Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level PHYSICS

Paper 3
Section B Engineering physics

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
- a protractor.

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	

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ANSWER IN THE SPACES PROVIDED

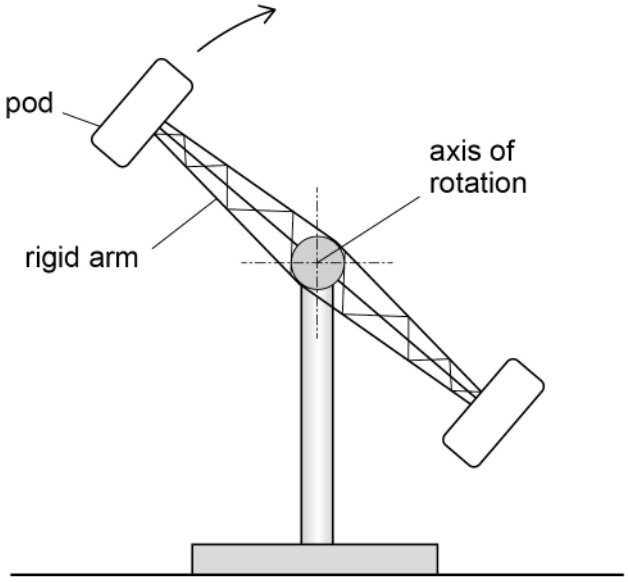
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Section B

Answer **all** questions in this section.

0 1 **Figure 1** shows a fairground ride.

Figure 1



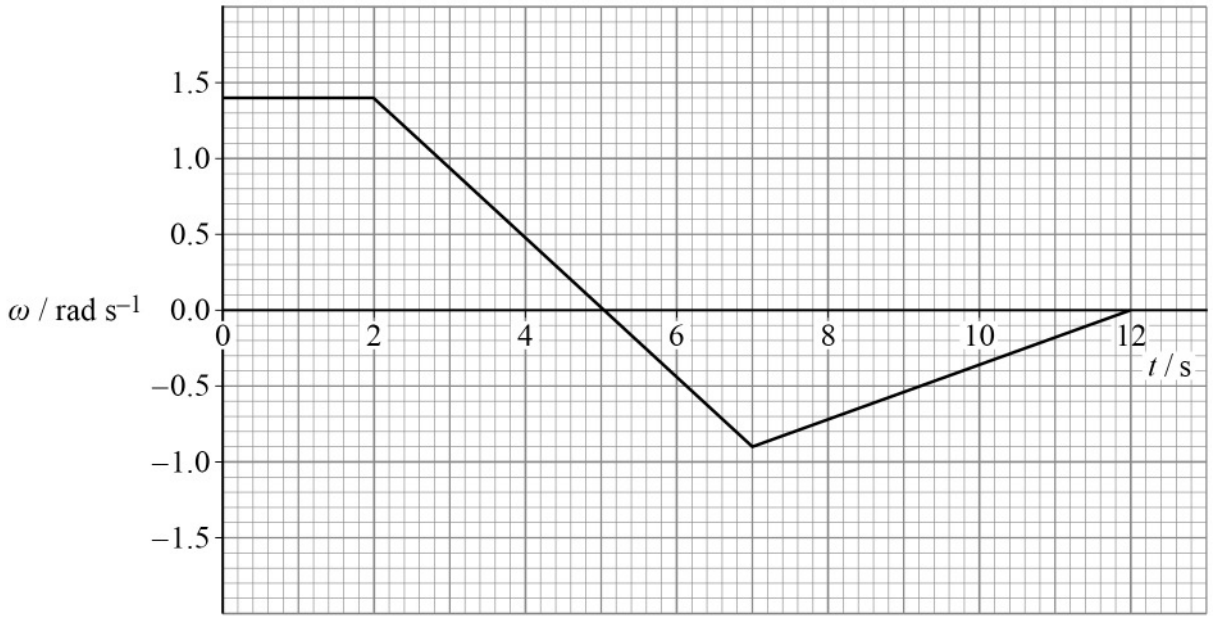
The ride consists of a rotor that rotates in a vertical circle about a horizontal axis.
The rotor has two rigid arms. A pod containing passengers is attached to each arm.
The rotor is perfectly balanced.
The direction of rotation of the rotor is reversed at times during the ride.

Question 1 continues on the next page

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Figure 2 shows the variation of the angular velocity ω of the rotor with time t during a 12 s period.

Figure 2



0 1 . 1 Determine the mean angular velocity of the rotor during the 12 s period.

[2 marks]

mean angular velocity = _____ rad s^{-1}

Do not write outside the box

The moment of inertia of the rotor about its axis of rotation is 2.1×10^4 kg m^2.
A constant frictional torque of 390 N m acts at the bearings of the rotor.

0 1 . 2 Calculate the power output of the driving mechanism during the first 2 s shown in **Figure 2**.

[1 mark]

power output = _____ W

0 1 . 3 Calculate the maximum torque applied by the driving mechanism to the rotor during the 12 s period.

[3 marks]

maximum torque = _____ N m

0 1 . 4 Calculate the magnitude of the angular impulse on the rotor between $t = 2.0$ s and $t = 7.0$ s.

[1 mark]

angular impulse = _____ N m s

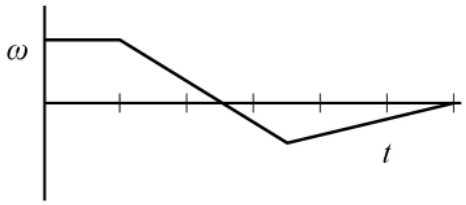
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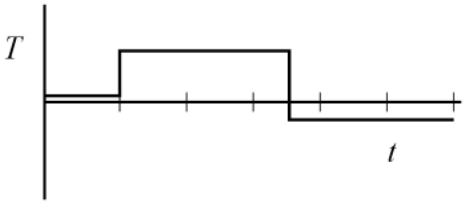
0 1 . 5 Which graph best shows the variation of the torque T applied to the rotor for the 12 s period?
Tick (✓) **one** box.

A copy of **Figure 2** is provided to help you.

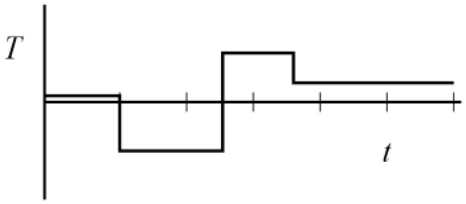
[1 mark]



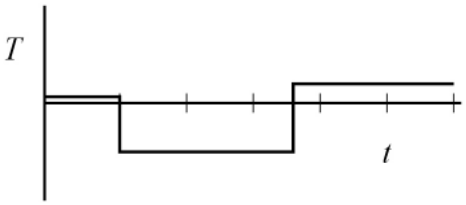
copy of **Figure 2**



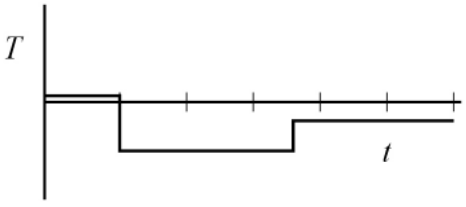
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0 2 A moving tram is powered by energy stored in a rapidly spinning flywheel.

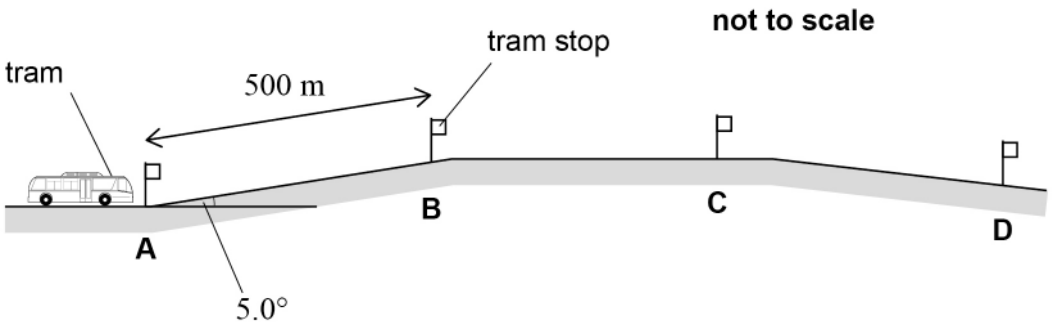
When the tram is at a tram stop, the flywheel is 'charged' by being accelerated to a high rotational speed.

The mass of the tram, flywheel and passengers is 1.46×10^4 kg.

The distance between tram stops is 500 m.

Figure 3 shows that between stops **A** and **B** the track is inclined at a constant 5.0° to the horizontal.

Figure 3



The tram must travel 500 m along this incline on one charge of energy.

The total resistive force on the tram due to its motion is constant at 1.18 kN.

The flywheel is a solid steel disc of diameter 1.00 m. It has a moment of inertia of 62.5 kg m^2.

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0 2 . 1 Calculate the minimum angular speed of the flywheel when the tram leaves stop **A** so that the tram reaches stop **B** using only energy stored in the flywheel.

[3 marks]

minimum angular speed = _____ rad s^{-1}

0 2 . 2 Between stops **C** and **D** the tram travels downhill.

Suggest **two** advantages of keeping the flywheel connected to the driving wheels when the tram travels downhill.

[2 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

Question 2 continues on the next page

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0 2 . 3 The same tram is to be used on a track where the stops are further apart, so the flywheel system needs to be modified.

Discuss the design features of the flywheel that will enable it to store more energy without increasing the mass of the tram.

In your answer you should consider:

- the design of the flywheel
- how the choice of materials used to make the flywheel is influenced by its design and maximum angular speed
- other design aspects that allow for high angular speeds of the flywheel.

[6 marks]

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11

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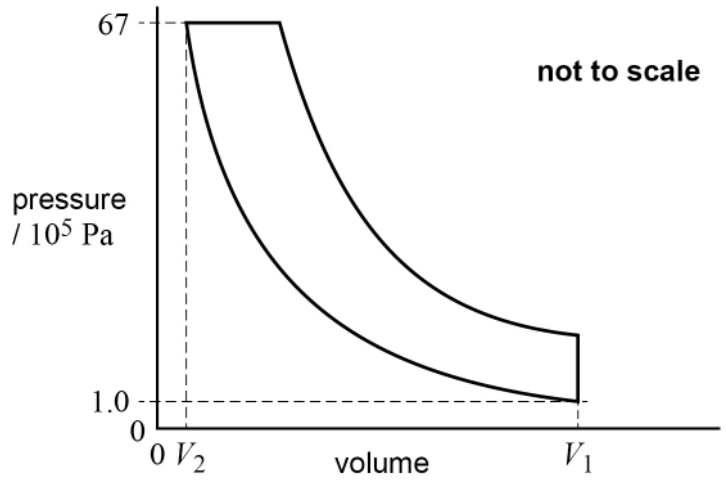
0 3 . 1 Explain what is meant by an adiabatic change.

[1 mark]

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0 3 . 2 **Figure 4** shows the p–V diagram for an ideal diesel engine cycle.

Figure 4



In this cycle, air is compressed adiabatically from a pressure of 1.0×10^5 Pa and volume V_1 to a pressure of 67×10^5 Pa and volume V_2.
The adiabatic index γ for air = 1.4

Calculate the compression ratio $\frac{V_1}{V_2}$.

[2 marks]

compression ratio = _____

Question 3 continues on the next page

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0 3 . 3 Explain why the compression ratio for a diesel engine must be greater than the compression ratio for a petrol engine.

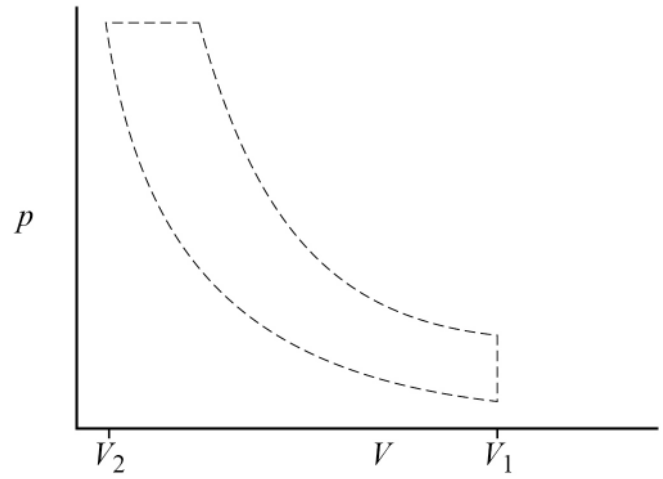
[2 marks]

The dashed lines in **Figure 5** show the p–V diagram for the ideal diesel engine cycle.

0 3 . 4 Draw, on **Figure 5**, a typical indicator diagram for a real four-stroke diesel engine with the same values of V_1 and V_2.

[2 marks]

Figure 5



0 3 . 5 Mark with an **X** on your diagram the point where the injection of fuel starts.

[1 mark]

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0 3 . 6 Explain **two** differences between the ideal cycle and the indicator diagram for the real engine.

[2 marks]

1 _____

_____

_____

_____

2 _____

_____

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_____

10

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0 4 **Figure 6** shows a low-voltage solid-state thermoelectric cooling element. The element is a square of side 40 mm and is 4 mm thick.

Figure 6

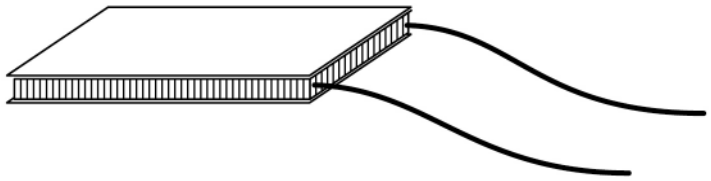
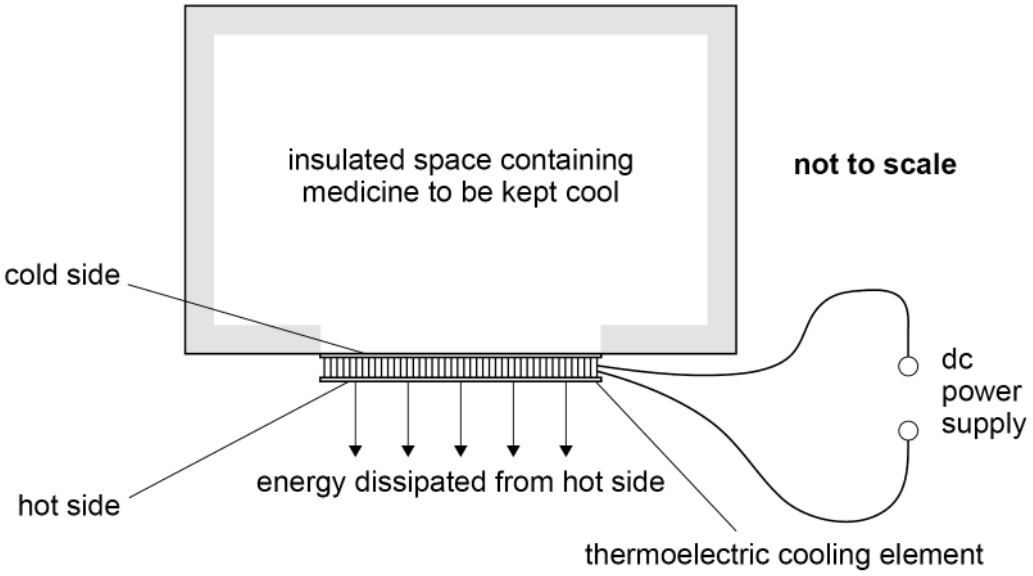


Figure 7 shows how the element is used as part of a thermoelectric refrigerator to keep small quantities of medicine at a low temperature.

Figure 7



The manufacturer's data for the element show that when the temperature of the hot side is 35 °C and the temperature of the cold side is 5 °C:

- the rate at which energy is dissipated from the hot side is 65 W
- the electrical power supplied is 28 W.

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0 4 . 1 It is claimed that the coefficient of performance (COP) of a thermoelectric refrigerator is much less than the COP of an ideal refrigerator.

Discuss whether the claim is valid for the thermoelectric refrigerator in this question.

[4 marks]

0 4 . 2 Suggest why a small value of the COP might be acceptable for this particular application of a thermoelectric cooling element.

[2 marks]

6

END OF QUESTIONS

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