Part 12

Solving N equations with the methode

of GAUSS and decomposition method of CROUT.

Program **GAUSSNEQUATIONS** with GAUSS and CROUT.

Example page 1.

```
2*X1   +3*X2   +4*X3 =  8
5*X1  +10*X2  +15*X3 = 30
3*X1   +6*X2   +5*X3 = -2
```

1	2,00	3,00	4,00	x	XX(1)	=	8,00
2	5,00	10,00	15,00	x	XX(2)	=	30,00
3	3,00	6,00	5,00	x	XX(3)	=	-2,00

1	2,00	3,00	4,00	x	3,00	=	8,00
2	0,00	2,50	5,00	x	-6,00	=	10,00
3	0,00	0,00	-4,00	x	5,00	=	-20,00

OK Again Cls
EX1 EX2 EX3 EX4 EX5 EX6 EX7 GAUSS End
PrF STORE NR=? GET CROUT XX(I)

1	2,00	3,00	4,00	x	XX(1)	=	8,00
2	0,00	2,50	5,00	x	XX(2)	=	10,00
3	0,00	0,00	-4,00	x	XX(3)	=	-20,00

1	2,00	.	.	x	4,00	=	8,00
2	0,00	2,50	.	x	4,00	=	10,00
3	0,00	0,00	-4,00	x	5,00	=	-20,00

1	1	1,50	2,00	x	3,00	=	4,00
2	.	1	2,00	x	-6,00	=	4,00
3	.	.	1	x	5,00	=	5,00

OK Again Cls
EX1 EX2 EX3 EX4 EX5 EX6 EX7 GAUSS End
PrF STORE NR=? GET CROUT XX(I)

GAUSS is applied in all other programs!!

Solution of N equations with the elimination method of GAUSS.

```
A11X1 +A12X2 +A13X3= B1      1)

A21X1 +A22X2 +A23X3= B2      2)

A31X1 +A32X2 +A33X3= B3      3)
```

The given set of three equations with three unknowns will be converted into an upper triangle set.
One may read this way, A11X1 as A11 times X1, 2X1 as 2 times X1, etc.

Elimination of X1 from eq. 2) and 3).

```
 2X1 +  3X2 +  4X3=  8      1)

 5X1 + 10X2 + 15X3= 30      2)

 3X1 +  6X2 +  5X3= -2      3)
```

X1 from eq. 2).
Equation 1) is divided by A11 is 2, and multiplied by A21 is 5,
(A21/A11) is 5/2, times eq. 1).

(5/2)(2X1 + 3X2 + 4X3=8) gives

5X1 +7,5X2 + 10X3= 20. This equation is subtracted from eq. 2). One finds eq. 2'). X1 is eliminated from eq. 2), A21 has become zero.

```
            5X1 + 10X2 + 15X3= 30    2)
(5/2)*1)    5X1 +7,5X2 + 10X3= 20 -
           ---------------------
                 2,5X2 +  5X3= 10    2')
```

X1 from eq. 3).
Equation 1) is divided by A11 is 2, and multiplied by A31 is 3,
(A31/A11) is 3/2, times eq. 1).

(3/2)(2X1 + 3X2 + 4X3=8) gives

3X1 +4,5X2 + 6X3= 12. This equation is subtracted from eq. 3). One finds eq. 3'). X1 is eliminated from eq. 3), A31 has become zero.

```
            3X1 +  6X2 +  5X3= -2    3)
(3/2)*1)    3X1 +4,5X2 +  6X3= 12 -
           ---------------------
                 1,5X2 -   X3=-14    3')
```

Elimination of X2 from equation 3).

Equation 2') is divided by the 'new' A22 is 2,5 and multiplied by A32 is 1,5 of eq. 3').
(A32/A22) is 1,5/2,5 times eq. 2').

```
 2X1 +  3X2 +  4X3=  8      1)
      2,5X2 +  5X3= 10      2')
      1,5X2 -   X3=-14      3')
```

(1,5/2,5)/(2,5X2 + 5X3= 10) gives

1,5X2 + 3X3= 6. This equation is subtracted from eq. 3'). One finds wq. 3'').
X2 is eliminated from eq. 3', A32 has become zero.

```
                    1,5X2 -   X3=-14    3')
(1,5/2,5)*2')       1,5X2 +  3X3=  6 -
                   ------------------
                          -  4X3=-20    3'')
```

This way three equations are found from which the three unknowns can be solved by backward substitution. One starts with the last equation and works back to the first equation.

Backward substitution.

```
 2X1 +  3X2 +  4X3=  8      1)
      2,5X2 +  5X3= 10      2')
            -  4X3=-20      3'')
```

From eq. 3'') follows X3=-20/A33.
And with A33=-4 is X3=-20/-4=5.

In the beginning was A33=5, became in eq. 3') A33=-1, and in eq. 3'') A33=-4.

```
 A11X1 +A12X2 +A13X3=  8
        A22X2 +A23X3= 10
               A33X3=-20
```

From eq 2') follows X2=(10-5X3)/A22 or
X2=(10-5(5))/2,5=-15/2,5=-6.

From eq.1) follows X1=(8-4X3-3X2)/A11 or
X1=(8-4(5)-3(-6))/2=(8-20+18)/2=6/2=3.

Solution: X1=3   X2=-6   X3=5

```
Private Sub GAUSS()
NNG=0
For K=1 To N-1
If AA(K,K)=0 Then
T=0 : For I=K+1 To N
If AA(I,K)<>0 Then
T=1 : For J=K To N
R=AA(K,J) : AA(K,J)=AA(I,J)
AA(I,J)=R
Next J
R=BB(K) : BB(K)=BB(I) : BB(I)=R
Exit For
End If
Next I
If T=0 Then ... See next page.

End If
```

A11X1 +A12X2 +A13X3 +A14X4= B1   1)

A22X2 +A23X3 +A24X4= B2   2')

A32X2 +A33X3 +A34X4= B3   3')

A42X2 +A43X3 +A44X4= B4   4')

$$\underset{A}{\begin{bmatrix} A11 & A12 & A13 & A14 \\ 0 & A22 & A23 & A24 \\ 0 & A32 & A33 & A34 \\ 0 & A42 & A43 & A44 \end{bmatrix}} \underset{\underline{x}}{\begin{bmatrix} X1 \\ X2 \\ X3 \\ X4 \end{bmatrix}} \underset{\underline{b}}{\begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix}}$$

I=3 Suppose AA(I,K)=AA(3,2)=0
Then follows Next I.
I=4 Supp. AA(4,2)<>0 then the elements
J=K To N=2 To 4 of row K=2 and row I=4
of matrix AA, are exchanged,
T becomes T-1.

J=2
R=AA(2,2)   AA(2,2)=AA(4,2)   AA(4,2)=R
AA(2,2) has become <>0.
J=3
R=AA(2,3)   AA(2,3)=AA(4,3)   AA(4,3)=R
J=4
R=AA(2,4)   AA(2,4)=AA(4,4)   AA(4,4)=R

R=BB(2)   BB(2)=B(4)   BB(4)=R

```
'The elimnation process.
For I=K+1 To N

V=AA(I,K)/AA(K,K) : NNG=NNG+1
For J=K To N : NNG=NNG+1
AA(I,J)=AA(I,J)-V*AA(K,J)
Next J
BB(I)=BB(I)-V*BB(K) : NNG=NNG+1
Next I

Next K
```

Private Sub GAUSS()

The solution of N equations with the elimina=tion method of Gauss.

For K=1 To N-1 the elimination process will be carried out in the equations I=K+1 To N.
Suppose N=4 equations, then as follows:
if K=1 then X1 from eq. 2 to 4,
if K=2 then X2 from eq. 3 to 4,
if K=3 then X3 from equation 4.

In the program code the arrays are
AA(,) BB() and XX().
In the elimination process there is divided by the diagonal element AA(K,K), see left below.
So AA(K,K) can not be zero.
Is AA(K,K)=0 then in the column under AA(K,K) shall be searched for an element AA(I,K)<>0. As soon it is found equation K and I will be ex-changed;
the elements J=K To N of the rows K and I of matrix AA, and
the elements K and I of vector/column BB.

Suppose the first elimination is done, see on the left, and that AA(K,K)=AA(2,2)=0. Then in the K=2nd column of AA for I=3 To 4 will e searched for an element AA(I,2)<>0.
Before it is assumed with T=0 (third line left above) that such an element is not found.
Is after Next I..........End If still T=0 then a solution is not possible and is the subroutine left with Exit Sub.

Has T become T=1 then an element AA(K,I)<> has been found, and after the exchange, the elimi-nation process is carried out with the 'new' AA(2,2).

K=2 Elimination of X2 from eq. 3' en 4'.

For I=K+1 To N= 3 To 4

X2 from eq. I=3. (that's eq. 3')
The elements AA(K,J), AA(2,2) to AA(2,4) of equation K=2 (is 2'), are divided by AA(K,K) is AA(2,2) and multiplied by AA(I,K) is AA(3,2).

But first V=AA(I,K)/AA(K,K) is AA(3,2)/AA(2,2).

For J=K To N=2 TO 4 the elements AA(2,J) are multiplied by V and subtracted from the ele-ments AA(3,J).

AA(I,J)=AA(I,J)-V*AA(K,J)

J=2 AA(3,2)=AA(3,2)-V*AA(2,2)
AA(3,2) has become zero.
J=3 AA(3,3)=AA(3,3)-V*AA(2,3)
V 'holds' AA(3,2) from before For J= K To N, so, not the AA(3,2) which became just zero.
J=4 AA(3,4)=AA(3,4)-V*AA(2,4) and after
Next J Follows

BB(I)=BB(I)-V*BB(K)
BB(3)=BB(3)-V*BB(2)

This way the third equation 3''has arisen.

See preceding page.

```
Next I

If T=0 Then
CurrentX=900 : CurrentY=750
Print "No solution possible"
Exit Sub
End If

End If
```

```
A11X1 +A12X2 +A13X3 +A14X4= B1    1)

      A22X2 +A23X3 +A24X4= B2    2')

             A33X3 +A34X4= B3    3'')

                    A44X4= B4    4''')
```

$$\begin{bmatrix} A11 & A12 & A13 & A14 \\ . & A22 & A23 & A24 \\ . & . & A33 & A34 \\ . & . & . & A44 \end{bmatrix} \cdot \begin{bmatrix} X1 \\ X2 \\ X3 \\ X4 \end{bmatrix} = \begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix}$$

```
If AA(N,N)=0 Then
CurrentX=900 : CurrentY=750
Print "No solution possible"
Exit Sub
End If
'Backward substitution.
G=N+1
For I=N To 1 Step-1 : S=0
If I<N THEN
For J=N To G Step-1
S=S+AA(I,J)*XX(J)  : NNG=NNG+1
Next J
End If
G=G-1 : NNG=NNG+1
XX(I)=(BB(I)-S)/AA(I,I)
Next I

End Sub
```

X2 from eq. I=4.

V=AA(I,K)/AA(K,K)=AA(4,2)/AA(2,2)
For J=K To N=2 To N the elements AA(2,J) are multiplied by V and subtracted from the elements AA(4,J).

```
J=2    AA(4,2)=AA(4,2)-V*AA(2,2)
       AA(4,2) has become zero.
J=3    AA(4,3)=AA(4,3)-V*AA(2,3)
J=4    AA(4,4)=AA(4,4)-V*AA(2,4)

       BB(4)=BB(4)-V*BB(2)
```

This way arises eq. 4'').

Next follows the elimination of X3 from equation I=4 (is 4'') and arises eq. 4''').

Backward substitution.

After the elimination process N equations are arisen from which the N to 1 (counting back) unknowns can be solved, as is written out below for N=4.

```
I=4   X4={(B4 -(           0           ))}/A44
I=3   X3={(B3 -(A34X4                  ))}/A33
I=2   X2={(B2 -(A24X4 +A23X3           ))}/A22
I=1   X1={(B1 -(A14X4 +A13X3 +A12X2))}/A11
```

But first G=N+1.
And then the calculation of XX(I).

For I=N To 1 Step-1 : S=0
For each I sum S is determined with
For J=N To G Step-1 except when I=N.
If I<N Then .... sum S .... End If
After End If becomes G=G-1.
After that XX(I) is calculated for each I with
XX(I)=(BB(I)-S)/AA(I,I)

With N=4 is G=N+1=5

```
I=4   I<4?  no   S stays S=0
            XX(4)=(BB(4)-0)/AA(4,4)     G=G-1=4

I=3   I<4?  yes    J=N To G=4 To 4 Step-1
      J=4   S=0 +AA(3,4)*XX(4)        G=G-1=3

            XX(3)=(BB(3)-S)/AA(3,3)

I=2   I<4?  yes    J=N To G=4 To 3 Step-1
      J=4    S=0 +AA(2,4)*XX(4)
      J=3   S=S +AA(2,3)*XX(3)        G=G-1=2

            XX(2)=(BB(2)-S)/AA(2,2)

I=1   I<4?  yes    J=N To G=4 To 2 Step-1
      J=4   S=0 +AA(1,4)*XX(4)
      J=3   S=S +AA(1,3)*XX(3)
      J=2   S=S +AA(1,2)*XX(2)        G=G-1=1

            XX(1)=(BB(1)-S)/AA(1,1)
```

End Sub

$$\underset{A}{\begin{bmatrix} A11 & A12 & A13 & A14 \\ A21 & A22 & A23 & A24 \\ A31 & A32 & A33 & A34 \\ A41 & A42 & A43 & A44 \end{bmatrix}} \cdot \underset{\underline{x}}{\begin{bmatrix} X1 \\ X2 \\ X3 \\ X4 \end{bmatrix}} = \underset{\underline{b}}{\begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix}}$$

$$\underset{D}{\begin{bmatrix} D11 & . & . & . \\ D21 & D22 & . & . \\ D31 & D32 & D33 & . \\ D41 & D42 & D43 & D44 \end{bmatrix}}$$

$$\underset{E}{\begin{bmatrix} 1 & E12 & E13 & E14 \\ . & 1 & E23 & E24 \\ . & . & 1 & E34 \\ . & . & . & 1 \end{bmatrix}} \cdot \underset{\underline{x}}{\begin{bmatrix} X1 \\ X2 \\ X3 \\ X4 \end{bmatrix}} = \underset{\underline{b}}{\begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix}}$$

$$\underset{D}{\begin{bmatrix} D11 & . & . & . \\ D21 & D22 & . & . \\ D31 & D32 & D33 & . \\ D41 & D42 & D43 & D44 \end{bmatrix}} \cdot \underset{\underline{y}}{\begin{bmatrix} Y1 \\ Y2 \\ Y3 \\ Y4 \end{bmatrix}} = \underset{\underline{b}}{\begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix}}$$

$$\underset{E}{\begin{bmatrix} 1 & E12 & E13 & E14 \\ . & 1 & E23 & E24 \\ . & . & 1 & E34 \\ . & . & . & 1 \end{bmatrix}} \cdot \underset{\underline{x}}{\begin{bmatrix} X1 \\ X2 \\ X3 \\ X4 \end{bmatrix}} = \underset{\underline{y}}{\begin{bmatrix} Y1 \\ Y2 \\ Y3 \\ Y4 \end{bmatrix}}$$

Fig.1.

$$\begin{bmatrix} \underline{D11} & . & . & . \\ \underline{D21} & & . & . \\ \underline{D31} & & & . \\ \underline{D41} & & & \end{bmatrix} \qquad \underline{I=1}$$

$$\begin{bmatrix} 1 & \underline{E12} & \underline{E13} & \underline{E14} \\ . & 1 & & \\ . & . & 1 & \\ . & . & . & 1 \end{bmatrix}$$

Fig.2a.

<u>Solution of N equations with the decomposition method of CROUT.</u>

Fig.1.
The set of N equations will be solved by decomposing
matrix of coefficients A ito
lower triangular matrix D and
upper triangular matrix E in such way that
$A\ \underline{x} = D \cdot E\ \underline{x} = \underline{b}$.

With $E\ \underline{x} = \underline{y}$ becomes $D\ \underline{y} = \underline{b}$.

The unknowns Y are solved from $D\ \underline{y} = \underline{b}$,
after that the unknowns X from $E\ \underline{x} = \underline{y}$;
see page .

For that first the elements of D and E must be dtermined using matrix multiplication $A = D \cdot E$.

Row I of matrix D times column J of matrix E.
For each I, except whwn I=N, the calculation is carried out in three steps, of

a) the diagonal element D(I,I),
b) the elements under D(I,I), and
c) the elements right of E(I,I)=1.

Fig.2a and 1.

a) The 1st diagonal element D(1,1).
A11= 1st row of D times 1st column of E.
A11=D11*E11+D12*E21+D13*E31+D14*E41
=D11*1 + 0*0 + 0*0 + 0*0 so that
<u>D11=A11</u>.

b) The 2nd to 4th element of D under D(1,1).
A21= 2nd row of D times 1st column of E.
A21=D21*E11+D22*E21+D23*E31+D24*E41
=D21*1 +D22*0 + 0*0 + 0*0 so that
<u>D21=A21</u>.

A31= 3rd row of D times 1st column of E.
=D31*1 +D32*0 +D33*0 + 0*0 so that
<u>D31=A31</u>.

A41= 4th row of D times 1st column of E.
D41*1 +D42*0 +D43*0 +D44*0 so that
<u>D41=A41</u>.

c) Element 2 t/m 4 rechts van E(1,1).
A12= 1e rij van D maal 2e kolom van E.
A12=D11*E12+D12*E22+D13*E32+D14*E42
=D11*E12+ 0*1 + 0*0 + 0*0 zodat
<u>E12=A12/D11</u>.

A13= 1st row of D times 3e column of E.
=D11*E13+ 0*E23+ 0*1 + 0*0 so that
<u>E13=A13/D11</u>.

A14= 1st row of D times 4th column of E.
=D11*E14+ 0*E24+ 0*E34+ 0*1 so that
<u>E14=A14/D11</u>.

E23, E24, and E34 are still unknown, no prblem, they are multiplied by zero.
There will be divided by diagonal element D11
Er wordt gedeeld door het diagonaalelement D11
which must be <>0.

$$\begin{bmatrix} D11 & . & . & . \\ D21 & \underline{D22} & . & . \\ D31 & \underline{D32} & & . \\ D41 & \underline{D42} & & \end{bmatrix} \quad \begin{bmatrix} 1 & E12 & E13 & E14 \\ . & 1 & \underline{E23} & \underline{E24} \\ . & . & 1 & \\ . & . & . & 1 \end{bmatrix}$$

<u>I=2</u>

Fig.2b.

$$\begin{bmatrix} D11 & . & . & . \\ D21 & D22 & . & . \\ D31 & D32 & \underline{D33} & . \\ D41 & D42 & \underline{D43} & D44 \end{bmatrix} \quad \begin{bmatrix} 1 & E12 & E13 & E14 \\ . & 1 & E23 & E24 \\ . & . & 1 & \underline{E34} \\ . & . & . & 1 \end{bmatrix}$$

<u>I=3</u>

Fig.2c.

$$\begin{bmatrix} D11 & E12 & E13 & E14 \\ D21 & D22 & E23 & E24 \\ D31 & D32 & D33 & E34 \\ D41 & D42 & D43 & D44 \end{bmatrix}$$

A

Fig.2d.

a)	D11	A11
b)	D21	A21
	D31	A31
	D41	A41
c)	E12	A12 D11
	E13	A13 D11
	E14	A14 D11
a)	D22	A22 D21 E12
b)	D32	A32 D31 E12
	D42	A42 D41 E12
c)	E23	A23 D21 E13 D22
	E24	A24 D21 E14 D22
a)	D33	A33 D31 E13 D32 E33
b)	D43	A43 D41 E13 D42 E33
c)	E34	A34 D31 E14 D32 E24 D33
a)	D44	A44 D41 E14 D42 E24 D43 E34

Fig.2b.

a) The 2nd diagonal element D(2,2).
A22= 2nd row of D times 2nd column of E.
Multiplications bij zero are not shown!
A22=D21*E12+D22*1 from which follows
<u>D22=A22-D21*E12</u>.

b) The 3rd and 4th element of D under D(2,2).
A32= 3rd row of D times 2nd column of E.
=D31*E12+D32*1 so that
<u>D32=A32-D31*E12</u>.

A42= 4th row of D times 2nd column of E.
=D41*E12+D42*1 so that
<u>D42=A42-D41*E12</u>.

c) The elemnets 3 and 4 of E right of E(2,2).
A23= 2nd row of D times 3rd column of E.
=D21*E13+D22*E23 so that
<u>E23=(A23-D21*E13)/D22</u>.

A24= 2nd row of D times 4th column of E.
=D21*E14+D22*E24 so that
<u>E24=(A24-D21*E14)/D22</u>.

Fig.2c.

a) The 3rd diagonal element D(3,3).
A33= 3rd row of D times 3rd column of E.
=D31*E13+D32*E23+D33*1 so that
<u>D33=A33-D31*E13-D32*E23</u>.

b) The 4th element of D under D(3,3).
A43= 4th row of D times 3rd column of E.
D41*E13+D42*E23+D43*1 zodat
<u>D43=A43-D41*E13-D42*E23</u>.

c) The 4th element of E right of E(3,3).
A34= 3rd row of D times 4th column of E.
=D31*E14+D32*E24+D33*E34 so that
<u>E34=(A34-D31*E14-D32*E24)/D33</u>.

a) And finally the 4th diagonal element D(4,4).
A44= 4th row of D times 4th column of E.
=D41*E14+D42*E24+D43*E34+D44*1 from which
<u>D44=A44-D41*E14-D42*E24-D43*E34</u>.

Fig.2d.

The calculated elements of the matrices D and E can be placed in one single matrix. On the left one sees in the first column in order the to be calculated elements of matrix D and E.
Each calculated element does not change any more and will be used at least one time when following elements are calculated, except D44.

Row- and column number of a calculated element are the same as that of the used element of matrix A which will not be used any more.

E.g. D32=A32-D31*E12 Now one can write
A32=A32-D31*E12. The old A32 is replaced by the new A32, and so on.

After the complete calculation the old matrix A is replaced by a new matrix A.

```
Private Sub CROUT()
NNC=0
For I=1 To N : S=0
'a) The diagonal elements AA(I,I)
If I>1 Then
For J=1 To I-1
S=S+AA(I,J)*AA(J,I)  : NNC=NNC+1
Next J
End If

AA(I,I)=AA(I)-S
If AA(I,I)=0 Then
CurrentY=CurrentY+210
CurrentX=300
Print "No solution possible."
Exit Sub
End If
```

$$\begin{bmatrix} D11 & . & . & . & . \\ D21 & D22 & . & . & . \\ \underline{D31} & \underline{D32} & \underline{D33} & . & . \\ D41 & D42 & & & \\ D51 & D52 & & & \end{bmatrix}$$

$$\begin{bmatrix} 1 & E12 & \underline{E13} & E14 & E15 \\ . & 1 & \underline{E23} & E24 & E25 \\ . & . & 1 & & \\ . & . & . & 1 & \\ . & . & . & . & 1 \end{bmatrix}$$

$$\begin{bmatrix} A11 & A12 & \underline{A13} & A14 & A15 \\ A21 & A22 & \underline{A23} & A24 & A25 \\ \underline{A31} & \underline{A32} & \underline{A33} & & \\ A41 & A42 & & & \\ A51 & A52 & & & \end{bmatrix}$$

Fig.1.

Private Sub CROUT()

The solution of N equations with the decomposition method of CROUT in coefficient matrix AA. The calculated elements of the matrices DD and EE give new values to the elements of matrix AA. In explanation A instead of AA, etc. and values simplified.
For N=1 To N=5 the elements are calculated in three steps.

a) The diagonal elements A(I,I).
These were D(I,I) on the preceding pages.
With help of the calculation order shown there follow the elements for matrix A.

```
A11=A11-(                0                 )
A22=A22-(A21*A12                           )
A33=A33-(A31*A13 +A32*A23                  )
A44=A44-(A41*A14 +A42*A24 +A43*A34         )
A55=A55-(A51*A15 +A52*A25 +A53*A35 +A54*A45)
         ----------------------------------
                       sum S
```

If I>1 then calculation of sum S follows, but first S=0. The number of times that for sum S has to be multiplied is
For J=1 To I-1 and sum S then becomes
S=S+A(I,J)*A(J,I).   (That was D(I,J)*E(J,I).)
And then the diagonal element with
A(I,I)=A(I,I)-S.

Is A(I,I)=0 then a solution is not possible and is the subroutine left with Exit Sub. There will be divided by A(I,I), see next page.
Is A(I,I) <>0 then the calculation can be continued.

Fig.1.

```
I=1  S=0  I>1?  no, no calculation of S, S=0.
     A(1,1)=A(1,1)-0
     Then follow step b) and c) and are the
     elements under A(1,1) and the elements on
     the right of A(1,1)rechts van A(1,1) cal-
     culated.

I=2  S=0  I>1  For J=1 To I-1=1 To 1
     S=0+A(2,1)*A(1,2)         D(2,1)*E(1,2)
     A(2,2)=A(2,2)-S  after that step b) en c)

I=3  S=0  I>1  FOR J=1 To I-1=1 To 2
     See the underlined elements.
     S=0+A(3,1)*A(1,3)         D(3,1)*E(1,3)
     S=S+A(3,2)*A(2,3)         D(3,2)*E(2,3)
     A(3,3)=A(3,3)-S  after that step b) en c)

I=4  S=0       For J=1 To 3
     S=0+A(4,1)*A(1,4)
     S=S+A(4,2)*A(2,4)
     S=S+A(4,3)*A(3,4)
     A(4,4)=A(4,4)-S

I=5  S=0       For J=1 To 4
     S=0+A(5,1)*A(1,5)
     S=S+A(5,2)*A(2,5)
     S=S+A(5,3)*A(3,5)
     S=S+A(5,4)*A(4,5)
     A(5,5)=A(5,5)-S
```

```
'b) The elements under AA(I,I).
For J=I+1 To N : S=0
If I>0 Then
For K=1 To I-1
S=S+AA(J,K)*AA(K,I)  : NNC=NNC+1
Next K
End If
AA(J,I)=AA(J,I)-S
Next J
```

```
A11 A12 A13 A14 A15
A21 A22 A23 A24 A25
A31 A32 A33                I=3  J=4
A41 A42 A43
A51 A52
```

```
A11 A12 A13 A14 A15
A21 A22 A23 A24 A25
A31 A32 A33                I=3  J=5
A41 A42 A43
A51 A52 A53
```

Fig.2.

b) The elements under A(I,I).   Was D(I,I).
For I=1 To N=5 these elements become

```
A21=A21 - (               0                )
A31=A31 - (               0                )
A41=A41 - (               0                )
A51=A51 - (               0                )

A32=A32 - (A31*A12                         )
A42=A42 - (A41*A12                         )
A52=A52 - (A51*A12                         )

A43=A43 - (A41*A13 + A42*A23               )
A53=A53 - (A51*A13 + A52*A23               )

A54=A54 - (A51*A14 + A52*A24 + A53*A34)
          -----------------------------
                     sum S
```

J=I+1 To N times an element under A(I,I) will be calculated for an I.
Is I>1 then sum S is calculated for which
For K=1 To I-1 element products A(J,K)*A(K,I)
are summed with
S=S+A(J,K)*A(K,I).
Next K
After that the element under A(I,I) becomes
A(J,I)=A(J,I)-S.

Fig.2.

```
I=3  For J=I+1 To N=4 To 5
     S=0  I>1  For K=1 To I-1=1 To 2
     J=4  K=1  S=0+A(4,1)*A(1,3)
          K=2  S=S+A(4,2)*A(2,3)
               A(4,3)=A(4,3)-S  and then J=5  etc.
```

```
'c) The elements right of AA(I,I).
For J=I+1 To N : S=0
If I>1 Then
For K=1 To I-1
S=S+AA(I,K)*AA(K,J)  : NNC=NNC+1
Next K
End If
AA(I,J)=(AA(I,J)-S)/AA(I,I)
NNC=NNC+1
Next J
Next I
```

```
A11 A12 A13 A14 A15
A21 A22 A23 A24 A25
A31 A32 A33 A34            I=3  J=4
A41 A42 A43
A51 A52 A53
```

```
A11 A12 A13 A14 A15
A21 A22 A23 A24 A25
A31 A32 A33 A34 A35        I=3  J=5
A41 A42 A43
A51 A52 A53
```

Fig.3.

The elements righ of A(I,I).   Was E(I,I).

```
A12=(A12 - (              0                ))/A11
A13=(A13 - (              0                ))/A11
A14=(A14 - (              0                ))/A11
A15=(A15 - (              0                ))/A11

A23=(A23 - (A21*A13                        ))/A22
A24=(A24 - (A21*A14                        ))/A22
A25=(A25 - (A21*A15                        ))/A22

A34=(A34 - (A31*A14 + A32*A24              ))/A33
A35=(A35 - (A31*A15 + A32*A25              ))/A33

A45=(A45 - (A41*A15 + A42*A25 + A43*A35))/A44
```

Like above, now with addition
S=S+A(I,K)*A(K,J) and
Next K and the element right of A(I,I) becomes
A(I,J)=(A(I,J)-S)/A(I,I).

Fig.3.

```
I=3  For J=I+1 To N=4 To 5
     S=0  I>1  For K=1 To I-1=1 To 2
     J=4  K=1  S=0+A(3,1)*A(1,4)
          K=2  S=S+A(3,2)*A(2,4)
               A(3,4)=(A(3,4)-S)/A33  etc.
```

Is I=5 then follows
For J=I+1 To N=6 To 5, which means that the calculation for step b) and c) is not carried out.

```
'Forward substitution.
G=0
For I=1 To N : S=0
If I>1 Then
For J=1 To G
S=S+AA(I,J)*YY(J)
Next J
End If
YY(I)=(BB(I)-S)/AA(I,I)
G=G+1
Next I
```

```
D11*Y1                          =B1

D21*Y1+D22*Y2                   =B2

D31*Y1+D32*Y2+D33*Y3            =B3

D41*Y1+D42*Y2+D43*Y3+D44*Y4=B4
```

$$\begin{bmatrix} A11 & . & . & . \\ A21 & A22 & . & . \\ A31 & A32 & A33 & . \\ A41 & A42 & A43 & A44 \end{bmatrix} \cdot \underline{\begin{bmatrix} Y1 \\ Y2 \\ Y3 \\ Y4 \end{bmatrix}} = \begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix}$$

Fig.3.

```
'Backward substitution.
G=N+1
For I=N To 1 Step -1 : S=0
If I<N Then
For J=N To G Step -1
S=S+AA(I,J)*XX(J)
Next J
End If
XX(I)=YY(I)-S
G=G-1
Next I
End Sub
```

```
1*1 +E12*X2+E13*X3+E14*X4=Y1

       1*X2+E23*X3+E24*X4=Y2

              1*X3+E34*X4=Y3

                     1*X4=Y4
```

$$\begin{bmatrix} 1 & E12 & E13 & E14 \\ . & 1 & E23 & E24 \\ . & . & 1 & E34 \\ . & . & . & 1 \end{bmatrix} \cdot \begin{bmatrix} X1 \\ X2 \\ X3 \\ X4 \end{bmatrix} = \underline{\begin{bmatrix} Y1 \\ Y2 \\ Y3 \\ Y4 \end{bmatrix}}$$

Fig.4.

The solution of the N equations in two steps: Calculation of the unknowns y from D $\underline{y}$ = $\underline{b}$ and calculation of the unknowns x from E $\underline{x}$ = $\underline{y}$.

<u>Forward substitution.</u> D $\underline{y}$ = $\underline{b}$
Fig.3.
The elements of the lower triangularmatrix D, see page 5 , are now the elements of the lower triangularmatrix A. The solution of the unknowns y is written out below.

```
Y1=(B1 - (           0           ))/A11
Y2=(B2 - (A21*Y1                 ))/A22
Y3=(B3 - (A31*Y1 + A32*Y2        ))/A33
Y4=(B4 - (A41*Y1 + A42*Y2 + A43*Y3))/A44
          ________________________
                   sum S
```

Before G=0 and then the calculation of Y(I).
For I=1 To N : S=0
Is I>0 then sum S is calculated.
The number of multiplications follows with
For J=1 To G   and the sum becomes
S=S+A(I,J)*Y(J)
Next J and after End If follows
Y(I)=(B(I)-S)/A(I,I) and after that follows
G=G+1;
for the next I the number of multiplications in-creases with 1.

```
I=1   I>1?  no   S stays S=0
      Y(1)=(B(1)-0)/A(1,1)          G=G+1=0+1=1

I=2   I>1  yes   For J=1 To G=1 To 1
      J=1        S=0+A(2,1)*Y(1)
      Y(2)=(B(2)-S)/A(2,2)          G=G+1=1+1=2

I=3   I>1  yes   For J=1 To G=1 To 2
      J=1        S=0+A(3,1)*Y(1)
      J=2        S=S+A(3,2)*Y(2)  with
      Y(3)=(B(3)-S)/A(3,3)          G=G+1=2+1=3

I=4   I>1  yes   For J=1 To G=1 To 3
      J=1        S=0+A(4,1)*Y(1)
      J=2        S=S+A(4,2)*Y(2)
      J=3        S=S+A(4,3)*Y(3)
      Y(4)=(B(4)-S)/A(4,4)
```

Now the unknowns Y(I) are known the unknowns X(I) can be solved from E $\underline{x}$ = $\underline{y}$.

<u>Backward substitution.</u>
Fig.4.
The elements of upper triangularmatrix E unequal to 1 are now the elements of upper tri-angularmatrix A (without main diagonal).
Starting with X(4) then follow

```
X(4)=Y(4)-(                0                )
X(3)=Y(3)-(A(3,4)*X(4)                      )
X(2)=Y(2)-(A(2,4)*X(4)+A(2,3)*X(3)          )
X(1)=Y(1)-(A(1,4)*X(4)+A(1,3)*X(3)+A(1,2)*X(2))
```

This part of the program is the same as with the elimination method of GAUSS, page 3 , but now
X(I)=Y(I)-S in stead of
X(I)=(B(I)-S)/A(I,I), and A(I,I)=1 can be omitted. Finally
End Sub.

Subroutines GAUSS and CROUT from the program.
"No solution possible" to appear in case of division by zero here below.
Also for CROUT if AA(I,I)=0.

With NNG and NNC the multiplications and divisions are counted printed with NMD, see the eamples.

```
Private Sub GAUSS()
NNG=0
For K=1 To N-1
If AA(K,K)=0 Then
T=0 : For I=K+1 To N
If AA(I,K)<>0 Then
T=1 : For J=K To N
R=AA(K,J) : AA(K,J)=AA(I,J)
AA(I,J)=R
Next J
R=BB(K) : BB(K)=BB(I) : BB(I)=R
Exit For
End If
Next I

If T=0 Then
CurrentX=900 : CurrentY=750
Print "No solution possible"
Exit Sub
End If

End If

'The elimination process.
For I=K+1 To N

V=AA(I,K)/AA(K,K) : NNG=NNG+1
For J=K To N : NNG=NNG+1
AA(I,J)=AA(I,J)-V*AA(K,J)
Next J
BB(I)=BB(I)-V*BB(K) : NNG=NNG+1
Next I

Next K

If AA(N,N)=0 Then
CurrentX=900 : CurrentY=750
Print "No solution possible"
Exit Sub
End If

'Backward substitution.
G=N+1
For I=N To 1 Step-1 : S=0
If I<N THEN
For J=N To G Step-1
S=S+AA(I,J)*XX(J) : NNG=NNG+1
Next J
End If
G=G-1 : NNG=NNG+1
XX(I)=(BB(I)-S)/AA(I,I)
Next I

End Sub
```

```
Private Sub CROUT()
NNC=0
For I=1 To N : S=0
'a) The diagonal elements AA(I,I)
If I>1 Then
For J=1 To I-1
S=S+AA(I,J)*AA(J,I) : NNC=NNC+1
Next J
End If

AA(I,I)=AA(I)-S
If AA(I,I)=0 Then
CurrentY=CurrentY+210
CurrentX=300
Print "No solution possible."
Exit Sub
End If

'b) The elements under AA(I,I).
For J=I+1 To N : S=0
If I>0 Then
For K=1 To I-1
S=S+AA(J,K)*AA(K,I) : NNC=NNC+1
Next K
End If
AA(J,I)=AA(J,I)-S
Next J

'c) The elements right of AA(I,I).
For J=I+1 To N : S=0
If I>1 Then
For K=1 To I-1
S=S+AA(I,K)*AA(K,J) : NNC=NNC+1
Next K
End If
AA(I,J)=(AA(I,J)-S)/AA(I,I)
NNC=NNC+1
Next J
Next I

'Forward substitution.
G=0
For I=1 To N : S=0
If I>1 Then
For J=1 To G
S=S+AA(I,J)*YY(J)
Next J
End If
YY(I)=(BB(I)-S)/AA(I,I)
G=G+1
Next I

'Backward substitution.
G=N+1
For I=N To 1 Step -1 : S=0
If I<N Then
For J=N To G Step -1
S=S+AA(I,J)*XX(J)
Next J
End If
XX(I)=YY(I)-S
G=G-1
Next I
End Sub
```

```
N= 2
I=1  5.47  -2.5
I=2  -2.5  5.83                                    EX2
```

```
[OK]  Again   Cls
 EX1  EX2  EX3  EX4  EX5  EX6  EX7   GAUSS        End
PrF       STORE  NR=?  GET           CROUT  XX(I)
```

```
1   5,47  -2,50 x  XX(1)  =   -9,00
2  -2,50   5,83 x  XX(2)  =    9,00
```

```
1   5,47  -2,50 x  -1,17  =   -9,00
2   0,00   4,69 x   1,04  =    4,89
```

```
XX(1)=   -1,17
XX(2)=    1,04    GAUSS  NMD= 7
```

```
N= 3
I=1  .465  .308  -.071   3
I=2  .308  .488  -.177  -5                         EX3
I=3  -.071  -.177  .427   0
```

```
[OK]  Again   Cls
 EX1  EX2  EX3  EX4  EX5  EX6  EX7   GAUSS        End
PrF       STORE  NR=?  GET           CROUT  XX(I)
```

```
1   0,47   0,31  -0,07 x  XX(1) =   3,00
2   0,31   0,49  -0,18 x  XX(2) =  -5,00
3  -0,07  -0,18   0,43 x  XX(3) =   0,00
```

```
1   0,47   0,31  -0,07 x  23,90 =   3,00
2   0,00   0,28  -0,13 x -28,12 =  -6,99
3   0,00   0,00   0,36 x  -7,68 =  -2,74
```

```
XX(1)=   23,90
XX(2)=  -28,12
XX(3)=   -7,68    GAUSS  NMD= 20
```

```
1   0,47   0,31  -0,07 =   3,00
2   0,31   0,49  -0,18 =  -5,00
3  -0,07  -0,18   0,43 =   0,00
```

```
1   0,47      .      . x   6,45 =   3,00
2   0,31   0,28      . x -24,60 =  -5,00
3  -0,07  -0,13   0,36 x  -7,68 =   0,00
```

```
1      1   0,66  -0,15 x  23,90 =   6,45
2      .      1  -0,46 x -28,12 = -24,60
3      .      .      1 x  -7,68 =  -7,68
```

```
XX(1)=   23,90
XX(2)=  -28,12
XX(3)=   -7,68    CROUT  NMD= 17
```

Example of page 1. N=3 equations. EX1

```
2*X1  +3*X2  +4*X3 =  8     1)
5*X1 +10*X2 +15*X3 = 30     2)
3*X1  +6*X2  +5*X3 = -2     3)
```

Input like shown here below and find the results X1=3 X2=-6 X3=5.

Example. N=2 equations. EX2

```
 5,47*X1 -2,50*X2= -9     1)
-2,50*X1 +5,83*X2=  9     2)
```

Type in TSTRING N=2 Enter,
N=2 appears in the second rectangular.
Equation I=1.
Type in TSTRING **I=1**,5.47,-2.5,**-9** Enter.
the line with data appears below N=2.
Equation I=2.
Type in TSTRING **I=2**,-2.5,5.83,**9** Enter.

Next click GAUSS, the equations are shown and below the solution after the elimation process.

XX(1)= -1,17/EA and XX(2)= 1,04/EA.

A click on XX(I) also shows the results and GAUSS NMD=7, the number of multiplications and divisions with the method of GAUSS.

For solution with CROUT the data should be put in again, but, see here below to store the data put in for later use.

The equations of this eaxample can be found on page 11 of Displacement/deformation method.

Example. N=3 equations. EX3

```
 0,465*X1 +0,308*X2 -0,071*X3 =  3     1)
 0,308^X1 +0,488*X2 -0,177*X3 = -5     2)
-0,071*X1 -0,177*X2 +0,427*X3 =  0     3)
```

Input of equation data. N=3 Enter.

I=1,.465,.308,-.071,**3** Enter,

I=2,.308,.488,-.177,**-5** Enter and

I=3,-.071,-.177,.427,**0** Enter.

Click STORE, if e.g. NR=3 is not underlined, then become STORE and NR=3 underlined.

If the input of a line is not correct then put in one more time the line of data to repair the mistake/error.
Click GAUSS with the following results,

XX(1)= 23,90/EA, XX(2)= -28,12/EA and
XX(3)= -7,68/EA. GAUSS NMD=20.

With CROUT. Click first Again, next click NR= to e.g. NR=3 and click GET becoming GET, and click CROUT to get the same results shown on the left and click XX(I) with CROUT NMD=17. number of multiplications and divisions.

See page 27 of displcement/deformation method, here with rounded numbers/values.

```
1  94,20  15,90   6,90  40,90 = 524,00
2  15,90 188,70  40,90  30,90 =-320,00          EX4
3   6,90  40,90  59,50  47,70 =-320,00
4  40,90  30,90  47,70  87,30 =-427,00
```

```
1  94,20  15,90   6,90  40,90 x  10,34 =  524,00
2   0,00 186,02  39,74  24,00 x  -1,47 = -408,45
3   0,00   0,00  50,51  39,58 x   3,24 = -271,13
4   0,00   0,00   0,00  35,43 x -10,99 = -389,35
```

```
                                  OK  Again     Cls
  EX1  EX2  EX3  EX4  EX5  EX6  EX7  GAUSS       End
PrF      STORE  NR=?  GET            CROUT  XX(I)
```

```
XX(1)=   10,34
XX(2)=   -1,47
XX(3)=    3,24
XX(4)=  -10,99    GAUSS  NMD= 42
```

Example.   N=4 equations.   EX4

See page 91 of Displacement method.
The data of the four equations are hundred times as large put in.

N=4
I=1,94.2,15.9,6.9,40.9,524 Enter,
I=2,15.9,188.7,40.9,30.9,-320 Enter,
I=3,6.9,40.9,59.5,47.7,-320 Enter and
I=4,40.9,30.9,47.7,87.3,-427 Enter.

```
1  94,20  15,90   6,90  40,90 x XX(1) =  524,00
2  15,90 188,70  40,90  30,90 x XX(2) = -320,00
3   6,90  40,90  59,50  47,70 x XX(3) = -320,00
4  40,90  30,90  47,70  87,30 x XX(4) = -427,00
```

```
1  94,20    .      .      .   x   5,56 =  524,00
2  15,90 186,02    .      .   x  -2,20 = -320,00
3   6,90  39,74  50,51    .   x  -5,37 = -320,00
4  40,90  24,00  39,58  35,43 x -10,99 = -427,00
```

```
1     1    0,17   0,07   0,43 x  10,34 =    5,56
2     .      1    0,21   0,13 x  -1,47 =   -2,20
3     .      .      1    0,78 x   3,24 =   -5,37
4     .      .      .      1  x -10,99 =  -10,99
```

```
XX(1)=   10,34
XX(2)=   -1,47
XX(3)=    3,24
XX(4)=  -10,99    CROUT  NMD= 36
```

Example.   N=5 equationsU,   EX5

See page 34 of Displacement/deformation method, the data there are multiplied by 1000 to make input of data easier. After input it looks like shown here below.

```
N= 5
I=1  148  -57   53  -30  -35  9000
I=2  -57  329  -41   54   64  0
I=3   53  -41   47  -35  -42  0
I=4  -30   54  -35  134   46  0
I=5  -35   64  -42   46  406  0
```

```
1 148,00 -57,00  53,00 -30,00 -35,00 x XX(1) = 9000,00
2 -57,00 329,00 -41,00  54,00  64,00 x XX(2) =    0,00
3  53,00 -41,00  47,00 -35,00 -42,00 x XX(3) =    0,00
4 -30,00  54,00 -35,00 134,00  46,00 x XX(4) =    0,00
5 -35,00  64,00 -42,00  46,00 406,00 x XX(5) =    0,00
```

```
1   0,15  -0,06   0,05  -0,03  -0,04 =   9,00
2  -0,06   0,33  -0,04   0,05   0,06 =   0,00
3   0,05  -0,04   0,05  -0,04  -0,04 =   0,00
4  -0,03   0,05  -0,04   0,13   0,05 =   0,00
5  -0,04   0,06  -0,04   0,05   0,41 =   0,00
```

```
1   0,15  -0,06   0,05  -0,03  -0,04 x  104,13 =   9,00
2   0,00   0,31  -0,02   0,04   0,05 x    4,93 =   3,47
3   0,00   0,00   0,03  -0,02  -0,03 x -123,48 =  -2,99
4   0,00   0,00   0,00   0,10   0,01 x   -9,73 =  -1,06
5   0,00   0,00   0,00   0,00   0,36 x   -3,47 =  -1,26
```

```
XX(4)=    -9,73
XX(5)=    -3,47    GAUSS  NMD= 75
```

```
1 148,00 -57,00  53,00 -30,00 -35,00 x XX(1) = 9000,00
2 -57,00 329,00 -41,00  54,00  64,00 x XX(2) =    0,00
3  53,00 -41,00  47,00 -35,00 -42,00 x XX(3) =    0,00
4 -30,00  54,00 -35,00 134,00  46,00 x XX(4) =    0,00
5 -35,00  64,00 -42,00  46,00 406,00 x XX(5) =    0,00
```

```
1 148,00    .      .      .      .   x   60,81 = 9000,00
2 -57,00 307,05    .      .      .   x   11,29 =    0,00
3  53,00 -20,59  26,64    .      .   x -112,26 =    0,00
4 -30,00  42,45 -21,41 104,84    .   x  -10,09 =    0,00
5 -35,00  50,52 -26,08  10,96 362,73 x   -3,47 =    0,00
```

```
1     1   -0,39   0,36  -0,20  -0,24 x  104,13 =   60,81
2     .      1   -0,07   0,14   0,16 x    4,93 =   11,29
3     .      .      1   -0,80  -0,98 x -123,48 = -112,26
4     .      .      .      1    0,10 x   -9,73 =  -10,09
5     .      .      .      .      1  x   -3,47 =   -3,47
```

```
XX(1)=   104,13
XX(2)=     4,93
XX(3)=  -123,48
XX(4)=    -9,73
XX(5)=    -3,47    CROUT  NMD= 65
```

1	9,14	-3,08	-0,10	-9,12	3,08	0,00	x	XX(1)	=	0,46
2	-3,08	13,54	0,08	3,08	-1,06	0,00	x	XX(2)	=	5,80
3	-0,10	0,08	1,13	-0,03	-0,08	0,00	x	XX(3)	=	8,60
4	-9,12	3,08	-0,03	18,23	-0,01	-0,06	x	XX(4)	=	-0,48
5	3,08	-1,06	-0,08	-0,01	2,16	0,16	x	XX(5)	=	11,07
6	0,00	0,00	0,00	-0,06	0,16	0,68	x	XX(6)	=	8,27
1	9,14	-3,08	-0,10	-9,12	3,08	0,00	x	-130,30	=	0,46
2	0,00	12,50	0,05	0,01	-0,02	0,00	x	0,80	=	5,96
3	0,00	0,00	1,13	-0,13	-0,05	0,00	x	8,29	=	8,58
4	0,00	0,00	0,00	9,13	3,05	-0,06	x	-65,26	=	0,96
5	0,00	0,00	0,00	0,00	0,09	0,18	x	194,76	=	10,96
6	0,00	0,00	0,00	0,00	0,00	0,32	x	-39,98	=	-12,99

XX(1)= -130,30
XX(2)= 0,80
XX(3)= 8,29
XX(4)= -65,26
XX(5)= 194,76
XX(6)= -39,98 GAUSS NMD= 121

Example. N=6 equationsU, EX6

See page 72 of Displacement/deformation method. Not enough space on the form, moving the right edge to see more.

N=6
I=1,9.142,-3.081,-0.102,-9.115,3.081,0,0.46
like done for this example.

Or, 'shorter' as follows, x 1000,
I=1,9142,-3081,-102,-9115,3081,0,460
Etc.

XX(1)= -130,30
XX(2)= 0,80
XX(3)= 8,29
XX(4)= -65,26
XX(5)= 194,76
XX(6)= -39,98 CROUT NMD= 106

1	9,142	-3,081	-0,102	-9,115	3,081	0		U2X		0,46	4	F21X+F23X
2	-3,081	13,538	0,082	3,081	-1,058	0		U2Y		5,80	5	F21Y+F23Y
3	-0,102	0,082	1,133	-0,028	-0,082	0		UR2	=	8,60	6	M21+M23
4	-9,115	3,081	-0,028	18,234	-0,013	-0,055	·	U3X		-0,48	7	F32X+F34X
5	3,081	-1,058	-0,082	-0,013	2,155	0,163		U3Y		11,07	8	F32Y+F34Y
6	0	0	0	-0,055	0,163	0,677		UR3		8,27	9	M32+M34

(Moved the right vertical line to the right.)

N= 6
I=1 9.142 -3.081 -0.102 -9.115 3.081 0 0.46
I=2 -3.081 13.538 0.082 3.081 -1.058 0 5.80
I=3 -0.102 0.082 1.133 -0.028 -0.082 0 8.60
I=4 -9.115 3.081 -0.028 18.234 -0.013 -0.055 -0.48
I=5 3.081 -1.058 -0.082 -0.013 2.155 0.163 11.07
I=6 0 0 0 -0.055 0.163 0.677 8.27

1	0,83	-0,26	0,00	0,42	0,00	0,00	0,00	x	XX(1)	=	0,00
2	-0,26	9,23	-3,07	-0,21	-9,12	3,07	0,06	x	XX(2)	=	0,05
3	0,00	-3,07	13,58	0,16	3,07	-1,10	0,16	x	XX(3)	=	4,60
4	0,42	-0,21	0,16	1,51	-0,06	-0,16	0,34	x	XX(4)	=	6,11
5	0,00	-9,12	3,07	-0,06	18,23	0,01	-0,06	x	XX(5)	=	0,61
6	0,00	3,07	-1,10	-0,16	0,01	2,16	-0,16	x	XX(6)	=	10,28
7	0,00	-0,06	0,16	0,34	-0,06	-0,16	0,68	x	XX(7)	=	-4,97
1	0,83	-0,26	0,00	0,42	0,00	0,00	0,00	x	-44,02	=	0,00
2	0,00	9,15	-3,07	-0,07	-9,12	3,07	0,06	x	-127,87	=	0,05
3	0,00	0,00	12,55	0,14	0,01	-0,07	0,18	x	0,79	=	4,62
4	0,00	0,00	0,00	1,30	-0,13	-0,14	0,34	x	8,20	=	6,06
5	0,00	0,00	0,00	0,00	9,13	3,06	0,03	x	-64,04	=	1,26
6	0,00	0,00	0,00	0,00	0,00	0,09	-0,16	x	191,22	=	10,51
7	0,00	0,00	0,00	0,00	0,00	0,00	0,31	x	39,60	=	12,18

OK Again Cls

EX1 EX2 EX3 EX4 EX5 EX6 EX7 GAUSS End

PrF STORE NR=? GET CROUT XX(I)

Example. N=7 equations. EX7

See page 77 of Displacement/deformation method. The data of Seven equations to put in, it can be done, easily making a mistake, but after some mistakes the results can be found.
On the left the print after clicking EX7 and GAUSS.

The data of EX7 are written with three decimals, shown/printed with two. See page 77.

XX(1)= -44,02
XX(2)= -127,87
XX(3)= 0,79
XX(4)= 8,20
XX(5)= -64,04
XX(6)= 191,22
XX(7)= 39,60 GAUSS NMD= 182

XX(1)= -44,02
XX(2)= -127,87
XX(3)= 0,79
XX(4)= 8,20
XX(5)= -64,04
XX(6)= 191,22
XX(7)= 39,60 CROUT NMD= 161

AA(1,1(=0.833 : AA(1,2)=-0.26 : AA(1,3)=0
AA(2,1)=-0.26 : AA(2,2)9.228
AA(2,4)=-0.205 : AA(2,-9.117 etc.
Click Again, next EX7 and CROUT, the screen shows the three matrices, but nothing of them shown here,

In both cases click XX(I) giving
GAUSS NMD= 182 and CROUT NMD= 141.