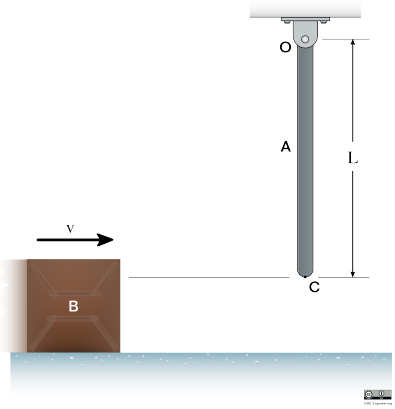
22-R-IM-JL-34

A block of mass $m_B = 6$ kg is sliding along a slippery, icy surface with no friction. It hits a slender bar of mass $m_A = 4$ kg and length $L = 5$ m at a speed of $v = 14$ m/s at point C. If the coefficient of restitution between the slender bar and the block is $e = 0.7$, find the angular velocity of the bar just after the impact.



Solution

First applying conservation of momentum about point O:

$(H_O)_1 = (H_O)_2$

$L\,(m_B)\,(v_{B1}) = L\,(m_B)\,(v_{B2}) + I_O\,(\omega_{A2})$

$L\,(m_B)\,(v_{B1}) = L\,(m_B)\,(v_{B2}) + \frac{L}{3}\,(m_A)\,(v_{A2})$

Next, using the coefficient of restitution equation:

$e = \dfrac{v_{A2} - v_{B2}}{v_{B1} - v_{A1}} = \dfrac{v_{A2} - v_{B2}}{v_{B1}}$ (since $v_{A1} = 0$ as the bar started at rest)

$v_{B2} = v_{A2} - v_{B1}e$

Substituting the value for v_{B2} back into our momentum equation we can solve for v_{A2}:

$L\,(m_B)\,(v_{B1}) = L\,(m_B)\,(v_{A2} - v_{B1}e) + \frac{L}{3}\,(m_A)\,(v_{A2})$

Rearranging for v_{A2} we have:

$$v_{A2} = \frac{v_{B1}(m_B + e)}{m_B + m_A/3} = \frac{14(6 + 0.7)}{6 + 4/3} = 12.79 \ \ [\text{m/s}]$$

Finally, getting the angular velocity we have $\omega_{A2} = v_{A2}/L = 2.56$ [rad/s]