Project 08 PID Controller

Effect of Proportional Gain (Kp):

- Primary objective: Reduce time required to get to the required error value.
- Functioning: The corrective term is directly proportional to error value.
- Drawback:
  - Error does not completely go to zero
  - Higher (than optimal) gain value can cause overshoot and oscillations
  - Lower (than optimal) gain value can cause a long time to correct / reach required state
- Value chosen was 0.3.
  - This value still causes some oscillations but gives a good performance over the entire track
  - While lower values (0.1-0.3) could still work, one part of the track with sharper turns requires a higher value. Choosing a higher value can cause more oscillations without improving the performance further.

Effect of Derivative Gain (Kd):

- Primary objective: Reduce overshoots and oscillations.
- Functioning: The corrective term is directly proportional to the rate of change of error.
- Drawback:
  - Usually in real world systems due to a more discretized environment, Derivative control is a noisy operation.
  - Its function is to somewhat counter the proportional gain. Therefore a higher value can dampen the rate of convergence.
- Value chosen was 10 which gives satisfactory results in terms of controlling overshoot/oscillations.

Effect of Integral Gain (Ki):

- Primary objective: Remove steady state error / systematic bias
- Functioning: The corrective term is directly proportional to the cumulative sum of past errors
- Drawback:
  - The drawbacks of using integral term in this case are not obviously visible as terms like windup and response speed are not affected in a simulation environment but have an effect on performance in the real world.
- Value chosen was 0.001 and gives a good performance of trying to keep the error to a low value.
  - Value is very small as the cumulative error number is approximately between -150 to 150.

Tuning Process:

- Manual tuning was done
- Initial values chosen were Kp=0.03, Kd=3, Ki=0.0003
  - These values were chosen such that Kd = 100 * Kp and Kp = 100 * Ki
- Final values were Kp=0.3, Kd=10, Ki=0.001 which were tuned as per requirements described above.