

# Problem 12-19:

## Solution

```

1  clear;clc;close all;
2
3  A = [-0.0140      0    -1.4000      0      0;
4        0.0230    -0.0230    -0.0230      0      0;
5        0.1340    0.6700    -0.6700    0.3800    0.003246;
6        0          0    0.0600   -0.0600      0;
7        0          0    0.0017      0   -0.0010  ];
8  B = [1,0,0,0,0]';
9  C = [1,0,0,0,0];
10 D = 0;
11
12 % Part A
13 Co = ctrb(A,B);
14 size_A = size(A);
15 if (rank(Co)-size_A(1) >= 0)
16     fprintf("controllable\n");
17 else
18     fprintf("not controllable\n");
19 end
20 P = Co/Co;
21
22 % :wPart B
23 % at least two ways to calculate the phase variable form
24 sys = ss(A,B,C,D);
25 sys = canon(sys, 'companion');
26 A_phase = sys.A';
27 B_phase = zeros(length(A_phase),1);
28 B_phase(length(A_phase)) = 1;
29 fprintf('A matrix in phase var form');
30 A_phase
31 fprintf('B matrix in phase var form');
32 B_phase
33
34 % second way
35 [num,den] = ss2tf(A,B,C,D);
36 den = den(2:end);
37 den = den(end:-1:1);
38 A_phase2 = [zeros(length(A)-1,1),eye(length(A)-1)];
39 A_phase2 = [A_phase2;-den];
40 fprintf('A matrix in phase var form');
41 A_phase2
42 fprintf('B matrix in phase var form');
43 B_phase2 = B_phase
44
45 fprintf('The difference between two methods');
46 A_phase - A_phase2

```

The out put is :

```

1  controllable
2  A matrix in phase var form
3  A_phase =
4
5      0    1.0000      0      0      0
6      0      0    1.0000      0      0
7      0      0      0    1.0000      0
8      0      0      0      0    1.0000
9     -0.0000   -0.0016   -0.0394   -0.2485   -0.7680
10
11 B matrix in phase var form
12 B_phase =
13
14      0
15      0
16      0
17      0
18      1
19
20 A matrix in phase var form
21 A_phase2 =
22

```

```

23         0      1.0000      0      0      0
24         0      0      1.0000      0      0
25         0      0      0      1.0000      0
26         0      0      0      0      1.0000
27    -0.0000  -0.0016  -0.0394  -0.2485  -0.7680
28
29    B matrix in phase var form
30    B_phase2 =
31
32         0
33         0
34         0
35         0
36         1
37
38    The difference between two methods
39    ans =
40
41    1.0e-14 *
42
43         0      0      0      0      0
44         0      0      0      0      0
45         0      0      0      0      0
46         0      0      0      0      0
47    0.0007    0.0152    0.0867    0.2470    0.3109

```