Modal_Example_Week7

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Computation of modal matrix using numeric codes in Matlab

start with diagaonal form with roots {-1, -5, -2+/-j3}

```
format rat
J = [-1     0       0       0;...
      0    -5       0       0;...
      0     0       -2+j*3  0;...
      0     0        0    -2-j*3]

  % define QB as on pg 11 of Week 7 notes
  QB = [1       0       0       0;...
        0       1       0       0;...
        0       0       1/2     -j*(1/2);...
        0       0       1/2     +j*(1/2)]

J_in_M = inv(QB)*J*QB   % "modal" form
```

note: if you put one complex number in an array, Matlab generally will display the array as shwon below

```
J =

  Columns 1 through 2

     -1         +     0i              0         +     0i
      0         +     0i             -5         +     0i
      0         +     0i              0         +     0i
      0         +     0i              0         +     0i

  Columns 3 through 4

      0         +     0i              0         +     0i
      0         +     0i              0         +     0i
     -2         +     3i              0         +     0i
      0         +     0i             -2         -     3i


QB =
```

```
  Columns 1 through 2

     1         +    0i              0         +    0i
     0         +    0i              1         +    0i
     0         +    0i              0         +    0i
     0         +    0i              0         +    0i

  Columns 3 through 4

     0         +    0i              0         +    0i
     0         +    0i              0         +    0i
     1/2       +    0i              0         -    1/2i
     1/2       +    0i              0         +    1/2i


J_in_M =

    -1              0              0              0
     0             -5              0              0
     0              0             -2              3
     0              0             -3             -2
```

Computation of modal matrix using symbolic variables and tools

this surprsses the +j0 entries in the JB martix for real entries remember these are symbolic variables see note at end of the cell

```
clear all;
clc
J = sym([-1      0       0       0;...
      0    -5       0       0;...
      0     0       -2+j*3  0;...
      0     0        0     -2-j*3])

  % define QB as on pg 11 of Week 7 notes
  QB = sym([1       0       0       0;...
        0       1       0       0;...
        0       0       1/2     -j*(1/2);...
        0       0       1/2     +j*(1/2)])

J_in_M = inv(QB)*J*QB
% one way to to get back to numeric so you can use in numeric program
J_in_M_num= eval(J_in_M)
```

```
J =

[ -1,  0,        0,        0]
[  0, -5,        0,        0]
[  0,  0, - 2 + 3i,        0]
```

```
[  0,  0,        0, - 2 - 3i]


QB =

[ 1, 0,   0,      0]
[ 0, 1,   0,      0]
[ 0, 0, 1/2, -1i/2]
[ 0, 0, 1/2,  1i/2]


J_in_M =

[ -1,  0,  0,  0]
[  0, -5,  0,  0]
[  0,  0, -2,  3]
[  0,  0, -3, -2]


J_in_M_num =

    -1     0     0     0
     0    -5     0     0
     0     0    -2     3
     0     0    -3    -2
```

Finding Q*Q_bar = inv(P) see pg 11 notes bottom

this is direct transform to get modal form from A start with A in PVCV similar to above diagaonal form with roots {-1, -5, -2+/-j3}

```
den_coeff = conv([conv([1 1], [1,5])], [conv([1 2+j*3],[1 2-j*3])]) % coeff of CE
% validate by finding roots
roots(den_coeff)
coeffs= fliplr(den_coeff) % flip so we can put in PVCF matrix easily
A = [0 1 0 0; 0 0 1 0; 0 0 0 1; -coeffs(1:4)]  % put in PVCF (only 1st 4 coeffs)
[V, D] = eig(A)  % eig works since no repeated roots and no GEVs
```

```
den_coeff =

     1    10    42    98    65



ans =

    -5    +   0i
    -2    +   3i
```

```
     -2         -    3i
     -1         +    0i


coeffs =

     65             98             42             10              1



A =

      0              1              0              0
      0              0              1              0
      0              0              0              1
    -65            -98            -42            -10


V =

  Columns 1 through 2

     71/9058    +    0i            -176/8749    +   94/23883i
    -97/2475    +    0i              479/16851  -  430/6303i
     97/495     +    0i              997/6745   + 3040/13711i
    -97/99      +    0i           -13206/13745  +    0i

  Columns 3 through 4

   -176/8749    -   94/23883i        1/2       +    0i
    479/16851   +  430/6303i        -1/2       +    0i
    997/6745    - 3040/13711i        1/2       +    0i
  -13206/13745  +    0i             -1/2       +    0i


D =

  Columns 1 through 2

     -5         +    0i             0          +    0i
      0         +    0i            -2          +    3i
      0         +    0i             0          +    0i
      0         +    0i             0          +    0i

  Columns 3 through 4

      0         +    0i             0          +    0i
      0         +    0i             0          +    0i
     -2         -    3i             0          +    0i
      0         +    0i            -1          +    0i
```

as seen the complex conjugate roots of D are in the two center locations corresponding to cols 2 and 3 of V this was a Matlab ordering - you have to check

notation from lecture pg 11

```
QQB = [V(:,1), real(V(:,2)), imag(V(:,3)), V(:,4)] % where A = QQB
 Modal inv(QB)Inv(Q)
% starting with A we get modal for and bypass diagonal with complex
 roots
% on diagonal.  the basic algorithm is to find the cols in V
 corresponding
% to the complex roots and make the first col real compoents the
 second
% imag components
format short
QQB
```

```
QQB =

      71/9058       -176/8749        -94/23883         1/2
     -97/2475        479/16851       430/6303         -1/2
      97/495         997/6745      -3040/13711         1/2
     -97/99       -13206/13745         0              -1/2


QQB =

    0.0078   -0.0201   -0.0039    0.5000
   -0.0392    0.0284    0.0682   -0.5000
    0.1960    0.1478   -0.2217    0.5000
   -0.9798   -0.9608         0   -0.5000
```

note no imaginary cols are in QQB

```
MM = inv(QQB)*A*QQB
```

```
MM =

   -5.0000    0.0000    0.0000   -0.0000
   -0.0000   -2.0000   -3.0000   -0.0000
    0.0000    3.0000   -2.0000    0.0000
    0.0000    0.0000         0   -1.0000
```

Modal form

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