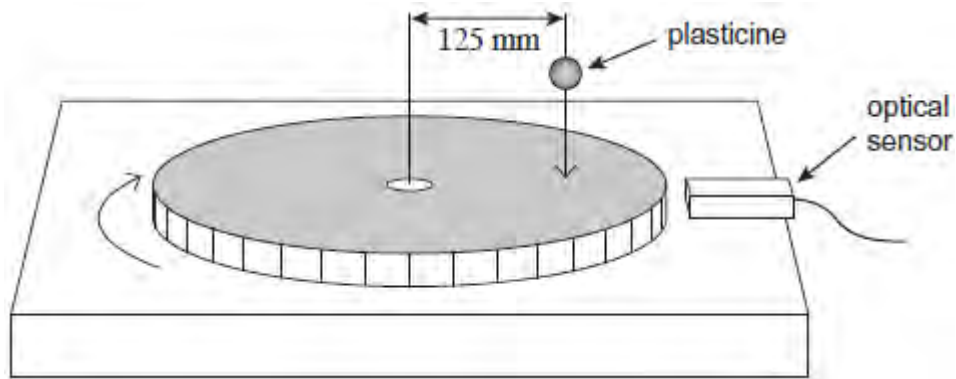


Q1. A student carries out an experiment to determine the moment of inertia of a turntable. The diagram shows the turntable with a small lump of plasticine held above it. An optical sensor connected to a data recorder measures the angular speed of the turntable.



The turntable is made to rotate and then it rotates freely. The lump of plasticine is dropped from a small height above the turntable and sticks to it. Results from the experiment are as follows.

- mass of plasticine = 16.0 g
- radius at which plasticine sticks to the turntable = 125 mm
- angular speed of turntable immediately before plasticine is dropped = 3.46 rad s^{-1}
- angular speed of turntable immediately after plasticine is dropped = 3.31 rad s^{-1}

The student treats the plasticine as a point mass.

(a) Explain why the turntable speed decreases when the plasticine sticks to it.

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(3)

(b) Use the results of the experiment to determine the moment of inertia of the turntable.

Give your answer to an appropriate number of significant figures.

moment of inertia kg m²

(3)

- (c) (i) Calculate the change in rotational kinetic energy of the turntable and plasticine from the instant before the plasticine is dropped until immediately after it sticks to the turntable.

change in kinetic energy J

(2)

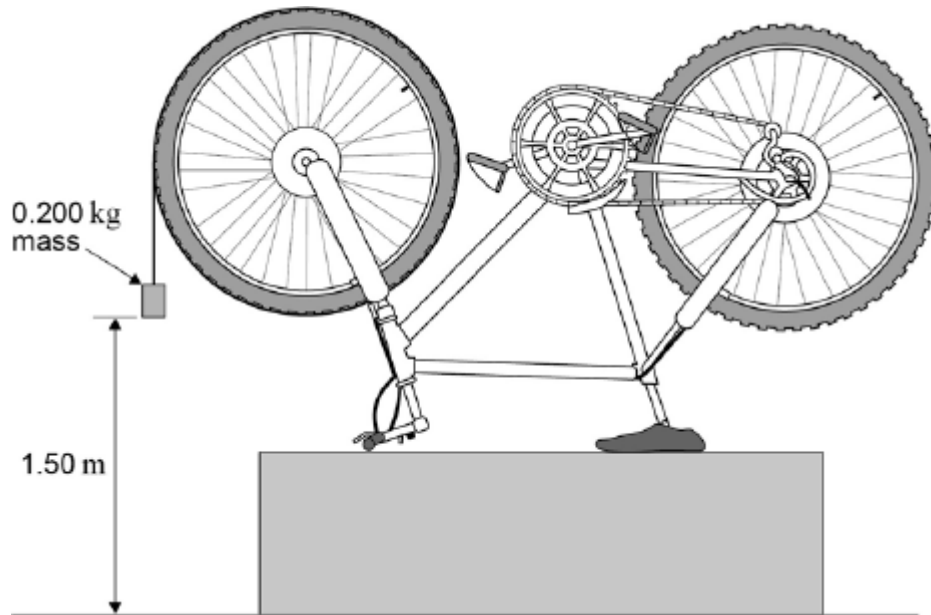
- (ii) Explain the change in rotational kinetic energy.

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(1)

(Total 9 marks)

Q2. The figure below shows an experiment to determine the moment of inertia of a bicycle wheel. One end of a length of strong thread is attached to the tyre. The thread is wrapped around the wheel and a 0.200 kg mass is attached to the free end. The wheel is held so that the mass is at a height of 1.50 m above the floor. The wheel is released and the time taken for the mass to reach the floor is measured.



- (a) State the energy transfers that take place from the moment the wheel is released until the mass hits the floor.

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(2)

- (b) Calculations based on the measurements made show that at the instant the mass hits the floor:

- the speed of the mass is 2.22 m s^{-1}
- the wheel is rotating at 6.73 rad s^{-1}
- the wheel has turned through an angle of 4.55 rad from the point of release.

A separate experiment shows that a constant frictional torque of $7.50 \times 10^{-3} \text{ N m}$ acts on the wheel when it is rotating.

By considering the energy changes in the system, show that the moment of inertia of the wheel about its axis is approximately 0.1 kg m^2 .

(3)

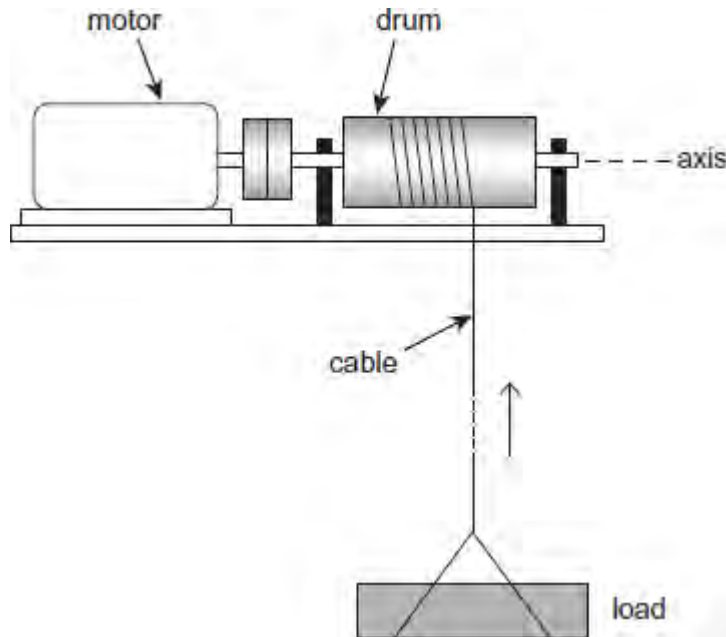
(c) When the mass hits the floor the thread is released from the wheel.

Calculate the angle turned through by the wheel before it comes to rest after the thread is released.

angle = rad

(2)
(Total 7 marks)

Q3. The following figure shows a motor-driven winch for raising loads on a building site. As the motor turns the cable is wound around the drum, raising the load.



The drum, axle and other rotating parts have a moment of inertia about the axis of rotation of 7.4 kg m^2 , and the mass of the load is 85 kg . The drum has a radius of 0.088 m .

The load is accelerated uniformly from rest to a speed of 2.2 m s^{-1} . When it is accelerating

it rises through a height of 3.5 m. It then continues at the constant speed of 2.2 m s^{-1} .

(a) Show that the drum turns through 40 rad as the load accelerates.

(1)

(b) Calculate the angular speed of the drum when the load is moving at 2.2 m s^{-1} .

angular speed rad s^{-1}

(1)

(c) (i) Show that for the time that the load is accelerating the total increase in energy of the load and the rotating parts is about 5400 J.

(3)

(ii) A constant frictional torque of 5.2 N m acts at the bearings of the winch.

Calculate the total work done by the motor to accelerate the load.

Give your answer to an appropriate number of significant figures.

total work done J

(3)

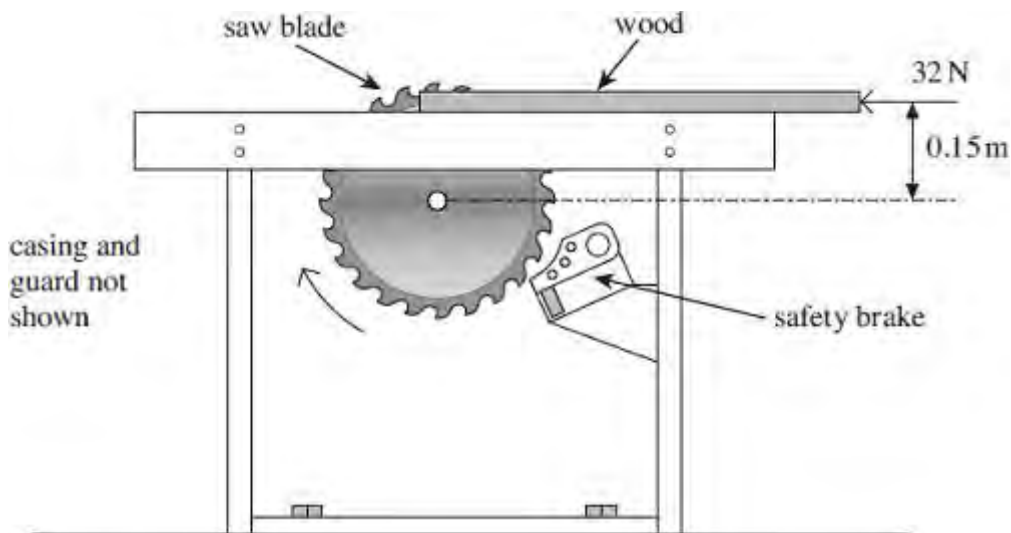
(d) Calculate the **maximum** power developed by the motor.

maximum power W

(2)

(Total 10 marks)

Q4. The figure below shows a type of circular saw. The blade is driven by an electric motor and rotates at $2600 \text{ rev min}^{-1}$ when cutting a piece of wood. A constant frictional torque of 1.2 Nm acts at the bearings of the motor and axle.



A horizontal force of 32 N is needed to push a piece of wood into the saw. The force acts on the blade at an effective radius of 0.15 m .

(a) (i) Calculate the torque on the saw blade resulting from the horizontal force on the wood.

answer = Nm (1)

(ii) Calculate the output power of the motor when the saw is cutting the wood.

answer = W (3)

(b) Immediately after cutting the wood the motor is switched off. The time taken for the saw blade to come to rest is 8.5 s. Calculate the moment of inertia of the rotating parts (i.e. the motor rotor, axle and blade). State an appropriate unit.

answer = unit = (3)

(c) If the blade is accidentally touched when it is rotating, an electronic safety brake stops the blade in 5.0 ms. This is fast enough to prevent serious injury. The safety brake works by forcing a block of aluminium into the saw teeth.

Estimate the rate at which the rotational kinetic energy is dissipated as heat and in deforming the aluminium when the brake operates.

answer = W (2)
(Total 9 marks)

