Exercise 1:

1) In Matlab

2) $G(s) = \begin{bmatrix} \frac{1}{s} & \frac{s+3}{s+1} \\ \frac{1}{s+3} & \frac{s}{s+1} \end{bmatrix}$; $G(s) = G_{sp}(s) + D$

$D = G(s \to \infty) = \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix}$

$\Delta s = (s+3)(s+1)(s) = (s^2+4s+3)(s) = s^3+4s^2+3s$

$G_{sp} = G(s) - D = \begin{bmatrix} \frac{1}{s} & \frac{2}{s+1} \\ \frac{1}{s+3} & \frac{-1}{s+1} \end{bmatrix}$

$G_{sp} = \frac{1}{\Delta s}\begin{bmatrix} (s+3)(s+1) & 2(s+3)(s) \\ (s+1)(s) & -(s)(s+3) \end{bmatrix} = \frac{1}{\Delta s}\left(\begin{bmatrix} 1 & 2 \\ 1 & -1 \end{bmatrix}s^2 + \begin{bmatrix} 4 & 6 \\ 1 & -3 \end{bmatrix}s + \begin{bmatrix} 3 & 0 \\ 0 & 0 \end{bmatrix}\right)$

N_1 N_2 N_3

$A = \begin{bmatrix} -4 & 0 & -3 & 0 & 0 & 0 \\ 0 & -4 & 0 & -3 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$, $B = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 2 & 4 & 6 & 3 & 0 \\ 1 & -1 & 1 & -3 & 0 & 0 \end{bmatrix}$,

$D = \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix}$

3) In Matlab

4) In Matlab

Exercise 2:

1) Done in Python file (to run, open shell/terminal and run python "filename")

2) Done in Python file
   - * Note that Matlab graphs appear different based on computational differences. As long as your reasoning matches your graphs, you will get full points.

3) Done in Python file
   - If only the heading error is measured, the rank of Q matrix is NOT full rank. Thus, the system is not observable and the internal state can't be wholly measured from the input and output.

4) Provide reasonable explanation of how chosen poles affected system response and why change in desired pole locations was made. Explanation of how system response changes based on poles must be correct (i.e. poles closer to imag. axis on left half plane dominate system response).

5) Given the two error measurements, the estimate of the derivatives could be found from by subtracting the previous error from the current error and dividing by the time step.