Access Tuition

A-Level Physics

Work and Power

Question Paper

Time available: 45 minutes
Marks available: 32 marks

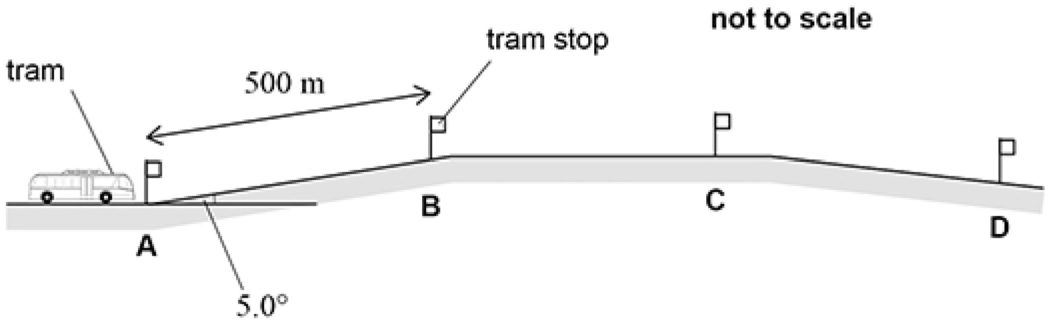
1. A moving tram is powered by energy stored in a rapidly spinning flywheel.

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.

The figure below 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.

(a) 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.

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

(3)

(b) 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.

1. ____

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2. ____

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(2)

(c) 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.

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(6)

(Total 11 marks)

2. The turntable of a microwave oven has a moment of inertia of 8.2×10^{-3} kg m^2 about its vertical axis of rotation.

(a) With the drive disconnected, the turntable is set spinning. Starting at an angular speed of 6.4 rad s^{-1} it makes 8.3 revolutions before coming to rest.

(i) Calculate the angular deceleration of the turntable, assuming that the deceleration is uniform. State an appropriate unit for your answer.

angular deceleration ____________________ unit ___________

(4)

(ii) Calculate the magnitude of the frictional torque acting at the turntable bearings.

torque ____________________ N m

(1)

(b) The turntable drive is reconnected. A circular pie is placed centrally on the turntable. The power input to the microwave oven is 900 W, and to cook the pie the oven is switched on for 270 seconds. The turntable reaches its operating speed of 0.78 rad s^{-1} almost immediately, and the friction torque is the same as in part (a)(ii).

(i) Calculate the work done to keep the turntable rotating for 270 s at a constant angular speed of 0.78 rad s^{-1} as the pie cooks.

work done ____________________ J

(2)

(ii) Show that the ratio

$$\frac{\text{energy supplied to oven}}{\text{work done to drive turntable}}$$

is of the order of 10^5.

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(2)

(Total 9 marks)

3. A grinding wheel is used to sharpen chisels in a school workshop. A chisel is forced against the edge of the grinding wheel so that the tangential force on the wheel is a steady 7.0 N as the wheel rotates at 120 rad s^{-1}. The diameter of the grinding wheel is 0.15 m.

(a) (i) Calculate the torque on the grinding wheel, giving an appropriate unit.

answer = ______________________

(2)

(ii) Calculate the power required to keep the wheel rotating at 120 rad s^{-1}.

answer = ______________________ W

(1)

(b) When the chisel is removed and the motor is switched off, it takes 6.2 s for the grinding wheel to come to rest.

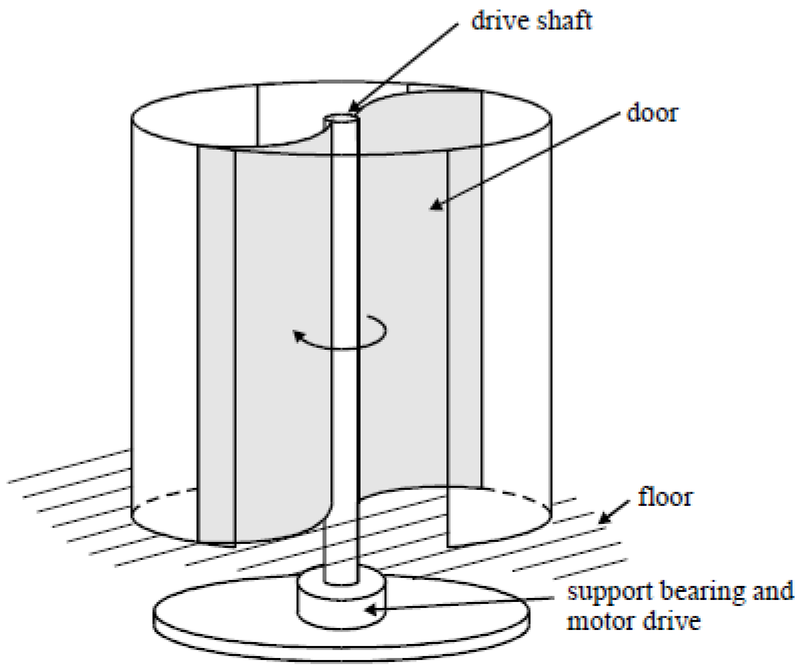
Calculate the number of rotations the grinding wheel makes in this time.

answer = ______________________

(2)

(Total 5 marks)

4. Shoppers enter and leave a supermarket by a continuously revolving door, as shown in the diagram. The door is fixed to a central column which acts as a drive shaft and extends beneath the floor to a support bearing and motor drive system.



During shopping hours the door revolves once every 18 s. When the supermarket closes, the motor is switched off and the system makes a further 3 complete revolutions whilst decelerating uniformly to rest. The total moment of inertia of the rotating system is 8.0×10^3 kg m^2.

(a) How long does it take for the system to come to rest?

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(3)

(b) Estimate the average frictional torque acting on the system.

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(2)

(c) What power output must the motor develop to keep the door turning at its normal steady speed?

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(2)

(Total 7 marks)