Problem 12-19:
Solution

```
clear;clc;close all;

A = [-0.0140         0   -1.4000         0         0;
      0.0230   -0.0230   -0.0230         0         0;
      0.1340    0.6700   -0.6700    0.3800    0.003246;
           0         0    0.0600   -0.0600         0;
           0         0    0.0017         0   -0.0010   ];
B = [1,0,0,0,0]';
C = [1,0,0,0,0];
D = 0;

% Part A
Co = ctrb(A,B);
size_A = size(A);
if (rank(Co)-size_A(1) ≥ 0)
    fprintf("controllable\n");
else
    fprintf("not controllable\n");
end
P = Co/Co;

% :wPart B
% at least two ways to calculate the phase variable form
sys = ss(A,B,C,D);
sys = canon(sys, 'companion');
A_phase = sys.A';
B_phase = zeros(length(A_phase),1);
B_phase(length(A_phase)) = 1;
fprintf('A matrix in phase var form');
A_phase
fprintf('B matrix in phase var form');
B_phase

% second way
[num,den] = ss2tf(A,B,C,D);
den = den(2:end);
den = den(end:-1:1);
A_phase2 = [zeros(length(A)-1,1),eye(length(A)-1)];
A_phase2 = [A_phase2;-den];
fprintf('A matrix in phase var form');
A_phase2
fprintf('B matrix in phase var form');
B_phase2 = B_phase

fprintf('The difference between two methods');
A_phase - A_phase2
```

The out put is :

```
controllable
A matrix in phase var form
A_phase =

         0    1.0000         0         0         0
         0         0    1.0000         0         0
         0         0         0    1.0000         0
         0         0         0         0    1.0000
   -0.0000   -0.0016   -0.0394   -0.2485   -0.7680

B matrix in phase var form
B_phase =

     0
     0
     0
     0
     1

A matrix in phase var form
A_phase2 =

```

```
          0    1.0000         0         0         0
          0         0    1.0000         0         0
          0         0         0    1.0000         0
          0         0         0         0    1.0000
   -0.0000   -0.0016   -0.0394   -0.2485   -0.7680

B matrix in phase var form
B_phase2 =

     0
     0
     0
     0
     1

The difference between two methods
ans =

   1.0e-14 *

          0         0         0         0         0
          0         0         0         0         0
          0         0         0         0         0
          0         0         0         0         0
    0.0007    0.0152    0.0867    0.2470    0.3109
```