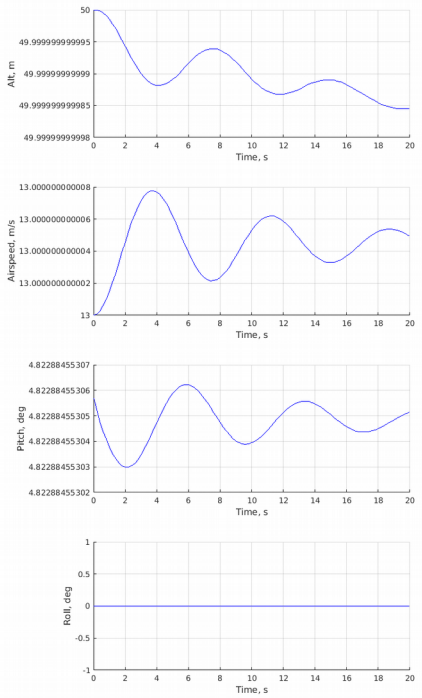
1.)

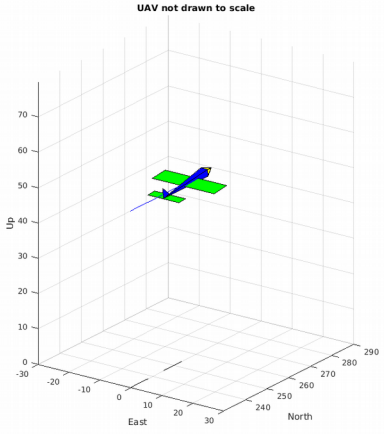
```
% Your code goes below...
R_ned2b = eulerToRotationMatrix(phi,theta,psi);

% compute wind vector in body frame (wind_ned is an input)
wind_b = R_ned2b*wind_ned;

% compute airspeed Va, angle-of-attack alpha, side-slip beta
[Va, alpha, beta] = makeVaAlphaBeta(vg_b - wind_b);

% Longitudinal Aero Coefficients
C_L = P.C_L_0 + (P.C_L_alpha * alpha) + (P.C_L_q*P.c/2/Va*q) +
(P.C_L_delta_e*delta_e);
C_D = P.C_D_0 + abs(P.C_D_alpha*alpha) + abs(P.C_D_q*P.c/2/Va*q) +
abs(P.C_D_delta_e*delta_e);
C_m = P.C_m_0 + (P.C_m_alpha*alpha) + (P.C_m_q*P.c/2/Va*q) +
(P.C_m_delta_e*delta_e);

% Lateral Aero Coefficients
C_Y = P.C_Y_0 + (P.C_Y_beta*beta)+(P.C_Y_p*P.b/2/Va*p) + (P.C_Y_r*P.b/2/Va*r) +
(P.C_Y_delta_a*delta_a) + (P.C_Y_delta_r*delta_r);
C_ell = P.C_ell_0 + (P.C_ell_beta*beta) + (P.C_ell_p*P.b/2/Va*p) +
(P.C_ell_r*P.b/2/Va*r) + (P.C_ell_delta_a*delta_a) + (P.C_ell_delta_r*delta_r);
C_n   = P.C_n_0 + (P.C_n_beta*beta) + (P.C_n_p*P.b/2/Va*p) + (P.C_n_r*P.b/2/Va*r) +
(P.C_n_delta_a*delta_a) + (P.C_n_delta_r*delta_r);

% Create and combine Forces
f_grav_ned = P.mass * [0; 0; P.gravity]; % Newtons

f_grav_b = R_ned2b*f_grav_ned;
f_aero_b = 0.5*P.rho*Va*Va*P.S_wing*[-C_D*cos(alpha) + C_L*sin(alpha);C_Y;-
C_D*sin(alpha)-C_L*cos(alpha)];
f_prop_b = [P.rho * P.C_prop * P.S_prop * (Va+delta_t*(P.k_motor - Va)) *
(delta_t*(P.k_motor - Va));0;0];
f_b = f_grav_b + f_aero_b + f_prop_b;

% Create and combine Moments
m_aero_b = 0.5 * P.rho * Va * Va * P.S_wing * [P.b*C_ell;P.c*C_m; P.b*C_n];
m_prop_b = [-P.k_Tp*((P.k_omega*delta_t)^2);0;0];
m_b = m_aero_b + m_prop_b;
```

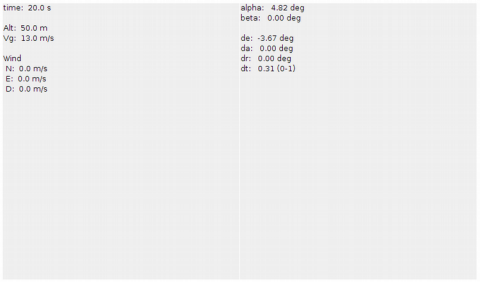
2.)
(a)

```
*****************************************************************
  Trim condition found, Jcost = 2.591968e-25
  Longitudinal trim: alpha=4.8229 deg, de=-3.6654 deg, dt=0.3138
*****************************************************************
```

(b) Vehicle is trimmed. See attached plots







3.)

```
min air speed 6.8 m/s
**************************************************************
  Trim condition found, Jcost = 5.904148e-25
  Longitudinal trim: alpha=29.8534 deg, de=-22.6886 deg, dt=0.2351
**************************************************************
max air speed 17.9 m/s
**************************************************************
  Trim condition found, Jcost = 5.786942e-25
  Longitudinal trim: alpha=0.1936 deg, de=-0.1471 deg, dt=0.9691
**************************************************************
```

At the slower min air speed of 6.8 m/s the vehicle gains and loses altitude, but mostly tries to maintain altitude. At the higher max air speed of 17.9 m/s the vehicle is trimmed.

4.)

```
load_uavsim;P.k_Tp = 5e-6;

trimmed_da = 0.0;
curr_min_cost = 100000000.0;
for da = linspace(-P.delta_a_max, P.delta_a_max, 100)
    P.delta_a0 = da;

    [~, trim_solution] = compute_longitudinal_trim(P);
    if trim_solution.valid && (trim_solution.cost < curr_min_cost)
        disp('====================================')
        disp(['trim_solution.valid = '
num2str(trim_solution.valid)] )
        disp(['da = ' num2str(da)] )
        disp('====================================')
        trimmed_da = da;
        curr_min_cost = trim_solution.cost;
    end
end

P.delta_a0 = trimmed_da;
trimmed_da
end
```

5.)

a.)

A_lon =

-0.1596	0.8507	-1.0930	-9.7719	0
-1.1004	-4.8392	12.9540	-0.8245	0
0.3909	-4.6327	-7.2717	0	0
0	0	1.0000	0	0
-0.0841	0.9965	0	-13.0000	0

```
B_lon =

    3.6463    3.6463
   -6.3799   -6.3799
  -79.5245  -79.5245
         0         0
         0         0


A_lat =

   -1.3407    0.8400  -12.9540    9.7719         0
   -3.1183   -4.8908    2.5778         0         0
    4.4056    0.2346   -4.3912         0         0
         0    1.0000    0.0844         0         0
         0         0    1.0036         0         0




B_lat =

   -3.0234   -3.0234
   63.7429   63.7429
    7.0128    7.0128
         0         0
         0         0



b.) Spot checks

udot_over_theta =
   -9.7719


M_q =
   -7.2717


M_de =
  -79.5245
```

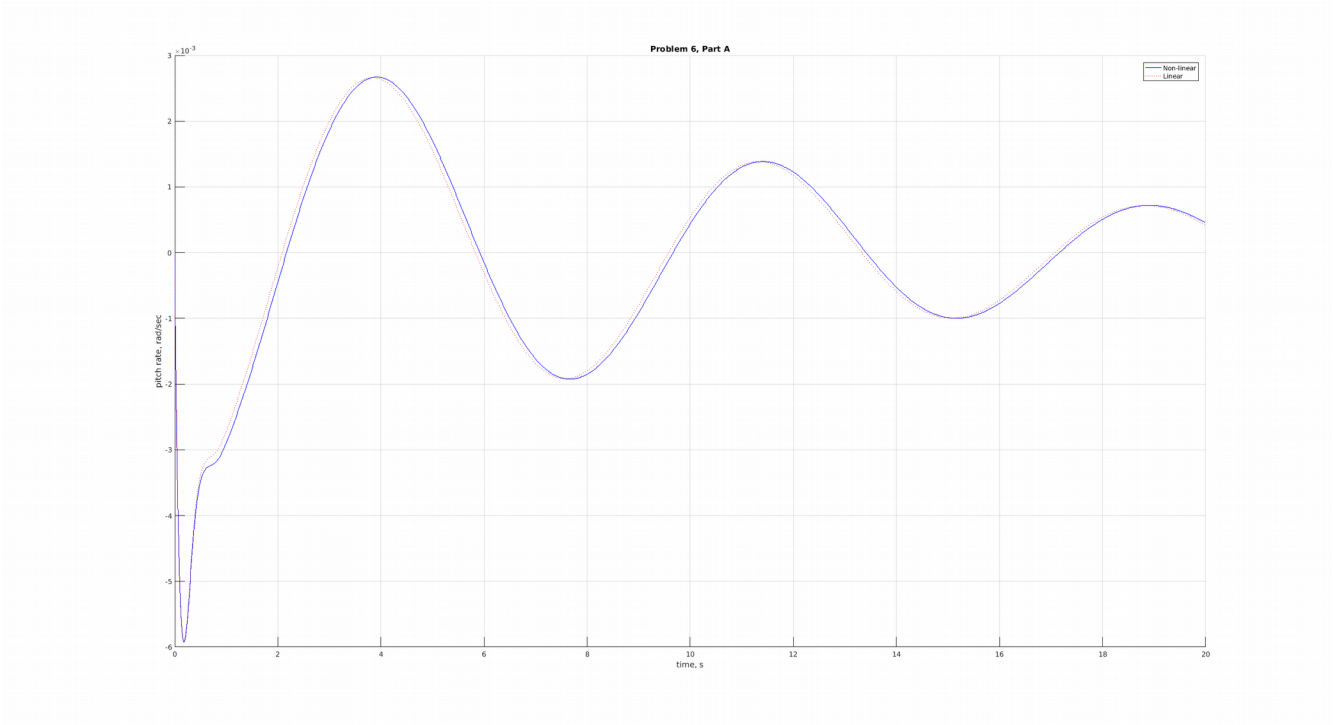
c.) de/q Transfer Function, zpk form

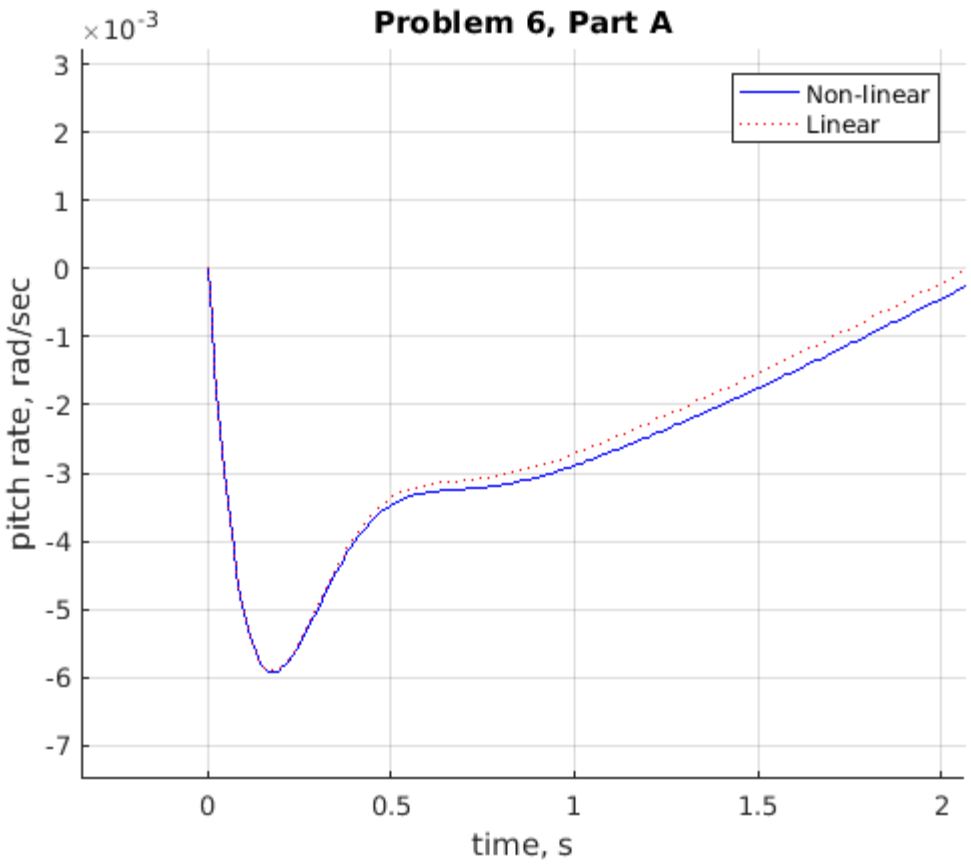
$$\frac{-79.525\ s\ (s+4.293)\ (s+0.3157)\ (s\wedge 2\ +\ 0.175s\ +\ 0.7104)\wedge 2\ (s\wedge 2\ +\ 12.1s\ +\ 95.67)\wedge 2}{(s\wedge 2\ +\ 0.175s\ +\ 0.7104)\wedge 3\ (s\wedge 2\ +\ 12.1s\ +\ 95.67)\wedge 3}$$

d.) dr/r Transfer Function, zpk form

$$\frac{7.0128\ (s+8.231)\ (s+5.014)\wedge 2\ (s+0.01746)\wedge 2\ (s\wedge 2\ -\ 1.767s\ +\ 51.24)\ (s\wedge 2\ +\ 5.592s\ +\ 64.79)\wedge 2}{(s+5.014)\wedge 3\ (s+0.01746)\wedge 3\ (s\wedge 2\ +\ 5.592s\ +\ 64.79)\wedge 3}$$

6)
a.)

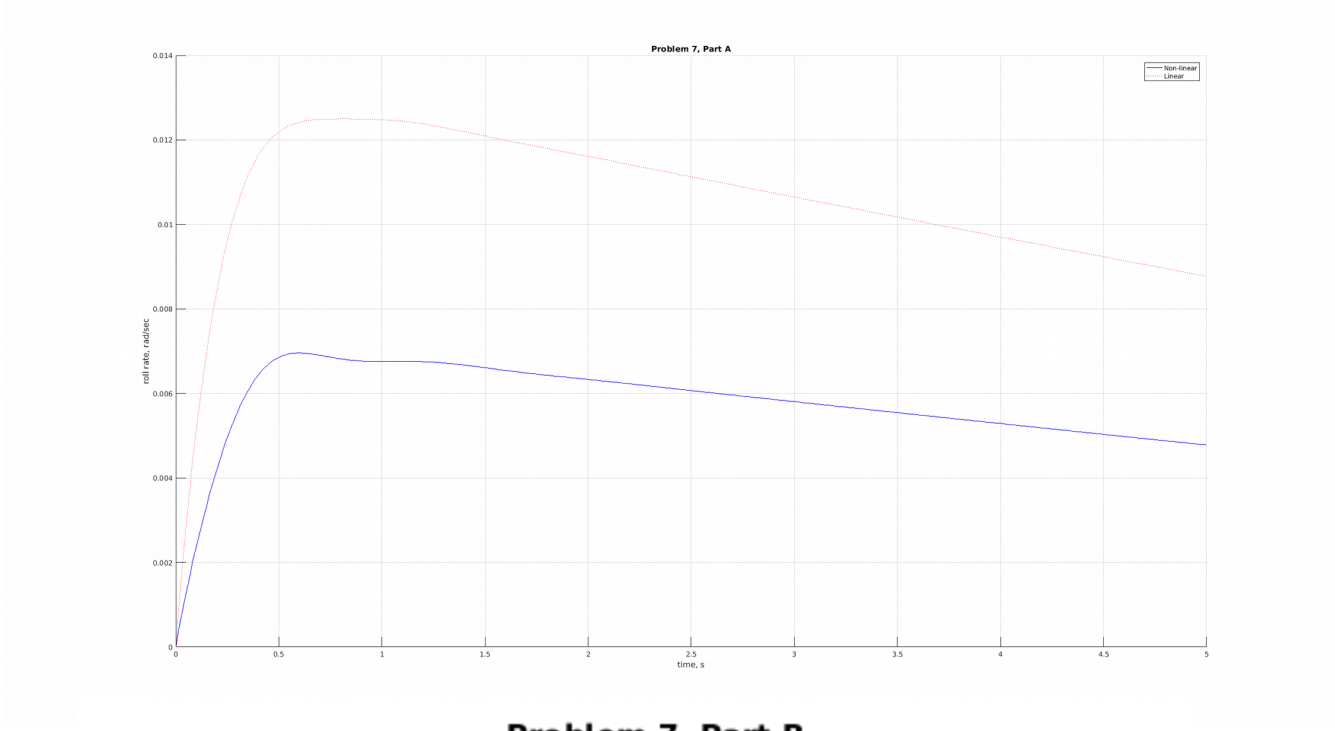


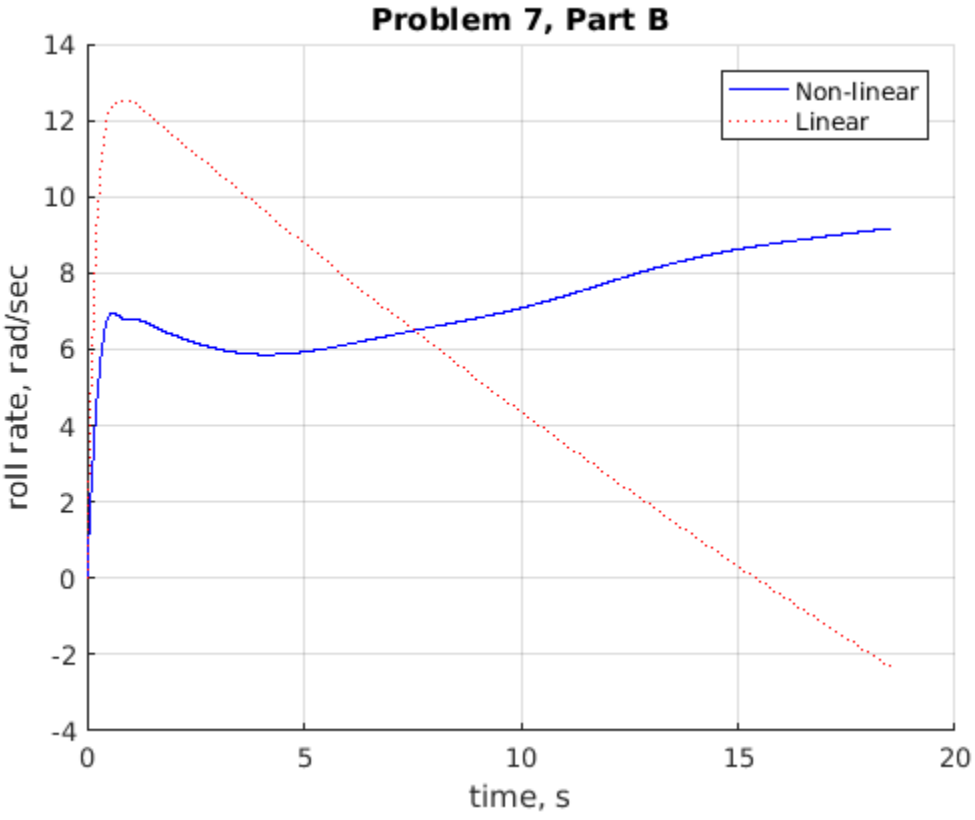

Problem 6, Part A
×10^-3
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
pitch rate, rad/sec
0
0.5
1
1.5
2
time, s
Non-linear
Linear

b.) Estimate fugoid mode

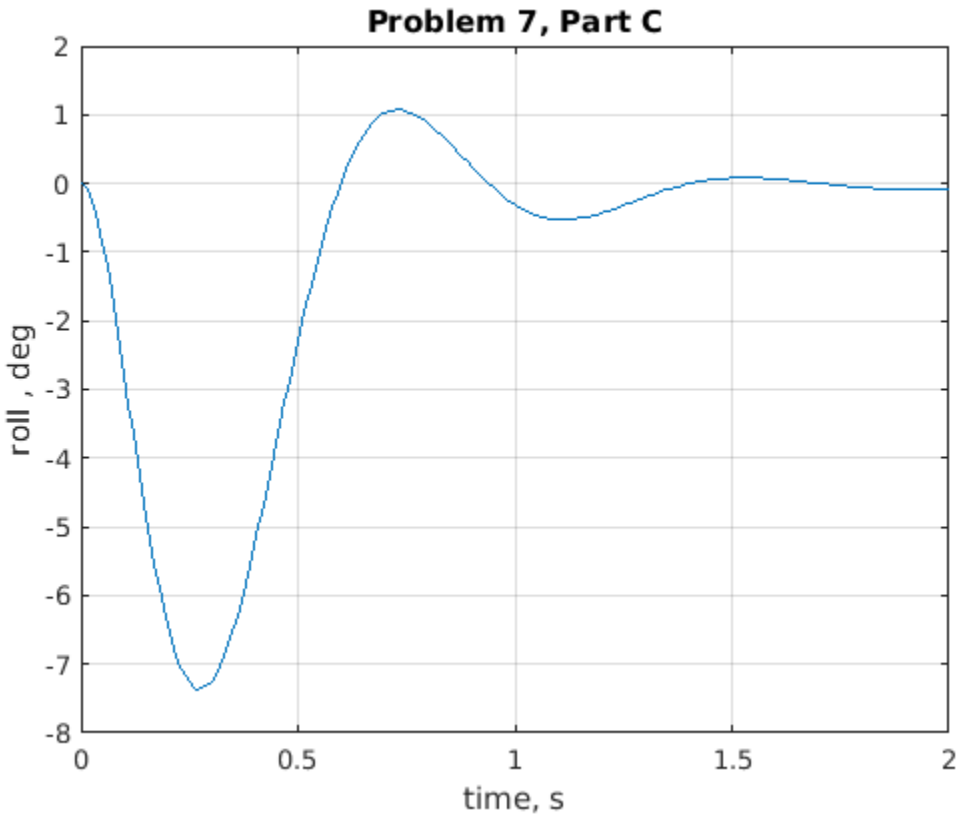
c.) Vehicle starts off climbing but starts to level off. Appears to be in a phugoid mode.

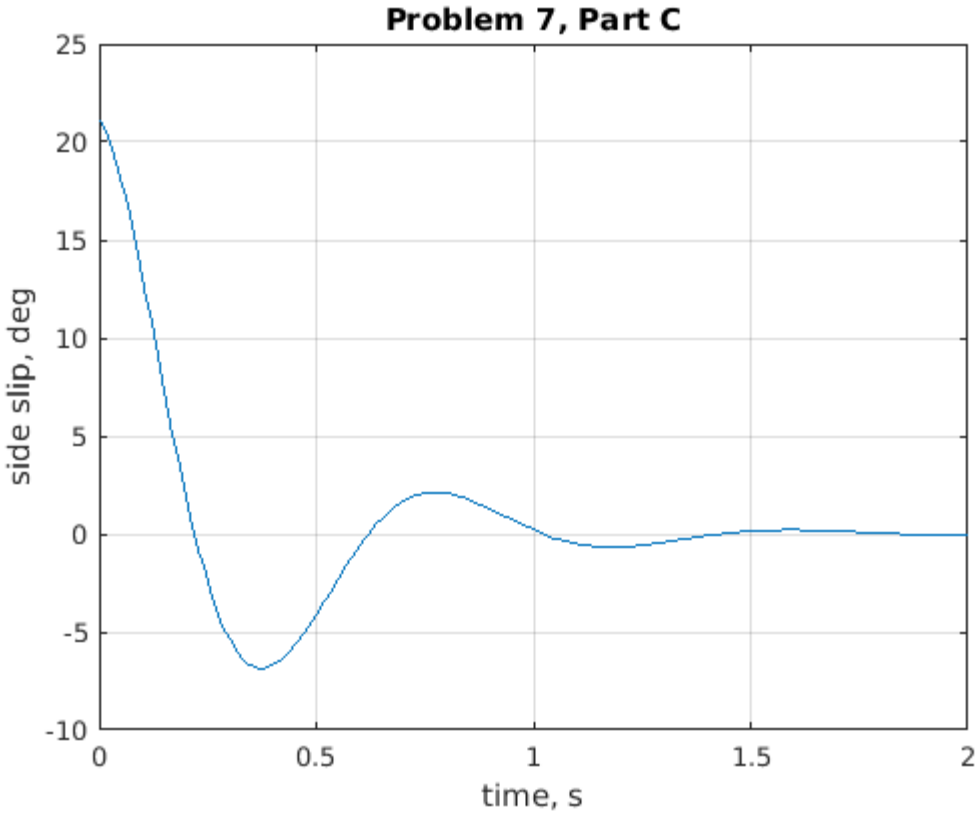
7)
a.)





c.)


Problem 7, Part C
roll , deg
time, s
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
0
0.5
1
1.5
2


Problem 7, Part C
side slip, deg
time, s
25
20
15
10
5
0
-5
-10
0
0.5
1
1.5
2