A

Surname ____________________

Other Names ____________________

Centre Number ____________________

Candidate Number ____________________

Candidate Signature ____________________

I declare this is my own work.

A-level

PHYSICS

Paper 3

Section B Engineering physics

7408/3BC

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

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 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.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write 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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

SECTION B

Answer ALL questions in this section.

0 1

FIGURE 1, on page 6, shows a fairground ride.

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.

FIGURE 2, on page 7, shows the variation of the angular velocity ω of the rotor with time t during a 12 s period.

[Turn over]

FIGURE 1

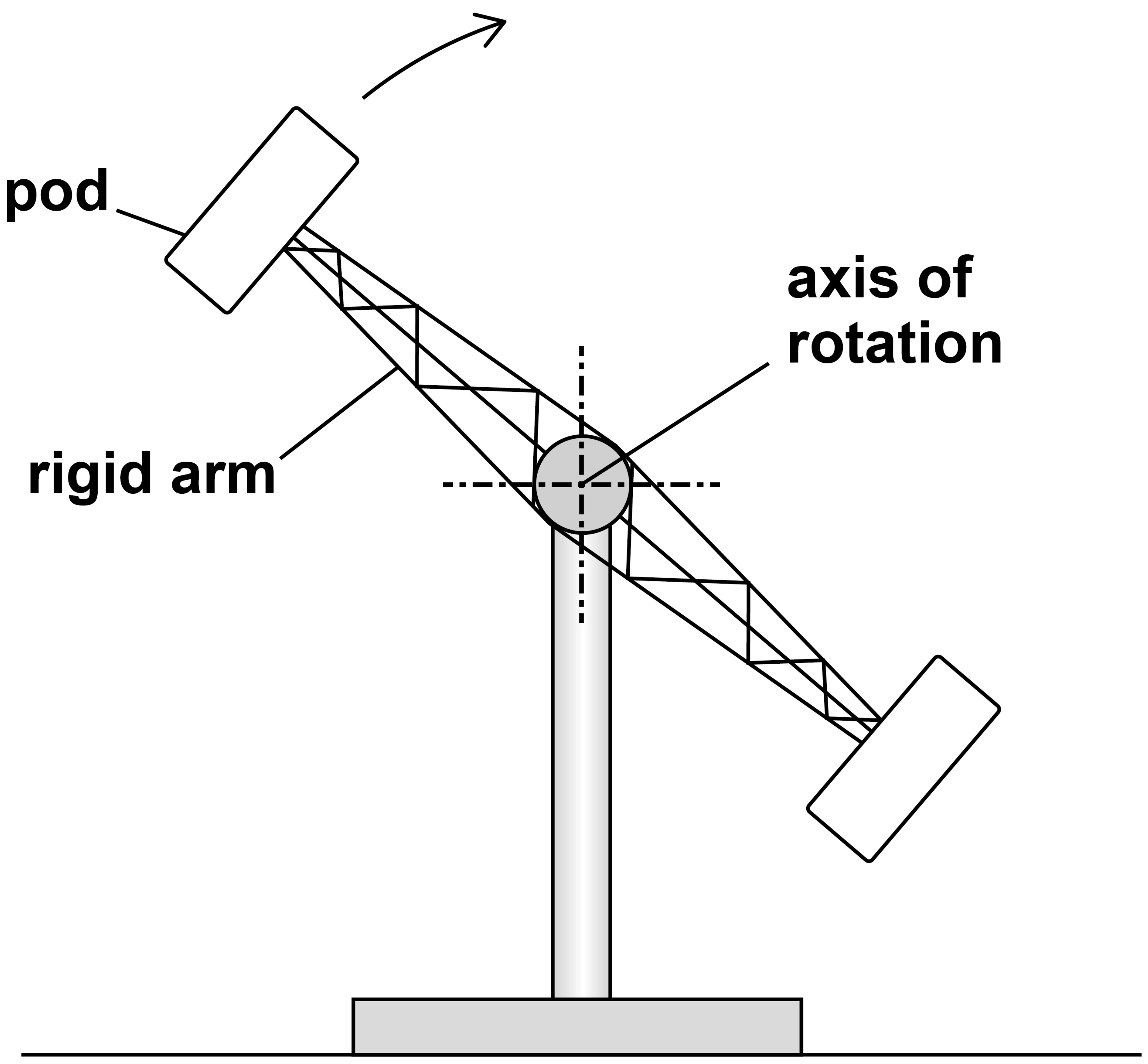
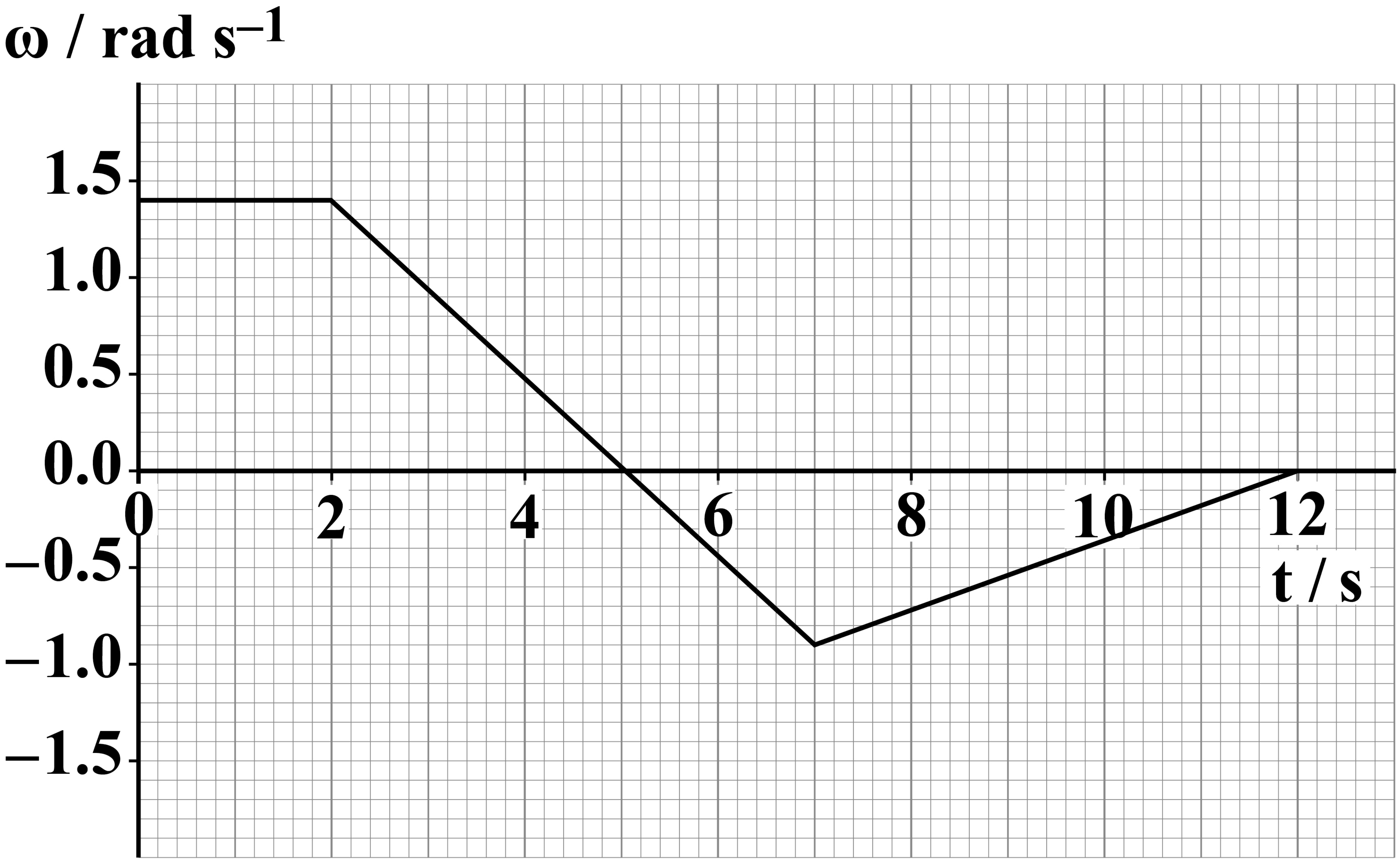


FIGURE 2



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0 1 . 1

Determine the mean angular velocity of the rotor during the 12 s period. [2 marks]

mean angular velocity = ____________________ $\mathrm{rad\ s^{-1}}$

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, on page 7. [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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[Turn over]

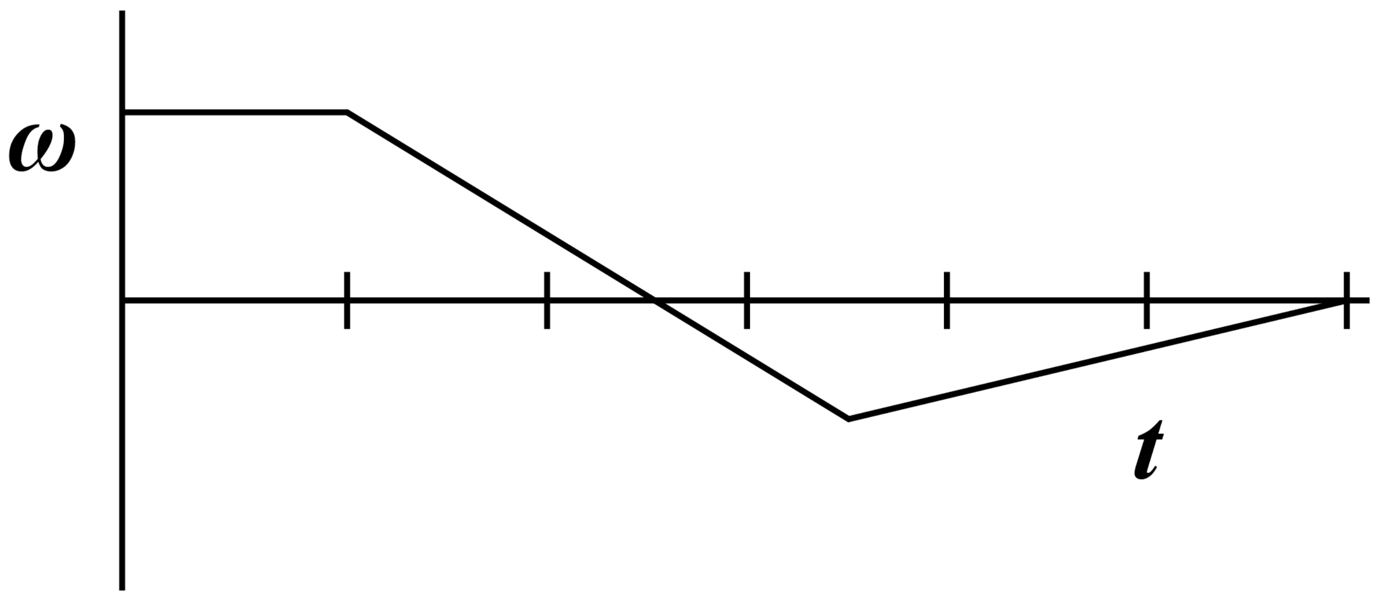
0 1 . 5

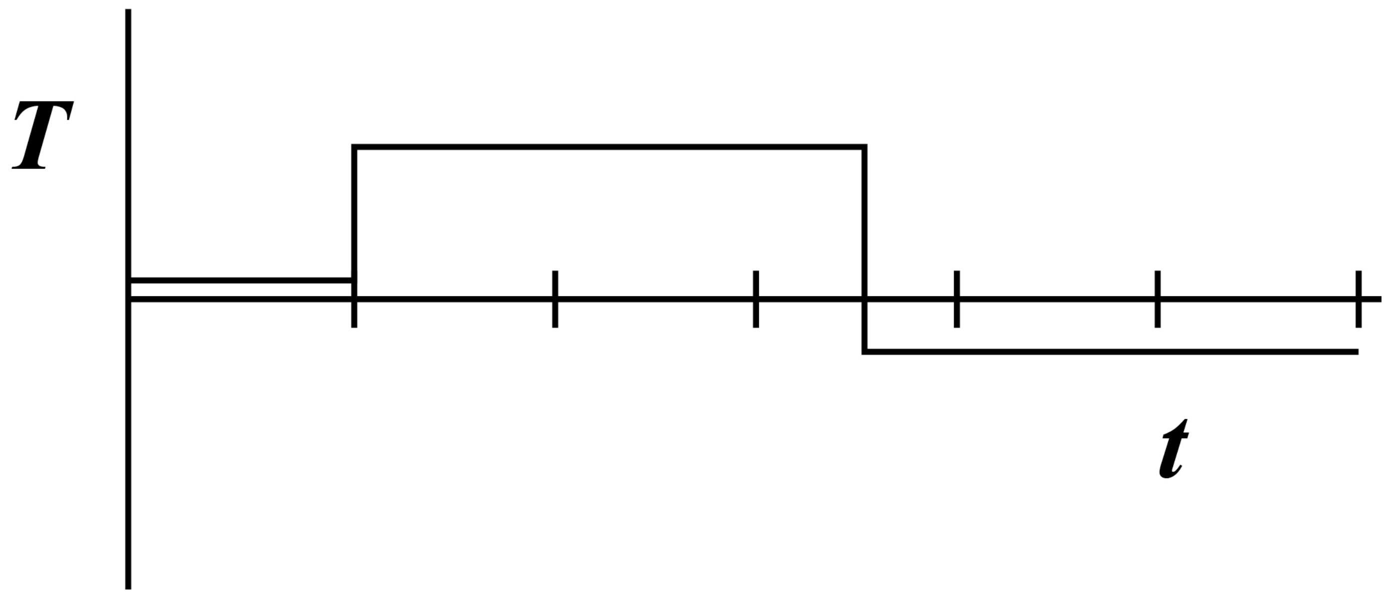
Which graph best shows the variation of the torque T applied to the rotor for the $12\ \mathrm{s}$ period?

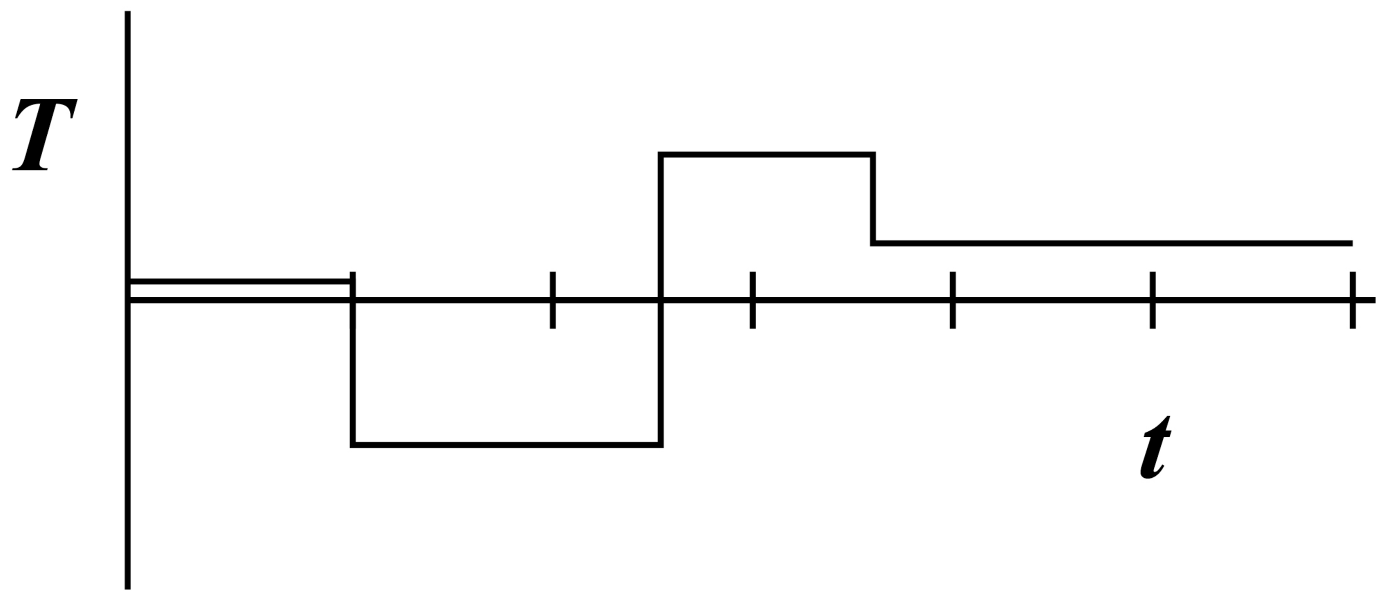
Tick (✓) ONE box, on pages 15 and 16.

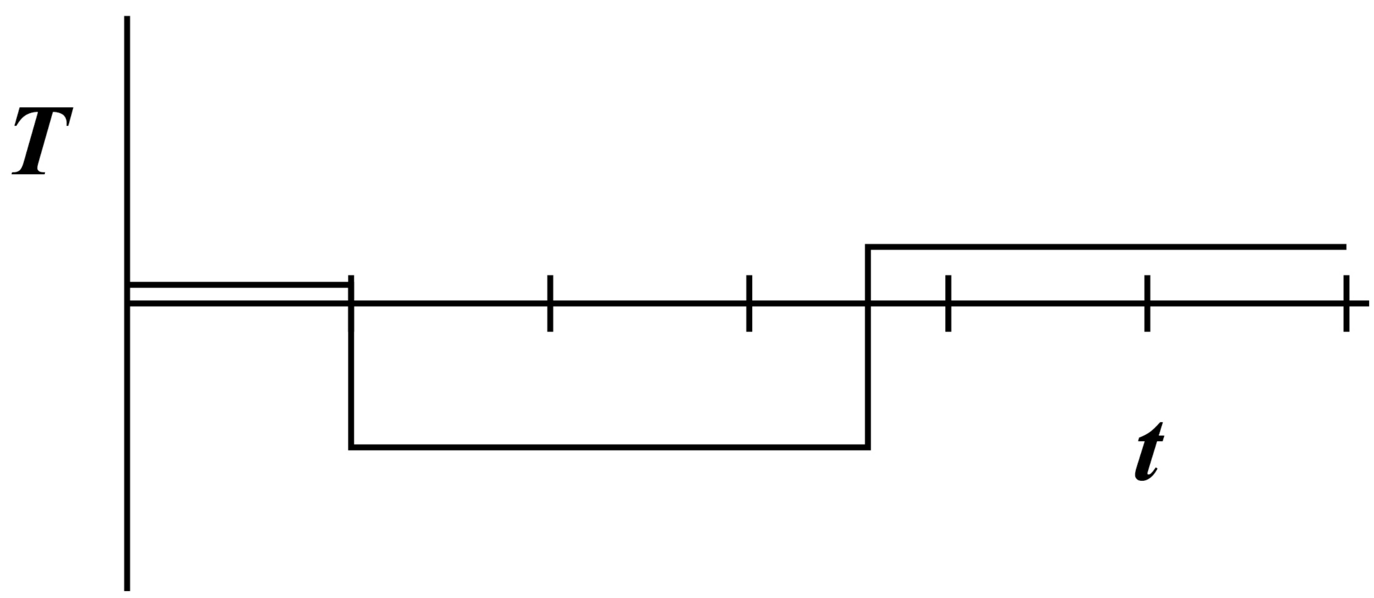
A copy of FIGURE 2 is provided to help you. [1 mark]

copy of FIGURE 2









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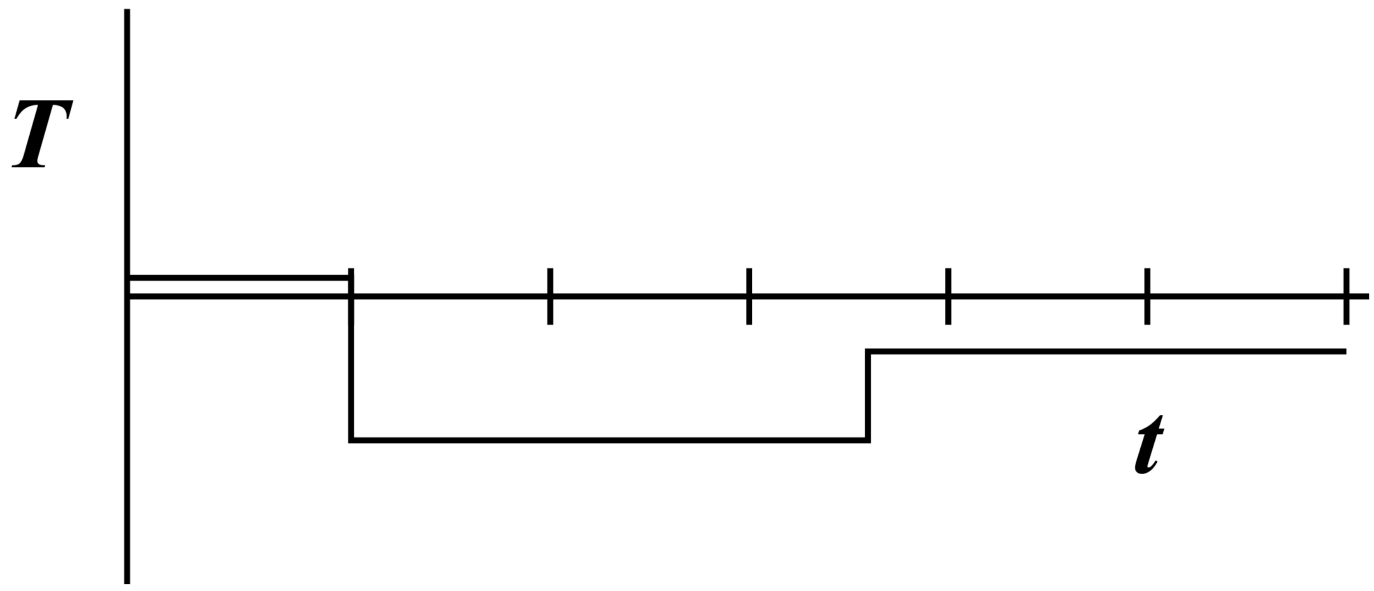

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[Turn over]

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.

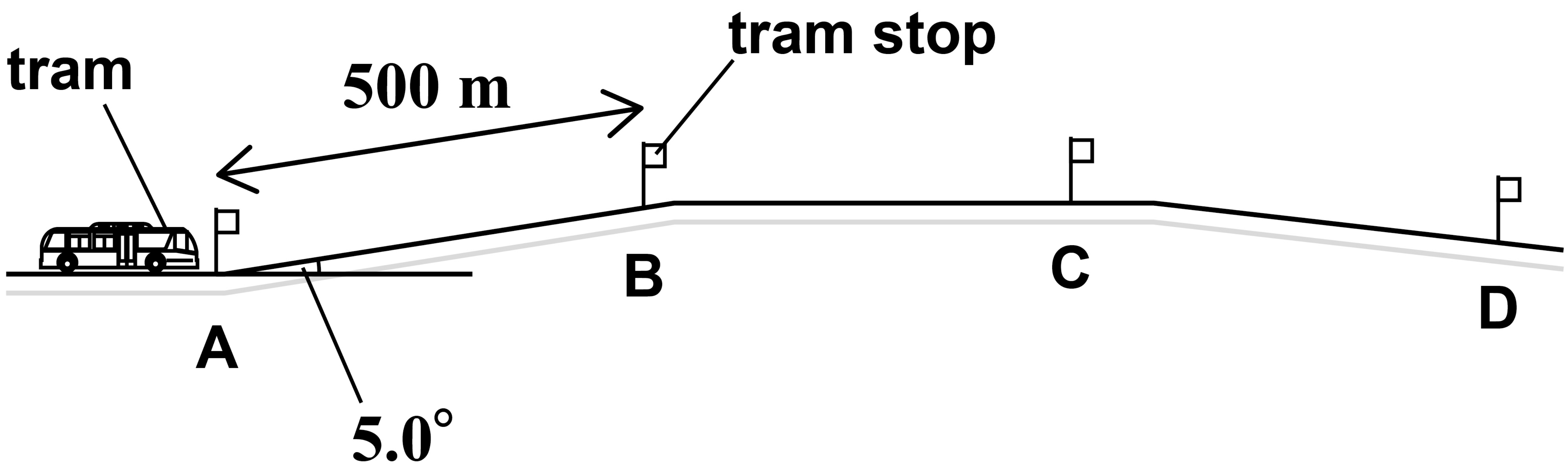
The mass of the tram, flywheel and passengers is 1.46×10^4 kg.

The distance between tram stops is 500 m.

FIGURE 3, on the opposite page, shows that between stops A and B the track is inclined at a constant 5.0° to the horizontal.

FIGURE 3

The diagram is not drawn accurately.



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

[Turn over]

The total resistive force on the tram due to its motion is constant at $1.18\ \mathrm{kN}$.

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

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]

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2 ______________________________

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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]

[Turn over]

11

03.1

Explain what is meant by an adiabatic change. [1 mark]

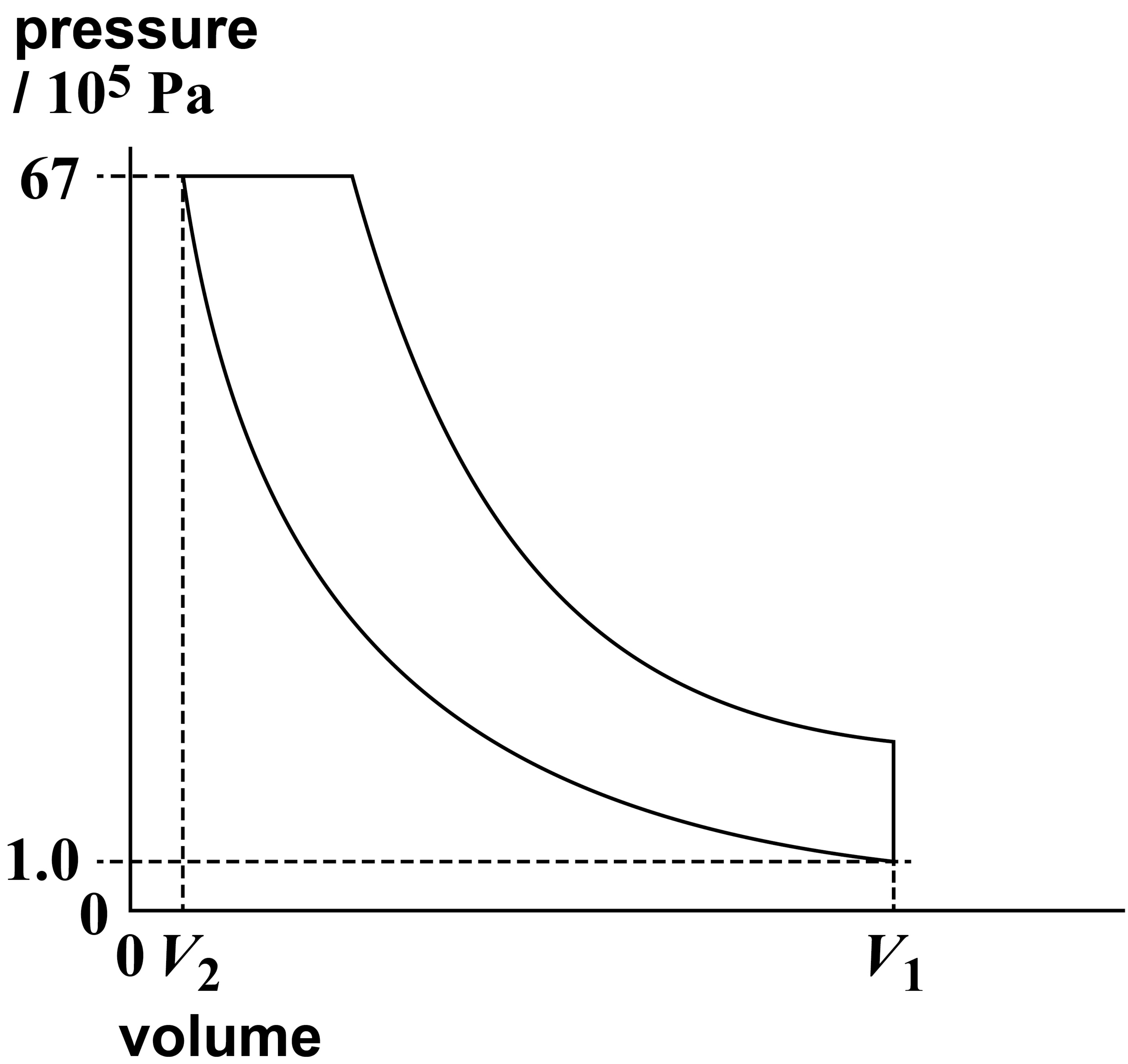
[Turn over]

0 3 . 2

FIGURE 4 shows the p–V diagram for an ideal diesel engine cycle.

FIGURE 4

The diagram is not drawn accurately.



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 = ______________________

[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]

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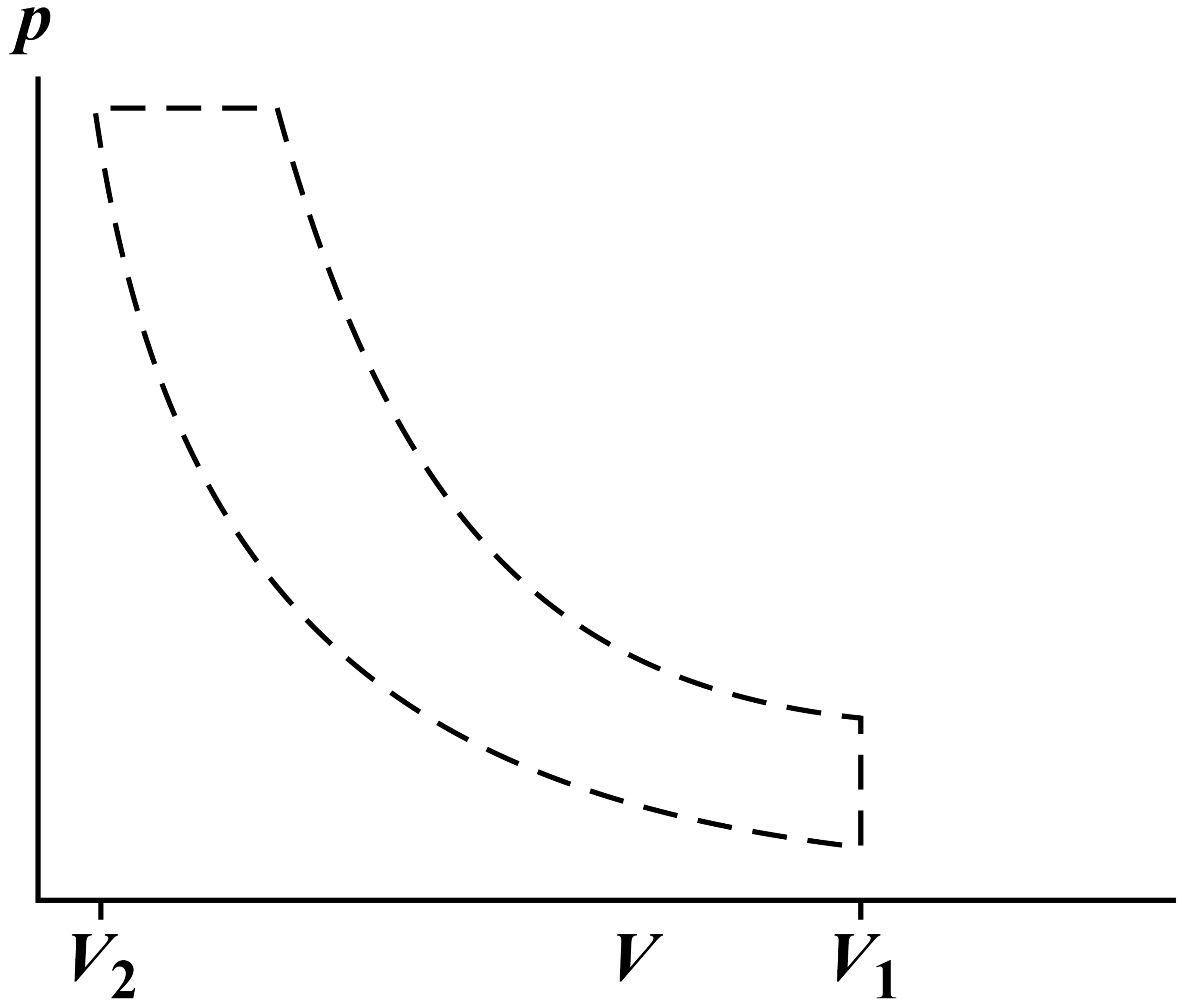
[Turn over]

The dashed lines in FIGURE 5, on the opposite page, 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]

0 3 . 6

Explain TWO differences between the ideal cycle and the indicator diagram for the real engine. [2 marks]

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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

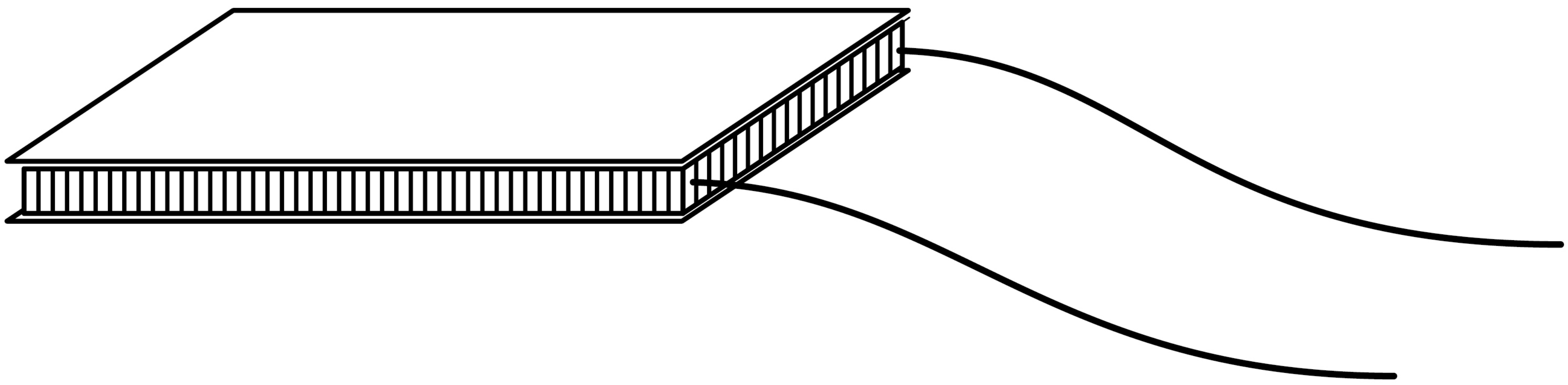
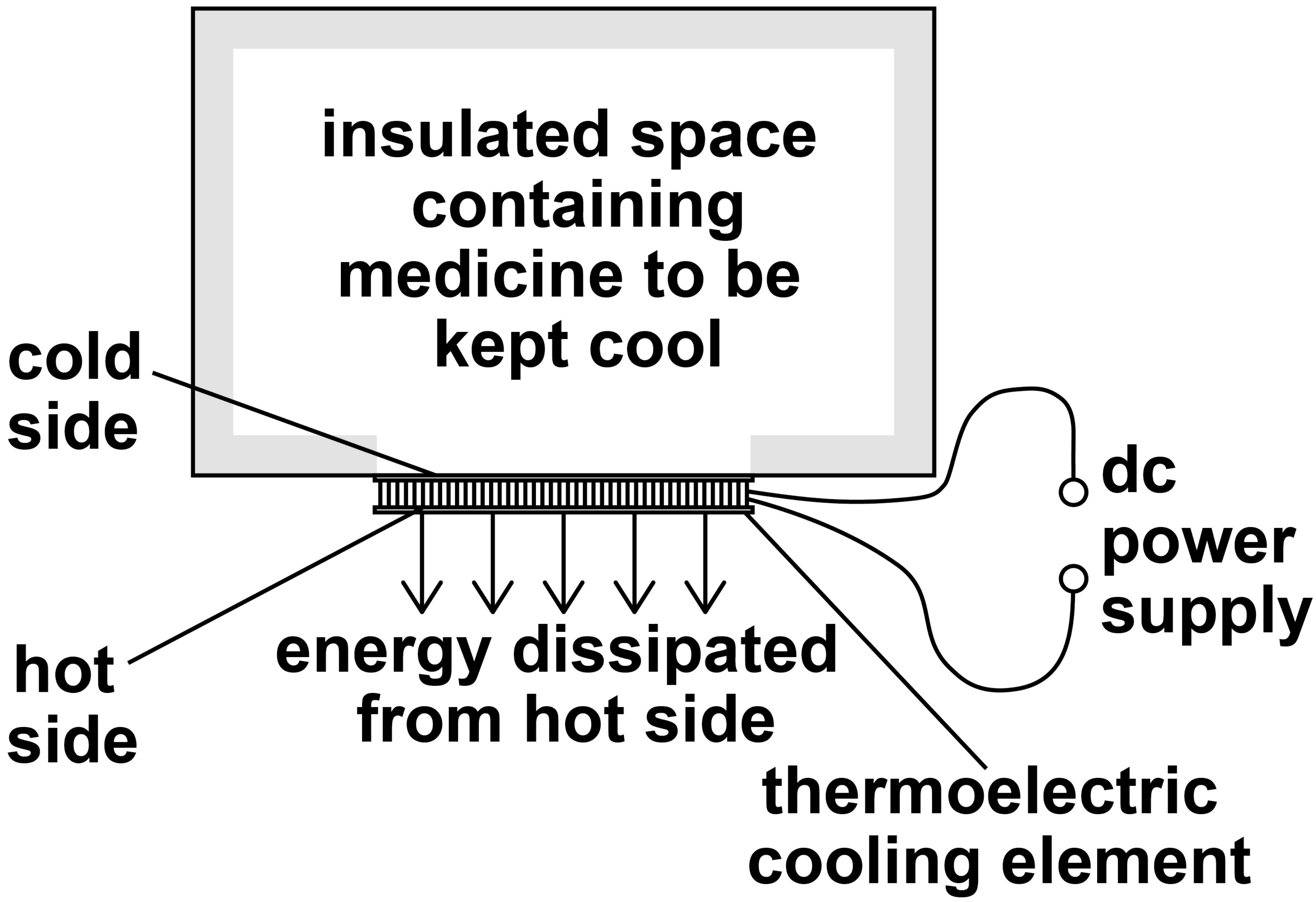


FIGURE 7, on page 39, shows how the element is used as part of a thermoelectric refrigerator to keep small quantities of medicine at a low temperature.

FIGURE 7

The diagram is not drawn accurately.



[Turn over]

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.

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]

[Turn over]

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]

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6

END OF QUESTIONS

Additional page, if required.

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Additional page, if required.
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For Examiner's Use	
Question	Mark
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TOTAL	