Lab 1 Report

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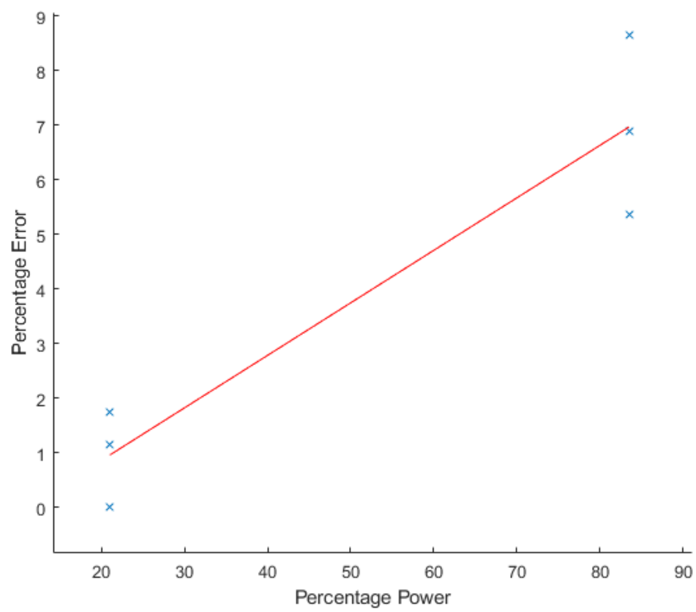
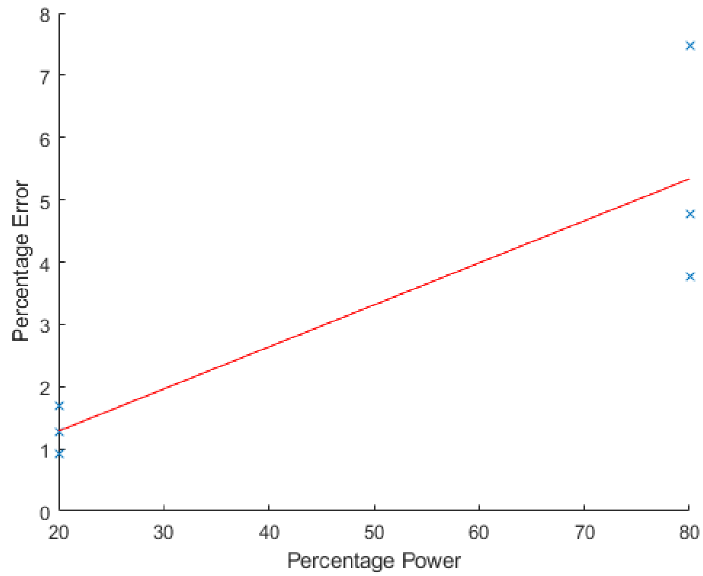
2) Error Collection & Analysis

- Measuring Error in a straight line: We measured the error by using a ruler, and by using an ultrasonic sensor. We measured the diameter of the wheels, which then allowed us to measure the circumference of the wheels. We would then ask the program to move a certain number of revolutions, and then we would measure how much the robot moved. We found that using the sensor is much more accurate than using a ruler. This is due to the accumulation of human error in: a) measuring the diameter of the wheels (which generates an error in our circumference calculation and b) measuring the initial and final position of the robot next to the ruler. We have also found that one of our motors is more powerful than the other, which means that if we try to get the robot to move forward by applying the same power to the wheels, it actually arcs, which translates to some error in our distance traveled measurement, so we had to account for that by applying different powers to the motors to get the robot to move in a straight line, but of course that line was not perfectly straight. Due to this, there is some error in our measurements for both methods, although there was a smaller percentage error when using the sensor. Also, the UltraSonic sensor on our robot is slightly slanted, which means that there is a slight difference in the distance its reading, and the actual perpendicular distance between the wall and the robot. We have found that the percentage error increases as the power to the wheels increases. We took some measurements at low and high percentage power and plotted a scatter plot of motor power against percentage error, and found a statistically significant relationship with an R-squared value of 0.8862 (refer to the graph below).

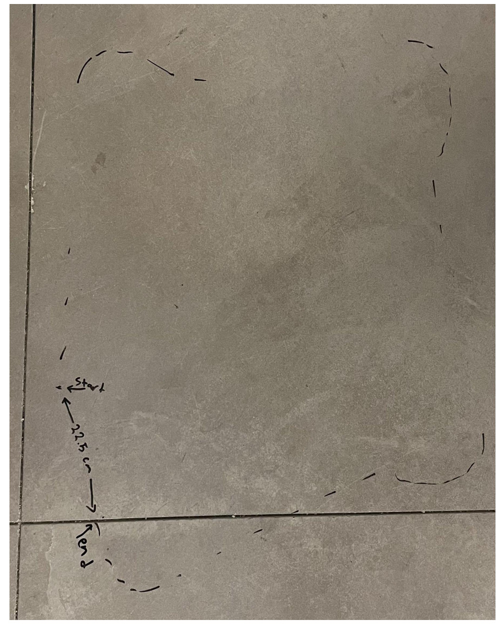


- <u>Measuring Error in Rotation:</u> For the error in rotation, I took measurements with a Gyro and on my own. The way I took my own measurements was I drew a line parallel to the orientation of the robot's wheels, then drew another similar line after the robot completed its rotation. I then extended those two lines until they intersected, then used a protractor to measure the angle between them. Similar to our findings when measuring error in a straight line movement, we found that if we increase motor power, percentage errors also increase. We ran a small linear regression on the measurements we took (similar to the one above) and found an R-squared value of 0.7692 (refer to graph below).

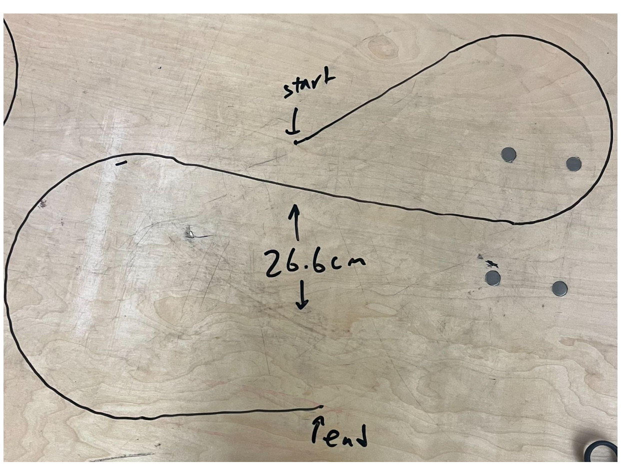


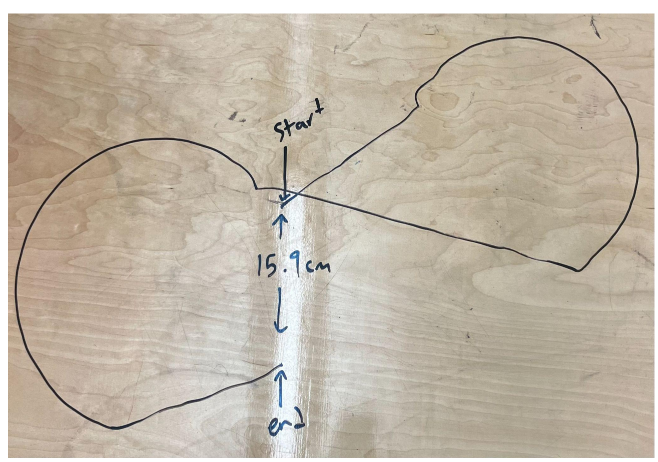
3) Shapes:

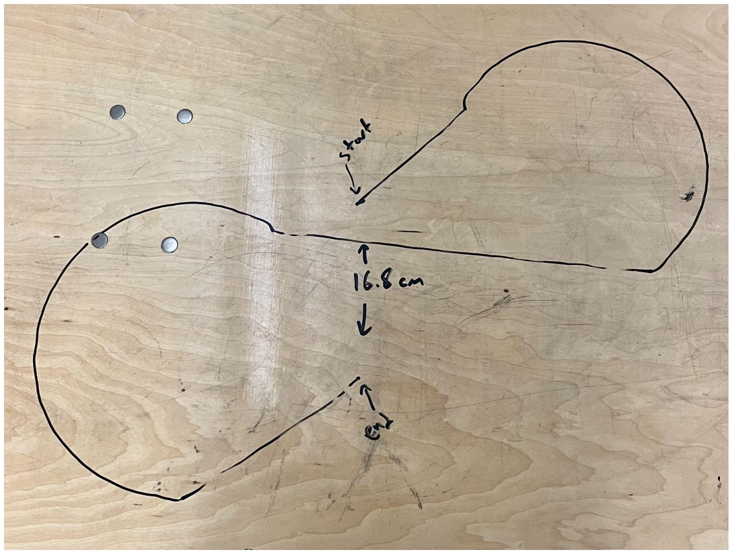
- Rectangle: From part 2, we know that there is some error in rotation and in moving in a straight line (meaning our robot deviates even though it's supposed to go straight, not just an error with distance covered). Other than that, the marker was placed on the side of the robot, which affected the final drawing by drawing a small arc at the corners of the "rectangle". We also made our rectangle sides long, which means there's a big accumulation of error, which, combined with what I mentioned above can explain the deviation between our starting point and ending point. For 2 of the 3 drawn rectangles, the errors are very similar, i.e. the start and end points are about the same distance apart in both. For the third rectangle, where the error is relatively small when compared to the first two. I think this is due to the irregularities of the different floor tiles (some tiles are smoother, some are more elevated than others, etc.), combined with the irregular shape of our robot's ski, turned out to be good conditions on this run and gave us a smaller error.



- Lemniscate: Similar to the rectangle, the accumulation of error when moving in a straight line and the errors in rotation are clear when we look at the drawings below, although in this case the error in rotation contributes more to the total error. Another thing that contributes to the irregularity of these drawings is the fact that the tables we've used to draw them on are themselves irregular - some parts have some old markings which increases friction between the table and the wheels, and some parts are slightly curved.







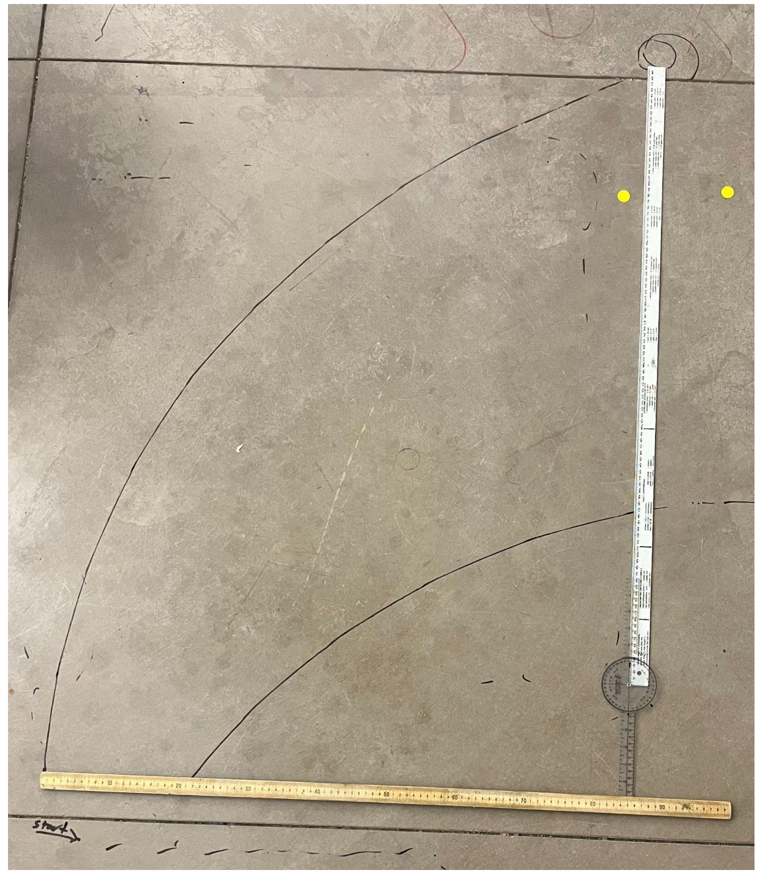
- We can conclude that we cannot trust our robot to perform the same action consistently. We must always use sensors and other methods of polling the state of the robot, and change what the robot is doing at a certain time point depending on its state. For example, we can use a gyro sensor when moving in a straight line such that if the robot starts deviating (possibly due to bumps in the road) we can update the power to the motors to get it back on track.

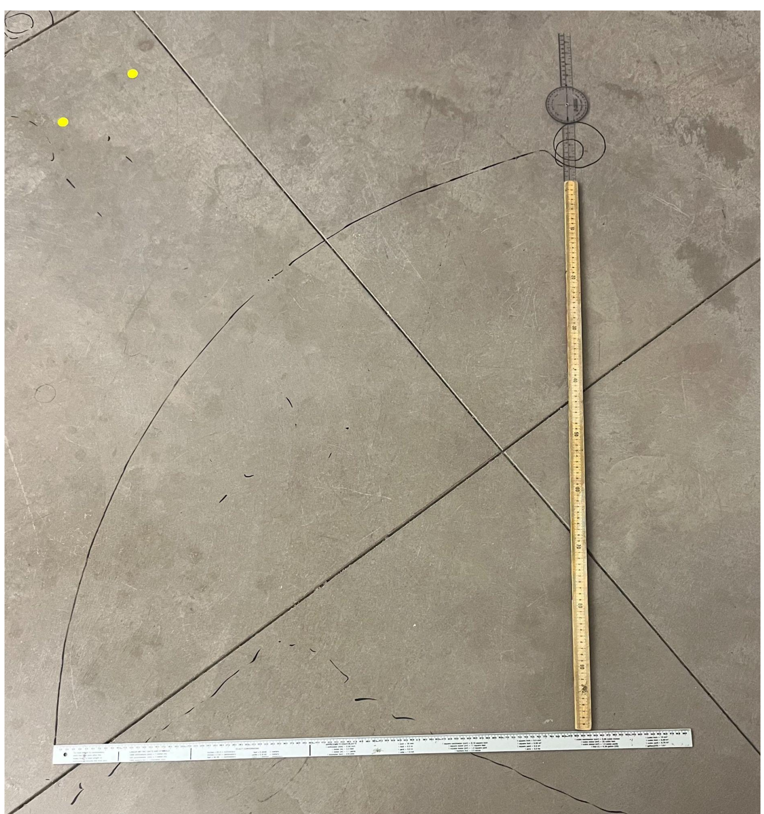
4) Dead Reckoning:

- For our formulas, we used the extra lab notes provided at the end of the lab description, so I won't be explaining them here. During this part, we realized that the formulas given do not actually calculate the true distance traveled. By this I mean that the formulas essentially take the total angle of rotation of the robot (at the end of its trajectory) and the average wheel velocities, and assume we have traveled at the average wheel velocity, oriented exactly like the final orientation of the robot. This means that where the robot thought it was was different from where it actually was (imagine drawing an arc, checking your final orientation, then assuming you traveled in that direction in a straight line). To fix this, instead of trying to calculate where we were using the final orientation and the average linear velocity over the whole trajectory, we broke the path into 0.25 second time intervals, and changed our formulas so the vectors it calculated actually aggregated to give us a good approximation of our final position and orientation.

- Here are some of the readings I took, along with the corresponding picture of the trajectory (format is [x, y, theta°]):
  Note: The actual measurements of angles are approximations. The "(+360°)" means that the robot completed 1 full revolution before reaching the approximate final orientation.

1. (Top Left Image)
   Kinematics: [129.8, -75.8, 696.2°]
   Actual Measurements: [123.5, -81.5, ~315° (+360°) = 685°]
2. (Top Right Image)
   Kinematics: [118.7, -76.6, 626.8°]
   Actual Measurements: [116.2, -85.0, ~247.5° (+360°) = 607.5°]
3. (Bottom Image)
   Kinematics: [105.4, 84.8, 670.8°]
   Actual Measurements: [101.3, -86.7, ~270° (+360°) = 630°]


Start



5) Braitenberg Vehicle Videos (Google Drive):

- Cowardice:
  https://drive.google.com/file/d/1vh2HPz6keCYzyaLko28966bNn9AZhs44/view?usp=sharing
- Aggression:
  https://drive.google.com/file/d/1MQBNGio22GSpkJxRJiq_igqaM5zI15ux/view?usp=sharing