Determining the required inertia of the wheel

Assume that the wheel (all of the rotating parts) stores all of the energy necessary to shoot the ball. The motor controller will be ineffective since the shot will be over before it can react, not to mention the backlash in the chain drive further decouples the wheel from the controller. The motor is there to get the wheel back up to speed once the ball has been shot. The amount of time that will take is dependent upon how many rpm we are willing to put into shooting the ball.

So, from conservation of energy, the amount of kinetic energy left in the wheel is equal to the amount we started with minus the amount put into spinning the ball and projecting along its path. There are a few simple steps to get to an equation that will tell us what the wheel inertial must be. Of course, we can't forget the energy wasted in compressing the ball, although we should get some of that back when it is uncompressed. There will also be frictional loss between the wheel and ball and the ball and hood.

Variable definitions:

I_{wheel}	mass moment of inertia of the wheel
ω_{wheel_1}	angular velocity of the wheel before the shot
ω_{wheel_2}	angular velocity of the wheel after the shot
I_{ball}	mass moment of inertia of the ball
m_{ball}	mass of the ball
ω_{ball}	angular velocity of the ball as it leaves
v_{ball}	velocity of the ball as it leaves
$k.e._{loss}$	the losses …

Solution:

$$\frac{1}{2} \cdot I_{wheel} \cdot {\omega_{wheel_2}}^2 = \frac{1}{2} \cdot I_{wheel} \cdot {\omega_{wheel_1}}^2 - \frac{1}{2} \cdot I_{ball} \cdot {\omega_{ball}}^2 - \frac{1}{2} \cdot m_{ball} \cdot {v_{ball}}^2 - k.e._{loss}$$

$$I_{wheel} \cdot \left({\omega_{wheel_2}}^2 - {\omega_{wheel_1}}^2\right) = -I_{ball} \cdot {\omega_{ball}}^2 - m_{ball} \cdot {v_{ball}}^2 - k.e._{loss}$$

$$I_{wheel} = \frac{-I_{ball} \cdot {\omega_{ball}}^2 - m_{ball} \cdot {v_{ball}}^2 - k.e._{loss}}{\left({\omega_{wheel_2}}^2 - {\omega_{wheel_1}}^2\right)}$$

$$I_{wheel} = \frac{I_{ball} \cdot {\omega_{ball}}^2 + m_{ball} \cdot {v_{ball}}^2 + k.e._{loss}}{\left({\omega_{wheel_1}}^2 - {\omega_{wheel_2}}^2\right)}$$

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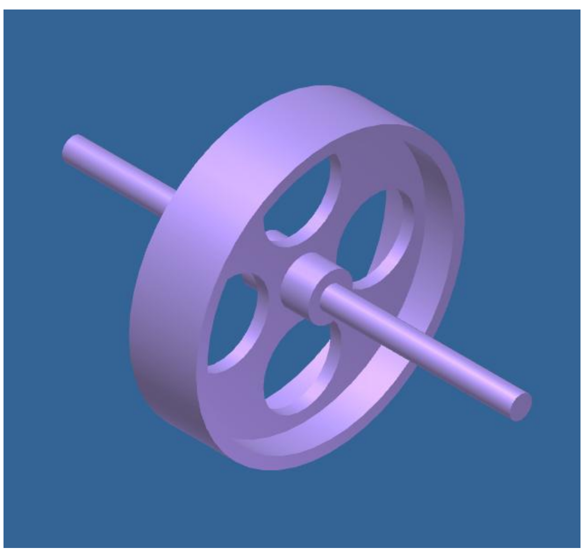
Example:

From the 45 degree solution for a free throw … (take my word for it)

ω_{wheel_1}	1800 rpm	= 192 rad/sec	
ω_{wheel_2}	1550 rpm	= 166 rad/sec	I'm choosing to lose 250 rpm
v_{ball}	300 ips	= 7.62 m/sec	velocity of the ball as it leaves
$\omega_{ball} = \frac{d_{wheel}}{d_{ball}} \cdot \omega_{wheel_2}$		= 150 rad/sec	angular velocity of the ball as it leaves
$I_{ball} = \frac{2}{5} \cdot m_{ball} \cdot (\frac{d_{ball}}{2})^2$		= .0014 kg-m^2	
m_{ball}	12 oz	= .034 kg	
d_{ball}	8 in	= .203 m	
$k.e._{loss}$		ignored, for now.	

$I_{wheel} = \frac{.0014 \cdot 150^2 + .034 \cdot 7.62^2 + 0}{(192^2 - 166^2)}$ = .004 kg-m^2



This wheel is steel, 6" in diameter, 1.5" wide, weighs 1.7 lbs and has a moment of inertia of .006 kg-m^s.

Not as heavy as I thought it would be. We could choose to lose fewer theoretical rpm and hope that the actual losses would put it around 250 rpm. We can afford to add .3 lbs, too.

Any comments?