Answer on Question 66740, Physics, Mechanics, Relativity

Question:

A solid cylinder of mass $3\ kg$ and radius $1.0\ m$ is rotating about its axis with a speed of $40\ rad/s$. Calculate the torque which must be applied to bring it to rest in 10 second. What would be the power required?

Solution:

a) We can find the torque from the formula:

$$\tau = I\alpha,$$

here, I is the moment of inertia of the solid cylinder, α is the angular acceleration of the solid cylinder.

The moment of inertia of the solid cylinder can be found from the formula:

$$I = \frac{1}{2}mr^2,$$

here, m is the mass of the solid cylinder, r is the radius of the solid cylinder.

Then, we get:

$$I = \frac{1}{2}mr^2 = \frac{1}{2} \cdot 3\ kg \cdot (1.0\ m)^2 = 1.5\ kg \cdot m^2.$$

We can find the angular acceleration of the solid cylinder from the kinematic equation:

$$\omega = \omega_i + \alpha t,$$

here, $\omega_i = 40\ rad/s$ is the initial angular speed of the cylinder, $\omega = 0\ rad/s$ is the final angular speed of the cylinder (when the cylinder is bring to rest), α is the angular acceleration of the cylinder and t is the time.

Then, from this formula we can find the angular acceleration of the solid cylinder:

$$\alpha = \frac{\omega - \omega_i}{t} = \frac{0\ \frac{rad}{s} - 40\ \frac{rad}{s}}{10\ s} = -4\ \frac{rad}{s^2}.$$

The sign minus indicates that the cylinder decelerates.

Substituting I and α into the first formula we can calculate the torque which must be applied to bring it to rest in 10 second:

$$\tau = I\alpha = 1.5\ kg \cdot m^2 \cdot \left(-4\ \frac{rad}{s^2}\right) = -6\ N \cdot m.$$

The sign minus indicates that the torque acting in the opposite direction to the rotation of the cylinder. So, the magnitude of the torque will be $\tau = 6\ N \cdot m$.

b) We can find the power required from the formula:

$$P = \tau\omega,$$

here, P is the power, τ is the torque applied to the cylinder, ω is the angular speed of the cylinder.

Then, we get:

$$P = \tau\omega = 6\ N \cdot m \cdot 40\ \frac{rad}{s} = 240\ W.$$

Answer:

a) $\tau = 6\ N \cdot m$.

b) $P = 240\ W$.