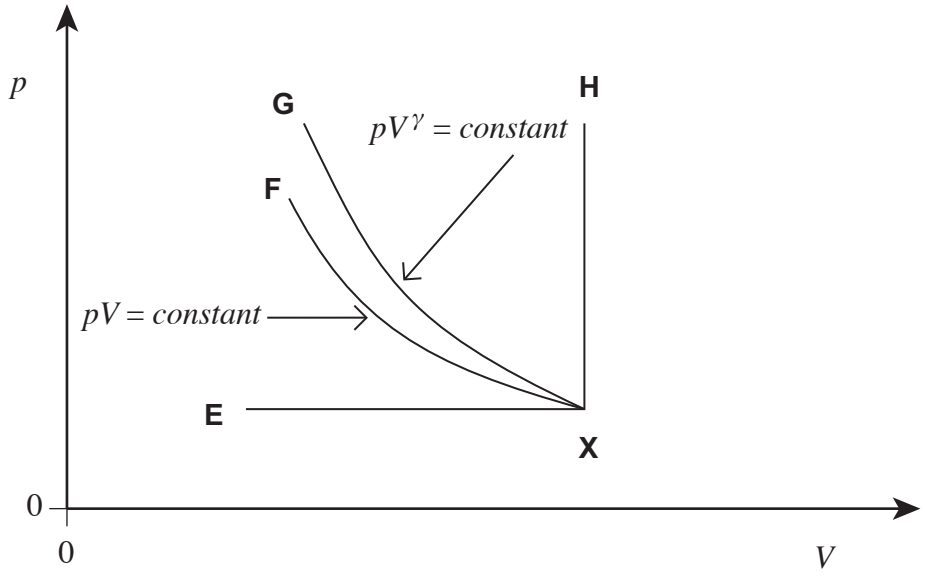
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**3 (a)** A fixed mass of gas undergoes a change from one of states **E**, **F**, **G**, **H** to state **X** as shown on the pressure–volume ($p$–$V$) diagram in **Figure 4**.

**Figure 4**




Which change gives an increase in internal energy of the gas?
Tick (✓) the correct answer.

**[1 mark]**

| | |
|---|---|
| **E** to **X** | |
| **F** to **X** | |
| **G** to **X** | |
| **H** to **X** | |

**Question 3 continues on the next page**

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**3 (b)** **Figure 5** shows a cross-section through the cylinder of a compressor used to supply air at high pressure to an air tank. The air tank is not shown. The high-pressure air in the tank is used to release and apply the brakes on a lorry.

On the outward stroke of the piston, air is drawn into the cylinder at atmospheric pressure through the inlet valve. The outlet valve remains closed. On the inward stroke, the inlet valve closes and the increasing pressure in the cylinder causes the outlet valve to open, forcing air into the tank. A small clearance volume exists when the piston is at the end of its inward stroke. The crankshaft of the pump is driven by the lorry engine by a gear wheel which acts as a flywheel.

Air is pumped into the air tank until the pressure reaches $8.0 \times 10^5$ Pa.

**Figure 6** shows the idealised $p$–$V$ diagram for one cycle in the initial stages of pumping, when the pressure in the air tank has reached approximately $4.5 \times 10^5$ Pa.
The compressed air in the clearance volume at **C** must expand to point **D** before the inlet valve will open.

**3 (b) (i)** The temperature of the air in the cylinder at the start of compression (point **A** on **Figure 6**) is 310 K.
Determine the temperature of the air at the point when the outlet valve is about to open. This is at point **B** on **Figure 6**.

**[2 marks]**

temperature ..... K

**3 (b) (ii)** Determine the net work done **on** the air during the cycle shown in **Figure 6**.

**[3 marks]**

work done ..... J

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**Figure 5**

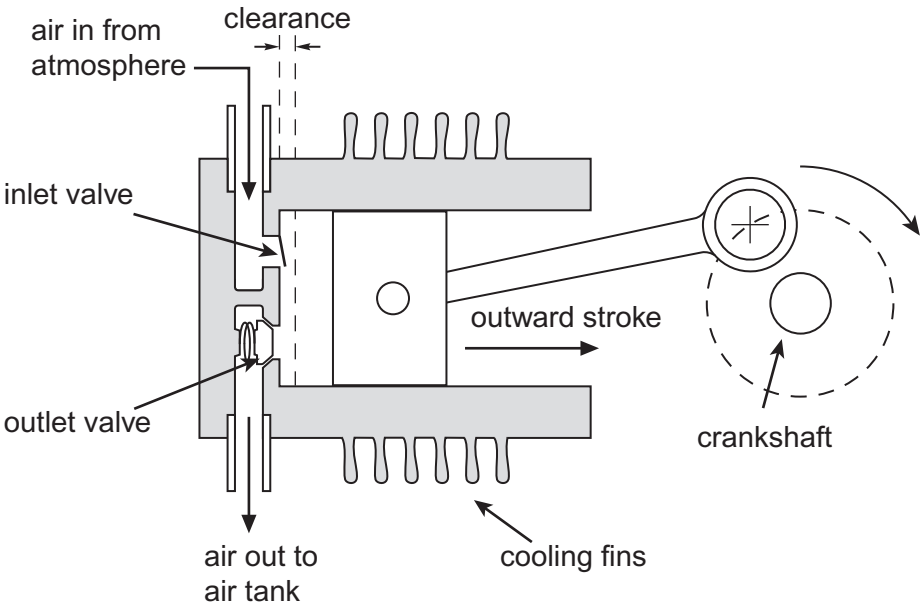
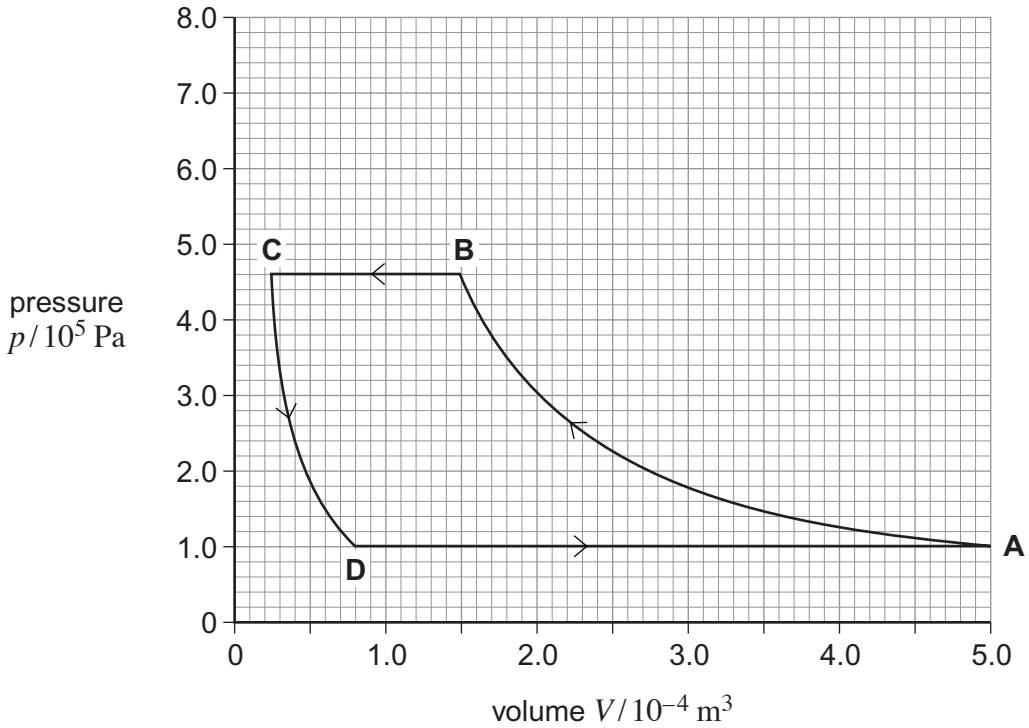



**Figure 6**




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**3 (b) (iii)** Determine the power input to the compressor when it runs at $420$ revolutions per minute.
**[1 mark]**

power ..... W

**3 (b) (iv)** Explain how the performance of the air compressor changes as the pressure in the tank **increases**. Calculations are not expected.

In your answer you should consider:

- how and why the $p-V$ diagram will change as the pressure in the tank increases
- how the temperature of the air in the cylinder changes
- the power input to the compressor, assuming it runs at constant speed
- the part played by the flywheel on the crankshaft.

The quality of your written communication will be assessed in your answer.
**[6 marks]**

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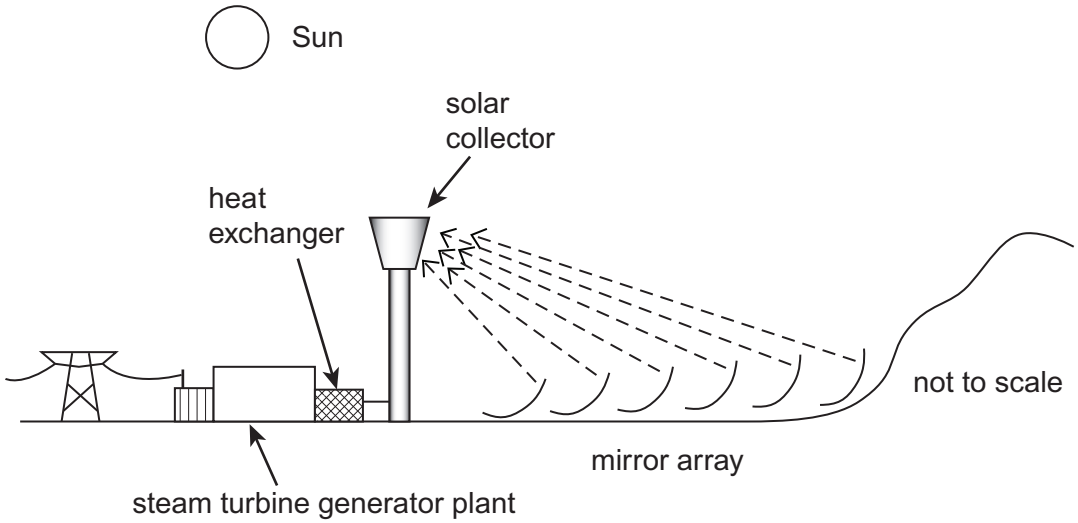
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**4** **Figure 7** shows the basic arrangement of a solar thermal power station. An array of mirrors tracks the Sun and reflects the Sun's rays onto a solar collector tower containing molten salt. The molten salt reaches a temperature of 540 °C. In the heat exchanger, the internal energy in the salt is transferred to water which turns to steam and drives a steam turbine generator to produce electricity. The steam turbine rejects energy to the atmosphere at 25 °C.

**Figure 7**




**4 (a)** Calculate the maximum theoretical efficiency of a heat engine operating between temperatures of 540 °C and 25 °C.

**[2 marks]**

maximum efficiency = .....

*Do not write outside the box*

**4 (b)** On one particular day the output of the power station is 48 MW. Calculate the input power to the power station assuming it can run at its maximum theoretical efficiency.

**[1 mark]**

input power = ..... W

**4 (c)** The actual efficiency of the steam turbine is about 38% when the molten salt is at 540 °C. State **two** reasons why the actual efficiency of the power station is much less than the maximum theoretical efficiency.

**[2 marks]**

1 .....

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**END OF QUESTIONS**

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