Very interesting experiment this week. I collected data for a little over an hour, from about 11:15 AM until 12:20 PM on Friday, March 9th. I set up my receiver on a table on the elevated patio at the East end of Wilcox Hall (the patio that overlooks the courtyard formed by 1938 Hall and 1927-Clapp Hall). The open, elevated platform gave me a great view of the sky and reduced the size of the buildings around me to only about one story high. The rest of my analysis will follow the data and graphs in the spreadsheet I have attached.

I had plenty of data to work with: well over 1800 data points. I began by converting my latitude and longitude into the format DD.dddd, to make calculations of standard errors easier. Next I found the average values for latitude and longitude, as well as the standard deviation for the entire data set. I plotted both the values of latitude and longitude over time, as well as the standardized deviations from the mean versus time (the first two charts). Both of these charts showed seemingly random variations, with the exception of one noticeable jump in the data about halfway through my collection time, when longitude and latitude plummet, and are incredibly far from the mean. Also, both seem to reveal a slight pattern, whereby latitude and longitude increase and decrease in sync with each other, with a few noticeable exceptions. This would mean that the error is not truly random, but in fact systematic, as the receiver updated its guess for position along a specified pattern (moving latitude and longitude together). To test this theory I plotted the different positions my receiver recorded, and indeed found that it followed a pattern whereby latitude and longitude were positively correlated. Finally, I plotted standard deviation from the mean for altitude, and found that it varied wildly, yet seemingly randomly, about zero.

However, for all four graphs, there is a noticeable spike midway through data collection, where the receiver drastically changed its position, and then slowly went about returning to more normal values. Many different things could explain this spike: loss of signal with a certain satellite, picking up a rebound signal instead of a true signal, or even some uncharted blip in the ionosphere. Regardless of the cause, I decided to try and clean up the data by removing these outliers. Thus, I transitioned from Sheet1 in excel to Sheet2 by deleting all values between row 935 and row 1029 (the apparent location of the outliers). I then proceeded to make the same 4 graphs I had made for the original data.

With the adjusted data, the movement of latitude and longitude (and standardized latitude and longitude) appeared to be less in sync, though the general pattern was still visible (peaks and valleys occurred at similar times). The position graph, however, is most telling. Although most points appear to be in a clump around the average values, the graph is clearly elongated in a linear fashion, meaning that latitude and longitude are positively correlated, rather than randomly scattered. This supports the claim I made before about error being systematic, rather than truly random. The standardized altitude, plotted versus time, was unremarkable, showing that guesses for altitude varied greatly at
the beginning, but eventually calmed down a bit around zero. Overall, adjusted data showed smaller variation, as I removed a large number of outliers.

In conclusion, there seems to be a systematic pattern to the error associated with GPS position. Rather than random noise, the receiver reacts to uncertainty in position by guessing along a predetermined pattern, that changes latitude and longitude in a positively correlated manner. Whenever the receiver has a change in signal, it appears to move both longitude and latitude drastically, as evident by the spike midway through data collection, as well as the minor upward-spike in latitude and longitude toward the end of data collection. This appears to be an attempt to systematically root out “noise”, but I am unsure whether this correction truly improves the accuracy of the receiver.

Overall though, when the data was adjusted to remove outliers, it was fairly accurate, with an overall range of about 11 meters in latitude between extreme points and about 5 meters in longitude (with the outliers included, those ranges are about 22m and 5m, respectively). Not too bad.