Answer on Question #72596, Physics / Mechanics | Relativity

A child of mass 50 kg is standing on the edge of a merry go round of mass 250 kg and radius 3.0 m which is rotating with an angular velocity of 3.0 rad s^{-1}. The child then starts walking towards the centre of the merry go round. What will be the final angular velocity of the merry go round when the child reaches the centre?

Solution:

We apply conservation of angular momentum (there are no net external torques on the system of merry-go-round and child).

Thus we have

$$L = constant$$

$$L = I_i\omega_i = I_f\omega_f$$

where I: rotational inertia, ω: angular velocity.

The final angular velocity will be

$$\omega_f = \frac{I_i\omega_i}{I_f}$$

so all that is left to do is to find the initial angular velocity and the initial and final moments of inertia. The initial angular velocity is $\omega_i = 3.0\ rad/s$.

The initial moment-of-inertia is that of the merry-go-round plus that of the child located at the rim

$$I_i = \frac{1}{2}MR^2 + mR^2 = 0.5 \times 250 \times 3.0^2 + 50 \times 3.0^2 = 1575\ kg \cdot m^2$$

Since the child ends up at the center (R=0), chlid contributes no rotational inertia in the final situation, so the I_f is just that of the merry-go-round, i.e.

$$I_f = \frac{1}{2}MR^2 = 0.5 \times 250 \times 3.0^2 = 1125\ kg \cdot m^2$$

Thus,

$$\omega_f = \frac{I_i\omega_i}{I_f} = \frac{(1575\ kg \cdot m^2)(3.0\ rad/s)}{(1125\ kg \cdot m^2)} = 4.2\ rad/s$$

Answer: $4.2\ rad/s$