1. Graph of Motor Set Speed vs Encoder RPM value Parameters:
   1. Y2: RPM of motor at higher speed.
   2. Y1: RPM of motor at lower speed.
   3. U2: Power of motor at higher speed.
   4. U1: Power of motor at lower speed.
   5. K: Gradient of the tangent of the steepest part of the curve.
   6. T(d): Time from the change of motor set speed by Arduino, to the point where the tangent meets lower bound.
   7. T(s): Time from the point where the tangent meets the lower bound, to the stabilization of RPM of the new motor set speed.
   8. U: The output set speed to be supplied to the motor.
2. First set of calculations for PID based controller:
3. Second set of calculations:
4. Third set of calculations:
5. Fourth set of calculations:
6. Calculation of digital PID control law:
7. Movement Information:
   1. Wheel radius is 3cm, circumference is 6\*π = 18.9cm.
   2. For one complete revolution of both wheels, the robot moves forward by approximately 19cm.
   3. For advancing 10cm, the wheel should rotate only 10/6π or 0.53 revolutions.
   4. For moving in a straight line, the RPM of both motors are the same.
   5. For turning left, right, or backwards, one motor’s RPM will be a negative value but of the same magnitude.
   6. Only need to upload the code for calibration once to obtain the value of U.
   7. Code does not need to be uploaded into the Arduino for evaluation.
8. Method to calibrate:
   1. Set the lower bound of motor set speed to 0.
   2. Set the upper bound of motor set speed to 400.
   3. Use the function millis() to keep track of the time each data point was recorded.
   4. The duration from the time the motor is at speed 0 to the time it reaches 400 is very short, use baud rate of 115200 to obtain as many data points as possible.
   5. The data obtained from each point shows the encoder output value at that point, which must be converted into the RPM of the wheel.
   6. Repeat the above steps a few times to obtain an average of all the data points.
   7. Plot the data points on a graph and obtain a curve in the form of a first order differential equation.
   8. Obtain a tangent at the steepest point of the curve and note where it intersects the horizontal lower bound.
   9. Obtain the values of K, T(d) and T(s) as shown above.
   10. Obtain the values of K(p), K(i) and K(d) as shown above.
   11. Determine the exact RPM that you want the wheel to turn at, such as 20RPM.
   12. Calculate the parameters K1, K2, K3 as shown above.
   13. Read the encoder value and convert it into RPM.
   14. Calculate the error between the set RPM and the current RPM.
   15. Find the motor set speed output ‘U’ using the digital PID control law as shown above.
   16. Repeat this process until a value of U is obtained for both motors.
   17. Only that value of U should be used as the fixed motor set speed for evaluation.
9. Left motor calculations:
   1. Duration of time interval: 112ms.
   2. K = (400 – 0) / (1111 – 999) = 3.57, for both motors.
   3. Tau(d) for Left motor: 66ms
   4. Tau(s) for Left motor: 66ms
   5. K(c) =
   6. T(i) =
   7. T(d) =
   8. K(p) =
   9. K(i) =
   10. K(d) =
   11. K1 =
   12. K2 =
   13. K3 =
   14. U =

1. Right motor calculations:
2. Duration of time interval: 112ms.
3. K = (400 – 0) / (1111 – 999) = 3.57, for both motors.
4. Tau(d) for Right motor: 66ms
5. Tau(s) for Right motor: 66ms
6. K(c) =
7. T(i) =
8. T(d) =
9. K(p) =
10. K(i) =
11. K(d) =
12. K1 =
13. K2 =
14. K3 =
15. U =