1 (a) Consider a vector $y \in R(AB)$; We can say that

$\Rightarrow y = (AB)x$

$\Rightarrow y = A(Bx)$

$\Rightarrow y = Ax'$ — (1) · [$x' = Bx$ is also a vector]

from (1) we can see that $R(AB) \subseteq R(A)$

So, $\boxed{\dim(R(AB)) \le \dim(R(A)) \text{ or } \text{Rank}(AB) \le \text{Rank}(A)}$ [dim(Range) = Rank]

(b) As B is non-singular, inverse of B exists.

~~We can~~

following the same procedure used in (a), we can say that $\Rightarrow \dim[R(ABB^{-1})] \le \dim[R(AB)]$ — (1)

Also from (a), $\dim[R(AB)] \le \dim[R(A)]$ — (2)

Combine (1) & (2)

$\Rightarrow \dim[R(ABB^{-1})] \le \dim[R(AB)] \le \dim[R(A)]$

$\Rightarrow \dim[R(A)] \le \dim[R(AB)] \le \dim[R(A)]$

$\Rightarrow \dim[R(AB)] = \dim[R(A)]$

1 c) from part (a) & (d)

$$\dim[N(AB)] \geq \dim[N(A)] \quad -(1)$$

$$\dim[N(AB)] \geq \dim[N(B)] \quad -(2)$$

Let n_a, n_b & n_{ab} are nullity of A, B & AB respectively

$$N(B) = \{x_1, x_2, \ldots x_{n_b}\} \Rightarrow \text{Basis of nullspace of } B$$

We can extend this to basis of $N(AB)$.

$$N(AB) = \{x_1, x_2, \ldots x_{n_b}, x_{n_{b+1}} \ldots x_{n_{ab}}\}$$

$$\Rightarrow \underbrace{c_1 x_1 + c_2 x_2 + \ldots c_{n_B} x_{n_B}} + \ldots c_{n_{ab}} x_{n_{ab}} = 0 - (1)$$

$$\Rightarrow \underbrace{c_1 B x_1 + c_2 B x_2 + \ldots c_{n_B} B x_{n_B}}_{=0} + \ldots c_{n_{ab}} B x_{n_{ab}} = 0$$

$$\Rightarrow B\left(c_{n_{b+1}} x_{n_{b+1}} + \ldots c_{n_{ab}} x_{n_{ab}}\right) = 0$$

where C is collection of coefficients in a matrix of (1) for which $\sum c_i x_j = 0$

1 (d) $\dim[R(A)] + \dim[N(A)] = n$

proof: $\dim[R(A)] = r$ (assumption) $r < n$ — ①

$\Rightarrow$ When we convert A in row-reduced echelon form.

~~No~~ There will be r non-zero ~~rows~~ column = Rank of A

also

There will be $n-r$ ~~non~~ zero ~~rows~~ column ~~for~~ in row reduced echleon form of A

which contributes to $Ax = 0$ ~~or~~

$= \dim(N(A))$

$n - r = \dim(N(A))$ — ②

from ① & ②

$\dim[R(A)] + \dim(N(A)) = r + (n-r)$

$= n$

$\therefore$ Hence proved

1e) proof:-

from part (c):

$$\dim[N(AB)] \le \dim[N(A)] + \dim[N(B)]$$

$\Rightarrow$ $\cancel{p} - rank(AB) \le n - rank(A) + \cancel{p} - rank(B)$ $[AB \in \mathbb{R}^{...}]$

$\Rightarrow$ $rank(AB) \ge rank(A) + rank(B) - n$ — (1)

also from part (A)

$$rank(AB) \le rank(A)$$
$$rank(AB) \le rank(B)$$

Combining above two eq^ns,

$$rank(AB) \le \min\{rank(A), rank(B)\} \quad -(2)$$

from (1) & (2) we can say that

$$\boxed{rank(A) + rank(B) - n \le rank(AB) \le \min\{rank(A), rank(B)\}}$$

∴ Hence proved.

1f) $rank(u) = 1$ [rank of non-zero vector = 1]

lets $u = A$ & $u^T = B$; then from part (a)

$$rank(AB) \le rank(A)$$
$$rank(uu^T) \le rank(u)$$
$$rank(uu^T) \le 1$$

[~~ran~~ rank = 0 ; only iff all elements are zero]

$$\boxed{rank(uu^T) = 1}$$

(19) Let $A \in \mathbb{R}^{m \times n}$

Let column rank of $A = y$ — ①

then there will exist a basis $(B) = \{b_1, b_2, \cdots b_y\}$.

where $b_i \in \mathbb{R}^k$

spans the column space of A

Now, we know that we can repreest column of A as linear combination of column of B

if $A = \begin{bmatrix} | & | & & | \\ a_1 & a_2 & \cdots & a_n \\ | & | & & | \end{bmatrix}$ then

$$a_1 = c_{11} b_1 + c_{21} b_2 + \cdots c_{y1} b_y$$
$$a_2 = c_{21} b_1 + c_{22} b_2 + \cdots c_{y2} b_y$$
$$\vdots$$
$$a_n = c_{n1} b_1 + c_{n2} b_2 + \cdots c_{yn} b_y$$

where c_{ij} are coefficients

We can write above equations as

$A = BC$ where $C \in \mathbb{R}^{y \times n}$ collections of coefficients

from class notes, we can represent

$A = BC = b_1 c_1 + b_2 c_2 + \cdots b_y c_y$

where c_i is ith row of C & b_i is column of B

~~Now we~~ We have y rows in C, so

A has maximum of y independent rows

So row rank = independent rows.

row rank $\leq y$

row rank $\leq$ column rank — ②

If we ~~ff~~ follow same procedure for rank we will get $A = D R$ where R is basis

$$\begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_z \end{bmatrix}$$

$\Rightarrow$ Column Rank $\leq$ Row Rank - (2)

$z \to$ Row rank

&

E is collection of coefficients

$E \in \mathbb{R}^{m \times z}$

from (1) & (2)

$$\boxed{\text{Column Rank} = \text{Row Rank}}$$

Problem-2

Solution:-

(a) Let D is a vector, $D = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \\ \vdots \\ d_8 \\ d_9 \\ d_{10} \end{bmatrix}$; $d \in \mathbb{R}^{10}$.

and

C is also a vector, $C = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_8 \\ c_9 \\ c_{10} \end{bmatrix}$; $c \in \mathbb{R}^{10}$

Let F is a matrix, whose entries are $f_j(i)$, where $i \Rightarrow$ row number and $j \Rightarrow$ column number. $f \in \mathbb{R}^{i \times j}$

for $d \in \mathbb{R}^{10}$, there always exists a set of real coefficients $c \in \mathbb{R}^{10}$, such that

$$\Rightarrow \sum_{j=1}^{10} c_j f_j(i) = d_i \quad \text{for } i \in \{1, 2, \cdots 9, 10\}$$

[Given in question]

$$\Rightarrow FC = D$$

It means range$(F) = \mathbb{R}^{10}$

This implies that null$(F) = \{0\}$

[Theorem 1.3, Trefethen Bau, If a matrix is full rank or range(F) = dim, then, null (F) = {0}]

As discussed in class, that if a matrix $A \in \mathbb{R}^{m \times n}$ is full rank, then

$\Rightarrow Ax_1 = y_1$; $Ax_2 = y_2$ [

$\Rightarrow x_1 \neq x_2$, then $y_1 \neq y_2$

So $d \in \mathbb{R}^{10}$ maps $c \in \mathbb{R}^{10}$ uniquely.

(b) Given :- $AD = C$; where $A \in \mathbb{R}^{10\times10}$

from previous part, $FC = D$,

we can write $AD = C$ as $AFC = C$,

$\Rightarrow$ As F is full rank, we can say that A is inverse of F, also $\boxed{A^{-1} = F}$

So i,j^{th} entry of $A^{-1} = f_j(i)$.

3 (a) $\Rightarrow Q = (I-S)^{-1}(I+S)$

Taking transpose on both sides

$$Q^T = \left[(I-S)^{-1}(I+S)\right]^T$$

$$= (I+S)^T\left((I-S)^{-1}\right)^T \qquad \left((A^T)^{-1} = (A^{-1})^T\right)$$

$$= (I+S)^T\left((I-S)^T\right)^{-1} \qquad \left((A+B)^T = A^T + B^T\right)$$

$$= (I^T+S^T)(I^T-S^T)^{-1} \qquad \text{(for skey-symmetric matrix } S^T = -S)$$

$$= (I-S)(I+S)^{-1} \quad \text{— (1)}$$

$$\Rightarrow QQ^T = (I-S)^{-1}(I+S)(I-S)(I+S)^{-1} \quad \text{(from (1))}$$

$$= (I-S)^{-1}(I^2-S^2)(I+S)^{-1}$$

$$= \underbrace{(I-S)^{-1}(I-S)}_{I}\underbrace{(I+S)(I+S)^{-1}}_{I}$$

$$= I$$

$\therefore$ hence proved.

3 (b) Let's assume, $u^TAu = 0$ [given]

$$\Rightarrow u^T(QDQ^T)u = 0$$

$$\Rightarrow \underline{u^TQ}\,D\,\underline{Q^Tu} = 0$$

Let $u^TQ = y_{1\times m}$ (row vector) $\Rightarrow (u^TQ)^T = Q^Tu^{TT} = Q^Tu = y^T$

$$\Rightarrow yDy^T = 0$$

If u is not zero vector then y is not zero vector; So above equation implies that $D=0$

$$D = 0 \Rightarrow QDQ^T = 0 \Rightarrow \boxed{A=0}$$

hence proved.

3c $u^T.S.u = [u_1, u_2 \cdots u_m]_{1\times m} \begin{bmatrix} s_{11} & s_{12} & s_{13} & \cdots & s_{1m} \\ s_{21} & & & & \vdots \\ \vdots & & & & \vdots \\ s_{m1} & \cdots & & & s_{mm} \end{bmatrix}_{m\times m} \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_m \end{bmatrix}$

s_{ij} = elements of S

$$= \begin{bmatrix} u_1 s_{11} & u_1 s_{12} & \cdots & u_1 s_{1m} \\ + & + & & + \\ u_2 s_{21} & u_2 s_{22} & \cdots & u_2 s_{2m} \\ + & + & & \vdots \\ u_3 s_{31} & u_3 s_{32} & & \vdots \\ \vdots & \vdots & & \vdots \\ u_m s_{m1} & u_m s_{m2} & & u_m s_{mm} \end{bmatrix}_{1\times m} \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_m \end{bmatrix}_{m\times 1}$$

$$= \left[\sum_{j=1}^{m} u_j \sum_{i=1}^{m} u_i s_{ij} \right]$$

We know if S is skew-symmetric $\boxed{s_{ij} = -s_{ji}}$

Then all terms will cancel out

$= 0$

[$j=1;\ i=2$
$u_1 u_2 s_{12}$
& for $j=2;\ i=1$
$u_2 u_1 s_{21} = -u_2 u_1 s_{12}$]
also $s_{ii} = 0$

This happens only iff S is skew-symmetric

hence proved.

Problem 4:- $x \in \mathbb{R}^m$; $A \in \mathbb{R}^{m \times n}$

(a) Assumption :- $|x_j| = \max_{1 \le i \le m} |x_i|$

$x = \begin{bmatrix} x_1 \\ \vdots \\ x_j \\ \vdots \\ x_m \end{bmatrix}$

Then

$\Rightarrow \|x\|_\infty = |x_j| \quad -①$

Also $\Rightarrow \|x\|_2 = \sqrt{\sum_{i=1}^{m} |x_i|^2} \quad -②$

$\Rightarrow \sqrt{\sum_{i=1}^{m} |x_i|^2} \geq |x_j|$

$\Rightarrow$ from ① and ②

$\Rightarrow \boxed{\|x\|_2 \geq \|x\|_\infty}$ hence proved

The equality holds, if $x = \alpha e_j$

where $\alpha \in \mathbb{R}$ and

$e_j = \begin{bmatrix} 0 \\ \vdots \\ 1 \\ \vdots \\ 0 \end{bmatrix}$ ← j^{th} entry, $1 \le j \le m$

(b) Assumption : $|x_j| = \max_{1 \le i \le m} |x_i|$; $x = \begin{bmatrix} x_1 \\ \vdots \\ x_j \\ \vdots \\ x_m \end{bmatrix}$

$\Rightarrow \sqrt{\sum_{i=1}^{m} |x_j|^2} \geq \sqrt{\sum_{i=1}^{m} |x_i|^2}$ [$|x_j|$ is max^m of all of the entries]

$\Rightarrow |x_j| \sqrt{\sum_{i=1}^{m}} \geq \|x\|_2$

$\Rightarrow \sqrt{m}\, |x_j| \geq \|x\|_2$

$\Rightarrow \boxed{\sqrt{m}\, \|x\|_\infty \geq \|x\|_2}$ [$\|x\|_\infty = \max_{1 \le i \le m} |x_i|$]

proved

if $x = \alpha \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}$; where $\alpha \in \mathbb{R}$, then the equality holds.

(c) As we know that

$$\boxed{\|A\|_p^{(m,n)} = \max_{\substack{x \in \mathbb{R}^n \\ x \notin \{0\}}} \frac{\|Ax\|_p^{(m)}}{\|x\|_p^{(n)}}}$$

$$\|A\|_\infty^{(m,n)} = \max \frac{\|Ax\|_\infty^{(m)}}{\|x\|_\infty^{(n)}} \quad -(1)$$

$$\|A\|_2^{(m,n)} = \max \frac{\|Ax\|_2^{(m)}}{\|x\|_2^{n}} \quad -(2)$$

from previous part (a), (b) and (1), (2)

We can say that

$$\Rightarrow \frac{\|Ax\|_\infty^{(m)}}{\sqrt{n}\,\|x\|_\infty^{(n)}} \leq \frac{\|Ax\|_2^{(m)}}{\|x\|_2^{(n)}}$$

$$\Rightarrow \frac{\|Ax\|_\infty^{(m)}}{\|x\|_\infty^{(n)}} \leq \sqrt{n}\left[\frac{\|Ax\|_2^{(m)}}{\|x\|_2^{(n)}}\right]$$

Take maximum on both sides

$$\Rightarrow \boxed{\|A\|_\infty \leq \sqrt{n}\,(\|A\|_2)} \quad [(1) \,\&\, (2)]$$

proved

Equality holds for $x = \begin{bmatrix} 0 \\ \vdots \\ 1 \\ \vdots \\ 0 \end{bmatrix}$

(d) from previous a, b & c parts.

$x \in \mathbb{R}^n$
$x \notin \{0\}$

$$\Rightarrow \frac{\|Ax\|_2}{\sqrt{m}\,\|x\|_2} \leq \frac{\|Ax\|_\infty}{\|x\|_\infty}$$

$$\Rightarrow \frac{\|Ax\|_2}{\|x\|_2} \leq \sqrt{m}\,\frac{\|Ax\|_\infty}{\|x\|_\infty}$$

$\Rightarrow$ Take maximum of ratios on both sides.

$$\Rightarrow \boxed{\|A\|_2 \leq \sqrt{m}\,\|A\|_\infty}$$

proved

Equality holds for $x = \begin{bmatrix} 0 \\ \vdots \\ 1 \\ \vdots \\ 0 \end{bmatrix}$

(e) Frebenious Norm:

$$A \in \mathbb{R}^{m\times n} ; \|A\|_F = \left(\sum_{i=1}^{m}\sum_{j=1}^{n} |a_{ij}|^2\right)^{1/2}$$

It is a 2-norm ~~vector~~ of a matrix when viewed as a non-dimensional vector

So, this can also be written in terms of individual rows or columns.

$$\Rightarrow \|A\|_F = \left(\sum_{j=1}^{n} \|a_j\|_2^2\right)^{1/2} \quad -(1)$$

$$\Rightarrow \boxed{\|A\|_F = \sqrt{tr(A^TA)}}$$

proved

$$\left[\|x\|_2 = \left(\sum_{i=1}^{m} |x_i|^2\right)^{1/2} = \sqrt{x^Tx} \right.$$

(f) From Holder's enquality :- $(p=2 ; q=2)$

$$|x^Ty| \leq \|x\|_2 \|y\|_2 \quad -(1)$$

Let $y = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}_{m\times 1}$ & $x \in \mathbb{R}^m$

then $x^Ty = [x_1 x_2 \dots x_m] \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}$

$$= [|x_1| + |x_2| + |x_3| + \dots |x_m|]$$

$$= \|x\|_1 \quad -(3)$$

$$\|y\|_2 = \sqrt{\underbrace{1^2+1^2+1^2+\dots+1^2}_{m}} = \sqrt{m} \quad -(4)$$

(3) & (4) in (1)

$$\boxed{\|x\|_1 \leq \|x\|_2 \sqrt{m}} \quad -(5)$$

from 5 ;

$$\|A\|_1 = \max_{\substack{x\in\mathbb{R}^n \\ x\neq 0}} \frac{\|Ax\|_1}{\|x\|_1} \le \max \frac{\sqrt{m}\,\|Ax\|_2}{\|x\|_2}$$

$\left[\ \|Ax\|_1 \le \ \|Ax\|_2 \quad \|x\|_1 \ge \|x\|_2\ \right]$

$$\|A\|_1 \le \sqrt{m}\,\|A\|_2 \quad -6$$

Now

$$\|A\|_2 = \max_{\substack{x\in\mathbb{R}^n \\ x\neq 0}} \frac{\|Ax\|_2}{\|x\|_2} \le \max_{\substack{x\in\mathbb{R}^n \\ x\neq 0}} \frac{\|Ax\|_1}{\frac{\|x\|_1}{\sqrt{n}}}$$

$\left[\ \frac{\|x\|_1}{\sqrt{n}} \le \|x\|_2\ \right]$

$$\|A\|_2 \le \sqrt{n}\,\|A\|_1 \quad -7$$

Combinin 6 & 7

$$\boxed{\frac{1}{\sqrt{m}}\|A\|_1 \le \|A\|_2 \le \sqrt{n}\,\|A\|_1}$$

Equality holds if $x = \begin{bmatrix} 0 \\ \vdots \\ 1 \\ \vdots \\ 0 \end{bmatrix}$

(4g) $\|A\|_2 \le \sqrt{\|A\|_1 \|A\|_\infty}$

proof:- from holder's ~~eq~~ enquality

$\Rightarrow |x^T y| \le \|x\|_p \|y\|_q$

Put $p = 1$ & $q = \infty$

$\Rightarrow$ let $x = A\underset{\sim}{x}$ & $y = A\underset{\sim}{x}$ is unit vector

$|(Ax)^T Ax| \le \|Ax\|_1 \|Ax\|_\infty$ — (1)

We know that from frobenious norm

$$\|A\|_2 = \sqrt{\max_{\substack{\|x\|=1 \\ x \neq 0}} (Ax)^T (Ax)}$$

Put above in (1)

$$(\|A\|_2)^2 \le \|A\|_1 \|A\|_\infty$$

$$\|A\|_2 \le \sqrt{\|A\|_1 \|A\|_\infty}$$

equality holds if $x = \begin{bmatrix} 0 \\ \vdots \\ 1 \\ \vdots \\ 0 \end{bmatrix}$

5.Solutions:-

Matlab Code:-

```
clc
clear all

%Creating a random matrix of size (100*2)
A = randn(100,2);
max_norm_of_Ax = double.empty(6,0); %Creating an empty vector to store maximumum
value of norms of A
j=0;

for p = [1 2 3 4 5 inf]
    j=j+1;
    norm_of_Ax = double.empty(1000,0); %Creating an empty vector to store norms of
A.
    for i = 1:1000
        temp = randn(2,1);%random 2x1 vector
        x = (temp/norm(temp));%normalizing random vector
        Ax= A*x;%matrix multiplication
        norm_of_Ax(i) = (norm(Ax, p));% function to calculate p-norm of Ax
        end
    max_norm_of_Ax(j) = max(norm_of_Ax);% Storing maximum value of p-norm of Ax
    fprintf("%d norm of Ax\t %.8f\n",p,max_norm_of_Ax(j));
end


norm_A = double.empty(3,0);%Creating an empty vector to store norms of A
i=0;
for p = [1 2 inf]
   i=i+1;
   norm_A(i) = vpa(norm(A,p));%Storing p-norm of A
   fprintf("%d norm of A\t\t %.8f\n",p,norm_A(i));
end
```

Output:-

For 1000 iterations

```matlab
clear all

%Creating a random matrix of size (100*2)
A = randn(100,2);
max_norm_of_Ax = double.empty(6,0); %Creating an empty vector to store maximumum value of norms of A
j=0;

for p = [1 2 3 4 5 inf]
    j=j+1;
    norm_of_Ax = double.empty(1000,0); %Creating an empty vector to store norms of A.
    for i = 1:1000
        temp = randn(2,1);%random 2x1 vector
        x = (temp/norm(temp));%normalizing random vector
        Ax= A*x;%matrix multiplication
        norm_of_Ax(i) = (norm(Ax, p));% function to calculate p-norm of Ax
    end
    max_norm_of_Ax(j) = max(norm_of_Ax);% Storing maximum value of p-norm of Ax
    fprintf("%d norm of Ax\t %.8f\n",p,max_norm_of_Ax(j));
end
```

```
1 norm of Ax      79.55824570
2 norm of Ax      10.06706107
3 norm of Ax      5.67502252
4 norm of Ax      4.48829252
5 norm of Ax      4.00162061
Inf norm of Ax    3.26003665
1 norm of A       79.41768755
2 norm of A       10.06706293
Inf norm of A         4.16808253
>>
```

For 10000 iterations

```matlab
clc
clear all

%Creating a random matrix of size (100*2)
A = randn(100,2);
max_norm_of_Ax = double.empty(6,0); %Creating an empty vector to store maximumum value of norms of A
j=0;

for p = [1 2 3 4 5 inf]
    j=j+1;
    norm_of_Ax = double.empty(10000,0); %Creating an empty vector to store norms of A.
    for i = 1:10000
        temp = randn(2,1);%random 2x1 vector
        x = (temp/norm(temp));%normalizing random vector
        Ax= A*x;%matrix multiplication
        norm_of_Ax(i) = (norm(Ax, p));% function to calculate p-norm of Ax
    end
    max_norm_of_Ax(j) = max(norm_of_Ax);% Storing maximum value of p-norm of Ax
    fprintf("%d norm of Ax\t %.8f\n",p,max_norm_of_Ax(j));
end


norm_A = double.empty(3,0);%Creating an empty vector to store norms of A
i=0;
for p = [1 2 inf]
   i=i+1;
   norm_A(i) = vpa(norm(A,p));%Storing p-norm of A
   fprintf("%d norm of A\t\t %.8f\n",p,norm_A(i));
end
```

```
1 norm of Ax      90.49609066
2 norm of Ax      11.37407890
3 norm of Ax      6.13782997
4 norm of Ax      4.71844533
5 norm of Ax      4.14475040
Inf norm of Ax    3.35715481
1 norm of A       90.26361301
2 norm of A       11.37407891
Inf norm of A         4.46537624
>>
```

For 1000000 iterations

Editor - C:\Users\vikra\Documents\MATLAB\numerical methods\ass1la.m

assign1la.m | modified_newton3a.m | ass1la.m | untitled.m

```matlab
clc
clear all

%Creating a random matrix of size (100*2)
A = randn(100,2);
max_norm_of_Ax = double.empty(6,0); %Creating an empty vector to store maximumum value of norms of A
j=0;

for p = [1 2 3 4 5 inf]
    j=j+1;
    norm_of_Ax = double.empty(1000000,0); %Creating an empty vector to store norms of A.
    for i = 1:1000000
        temp = randn(2,1);%random 2x1 vector
        x = (temp/norm(temp));%normalizing random vector
        Ax= A*x;%matrix multiplication
        norm_of_Ax(i) = (norm(Ax, p));% function to calculate p-norm of Ax
        end
    max_norm_of_Ax(j) = max(norm_of_Ax);% Storing maximum value of p-norm of Ax
    fprintf("%d norm of Ax\t %.8f\n",p,max_norm_of_Ax(j));
end


norm_A = double.empty(3,0);%Creating an empty vector to store norms of A
i=0;
for p = [1 2 inf]
   i=i+1;
   norm_A(i) = vpa(norm(A,p));%Storing p-norm of A
   fprintf("%d norm of A\t\t %.8f\n",p,norm_A(i));
end
```

Command Window

```
1 norm of Ax      84.13953457
2 norm of Ax      10.45116935
3 norm of Ax      5.55154753
4 norm of Ax      4.14940056
5 norm of Ax      3.55026312
Inf norm of Ax    2.86386105
1 norm of A       78.10282400
2 norm of A       10.45116935
Inf norm of A         3.81733453
fx >>
```