Question 2

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Establish symbolic variables

```
syms a b c d
```

Part A

```
A1 = [   -2  1   0   0   0;...
        0   -1  1   0   0;...
        0   0   -2  1   0;...
        0   0   0   -2  1;...
        0   0   0   0   -1]
B1 = [0 0; 0 0; a b ; c 0; 0 d]

testM = [B1 A1*B1 (A1^2)*B1 (A1^3)*B1 (A1^4)*B1]
rank1 = rank(testM)
% In order for A1 and B1 to allow reachability, the matrix testM must
 be Full Row Rank
% In this case testM has 5 rows, so rank(testM) must return 5
% If a, b, c, d are all diferent values then the pair will always be
% reachable. However if some of their values are identical they
% pair may or may not lead to reachability.
% If b and d or c and d equal zero then testM loses rank and becomes
% not reachable.
```

A1 =

```
    -2     1     0     0     0
     0    -1     1     0     0
     0     0    -2     1     0
     0     0     0    -2     1
     0     0     0     0    -1
```

B1 =

```
[ 0, 0]
[ 0, 0]
[ a, b]
[ c, 0]
[ 0, d]
```

```
testM =

[ 0, 0,       0,    0,         a,       b,    c - 5*a,        -5*b,
 17*a - 7*c,     17*b + d]
[ 0, 0,       a,    b,   c - 3*a,    -3*b,  7*a - 5*c,     7*b + d,
 17*c - 15*a, - 15*b - 6*d]
[ a, b, c - 2*a, -2*b, 4*a - 4*c, 4*b + d, 12*c - 8*a, - 8*b - 5*d,
 16*a - 32*c,  16*b + 17*d]
[ c, 0,    -2*c,    d,       4*c,    -3*d,       -8*c,          7*d,
     16*c,         -15*d]
[ 0, d,       0,   -d,         0,       d,          0,           -d,
        0,             d]


rank1 =

     5
```

Part B

```
A2 = [   -1  1   0   0   0;...
         0   0  1   0   0;...
         0   0   -1  0   0;...
         0   0   0   -1  1;...
         0   0   0   0   0];
B2 = [0 0; 0 0;a b; 0 0; c d];

testM2 = [B2 A2*B2 (A2^2)*B2 (A2^3)*B2 (A2^4)*B2 ]
rank2 = rank(testM2)

% In order for A2 and B2 to allow reachability, the matrix testM must
 be Full Row Rank
% In this case testM2 has 5 rows, so rank(testM2) must return 5
% If a, b, c, d are all diferent values then the pair will always be
% reachable. However if some of their values are identical they
% pair may or may not lead to reachability.
% If a=c and b=d pair is not reachable. If a and b or a and c or b and
 d or c and d equal zero then testM loses rank and becomes
% not reachable.


testM2 =

[ 0, 0,  0,  0,  a,  b, -2*a, -2*b, 3*a, 3*b]
[ 0, 0,  a,  b, -a, -b,    a,    b,  -a,  -b]
[ a, b, -a, -b,  a,  b,   -a,   -b,   a,   b]
[ 0, 0,  c,  d, -c, -d,    c,    d,  -c,  -d]
[ c, d,  0,  0,  0,  0,    0,    0,   0,   0]
```

```
rank2 =

     5
```

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