

Parameters and Equilibrium Conditions

```
P1 = [2 1 1 1 1 1];
P2 = [2 1 1 1 0.99 1];
P3 = [2 1 0.5 1 1 1];
P4 = [2 1 1 1 0.5 1];

E1 = [0 0 0];
E2 = [0 pi pi];

case1 = num2cell([P1,E1]);
case2 = num2cell([P1,E2]);

u = 0;
C = [1 0 0 0 0 0];
D = 0;
```

Case 1 (L1): P1, E1

```
% pull parameters and initial conditions for case 1
[m0, m1, m2, l1, l2, g, ye, thetale, theta2e] = deal(case1{:});

mt = m0 + m1 + m2;
M = [mt, -m1*l1*cos(theta1e), -m2*l2*cos(theta2e);
     -m1*l1*cos(theta1e), m1*l1^2, 0;
     -m2*l2*cos(theta2e), 0, m2*l2^2];
G = [0,0,0;0,m1*l1*g*cos(theta1e),0;0,0,m2*l2*g*cos(theta2e)];
W = [1 0 0]';
A = [zeros(3), eye(3); M^-1*(-G), zeros(3)]
```

```
A = 6x6
      0      0      0      1.0000      0      0
      0      0      0      0      1.0000      0
      0      0      0      0      0      1.0000
      0     -0.5000    -0.5000      0      0      0
      0     -1.5000    -0.5000      0      0      0
      0     -0.5000    -1.5000      0      0      0
```

```
B = [0;0;0;M^-1*W]
```

```
B = 6x1
      0
      0
      0
      0.5000
      0.5000
      0.5000
```

```
sys = ss(A,B,C,D);
[v,d] = eig(A)
```

```
v = 6x6 complex
      1.0000 + 0.0000i    -1.0000 + 0.0000i      0.0000 - 0.1925i      0.0000 + 0.1925i ...
      0.0000 + 0.0000i      0.0000 + 0.0000i     -0.0000 - 0.3849i     -0.0000 + 0.3849i
      0.0000 + 0.0000i      0.0000 + 0.0000i     -0.0000 - 0.3849i     -0.0000 + 0.3849i
      0.0000 + 0.0000i      0.0000 + 0.0000i      0.2722 - 0.0000i      0.2722 + 0.0000i
      0.0000 + 0.0000i      0.0000 + 0.0000i      0.5443 + 0.0000i      0.5443 + 0.0000i
```

```

0.0000 + 0.0000i    0.0000 + 0.0000i    0.5443 - 0.0000i    0.5443 + 0.0000i
d = 6x6 complex
0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i ...
0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i
0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 1.4142i    0.0000 + 0.0000i
0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 - 1.4142i
0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i
0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i    0.0000 + 0.0000i

```

```
pole(sys)
```

```

ans = 6x1 complex
0.0000 + 0.0000i
0.0000 + 0.0000i
0.0000 + 1.4142i
0.0000 - 1.4142i
-0.0000 + 1.0000i
-0.0000 - 1.0000i

```

```
zero(sys)
```

```

ans = 4x1 complex
0.0000 + 1.0000i
0.0000 - 1.0000i
0.0000 + 1.0000i
0.0000 - 1.0000i

```

Case 2 (L2): P1, E2

```

[m0, m1, m2, l1, l2, g, ye, thetale, theta2e] = deal(case2{:});
mt = m0 + m1 + m2;
M = [mt, -m1*l1*cos(thetale), -m2*l2*cos(theta2e);
     -m1*l1*cos(thetale), m1*l1^2, 0;
     -m2*l2*cos(theta2e), 0, m2*l2^2];
G = [0,0,0;0,m1*l1*g*cos(thetale),0;0,0,m2*l2*g*cos(theta2e)];
W = [1 0 0]';
A = [zeros(3), eye(3); M^-1*(-G), zeros(3)]

```

```

A = 6x6
    0         0         0    1.0000         0         0
    0         0         0         0    1.0000         0
    0         0         0         0         0    1.0000
    0   -0.5000   -0.5000         0         0         0
    0    1.5000    0.5000         0         0         0
    0    0.5000    1.5000         0         0         0

```

```
B = [0;0;0;M^-1*W]
```

```

B = 6x1
    0
    0
    0
    0.5000
   -0.5000
   -0.5000

```

```

sys = ss(A,B,C,D);
[v,d] = eig(A)

```

```
v = 6x6
  1.0000  -1.0000  -0.1925  -0.0000   0.1925   0.0000
      0      0      0.3849   0.5000  -0.3849  -0.5000
      0      0      0.3849  -0.5000  -0.3849   0.5000
      0      0.0000   0.2722   0.0000   0.2722   0.0000
      0      0     -0.5443  -0.5000  -0.5443  -0.5000
      0      0     -0.5443   0.5000  -0.5443   0.5000

d = 6x6
      0      0      0      0      0      0
      0      0      0      0      0      0
      0      0     -1.4142   0      0      0
      0      0      0     -1.0000   0      0
      0      0      0      0     1.4142   0
      0      0      0      0      0     1.0000
```

```
pole(sys)
```

```
ans = 6x1
      0
      0
     -1.4142
     -1.0000
      1.4142
      1.0000
```

```
zero(sys)
```

```
ans = 4x1
     -1.0000
      1.0000
     -1.0000
      1.0000
```