LINEAR ALGEBRA MATLAB EXECUTIONS

UE20MA251

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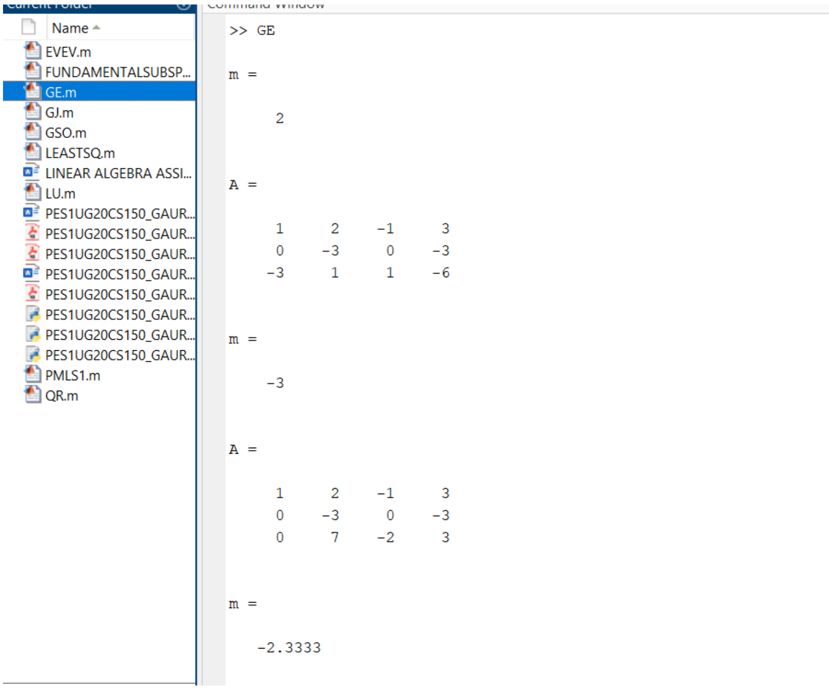
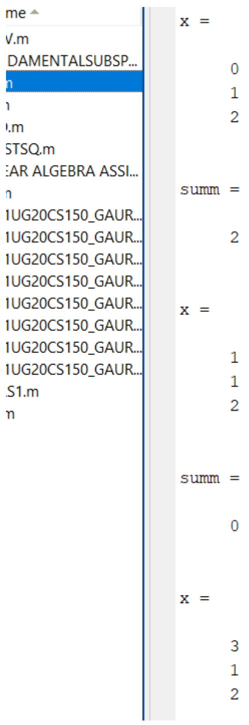
GAUSSIAN ELIMINATION

```
C = [1 2 -1; 2 1 -2; -3 1 1];
b= [3 3 -6]';
A = [C b];
n= size(A,1);
x = zeros(n,1); %variable matrix [x1 x2... xn] column
for i=1:n-1
for j=i+1:n
m = A(j,i)/A(i,i)
A(j,:) = A(j,:) - m*A(i,:)
end
end
x(n) = A(n,n+1)/A(n,n)
for i=n-1:-1:1
summ = 0;
for j=i+1:n
summ = summ + A(i,j)*x(j,:)
x(i,:) = (A(i,n+1) - summ)/A(i,i)
end
end
```





GAUSS JORDAN METHOD

```
C = [1 2 -1; 2 1 -2; -3 1 1];
b= [3 3 -6]';
A = [C b];
n= size(A,1);
x = zeros(n,1); %variable matrix [x1 x2... xn] column
for i=1:n-1
for j=i+1:n
m = A(j,i)/A(i,i)
A(j,:) = A(j,:) - m*A(i,:)
end
end
x(n) = A(n,n+1)/A(n,n)
for i=n-1:-1:1
summ = 0;
for j=i+1:n
summ = summ + A(i,j)*x(j,:)
x(i,:) = (A(i,n+1) - summ)/A(i,i)
end
end
```

```
>> GJ

Aug =

    1.0000         0         0    1.4000    0.2000   -0.4000
         0   -1.0000         0    1.5000         0   -0.5000
         0         0  -10.0000  -11.0000    2.0000    1.0000


Aug =

    1.0000         0         0    1.4000    0.2000   -0.4000
         0    1.0000         0   -1.5000         0    0.5000
         0         0  -10.0000  -11.0000    2.0000    1.0000


Aug =

    1.0000         0         0    1.4000    0.2000   -0.4000
         0    1.0000         0   -1.5000         0    0.5000
         0         0    1.0000    1.1000   -0.2000   -0.1000


B =

    1.4000    0.2000   -0.4000
   -1.5000         0    0.5000
    1.1000   -0.2000   -0.1000
```

LU DECOMPOSITION

```
%LU Decomposition
Ab = [1 1 -1;3 5 6;7 8 9]

n= length(Ab)

L = eye(n)

% With A(1,1) as pivot Element

for i =2:3

alpha = Ab(i,1)/Ab(1,1)

L(i,1) = alpha

Ab(i,:) = Ab(i,:) -alpha*Ab(1,:)

end

% With A(2,2) as pivot Element

i=3

alpha = Ab(i,2)/Ab(2,2)

L(i,2)= alpha

Ab(i,:) = Ab(i,:)-alpha*Ab(2,:)

U = Ab(1:n,1:n)
```

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```
>> LU

Ab =

     1     1    -1
     3     5     6
     7     8     9


n =

     3


L =

     1     0     0
     0     1     0
     0     0     1


alpha =

     3


L =

     1     0     0
     3     1     0
     0     0     1
```

```
Ab =

     1     1    -1
     0     2     9
     7     8     9


alpha =

     7


L =

     1     0     0
     3     1     0
     7     0     1


Ab =

     1     1    -1
     0     2     9
     0     1    16


i =

     3
```

```
1

    3


alpha =

    0.5000


L =

    1.0000         0         0
    3.0000    1.0000         0
    7.0000    0.5000    1.0000


Ab =

    1.0000    1.0000   -1.0000
         0    2.0000    9.0000
         0         0   11.5000


U =

    1.0000    1.0000   -1.0000
         0    2.0000    9.0000
         0         0   11.5000
```

FUNDAMENTAL SUBSPACES

```
clc;
clear all
close all
% Bases of four fundamental vector spaces of matrix A.
A=[1,2,3;2,-1,1]
% Row Reduced Echelon Form
[R, pivot] = rref(A)
% Rank
rank = length(pivot)
% basis of the column space of A
columnsp = A(:,pivot)
% basis of the nullspace of A
nullsp = null(A,'r')
% basis of the row space of A
rowsp = R(1:rank,:)'
% basis of the left nullspace of A
leftnullsp = null(A','r')
```

```
A =

     1     2     3
     2    -1     1


R =

     1     0     1
     0     1     1


pivot =

     1     2


rank =

     2


columnsp =

     1     2
     2    -1


nullsp =
```

```
rank =

     2


columnsp =

     1     2
     2    -1


nullsp =

    -1
    -1
     1


rowsp =

     1     0
     0     1
     1     1


leftnullsp =

  2×0 empty double matrix
```

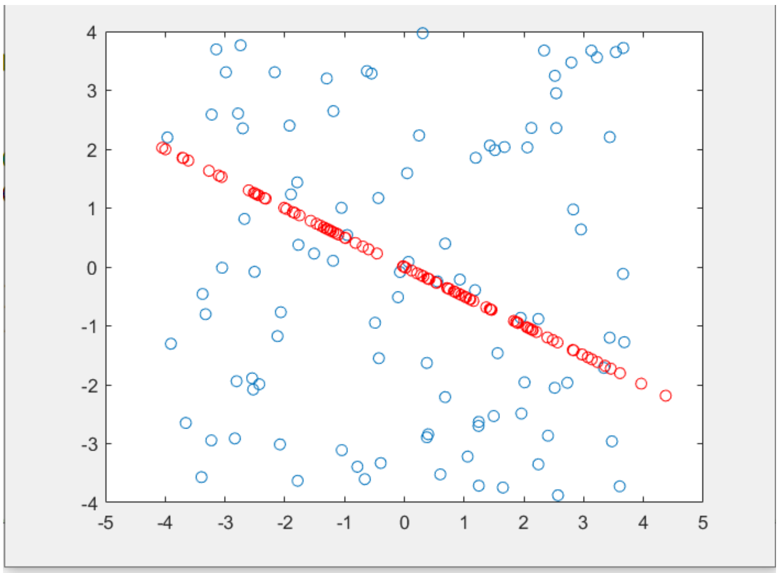
PROJECTION MATRICES AND LEAST SQUARES

```
%FIND THE POINT ON THE PLANE X+Y-Z=0 THAT IS CLOSEST TO (2,1,0)
% syms c
% P=[2,1,0]+c*[1,1,-1]
% s=1*(c+2)+1*(c+1)-1*(-c)==0
% s1=solve(s,c)
% p=[2,1,0]+s1*[1,1,-1]

%FIND THE POINT ON THE PLANE 3X+4Y+Z=1 THAT IS CLOSEST TO (1,0,1)
% syms c
% P=[1,0,1]+c*[3,4,1]
% s=3*(1+3*c)+4*(4*c)+(1+c)==1
% s1=solve(s,c)
% p=[1,0,1]+s1*[3,4,1]

%Let u=[1,7] onto v=[-4,2] and find P, the matrix that will project any matrix o
% u=[1;7]
% v=[-4;2]
% P=(v*transpose(v))/ (transpose (v)*v)
% P*u

% %PROJECTING A LOT OF VECTORS ON A SINGLE VECTOR
u=8*rand(2,100)-4
x=u(1,:)
y=u(2,: )
plot(x,y,'o')
P=[0.8,-0.4;-0.4,0.2]
Pu=P*u;
x=Pu(1,:)
y=Pu(2,:)
hold on
plot(x,y,'ro')
```

```
>> PMLS1

P =

[c + 2, c + 1, -c]


s =

3*c + 3 == 0


s1 =

-1


p =

[1, 0, 1]

>> PMLS1

P =

[3*c + 1, 4*c, c + 1]


s =

fx 26*c + 4 == 1
```

```
s1 =

-3/26


p =

[17/26, -6/13, 23/26]

>> PMLS1

u =

     1
     7


v =

    -4
     2


P =

    0.8000   -0.4000
   -0.4000    0.2000


ans =
```

```
ans =

    -2
     1
```



LEAST SQUARE

```
A=[1,0;0,2;3,1]
b=[1;0;4]
x = lsqr(A,b)
```

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ommand Window

```
>> LEASTSQ

A =

     1     0
     0     2
     3     1


b =

     1
     0
     4

lsqr converged at iteration 2 to a solution with relative residual 0.076.

x =

    1.2927
    0.0244
```

GRAM-SCHMIDT PROCESS

```
%Apply the Gram-Schmidt process to the vectors (1,0,1), (1,0,0) and (2,1,0)
% A=[1,1,2;0,0,1;1,0,0]
% Q=zeros(3)
% R=zeros(3)
% for j=1:3
% v=A(: , j)
% for i=1:j-1
% R(i,j)=Q(:,i)'*A(:,j)
% v=v-R(i,j)*Q(:,i)
% end
% R(j,j)=norm(v)
% Q(:,j)=v/R(j,j)
% end
%Apply the Gram-Schmidt process to the vectors a=(0,1,1,1),
%b=(1,1,-1,0) and c=(1,0,2,-1).
% A=[0,1,1;1,1,0;1,-1,2;1,0,-1]
% Q=zeros(4,3)
% R=zeros(3)
% for j=1:3
% v=A(: , j)
% for i=1:j-1
% R(i,j)=Q(:,i)'*A(:,j)
% v=v-R(i,j)*Q(:,i)
% end
% R(j,j)=norm(v)
% Q(:,j)=v/R(j,j)
% end
```

```
>> GSO

A =

     1     1     2
     0     0     1
     1     0     0


Q =

     0     0     0
     0     0     0
     0     0     0


R =

     0     0     0
     0     0     0
     0     0     0


v =

     1
     0
     1
```

```
R =

    1.4142         0         0
         0         0         0
         0         0         0


Q =

    0.7071         0         0
         0         0         0
    0.7071         0         0


v =

     1
     0
     0


R =

    1.4142    0.7071         0
         0         0         0
         0         0         0


v =

fx    0.5000
```

```
         0
   -0.5000


R =

    1.4142    0.7071         0
         0    0.7071         0
         0         0         0


Q =

    0.7071    0.7071         0
         0         0         0
    0.7071   -0.7071         0


v =

     2
     1
     0


R =

    1.4142    0.7071    1.4142
         0    0.7071         0
         0         0         0
```

```
v =

   -0.0000
    1.0000
    0.0000


R =

    1.4142    0.7071    1.4142
         0    0.7071    1.4142
         0         0    1.0000


Q =

    0.7071    0.7071   -0.0000
         0         0    1.0000
    0.7071   -0.7071    0.0000
```

```
A =

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


Q =

     0     0     0
     0     0     0
     0     0     0
     0     0     0


R =

     0     0     0
     0     0     0
     0     0     0


v =

     0
     1
     1
     1
```

```
R =

    1.7321         0         0
         0         0         0
         0         0         0


Q =

         0         0         0
    0.5774         0         0
    0.5774         0         0
    0.5774         0         0


v =

     1
     1
    -1
     0


R =

    1.7321         0         0
         0         0         0
         0         0         0


v =
```

```
R =

    1.7321         0    0.5774
         0    1.7321   -0.5774
         0         0         0


v =

    1.3333
         0
    1.3333
   -1.3333


R =

    1.7321         0    0.5774
         0    1.7321   -0.5774
         0         0    2.3094


Q =

         0    0.5774    0.5774
    0.5774    0.5774         0
    0.5774   -0.5774    0.5774
    0.5774         0   -0.5774
```

EIGEN VALUE-EIGEN VECTORS

```
>> EVEV

A =

     1     1     3
     1     5     1
     3     1     1


e =

   -2.0000
    3.0000
    6.0000


ans =

   -36


ans =

  -36.0000


ans =

     7
```

```
V =

   -0.7071    0.5774    0.4082
    0.0000   -0.5774    0.8165
    0.7071    0.5774    0.4082


D =

   -2.0000         0         0
         0    3.0000         0
         0         0    6.0000


ans =

   1.0e-14 *

    0.0666    0.0222    0.0444
    0.0723   -0.1110    0.0888
    0.0222    0.0666    0.0888


ans =

    1.4142
    0.0000
   -1.4142


ans =
```

```
ans =

    1.4142
   -0.0000
   -1.4142
```

```
A =

     2     2     1
     1     3     1
     1     2     2


e =

    1.0000
    5.0000
    1.0000


V =

   -0.9045    0.5774    0.0409
    0.3015    0.5774   -0.4631
    0.3015    0.5774    0.8853


D =

    1.0000         0         0
         0    5.0000         0
         0         0    1.0000
```

QR FACTORISATION

```
%A=[1,1,0;1,0,1;0,1,1]
%[Q,R]=qr (A)

% A=sym(pascal(3))
% [Q,R]=qr(A)
% isAlways(A == Q*R)

% A = sym(invhilb (5))
% b = sym([1:5]')
% [C,R] =qr (A,b)
% X = R\C
%
% isAlways(A*X ==b)
```

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Command Window

```
>> QR

A =

     1     1     0
     1     0     1
     0     1     1


Q =

   -0.7071    0.4082   -0.5774
   -0.7071   -0.4082    0.5774
         0    0.8165    0.5774


R =

   -1.4142   -0.7071   -0.7071
         0    1.2247    0.4082
         0         0    1.1547
```

```
>> QR

A =

[1, 1, 1]
[1, 2, 3]
[1, 3, 6]


Q =

[3^(1/2)/3, -2^(1/2)/2,  6^(1/2)/6]
[3^(1/2)/3,          0, -6^(1/2)/3]
[3^(1/2)/3,  2^(1/2)/2,  6^(1/2)/6]


R =

[3^(1/2), 2*3^(1/2), (10*3^(1/2))/3]
[      0,   2^(1/2),  (5*2^(1/2))/2]
[      0,         0,      6^(1/2)/6]
```

```
ans =

  3×3 logical array

   1   1   1
   1   1   1
   1   1   1

>> QR

A =

[   25,   -300,    1050,   -1400,    630]
[ -300,   4800,  -18900,   26880, -12600]
[ 1050, -18900,   79380, -117600,  56700]
[-1400,  26880, -117600,  179200, -88200]
[  630, -12600,   56700,  -88200,  44100]


b =

1
2
3
4
5


C =
```

```
C =

                                     (25*142001^(1/2))/142001
       -(1244173*142001^(1/2)*91552829^(1/2))/13000593270829
(145370538*91552829^(1/2)*125433709^(1/2))/1148381091 2761
     -(40805589*737641^(1/2)*125433709^(1/2))/92525046540469
                                   (5084*737641^(1/2))/737641


R =

[5*142001^(1/2),         -(13372500*142001^(1/2))/142001,                            (57881250*14200
[             0, (60*142001^(1/2)*91552829^(1/2))/142001, -(37960020000*142001^(1/2)*91552829^(1/2))
[             0,                                       0,              (420*91552829^(1/2)*125433709^
[             0,                                       0,
[             0,                                       0,


X =

      5
  71/20
 197/70
657/280
1271/630


ans =
```

```
X =

      5
  71/20
 197/70
657/280
1271/630


ans =

  5×1 logical array

   1
   1
   1
   1
   1
```