Video link: https://www.youtube.com/watch?v=2fZqq7YfPss&feature=youtu.be

Describe the effect each of the P, I, D components had in your implementation.

The proportional control provides the simplest control form but it introduces steady-state tracking errors. Thus, the integrator control is normally applied to compensate the steady-state errors; however, integration also introduces delayed actions that could lead to instability. Thus, sometimes the derivative control could help to provide damping of the closed loop dynamics and it also support immediate compensations against sudden changes of tracking references or disturbances. It should also be noted that the derivative control could cause noise amplification so a large gain may not be feasible in some practical settings.

Describe how the final hyperparameters were chosen.

For the project, my procedure of tuning for the base case is as follows: (1) Tune the P gain to reach a stable case but not ideal (weakly damped); (2) Tune the D gain to allow the introduction of the damping as the sole P control could be oscillatory around the tracking reference; (3) Gradually increase the I gain to allow elimination of the steady-state tracking errors and pose the car near the center of the line. After the base case is constructed, I apply the manual Twiddle procedure to minimize the average cte as described: (1) Change the P, I, D gains sequentially and observe the average cte over 200 time steps; (2) If the error reduces, keep the gains and increase the changes of the gains until the best error is achieved; otherwise, reduce the magnitude of changes. It took around 10~15 manual iterations to reach a reasonable setting of gains. In general, the system requires some minimum damping that is provided by the derivative control Also the controller output is divided by the car velocity (normalized efforts) so the gains are more applicable for different ranges of speed.