PES University, Bangalore

(Established under Karnataka Act No. 16 of 2013)

APRIL 2021: IN SEMESTER ASSESSMENT (ISA) B.TECH. IV SEMESTER

UE19MA251- LINEAR ALGEBRA

Mathematics Lab

Session: Jan-May 2021

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Branch : Electronics & Communication

Semester & Section : Semester IV Section A

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Marks : /05

Name of the Course Instructor : **Prof. Deepthi Rao**

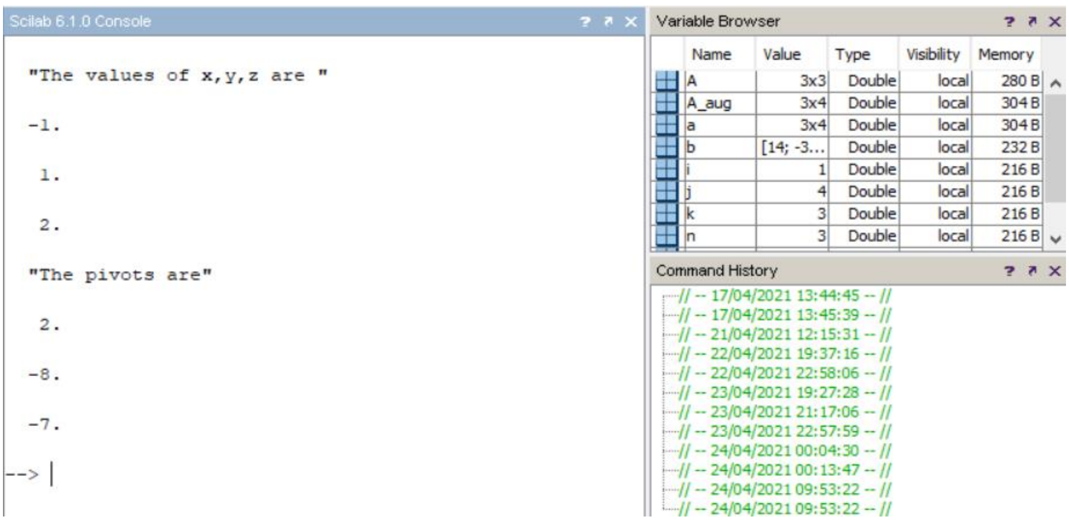
Signature of the Course Instructor : ______________________________

Topic: Gaussian Elimination

Example 1: Solve the system of equations 2x + 4y + 6z = 14, 3x -2 y + z = -3 and 4x + 2y – z = -4 using Gaussian Elimination. Also, identify the pivots.

Solution:

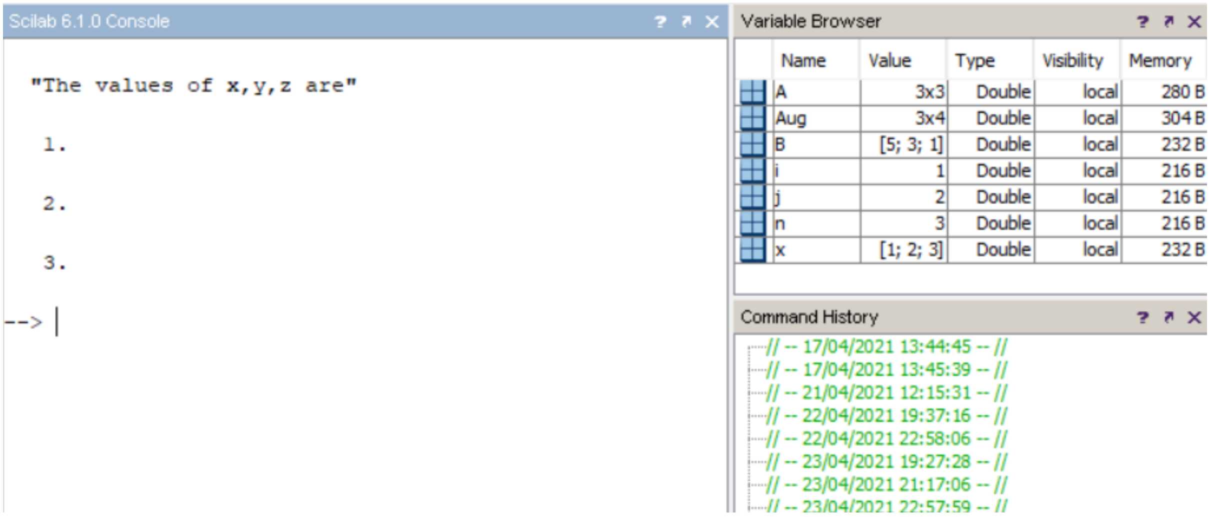
```
clc;
clear;
close;
A=[2,4,6;3,-2,1;4,2,-1],b=[14;-3;-4]
A_aug=[A b]
a=A_aug
n=3;
for i=2:n
    for j=2:n+1
        a(i,j)=a(i,j)-a(1,j)*a(i,1)/a(1,1);
end
a(i,1)=0;
end
for i=3:n
    for j=3:n+1
        a(i,j)=a(i,j)-a(2,j)*a(i,2)/a(2,2);
    end
    a(i,2)=0;
end
x(n)=a(n,n+1)/a(n,n);
for i=n-1:-1:1
    sumk=0;
    for k=i+1:n
        sumk=sumk+a(i,k)*x(k);
    end
    x(i)=(a(i,n+1)-sumk)/a(i,i);
end
disp('The values of x,y,z are ',x(1),x(2),x(3));
disp('The pivots are',a(1,1),a(2,2),a(3,3));
```



Example 2: Solve the system of equations 2x + 3y –z = 5, 4x + 4y -3 z = 3 and -2x + 3y –z = 1 by Gaussian Elimination.

Solution:

```
clc
clear
A=[2 3 -1;4 4 -3;-2 3 -1]; //coefficient
B=[5;3;1]; //constant
n=length(B);
Aug=[A,B];
//forward elimination
for j=1:n-1
    for i=j+1:n
        Aug(i,j:n+1)=Aug(i,j:n+1)-(Aug(i,j)/Aug(j,j)*Aug(j,j:n+1));
    end
end
//backward substitution
x=zeros(n,1);
x(n)=Aug(n,n+1)/Aug(n,n);
for i=n-1:-1:1
    x(i)=(Aug(i,n+1)-Aug(i,i+1:n)*x(i+1:n))/Aug(i,i);
end
disp('The values of x,y,z are',x(1),x(2),x(3))
```



Topic: LU decomposition of a matrix

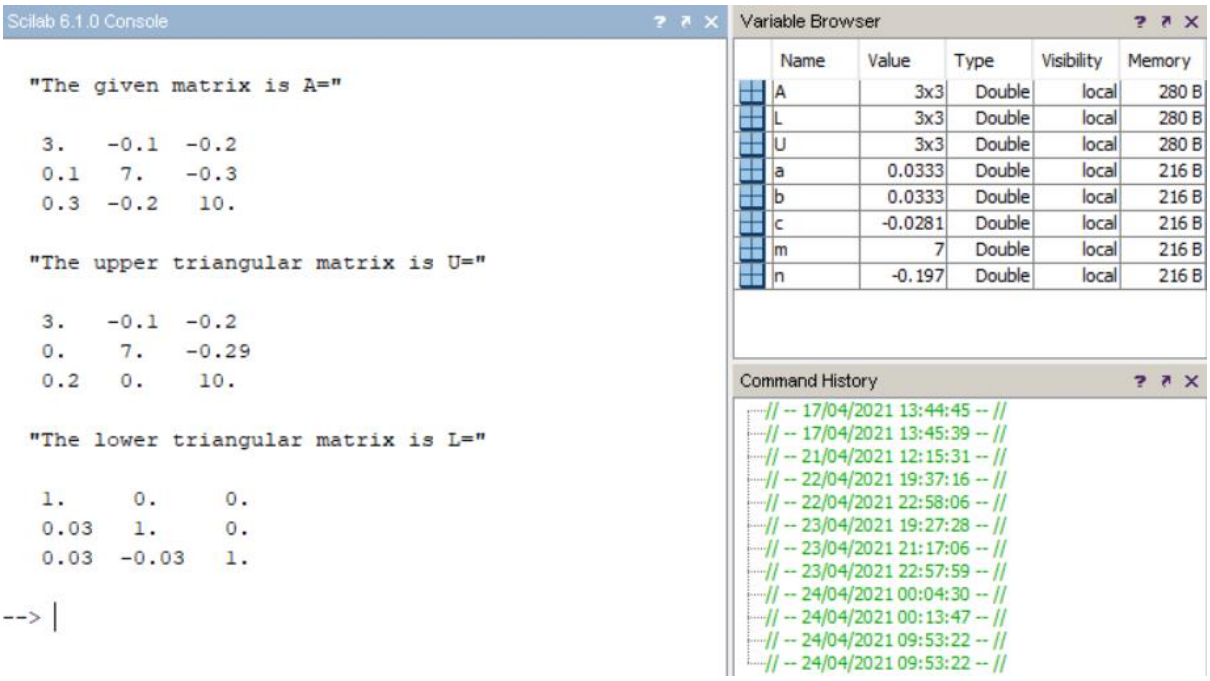
Example 3: Find the triangular factors L and U for the matrix A = [3 -0.1 -0.2

0.1 7 -0.3

0.3 -0.2 10]

Solution:

```
clc;
clear;
close;
A=[3,-0.1,-0.2;0.1,7,-0.3;0.3,-0.2,10];
U=A;
disp('The given matrix is A=',A)
m=det(U(1,1));
n=det(U(2,1));
a=n/m;
U(2,:)=U(2,:)-U(1,:)/(m/n);
b=n/m;
U(3,:)=U(3,:)-U(1,:)/(m/n);
m=det(U(2,2));
n=det(U(3,2));
c=n/m;
U(3,:)=U(3,:)-U(2,:)/(m/n);
disp('The upper triangular matrix is U=',U)
L=[1,0,0;a,1,0;b,c,1];
disp('The lower triangular matrix is L=',L)
```



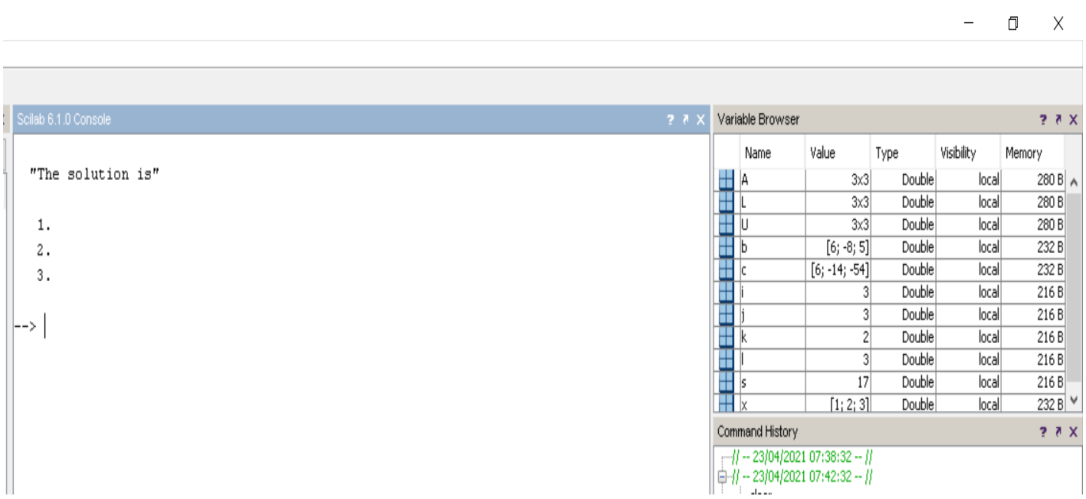
Example 4: Solve the system of equations 4x -2 y + 2z = 6, 4x -3 y -2 z = -8 and 2x + 3y –z = 5 by LU decomposition.

Solution:

```
clear;
close;
clc;
format('v',5);
A= {4 -2 2;4 -3 -2;2 3 -1};
for l=1:3
   L(l,l)=1;
end

for i=1:3
   for j=1:3
      s=0;
      if (j>=i)
         for k=1:i-1
            s=s+(L(i, k)*U(k, j));
         end
         U(i,j)=A(i,j)-s;
      else
         for k=1:j-1
            s=s+(L(i,k)*U(k,j));
         end
         L(i,j)=(A(i,j)-s)/U(j,j);
      end
   end
end

b=[6;-8;5];
c=L\b;
x=U\c;
disp( "Solution of the given equation is: ", x)
```



Topic: The Gauss - Jordan method of calculating A^{-1}

Example 5: Find the inverse of the matrix A = [1 1 1

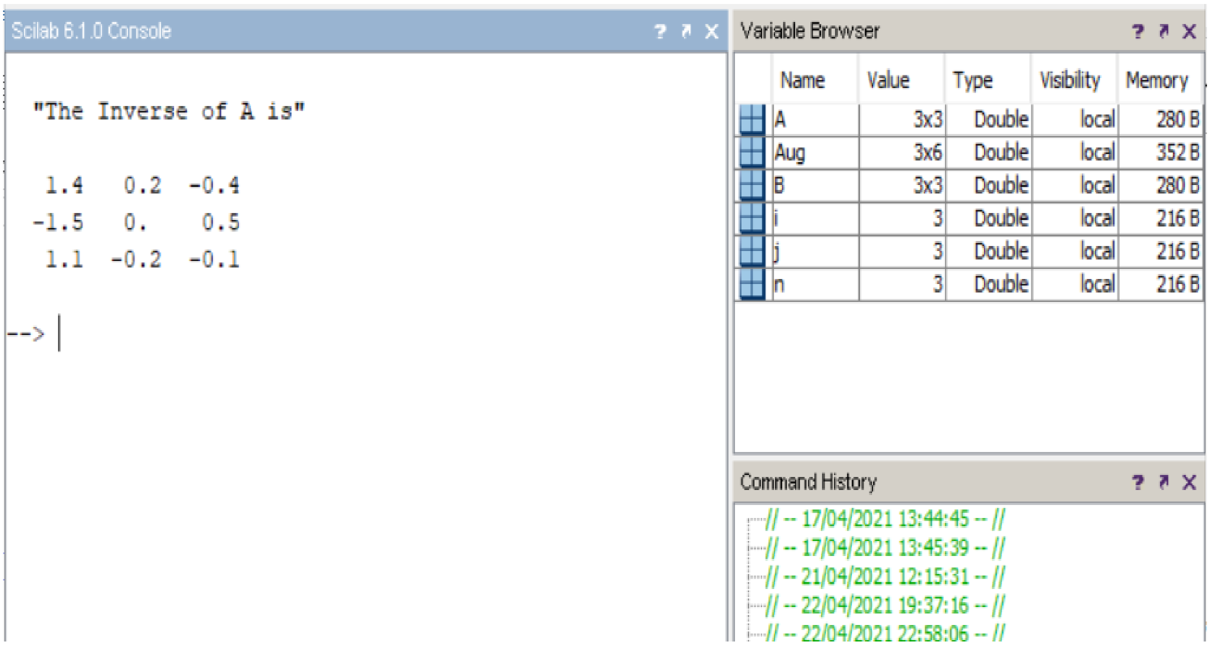
4 3 -1

3 5 3]

by Gauss – Jordan method.

Solution:

```
clc;
clear;
A=[1 1 1;4 3 -1;3 5 3];
n=length(A(1,:));
Aug=[A,eye(n,n)];
for j=1:n-1
    for i=j+1:n
        Aug(i,j:2*n)=Aug(i,j:2*n)-Aug(i,j)/Aug(j,j)*Aug(j,j:2*n);
        end
end
for j=n:-1:2
    Aug(1:j-1,:)=Aug(1:j-1,:)-Aug(1:j-1,j)/Aug(j,j)*Aug(j,:);
end
for j=1:n
    Aug(j,:)=Aug(j,:)/Aug(j,j);
end
B=Aug(:,n+1:2*n);
disp('The Inverse of A is',B);
```



Topic: Span of the Column Space of A

Example 6: Identify the columns that are in the column space of A where

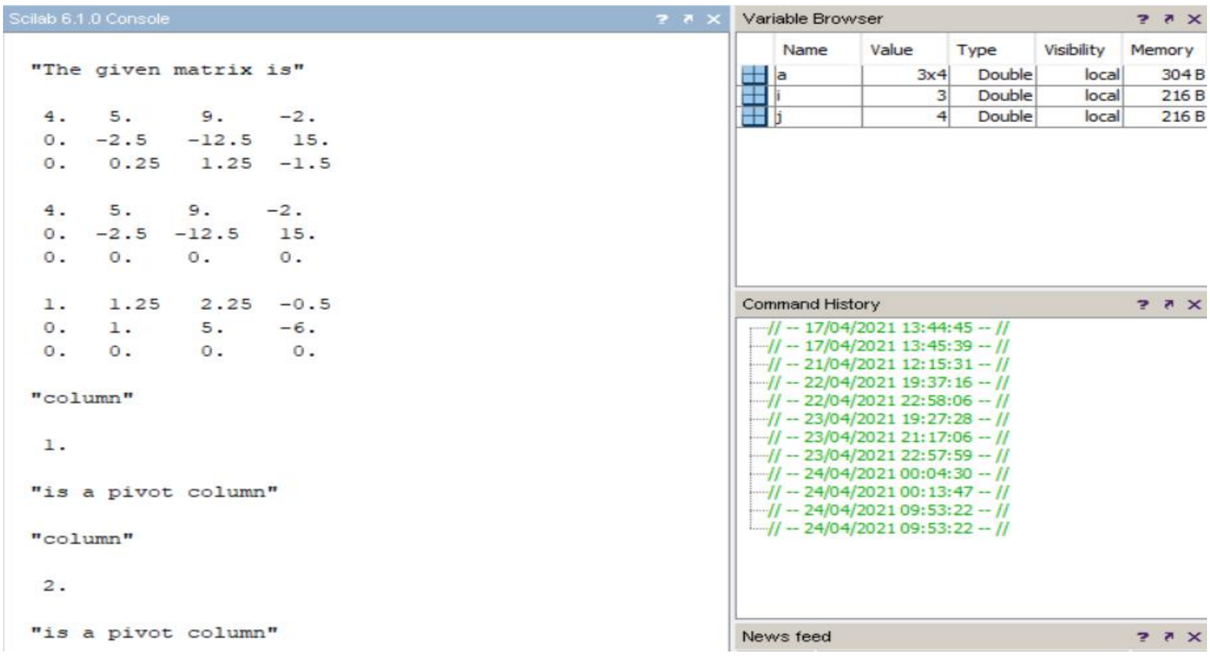
A = [4 5 9 -2

6 5 1 12

3 4 8 -3]

Solution:

```
clc;
clear;
close;
disp('The given matrix is')
a=[4 5 9 -2;6 5 1 12;3 4 8 -3]
a(2,:)=a(2,:)-(a(2,1)/a(1,1))*a(1,:)
a(3,:)=a(3,:)-(a(3,1)/a(1,1))*a(1,:)
disp(a)
a(3,:)=a(3,:)-(a(3,2)/a(2,2))*a(2,:)
disp(a)
a(1,:)=a(1,:)/a(1,1)
a(2,:)=a(2,:)/a(2,2)
disp(a)
for i=1:3
   for j=1:4
      if(a(i,j)<>0)
         disp('column',j,'is a pivot column')
         break
      end
   end
end
```



Topic: The Four Fundamental Subspaces

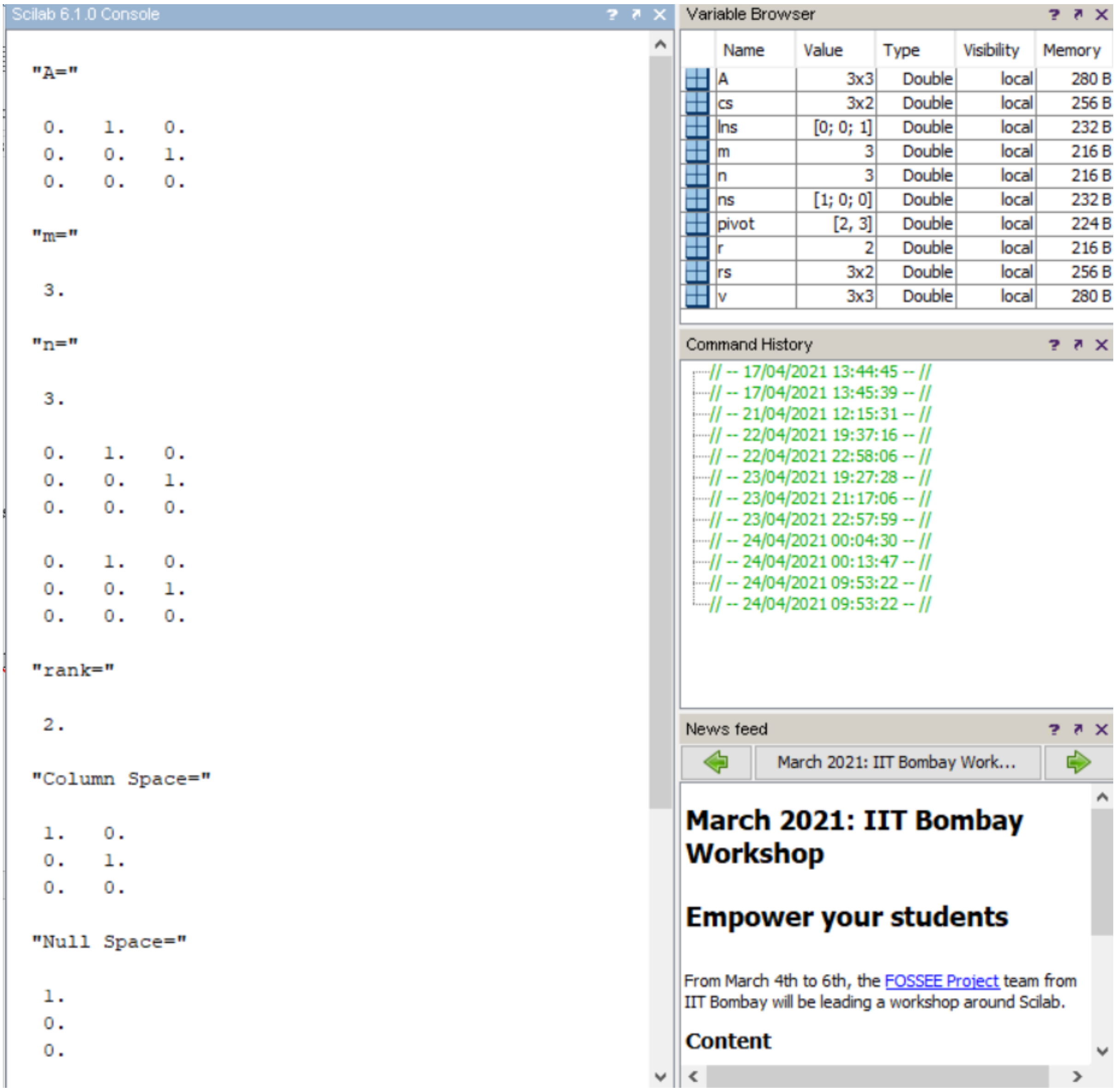
Example 7: Find the four fundamental subspaces of A =[0 1 0

0 0 1

0 0 1]

Solution:

```
clear;
close;
clc;
A=[0 1 0;0 0 1;0 0 0];
disp('A=',A);
[m,n]=size(A);
disp('m=',m);
disp('n=',n);
[v,pivot]=rref(A);
disp(rref(A));
disp(v);
r=length(pivot);
disp('rank=',r);
cs=A(:,pivot);
disp('Column Space=',cs);
ns=kernel(A);
disp('Null Space=',ns);
rs=v(1:r,:)';
disp('Row Space=',rs)
lns=kernel(A');
disp('Left Null Space=',lns );
```


Scilab 6.1.0 Console
"A="
0. 1. 0.
0. 0. 1.
0. 0. 0.
"m="
3.
"n="
3.
0. 1. 0.
0. 0. 1.
0. 0. 0.
0. 1. 0.
0. 0. 1.
0. 0. 0.
"rank="
2.
"Column Space="
1. 0.
0. 1.
0. 0.
"Null Space="
1.
0.
0.
Variable Browser
Name Value Type Visibility Memory
A 3x3 Double local 280 B
cs 3x2 Double local 256 B
lns [0; 0; 1] Double local 232 B
m 3 Double local 216 B
n 3 Double local 216 B
ns [1; 0; 0] Double local 232 B
pivot [2, 3] Double local 224 B
r 2 Double local 216 B
rs 3x2 Double local 256 B
v 3x3 Double local 280 B
Command History
// -- 17/04/2021 13:44:45 -- //
// -- 17/04/2021 13:45:39 -- //
// -- 21/04/2021 12:15:31 -- //
// -- 22/04/2021 19:37:16 -- //
// -- 22/04/2021 22:58:06 -- //
// -- 23/04/2021 19:27:28 -- //
// -- 23/04/2021 21:17:06 -- //
// -- 23/04/2021 22:57:59 -- //
// -- 24/04/2021 00:04:30 -- //
// -- 24/04/2021 00:13:47 -- //
// -- 24/04/2021 09:53:22 -- //
// -- 24/04/2021 09:53:22 -- //
News feed
March 2021: IIT Bombay Work...
March 2021: IIT Bombay Workshop
Empower your students
From March 4th to 6th, the FOSSEE Project team from IIT Bombay will be leading a workshop around Scilab.
Content


"Row Space="
0. 0.
1. 0.
0. 1.
"Left Null Space="
0.
0.
1.
News feed
March 2021: IIT Bombay Work...
March 2021: IIT Bombay Workshop
Empower your students
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Content

Topic: Projections by Least Squares

Example 8: Find the solution x = (C , D) of the system Ax = b and the line of best fit

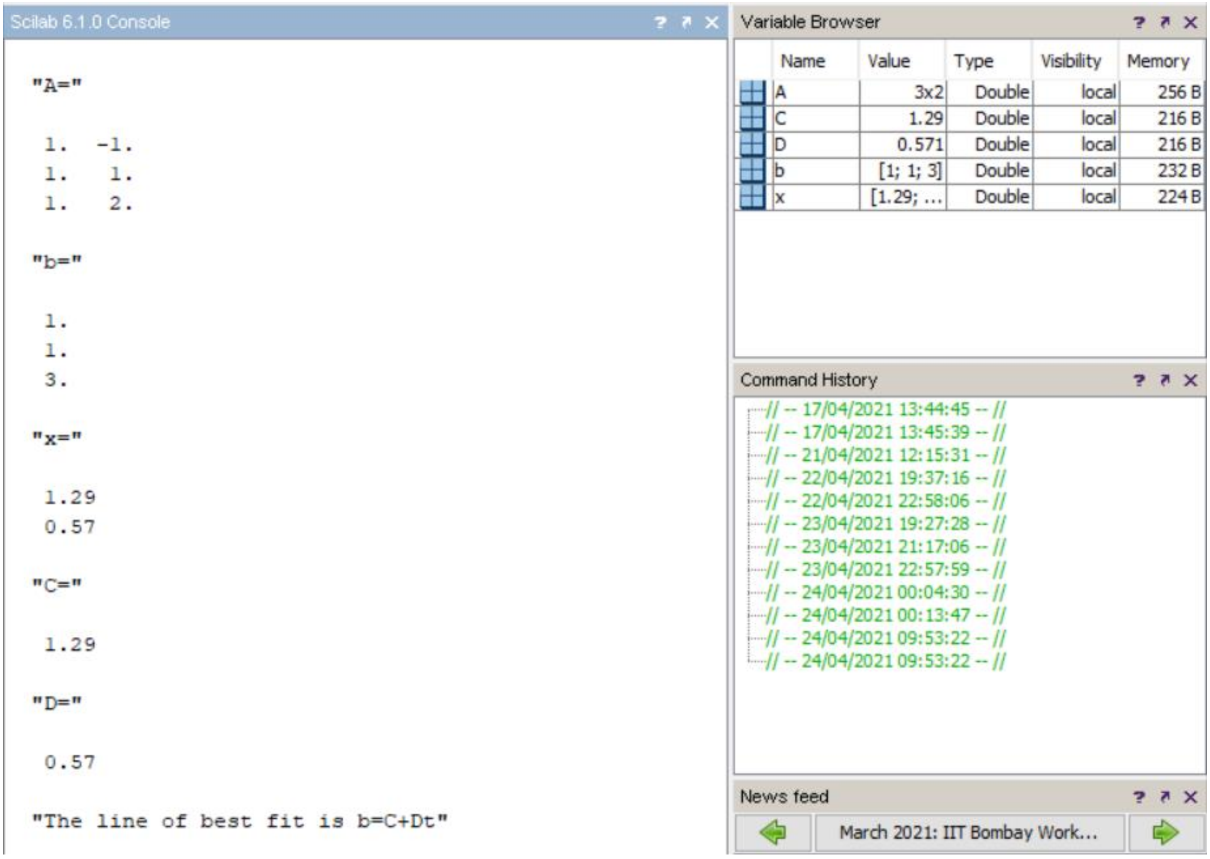
C + Dt = b given b = (1, 1, 3), A = [1 -1 ,

1 1,

1 2]

Solution:

```
clear;
close;
clc;
A=[1 -1;1 1;1 2];
disp('A=',A);
b=[1;1;3];
disp('b=',b);
x=(A'*A)\(A'*b);
disp('x=',x);
C=x(1,1);
D=x(2,1);
disp('C=',C);
disp('D=',D);
disp('The line of best fit is b=C+Dt');
```

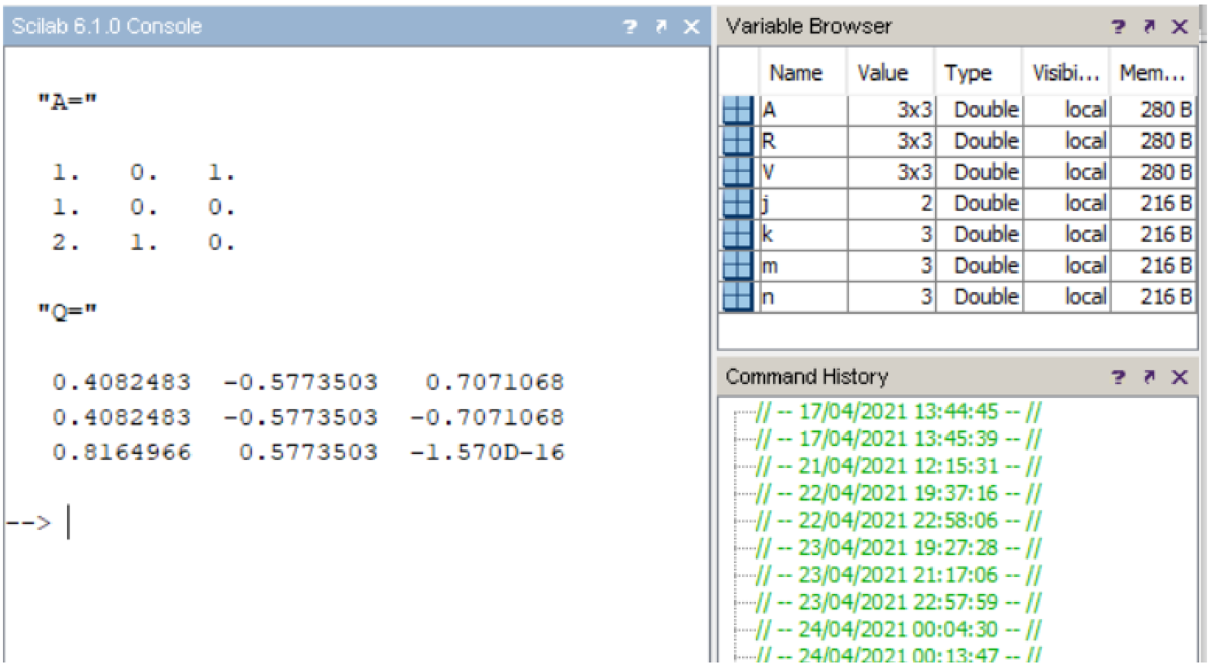


Topic: The Gram- Schmidt Orthogonalization

Example 9: Apply the Gram – Schmidt process to the vectors (1, 0, 1) , (1, 0, 0,) and (2, 1, 0) to produce a set of orthonormal vectors.

Solution:

```
clear;
close;
clc;
A=[1 0 1;1 0 0; 2 1 0];
disp('A=',A);
[m,n]=size(A);
for k=1:n
   V(:,k)=A(:,k);
   for j=1:k-1
      R(j,k)=V(:,j)'*A(:,k);
      V(:,k)=V(:,k)-R(j,k)*V(:,j);
   end
   R(k,k)=norm(V(:,k));
   V(:,k)=V(:,k)/R(k,k);
end
disp('Q=',V);
```



Topic: Eigen values and Eigen vectors of a given square matrix

Example 10: Find the Eigen values and the corresponding Eigen vectors of

A = [3 -2 5

-2 3 6

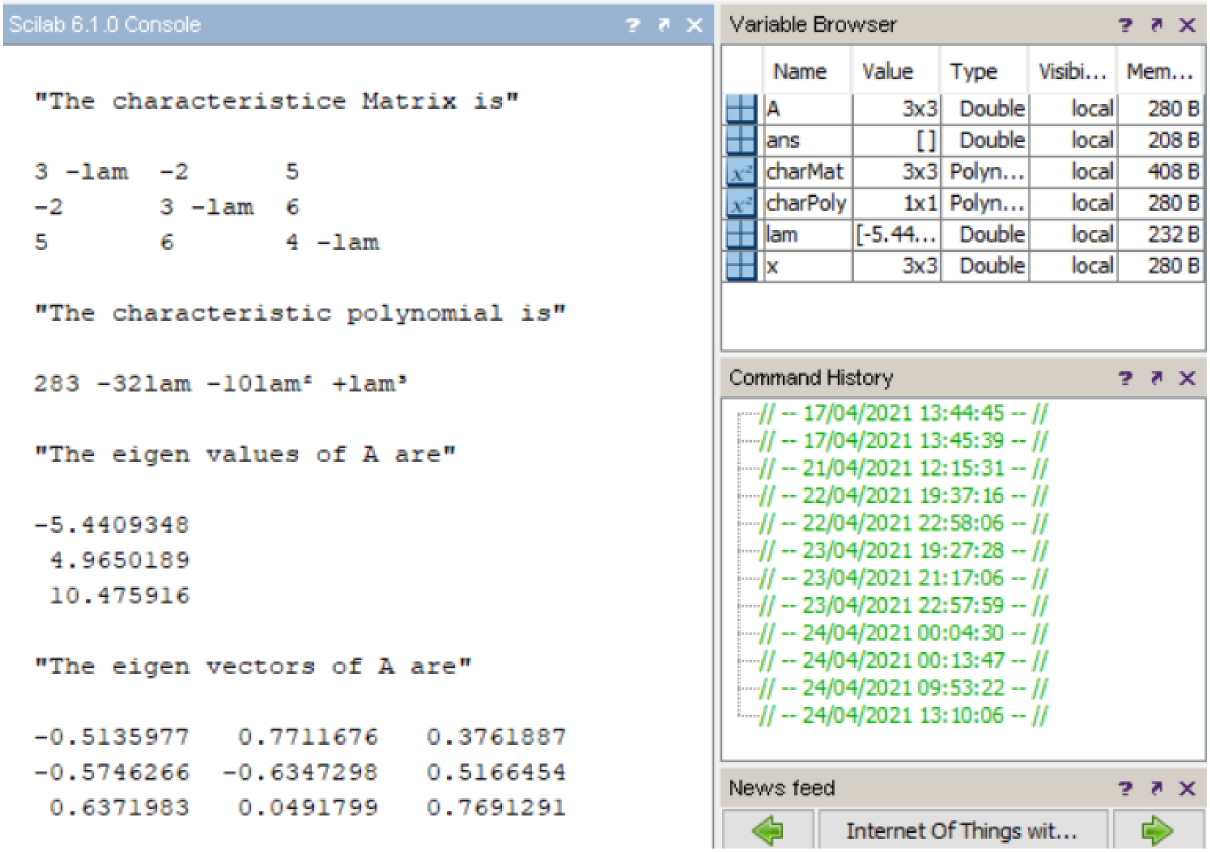
5 6 4]

Solution:

```
clear;
close;
clc;
format('v',5);
A= {4 -2 2;4 -3 -2;2 3 -1};
for l=1:3
   L(l,l)=1;
end

for i=1:3
   for j=1:3
      s=0;
      if (j>=i)
         for k=1:i-1
            s=s+(L(i, k)*U(k, j));
         end
         U(i,j)=A(i,j)-s;
      else
         for k=1:j-1
            s=s+(L(i,k)*U(k,j));
         end
         L(i,j)=(A(i,j)-s)/U(j,j);
      end
   end
end

b=[6;-8;5];
c=L\b;
x=U\c;
disp( "Solution of the given equation is: ", x)
```


Scilab 6.1.0 Console
"The characteristice Matrix is"
3 -lam   -2   5
-2   3 -lam   6
5   6   4 -lam
"The characteristic polynomial is"
283 -32lam -10lam² +lam³
"The eigen values of A are"
-5.4409348
4.9650189
10.475916
"The eigen vectors of A are"
-0.5135977   0.7711676   0.3761887
-0.5746266 -0.6347298   0.5166454
0.6371983   0.0491799   0.7691291
Variable Browser
Name Value Type Visibi... Mem...
A 3x3 Double local 280 B
ans [ ] Double local 208 B
charMat 3x3 Polyn... local 408 B
charPoly 1x1 Polyn... local 280 B
lam [-5.44... Double local 232 B
x 3x3 Double local 280 B
Command History
// -- 17/04/2021 13:44:45 -- //
// -- 17/04/2021 13:45:39 -- //
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// -- 24/04/2021 00:13:47 -- //
// -- 24/04/2021 09:53:22 -- //
// -- 24/04/2021 13:10:06 -- //
News feed
Internet Of Things wit...