Answer on Question#64088 – Physics – Mechanics – Relativity

10. A net torque of 36 N.m acts on a wheel rotating about a fixed axis for 6 s. During this time the angular speed of the wheel increases from 0 to 12 rad/s. The applied force is then removed, and the wheel comes to rest in 75 s.
a. What is the moment of inertia of the wheel?
b. What is the magnitude of the frictional torque?
c. How many revolutions does the wheel make?

Solution. In rotational motion, torque is required to produce an angular acceleration of an object. The amount of torque required to produce an angular acceleration depends on the distribution of the mass of the object. The moment of inertia is a value that describes the distribution. The torque on a given axis is the product of the moment of inertia and the angular acceleration.

$$T = Ia$$

T – torque, around a defined axis (Nm); I – moment of inertia (kg m^2); a – angular acceleration (radians/s^2).

a) Find the angular acceleration using the definition $a = \frac{12-0}{6} = 2\frac{rad}{s^2}$. Hence moment of inertia of the wheel

$$I = \frac{T}{a} = \frac{36}{2} = 18kg \cdot m^2$$

b) Find the angular acceleration using the definition $a = \frac{0-12}{75} = -0.16\frac{rad}{s^2}$. Moment of inertia of the wheel equal to $I = 18kg \cdot m^2$. Using formula $T = Ia$ find frictional torque

$$T = 18 \cdot (-0.16) = -2.88N \cdot m$$

Therefore magnitude of the frictional torque $2.88N \cdot m$.

c) Find angular displacement for both cases of motion

$\varphi_1 = \frac{\omega_1^2-\omega_0^2}{2a_1} = \frac{12^2-0}{4} = 36rad$

$\varphi_2 = \frac{\omega_2^2-\omega_1^2}{2a_2} = \frac{0-12^2}{-0.32} = 450rad$

The total angular displacement of the wheel $\varphi = \varphi_1 + \varphi_2 = 486rad$.

Angular displacement for 1 revolution equal to $2\pi rad$. The wheel did $N = \frac{486}{2\pi} = 77.3$ revolutions.

Answer. a) $I = 18kg \cdot m^2$; b) $2.88N \cdot m$; c) 77.3 revolutions.