**This is a guidance/Template document - use it to define sections and content – remove all non essential information such as this sentence or descriptions given.**

* **No more than 10 pages excluding cover page and appendix if used**
* **Make sure there are page numbers.**
* **The guiding rule – everything must be obvious – if I have questions your team did not write a good memo.**
* **Add any code/pictures/graphs that are relevant – make sure to label axes and have thick lines in plots.**
* **Submit a pdf and a word document – two**

**Cover page**

* Group members/major
* Date
* ECE-CT580 Final Project – Application of Kalman Filters

**Section 1: Introduction/Background**

* Management summary – this can be a repeat of the conclusion but it should tell you results in a few sentences
* Objective of the project – include how you simulated motion
* Data Gathering Summary, Summary of how you made measurements using the ultrasonic transducer, i.e did you use interrupts of pulsin(), etc; how did you collect data for processing, photo of your setup holding the transducer and yardstick, how many measurements did you take, etc
* Calibration curve if done: Show plot of ground truth (ruler) vs ultrasonic transducter

**Section 2: Alpha Filter**

* Section Objective: State again what we are measuring – simulating flagpole in wind
* Statistics and KF Parameters: What are the noise and state covariances? What is T? How did your team get these values--- show summary computations? What is K? What is P(k|k)? Table to summarize
* Data Analysis and Presentation:
  + Plots of data sets at different distances with error bands, show average value and its numeric value as well as values of error bands
* Look at how the data falls within error bands for each measurement set. Make some statement and graphic to describe what (if anything is going on) as the data varies say from 10 inches to 30 inches
* Compare the results of KF to averaging of multiple points

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Data point | Average value +/- 3 std | Variance by averaging | Number of points for average |  | Kalman filter value +/- 3 std dev  use last value in run | Kalman filter variance | comment |
| 10”nominal |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

**Section 3: Alpha-Beta Filter**

* Section Objective: State this is the model of train on tracks ut we are moving the transducer and taking data at fixed spatial locations; discuss T.
* Statistics and KF Parameters: What are the noise and state covariances? What is T? How did your team get these values--- show summary computations? What is K what is P(k|k) Table to summarize.
* Data Analysis and Presentation:
* Stem Plots of position vs. time and velocity vs. time for each data set (10 total),.. Note we expect the velocity to be “constant” and position to be a ramp.
* Make another plot that shows time vs ground truth (measured with ruler) and pick one or more of your data sets and overlay this result. For each point does the Kalman filter provide a better estimate than just the averages you found for the single point? Show +/-3 sigma for the position error from Kalman filter. You may have to blow up a few points to illustrate.
* Do a phase plane plot for Kalman filter output (pick two sets) , in which you plot velocity vs x. Use red circles to illustrate the points. Next overlay with ground truth with black asterisks. Next plot the error ellipse at each Kalman Filter point (or ground truth point) Ground truth (or Kalman points) should be inside the error ellipse.
  + Does it matter which is the center of the error ellipse? Discuss with some

Remember phase plot is horizontal axis position, vertical axis velocity

**Section 4: Summary and Conclusions**

This can be more detailed than the management summary in the introduction but they should match.

**Section 5: Appendix**

* **Optional does not count toward page count**
* **It must not contain info that should be in the memo – but it could contain additionl experiments or insights that you did or want to talk about.**