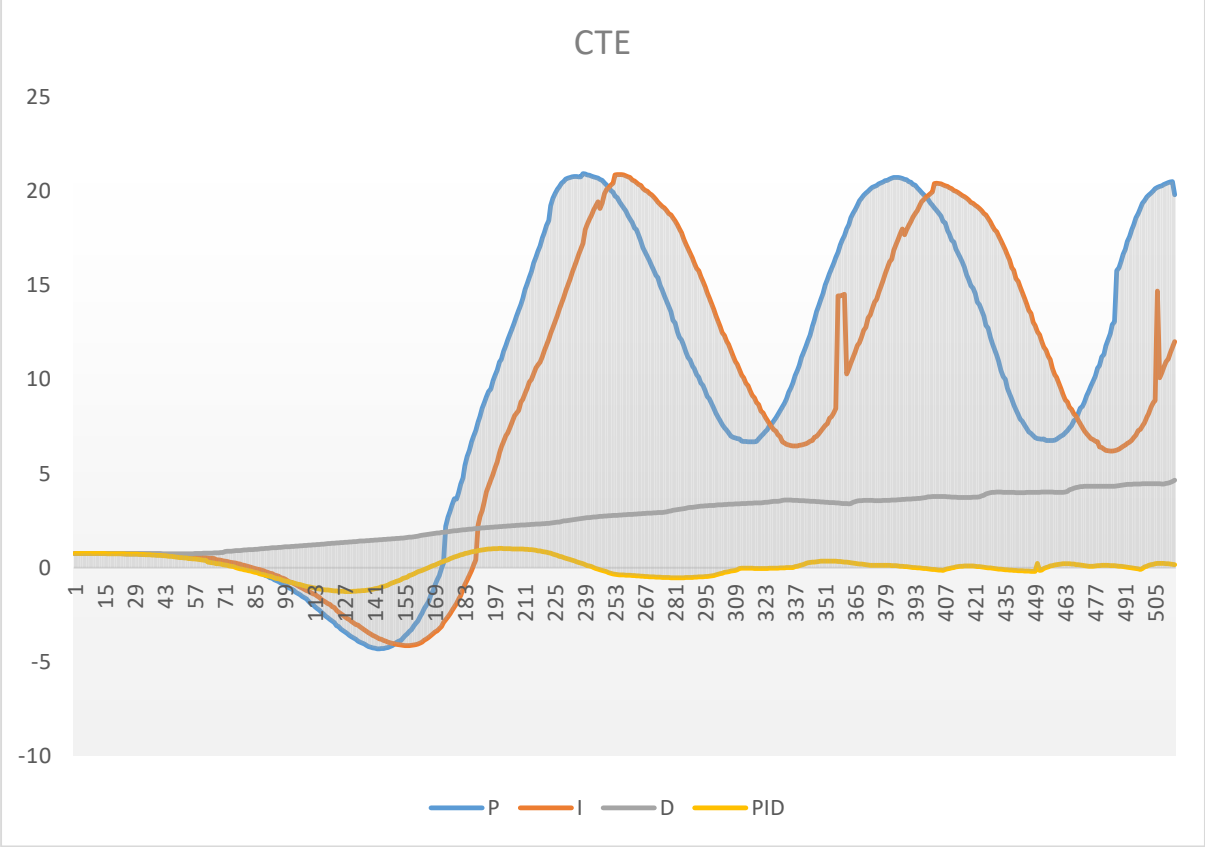
PID Controller Project.

Q1. Describe the effect each of the P, I, D components had in your implementation.

As explained in the lessons, the error signal of the PID controller is given by the following equation

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt}$$

The above equation shows the proportional, integral and differential components have additive effects on the overall response of the controller. It is also obvious from the equation that the response of each of the P, I, D component can be simple mathematical manipulations i.e for P, Ki and Kd are set to zero, for I, Kp and Kd are set to zero and so forth. Using this method, the effect each of the P, I, D components have is shown by the graph shown below, where the x-axis represents the time step and y-axis is the cross track error.



As evident from the above, the individual components work well for the first few instances but as the time proceeds the error begins to accumulate at rather higher rate causing the car to deviate from its original track as observed in the simulator. In the case of PID too, there are some overshoots that dwindle the car in the beginning but the controller succeeded to settle down by taking into account the combined effect of proportional, differential and integral behavior of the controller.

Also, I think the desired setpoint for the car is also changing continuously as it is running on the track, because the track is not a straight road, there are a lot of twists and turns along path. As a result, the setpoint increases on the straight path when the throttle is activated and decreases when the brakes need to apply has to turn safely. As there is latency issue in PID controller too, it is not robust enough to quickly reach the setpoint. This could be the reason of sinusoidal variation of the error signals in P and I cases.

Q2. Describe how the final hyperparameters were chosen.

The selection of the final hyperparameters is done manually but intuitively and they were carefully tweaked based on both the explanations by the experts on the Udacity forums and the way the car runs in the simulator, for instance, if the car dwindles more, then the controller gains are decreased.