Test for Gaussian elimination and solvers

```
%Define a random matrix and check that is non-singular with the
 condition
%number of A
A=zeros(20,20);
tol=100;
i=1;
%The following loop will redefine the matrix A until one of them has a
%condition number below tol.
while cond(A)>tol
A=rand(20); %Redefine A
i=i+1;      %Count how many tries
end
A
i
b=rand(20,1)
%We proceed with the Gaussian Elimination with Partial Pivoting.
[L,U,piv]=GEpiv(A)
%Then we obtain PA=A(piv,:), L and U, where PA=LU
A(piv,:)
L*U
%Observe that they are equal
%We are going to solve the following system: PAx=LUx=Pb, where
 Pb=b(piv).
%We start with the following: Lz=Pb, z=Ux.
z=Ltrisol(L,b(piv))
%Obtained z, we now calculate the solution x
x=Utrisol(U,z)
%Calculate the residue vector
r=b(piv)-A(piv,:)*x
%Calculate two norms of the residue vector
N1=norm(r,1)
N2=norm(r,2)

% About the row interchanges, the information is given by the vector
 piv.
```

```
A =

  Columns 1 through 7

    0.4856    0.5930    0.7996    0.5377    0.1989    0.9171    0.5428
    0.1369    0.0630    0.8763    0.0220    0.0706    0.4501    0.6363
    0.4253    0.4980    0.9023    0.7511    0.1336    0.8972    0.5981
    0.4973    0.3576    0.5877    0.0179    0.5903    0.2045    0.7137
    0.6214    0.1675    0.0347    0.9682    0.2744    0.6875    0.4507
    0.3481    0.7312    0.2358    0.3306    0.3383    0.3138    0.5605
    0.7156    0.7461    0.3716    0.6222    0.1502    0.0216    0.1570
    0.6233    0.6982    0.8947    0.5302    0.8222    0.7563    0.7952
    0.1476    0.5780    0.3697    0.9093    0.2266    0.7269    0.4854
```

```
    0.8012    0.1191    0.9690    0.5925    0.9914    0.5841    0.1917
    0.5061    0.7052    0.2950    0.2004    0.7593    0.1778    0.9070
    0.7847    0.6854    0.0844    0.7111    0.0269    0.0010    0.2699
    0.1460    0.3169    0.2330    0.1510    0.1763    0.5231    0.6661
    0.7363    0.2482    0.3520    0.5940    0.1637    0.8676    0.1785
    0.2731    0.2016    0.7430    0.9063    0.7438    0.3105    0.9825
    0.1750    0.3715    0.2289    0.9255    0.8399    0.5665    0.3676
    0.8521    0.0624    0.1749    0.2325    0.3982    0.4761    0.9482
    0.2315    0.6752    0.3337    0.3308    0.2556    0.0083    0.9673
    0.5352    0.9796    0.2979    0.9989    0.2560    0.7028    0.7657
    0.4918    0.3819    0.5880    0.6305    0.4300    0.9965    0.2946

Columns 8 through 14

    0.4460    0.6352    0.5297    0.9561    0.4568    0.6967    0.0361
    0.4355    0.2932    0.2852    0.3259    0.0675    0.8752    0.4630
    0.6875    0.4362    0.7475    0.1227    0.7364    0.6152    0.7124
    0.1723    0.6401    0.0642    0.0431    0.8830    0.6174    0.4077
    0.3623    0.8717    0.2787    0.9308    0.7932    0.4112    0.2351
    0.0931    0.2089    0.6208    0.7733    0.7277    0.5558    0.9380
    0.5259    0.8650    0.6880    0.0549    0.4027    0.5594    0.6787
    0.1812    0.1057    0.4667    0.6543    0.1586    0.7865    0.9045
    0.4971    0.0588    0.5352    0.5747    0.9890    0.5304    0.1457
    0.3884    0.2048    0.6159    0.5145    0.1526    0.0835    0.1272
    0.7470    0.4339    0.8171    0.8070    0.5044    0.6483    0.1021
    0.4351    0.4062    0.3208    0.6298    0.4927    0.4978    0.1589
    0.1685    0.2509    0.5841    0.7389    0.4226    0.9527    0.2415
    0.6594    0.6301    0.8484    0.6274    0.1110    0.3096    0.6884
    0.8694    0.4667    0.4255    0.0385    0.3502    0.2659    0.9604
    0.0747    0.6739    0.9843    0.3610    0.0739    0.8393    0.5402
    0.0134    0.0884    0.6982    0.3830    0.7622    0.5109    0.6270
    0.1320    0.3264    0.4350    0.3230    0.6110    0.3906    0.2186
    0.2306    0.9124    0.4660    0.7910    0.3098    0.2579    0.7671
    0.2344    0.3852    0.3627    0.3255    0.8622    0.7974    0.0548

Columns 15 through 20

    0.9856    0.6295    0.8647    0.7821    0.5778    0.2396
    0.5556    0.9101    0.1914    0.1319    0.8361    0.8349
    0.8498    0.8143    0.5428    0.6566    0.9357    0.1928
    0.7259    0.5469    0.1078    0.1251    0.9826    0.5054
    0.2396    0.9919    0.2524    0.8018    0.0040    0.0892
    0.9008    0.2584    0.1599    0.3147    0.3297    0.3094
    0.0563    0.5813    0.8019    0.0441    0.1307    0.1333
    0.6435    0.0189    0.8733    0.8035    0.7649    0.8888
    0.7074    0.7227    0.5698    0.6096    0.3658    0.6471
    0.6971    0.9499    0.4368    0.3018    0.6000    0.5042
    0.7487    0.3751    0.2562    0.4374    0.4871    0.4721
    0.1780    0.4144    0.0512    0.1220    0.0757    0.2236
    0.6589    0.5324    0.7670    0.9873    0.6988    0.9798
    0.9344    0.0384    0.4390    0.6170    0.2893    0.2812
    0.9637    0.9081    0.7825    0.1377    0.4151    0.0479
    0.9631    0.5358    0.3094    0.4219    0.6600    0.8389
    0.4241    0.9327    0.6005    0.8552    0.6381    0.7561
```

```
    0.0932    0.1343    0.3473    0.0921    0.7709    0.6813
    0.5710    0.6395    0.6782    0.0177    0.6238    0.7081
    0.5934    0.4827    0.6257    0.2370    0.7501    0.4262

i =

     7

b =

    0.0971
    0.4609
    0.8576
    0.1415
    0.0506
    0.5465
    0.2032
    0.3215
    0.8966
    0.4041
    0.8704
    0.5933
    0.0307
    0.1092
    0.7644
    0.2606
    0.4538
    0.1843
    0.7155
    0.9665

L =

  Columns 1 through 7

    1.0000         0         0         0         0         0         0
    0.6281    1.0000         0         0         0         0         0
    0.1607    0.0564    1.0000         0         0         0         0
    0.3205    0.1931    0.7767    1.0000         0         0         0
    0.5939    0.7104    0.0687   -0.7528    1.0000         0         0
    0.9208    0.6676   -0.2415   -0.1224   -0.2737    1.0000         0
    0.9403    0.0642    0.9462    0.5293    0.2944   -0.0570    1.0000
    0.8641    0.2066    0.1934    0.3200   -0.3868   -0.1873    0.5435
    0.1733    0.6031    0.2698    0.5189   -0.1681   -0.3902    0.1141
    0.2054    0.3814    0.1447    0.7840    0.2830   -0.7177    0.4279
    0.7293    0.1297   -0.1400    0.9482   -0.6081   -0.2234    0.2202
    0.5836    0.3415    0.5031   -0.5264    0.6895    0.1281    0.1427
    0.7315    0.6938    0.7597   -0.2561    0.6940   -0.2518    0.4817
    0.4085    0.7504    0.0277   -0.5621    0.5258    0.0084    0.0122
    0.8398    0.7376    0.1026   -0.2731   -0.0231    0.9729    0.1944
    0.2717    0.6999    0.1845   -0.4434    0.4222    0.3966   -0.4411
```

```
    0.5699    0.5927    0.7025   -0.0779    0.0118   -0.1897    0.3462
    0.5771    0.3678    0.4989    0.2991    0.0127   -0.5793    0.6247
    0.1714    0.3256    0.1693   -0.2176    0.2433   -0.4320   -0.0916
    0.4991    0.4964    0.8616    0.3717   -0.3073   -0.0702    0.2628

  Columns 8 through 14

         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
    1.0000         0         0         0         0         0         0
    0.4179    1.0000         0         0         0         0         0
   -0.0010   -0.2222    1.0000         0         0         0         0
    0.6562   -0.4183   -0.3571    1.0000         0         0         0
   -0.4505   -0.6586   -0.4118   -0.3462    1.0000         0         0
   -0.3407    0.5837   -0.3454   -0.2754   -0.2052    1.0000         0
   -0.2619    0.3191    0.3135   -0.0679    0.0733   -0.3763    1.0000
   -0.0911   -0.5434    0.6568   -0.8417    0.8007   -0.6477    0.1907
   -0.6888    0.0168    0.4347   -0.2823    0.1662   -0.6427    0.1098
    0.3107    0.1870   -0.1393    0.1302    0.0859   -0.0919   -0.1688
    0.4455    0.3458   -0.4429   -0.2560    0.5795    0.6183   -0.5431
    0.1358    0.2138    0.1800    0.2773   -0.1795    0.0504    0.1043
    0.4360    0.5191    0.1802   -0.7208    0.5265   -0.3020   -0.1374

  Columns 15 through 20

         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
    1.0000         0         0         0         0         0
    0.3149    1.0000         0         0         0         0
   -0.3427    0.3365    1.0000         0         0         0
    0.0800   -0.1196    0.0048    1.0000         0         0
   -0.2078    0.0335    0.8730    0.1127    1.0000         0
    0.4371    0.1569   -0.5519   -0.8043   -0.5630    1.0000


U =
```

```
  Columns 1 through 7

    0.8521    0.0624    0.1749    0.2325    0.3982    0.4761    0.9482
         0    0.9404    0.1880    0.8529    0.0060    0.4037    0.1701
         0         0    0.8376   -0.0634    0.0063    0.3508    0.4744
         0         0         0    0.7163    0.6102   -0.1925    0.2773
         0         0         0         0    0.9774   -0.5608    0.3991
         0         0         0         0         0   -0.7992   -0.4591
         0         0         0         0         0         0   -1.4500
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0

  Columns 8 through 14

    0.0134    0.0884    0.6982    0.3830    0.7622    0.5109    0.6270
    0.2222    0.8569    0.0274    0.5505   -0.1689   -0.0630    0.3733
    0.4209    0.2307    0.1715    0.2334   -0.0454    0.7967    0.3412
    0.4953    0.0937    0.0633   -0.3718    0.1738   -0.5045    0.4223
    0.9252   -0.1726    0.4187   -0.1075    0.3056   -0.0448   -0.2410
    0.6899   -0.2273   -0.1767   -0.1089   -0.0024    0.1878   -0.5995
   -0.5318   -0.1633   -0.3715    0.1204   -0.6924   -0.8557   -0.9959
    1.1381    0.2815    0.5168    0.1292   -0.0656    0.3715    0.2041
         0   -0.8010    0.1465    0.1780    1.0377    0.5348   -0.7453
         0         0    0.7028    0.2705    0.2907    1.6714   -0.2127
         0         0         0    0.9354    1.0067    1.4166   -1.2060
         0         0         0         0    1.6206    1.5017   -0.5541
         0         0         0         0         0    1.3026    0.5171
         0         0         0         0         0         0    1.2849
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0

  Columns 15 through 20

    0.4241    0.9327    0.6005    0.8552    0.6381    0.7561
    0.3047    0.0537    0.3011   -0.5195    0.2230    0.2332
    0.4703    0.7573    0.0780    0.0237    0.7210    0.7003
    0.4037    0.0106    0.4713   -0.0545   -0.3925   -0.7835
    0.5520   -0.2611    0.0351    0.2558   -0.3953   -0.7806
   -0.1019   -0.3675   -0.6166   -0.2496   -0.6429   -0.7688
```

```
   -0.5482   -0.5966   -0.5158   -0.5521   -0.4090   -0.2837
    0.7772   -0.7739   -0.1296    0.3504   -0.3730   -0.5968
   -0.0954    0.5232   -0.1031    0.6588    0.0152    0.4436
    0.3601    0.3868   -0.5643    0.6151    0.4758    0.9960
   -0.4138    1.1561   -0.8231    0.7870    0.1099    0.6973
    0.3533    0.4765   -0.6519    0.8146    0.4539    0.5718
    0.1268   -0.9166   -0.1839    0.8631   -0.0437    0.1170
    0.5449   -0.8224    0.0431    0.2055   -0.4147   -0.7746
   -1.1147    0.2657    0.9020    0.5637   -0.6133   -0.2893
         0   -1.3442   -0.2029    0.3466    0.0779   -0.1531
         0         0    0.8989    0.5941   -0.6153   -0.9874
         0         0         0   -0.6746   -0.0544   -0.5518
         0         0         0         0    0.5618    0.9773
         0         0         0         0         0   -1.1389

piv =

    17
    19
     2
    15
    11
    12
    10
    14
     9
    16
     5
     4
     8
     6
     7
    18
     1
    20
    13
     3


ans =

  Columns 1 through 7

    0.8521    0.0624    0.1749    0.2325    0.3982    0.4761    0.9482
    0.5352    0.9796    0.2979    0.9989    0.2560    0.7028    0.7657
    0.1369    0.0630    0.8763    0.0220    0.0706    0.4501    0.6363
    0.2731    0.2016    0.7430    0.9063    0.7438    0.3105    0.9825
    0.5061    0.7052    0.2950    0.2004    0.7593    0.1778    0.9070
    0.7847    0.6854    0.0844    0.7111    0.0269    0.0010    0.2699
    0.8012    0.1191    0.9690    0.5925    0.9914    0.5841    0.1917
    0.7363    0.2482    0.3520    0.5940    0.1637    0.8676    0.1785
    0.1476    0.5780    0.3697    0.9093    0.2266    0.7269    0.4854
    0.1750    0.3715    0.2289    0.9255    0.8399    0.5665    0.3676
```

```
    0.6214    0.1675    0.0347    0.9682    0.2744    0.6875    0.4507
    0.4973    0.3576    0.5877    0.0179    0.5903    0.2045    0.7137
    0.6233    0.6982    0.8947    0.5302    0.8222    0.7563    0.7952
    0.3481    0.7312    0.2358    0.3306    0.3383    0.3138    0.5605
    0.7156    0.7461    0.3716    0.6222    0.1502    0.0216    0.1570
    0.2315    0.6752    0.3337    0.3308    0.2556    0.0083    0.9673
    0.4856    0.5930    0.7996    0.5377    0.1989    0.9171    0.5428
    0.4918    0.3819    0.5880    0.6305    0.4300    0.9965    0.2946
    0.1460    0.3169    0.2330    0.1510    0.1763    0.5231    0.6661
    0.4253    0.4980    0.9023    0.7511    0.1336    0.8972    0.5981

Columns 8 through 14

    0.0134    0.0884    0.6982    0.3830    0.7622    0.5109    0.6270
    0.2306    0.9124    0.4660    0.7910    0.3098    0.2579    0.7671
    0.4355    0.2932    0.2852    0.3259    0.0675    0.8752    0.4630
    0.8694    0.4667    0.4255    0.0385    0.3502    0.2659    0.9604
    0.7470    0.4339    0.8171    0.8070    0.5044    0.6483    0.1021
    0.4351    0.4062    0.3208    0.6298    0.4927    0.4978    0.1589
    0.3884    0.2048    0.6159    0.5145    0.1526    0.0835    0.1272
    0.6594    0.6301    0.8484    0.6274    0.1110    0.3096    0.6884
    0.4971    0.0588    0.5352    0.5747    0.9890    0.5304    0.1457
    0.0747    0.6739    0.9843    0.3610    0.0739    0.8393    0.5402
    0.3623    0.8717    0.2787    0.9308    0.7932    0.4112    0.2351
    0.1723    0.6401    0.0642    0.0431    0.8830    0.6174    0.4077
    0.1812    0.1057    0.4667    0.6543    0.1586    0.7865    0.9045
    0.0931    0.2089    0.6208    0.7733    0.7277    0.5558    0.9380
    0.5259    0.8650    0.6880    0.0549    0.4027    0.5594    0.6787
    0.1320    0.3264    0.4350    0.3230    0.6110    0.3906    0.2186
    0.4460    0.6352    0.5297    0.9561    0.4568    0.6967    0.0361
    0.2344    0.3852    0.3627    0.3255    0.8622    0.7974    0.0548
    0.1685    0.2509    0.5841    0.7389    0.4226    0.9527    0.2415
    0.6875    0.4362    0.7475    0.1227    0.7364    0.6152    0.7124

Columns 15 through 20

    0.4241    0.9327    0.6005    0.8552    0.6381    0.7561
    0.5710    0.6395    0.6782    0.0177    0.6238    0.7081
    0.5556    0.9101    0.1914    0.1319    0.8361    0.8349
    0.9637    0.9081    0.7825    0.1377    0.4151    0.0479
    0.7487    0.3751    0.2562    0.4374    0.4871    0.4721
    0.1780    0.4144    0.0512    0.1220    0.0757    0.2236
    0.6971    0.9499    0.4368    0.3018    0.6000    0.5042
    0.9344    0.0384    0.4390    0.6170    0.2893    0.2812
    0.7074    0.7227    0.5698    0.6096    0.3658    0.6471
    0.9631    0.5358    0.3094    0.4219    0.6600    0.8389
    0.2396    0.9919    0.2524    0.8018    0.0040    0.0892
    0.7259    0.5469    0.1078    0.1251    0.9826    0.5054
    0.6435    0.0189    0.8733    0.8035    0.7649    0.8888
    0.9008    0.2584    0.1599    0.3147    0.3297    0.3094
    0.0563    0.5813    0.8019    0.0441    0.1307    0.1333
    0.0932    0.1343    0.3473    0.0921    0.7709    0.6813
    0.9856    0.6295    0.8647    0.7821    0.5778    0.2396
    0.5934    0.4827    0.6257    0.2370    0.7501    0.4262
```

```
    0.6589    0.5324    0.7670    0.9873    0.6988    0.9798
    0.8498    0.8143    0.5428    0.6566    0.9357    0.1928


ans =

  Columns 1 through 7

    0.8521    0.0624    0.1749    0.2325    0.3982    0.4761    0.9482
    0.5352    0.9796    0.2979    0.9989    0.2560    0.7028    0.7657
    0.1369    0.0630    0.8763    0.0220    0.0706    0.4501    0.6363
    0.2731    0.2016    0.7430    0.9063    0.7438    0.3105    0.9825
    0.5061    0.7052    0.2950    0.2004    0.7593    0.1778    0.9070
    0.7847    0.6854    0.0844    0.7111    0.0269    0.0010    0.2699
    0.8012    0.1191    0.9690    0.5925    0.9914    0.5841    0.1917
    0.7363    0.2482    0.3520    0.5940    0.1637    0.8676    0.1785
    0.1476    0.5780    0.3697    0.9093    0.2266    0.7269    0.4854
    0.1750    0.3715    0.2289    0.9255    0.8399    0.5665    0.3676
    0.6214    0.1675    0.0347    0.9682    0.2744    0.6875    0.4507
    0.4973    0.3576    0.5877    0.0179    0.5903    0.2045    0.7137
    0.6233    0.6982    0.8947    0.5302    0.8222    0.7563    0.7952
    0.3481    0.7312    0.2358    0.3306    0.3383    0.3138    0.5605
    0.7156    0.7461    0.3716    0.6222    0.1502    0.0216    0.1570
    0.2315    0.6752    0.3337    0.3308    0.2556    0.0083    0.9673
    0.4856    0.5930    0.7996    0.5377    0.1989    0.9171    0.5428
    0.4918    0.3819    0.5880    0.6305    0.4300    0.9965    0.2946
    0.1460    0.3169    0.2330    0.1510    0.1763    0.5231    0.6661
    0.4253    0.4980    0.9023    0.7511    0.1336    0.8972    0.5981

  Columns 8 through 14

    0.0134    0.0884    0.6982    0.3830    0.7622    0.5109    0.6270
    0.2306    0.9124    0.4660    0.7910    0.3098    0.2579    0.7671
    0.4355    0.2932    0.2852    0.3259    0.0675    0.8752    0.4630
    0.8694    0.4667    0.4255    0.0385    0.3502    0.2659    0.9604
    0.7470    0.4339    0.8171    0.8070    0.5044    0.6483    0.1021
    0.4351    0.4062    0.3208    0.6298    0.4927    0.4978    0.1589
    0.3884    0.2048    0.6159    0.5145    0.1526    0.0835    0.1272
    0.6594    0.6301    0.8484    0.6274    0.1110    0.3096    0.6884
    0.4971    0.0588    0.5352    0.5747    0.9890    0.5304    0.1457
    0.0747    0.6739    0.9843    0.3610    0.0739    0.8393    0.5402
    0.3623    0.8717    0.2787    0.9308    0.7932    0.4112    0.2351
    0.1723    0.6401    0.0642    0.0431    0.8830    0.6174    0.4077
    0.1812    0.1057    0.4667    0.6543    0.1586    0.7865    0.9045
    0.0931    0.2089    0.6208    0.7733    0.7277    0.5558    0.9380
    0.5259    0.8650    0.6880    0.0549    0.4027    0.5594    0.6787
    0.1320    0.3264    0.4350    0.3230    0.6110    0.3906    0.2186
    0.4460    0.6352    0.5297    0.9561    0.4568    0.6967    0.0361
    0.2344    0.3852    0.3627    0.3255    0.8622    0.7974    0.0548
    0.1685    0.2509    0.5841    0.7389    0.4226    0.9527    0.2415
    0.6875    0.4362    0.7475    0.1227    0.7364    0.6152    0.7124

  Columns 15 through 20
```

```
    0.4241    0.9327    0.6005    0.8552    0.6381    0.7561
    0.5710    0.6395    0.6782    0.0177    0.6238    0.7081
    0.5556    0.9101    0.1914    0.1319    0.8361    0.8349
    0.9637    0.9081    0.7825    0.1377    0.4151    0.0479
    0.7487    0.3751    0.2562    0.4374    0.4871    0.4721
    0.1780    0.4144    0.0512    0.1220    0.0757    0.2236
    0.6971    0.9499    0.4368    0.3018    0.6000    0.5042
    0.9344    0.0384    0.4390    0.6170    0.2893    0.2812
    0.7074    0.7227    0.5698    0.6096    0.3658    0.6471
    0.9631    0.5358    0.3094    0.4219    0.6600    0.8389
    0.2396    0.9919    0.2524    0.8018    0.0040    0.0892
    0.7259    0.5469    0.1078    0.1251    0.9826    0.5054
    0.6435    0.0189    0.8733    0.8035    0.7649    0.8888
    0.9008    0.2584    0.1599    0.3147    0.3297    0.3094
    0.0563    0.5813    0.8019    0.0441    0.1307    0.1333
    0.0932    0.1343    0.3473    0.0921    0.7709    0.6813
    0.9856    0.6295    0.8647    0.7821    0.5778    0.2396
    0.5934    0.4827    0.6257    0.2370    0.7501    0.4262
    0.6589    0.5324    0.7670    0.9873    0.6988    0.9798
    0.8498    0.8143    0.5428    0.6566    0.9357    0.1928

z =

    0.4538
    0.4305
    0.3637
    0.2534
    0.4608
    0.1330
   -0.6566
    0.0367
    0.5177
    0.1130
    0.1618
   -0.1009
   -0.7173
   -0.5074
   -0.3951
   -0.9829
   -0.4666
    0.8093
   -0.1515
    0.5466

x =

    0.1998
    0.7871
   -1.1736
   -0.0876
    0.4121
    1.0754
```

```
    0.1133
    0.9349
   -1.2463
   -0.0708
   -0.1010
   -0.1946
    0.4686
    0.1128
   -0.1946
    0.6132
   -0.0957
   -0.8527
    0.5653
   -0.4800


r =

   1.0e-15 *

    0.1110
    0.2220
   -0.0555
    0.1110
    0.4441
    0.4441
    0.0555
    0.4441
   -0.4441
    0.2776
    0.1665
    0.1388
   -0.2220
    0.3331
    0.3886
    0.3331
    0.0694
    0.6661
   -0.4441
   -0.3331


N1 =

   5.7038e-15


N2 =

   1.4737e-15
```

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Test for Gaussian elimination and solvers

```
%Define a random matrix and check that is non-singular with the
 condition
%number of A
A=zeros(20,20);
tol=100;
i=1;
%The following loop will redefine the matrix A until one of them has a
%condition number below tol.
while cond(A)>tol
A=rand(20); %Redefine A
i=i+1;      %Count how many tries
end
A
i
b=rand(20,1)
%We proceed with the Gaussian Elimination with Partial Pivoting.
[L,U,piv]=GEpiv(A)
%Then we obtain PA=A(piv,:), L and U, where PA=LU
A(piv,:)
L*U
%Observe that they are equal
%We are going to solve the following system: PAx=LUx=Pb, where
 Pb=b(piv).
%We start with the following: Lz=Pb, z=Ux.
z=Ltrisol(L,b(piv))
%Obtained z, we now calculate the solution x
x=Utrisol(U,z)
%Calculate the residue vector
r=b(piv)-A(piv,:)*x
%Calculate two norms of the residue vector
N1=norm(r,1)
N2=norm(r,2)

% About the row interchanges, the information is given by the vector
 piv.
```

```
A =

  Columns 1 through 7

    0.7890    0.5965    0.6131    0.2629    0.8841    0.7386    0.6366
    0.7744    0.2395    0.6565    0.4241    0.7346    0.2647    0.6778
    0.1901    0.9098    0.2855    0.1459    0.7702    0.4528    0.9734
    0.7428    0.7740    0.9430    0.0834    0.4128    0.9326    0.6976
    0.0276    0.6960    0.9409    0.7455    0.8018    0.6600    0.3758
    0.9291    0.7302    0.6883    0.0291    0.8269    0.3836    0.5081
    0.2393    0.3673    0.4503    0.6064    0.0705    0.4570    0.3758
    0.7255    0.9082    0.6915    0.1377    0.0709    0.5867    0.1724
    0.6934    0.9470    0.2201    0.0425    0.7664    0.1590    0.3993
```

```
    0.4937    0.4158    0.9855    0.3711    0.4603    0.9196    0.9223
    0.0309    0.6935    0.2397    0.7380    0.3664    0.7962    0.3695
    0.5046    0.7065    0.7412    0.6862    0.7158    0.1481    0.6890
    0.8918    0.0828    0.1268    0.6470    0.6401    0.3996    0.7997
    0.9787    0.1013    0.7459    0.3518    0.8869    0.0632    0.0447
    0.3957    0.3280    0.9077    0.2617    0.7077    0.1860    0.9383
    0.8929    0.5261    0.0477    0.4905    0.1270    0.8545    0.0499
    0.8315    0.1665    0.3363    0.6790    0.0967    0.5432    0.6146
    0.3322    0.1231    0.8889    0.8811    0.0932    0.4304    0.0869
    0.0415    0.3986    0.0034    0.0861    0.9026    0.4219    0.0508
    0.9661    0.6580    0.6814    0.3658    0.0902    0.2089    0.7651

Columns 8 through 14

    0.0388    0.7864    0.8387    0.1606    0.9184    0.0206    0.0199
    0.3879    0.2746    0.7095    0.9109    0.8577    0.3415    0.7313
    0.3278    0.8985    0.5748    0.1869    0.1515    0.0140    0.1597
    0.9236    0.3065    0.4061    0.2534    0.6289    0.3821    0.2462
    0.6720    0.8511    0.6005    0.9198    0.0481    0.2381    0.9522
    0.0976    0.8074    0.3011    0.8973    0.7750    0.8085    0.2164
    0.6728    0.4944    0.5174    0.4433    0.2508    0.5523    0.4740
    0.3904    0.4158    0.4289    0.6372    0.4232    0.5088    0.7661
    0.8889    0.8819    0.3731    0.5436    0.7323    0.4627    0.3842
    0.4560    0.4848    0.8103    0.5374    0.8510    0.5345    0.5654
    0.5687    0.8717    0.5836    0.3001    0.4008    0.9273    0.1058
    0.4438    0.1246    0.4417    0.5000    0.4710    0.4688    0.6939
    0.2630    0.9540    0.3059    0.9602    0.1496    0.9604    0.9112
    0.7030    0.9345    0.6755    0.6615    0.7345    0.8642    0.2094
    0.3494    0.7688    0.2283    0.9478    0.0735    0.6384    0.9691
    0.5966    0.5195    0.8501    0.7148    0.5806    0.1245    0.0903
    0.5286    0.1100    0.9752    0.7167    0.2275    0.2161    0.1068
    0.7615    0.7285    0.6128    0.8856    0.4885    0.8829    0.0778
    0.8506    0.8409    0.7446    0.0688    0.1508    0.9579    0.5428
    0.9624    0.4256    0.7716    0.5412    0.9387    0.1198    0.8527

Columns 15 through 20

    0.3123    0.9008    0.3597    0.0793    0.3221    0.4032
    0.8039    0.0981    0.8399    0.1733    0.9021    0.8560
    0.0741    0.8181    0.5949    0.3901    0.3350    0.1194
    0.1334    0.2337    0.5697    0.9838    0.2871    0.7819
    0.1517    0.6117    0.9931    0.4385    0.4587    0.2263
    0.8125    0.2151    0.9808    0.6382    0.8898    0.2880
    0.7856    0.8930    0.6132    0.5575    0.2089    0.0950
    0.1104    0.2159    0.8694    0.0957    0.8928    0.3521
    0.6581    0.2675    0.6658    0.9891    0.2139    0.5294
    0.0467    0.4617    0.8198    0.2967    0.3321    0.6841
    0.3366    0.3201    0.5328    0.9716    0.1067    0.9110
    0.4787    0.2353    0.8042    0.0216    0.3982    0.2528
    0.0970    0.3042    0.8078    0.0313    0.2384    0.0360
    0.5807    0.7792    0.8646    0.9663    0.9775    0.2637
    0.6617    0.6330    0.9480    0.7011    0.7369    0.5181
    0.4056    0.9197    0.1909    0.9438    0.6061    0.6551
    0.8415    0.6272    0.1674    0.3092    0.3222    0.8350
```

```
    0.3671    0.8444    0.4057    0.0566    0.2898    0.3228
    0.9796    0.5898    0.3688    0.8428    0.5066    0.1427
    0.7742    0.7687    0.4371    0.4471    0.2307    0.3842

i =

     7

b =

    0.0700
    0.3889
    0.0795
    0.2239
    0.7407
    0.6784
    0.1971
    0.7385
    0.8155
    0.6832
    0.3044
    0.8339
    0.5149
    0.5258
    0.3336
    0.0432
    0.3672
    0.1656
    0.2625
    0.7029

L =

  Columns 1 through 7

    1.0000         0         0         0         0         0         0
    0.1942    1.0000         0         0         0         0         0
    0.0282    0.7787    1.0000         0         0         0         0
    0.9112   -0.0107   -0.6804    1.0000         0         0         0
    0.7413    0.9360    0.0086   -0.2562    1.0000         0         0
    0.5045    0.4098    0.6807   -0.3785    0.3741    1.0000         0
    0.0424    0.4429   -0.1116    0.1427   -0.5526    0.5420    1.0000
    0.9872    0.6269   -0.1766    0.1133    0.9779   -0.6620   -0.9383
    0.5156    0.7350    0.3125    0.3010    0.2582   -0.9016   -0.7776
    0.7590    0.7831    0.3292   -0.5933    0.7053    0.9583    0.2425
    0.0316    0.7755    0.1322    0.7341    0.1788   -0.0813    0.3348
    0.7085    0.9833   -0.5511    0.1132    0.2500   -0.4565    0.0982
    0.9123    0.4871   -0.8653    0.9102    0.6598    0.2762    0.7854
    0.8062    0.5783   -0.0858   -0.0097    0.1317    0.7112    0.5036
    0.9494    0.7123   -0.1481   -0.3308    0.3331    0.2525    0.1336
    0.8496    0.0904   -0.3827    0.8027    0.5562   -0.0490   -0.2299
```

```
    0.3395    0.0997    0.7671    0.3000    0.4587   -0.2785   -0.4916
    0.2445    0.3848    0.2639    0.3971    0.4211   -0.2432   -0.2986
    0.7913    0.1790    0.0507    0.1240    0.0847    0.0455   -0.2855
    0.4043    0.3225    0.6919   -0.4738    0.0311    0.0957   -0.6853

  Columns 8 through 14

         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
    1.0000         0         0         0         0         0         0
    0.2320    1.0000         0         0         0         0         0
    0.2781    0.2574    1.0000         0         0         0         0
    0.1366   -0.2458   -0.3807    1.0000         0         0         0
    0.3584    0.1577    0.5545   -0.4547    1.0000         0         0
    0.0207    0.1588   -0.6731    0.3855   -0.1959    1.0000         0
   -0.6990    0.3471   -0.4550    0.5495   -0.1843    0.7226    1.0000
   -0.5247    0.2471    0.3032   -0.6467    0.8605   -0.0684   -0.1553
    0.4262    0.4293   -0.7816    0.0959   -0.9570    0.5435   -0.8633
    0.5225   -0.5924   -0.3338    0.5576   -0.1721   -0.3167   -0.7126
    0.5531   -0.2624   -0.1746    0.4915   -0.2865   -0.1537   -0.2648
    0.0202    0.6822   -0.1608   -0.7286    0.4413    0.2975   -0.1442
    0.1561   -0.1906    0.5896   -0.8277    0.2942   -0.7294   -0.5417

  Columns 15 through 20

         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
    1.0000         0         0         0         0         0
    0.6669    1.0000         0         0         0         0
    0.3378   -0.3291    1.0000         0         0         0
    0.4518   -0.5023   -0.6229    1.0000         0         0
    0.4237    0.5935   -0.4536    0.2425    1.0000         0
    0.9348   -0.3715    0.1868   -0.3423   -0.3393    1.0000


U =
```

```
  Columns 1 through 7

    0.9787    0.1013    0.7459    0.3518    0.8869    0.0632    0.0447
         0    0.8901    0.1406    0.0776    0.5979    0.4406    0.9647
         0         0    0.8104    0.6752    0.3112    0.3152   -0.3767
         0         0         0    0.7866    0.0500    0.5612    0.5130
         0         0         0         0   -1.1361    0.2686   -0.6290
         0         0         0         0         0    0.6046    1.1903
         0         0         0         0         0         0   -1.4863
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0

  Columns 8 through 14

    0.7030    0.9345    0.6755    0.6615    0.7345    0.8642    0.2094
    0.1913    0.7170    0.4436    0.0584    0.0089   -0.1539    0.1191
    0.5033    0.2665    0.2360    0.8557    0.0205    0.3335    0.8536
   -0.0331    0.2915   -0.1443    0.9402   -0.5057    0.3981    1.3024
   -0.3225   -0.8756   -0.5261    0.3257   -0.2592    0.1113    0.8258
   -0.2115   -0.0240    0.2693   -0.1686    0.3685    0.0436    0.0140
    0.7334    0.0010    0.1298    0.2477   -0.1527    1.0077    0.8394
    1.1047   -0.0910    0.6991   -0.3016    0.6230    0.2426    0.5640
         0   -0.8289    0.0543   -0.4079    0.3673    0.6501    0.1609
         0         0   -0.7443    0.0424   -0.6432   -0.6264   -0.5120
         0         0         0   -0.7671    0.6269    0.2174   -1.7220
         0         0         0         0    0.8803    0.2904   -0.5673
         0         0         0         0         0   -2.0965   -1.6427
         0         0         0         0         0         0    1.4608
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0

  Columns 15 through 20

    0.5807    0.7792    0.8646    0.9663    0.9775    0.2637
   -0.0386    0.6668    0.4269    0.2025    0.1452    0.0682
    0.1655    0.0705    0.6363    0.2536    0.3182    0.1658
   -0.3199   -0.3506    0.4574   -0.6745   -0.4342   -0.0907
   -0.3672   -1.0762   -0.0594   -0.9850   -0.0816    0.0682
   -0.3268    0.0173   -0.0290   -0.3332   -0.5709    0.3504
```

```
    1.0105   -0.2847    0.1317    0.4730    0.7626   -0.0195
    1.3815    0.4303   -0.4611    0.6739   -0.3024    0.2677
    0.5176   -0.6009   -0.0934   -0.3363   -0.0116    0.2632
   -0.7117   -0.2644   -0.1689    0.4068   -0.4240   -0.1014
   -0.0704    0.0086   -0.3055    1.2166   -0.1701    0.9068
    0.0414   -0.4656    0.0556    0.5085   -0.4440    0.8531
   -0.6866    1.0072   -0.6885    1.1112   -0.3720    0.1829
    0.6541   -0.2668   -0.2542   -1.2781   -0.6138   -0.5075
    1.0635    0.1751   -0.3888    0.2800   -0.0447   -0.2328
         0   -0.7256   -0.0663   -0.6003   -0.7623    0.7567
         0         0   -0.4523   -1.5497   -0.6799   -0.1694
         0         0         0   -1.4840   -0.8337    0.0228
         0         0         0         0    0.7961    0.1333
         0         0         0         0         0    1.1923

piv =

    14
     3
     5
    13
     8
    10
    19
    20
    12
     4
    11
     9
    16
     1
     6
    17
    18
     7
     2
    15


ans =

  Columns 1 through 7

    0.9787    0.1013    0.7459    0.3518    0.8869    0.0632    0.0447
    0.1901    0.9098    0.2855    0.1459    0.7702    0.4528    0.9734
    0.0276    0.6960    0.9409    0.7455    0.8018    0.6600    0.3758
    0.8918    0.0828    0.1268    0.6470    0.6401    0.3996    0.7997
    0.7255    0.9082    0.6915    0.1377    0.0709    0.5867    0.1724
    0.4937    0.4158    0.9855    0.3711    0.4603    0.9196    0.9223
    0.0415    0.3986    0.0034    0.0861    0.9026    0.4219    0.0508
    0.9661    0.6580    0.6814    0.3658    0.0902    0.2089    0.7651
    0.5046    0.7065    0.7412    0.6862    0.7158    0.1481    0.6890
    0.7428    0.7740    0.9430    0.0834    0.4128    0.9326    0.6976
```

```
    0.0309    0.6935    0.2397    0.7380    0.3664    0.7962    0.3695
    0.6934    0.9470    0.2201    0.0425    0.7664    0.1590    0.3993
    0.8929    0.5261    0.0477    0.4905    0.1270    0.8545    0.0499
    0.7890    0.5965    0.6131    0.2629    0.8841    0.7386    0.6366
    0.9291    0.7302    0.6883    0.0291    0.8269    0.3836    0.5081
    0.8315    0.1665    0.3363    0.6790    0.0967    0.5432    0.6146
    0.3322    0.1231    0.8889    0.8811    0.0932    0.4304    0.0869
    0.2393    0.3673    0.4503    0.6064    0.0705    0.4570    0.3758
    0.7744    0.2395    0.6565    0.4241    0.7346    0.2647    0.6778
    0.3957    0.3280    0.9077    0.2617    0.7077    0.1860    0.9383

Columns 8 through 14

    0.7030    0.9345    0.6755    0.6615    0.7345    0.8642    0.2094
    0.3278    0.8985    0.5748    0.1869    0.1515    0.0140    0.1597
    0.6720    0.8511    0.6005    0.9198    0.0481    0.2381    0.9522
    0.2630    0.9540    0.3059    0.9602    0.1496    0.9604    0.9112
    0.3904    0.4158    0.4289    0.6372    0.4232    0.5088    0.7661
    0.4560    0.4848    0.8103    0.5374    0.8510    0.5345    0.5654
    0.8506    0.8409    0.7446    0.0688    0.1508    0.9579    0.5428
    0.9624    0.4256    0.7716    0.5412    0.9387    0.1198    0.8527
    0.4438    0.1246    0.4417    0.5000    0.4710    0.4688    0.6939
    0.9236    0.3065    0.4061    0.2534    0.6289    0.3821    0.2462
    0.5687    0.8717    0.5836    0.3001    0.4008    0.9273    0.1058
    0.8889    0.8819    0.3731    0.5436    0.7323    0.4627    0.3842
    0.5966    0.5195    0.8501    0.7148    0.5806    0.1245    0.0903
    0.0388    0.7864    0.8387    0.1606    0.9184    0.0206    0.0199
    0.0976    0.8074    0.3011    0.8973    0.7750    0.8085    0.2164
    0.5286    0.1100    0.9752    0.7167    0.2275    0.2161    0.1068
    0.7615    0.7285    0.6128    0.8856    0.4885    0.8829    0.0778
    0.6728    0.4944    0.5174    0.4433    0.2508    0.5523    0.4740
    0.3879    0.2746    0.7095    0.9109    0.8577    0.3415    0.7313
    0.3494    0.7688    0.2283    0.9478    0.0735    0.6384    0.9691

Columns 15 through 20

    0.5807    0.7792    0.8646    0.9663    0.9775    0.2637
    0.0741    0.8181    0.5949    0.3901    0.3350    0.1194
    0.1517    0.6117    0.9931    0.4385    0.4587    0.2263
    0.0970    0.3042    0.8078    0.0313    0.2384    0.0360
    0.1104    0.2159    0.8694    0.0957    0.8928    0.3521
    0.0467    0.4617    0.8198    0.2967    0.3321    0.6841
    0.9796    0.5898    0.3688    0.8428    0.5066    0.1427
    0.7742    0.7687    0.4371    0.4471    0.2307    0.3842
    0.4787    0.2353    0.8042    0.0216    0.3982    0.2528
    0.1334    0.2337    0.5697    0.9838    0.2871    0.7819
    0.3366    0.3201    0.5328    0.9716    0.1067    0.9110
    0.6581    0.2675    0.6658    0.9891    0.2139    0.5294
    0.4056    0.9197    0.1909    0.9438    0.6061    0.6551
    0.3123    0.9008    0.3597    0.0793    0.3221    0.4032
    0.8125    0.2151    0.9808    0.6382    0.8898    0.2880
    0.8415    0.6272    0.1674    0.3092    0.3222    0.8350
    0.3671    0.8444    0.4057    0.0566    0.2898    0.3228
    0.7856    0.8930    0.6132    0.5575    0.2089    0.0950
```

```
    0.8039    0.0981    0.8399    0.1733    0.9021    0.8560
    0.6617    0.6330    0.9480    0.7011    0.7369    0.5181


ans =

  Columns 1 through 7

    0.9787    0.1013    0.7459    0.3518    0.8869    0.0632    0.0447
    0.1901    0.9098    0.2855    0.1459    0.7702    0.4528    0.9734
    0.0276    0.6960    0.9409    0.7455    0.8018    0.6600    0.3758
    0.8918    0.0828    0.1268    0.6470    0.6401    0.3996    0.7997
    0.7255    0.9082    0.6915    0.1377    0.0709    0.5867    0.1724
    0.4937    0.4158    0.9855    0.3711    0.4603    0.9196    0.9223
    0.0415    0.3986    0.0034    0.0861    0.9026    0.4219    0.0508
    0.9661    0.6580    0.6814    0.3658    0.0902    0.2089    0.7651
    0.5046    0.7065    0.7412    0.6862    0.7158    0.1481    0.6890
    0.7428    0.7740    0.9430    0.0834    0.4128    0.9326    0.6976
    0.0309    0.6935    0.2397    0.7380    0.3664    0.7962    0.3695
    0.6934    0.9470    0.2201    0.0425    0.7664    0.1590    0.3993
    0.8929    0.5261    0.0477    0.4905    0.1270    0.8545    0.0499
    0.7890    0.5965    0.6131    0.2629    0.8841    0.7386    0.6366
    0.9291    0.7302    0.6883    0.0291    0.8269    0.3836    0.5081
    0.8315    0.1665    0.3363    0.6790    0.0967    0.5432    0.6146
    0.3322    0.1231    0.8889    0.8811    0.0932    0.4304    0.0869
    0.2393    0.3673    0.4503    0.6064    0.0705    0.4570    0.3758
    0.7744    0.2395    0.6565    0.4241    0.7346    0.2647    0.6778
    0.3957    0.3280    0.9077    0.2617    0.7077    0.1860    0.9383

  Columns 8 through 14

    0.7030    0.9345    0.6755    0.6615    0.7345    0.8642    0.2094
    0.3278    0.8985    0.5748    0.1869    0.1515    0.0140    0.1597
    0.6720    0.8511    0.6005    0.9198    0.0481    0.2381    0.9522
    0.2630    0.9540    0.3059    0.9602    0.1496    0.9604    0.9112
    0.3904    0.4158    0.4289    0.6372    0.4232    0.5088    0.7661
    0.4560    0.4848    0.8103    0.5374    0.8510    0.5345    0.5654
    0.8506    0.8409    0.7446    0.0688    0.1508    0.9579    0.5428
    0.9624    0.4256    0.7716    0.5412    0.9387    0.1198    0.8527
    0.4438    0.1246    0.4417    0.5000    0.4710    0.4688    0.6939
    0.9236    0.3065    0.4061    0.2534    0.6289    0.3821    0.2462
    0.5687    0.8717    0.5836    0.3001    0.4008    0.9273    0.1058
    0.8889    0.8819    0.3731    0.5436    0.7323    0.4627    0.3842
    0.5966    0.5195    0.8501    0.7148    0.5806    0.1245    0.0903
    0.0388    0.7864    0.8387    0.1606    0.9184    0.0206    0.0199
    0.0976    0.8074    0.3011    0.8973    0.7750    0.8085    0.2164
    0.5286    0.1100    0.9752    0.7167    0.2275    0.2161    0.1068
    0.7615    0.7285    0.6128    0.8856    0.4885    0.8829    0.0778
    0.6728    0.4944    0.5174    0.4433    0.2508    0.5523    0.4740
    0.3879    0.2746    0.7095    0.9109    0.8577    0.3415    0.7313
    0.3494    0.7688    0.2283    0.9478    0.0735    0.6384    0.9691

  Columns 15 through 20
```

```
    0.5807    0.7792    0.8646    0.9663    0.9775    0.2637
    0.0741    0.8181    0.5949    0.3901    0.3350    0.1194
    0.1517    0.6117    0.9931    0.4385    0.4587    0.2263
    0.0970    0.3042    0.8078    0.0313    0.2384    0.0360
    0.1104    0.2159    0.8694    0.0957    0.8928    0.3521
    0.0467    0.4617    0.8198    0.2967    0.3321    0.6841
    0.9796    0.5898    0.3688    0.8428    0.5066    0.1427
    0.7742    0.7687    0.4371    0.4471    0.2307    0.3842
    0.4787    0.2353    0.8042    0.0216    0.3982    0.2528
    0.1334    0.2337    0.5697    0.9838    0.2871    0.7819
    0.3366    0.3201    0.5328    0.9716    0.1067    0.9110
    0.6581    0.2675    0.6658    0.9891    0.2139    0.5294
    0.4056    0.9197    0.1909    0.9438    0.6061    0.6551
    0.3123    0.9008    0.3597    0.0793    0.3221    0.4032
    0.8125    0.2151    0.9808    0.6382    0.8898    0.2880
    0.8415    0.6272    0.1674    0.3092    0.3222    0.8350
    0.3671    0.8444    0.4057    0.0566    0.2898    0.3228
    0.7856    0.8930    0.6132    0.5575    0.2089    0.0950
    0.8039    0.0981    0.8399    0.1733    0.9021    0.8560
    0.6617    0.6330    0.9480    0.7011    0.7369    0.5181
```

```
z =

    0.5258
   -0.0226
    0.7435
    0.5415
    0.5022
   -0.0618
    0.5670
    0.2681
    0.3774
   -0.6852
   -0.6798
    0.5194
   -1.1974
    0.4998
   -0.3785
    0.7055
   -0.0521
    0.3642
   -1.0454
   -0.2393
```

```
x =

    0.2553
    0.7290
    0.3956
   -0.5838
    0.0438
   -0.8720
```

```
   -0.5064
   -0.7411
   -0.5871
    1.7947
    0.6928
   -0.2646
    0.5820
    0.3402
   -0.3490
   -0.2723
    0.5023
    0.4704
   -1.2796
   -0.2007


r =

   1.0e-15 *

   -0.1110
   -0.1249
   -0.1110
         0
    0.3331
    0.5551
   -0.2776
         0
         0
         0
   -0.4441
   -0.1110
    0.4441
   -0.1665
         0
         0
   -0.3331
   -0.3053
         0
    0.5551


N1 =

   3.8719e-15


N2 =

   1.2179e-15
```

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Test for Gaussian elimination and solvers

```
%Define a random matrix and check that is non-singular with the
 condition
%number of A
A=zeros(20,20);
tol=100;
i=1;
%The following loop will redefine the matrix A until one of them has a
%condition number below tol.
while cond(A)>tol
A=rand(20); %Redefine A
i=i+1;      %Count how many tries
end
A
i
b=rand(20,1)
%We proceed with the Gaussian Elimination with Partial Pivoting.
[L,U,piv]=GEpiv(A)
%Then we obtain PA=A(piv,:), L and U, where PA=LU
A(piv,:)
L*U
%Observe that they are equal
%We are going to solve the following system: PAx=LUx=Pb, where
 Pb=b(piv).
%We start with the following: Lz=Pb, z=Ux.
z=Ltrisol(L,b(piv))
%Obtained z, we now calculate the solution x
x=Utrisol(U,z)
%Calculate the residue vector
r=b(piv)-A(piv,:)*x
%Calculate two norms of the residue vector
N1=norm(r,1)
N2=norm(r,2)

% About the row interchanges, the information is given by the vector
 piv.
```

```
A =

  Columns 1 through 7

    0.9814    0.9056    0.5927    0.9865    0.1768    0.6421    0.8229
    0.5417    0.8843    0.4492    0.7884    0.8413    0.0279    0.6141
    0.1358    0.3935    0.7878    0.9682    0.4997    0.4560    0.6187
    0.5290    0.5131    0.0530    0.1651    0.6768    0.9730    0.3930
    0.0228    0.2320    0.7071    0.1843    0.1789    0.4326    0.9516
    0.6541    0.0953    0.6603    0.8710    0.2637    0.5066    0.0978
    0.4974    0.0598    0.7553    0.3211    0.6997    0.3540    0.2361
    0.8456    0.9749    0.0997    0.8258    0.4169    0.7034    0.0183
    0.5978    0.6570    0.6203    0.4834    0.6857    0.3433    0.5898
```

```
    0.0812    0.5670    0.5470    0.9941    0.5198    0.7452    0.3096
    0.7135    0.2368    0.3159    0.1590    0.9311    0.9679    0.7895
    0.3585    0.9204    0.1471    0.6279    0.1411    0.2208    0.7363
    0.2767    0.7006    0.7986    0.3642    0.6537    0.0638    0.7674
    0.9097    0.3101    0.4180    0.4518    0.3021    0.1531    0.7612
    0.0663    0.4592    0.6174    0.8602    0.9471    0.1632    0.4434
    0.4087    0.5456    0.8045    0.9426    0.9932    0.6381    0.4301
    0.9471    0.8189    0.8817    0.6914    0.2992    0.7603    0.6049
    0.5313    0.7846    0.8723    0.4783    0.3917    0.7953    0.8727
    0.3295    0.7091    0.5363    0.4762    0.4322    0.6652    0.7783
    0.9239    0.1987    0.9394    0.0163    0.1262    0.2233    0.0534

Columns 8 through 14

    0.0226    0.5468    0.5330    0.8822    0.7296    0.6289    0.6860
    0.3498    0.0309    0.6701    0.6577    0.9630    0.7104    0.3656
    0.5538    0.0421    0.6035    0.3528    0.8209    0.7819    0.7047
    0.5525    0.6292    0.5441    0.1807    0.5439    0.0062    0.5190
    0.7511    0.9211    0.5359    0.8888    0.2686    0.9147    0.5099
    0.8829    0.5770    0.4814    0.3754    0.9512    0.8505    0.7561
    0.8836    0.5983    0.0159    0.4957    0.7239    0.2305    0.1555
    0.2053    0.2941    0.3235    0.8784    0.0506    0.7581    0.0087
    0.2390    0.4506    0.9691    0.8574    0.0521    0.9309    0.1028
    0.8378    0.7621    0.8568    0.2588    0.9822    0.2926    0.8241
    0.1844    0.1707    0.3100    0.1206    0.8424    0.7768    0.7449
    0.8533    0.6461    0.5774    0.1966    0.2384    0.9449    0.7628
    0.5814    0.3524    0.0111    0.1423    0.8119    0.9320    0.0621
    0.5607    0.3426    0.9944    0.6615    0.5759    0.5950    0.5142
    0.7038    0.4044    0.9665    0.4041    0.0045    0.7411    0.5604
    0.8903    0.0954    0.4969    0.7975    0.6367    0.1906    0.1202
    0.2436    0.2206    0.7631    0.1449    0.1722    0.0572    0.5438
    0.0015    0.6639    0.2467    0.2297    0.1146    0.8016    0.1176
    0.6214    0.9673    0.6206    0.1164    0.0499    0.0878    0.1558
    0.0742    0.1094    0.0799    0.7624    0.9962    0.0125    0.7979

Columns 15 through 20

    0.7114    0.4676    0.7022    0.2876    0.8059    0.0548
    0.7046    0.7998    0.8983    0.2867    0.8281    0.6627
    0.0448    0.6660    0.6649    0.6348    0.1104    0.4709
    0.0837    0.7143    0.6589    0.2303    0.6784    0.8793
    0.3276    0.8059    0.3371    0.8290    0.8410    0.9374
    0.0912    0.6201    0.9211    0.2238    0.2403    0.8490
    0.6737    0.7140    0.0317    0.7972    0.0488    0.4931
    0.4887    0.1084    0.7959    0.7723    0.9956    0.0514
    0.0573    0.3222    0.4188    0.7583    0.3279    0.5451
    0.5622    0.7808    0.0115    0.2690    0.8856    0.8571
    0.3239    0.9918    0.0679    0.0952    0.8658    0.7567
    0.3574    0.4093    0.5026    0.8761    0.8903    0.7449
    0.6902    0.2365    0.4171    0.1939    0.6647    0.4311
    0.9830    0.7149    0.4246    0.1056    0.5691    0.0797
    0.5958    0.6709    0.9735    0.7823    0.7248    0.5618
    0.3307    0.1980    0.7169    0.9423    0.2212    0.3106
    0.0132    0.8397    0.6079    0.7192    0.2949    0.8399
```

```
    0.6696    0.1257    0.1860    0.5673    0.7246    0.4869
    0.1740    0.4291    0.6106    0.9607    0.7438    0.6246
    0.8157    0.5719    0.1590    0.6812    0.3689    0.6474


i =

    10


b =

    0.8118
    0.1336
    0.7644
    0.7205
    0.8484
    0.1252
    0.6245
    0.2960
    0.6733
    0.8644
    0.4441
    0.5453
    0.0388
    0.0070
    0.6693
    0.1621
    0.7675
    0.2533
    0.3828
    0.0642


L =

  Columns 1 through 7

    1.0000         0         0         0         0         0         0
    0.9415    1.0000         0         0         0         0         0
    0.2819   -0.6809    1.0000         0         0         0         0
    0.1384   -0.4102    0.9676    1.0000         0         0         0
    0.7271    0.6448   -0.4050   -0.1913    1.0000         0         0
    0.5414   -0.4501    0.8114   -0.0329   -0.1851    1.0000         0
    0.8617   -0.2975   -0.3339   -0.4864    0.3805   -0.1059    1.0000
    0.0233   -0.3226    0.9160    0.3663   -0.3163    0.8916   -0.6063
    0.0676   -0.6087    0.9083    0.7427    0.4416   -0.6952    0.3648
    0.5069    0.6105    0.2492    0.5244    0.5205   -0.4283    0.1129
    0.3653   -0.9017    0.3079   -0.4002   -0.1697    0.1480    0.0681
    0.0828   -0.7525    0.8807    0.7149    0.0363    0.4104    0.5373
    0.6665    0.7775   -0.0350    0.9269    0.2773   -0.5016    0.1290
    0.9270    0.8096   -0.4939    0.0120    0.4378   -0.8682   -0.4439
    0.9651    0.0843    0.3113   -0.0175   -0.0473    0.4560    0.1878
    0.4165   -0.2576    0.7360    0.7082    0.5321   -0.3178    0.5296
```

```
    0.6091   -0.1611    0.3598   -0.0737    0.3421   -0.2355    0.2129
    0.3358   -0.6194    0.6435   -0.0776   -0.0295    0.7131    0.0796
    0.5390   -0.0382   -0.2827   -0.5668    0.6584    0.5033    0.5094
    0.5520   -0.5879    0.3884   -0.0867    0.4674   -0.9350    0.3853

  Columns 8 through 14

         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
    1.0000         0         0         0         0         0         0
   -0.4063    1.0000         0         0         0         0         0
    0.3618    0.8254    1.0000         0         0         0         0
    0.9741   -0.5275   -0.4754    1.0000         0         0         0
    0.4758    0.5683    0.2797    0.5462    1.0000         0         0
    0.6347    0.6700    0.9124    0.6792    0.2316    1.0000         0
    0.4428   -0.0191   -0.5163    0.7256   -0.4019    0.0643    1.0000
    0.2337   -0.5202   -0.6535    0.8984   -0.3181   -0.6529    0.7411
    0.0181    0.2240    0.2224   -0.2305   -0.2290   -0.9415    0.3543
   -0.3117    0.4554   -0.5692   -0.0399   -0.0832    0.0534    0.6000
    0.6524    0.1653   -0.0576    0.6715    0.2416   -0.5769    0.4370
    0.6719   -0.0153   -0.1707    0.6279    0.5533   -0.5671    0.3138
   -0.6198    0.2135   -0.5332   -0.1805    0.0935   -0.2629    0.3024

  Columns 15 through 20

         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
         0         0         0         0         0         0
    1.0000         0         0         0         0         0
    0.4061    1.0000         0         0         0         0
    0.9783    0.6130    1.0000         0         0         0
    0.8489    0.4616   -0.1403    1.0000         0         0
    0.7366    0.5578   -0.3241    0.8678    1.0000         0
    0.2851   -0.1856    0.0862    0.4232    0.0818    1.0000

U =
```

```
  Columns 1 through 7

    0.9814    0.9056    0.5927    0.9865    0.1768    0.6421    0.8229
         0   -0.6539    0.3813   -0.9124   -0.0403   -0.3813   -0.7213
         0         0    0.8911   -0.5352    0.5764   -0.3768    0.0442
         0         0         0    0.9753   -0.0990    0.5753    0.1661
         0         0         0         0    1.0431    0.7044    0.7060
         0         0         0         0         0    0.7312    0.2028
         0         0         0         0         0         0   -1.0569
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0

  Columns 8 through 14

    0.0226    0.5468    0.5330    0.8822    0.7296    0.6289    0.6860
    0.0529   -0.4054   -0.4220   -0.0681    0.3093   -0.5796    0.1521
    0.6111   -0.0778   -0.4265   -0.1528    0.8168    0.3601   -0.0277
   -0.0188   -0.1245    0.7694    0.3507    0.0565    0.1088    0.6990
    0.3778   -0.0208    0.1690   -0.4716    0.4541    0.8600    0.2706
   -0.4134    0.2406    0.1710   -0.2304   -0.7180    0.0709   -0.0897
    0.2089   -0.3508   -0.0758    0.3725   -0.4345   -0.1028   -0.3189
    0.8296    0.4608    0.3512    1.1399    0.1028    0.4899    0.2846
         0    0.7755    0.7043    0.5567   -1.1398   -0.1559    0.1628
         0         0   -1.0084   -0.8229    0.3408   -0.3354   -1.0253
         0         0         0   -1.2789   -0.3046   -0.4513    0.3399
         0         0         0         0    1.5763   -0.3998    0.4781
         0         0         0         0         0    1.1027   -0.2429
         0         0         0         0         0         0   -1.2959
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0
         0         0         0         0         0         0         0

  Columns 15 through 20

    0.7114    0.4676    0.7022    0.2876    0.8059    0.0548
    0.1459    0.1317   -0.5021    0.4104   -0.3898    0.5958
    0.5890    0.1944   -0.1227    0.3922    0.1720    0.8213
   -0.5636    0.4672    0.4805    0.3838   -0.3274   -0.0870
   -0.1567    0.7351   -0.0766   -0.1463    0.5383    0.6487
   -0.1754   -0.0744   -0.3190    0.2637    0.0621    0.1762
```

```
   -0.1174   -0.2507    0.2296    1.0478   -0.1148    0.1853
    0.0607    0.6351    0.4945    0.8088    0.7041    0.5683
    0.5349    0.1691    0.3043    0.5656    0.6535    0.2387
   -0.0710   -0.6524   -0.7919   -0.5868   -1.0276   -0.7432
    0.0189   -0.2024   -0.6556    0.2703   -0.6792    0.2649
    0.3147    0.3693   -0.4781   -1.4214    0.5769    0.1015
   -0.4006   -0.2983    0.9861   -0.8027    0.5930    0.2974
    0.4526   -0.5330   -0.4297   -0.9122   -0.1495   -0.8968
   -1.0805    0.4533    1.0421   -0.8538    0.3048    0.5538
         0   -0.8612    0.3588   -0.3855    0.2170    0.0697
         0         0   -1.6435    1.6403   -1.4722   -0.3119
         0         0         0    1.1954   -0.3915   -0.3192
         0         0         0         0   -0.8659   -0.1030
         0         0         0         0         0    0.7645

piv =

     1
    20
    13
     3
    11
    18
     8
     5
    15
     7
    12
    10
     6
    14
    17
    16
     9
    19
     4
     2


ans =

  Columns 1 through 7

    0.9814    0.9056    0.5927    0.9865    0.1768    0.6421    0.8229
    0.9239    0.1987    0.9394    0.0163    0.1262    0.2233    0.0534
    0.2767    0.7006    0.7986    0.3642    0.6537    0.0638    0.7674
    0.1358    0.3935    0.7878    0.9682    0.4997    0.4560    0.6187
    0.7135    0.2368    0.3159    0.1590    0.9311    0.9679    0.7895
    0.5313    0.7846    0.8723    0.4783    0.3917    0.7953    0.8727
    0.8456    0.9749    0.0997    0.8258    0.4169    0.7034    0.0183
    0.0228    0.2320    0.7071    0.1843    0.1789    0.4326    0.9516
    0.0663    0.4592    0.6174    0.8602    0.9471    0.1632    0.4434
    0.4974    0.0598    0.7553    0.3211    0.6997    0.3540    0.2361
```

```
    0.3585    0.9204    0.1471    0.6279    0.1411    0.2208    0.7363
    0.0812    0.5670    0.5470    0.9941    0.5198    0.7452    0.3096
    0.6541    0.0953    0.6603    0.8710    0.2637    0.5066    0.0978
    0.9097    0.3101    0.4180    0.4518    0.3021    0.1531    0.7612
    0.9471    0.8189    0.8817    0.6914    0.2992    0.7603    0.6049
    0.4087    0.5456    0.8045    0.9426    0.9932    0.6381    0.4301
    0.5978    0.6570    0.6203    0.4834    0.6857    0.3433    0.5898
    0.3295    0.7091    0.5363    0.4762    0.4322    0.6652    0.7783
    0.5290    0.5131    0.0530    0.1651    0.6768    0.9730    0.3930
    0.5417    0.8843    0.4492    0.7884    0.8413    0.0279    0.6141

Columns 8 through 14

    0.0226    0.5468    0.5330    0.8822    0.7296    0.6289    0.6860
    0.0742    0.1094    0.0799    0.7624    0.9962    0.0125    0.7979
    0.5814    0.3524    0.0111    0.1423    0.8119    0.9320    0.0621
    0.5538    0.0421    0.6035    0.3528    0.8209    0.7819    0.7047
    0.1844    0.1707    0.3100    0.1206    0.8424    0.7768    0.7449
    0.0015    0.6639    0.2467    0.2297    0.1146    0.8016    0.1176
    0.2053    0.2941    0.3235    0.8784    0.0506    0.7581    0.0087
    0.7511    0.9211    0.5359    0.8888    0.2686    0.9147    0.5099
    0.7038    0.4044    0.9665    0.4041    0.0045    0.7411    0.5604
    0.8836    0.5983    0.0159    0.4957    0.7239    0.2305    0.1555
    0.8533    0.6461    0.5774    0.1966    0.2384    0.9449    0.7628
    0.8378    0.7621    0.8568    0.2588    0.9822    0.2926    0.8241
    0.8829    0.5770    0.4814    0.3754    0.9512    0.8505    0.7561
    0.5607    0.3426    0.9944    0.6615    0.5759    0.5950    0.5142
    0.2436    0.2206    0.7631    0.1449    0.1722    0.0572    0.5438
    0.8903    0.0954    0.4969    0.7975    0.6367    0.1906    0.1202
    0.2390    0.4506    0.9691    0.8574    0.0521    0.9309    0.1028
    0.6214    0.9673    0.6206    0.1164    0.0499    0.0878    0.1558
    0.5525    0.6292    0.5441    0.1807    0.5439    0.0062    0.5190
    0.3498    0.0309    0.6701    0.6577    0.9630    0.7104    0.3656

Columns 15 through 20

    0.7114    0.4676    0.7022    0.2876    0.8059    0.0548
    0.8157    0.5719    0.1590    0.6812    0.3689    0.6474
    0.6902    0.2365    0.4171    0.1939    0.6647    0.4311
    0.0448    0.6660    0.6649    0.6348    0.1104    0.4709
    0.3239    0.9918    0.0679    0.0952    0.8658    0.7567
    0.6696    0.1257    0.1860    0.5673    0.7246    0.4869
    0.4887    0.1084    0.7959    0.7723    0.9956    0.0514
    0.3276    0.8059    0.3371    0.8290    0.8410    0.9374
    0.5958    0.6709    0.9735    0.7823    0.7248    0.5618
    0.6737    0.7140    0.0317    0.7972    0.0488    0.4931
    0.3574    0.4093    0.5026    0.8761    0.8903    0.7449
    0.5622    0.7808    0.0115    0.2690    0.8856    0.8571
    0.0912    0.6201    0.9211    0.2238    0.2403    0.8490
    0.9830    0.7149    0.4246    0.1056    0.5691    0.0797
    0.0132    0.8397    0.6079    0.7192    0.2949    0.8399
    0.3307    0.1980    0.7169    0.9423    0.2212    0.3106
    0.0573    0.3222    0.4188    0.7583    0.3279    0.5451
    0.1740    0.4291    0.6106    0.9607    0.7438    0.6246
```

```
    0.0837    0.7143    0.6589    0.2303    0.6784    0.8793
    0.7046    0.7998    0.8983    0.2867    0.8281    0.6627


ans =

  Columns 1 through 7

    0.9814    0.9056    0.5927    0.9865    0.1768    0.6421    0.8229
    0.9239    0.1987    0.9394    0.0163    0.1262    0.2233    0.0534
    0.2767    0.7006    0.7986    0.3642    0.6537    0.0638    0.7674
    0.1358    0.3935    0.7878    0.9682    0.4997    0.4560    0.6187
    0.7135    0.2368    0.3159    0.1590    0.9311    0.9679    0.7895
    0.5313    0.7846    0.8723    0.4783    0.3917    0.7953    0.8727
    0.8456    0.9749    0.0997    0.8258    0.4169    0.7034    0.0183
    0.0228    0.2320    0.7071    0.1843    0.1789    0.4326    0.9516
    0.0663    0.4592    0.6174    0.8602    0.9471    0.1632    0.4434
    0.4974    0.0598    0.7553    0.3211    0.6997    0.3540    0.2361
    0.3585    0.9204    0.1471    0.6279    0.1411    0.2208    0.7363
    0.0812    0.5670    0.5470    0.9941    0.5198    0.7452    0.3096
    0.6541    0.0953    0.6603    0.8710    0.2637    0.5066    0.0978
    0.9097    0.3101    0.4180    0.4518    0.3021    0.1531    0.7612
    0.9471    0.8189    0.8817    0.6914    0.2992    0.7603    0.6049
    0.4087    0.5456    0.8045    0.9426    0.9932    0.6381    0.4301
    0.5978    0.6570    0.6203    0.4834    0.6857    0.3433    0.5898
    0.3295    0.7091    0.5363    0.4762    0.4322    0.6652    0.7783
    0.5290    0.5131    0.0530    0.1651    0.6768    0.9730    0.3930
    0.5417    0.8843    0.4492    0.7884    0.8413    0.0279    0.6141

  Columns 8 through 14

    0.0226    0.5468    0.5330    0.8822    0.7296    0.6289    0.6860
    0.0742    0.1094    0.0799    0.7624    0.9962    0.0125    0.7979
    0.5814    0.3524    0.0111    0.1423    0.8119    0.9320    0.0621
    0.5538    0.0421    0.6035    0.3528    0.8209    0.7819    0.7047
    0.1844    0.1707    0.3100    0.1206    0.8424    0.7768    0.7449
    0.0015    0.6639    0.2467    0.2297    0.1146    0.8016    0.1176
    0.2053    0.2941    0.3235    0.8784    0.0506    0.7581    0.0087
    0.7511    0.9211    0.5359    0.8888    0.2686    0.9147    0.5099
    0.7038    0.4044    0.9665    0.4041    0.0045    0.7411    0.5604
    0.8836    0.5983    0.0159    0.4957    0.7239    0.2305    0.1555
    0.8533    0.6461    0.5774    0.1966    0.2384    0.9449    0.7628
    0.8378    0.7621    0.8568    0.2588    0.9822    0.2926    0.8241
    0.8829    0.5770    0.4814    0.3754    0.9512    0.8505    0.7561
    0.5607    0.3426    0.9944    0.6615    0.5759    0.5950    0.5142
    0.2436    0.2206    0.7631    0.1449    0.1722    0.0572    0.5438
    0.8903    0.0954    0.4969    0.7975    0.6367    0.1906    0.1202
    0.2390    0.4506    0.9691    0.8574    0.0521    0.9309    0.1028
    0.6214    0.9673    0.6206    0.1164    0.0499    0.0878    0.1558
    0.5525    0.6292    0.5441    0.1807    0.5439    0.0062    0.5190
    0.3498    0.0309    0.6701    0.6577    0.9630    0.7104    0.3656

  Columns 15 through 20
```

```
    0.7114    0.4676    0.7022    0.2876    0.8059    0.0548
    0.8157    0.5719    0.1590    0.6812    0.3689    0.6474
    0.6902    0.2365    0.4171    0.1939    0.6647    0.4311
    0.0448    0.6660    0.6649    0.6348    0.1104    0.4709
    0.3239    0.9918    0.0679    0.0952    0.8658    0.7567
    0.6696    0.1257    0.1860    0.5673    0.7246    0.4869
    0.4887    0.1084    0.7959    0.7723    0.9956    0.0514
    0.3276    0.8059    0.3371    0.8290    0.8410    0.9374
    0.5958    0.6709    0.9735    0.7823    0.7248    0.5618
    0.6737    0.7140    0.0317    0.7972    0.0488    0.4931
    0.3574    0.4093    0.5026    0.8761    0.8903    0.7449
    0.5622    0.7808    0.0115    0.2690    0.8856    0.8571
    0.0912    0.6201    0.9211    0.2238    0.2403    0.8490
    0.9830    0.7149    0.4246    0.1056    0.5691    0.0797
    0.0132    0.8397    0.6079    0.7192    0.2949    0.8399
    0.3307    0.1980    0.7169    0.9423    0.2212    0.3106
    0.0573    0.3222    0.4188    0.7583    0.3279    0.5451
    0.1740    0.4291    0.6106    0.9607    0.7438    0.6246
    0.0837    0.7143    0.6589    0.2303    0.6784    0.8793
    0.7046    0.7998    0.8983    0.2867    0.8281    0.6627

z =

    0.8118
   -0.7001
   -0.6667
    1.0100
    0.2285
    0.1152
   -0.4180
    0.5605
    0.4032
   -0.2811
   -0.1897
   -0.0089
   -1.0214
   -0.8916
    0.3616
   -1.3208
    1.2866
    0.1067
    0.8454
   -0.7118

x =

   -0.7462
    1.6940
    0.3712
   -0.4992
    0.4908
    0.2950
```

```
   -0.5118
    0.1277
    0.7798
   -0.4721
    0.6423
   -0.6425
    0.1724
    1.1452
   -0.4134
    1.3248
   -0.2728
   -0.4429
   -0.8657
   -0.9310


r =

   1.0e-14 *

         0
   -0.0111
    0.0555
         0
    0.0333
   -0.0389
    0.0722
   -0.0555
    0.1110
   -0.0777
   -0.0333
    0.0999
   -0.0666
   -0.0444
   -0.0111
    0.0111
    0.0777
    0.0222
    0.0444
    0.0555


N1 =

   9.2149e-15


N2 =

   2.4863e-15
```

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```
function [L,U,piv]=GEpiv(A)
[n,m]=size(A);
%First check that the matrix is square
if n~=m
    error('ERROR: The matrix given is not square.')
end
piv=(1:n)';
for k=1:n-1
    [maxV,r]=max(abs(A(k:n,k)));
    %If r=1 there is no row interchange.
    q=r+k-1; %position of the max in A(1:n,k)
    %Now interchange rows in the pivot vector and in the matrix A
    piv([k,q])=piv([q,k]);
    A([k,q],:)=A([q,k],:);
    if A(k,k)~=0
        A(k+1:n,k)=A(k+1:n,k)/A(k,k);
        A(k+1:n,k+1:n)=A(k+1:n,k+1:n)-A(k+1:n,k)*A(k,k+1:n); %Update A
    end
end
L=eye(n)+tril(A,-1);
U=triu(A);
end
```

```
Not enough input arguments.

Error in GEpiv (line 2)
[n,m]=size(A);
```

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```
function x=Ltrisol(L,b)
%Column orientated version of lower diagonal solver
n=length(b);
x=zeros(n,1); %reserved storage of x
for j=1:n-1
    x(j)=b(j)/L(j,j); %block multiplication
    b(j+1:n)=b(j+1:n)-x(j)*L(j+1:n,j);  %update b
end
x(n)=b(n)/L(n,n);
end
```

```
Not enough input arguments.

Error in Ltrisol (line 3)
n=length(b);
```

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```
function x=Utrisol(U,b)
% Column oriented version of upper triangular solver
n=length(b);
x=zeros(n,1);
for j=n:-1:2
    x(j)=b(j)/U(j,j);  %block multiplication
    b(1:j-1)=b(1:j-1)-x(j)*U(1:j-1,j);  %update b
end
x(1)=b(1)/U(1,1);
end
```

```
Not enough input arguments.

Error in Utrisol (line 3)
n=length(b);
```

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