Power Transmission Basics

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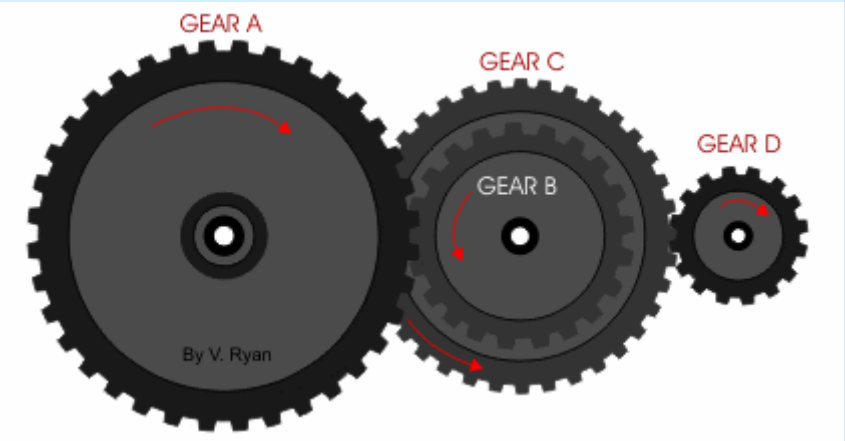
A Power Transmission, for the most part, allows rotational motion to be altered and moved around a mechanism. This allows for a mechanism to be far away from a motor and have more speed or torque than the motor outputs. Think about a bike chain, which can have its torque increased or decreased by moving to a larger or smaller sprocket on its casette. This works similarly, just on a smaller scale.

Ratios

These allow us to modify the torque and speed of a mechanism by making one rotation take longer than the other. This is by using the properties of a circle, and making the rotation of one gear take longer/shorter than the next. Watch this video for a pretty good explanation. A reduction indicates that the input gear is smaller than the output gear, which means that the torque increases. Conversely, a step-up indicates that the output is smaller than the input, making a mechanism speed up with less torque.
Ratios can stack, such that many gears next to each other multiply.
For example, a 12 tooth motor pinion interacts with a 48 tooth gear, creating a ratio of 4:1. On the same shaft as the 48 tooth gear, a 24 tooth gear drives a 60 tooth gear on another shaft, which has a ratio of 2.5:1, resulting in an overall ratio of 10:1 by multiplying the two.

Gears



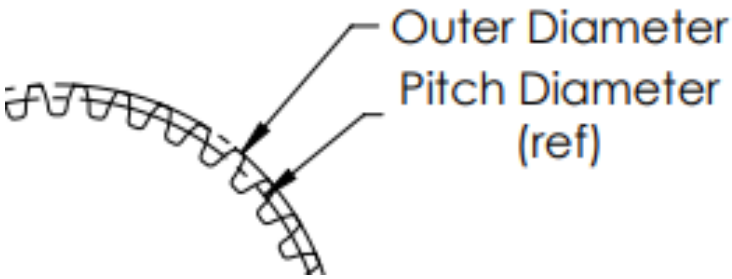
An example of a two-stage gearbox. Notice the difference in rotation speeds of the gears and their directions.

Gears are used for two primary purposes:

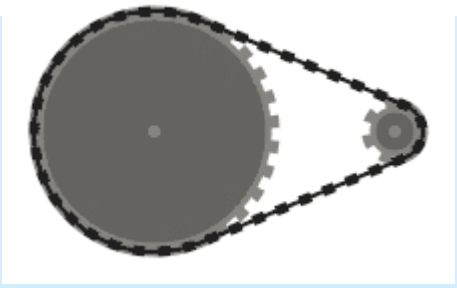
- Gear Ratios - By having a large amount of teeth and directly touching each other, it allows for a lot of compact reduction that is more reliable than chain or pulley.
- Inverting motion - Input and output gears spin opposite to each other, allowing one mechanism to make two things spin in different directions.

Most gears have the following important dimensions

- DP (Diametrical Pitch) - how many teeth in one inch. Most FRC Gears are 20DP, but 10DP and 32DP are also seen sometimes.
- Pitch diameter - how far the center is from where the next gear should interact with the gear. When making center to center distances for gears, use Pitch Diameter.
- Outer diameter - The actual diameter from the center of the gear to the outside of the teeth. This should be used for clearances.



Chains



An example of a one-stage chain reduction, with the large sprocket rotating much slower than the small sprocket, but notice the chain moves the same speed all around.

Chains are best for when lots of torque needs to be transmitted across a distance. They use a loop of chain around 2+ sprockets, which turn with the chain. Often seen on large mechanisms like elevators, arms, slapdown intakes, or tank drive systems.

However, some downsides is that they must be tensioned with either an idler sprocket, which is a sprocket that presses against the chain loop to keep it tensioned, a Cam to physically move the sprockets away, or an In line tensioner, to make the loop tight by shrinking its length.
They have the following important dimensions:

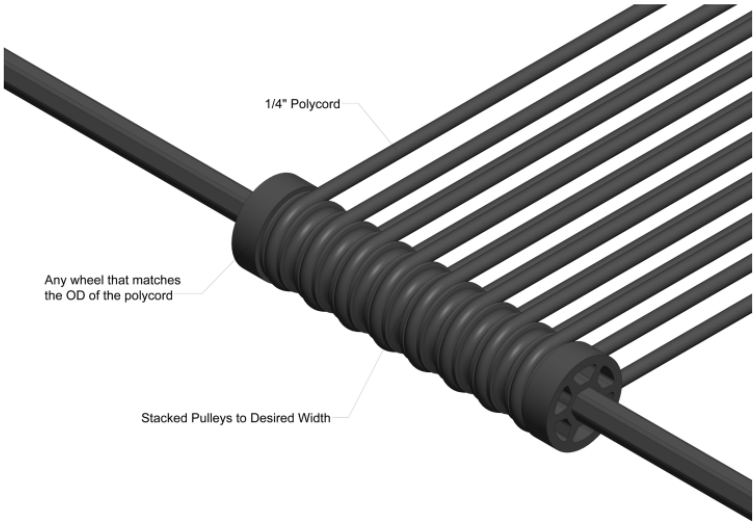
- Pitch - the distance between the centers of two cylinders in the chain. The most common in FRC are #25 and #35 (.25in and .35 in pitch diameter, respectively.)
- #25 vs #35 - #25 is lighter and has smaller sprockets, but has a lower strength compared to #35, which is approximately 3 times heavier. If you wanna use #25 chain in a high load environment, #25H adds some tensile strength and still works with #25 chain by simply adding a plate to the chain.

Belts

Belts are typically found in places where not much reduction is needed, but the motion needs to be transmitted to another spot. Belts interact with Pulleys, which turn a belt's linear motion into rotational motion. They are often found in roller wheel systems, as they are extremely light and easier to package than chains. There are multiple types of belts, but the most common in FRC are the following:

- Timing Belts - Belts with rounded teeth to interact with a toothed pulley. These have the least slip and are most efficient with power. Most common in FRC are HTD 5mm timing belts o [illegible] D is stronger, but GT2 is smaller and lighter.

- V-Belts - Timing belts with V-shaped teeth. Not super common in FRC.
- Polycord Belts - Belts that come in a spool and must be fused together. Can have toothless pulleys, and are more used for moving items linearly, such as game pieces in an indexer. Not often seen for power transmissions though.



Math

We do not make vibes-based robots, so there is math and intention behind every power transmission. You should be using Reca.lc, ambcalc.com, or JVN Mechanical Design Calculator on all mechanisms. Find the belt or chain calculator, and input your sprockets or pulleys and center-center distance. This will give you the specific belts you need, or how many chain links you should use. For individual mechanisms, calculate the gear ratio first, then input that into their respective calculators.

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