Transferring Motion

The Antidote - FTC 14320

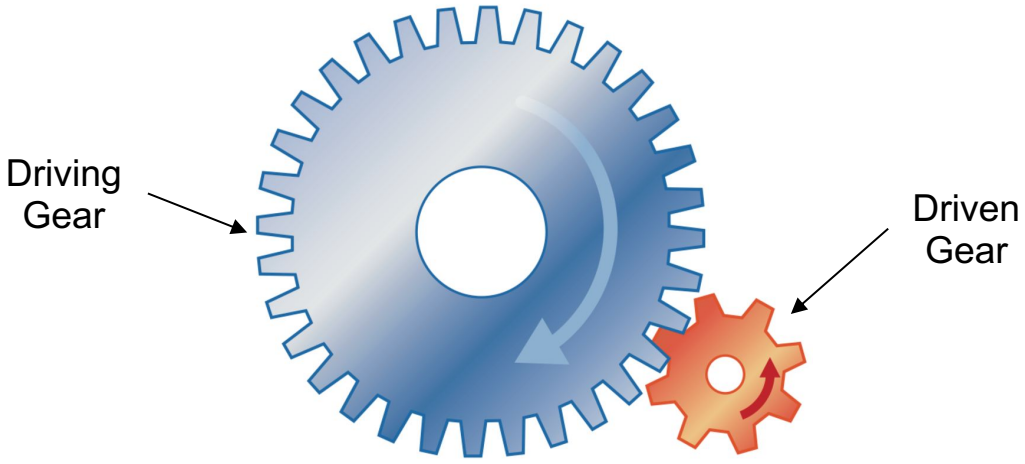
Motion

- Most FTC mechanical systems require **powered rotational motion** of an object.
- There are **four** main ways to connect an object to a motor or servo for transmission of powered rotation:
  - Direct Drive
  - Geared Drive
  - Chain Drive
  - Belt Drive

Our Intake mechanism for grabbing stones in the 19-20 season

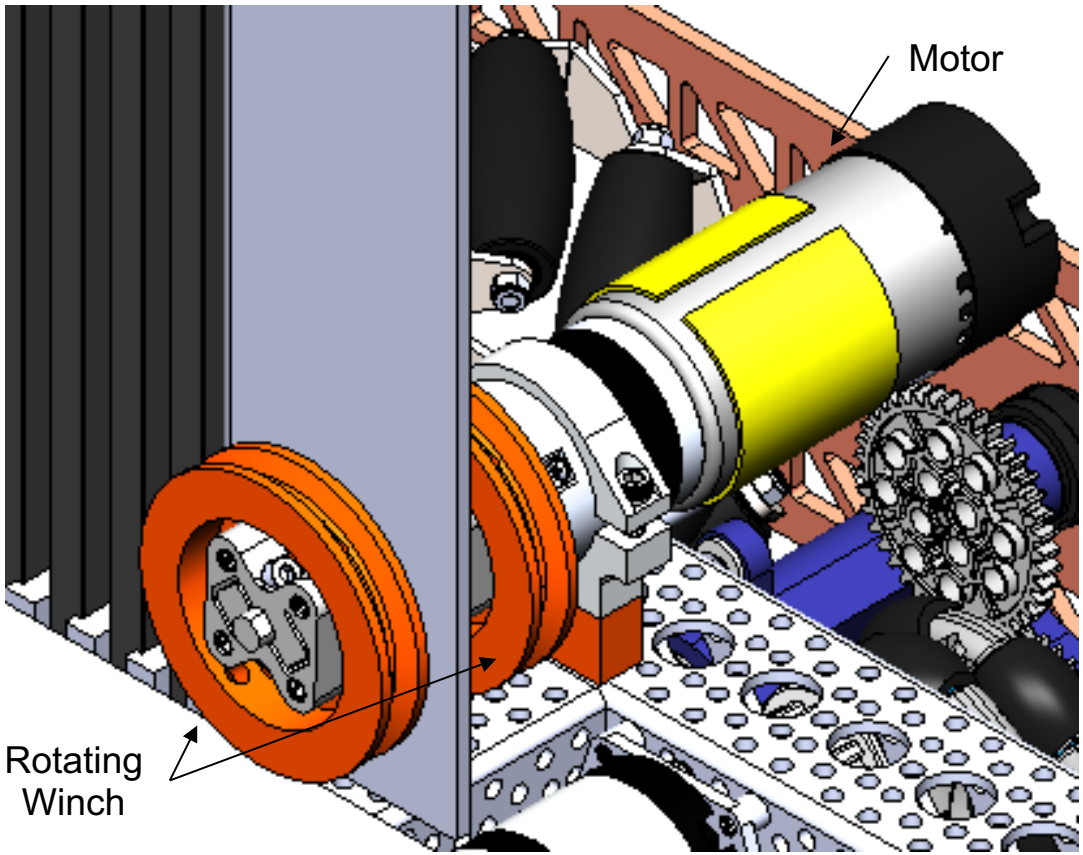
Vocabulary

- Speed: Rotational velocity of a rotating object (Shaft, Gear, etc.).
- Torque: Rotational force of a rotating object. Higher torque allows movement of heavier objects.
- Driving: The gear, sprocket, or pulley which is turning another gear, sprocket or pulley, usually the one connected to the motor/servo.
- Driven: The gear, sprocket or pulley which is being turned or driven.



Direct Drive

- Direct Drive is when the motor/servo is **directly connected** to an object via the drive shaft.



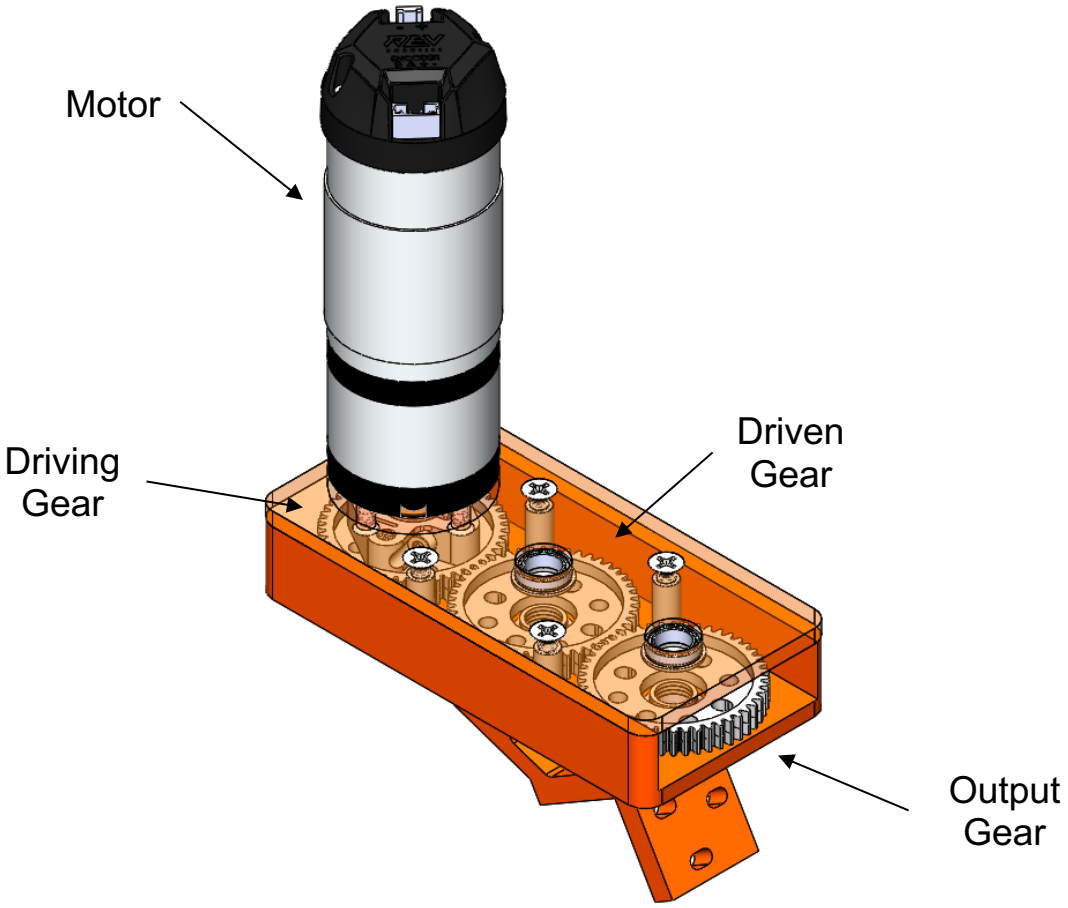
Directly driven winch system for linear slides

Direct Drive Pros & Cons

- Pros:
  - Direct Drive is the **most compact** way of transferring rotation, allowing for compact designs
  - Directly driven systems are incredibly **easy to create**, perfect for prototyping or simple mechanisms
- Cons:
  - Direct drive does not offer torque or speed reductions, so the powered object will spin at the **same speed and with the same torque as the driving motor**.
  - Any shock delivered to the object will impact the motor, leading to possible damage to the motor shaft or gearbox.
    - Especially problematic for use in high-stress situations such as drivetrains

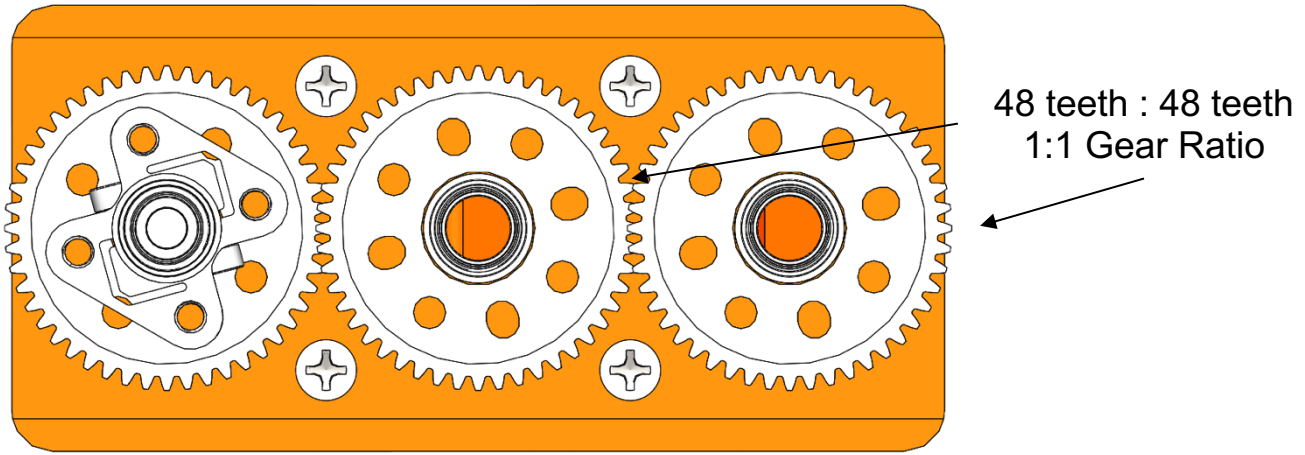
Gear Drive

- Gear Drive is when a motor/servo rotates an object through **side-by-side gear transmissions**.



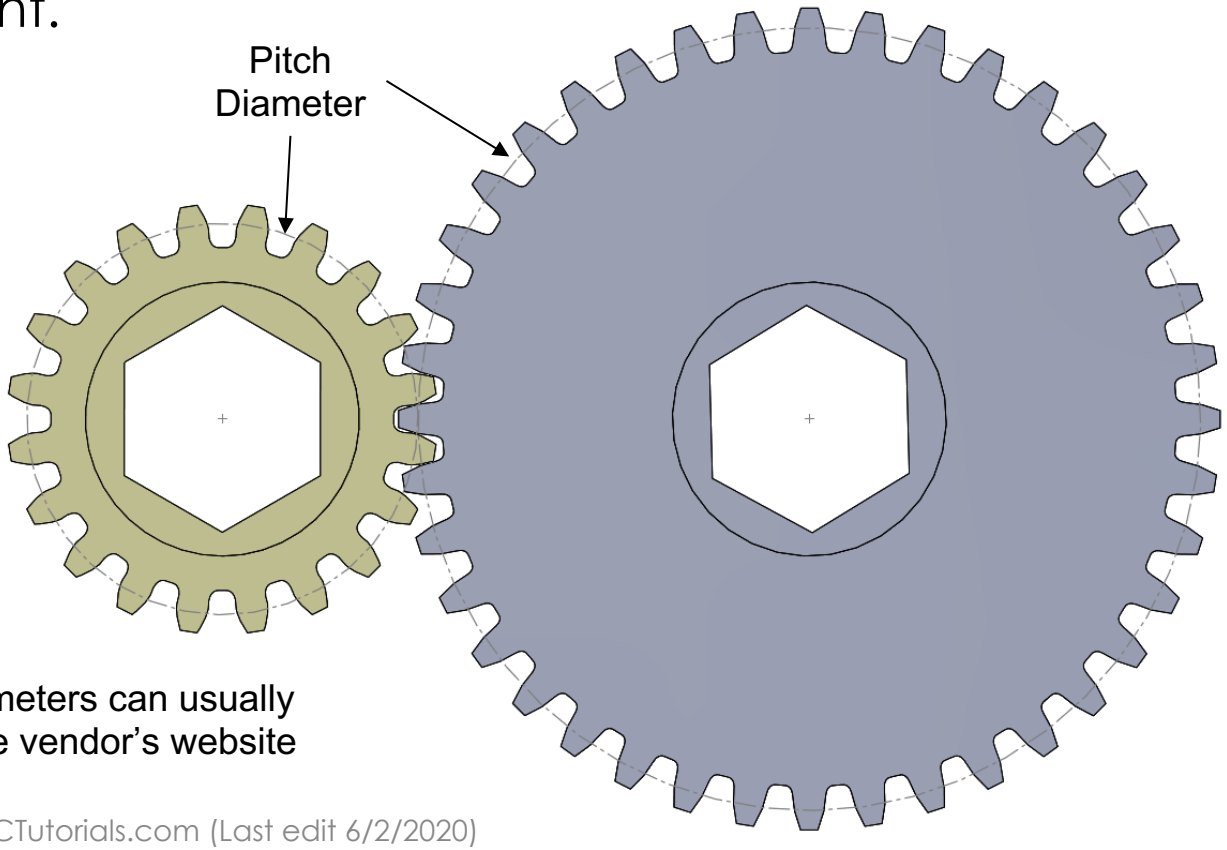
Gear Ratios

- Gears, along with pulleys and sprockets, allow for reductions, which is the increasing or decreasing of speed and torque.
  - A larger driving gear increases the speed of the driven gear but decreases the torque.
  - A smaller driving gear decreases the speed of the driven gear but increases the torque.
- Calculating Gear Ratios:
  - Number of teeth (Driving) : Number of teeth (Driven)



Gear Positioning

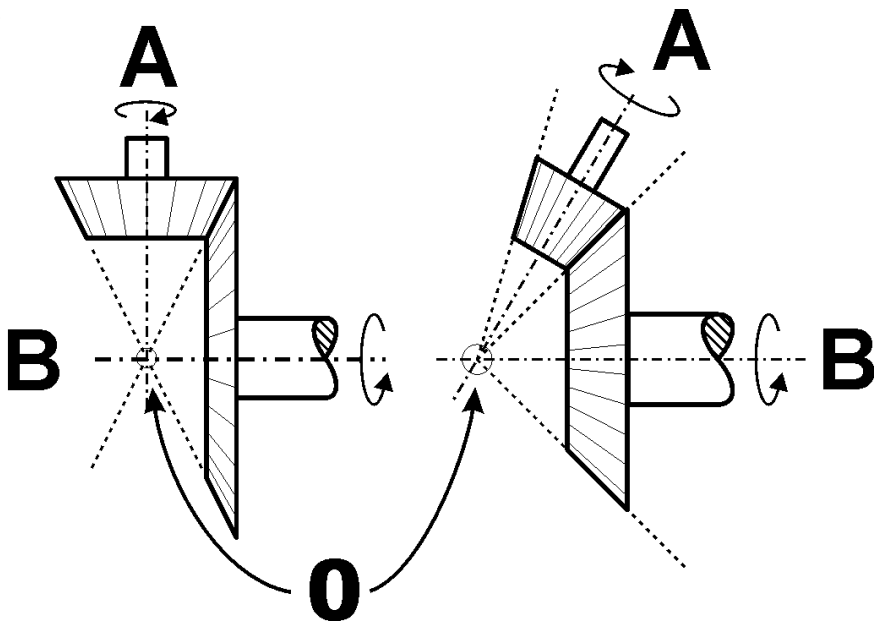
- Gear driven transmissions requires gears to be set at precise distances from each other for optimal performance
- For gears to work best together, the **pitch diameters** need to be tangent.



Gear pitch diameters can usually be found on the vendor's website

Gears at Angles

- Gears can be used to transfer motion at angles as well
- **Specialized gears** are required for angular transfer of motion, known as **bevel gears**.
- There are two main types of bevel gears:
  - Standard bevel gears
  - Miter gears



Bevel Gears

- Standard bevel gears are used for non-90-degree angles or gear ratios other than 1:1.
- Most common and reliable bevel gear is the 2:1 GoBILDA bevel gear set

Miter Gears

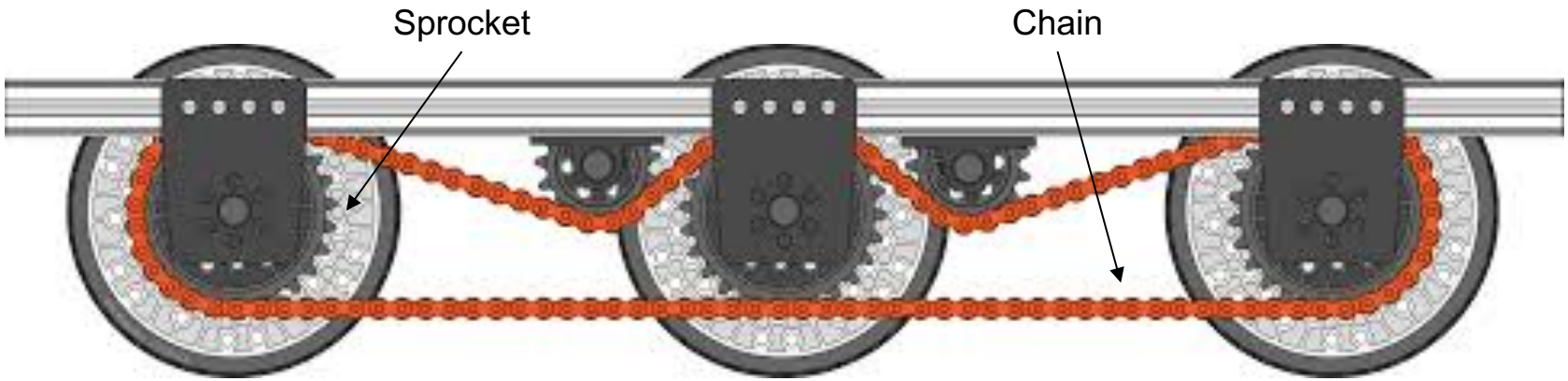
- Miter gears are specially designed for 1:1 90-degree angles
- GoBILDA's miter gears are extremely reliable COTS (Commercial Off The Shelf) parts for use in these situations

Gear Drive Pros & Cons

- Pros:
  - Easy use of reductions to increase or decrease speed and torque for the final output
  - Specialized gears such as bevel gears allow transferring rotation at angles
  - More compact for transferring rotation over small distances
- Cons:
  - Difficult to transfer rotation over long distances.
  - Small room for error when placing gears
    - Need to be a set distance apart for optimal performance

Chain Drive

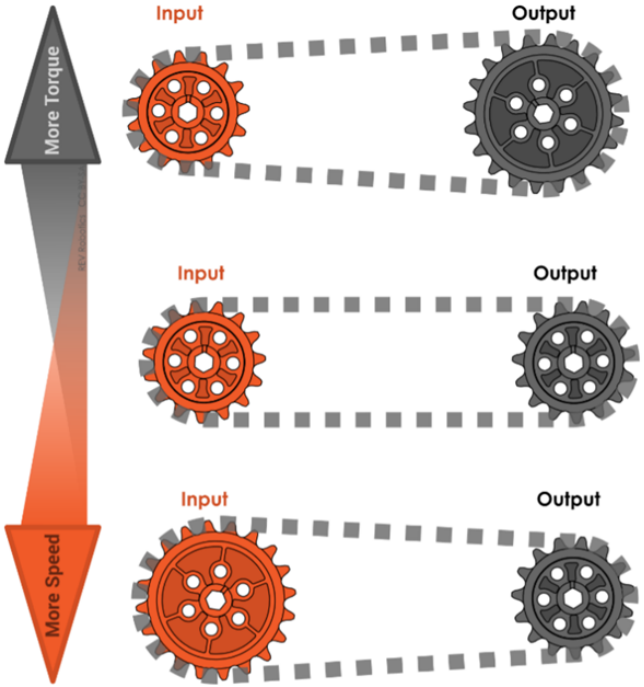
- Chain Drive is when a motor/servo rotates an object through **chain-connected sprockets**.



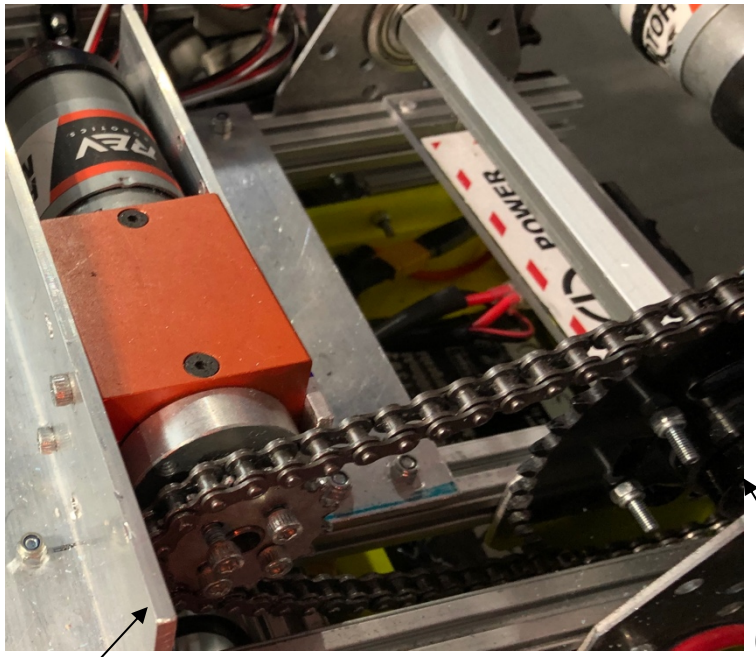
REV Robotics Chain Drivetrain

Gear Ratios With Chain

- Gear ratios work the same way with sprockets as with gears.
- A **larger driving sprocket** gives the driven sprocket **more speed**
- A **smaller driving sprocket** gives the driven sprocket **more torque**



REV Robotics Chain Guide



High-torque reduction from 18-19 season robot

Sprocket Positioning

- Positioning sprockets is much easier than positioning gears because of the leeway chain allows while still transferring motion
- Even though chain allows more leeway, it is important to **remove as much slack from the chain was possible**.
  - The less tension in the chain, the more the sprockets will wiggle independently

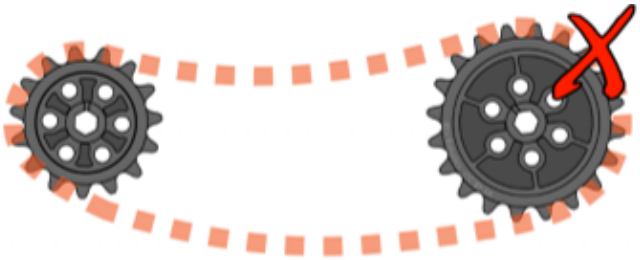


Figure 16: Incorrectly Spaced Sprockets (Chain too Loose)

Figure 17: Correctly Spaced Sprockets (Chain Correctly Tensioned)

REV Robotics Chain Guide

Sprocket Positioning Continued

- In order to find the length of chain required for two sprockets a set distance apart, a **chain length calculator can be used**.
- By searching for chain length calculators on the internet, various websites can be found that use the distance between and size of sprockets to determine the number of chain links required.
- Most calculators can also use the chain length and sprocket size to calculate the optimal sprocket distance.
- Some useful sites are:
  - http://www.botlanta.org/converters/dale-calc/sprocket.html
  - https://electricscooterparts.com/chainlengthcalculator.html

Chain Breaking

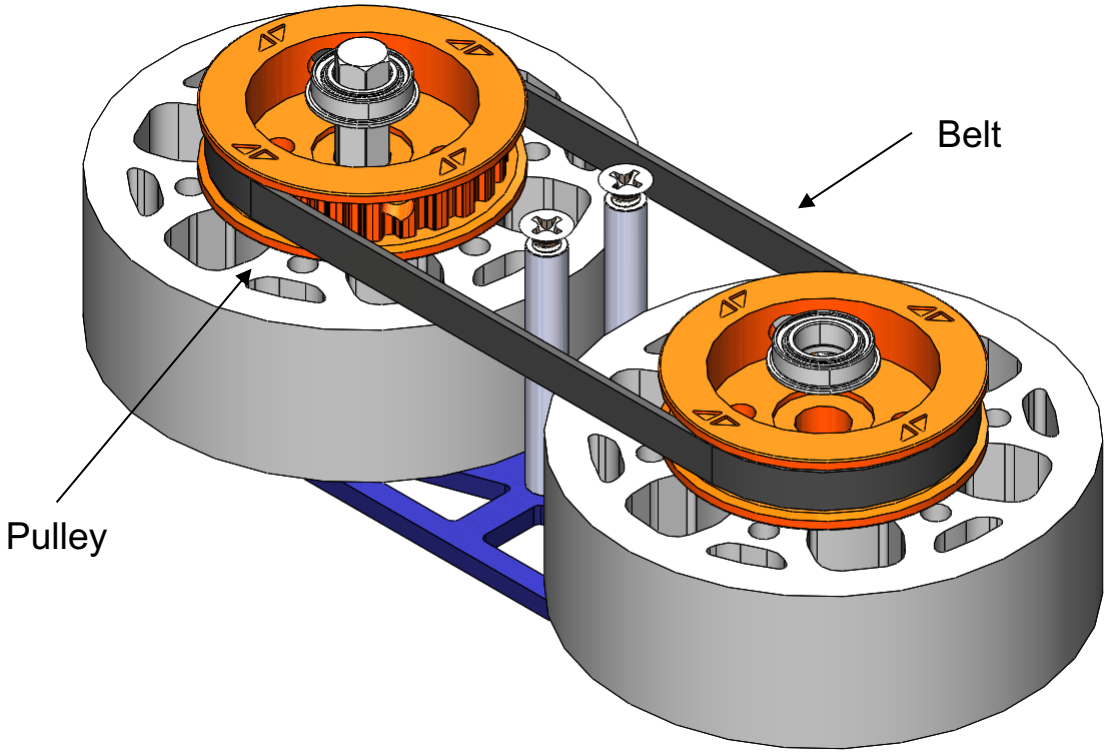
- In order the adjust the length of the chain, it must be broken at the appropriate links and put back together.
- Breaking chain and reconnecting it is extremely simple, and it can be reconnected in two different ways:
  - Using a master link
  - Resetting the chain
- A great guide created by REV Robotics for chain breaking can be found here:
  - https://www.revrobotics.com/content/docs/REV-41-1442-UM.pdf
  - The above link uses the REV chain breaker, but it can be done with any chain breaker rated for the chain being broken (#25 chain breaker for #25 chain)

Chain Drive Pros & Cons

- Pros:
  - Easy to transfer motion over large distances
  - More forgiving of spacing errors
  - Simple to put together
  - Durable
- Cons:
  - Cannot transfer motion at angles
  - Slightly less efficient than gears and belts
    - A small amount of motion is lost to the sprockets wiggling independently.

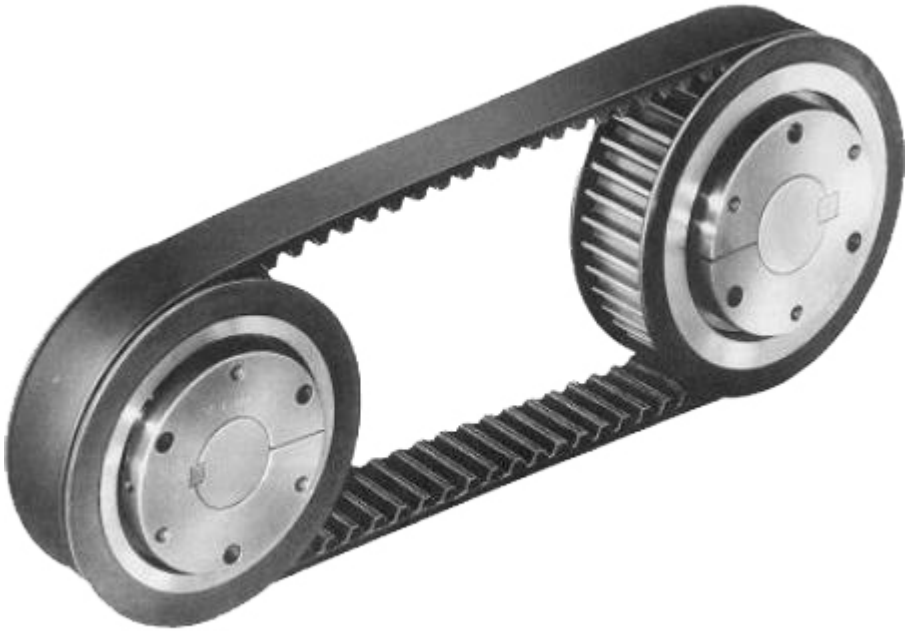
Belt Drive

- Belt Drive is when a motor/servo rotates an object through **belt-connected pulleys**.



Timing Belt

- The timing belt is the most used belt for FTC
- Timing belts are belts with **teeth on the inside** to move the pulleys with more friction
- Timing belt pulleys are similar to sprockets, however the teeth are usually shorter and smaller



Pulley Positioning

- Pulleys need to be accurately positioned for belt drive to work
- Too low tension prevents the belt from pulling on the teeth of the pulley
- Too high tension snaps the belt
- The best way to position pulleys is to use a **belt length calculator**
  - Very similar to a chain length calculator
  - The belt length calculator can calculate **belt size given pulley size and spacing**
  - It can also calculate **pulley spacing given belt length and pulley size**
- Some calculators:
  - https://www.bbman.com/belt-length-calculator
  - https://sdp-si.com/eStore/CenterDistanceDesigner

Belt Drive Pros & Cons

- Pros:
  - Extremely efficient
  - Easy to transfer distance over large distances
  - Quieter and lighter
- Cons:
  - Need to be precisely positioned to work
  - Tension needs to be exactly right to allow the belt to work
  - More expensive than chain options
  - Difficult to prototype with

Credits

- This lesson was written by The Antidote 14320 for FTCTutorials.com
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