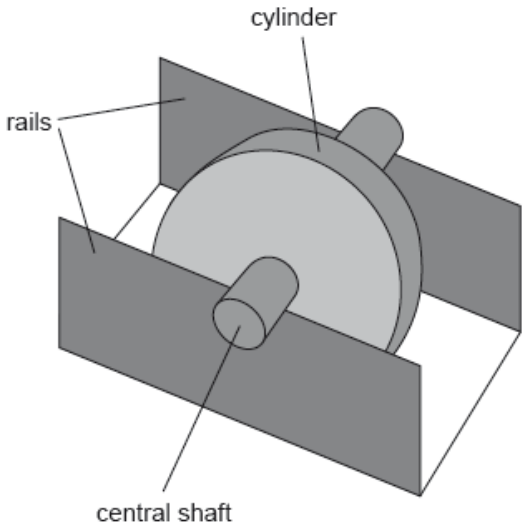
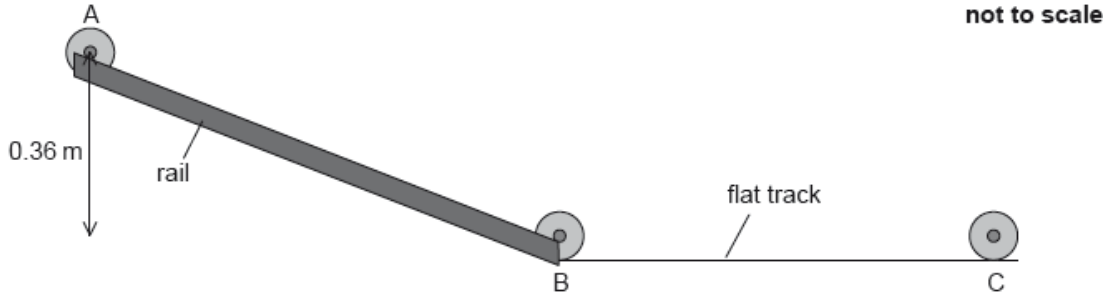
SL Paper 3

A wheel of mass 0.25 kg consists of a cylinder mounted on a central shaft. The shaft has a radius of 1.2 cm and the cylinder has a radius of 4.0 cm.

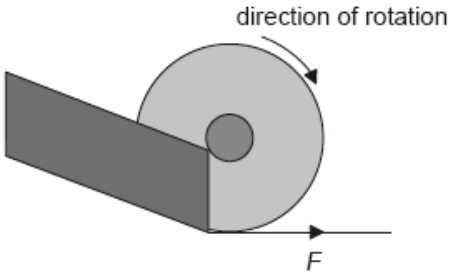
The shaft rests on two rails with the cylinder able to spin freely between the rails.



The stationary wheel is released from rest and rolls down a slope with the shaft rolling on the rails without slipping from point A to point B.



The wheel leaves the rails at point B and travels along the flat track to point C. For a short time the wheel slips and a frictional force *F* exists on the edge of the wheel as shown.



a.i. The moment of inertia of the wheel is 1.3×10^{-4} kg m^2. Outline what is meant by the moment of inertia. [1]

a.ii. In moving from point A to point B, the centre of mass of the wheel falls through a vertical distance of 0.36 m. Show that the translational speed of the wheel is about 1 m s^{-1} after its displacement. [3]

a.iii Determine the angular velocity of the wheel at B. [1]

b.i. Describe the effect of *F* on the linear speed of the wheel. [2]

b.ii. Describe the effect of *F* on the angular speed of the wheel. [2]

Markscheme

a.i. an object's resistance to change in rotational motion

OR

equivalent of mass in rotational equations

OWTTE

[1 mark]

a.ii. ΔKE + Δrotational KE = ΔGPE

OR

$\frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{r^2} = mgh$

$\frac{1}{2} \times 0.250 \times v^2 + \frac{1}{2} \times 1.3 \times 10^{-4} \times \frac{v^2}{1.44 \times 10^{-4}} = 0.250 \times 9.81 \times 0.36$

v = 1.2 «m s^{-1}»

[3 marks]

a.iii ω «= $\frac{1.2}{0.012}$» = 100 «rad s^{-1}»

[1 mark]

b.i. force in direction of motion

so linear speed increases

[2 marks]

b.ii. force gives rise to anticlockwise/opposing torque on

wheel ✓ so angular speed decreases ✓

OWTTE

[2 marks]

Examiners report

a.i. [N/A]
a.ii. [N/A]
a.iii. [N/A]
b.i. [N/A]
b.ii. [N/A]