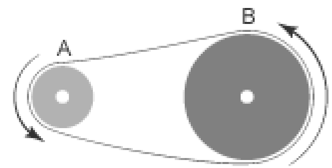
Belt Drive

The rotary joint is responsible for aligning the end-effector either in position to access the magazine or the x-carriage. This joint will be belt driven to provide the necessary output torque and fit in a compact design.

The calculations for the output torque of an open belt configuration are quite simple. First assumptions need to be made. Since a belt can only provide a pulling force and not a pushing one to drive a pulley, we may expect one side of the belt to have slack and the other to be tight. However, we will assume this is not happening in our case and that all points on the belt are moving with equal velocity.



Open Belt Configuration

If all points on the belt are moving with equal velocity, so are the outer points on the pulleys. Therefore the following system of equations may be created.

$$\begin{cases} v_A = \omega_A d_A \\ v_B = \omega_B d_B \\ v_A = v_B \end{cases} \quad \Rightarrow \quad \omega_B = \omega_A \frac{d_A}{d_B}$$

Now we have a relationship of angular velocities between the two pulleys.

To derive the torque transmission we may refer to the conservation of energy.

$$\begin{cases} P_A = T_A \omega_A \\ P_B = T_B \omega_B \\ P_A = P_B \end{cases} \quad \Rightarrow \quad T_B = T_A \frac{\omega_A}{\omega_B}$$

If we relate both of our derived equations we get the following.

$$T_B = T_A \frac{d_B}{d_A}$$

Where $\frac{d_B}{d_A}$ is the gear/pulley ratio. The entire formula may be summed up nicely like so.

Motor Torque x Gear/Pulley Ratio = Torque Output

We want our arm to be able to handle 0.5kg(5N) at a distance of 20cm. This will provide a moment of 100Ncm.

Our design may incorporate a 15mm diameter driving pulley and a 45mm driven pulley. A Nema17 motor with a holding torque of 42Ncm will output a torque of 126Ncm on the pulley. This fulfills our requirements.