ME 594
Final Exam

SHOW ALL OF YOUR WORK. This includes writing the proper equation(s), inserting the proper value(s), & calculating the final answer(s). If you utilize MATLAB or similar software, you may attach code and/or command line output to supplement your written work. Include the following statement at the top of your assignment:

"I ATTEST THAT I HAVE NEITHER GIVEN NOR RECEIVED HELP (other than from the instructor or my chosen teammates) ON THIS ASSIGNMENT."

1. This problem pertains to the analysis and processing of space images, as we've covered this week. A set of 5 images has been taken by a sensor. An automated algorithm has found 17 illuminated objects in each image and calculated the centroid of each object. The attached spreadsheet contains these centroid locations as given in camera frame ($x_{\_cam}$, $y_{\_cam}$) coordinates. It is known that the images were taken in inertial mode—i.e. the sensor was attempting, as accurately as possible, to stare in the same direction in inertial space for all the images.

   Given this information, how many Earth-orbiting objects (if any) do you think there are in this image set? Explain your reasoning, along with a list of which centroid ($x_{\_cam}$, $y_{\_cam}$) locations in each image constitute an Earth-orbiting object, and any supporting information (e.g. tables or charts) that you feel will help justify your conclusion.

2. For this problem, you will refine a Laplace IOD orbit solution for an object using batch least-squares POD. You will utilize the following information you generated for the Midterm Exam:
   - The Earth-orbiting object you defined, i.e. the parameters defining the object's orbit
   - The location for your optical sensor
   - The three measurement times you chose and the sensor-to-object line-of-sight vector at those measurement times

   Using this information, perform the following steps:
   - Choose several more measurement times subsequent to the first three (say, 10-20 additional times), propagate the object's motion (assuming 2-body gravity) to each of these times, and calculate the sensor-to-object line-of-sight vector at each measurement time
   - Add error to each of these new measurements, as discussed in the BONUS section of the Midterm
   - Using your IOD solution from the Midterm as an initial guess, perform the batch least-squares POD method for several iterations (you may choose either the NUMERICAL or ANALYTICAL approach), processing all of the new measurements at each iteration
   - Comment on the convergence (or lack thereof) of your solution; if the solution appears to converge, define a stopping criterion based on the values of either the states or the residuals
   - Compare your final orbit solution to the object's true orbit (propagating them to the same time as necessary) and comment on the accuracy of this method for your scenario

   Your submitted work should include a careful outlining of each step above, with the quantities asked for in each step clearly marked (e.g. your object's orbit parameters, location of your sensor, chosen measurement times, orbit solution and residual values at each iteration, etc).

A FEW NOTES:

- You do not have to utilize the information you generated for the Midterm in this exercise, i.e. you may start with an entirely new defined object and measurement set, perform the Laplace method to obtain an IOD solution, and perform POD from there. But obviously the former option will incur much less effort.
- If you have not arrived at an IOD solution you are happy with, you may instead take the true states (i.e. the position/velocity used to propagate your object's motion in order to create the measurements), change them slightly from their true values, and use that as your initial guess.
- For purposes of comparing your final orbit solution to the object's true orbit, as before, you may convert position/velocity to orbit elements and compare those values.