AQA

Please write clearly in block capitals.

Centre number	
Candidate number	
Surname	
Forename(s)	
Candidate signature	

A-level
PHYSICS

Paper 3
Section B Engineering physics

Monday 3 June 2019 Afternoon

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet.

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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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 paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

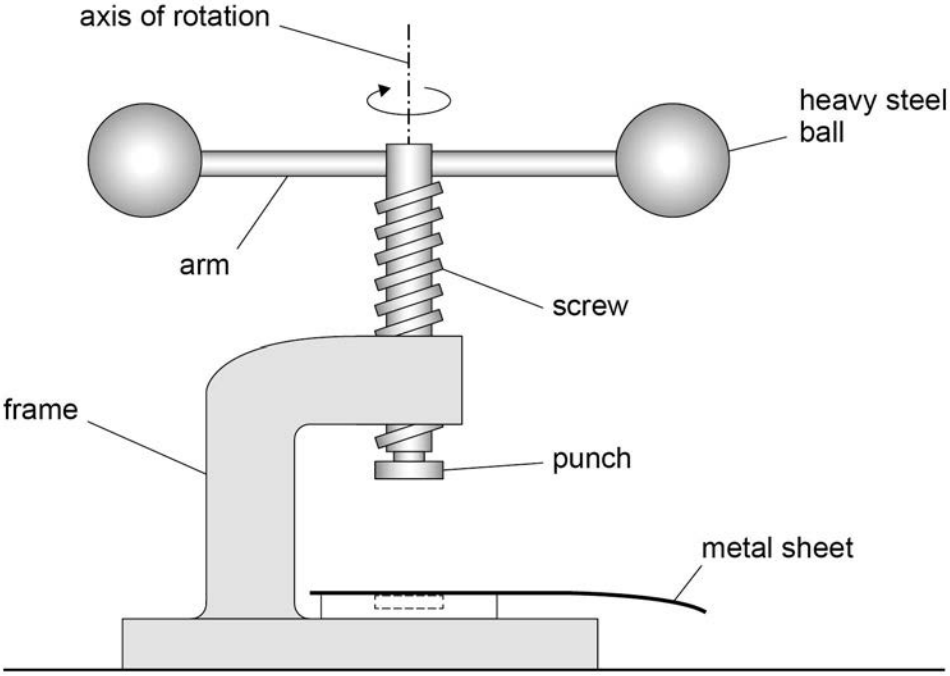
For Examiner's Use	
Question	Mark
1	
2	
3	
4	
TOTAL	

Section B

Answer **all** questions in this section.

0 1 The fly-press shown in **Figure 1** is used by a jeweller to punch shapes out of a thin metal sheet.

Figure 1



The frame holds a screw and punch. Two arms are attached to the screw, each loaded with a heavy steel ball. The screw is driven downwards when the arms are rotated.
Kinetic energy is stored in the rotating parts: the balls, arms, screw and punch. This energy is used to punch the shape out of the metal sheet.

0 1 . 1 When the punch reaches the metal sheet, the rotational speed of the arms is 2.9 rev s^{-1}. At this speed the rotational kinetic energy of the rotating parts is 10.3 J.

Calculate the moment of inertia of the rotating parts about the axis of rotation.

[2 marks]

moment of inertia = ____________________ kg m^2

Do not write outside the box

0 1 . 2 The total mass of the screw, punch and arms is the same as the total mass of the two balls.

Explain why the moment of inertia of the screw, punch and arms about the axis of rotation is **much** smaller than the moment of inertia of the steel balls about the same axis.

[2 marks]

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0 1 . 3 During the punching of the metal sheet, the rotating parts of the fly-press are brought uniformly to rest from an initial rotational speed of 2.9 rev s^{-1} in a time of 89 ms.

Determine

- the angular deceleration
- the angle turned through by the rotating parts.

[3 marks]

angular deceleration = ____________________ rad s^{-2}

angle = ____________________ rad

Question 1 continues on the next page

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0 1 . 4 For thicker or stiffer metal sheets the rotational kinetic energy at $2.9\ \text{rev s}^{-1}$ is not enough to punch out the shape.

The distance from the axis of rotation to the centre of each ball is y.
The radius of each ball is R.

The stored energy can be increased by

either
- increasing y by 15% without changing R

or
- increasing R by 15% without changing y.

Deduce which of these would produce the greater increase in stored energy.

[3 marks]

Do not write outside the box

0 1 . 5 Which of the following is the SI unit for angular impulse?
Tick (✓) **one** box.

[1 mark]

N m s^{-1} ☐

N s ☐

N m s ☐

kg m^2 s^{-2} ☐

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Turn over for the next question

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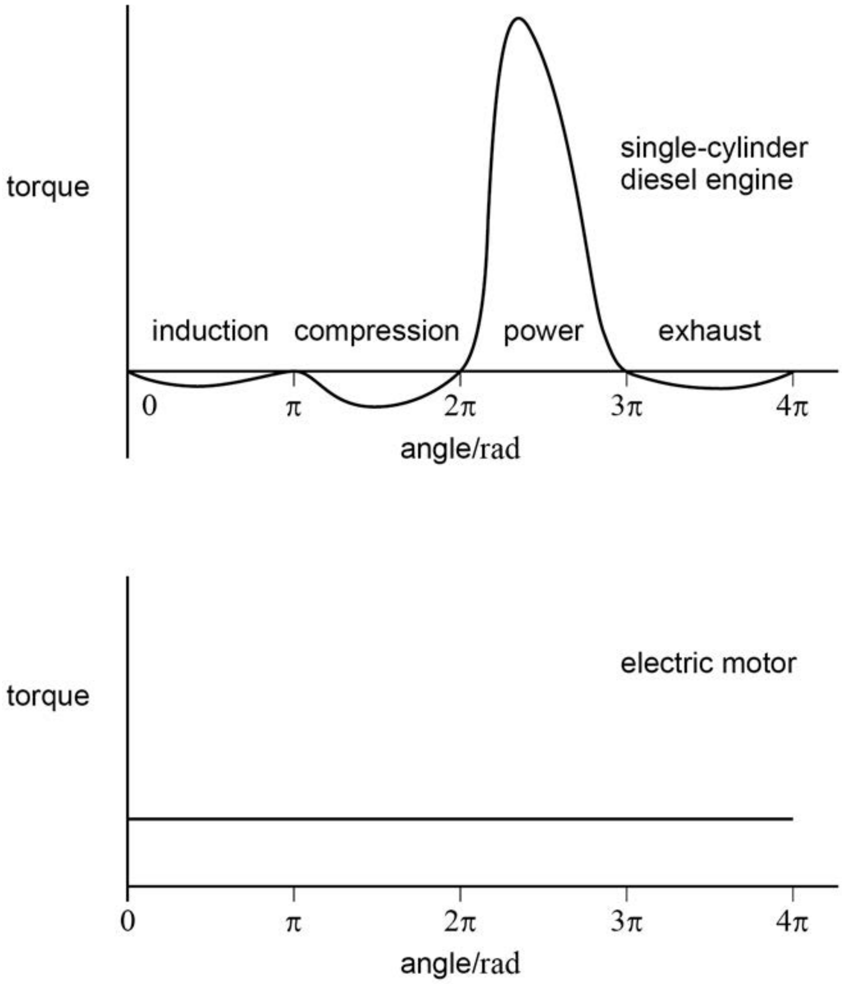
0 2 A turning moment diagram is a graph showing the variation of torque produced by an engine or motor with the angle of rotation of the output shaft.

Figure 2 shows the turning moment diagrams for a single-cylinder diesel engine and an electric motor that have the same output power.

Figure 2



0 2 . 1 State what is represented by the area between the curve and the angle axis for a turning moment diagram.

[1 mark]

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0 2 . 2 The diesel engine or the electric motor may be used to drive a machine that has a low moment of inertia and that requires an almost constant torque.

Discuss why, to drive this machine, the diesel engine would need to be fitted with a flywheel.

In your answer you should explain

- why the electric motor does **not** require a flywheel
- why the torque of the diesel engine varies over one cycle, including why there are points where the torque is zero
- how the moment of inertia of the flywheel influences the motion of the output shaft of the diesel engine.

[6 marks]

Question 2 continues on the next page

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0 3 In an ideal heat-engine cycle a fixed mass of air is taken through the following four processes.

A → **B** isothermal compression from an initial pressure of 1.0×10^5 Pa and a volume of 9.0×10^{-2} m^3 to a pressure of 2.2×10^5 Pa. The work done on the air is 7100 J.

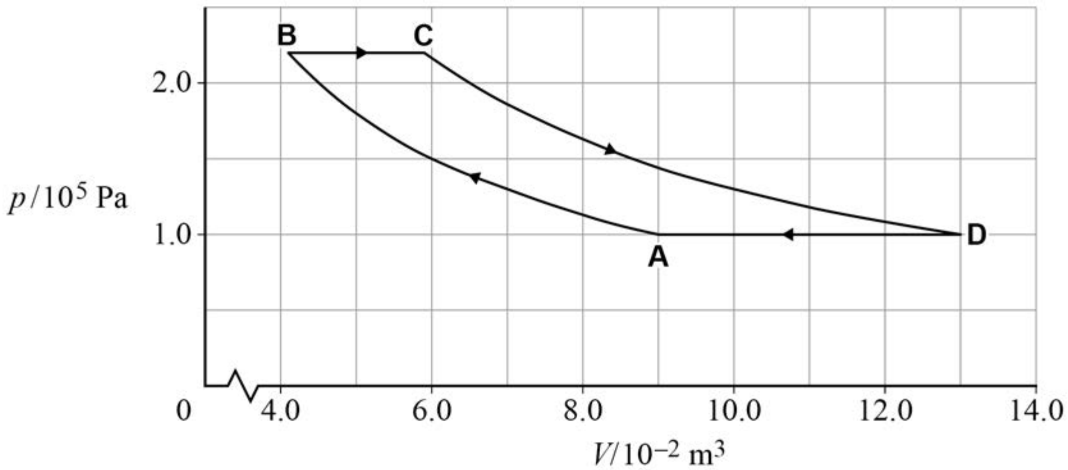
B → **C** increase in volume at constant pressure to a volume of 5.9×10^{-2} m^3.

C → **D** isothermal expansion to a pressure of 1.0×10^5 Pa and a volume of 13×10^{-2} m^3. The work done by the air is 10 300 J.

D → **A** reduction in volume at constant pressure to the original volume.

Figure 3 shows the cycle.

Figure 3



0 3 . 1 Show, by calculation, that the volume at **B** is 4.1×10^{-2} m^3.

[1 mark]

0 3 . 2 The temperature of the air between **A** and **B** is 295 K.

Show that the temperature of the air at **C** is about 420 K.

[2 marks]

0 3 . 3 An ideal engine based on this cycle uses a device called an economiser. The economiser stores **all** the energy transferred in the cooling process **D** → **A** and gives up **all** this energy to the air in process **B** → **C**.
This means that an external source supplies energy to the air by heating only in process **C** → **D**.

Complete **Table 1** to show the values of work done W and energy transfer Q in each of the four processes.
Use the space below **Table 1** for any calculations.
Use a consistent sign convention.

[2 marks]

Table 1

Process	Work done W / J	Energy transfer Q / J
A → **B**	−7100	−7100
B → **C**	4000	
C → **D**	10 300	10 300
D → **A**		−14 000

Question 3 continues on the next page

0 3 . 4 Explain why W is equal to Q in process **A** → **B** and in process **C** → **D**.

[2 marks]

0 3 . 5 It is claimed that the efficiency of this engine cycle is the same as the maximum theoretical efficiency of a heat engine operating between the same temperatures.

Deduce whether this claim is true.

[3 marks]

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0 3 . 6 Discuss **one** problem that would be faced by an engineer designing a real engine based on this cycle.

[2 marks]

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0 4 Tumble-dryers blow hot air over wet clothes that are moving in a rotating drum. Conventional tumble-dryers heat the air in the drum electrically; other dryers use a heat pump to heat the air.

0 4 . 1 A typical conventional tumble-dryer uses about 0.6 kW h per kg of clothes. A heat pump tumble-dryer uses about 0.25 kW h per kg.

Explain why the heat pump tumble-dryer uses less electrical energy than the conventional tumble-dryer to dry the same load.

[2 marks]

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0 4 . 2 The cold space of the heat pump is the room in which the tumble-dryer is placed. The hot space is the air in the tumble-dryer and is at a temperature of 160 °C.

A heat pump tumble-dryer can be placed in a kitchen at a temperature of 20 °C, or in a garage at around 5 °C.

Deduce which place would result in lower running costs for the tumble-dryer. Support your answer with calculations.

[3 marks]

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END OF QUESTIONS

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