

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	

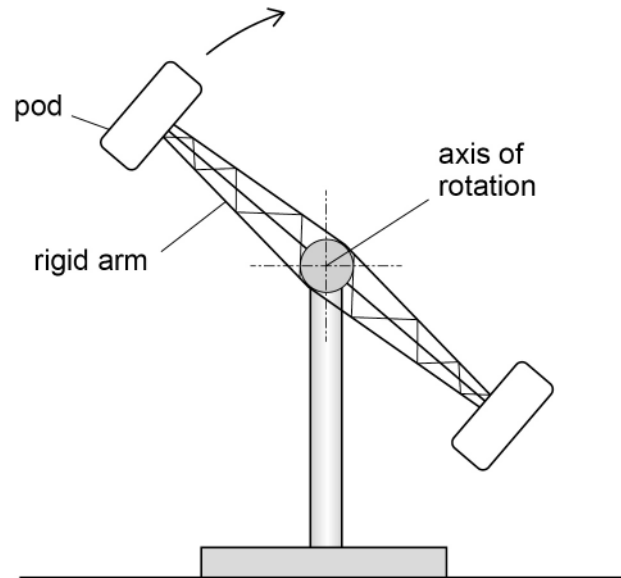


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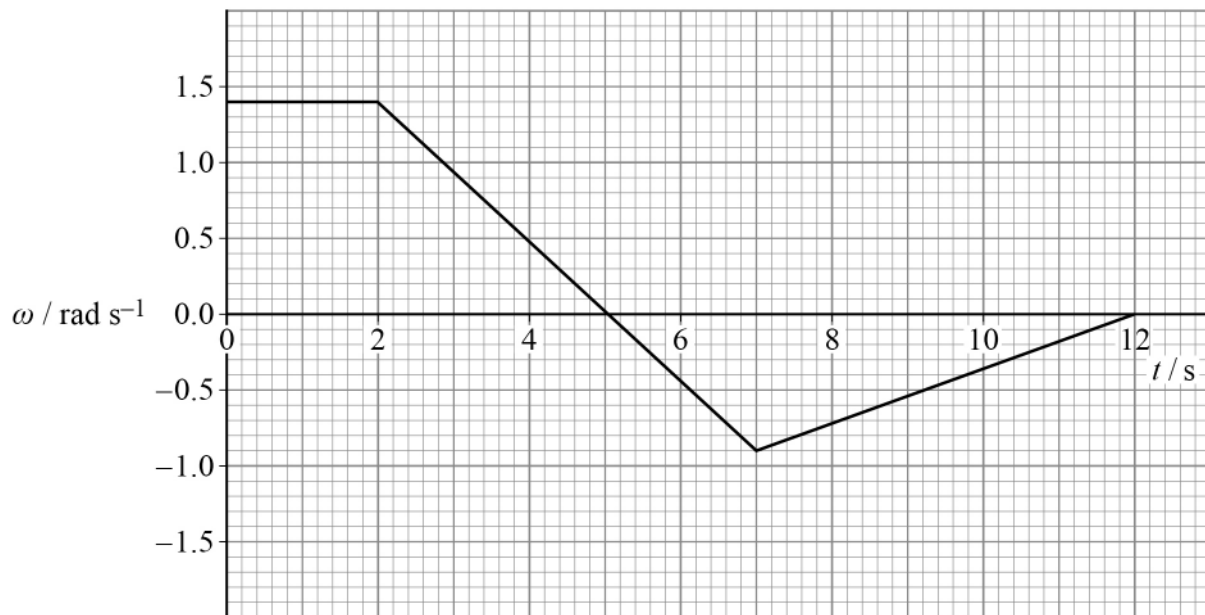
Section BAnswer **all** questions in this section.**0 1****Figure 1** shows a fairground ride.**Figure 1**

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**Turn over ►**

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



The moment of inertia of the rotor about its axis of rotation is $2.1 \times 10^4 \text{ kg m}^2$.
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 $t = 2.0 \text{ s}$ and $t = 7.0 \text{ s}$.

[1 mark]

angular impulse = _____ N m s

Question 1 continues on the next page

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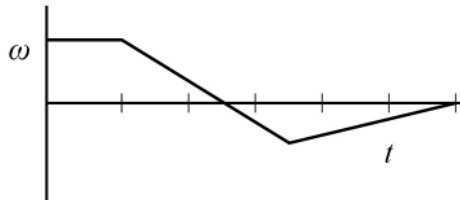
0 1 . 5

Which graph best shows the variation of the torque T applied to the rotor for the 12 s period?

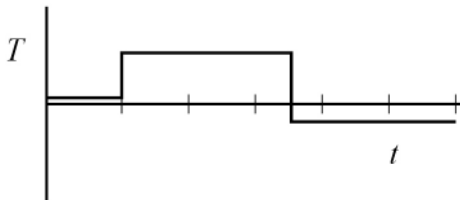
Tick (✓) **one** box.

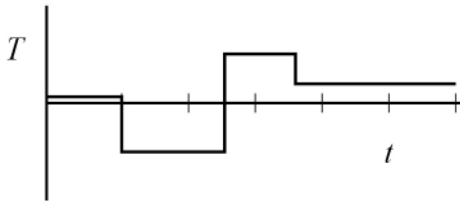
A copy of **Figure 2** is provided to help you.

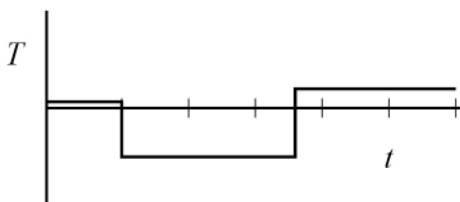
[1 mark]

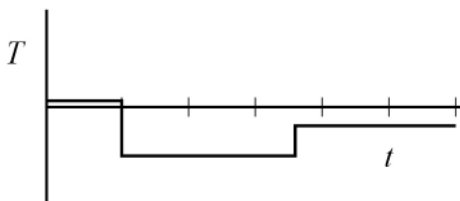


copy of **Figure 2**









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0 2

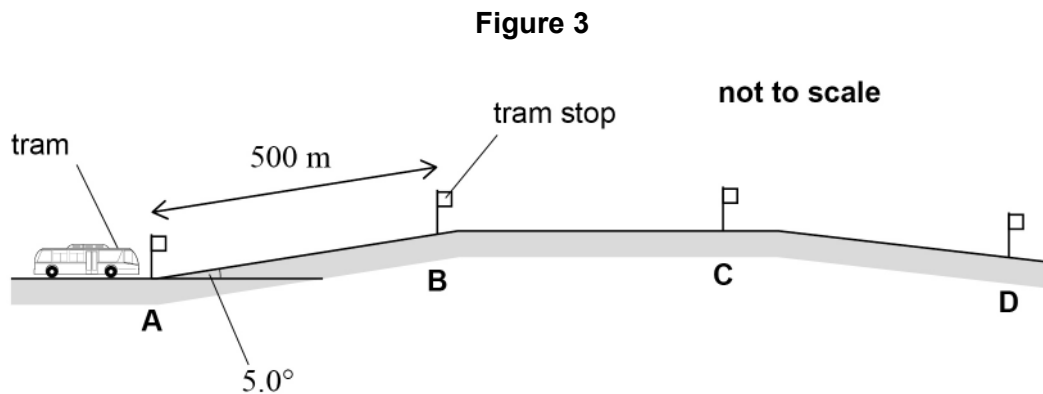
A moving tram is powered by energy stored in a rapidly spinning flywheel.

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.



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 .



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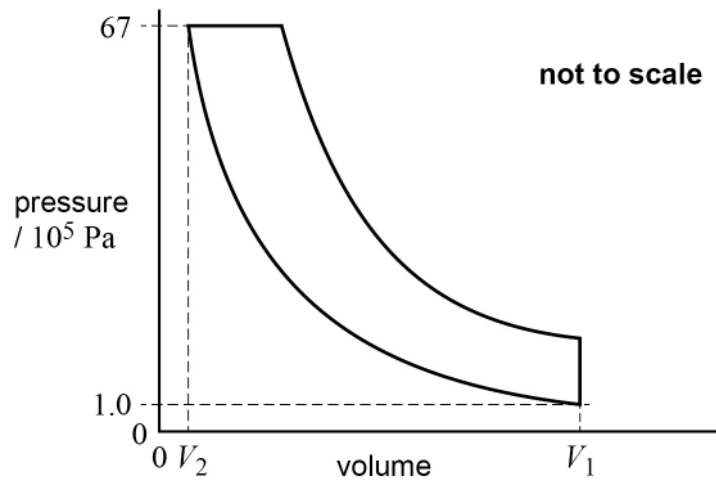
0 3 . 1 Explain what is meant by an adiabatic change.

[1 mark]



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 = _____

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Turn over ►



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]

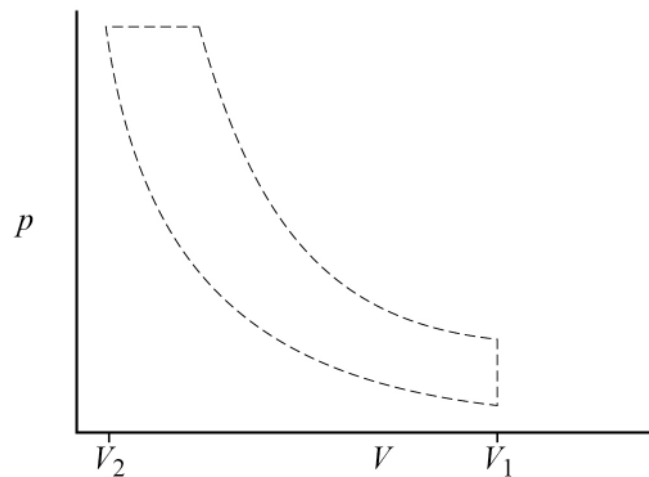
The dashed lines in **Figure 5** show the p - V diagram for the ideal diesel engine cycle.

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 _____

10

Turn over for the next question

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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.

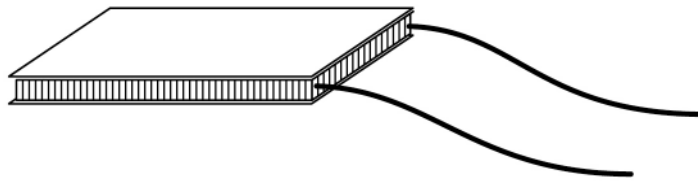
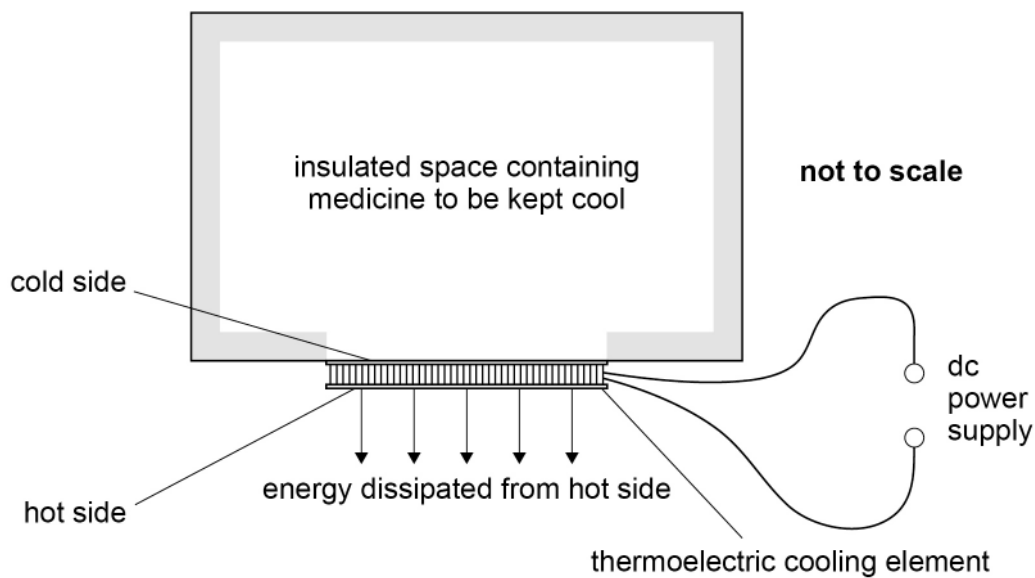
Figure 6

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 $35\text{ }^{\circ}\text{C}$ and the temperature of the cold side is $5\text{ }^{\circ}\text{C}$:

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



0	4	.	1
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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
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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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