5970/6970 Homework Due 9/2/2022

1) Given that 1 minute of latitude is approximately equal to 1 nautical mile (1852 meters), how many significant digits after the decimal must be included for a latitude represented in decimal degrees to describe a position that is accurate to 1 cm? How many significant digits are required after the decimal in the arc-seconds field if the latitude is represented in degrees, arc-minutes, and arc-seconds to describe the same accuracy (1cm)? Note 1 degree = 60 arc-minute and 1 arc-minute = 60 arc-seconds.[1]

2) Find an outdoor location where you can identify multiple distinction objects/features in your surroundings. Use a compass, map, and the line of bearing to an object in the field technique discussed in class to triangulate your position in geodetic coordinates (latitude and longitude). You can download topographic maps at the link below. You can you the compass on your phone or I have several analog compasses that can be barrowed. Determine your position using two, three, and four features. Compare the accuracy of those solutions to you true location. You may use GPS, Google Maps, or other references to determine your "true" position. To how many significant digits was your estimated position accurate?

   https://ngmdb.usgs.gov/topoview/viewer/#4/39.98/-100.06

3) Find and discuss a documented instance of a failure of navigation in a transoceanic flight. Be specific as to what went wrong and how this affected the mission.[2]

4) Find and discuss a documented instance of a failure of guidance in a transoceanic flight. Be specific as to what went wrong and how this affected the mission.[2]

5) Assume that you have 1000 noisy biased measurements of the acceleration (scalar) of a ***stationary*** body over 100 seconds (i.e. dt = 0.1) as shown in the equation below. Numerically integrate the noisy biased measurements of acceleration to calculate "velocity" and "position" (assume zero initial conditions). Repeat this process 100 times such that you have 100 random velocity and position values from each time step. Calculate the variance of the velocity and position at each time step and plot them versus time.

$$\tilde{\ddot{x}} = \ddot{x} + b + \eta$$
$$b = 3$$
$$\eta \sim N(0,1)$$

Note: $N(0,1)$ indicated a normally distributed random variable with mean 0 and variance 1. The Matlab command randn generates normally distributed samples with a variance of 1.

Problems 6 and 7 are required for graduate students only.

6) Given the simulated acceleration measurements for problem 5, how would you estimate the bias? Compute 100 estimates of the bias use each set of 1000 measurements. What is the mean and variances of the bias estimates?

7) You set out from town A and head east to town B 120 km away. Your vehicle has an odometer that is not particularly accurate (it could be off by 1-2 km after 50 km of driving). You carry a decent watch, which is great at keeping time over short intervals, but it has been months since you last reset it. In other words, you can measure time intervals accurately, but do not know exactly what time it is. A short time into your journey, the car breaks down.

    a) According to your odometer, you have traveled 56 km. Estimate your position.
    b) As you push your car to the shoulder of the road, a red bus zooms by heading from A to B. You glance at your watch and notice that it is exactly 21 minute past the hour. You know that the red buses are prompt, and they leave town A every hour on the hour traveling at exactly 3 km/min. Can you estimate your position without using the odometer information?
    c) Estimate your position and clock bias based on all the information so far (Hint: Write two equations that relate your position and clock bias to the available information. These equations are sometimes referred to as navigation equations).
    d) At 25 minutes past hour by your watch, you observe a blue bus zoom past at 2.5 km/min, going from B to A. Blue buses leave town B every hour on the hour promptly and drive to town A at a constant speed. Estimate your position and clock bias based on all the information so far. (Hint: Recall that your watch can measurement delta time accurately)
    e) How would your solution be affected if your watch were exactly five minutes fast and all the clocks in town A and town B were running five minutes fast?
    f) Now suppose that your odometer never worked and the only vehicles you see are identical yellow cabs of carrier L1. These cabs leave town A every minute on the minute and travel exactly 1 km/min to town B. Can you estimate your position and clock error? Would it help if there were identical green carbs of carrier L2 leaving town B every minute on the minute and traveling at 1 km/min to town A? Explain briefly.