# MA 423 – Matrix Computations

# Lab – 2

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## 1 Question - 1:

a) The factors L and U of A are:

```
L      =  1.0e+20 * [  0.0000     0
                       1.0000     0.0000  ]

U      =  1.0e+20 * [ 0.0000     0.0000
                      0         -1.0000  ]

A - LU = [    0          0
              0.0000     1.0000   ]
```

b) Computed solution for Ax = b using genp: x = [ 0 1 ]'

Exact solution for Ax = b: x = [-1 1]'

Difference of computed answer with the correct solution in the 2-norm = 1.000000

## Observations:

We can conclude that when the pivots are very small, the GENP algorithm fails to correctly solve the system of equations. It is a numerically unstable method.

The step at which things start to go wrong is when the pivot values are used to create zeros in that column of the matrix. Since the pivot values are very small (tending to zero), the calculation suffers from numerical problems leading to incorrect solutions.

This can be avoided by using pivoting technique (GEPP).

# 2 QUESTION - 2:

The table comparing different values for 10 random 5x5 matrices are:

| SI No. | $\|\| A(p, :) - LU \|\|_2$ | $\|\| L - L_{matlab} \|\|_2$ | $\|\| U - U_{matlab} \|\|_2$ | $\|\| p - p_{matlab} \|\|_2$ |
|---|---|---|---|---|
| 1 | 2.293e-16 | 2.7756e-17 | 1.1102e-16 | 0 |
| 2 | 2.8913e-16 | 2.6635e-16 | 9.0886e-16 | 0 |
| 3 | 2.2384e-16 | 1.1814e-16 | 2.7178e-16 | 0 |
| 4 | 2.4099e-16 | 2.5579e-16 | 2.7105e-16 | 0 |
| 5 | 2.568e-16 | 7.9125e-17 | 5.5511e-17 | 0 |
| 6 | 1.2973e-16 | 1.6237e-16 | 2.8256e-16 | 0 |
| 7 | 2.2204e-16 | 1.6214e-16 | 3.5016e-16 | 0 |
| 8 | 3.2678e-16 | 2.2435e-16 | 2.8663e-16 | 0 |
| 9 | 2.682e-16 | 1.2705e-16 | 2.238e-16 | 0 |
| 10 | 3.4144e-16 | 1.8603e-16 | 2.2377e-16 | 0 |

# 3 QUESTION - 3:

The table comparing the solutions for system of equation Ax = b for 10 random 5x5 matrices are:

| SI No. | $\|\| x_{gepp} - x_{matlab} \|\|_2$ |
|---|---|
| 1 | 9.2389e-16 |
| 2 | 2.7104e-15 |
| 3 | 7.5886e-15 |
| 4 | 7.3778e-15 |
| 5 | 3.0058e-15 |
| 6 | 1.0991e-15 |
| 7 | 6.2804e-15 |
| 8 | 5.7972e-16 |
| 9 | 1.3279e-15 |
| 10 | 5.1677e-14 |

# 4 QUESTION - 4:

The output of the driver code for a random 3x3 matrix is:

```
Matrix is:     0.5525    0.0859   -1.0616
               1.1006   -1.4916    2.3505
               1.5442   -0.7423   -0.6156
```

```
Determinant using mydet           =     0.263605
Determinant using inbuilt det     =     0.263605
Absolute difference               =     1.1102e-16
```

# 5 QUESTION - 5:

The output of the driver code for 3 iterations and random 3x3 matrix is:

```
******** Iteration no - 1 ********
Matrix is:       8.7546     4.0020    -7.6878
                 4.0020     2.5550    -4.9440
                -7.6878    -4.9440    13.1103

Cholesky factor using mychol:    2.9588     1.3526    -2.5983
                                 0          0.8518    -1.6784
                                 0          0          1.8820

Cholesky factor using chol:      2.9588     1.3526    -2.5983
                                 0          0.8518    -1.6784
                                 0          0          1.8820

Norm difference (2-norm) =       3.1402e-16

******** Iteration no - 2 ********
Matrix is:       18.7027     4.2633     4.1211
                 4.2633     1.0410     0.9239
                 4.1211     0.9239     2.2766

Cholesky factor using mychol:    4.3247     0.9858     0.9529
                                 0          0.2631    -0.0589
                                 0          0          1.1684
```

```
Cholesky factor using chol:      4.3247    0.9858    0.9529
                                 0         0.2631   -0.0589
                                 0         0         1.1684

Norm difference (2-norm) =       4.3798e-16


******** Iteration no - 3 ********
Matrix is:       4.4447    0.4098    2.6433
                 0.4098    4.6301    1.3368
                 2.6433    1.3368    1.8380

Cholesky factor using mychol:        2.1083    0.1944    1.2538
                                     0         2.1430    0.5101
                                     0         0         0.0760

Cholesky factor using chol:          2.1083    0.1944    1.2538
                                     0         2.1430    0.5101
                                     0         0         0.0760

Norm difference (2-norm) =           3.7470e-16
```

## Observations:

As we can observe that the difference in 2-norm of both the matrices are in the range of $10^{-16}$. Hence the function program ‘mychol’ is working within the theoretical expectations.