Answer on Question #61695, Physics / Mechanics | Relativity

A cylindrical centrifuge of mass 8 kg and radius 10 cm spins at a speed of 80,000 rpm.

Calculate the minimum braking torque that must be applied to stop the rotor within 30 s from the instant the motor is turned off.

Solution:

We apply a constant braking force [F] perpendicularly to the radius of spin. Then the torque (moment of force) will be

$$\tau = F \cdot r$$

From the other hand, this torque will cause an angular acceleration (deceleration in this case) α, and the relation between them is

$$\tau = I \cdot \alpha$$

where *I* is the moment of inertia of a centrifuge.

For an object whose mass is at the constant distance from the axis of rotation, the moment of inertia is

$$I = mr^2$$

Therefore, we obtain

$$\tau = mr^2\alpha$$

The angular speed ω will decrease uniformly at a rate α

$$\omega = \omega_0 - \alpha\, t$$

A centrifuge stops when ω=0, so

$$\alpha = \frac{\omega_0}{t_1}$$

wherev$_0$ is the initial angular speed and t_1 is the given time of braking.

Rotations per minute (abbreviated rpm) are a measure of the frequency of a rotation. It annotates the number of turns completed in one minute around a fixed axis.

We have

$$f = 80000 \text{ rpm} = \frac{80000 \text{ rotation}}{60 \text{ s}} = 1333.3 \text{ Hz}$$

The conversion between a frequency f measured in hertz and an angular speed ω measured in radians per second are:

$$\omega_0 = 2\pi f = 6.28 \cdot 1333.3 = 8373.3 \frac{rad}{s}$$

Thus,

$$\alpha = \frac{\omega_0}{t_1} = \frac{8373.3}{30} = 279.1 \text{ rad/s}^2$$

Finally,

$$\tau = 8 \cdot 0.1^2 \cdot 279.1 = 22.33\, N \cdot m$$

Answer: $22.3\, N \cdot m$