Q1.

A wheel of diameter 3.0 cm has a 4.0 m cord wrapped around its periphery statring from rest, the wheel is given a constant angular acceleration of 2.0 rad/s^2. How much time it will take for the cord to unwind?

Ans.

$$\theta = \omega_i t + \frac{1}{2}\alpha t^2$$

$$but \quad \omega_i = 0 \quad so \qquad \theta = \frac{1}{2}\alpha t^2 - - - - - (1)$$

$$\theta = \frac{S}{r}; \ S = 4\,m \ \ and\, r = \frac{3.0}{2} = 1.5\,cm = 0.015\,m$$

$$\theta = \frac{4}{0.015} = 267\,rad$$

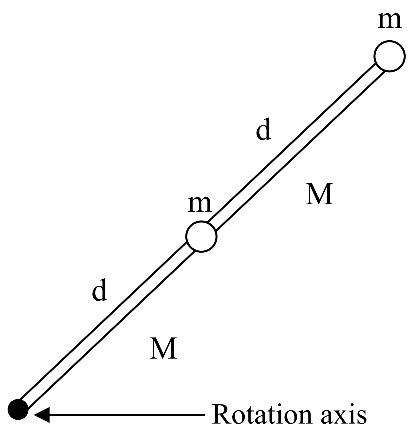
Using this value of θ in eq. (1)

$$267 = \frac{1}{2} \times 2.0 \times t^2 \quad \Rightarrow t^2 = 267$$

$$t = \sqrt{267} = 16.35\,s$$

Q2.

As shown in the figure, two particles each of mass m=1.5 kg, are fastened to each other, and to a rotation axis at O by two identical thin rods with length d= 5.0 cm and mass M= 1.5 kg. The combination rotates around the rotation axis with angular speed $\boldsymbol{\omega}$=0.5 rad/s. Calculate their kinetic energy?



Ans

$$I = I_{rod1} + I_{mass-1} + I_{rod-2} + I_{mass-2}$$

$$I_{rod-1} = \frac{1}{12}(M)(d)^2 + M(\frac{d}{2})^2 = \frac{1}{3}Md^2$$

$$I_{rod-2} = \frac{1}{12}(M)(d)^2 + M(\frac{3d}{2})^2 = \frac{7}{3}Md^2$$

$$I_{mass-1} = md^2 = md^2$$

$$I_{mass-2} = m(2d)^2 = 4md^2$$

$$I = \frac{1}{3}Md^2 + md^2 + \frac{7}{3}Md^2 + 4md^2 = \frac{23}{3}md^2 \qquad since\ M = m$$

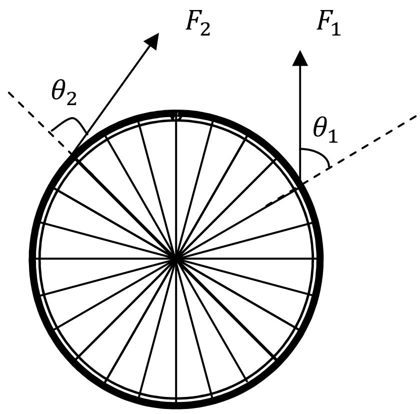
$$= \frac{23}{3} \times 1.5 \times (0.05)^2$$

$$I = 0.0288\,kg\,m^2$$

$$K = \frac{1}{2}I\omega^2 = 0.5 \times 0.0288 \times 0.5^2 = 3.6 \times 10^{-3}\,J$$

Q3.

Two forces act on a wheel, as shown in the figure. The wheel is free to rotate about it fixed axis without friction, has a radius of 0.5 m, and is initially at rest. Given that F_1=12N, F_2=10N, θ_1=50° and θ_2=70° find the net torque caused by the two forces.



Ans.

$\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2$

τ_1 is the torque due to force F1 and it rotates the wheel in counter clockwise directions whereas τ_2 is the torque by force F2 and it rotates the wheel in clockwise direction. So τ_1 is positive and τ_2 is negative. And the net torque τ is given as:

$\tau = RF_1 sin\theta_1 - RF_2 sin\theta_2$

$\tau = 0.5 \times 12 sin50 - 0.5 \times 10 sin70 = -0.1\ N.m$