Using VEX IQ Plastic Gears, Sprockets, and Pulleys

https://kb.vex.com/hc/en-us/articles/360039539291-Using-VEX-IQ-Plastic-Gears-Sprockets-and-Pulleys

In This Article

As new users begin to assemble their own custom robot designs they may at some point want more from their VEX IQ Smart motors. The VEX IQ Smart Motors have perhaps the best performance and sensing of any snap-together robotic system available. Nonetheless, users could want the motors to move things faster, lift heavier things, or move mechanisms far away from the motor. VEX IQ Gears, Sprockets, and Pulleys can allow these requirements to happen.

Gears	Sprockets	Pulleys
		

Output/input ratios

When discussing the VEX Plastic Gears/Sprockets/Pulleys there are some standard terms which are used:

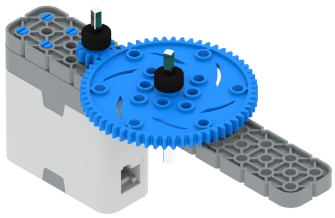
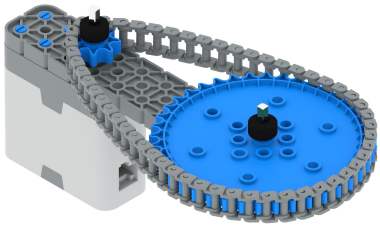
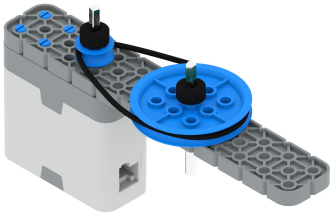
- **Driving/Input -** This is the Gear/Sprocket/Pulley placed on the shaft a Smart Motor is forcing to spin.
- **Driven/Output -** This is the Gear/Sprocket/Pulley placed on the shaft of the component (such as a wheel or an arm) which will be forced to spin from the input.

- **Rotational Speed -** This is how fast a shaft is spinning, commonly measured in how many times it spins in one minute, also known as, revolutions per minute (rpm).

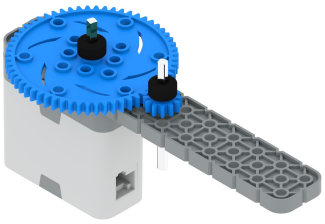
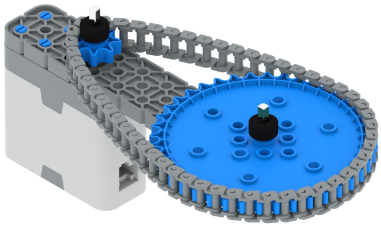
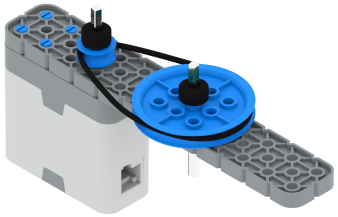
- **Torque -** This is the amount of force needed to rotate a load at a distance. For example, it takes more torque to rotate a longer arm or when there is more weight placed on the arm. It also takes more torque to rotate a larger diameter wheel, or when a wheel is moving something heavy. Torque is commonly measured in the metric unit which combines force and distance call the Newton-meter (Nm).

There are two principles which will help users understand how to use VEX Plastic Gears, Sprockets, and Pulleys:

Increased Torque: When the input Gear/Sprocket/Pulley (component) has a smaller diameter than the output component, this will increase the output torque of the system. However, it will proportionally decrease the output rotational speed of the system. In other words, if the motor cannot lift an arm, the motor needs to have a smaller component driving a larger component on the arm's shaft.

Gear Increase Torque	Sprocket Increase Torque	Pulley Increase Torque
		

Increased Speed: When the input component has a larger diameter than the output component, this will increase the output rotational speed of the system. However, it will proportionally decrease the output torque of the system. For example, if a user wants a wheel to spin faster than the motor can spin, the motor needs to have a larger component driving a smaller component on the wheel's shaft.

Gear Increase Speed	Sprocket Increase Speed	Pulley Increase Speed
		

The amount of these relationships can be calculated by an output/input ratio. This is:

- The number of output gear teeth / the number of input gear teeth yields the torque gear ratio.
- The number of output sprocket teeth / the number of input sprocket teeth yields the torque sprocket ratio.
- The diameter of the output pulley / the diameter of the input pulley yields the torque pulley ratio.

Ratio Equations:

$$GearRatio = \frac{DrivenGear\#ofTeeth(Output)}{DrivingGear\#ofTeeth(Input)}$$

$$SprocketRatio = \frac{DrivenSprocket\#ofTeeth(Output)}{DrivingSprocket\#ofTeeth(Input)}$$

$$PulleyRatio = \frac{DrivenPulleyDiameter(Output)}{DrivingPulleyDiameter(Input)}$$

VEX Plastic Gear Ratios (60 teeth, 36 teeth, 12 teeth)

Output Gear	Input Gear	Gear Ratio	Output for 100 RPM Motor Input	Output for 0.4 Nm Motor Input
60 teeth	12 teeth	5:1	20 rpm	2.0 Nm
36 teeth	12 teeth	3:1	33 rpm	1.2 Nm
60 teeth	36 teeth	5:3	60 rpm	0.67 Nm
36 teeth	60 teeth	3:5	167 rpm	0.24 Nm
12 teeth	36 teeth	1:3	300 rpm	0.13 Nm
12 teeth	60 teeth	1:5	500 rpm	0.08 Nm

(24 tooth and 48 tooth gears are available in an add-on pack)

From the VEX Plastic Gear Ratio chart above it should be apparent that ratios can dramatically change the amount of output rotational speed and output torque of a Smart Motor. It is important to realize when using output/input ratios these do not take into account friction and other factors in the robot's system.

For instance, it might be tempting to build a 1:5 gear ratio for the drivetrain so the robot will move very fast (500 rpm). There are several factors, which make this impractical. First, the 60 teeth gears are larger than the standard 200mm Travel Wheels so the gear will hold the wheel off the ground. In addition, the output torque will be so small (0.08 Nm) the Smart Motor may not be able to move the wheel/robot. Even if it were possible to use this ratio, if the robot were to move at five times its normal speed it would be very difficult to control.

This example illustrates how when using output/input ratios the objective is to find a "sweet spot" balance between torque and speed. It is also important to make sure the components will fit into the robot's design.

VEX Plastic Sprockets have five different sizes of Sprockets (8 Tooth Sprocket, 16 Tooth Sprocket, 24 Tooth Sprocket, 32 Tooth Sprocket, 40 Tooth Sprocket) which can be combined. The VEX Plastic Pulleys have four available sizes (10mm, 20mm, 30mm, 40mm).

Power Transfer

VEX Plastic Gears, Sprockets, and Pulleys may also be used for power transfer. This is needed when a design does not allow a Smart Motor to directly drive the shaft of a wheel or other component. In this case, the input and output

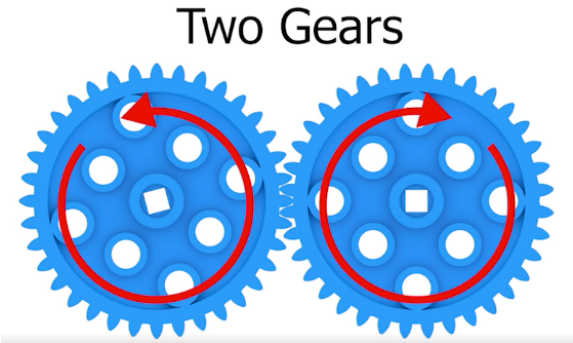
Gears/Sprockets/Pulleys will be the same size so there is no change to the torque or the rotational speed. This is often called an 1:1 ratio.

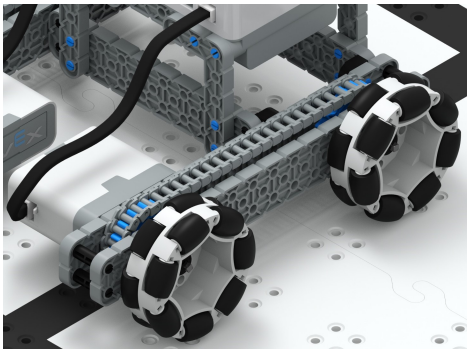
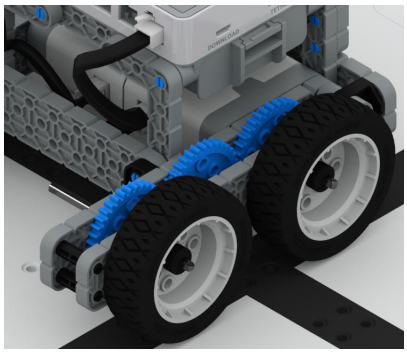
Some examples of this might include:

- A drivetrain can power both wheels on a side by direct driving one wheel with a Smart Motor and power the other wheel by connecting them together with 1:1 Sprockets and Chain.

- A drivetrain can have 3 gears (or any other odd-number) in a series and have a wheel attached to the first gear and a wheel attached to the last gear. If all the gears are the same size, the motor can drive any one of the gears.

Please note when using gears within a drivetrain it is important to have an odd number of gears between the wheels. This is because when one gear drives another, they rotate in opposite directions. An even number of gears between wheels will have the two wheels turning against one another.



Power Transfer Sprockets	Power Transfer Gears
	

Deciding on which component to use: Gears, Sprockets, or Pulleys

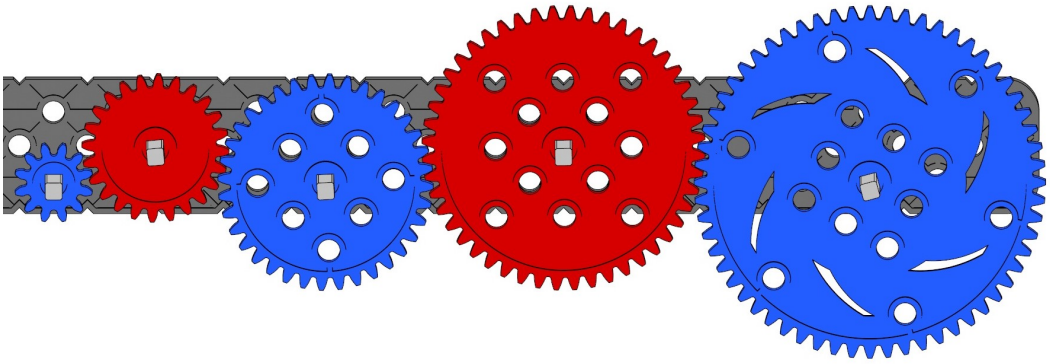
There are a number of factors which determine whether Gears, Sprockets. or Pulleys should be used with a robot design. Some of these include:
Gears: Gears are one of the most reliable of the three choices of components. Unless there is too large a span between the supports of the gear shafts allowing the shafts to flex enough for the two gears' teeth to separate; with gears, when the input gear spins, the output gear will spin. However there are some drawbacks:

- Gears have to be arranged at fixed distances from one another so the teeth of one gear intermesh with the teeth of the next.

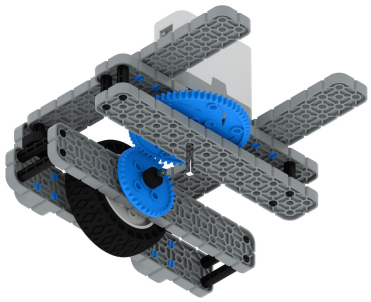
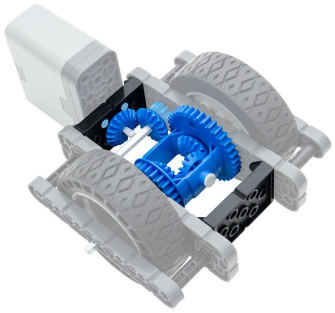
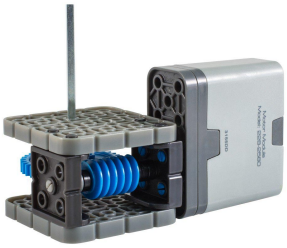
- Gears need to be aligned in a straight line to one another. (Noted exception: to mix "Primary" 12/36/50 tooth gears with the "Secondary" 24/48 gears. The secondary gears need to be either offset by half a pitch, or need to use the extra middle hole in even-length 1x Beams).

- As mentioned before, an odd number of gears in a line will have the input and output gears spinning in the same direction, and an even number will have the input/output gears spinning in opposite directions.
Mixing "Primary" 12/36/60 tooth gears with the "Secondary" 24/48 gears

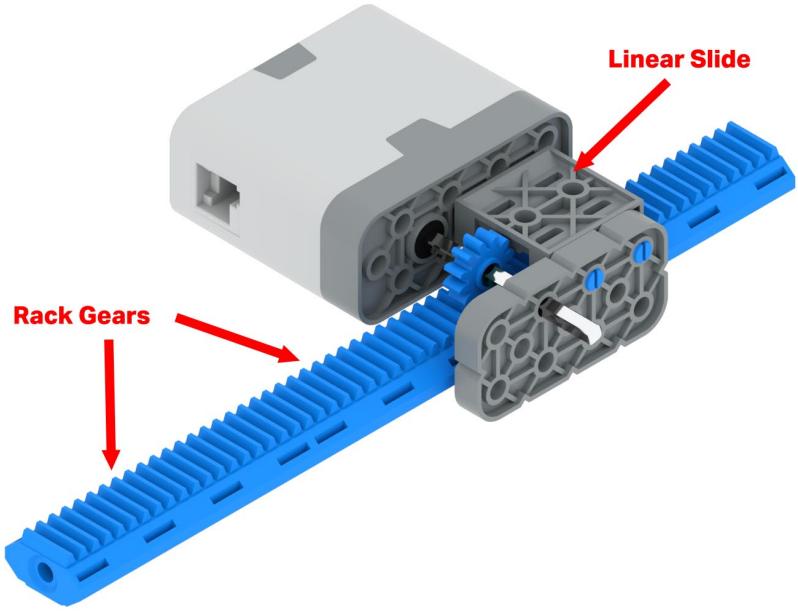
Mixing "Primary" 12/36/60 tooth gears with the "Secondary" 24/48 gears



Special note: When using a gear ratio, only the input gear size and the last output gear size need to be considered. Any gears in between those two gears only transfer the motion and their sizes have no effect on the gear ratio.
VEX Plastic Gears also have a Crown Gears which will allow for a 90^{o} connection between gears. There are also Worm gears and a Differential & Bevel Gear Pack which allow this.

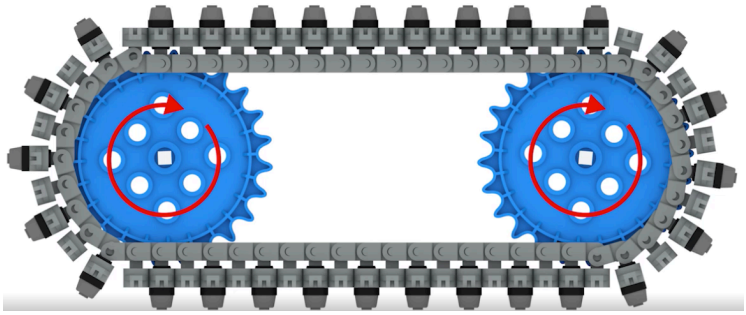
Crown Gears	Differential & Bevel Gears	Worm Gears
		

In addition, VEX Plastic Rack Gears from the Gear Add-on kit will allow for linear motion.

Rack Gears


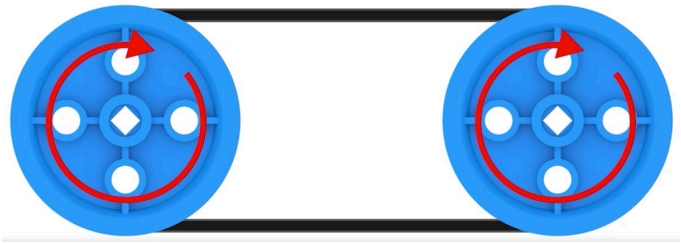
Sprockets: Sprockets are also a good option. Their shafts can be separated at any number of different pitch distances because the chain is assembled from individual snap-together links, which can be put together in custom lengths. The input Sprocket and output Sprocket will always be spinning in the same direction. The driving Sprocket should have at least 120^{o} of chain wrapped around it or the chain can skip teeth on the Sprocket. Sprockets can also be connected together with Tank Tread.

Two Sprockets Rotates Same Direction



Pulleys: Pulleys are intended for light loads. They are limited by the distances they can be separated by the lengths of the available Rubber Belts (30mm. 40mm. 50mm. 60mm). Like Sprockets, the input Pulley and the output Pulley spin in the same direction. The Rubber Belts for the Pulley system are smooth. The belts will slip if the load the system is trying to move is too large. (Note: rubber belts can be crossed over to reverse the output pulley direction.)

Two Pulleys Rotates Same Direction



Whether the robot design uses Gears, Sprockets, or Pulleys, there is a large choice of options to change the output/input ratio or power transfer of the VEX IQ Smart Motors.

Safety Hazard!	Pinch Points
	Be sure to keep fingers, clothing, wires, and other objects from getting caught between moving components.