Once you’ve built your robot, you’re going to want it to go somewhere—and everyone knows the shortest distance between two places is a straight line. In the world of LEGO robots, going straight is one of those things that is easier said than done. Many new teams in FLL will rely on odometry, or dead-reckoning, to get their robot to the desired location on the game field.

Odometry is when you use measurements or rotations as a way to navigate your robot to a point on the field. You’re simply telling the robot to go a predefined distance, and using the rotation sensors built into your robot’s NXT motor to determine if you’ve gone the desired distance. The position will be measured relative to your starting point. As you will discover, this does not always land your robot where you expected it to end up.

Solely relying on odometry for navigation of your robot is not a good idea; a smart robot will find ways to incorporate landmarks on the game field and be able to analyze where it is in relation to its target using various methods and sensors. It is important to recognize the limitations of the technique, including its risks and to use it only when appropriate. In the FLL Smart Moves challenge, some field items were put in place to purposely limit the use of pure odometry in navigating the missions. So while it can be quick a way to get started on some missions, try not to rely on it too much.

**Wheel Circumference**

Knowing the circumference of your drive wheels is important when determining how far your robot is going to travel, assuming you are running your wheel directly off the motor, and not going through a series of gears. If you program your Move block to turn four rotations, how far is your robot actually going to travel? This is where knowing your wheel’s circumference is important. So now you get to use some math. A basic formula to know is circumference = \(\pi \times \text{diameter}\). The circumference is the distance the wheel will travel after one complete rotation, as seen in Figure 7-1.
Ni refers to the standard mathematical value by which you multiply the diameter to obtain the circumference. Pi is a never-ending string of decimal digits, but 3.14 is a reasonable approximation.

Figure 7-1. Calculating the circumference of a wheel

If your wheel has a circumference of 3 inches and you’re moving four rotations, the expected result is that your robot is going to move forward 12 inches (circumference × rotations); or if you need to calculate the number of wheel rotations, then the formula would be duration = distance/ circumference. This may seem very straightforward to understand, but so many teams skip right over doing such calculations and just use “trial and error” to get the correct value for their count of the wheel rotations. And then what happens is that something changes with their robot, such as gear ratios or wheel size, and now all their movements are miscalculated and they have to start over with a guessing process to determine the proper rotations.

But if a team understands the math behind calculating the proper rotations from the beginning, then changes will have a very minimal effect on their progress and will not delay the team in moving forward. Also, these are good talking points the team should share with an event’s robot design judges. Judges are much more impressed with teams that understand and explain why the robot is performing the way that it is. If a judge asked a team member why the team chose to use four rotations in their program, and the team member simply states that they “just kept trying numbers until something worked,” it doesn’t sound nearly as impressive as being able to explain the true mathematical reason why four is the correct number of rotations needed for the robot.

Don’t forget to take any gear ratios into account when calculating the proper rotation. The gear ratio is the value determined by the number of rotations one gear may have in relation to another gear that is driving it. For example, if a small gear is driving a larger gear, the small gear will turn more times than the larger gear. The small gear may turn three times for every single turn of the large gear. Such would be a 3 to 1 ratio, often expressed as 3:1.

In a scenario involving a gear ratio from a driving gear, you would determine the number of wheel rotations using the following formula:

\[ \text{duration} = \frac{\text{distance}}{(\text{circumference} \times \text{ratio})} \]

For example, say that you have a wheel with a circumference of 3 inches that is being driven by a motor hooked to a gear setup with a 3:1 ratio. Your formula would be:

\[ \text{rotation} = \frac{12}{(3 \times 1/3)} \]