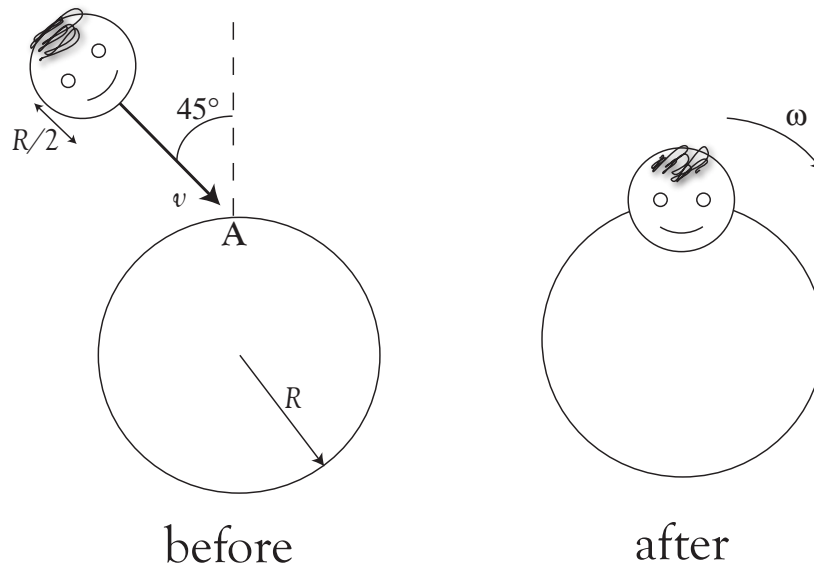


FP16

Problem 2 (10 points) - A Cylindrical Child

A playground merry-go-round of uniformly distributed mass M and radius R is initially at rest. A kid with uniformly distributed mass $2M$ (whose shape is remarkably close to that of a disk of radius $R/2$) runs at a constant velocity \vec{v} towards point **A** on the edge of the merry-go-round. The angle between \vec{v} and the line that runs from **A** to the center of the merry-go-round is 45° , as shown in the figure.



At the instant when he jumps aboard, the child grabs hold of the edge so that he is fixed with respect to the merry-go-round, with his center of mass at point **A**. The merry-go-round then begins turning with angular velocity ω .

- (2 points)** Find the total moment of inertia I_{tot} of the system about the axis of the merry-go-round, after the child has jumped on.
- (3 points)** Find the angular velocity ω of the system after the jump. Express your answer in terms of v , M , and R .
- (2 points)** Find the fraction of the initial kinetic energy that is lost in the “collision” between the kid and the merry-go-round.
- (3 points)** After a few revolutions at a constant angular velocity ω , the kid decides to move to the center of the merry-go-round with a constant radial speed $v_r = -dr/dt$. Find the angular acceleration α of the merry-go-round as a function of r . Express your answer in terms of M , R , v_r and the initial angular velocity ω .

Hint: You might want to save yourself some computation by first finding an expression for ω as a function of r , and then using the chain rule $\alpha = \frac{d\omega}{dt} = \frac{d\omega}{dr} \frac{dr}{dt}$.