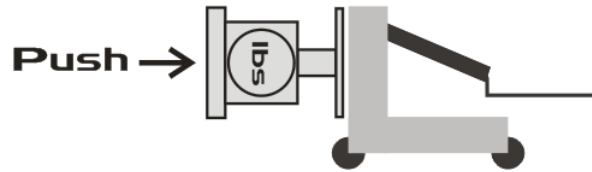


Calculating Torque and Speed

In this document, I am going to explain how to calculate the torque and speed of your VRC robot. It is very important to design robots with a good balance of speed and torque because increasing one will often sacrifice the other.

How much torque do you need?

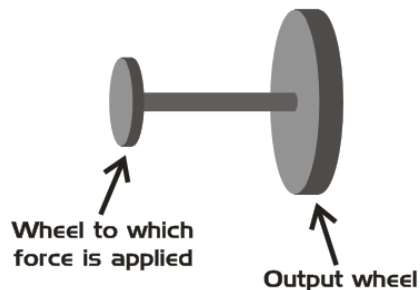
A good way to find out is to disconnect the wheels from the motors and slowly push the robot using a scale.



The pound reading of the scale at which the robot starts moving is equivalent to the torque needed to overcome static friction. This is the minimum amount of torque your robot needs to supply in order to move. It is a good idea to have around twice this amount, as you do not want to get shoved around by other robots during a match.

How do you calculate the torque your planned configuration yields?

First, let me define some terms. On the left is the wheel to which force is applied. This is the gear inside the motor that is connected to the axel. On the right is the output wheel. This is your robot's tire.



The formula for calculating the torque of the output wheel is:

$$\text{Torque of output wheel} = \frac{\text{Radius of wheel to which force is applied} \times \text{Torque of motor}}{\text{Radius of output wheel}}$$

For this example, let's say that you are using a 269 motor attached to a 4" wheel, with 1:1 or no gearing, and the force needed to overcome static friction is measured as .5625 pounds.

To get the radius of the wheel to which torque is applied, you have to look inside of the motor. The radius of the wheel to which force is applied for the 269 is .268.

Solving for the wheel torque, we get 1.1524. We see that with this setup, we have more than enough torque to overcome static friction.

What do you do if your robot does not have enough torque?

You add gearing. All you have to do is take the torque that you calculated before and multiply it by the gear ratio. In our example, let’s apply a 3:2 motor to wheel gear ratio. Taking our wheel torque, 1.1524, times 3/2 we get 1.7286, higher than our original example without changing the motor or wheel.

How do we know what the speed of our drive train is?

The formula for calculating speed in feet per second is:

$$\frac{\text{Circumference of wheel (in)}}{12} \times \frac{\text{Motor RPM}}{60} \times \frac{1}{\text{Gear Ratio}}$$

Solving for FPS, we get 1.1654 feet per second. According to the users of the Vex forum, VRC robots typically have a speed of around 2.5 FPS, so for this robot we might want to change the gears to make it faster.

If you study the formulas, you will see that changes to the gearing to increase speed will decrease your torque, and changes to increase torque will reduce speed.

Motor specs

	Torque (in-lbs)	Speed (RPM)
2 wire 269	8.6	100
2 wire 393	13.5	100
3-wire Motor	6.5	100

Radius of wheel to which torque is applied

	Internal Gear Size
2 wire 269	0.268
2 wire 393	0.327
3-wire Motor	0.341