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```
close
clear
```

Physical constants

```
m_h = 0.4; % Total mass of the motors.
m_g = 0.03; % Effective mass of the helicopter.
l_a = 0.65; % Distance from elevation axis to helicopter body
l_h = 0.17; % Distance from pitch axis to motor

% Moments of inertia
J_e = 2 * m_h * l_a *l_a;         % Moment of interia for elevation
J_p = 2 * ( m_h/2 * l_h * l_h);   % Moment of interia for pitch
J_t = 2 * m_h * l_a *l_a;         % Moment of interia for travel

% Identified voltage sum and difference
V_s_eq = 6.87;%87;% Identified equilibrium voltage sum.
V_d_eq = 0; % % Identified equilibrium voltage difference.

% Model parameters
K_p = m_g*9.81; % Force to lift the helicopter from the ground.
K_f = K_p/V_s_eq; % Force motor constant.
K_1 = l_h*K_f/J_p;
K_2 = K_p*l_a/J_t;
K_3 = K_f*l_a/J_e;
K_4 = K_p*l_a/J_e;
```

Pitch closed loop syntesis

Controller parameters

```
w_p = 1.8; % Pitch controller bandwidth.
d_p = 1.0; % Pitch controller rel. damping.
K_pp = w_p^2/K_1;
K_pd = 2*d_p*sqrt(K_pp/K_1);
Vd_ff = V_d_eq;

% Closed loop transfer functions
Vd_max = 10 - V_s_eq; % Maximum voltage difference
deg2rad = @(x) x*pi/180;
Rp_max = deg2rad(15); % Maximum reference step
```

```
s = tf('s');
G_p = K_1/(s^2);
C_p = K_pp + K_pd*s/(1+0.1*w_p*s);
L_p = G_p*C_p;
S_p = (1 + L_p)^(-1);
```

Elevation closed loop analysis

Controller parameters

```
w_e = 0.5; % Elevation controller bandwidth.
d_e = 1.0; % Elevation controller rel. damping.
K_ep = w_e^2/K_3;
K_ed = 2*d_e*sqrt(K_ep/K_3);
K_ei = K_ep*0.1;
Vs_ff = V_s_eq;

% Closed loop transfer functions
Vs_max = 10 - V_s_eq; % Maximum voltage sum
Re_max = deg2rad(10); % Maximum elevation step
G_e = K_3/(s^2);
C_e = K_ep + K_ed*s/(1+0.1*w_e*s) + K_ei/s;
L_e = G_e*C_e;
S_e = (1 + L_e)^(-1);
```

The initial internal state of the system for the integrator.

```
You should not need to change this.
This is the state that the integrator sees.
The order is:
[travel, elevation, pitch, travel rate, elevation rate, pitch rate],
which is not the same as the order used in the lab assignment.
I repeat: No need to change this.

x0_sim = [pi, -deg2rad(30),0,0,0,0]';
```

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