



Please write clearly in block capitals.

Centre number

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Candidate number

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Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level PHYSICS

Paper 3 Section B Engineering physics

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.

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.

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



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ANSWER IN THE SPACES PROVIDED**



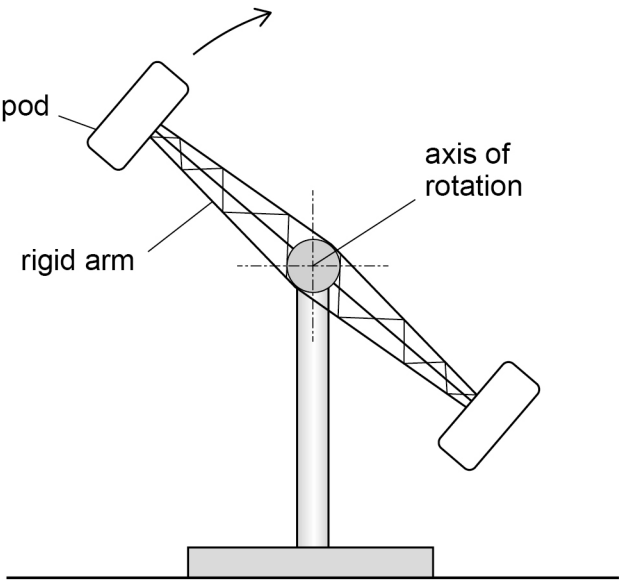
Section B

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.

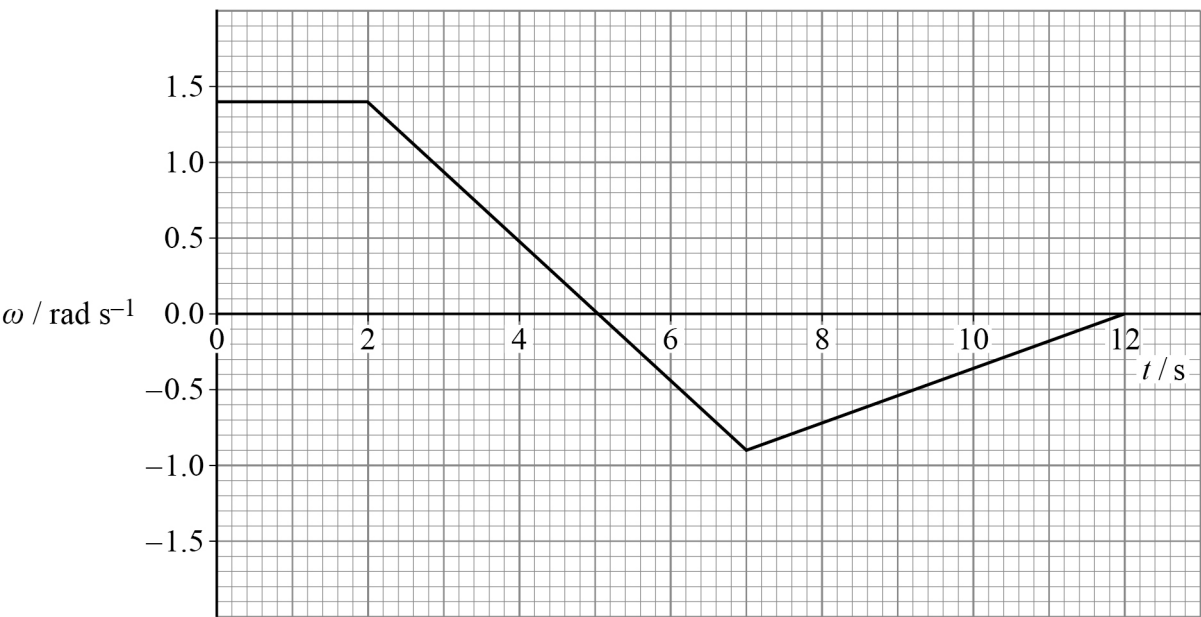
Question 1 continues on the next page

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
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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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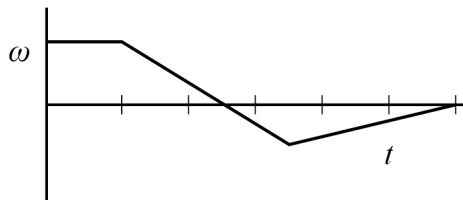


0 1 . 5

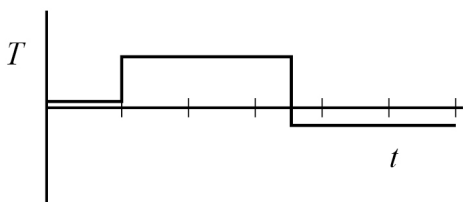
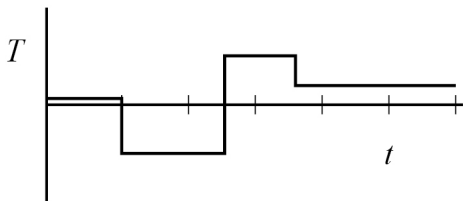
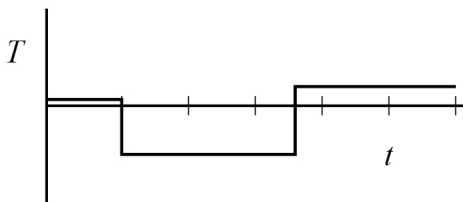
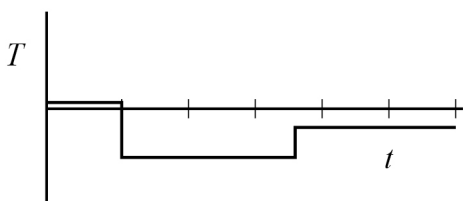
Which graph best shows the variation of the torque T applied to the rotor for the 12 s period?
Tick (✓) **one** box.

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

[1 mark]



copy of **Figure 2**

☐☐☐☐

8



Turn over for the next question

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0 2

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

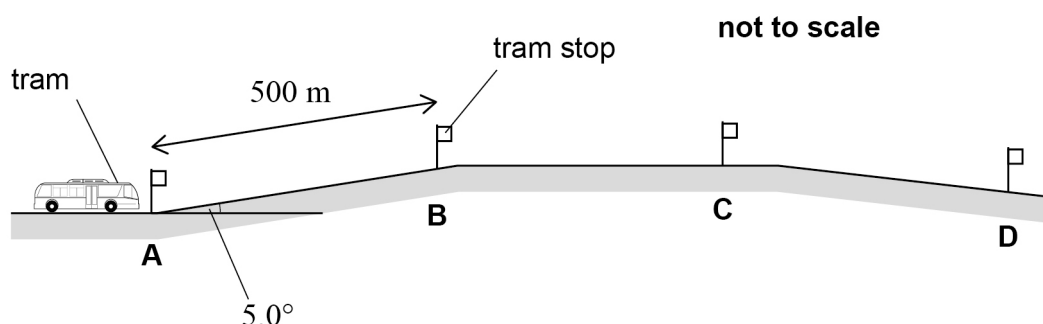
When the tram is at a tram stop, the flywheel is 'charged' by being accelerated to a high rotational speed.

The mass of the tram, flywheel and passengers is $1.46 \times 10^4 \text{ kg}$.

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 _____

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03.1

Explain what is meant by an adiabatic change.

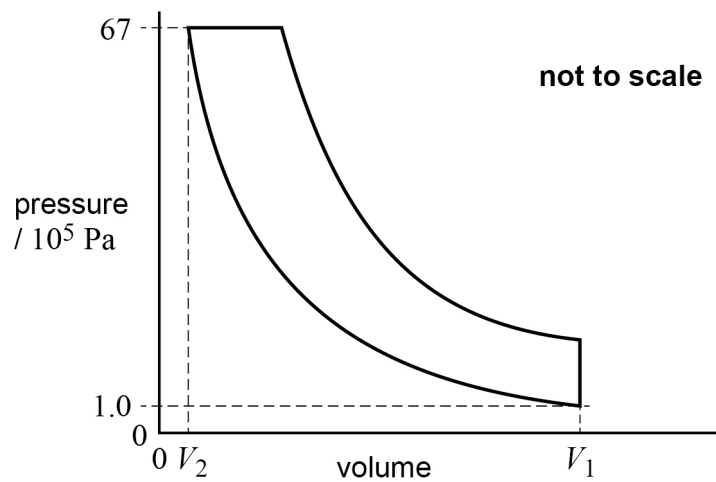
[1 mark]



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 = _____

Question 3 continues on the next page

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03.3

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

[2 marks]

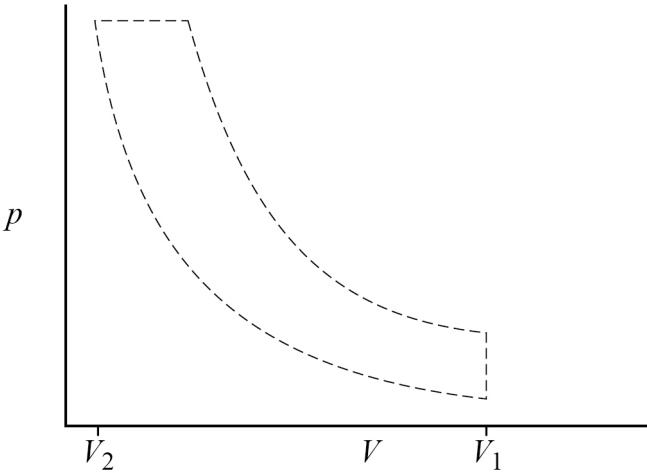
The dashed lines in **Figure 5** show the p - V diagram for the ideal diesel engine cycle.

03.4

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



03.5

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

[1 mark]



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03.6

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

[2 marks]

1

2

10

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Turn over ►



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

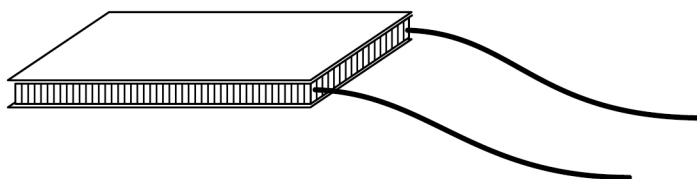
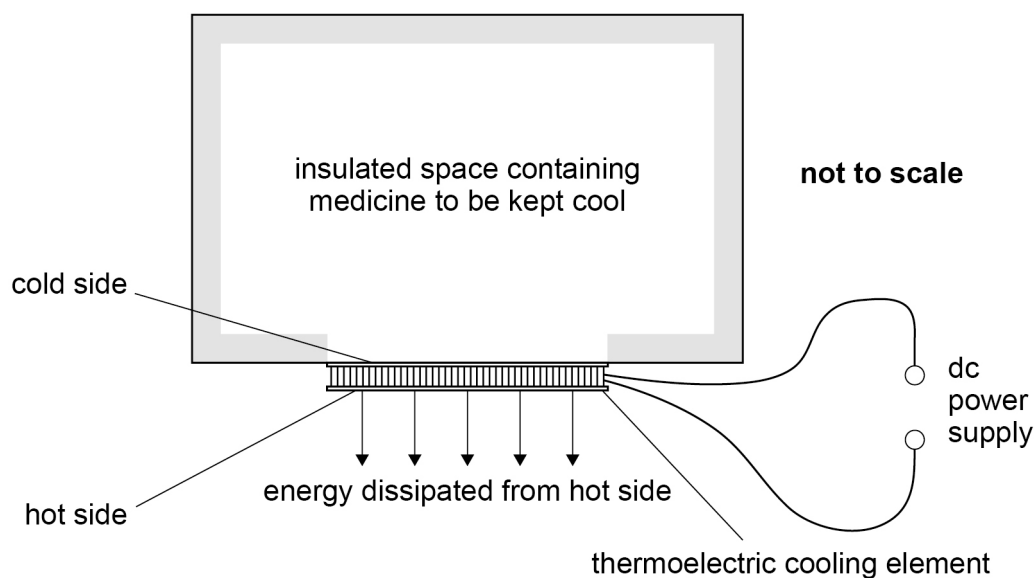


Figure 7 shows how the element is used as part of a thermoelectric refrigerator to keep small quantities of medicine at a low temperature.

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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