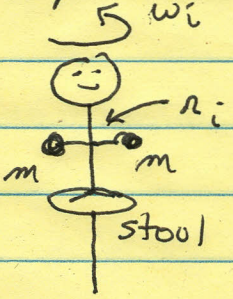
49. A student's rotational inertia about a vertical axis through his center is 4.5 kg·m^2 with his arms held to his chest and 5.6 kg·m^2 with his arms outstretched. In a physics demonstration, the student stands on a turntable rotating at 1.0 rev/s, clutching two 7.5-kg weights to his chest. The turntable's rotational inertia is 4.0 kg·m^2. If the student extends his arms fully so the weights are each 95 cm from his rotation axis, what will be his new angular speed?

Example: Student / stool (#49)



Initial

$\omega_i = 1.0 \text{ rev/s} \times 2\pi \text{ rad/rev} = 2\pi \text{ rad/s}$

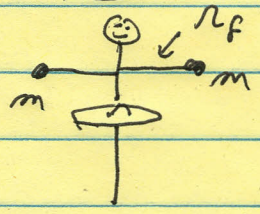
$I_{turntable} = 4.0 \text{ kg m}^2$

$I_{student,i} = 4.5 \text{ kg m}^2$

$m = 7.5 \text{ kg}$

$r_i = 0$. (assume very small)

$I_i = I_{turntable} + I_{student,i} + 2mr_i^2 = 8.5 \text{ kg m}^2$



Final

$I_{student,f} = 5.6 \text{ kg m}^2$

$r_f = 0.95 \text{ m}$

$I_f = I_{turntable} + I_{student,f} + 2mr_f^2 =$

$4.0 + 5.6 + 2(7.5)(0.95)^2 \text{ kg m}^2$

$I_f = 23.14 \text{ kg m}^2$

Since $\Sigma \tau_{ext} = 0$, $L_i = L_f$

$I_i \omega_i = I_f \omega_f$

$\omega_f = \frac{I_i \omega_i}{I_f} = \left(\frac{8.5}{23.14}\right)\left(2\pi \text{ rad/s}\right) = 2.31 \text{ rad/s}$

$\omega_f = 2.31 \text{ rad/s}$, or 0.367 rev/s.

Energy? $K_i = \frac{1}{2} I_i \omega_i^2 = 167.8 \text{ J}$

$K_f = \frac{1}{2} I_f \omega_f^2 = 61.7 \text{ J}$

Where did it go? Student did work moving the weights.