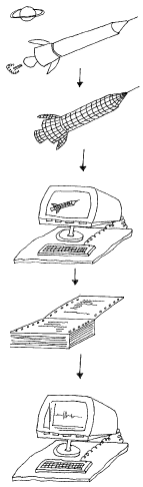
The Finite Element Process



A REAL STRUCTURE ...

A DISCRETIZED MATHEMATICAL MODEL containing finite elements, loads, constraints, and structural properties ...

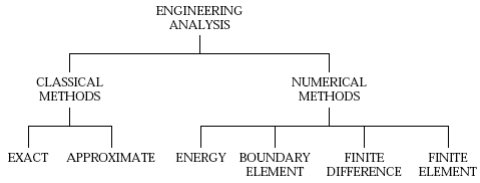
YOUR COMPUTER, MSC.Nastran, and a few million calculations ...

DISPLACEMENTS, STRESSES, FORCES, MODE SHAPES ... Whatever you asked for and designed the model to calculate.

VISUALIZATION OF RESULTS

1. Problem Description
2. Model Creation/Model Reduction
   - Geometry Simplification

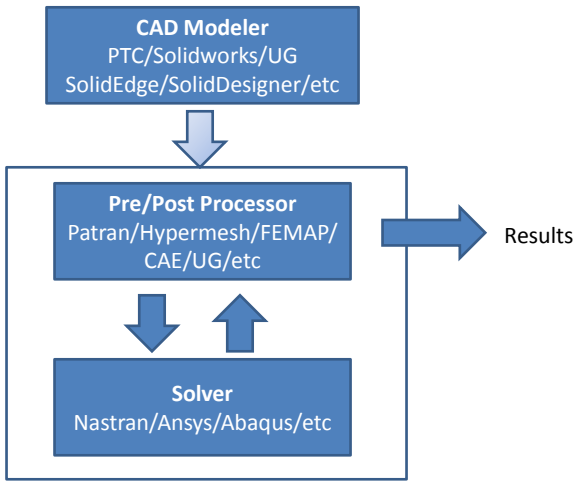
   80%
3. FE Model Creation
4. Solution
5. Interpretation of results
6. Report/Presentation of results



Modeling Process

C:\Student.temp>patran

C:\Student.temp>nastran



NASTRAN Solution Sequences

SOL Number	SOL Name	Description
101	SESTATIC	Statics with options: Linear Heat Transfer Alternate Reduction Inertia Relief Design Sensitivity - Statics
103	SEMODES	Normal Modes with option: Design Sensitivity - Modes
105	SEBUCKL	Buckling with options: Static Analysis Design Sensitivity - Buckling
106	NLSTATIC	Nonlinear Statics
107	SEDCEIG	Direct Complex Eigenvalues
108	SEDFREQ	Direct Frequency Response
109	SEDTRAN	Direct Transient Response
110	SEMCEIG	Modal Complex Eigenvalues
111	SEMFREQ	Modal Frequency Response
112	SEMTRAN	Modal Transient Response
114	CYCSTATX	Cyclic Statics with Option: Alternate Reduction
115	CYCMODE	Cyclic Normal Modes
116	CYCBUCKL	Cyclic Buckling
118	CYCFREQ	Cyclic Direct Frequency Response
129	NLTRAN	Nonlinear Transient Response
144	AESTAT	Static Aeroelastic Response
145	SEFLUTTR	Aerodynamic Flutter
146	SEAERO	Aeroelastic Response
153	NLSCSH	Steady Nonlinear Heat Transfer
159	NLTCSH	Transient Nonlinear Heat Transfer
190	DBTRANS	Database Transfer
200	DESOPT	Design Optimization

Typical Descritization

- Point Element (not a finite element, but can be included in the finite element model)

CMASS1 (Scalar mass connection)
CONM1 (Concentrated mass)

- Spring Elements (they behave like simple extensional or rotational springs)

CELAS2

- Line Elements (they behave like rods, bars, or beams)

CROD, CBAR, CBEAM

- Surface Elements (they behave like membranes or thin plates)

CTRIA3

CQUAD4

- Solid Elements (they behave like bricks or thick plates)

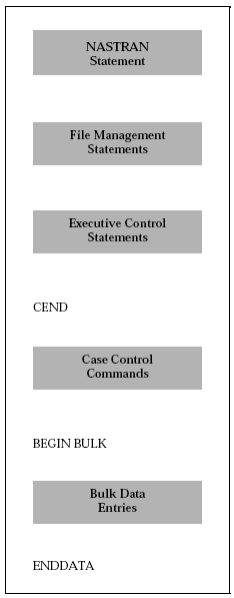
CHEXA

CPENTA

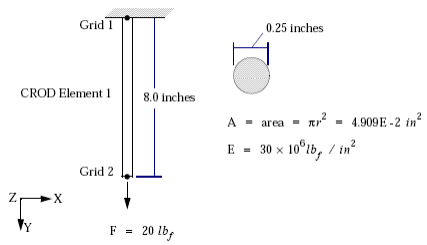
CTETRA

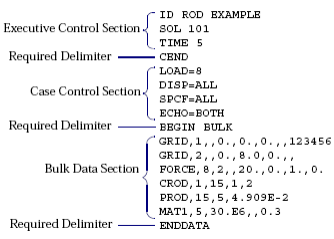
- Rigid Bar (infinitely stiff without causing numerical difficulties in the mathematical model)

Structure of NASTRAN File



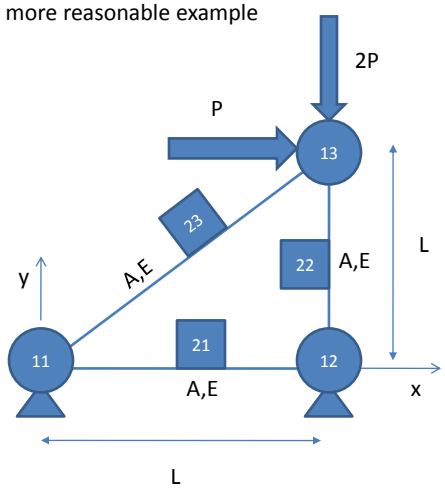
Optional
Optional
Required Section
Required Delimiter
Required Section
Required
Required Section
Required





Flat Text or ASCII File: Notepad, Wordpad, PFE

A more reasonable example

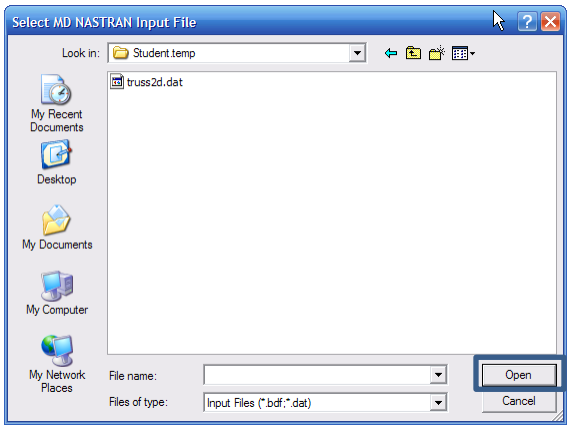


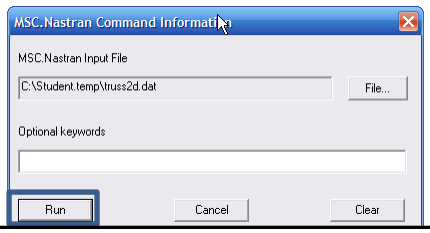
Simple 2D Truss System
Pinned Joints – No Moments

$A = 1\ in^2$
$E = 10^7\ psi$
$L = 100\ in$
$P = 100\#$

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

OR Start->programs->MSC.Software->MD Nastran->MD R2 Nastran





Working Directory: C:\Student.temp

Shared Directory:

- It is OK to delete all files in that directory before working
- Make sure you copy files

Files Created:

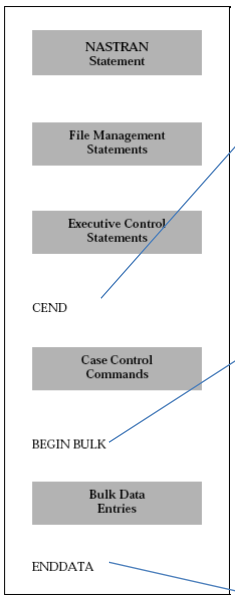
Name	Size	Type
truss2d.dat	1 KB	DAT File
truss2d.f04	34 KB	F04 File
truss2d.f06	30 KB	F06 File
truss2d.log	5 KB	Text Document

truss2d.

DBALL	Contains permanent data for database runs.
f04	Contains database file information and a module execution summary.
f06	Contains the MSC.Nastran analysis results.
LOG	Contains system information and system error messages.
MASTER	The master directory for database runs.

xdb file will be necessary for PATRAN to post

Structure of NASTRAN File




```
$        2d Truss Problem
time 2                          $ Set internal CPU limit in seconds
sol 101                         $ Linear Static Analysis
cend                            $ ** Required **
title=example 2d truss
subtitle=linear statics         $
spc=100                         $ Turn on BC Set 100 above subcase level
disp=all                        $ Output displacements of all grid points
spcforces=all                   $ Output reactions at BC
subcase 1
  label=first load set
  load=501                      $ Turn on load set 501
  forces=all                    $ Output Forces in all elements
  stress=all                    $ Output Stresses in all elements
subcase 2
  label=second load set
  load=502                      $ Turn on load set 502
begin bulk                      $ Required with blank
grid,11,,0.,0.                  $ Define points in space
grid,12,,100.,0.                $ Free format with commas
grid,13,,100.,100.              $ Integer=no decimal point, real=decimal point
crod,21,20,11,12                $ Element connections to grids and property
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.                   $ Element properties = material id # and area
mat1,40,1+7,,0.3,2.6-4          $ Material properties: E,G,nu,rho
,2000.,2000.                    $ Stress limits in compression and tension
spc1,100,12,11,12               $ Boundary conditions on grids
force,501,13,,200.,0.,-1.       $ Applied loads on grids = magnitude and direction
force,501,13,,100.,1.           $ 501 = first load set
force,502,13,,200.,1.           $ 502 = second load set
param,grdpnt,0                  $ request mass property data
param,post,0                    $ create output file that can be "posted"
param,prtmaxim,yes              $ print max of  some results
enddata                         $ end delimiter (no blanks)
```

Consistent units

Quantity	English	SI
Input:		
Grid Point Geometry	inch	meter
Elastic Modulus	$lb_f/inch^2$	Newton/$meter^2$
Applied Moment	inch-lb_f	Newton-meter
Applied Force	lb_f	Newton
Mass	lb_f-sec^2/inch	Kilogram
Time	second	second
Output:		
Displacements	inch	meter
Stresses	$lb_f/inch^2$	Newton/$meter^2$

Note:
mm is not a fundamental SI unit

$$1\,N = 1\,kg\cdot\frac{m}{s^2} \qquad 1\,Pa = 1\,\frac{N}{m^2}$$

$$mm = 1\times10^{-3}\,m$$

$$mN \equiv \frac{N}{1000}$$

$$mN = 1\,kg\cdot\frac{mm}{s^2}$$

$$1\,\frac{mN}{mm^2} = 1\times10^{3}\,Pa \qquad 1\,kPa = 1\,\frac{mN}{mm^2}$$

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

TIME Sets maximum CPU and I/O time

Sets the maximum CPU and I/O time.

Format:

TIME[=]t1[,t2]

Describer	Meaning
t1	Maximum allowable execution time in CPU minutes. (Real or Integer>0; Default=1.89E9 seconds)
t2	Maximum allowable I/O limit in minutes. (Real or Integer>0; Default is infinity, which is machine dependent.)

Remarks:

1. The TIME statement is optional.
2. If t2 is specified then t1 must be specified.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

SOL Executes a Solution Sequence

Specifies the solution sequence or main subDMAP to be executed.

Format:

SOL { n / subDMAP-name } [SOLIN = obj-DBset NOEXE]

Describer	Meaning
n	Solution number. See Remark 6. for the list of valid numbers. (Integer>0)

SOL Number	SOL Name	Description
101	SESTATIC	Statics with options: Linear Heat Transfer Alternate Reduction Inertia Relief Design Sensitivity - Statics
103	SEMODES	Normal Modes with option: Design Sensitivity - Modes
105	SEBUCKL	Buckling with options: Static Analysis Design Sensitivity - Buckling
106	NLSTATIC	Nonlinear Statics
107	SEDCEIG	Direct Complex Eigenvalues
108	SEDFREQ	Direct Frequency Response
109	SEDTRAN	Direct Transient Response
110	SEMCEIG	Modal Complex Eigenvalues
111	SEMFREQ	Modal Frequency Response
112	SEMTRAN	Modal Transient Response
114	CYCSTATX	Cyclic Statics with Option: Alternate Reduction
115	CYCMODE	Cyclic Normal Modes
116	CYCBUCKL	Cyclic Buckling

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

CEND End of Executive Control Delimiter

Designates the end of the Executive Control Section.

Format:

CEND

Remark:

1. CEND is an optional statement. If CEND is not specified, then the program will automatically insert one.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

TITLE Output Title

Defines a character string that will appear on the first heading line of each page of MSC Nastran printer output.

Format:

TITLE=title

Example:

TITLE=RIGHT WING, LOAD CASE 3.

Describer	Meaning
title	Any character string.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

SUBTITLE Output Subtitle

Defines a subtitle that will appear on the second heading line of each page of printer output.

Format:

SUBTITLE=subtitle

Example:

SUBTITLE=PROBLEM NO. 5-1A

Describer	Meaning
subtitle	Any character string.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

SPC Single-Point Constraint Set Selection

Selects a single-point constraint set to be applied.

Format:

SPC=n

Example:

SPC=10

Describer	Meaning
n	Set identification number of a single-point constraint that appears on a SPC, SPC1, or SPCADD Bulk Data entry. (Integer>0)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

DISPLACEMENT Displacement Output Request

Requests the form and type of displacement or pressure vector output. Note: PRESSURE and VECTOR are equivalent commands.

Format:

DISPLACEMENT [(SORT1 or SORT2), [PRINT, PUNCH or PLOT], [REAL or IMAG or PHASE], [PSDF, ATOC, CRMS or RALL], [RPRINT or NORPRINT, RPUNCH], CID, [TM = f or T1 = f, T2 = f, T3 = f], [RM = f or R1 = f, R2 = f, R3 = f], [CONNECTOR = [ALL or m]]] = { ALL / n / NONE }

Examples:

DISPLACEMENT=5
DISPLACEMENTS(REAL)=ALL

Describer	Meaning
SORT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the solution sequence.
SORT2	Output will be presented as a tabular listing of load, frequency or time for each grid point.
PRINT	The printer will be the output medium.
PUNCH	The punch file will be the output medium.
PLOT	Generates, but does not print, displacement data.
REAL or IMAG	Requests rectangular format (real and imaginary) of complex output. Use of either REAL or IMAG yields the same output.
ALL	Displacements for all points will be output.
n	Set identification of a previously appearing SET command. Only displacements of points with identification numbers that appear on this SET command will be output. (Integer>0)
NONE	Displacement for no points will be output.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

SPCFORCES Single-Point Forces of Constraint Output Request

Requests the form and type of single-point force of constraint vector output.

Format:

PFORCES [(SORT1 / SORT2) , [PRINT, PUNCH / PLOT] , [REAL or NOZPRINT / PHASE] [PSDF, ATOC, CRMS / or RALL] , [RPRINT / NORPRINT , RPUNCH] , (CID)] = { ALL / n / NONE }

Examples:

SPCFORCES = 5
SPCFORCES(SORT2, PUNCH, PRINT, IMAG) = ALL
SPCFORCES(PHASE) = NONE
SPCFORCES(SORT2, PRINT, PSDF, CRMS, RPUNCH)=20
SPCFORCES(PRINT, RALL, NORPRINT)=ALL

Describer	Meaning
SORT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the solution sequence.
SORT2	Output will be presented as a tabular listing of frequency or time for each grid point.
PRINT	The printer will be the output medium.
PUNCH	The punch file will be the output medium.
CID	Request to print output coordinate system ID in printed output file, F06 file.
ALL	Single-point forces of constraint for all points will be output. See Remarks 2. and 5.
NONE	Single-point forces of constraint for no points will be output.
n	Set identification of a previously appearing SET command. Only single-point forces constraint for points with identification numbers that appear on this SET command will be output. (Integer>0)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

SUBCASE Subcase Delimiter

Delimits and identifies a subcase.

Format:

SUBCASE=n

Example:

SUBCASE=101

Describer	Meaning
n	Subcase identification number. (Integer>0)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

LABEL Output Label

Defines a character string that will appear on the third heading line of each page of printer output.

Format:

LABEL=label

Example:

LABEL=DEMONSTRATION PROBLEM

Describer	Meaning
label	Any character string.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

LOAD External Static Load Set Selection

Selects an external static load set.

Format:

LOAD=n

Example:

LOAD=15

Describer	Meaning
n	Set identification of at least one external load Bulk Data entry. The set identification must appear on at least one FORCE, FORCE1, FORCE2, FORCEAX, GRAV, MOMAX, MOMENT, MOMENT1, MOMENT2, LOAD, PLOAD, PLOAD1, PLOAD2, PLOAD4, PLOADX, QVOL, QVECT, QHBDY, QBDY1, QBDY2, QBDY3, PRESAX, RFORCE, SPCD, or SLOAD entry. (Integer>0)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

FORCE — Element Force Output or Particle Velocity Request

Requests the form and type of element force output or particle velocity output in coupled fluid-structural analysis. Note: ELFORCE is an equivalent command.

Format:

FORCE ([SORT1 / SORT2], [PRINT, PUNCH / PLOT], [REAL or IMAG / PHASE], [CENTER / CORNER or BILIN / SGAGE / CUBIC], [PSDF, ATOC, CRMS or RALL], [RPRINT / NORPRINT, RPUNCH]) = { ALL / n / NONE }

Examples:

FORCE=ALL
FORCE(REAL, PUNCH, PRINT)=17
FORCE=25
FORCE(SORT2, PRINT, PSDF, CRMS, RPUNCH)=20
FORCE(PRINT, RALL, NORPRINT)=ALL

Describer	Meaning
SORT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the solution sequence.
SORT2	Output will be presented as a tabular listing of frequency or time for each element type.
PLOT	Generates force output for requested set but no printed output.
ALL	Forces for all elements will be output.
n	Set identification of a previously appearing SET command. Only forces of elements with identification numbers that appear on this SET command will be output. (Integer>0)
NONE	Forces for no elements will be output.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

STRESS — Element Stress Output Request

Requests the form and type of element stress output. Note: ELSTRESS is an equivalent command.

Format:

STRESS ([SORT1 / SORT2], [PRINT, PUNCH / PLOT], [REAL or IMAG / PHASE], [VONMISES / MAXS or SHEAR], [CENTER / CUBIC / SGAGE / CORNER or BILIN], [PSDF, ATOC, CRMS or RALL], [RPRINT / NORPRINT, RPUNCH]) = { ALL / n / NONE }

Examples:

STRESS=5
STRESS(CORNER)=ALL
STRESS (SORT1,PRINT,PUNCH,PHASE)=15
STRESS(PLOT)=ALL
STRESS(PRINT, PSDF, CRMS, RPUNCH)=20
STRESS(PRINT, RALL, NORPRINT)=ALL

Describer	Meaning
SORT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the solution sequence.
SORT2	Output will be presented as a tabular listing of frequency or time for each element type.
PRINT	The printer will be the output medium.
PUNCH	The punch file will be the output medium.
PLOT	Generates stresses for requested set but no printer output.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET command. Only stresses for elements with identification numbers that appear on this SET command will be output. (Integer>0)
NONE	No element stress will be output.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

BEGIN BULK Case Control and Bulk Data Delimiter

Designates the end of the Case Control Section and/or the beginning of a Bulk Data Section.

Format:

BEGIN [BULK] [AUXMODEL = auxmid / SUPER = seid]

Examples:

BEGIN BULK
BEGIN AUXMODEL=22

Describer	Meaning
AUXMODEL	Indicates the beginning of an auxiliary model Bulk Data Section.
auxmid	Auxiliary model identification number. (Integer > 0)
SUPER	Indicates the beginning of partitioned superelement Bulk Data Section.
seid	Superelement identification number. (Integer ≥ 0)

Remarks:

1. BEGIN BULK is not required. If not specified, then the program will automatically insert one.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

Note Must

Format of Bulk Data Entries

Real, Integer, and Character Input Data

MSC Nastran is quite particular about the input requirements for data entry. The three possible types of data entries are Integer, Real, and Character (sometimes called literal, or BCD-binary coded decimal). The three types of data are described as follows:

Integer	Cannot contain a decimal point.
Real	Must contain a decimal point.
Character	Can be alphanumeric, but must always start with an alpha character and be 8 characters or less in length.

Real numbers may be entered in a variety of ways. For example, the following are all acceptable versions of the real number seven:

7.0 .7E1 0.7+1
.70+1 7.E+0 70.-1

Free, Small, and Large Field Formats

MSC Nastran has three different field formats for input data:

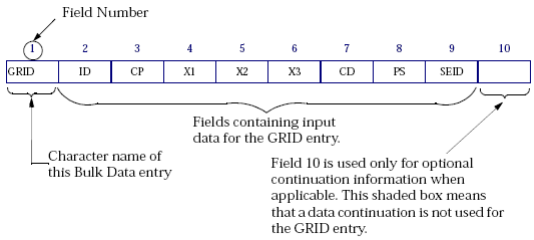
Free Field Format	Input data fields are separated by commas.
Small Field Format	Ten fields of eight characters each.
Large Field Format	Ten fields-fields containing actual data are sixteen characters each. Large fields are used when greater numerical accuracy is required.

The NASTRAN statement, File Management Section, Executive Control Section, and Case Control Section use free field format. The Bulk Data Section allows the use of any of the three formats.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

MSC Nastran Bulk Data contains ten fields per input data entry. The first field contains the character name of the Bulk Data item (e.g., GRID, CBAR, MAT1, etc.). Fields two through nine contain data input information for the Bulk Data entry. The tenth field never contains data-it is reserved for entry continuation information, if applicable.

Consider the format of a typical MSC Nastran Bulk Data entry, the GRID entry, which is used in MSC Nastran to describe the geometry of the structural model.



Example:

1	2	3	4	5	6	7	8	9	10
GRID	2		1.0	-2.0	3.0		136		

We will now represent this example in free field, small field, and large field formats.

Free Field Format

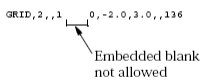
In free field format, data fields are separated by commas or blanks (commas are strongly recommended). The following shows the GRID Bulk Data entry example in free field format:

Grid,2,,1.0,-2.0,3.0,,136


```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```


The rules for free field format are as follows:

- Free field data entries must start in column 1.
- To skip one field, use two commas in succession. To skip two fields, use three commas in succession (and so on).
- Integer or character fields with more than eight characters cause a fatal error.
- Real numbers with more than eight characters are rounded off and lose some precision. For example, an entry of 1.2345678+2 becomes 123.4568. If more significant digits are needed, use the large field format.
- Free field data cannot contain embedded blanks. An example of a free field embedded blank is shown:

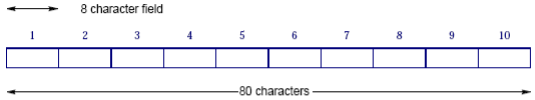


- A dollar sign terminates the entry and comments may follow.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

Small Field Format

Small field format separates a Bulk Data entry into ten equal fields of eight characters each:

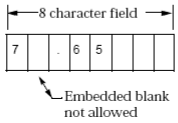


The following is an example of the GRID entry in small field format:

1	2	3	4	5	6	7	8	9	10
GRID	2		1.0	-2.0	3.0		136		

The rules for small field format are as follows:

- Fields 1 and 10 must be left justified.
- Fields 2 through 9 do not need to be either right or left justified, although aligning the data fields is good practice.
- Small field input data cannot contain any embedded blanks. An example of a small field embedded blank is shown below:




```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

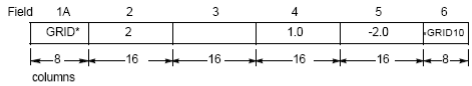
Large Field Format

A high degree of numerical accuracy is required in some MSC Nastran applications. Large field format is used when small field format does not provide enough significant digits (recall that a minus sign, decimal point, and the "E" in scientific notation count as characters).

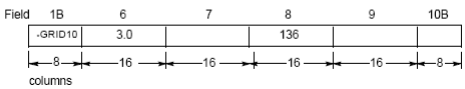
Large field format requires (at least) two lines for each entry: the first and last field of each line contains eight columns, and the fields in between contain 16 columns. Short field becomes two lines. Large field entries are denoted by an asterisk (*) immediately following the character string in field 1A of the first line and immediately preceding the character string in field 1B of the second line.

The following is an example of the GRID Bulk Data entry example in large field format:

First Line: (Left half of single field)



Second Line: (Right half of single field)



```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

Large Field Format

Continuations

Some Bulk Data entries require more than eight fields (72 columns) of data. Continuations are required in such cases. To do this, a parent entry (the first line) is followed by one or more continuation entries on subsequent lines. For example, consider the following PBAR simple beam property entry (do not worry about what each field represents-this will be explained later):

Format:

1	2	3	4	5	6	7	8	9	10
PBAR	PID	MID	A	I1	I2	J	NSM		
	C1	C2	D1	D2	E1	E2	F1	F2	
	K1	K2	I12						

Continuation Example:

PBAR	39	6	2.9	1.86	2.92	.48			+PB1
+PB1	0.	0.	0.	1.	1.	1.	1.	0.	+PB2
+PB2	.86	.86							


```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```


GRID Grid Point

Defines the location of a geometric grid point, the directions of its displacement, and its permanent single-point constraints.

Format:

1	2	3	4	5	6	7	8	9	10
GRID	ID	CP	X1	X2	X3	CD	PS	SEID	

Example:

GRID	2	3	1.0	-2.0	3.0		316		

Field	Contents
ID	Grid point identification number. (0 < Integer < 100000000)
CP	Identification number of coordinate system in which the location of the grid point is defined. (Integer ≥ 0 or blank*)
X1, X2, X3	Location of the grid point in coordinate system CP. (Real; Default = 0.0)
CD	Identification number of coordinate system in which the displacements, degrees-of-freedom, constraints, and solution vectors are defined at the grid point. (Integer ≥ -1 or blank)*
PS	Permanent single-point constraints associated with the grid point. (Any of the Integers 1 through 6 with no embedded blanks, or blank*.)
SEID	Superelement identification number. (Integer ≥ 0; Default = 0)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

CROD Rod Element Connection

Defines a tension-compression-torsion element.

Format:

1	2	3	4	5	6	7	8	9	10
CROD	EID	PID	G1	G2					

Example:

CROD	12	13	21	23					

Field	Contents
EID	Element identification number. (Integer > 0)
PID	Property identification number of a PROD entry. (Integer > 0; Default = EID)
G1, G2	Grid point identification numbers of connection points. (Integer > 0;

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

PROD Rod Property

Defines the properties of a rod element (CROD entry).

Format:

1	2	3	4	5	6	7	8	9	10
PROD	PID	MID	A	J	C	NSM			

Example:

PROD	17	23	42.6	17.92	4.2356	0.5			

Field	Contents
PID	Property identification number. (Integer > 0)
MID	Material identification number. See Remarks 2. and 3. (Integer > 0)
A	Area of the rod. (Real)
J	Torsional constant. (Real)
C	Coefficient to determine torsional stress. (Real; Default = 0.0)
NSM	Nonstructural mass per unit length. (Real)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

MAT1 Isotropic Material Property Definition

Defines the material properties for linear isotropic materials.

Format:

1	2	3	4	5	6	7	8	9	10
MAT1	MID	E	G	NU	RHO	A	TREF	GE	
	ST	SC	SS	MCSID					

Example:

MAT1	17	3.+7		0.33	4.28	6.5-6	5.37+2	0.23	
	20.+4	15.+4	12.+4	1003					

Field	Contents
MID	Material identification number. (Integer > 0)
E	Young's modulus. (Real ≥ 0.0 or blank)
G	Shear modulus. (Real ≥ 0.0 or blank)
NU	Poisson's ratio. (-1.0 < Real ≤ 0.5 or blank)
RHO	Mass density. See Remark 5. (Real)
A	Thermal expansion coefficient. (Real)
TREF	Reference temperature for the calculation of thermal loads, or a temperature-dependent thermal expansion coefficient. See Remarks 9. and 10. (Real; Default = 0.0 if A is specified.)
GE	Structural element damping coefficient. See Remarks 8., 9., and 4. (Real)
ST, SC, SS	Stress limits for tension, compression, and shear are optionally supplied, used only to compute margins of safety in certain elements; and have no effect on the computational procedures. See "Beam Element (CBEAM)" in Chapter 3 in the *MSC Nastran Reference Manual*. (Real ≥ 0.0 or blank)
MCSID	Material coordinate system identification number. Used only for PARAM,CURV processing. See "Parameters" on page 645.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

SPC1 Single-Point Constraint, Alternate Form

Defines a set of single-point constraints.

Format:

1	2	3	4	5	6	7	8	9	10
SPC1	SID	C	G1	G2	G3	G4	G5	G6	
	G7	G8	G9	-etc.-					

Example:

SPC1	3	2	1	3	10	9	6	5	
	2	8							

Alternate Format and Example:

SPC1	SID	C	G1	"THRU"	G2				
SPC1	313	12456	6	THRU	32				

Field	Contents
SID	Identification number of single-point constraint set. (Integer > 0)
C	Component numbers. (Any unique combination of the Integers 1 through 6 with no embedded blanks for grid points. This number must be Integer 0 or blank for scalar points.)
G1	Grid or scalar point identification numbers. (Integer > 0 or "THRU"; For "THRU" option, G1 < G2.)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

FORCE Static Force

Defines a static concentrated force at a grid point by specifying a vector.

Format:

1	2	3	4	5	6	7	8	9	10
FORCE	SID	G	CID	F	N1	N2	N3		

Example:

FORCE	2	5	6	2.9	0.0	1.0	0.0		

Field	Contents
SID	Load set identification number. (Integer > 0)
G	Grid point identification number. (Integer > 0)
CID	Coordinate system identification number. (Integer ≥ 0; Default = 0)
F	Scale factor. (Real)
Ni	Components of a vector measured in coordinate system defined by CID. (Real; at least one Ni ≠ 0.0. unless F is zero)

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

PARAM Parameter

Specifies values for parameters used in solution sequences or user-written DMAP programs.

Format:

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						

Example:

PARAM	IRES	1							

Field	Contents
N	Parameter name (one to eight alphanumeric characters, the first of which is alphabetic).
V1, V2	Parameter value based on parameter type, as follows:

Type	V1	V2
Integer	Integer	Blank
Real, single-precision	Real	Blank
Character	Character	Blank
Real, double-precision	Double-precision real	Blank
Complex, single-precision	Real or blank	Real or blank
Complex, double-precision	Double-precision real	Double-precision real

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

PARAM Parameter

Specifies values for parameters used in solution sequences or user-written DMAP programs.

Format:

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						

Example:

PARAM	IRES	1							

Field	Contents
N	Parameter name (one to eight alphanumeric characters, the first of which is alphabetic).
V1, V2	Parameter value based on parameter type, as follows:

GRDPNT Default = -1

GRDPNT>-1 will cause the grid point weight generator to be executed. The default value (GRDPNT=-1) suppresses the computation and output of this data. GRDPNT specifies the identification number of the grid point to be used as a reference point. If GRDPNT=0 or is not a defined grid point, the reference point is taken as the origin of the basic coordinate system. All fluid-related masses and masses on scalar points are ignored. The following weight and balance information is automatically printed following the execution of the grid point weight generator.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

PARAM Parameter

Specifies values for parameters used in solution sequences or user-written DMAP programs.

Format:

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						

Example:

PARAM	IRES	1							

Field	Contents
N	Parameter name (one to eight alphanumeric characters, the first of which is alphabetic).
V1, V2	Parameter value based on parameter type, as follows:

POST Default = 1

If PARAM,POST,0, then the following parameters and discussion apply:

The data blocks often used for pre- and postprocessing will be stored in the database and also converted, by the DBC module (see *MSC Nastran DMAP Programmer's Guide*), to a format suitable for processing by MSC.Patran, MSC/XL and MSC.Aries. These data blocks include input data related to geometry, connectivity, element and material properties, and static loads; they also include output data requested through the Case Control commands OLOAD, SPCF, DISP, VELO, ACCE, THERMAL, ELSTRESS, ELFORCE, FLUX, GPSTRESS, GPFORCE, ESE, GPSDCON, and ELSDCON.

```
time 2
sol 101
cend
title=example 2d truss
subtitle=linear statics
spc=100
disp=all
spcforces=all
subcase 1
  label=first load set
  load=501
  forces=all
  stress=all
subcase 2
  label=second load set
  load=502
begin bulk
grid,11,,0.,0.
grid,12,,100.,0.
grid,13,,100.,100.
crod,21,20,11,12
crod,22,20,12,13
crod,23,20,11,13
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,12
force,501,13,,200.,0.,-1.
force,501,13,,100.,1.
force,502,13,,200.,1.
param,grdpnt,0
param,post,0
param,prtmaxim,yes
enddata
```

PARAM Parameter

Specifies values for parameters used in solution sequences or user-written DMAP programs.

Format:

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						

Example:

PARAM	IRES	1							

Field	Contents
N	Parameter name (one to eight alphanumeric characters, the first of which is alphabetic).
V1, V2	Parameter value based on parameter type, as follows:

PRTMAXIM Default = NO

PRTMAXIM controls the printout of the maximums of applied loads, single-point forces of constraint, multipoint forces of constraint, and displacements. The printouts are titled "MAXIMUM APPLIED LOADS", "MAXIMUM SPCFORCES", "MAXIMUM MPCFORCES", and "MAXIMUM DISPLACEMENTS".

ENDDATA Bulk Data Delimiter

Designates the end of the Bulk Data Section.

Format:

ENDDATA

Remark:

1. ENDDATA is optional.

```
1                                                                          AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE     2

0       N A S T R A N    E X E C U T I V E    C O N T R O L    E C H O
0


     TIME 2                        $ SET INTERNAL CPU LIMIT IN SECONDS
     SOL 101                       $ LINEAR STATIC ANALYSIS
     CEND                          $ ** REQUIRED **
1    EXAMPLE 2D TRUSS                                                      AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE     3
      LINEAR STATICS         $
0
0                                    C A S E    C O N T R O L    E C H O
                 COMMAND
                 COUNT
                   1       TITLE=EXAMPLE 2D TRUSS
                   2       SUBTITLE=LINEAR STATICS          $
                   3       SPC=100                          $ TURN ON BC SET 100 ABOVE SUBCASE LEVEL
                   4       DISP=ALL                         $ OUTPUT DISPLACEMENTS OF ALL GRID POINT        S
                   5       SPCFORCES=ALL                    $ OUTPUT REACTIONS AT BC
                   6       SUBCASE 1
                   7         LABEL=FIRST LOAD SET
                   8         LOAD=501                       $ TURN ON LOAD SET 501
                   9         FORCES=ALL                     $ OUTPUT FORCES IN ALL ELEMENTS
                  10         STRESS=ALL                     $ OUTPUT STRESSES IN ALL ELEMENTS
                  11       SUBCASE 2
                  12         LABEL=SECOND LOAD SET
                  13         LOAD=502                       $ TURN ON LOAD SET 502
                  14       BEGIN BULK                       $ REQUIED WITH BLANK
0                            INPUT BULK DATA ENTRY COUNT =      16
1    EXAMPLE 2D TRUSS                                                      AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE     4
      LINEAR STATICS         $
0
0                                       S O R T E D    B U L K    D A T A    E C H O
                 ENTRY
                 COUNT        .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  .. 10  .
                   1-        CROD    21      20      11      12
                   2-        CROD    22      20      12      13
                   3-        CROD    23      20      11      13
                   4-        FORCE   501     13              200.    0.      -1.
                   5-        FORCE   501     13              100.    1.
                   6-        FORCE   502     13              200.    1.
                   7-        GRID    11              0.      0.
                   8-        GRID    12              100.    0.
                   9-        GRID    13              100.    100.
                  10-        MAT1    40      1+7             0.3     2.6-4                           +000001
                  11-        ++000001 2000.  2000.                                                   +000002
                  12-        PARAM   GRDPNT  0
                  13-        PARAM   POST    0
                  14-        PROD    20      40      1.
                  15-        SPC1    100     12      11      12
                             ENDDATA
0                       TOTAL COUNT=        16


                                        M O D E L    S U M M A R Y

                                     NUMBER OF GRID     POINTS   =        3

                                     NUMBER OF CROD     ELEMENTS =        3
```

Bulk Echo: Note Card Format

```
1    EXAMPLE 2D TRUSS                                                      AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE     5
      LINEAR STATICS         $
0
                          O U T P U T    F R O M    G R I D    P O I N T    W E I G H T    G E N E R A T O R
0                                                 REFERENCE POINT =        0
                                                              M O
                        *  8.876956E-02  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00 -3.138478E+00 *
                        *  0.000000E+00  8.876956E-02  0.000000E+00  0.000000E+00  0.000000E+00  5.738478E+00 *
                        *  0.000000E+00  0.000000E+00  8.876956E-02  3.138478E+00 -5.738478E+00  0.000000E+00 *
                        *  0.000000E+00  0.000000E+00  3.138478E+00  3.138478E+02 -3.138478E+02  0.000000E+00 *
                        *  0.000000E+00  0.000000E+00 -5.738478E+00 -3.138478E+02  5.738478E+02  0.000000E+00 *
                        * -3.138478E+00  5.738478E+00  0.000000E+00  0.000000E+00  0.000000E+00  8.876956E+02 *
                                                                S

                                        *  1.000000E+00  0.000000E+00  0.000000E+00 *
                                        *  0.000000E+00  1.000000E+00  0.000000E+00 *
                                        *  0.000000E+00  0.000000E+00  1.000000E+00 *
                                DIRECTION
                           MASS AXIS SYSTEM (S)     MASS              X-C.G.          Y-C.G.          Z-C.G.
                                  X             8.876956E-02      0.000000E+00  3.535534E+01  0.000000E+00
                                  Y             8.876956E-02      6.464466E+01  0.000000E+00  0.000000E+00
                                  Z             8.876956E-02      6.464466E+01  3.535534E+01  0.000000E+00
                                                          I(S)
                                        *  2.028858E+02  1.109619E+02  0.000000E+00 *
                                        *  1.109619E+02  2.028858E+02  0.000000E+00 *
                                        *  0.000000E+00  0.000000E+00  4.057716E+02 *
                                                          I(Q)
                                        *  3.138478E+02                             *
                                        *                9.192388E+01               *
                                        *                             4.057716E+02 *
                                                                Q
                                        *  7.071068E-01  7.071068E-01  0.000000E+00 *
                                        * -7.071068E-01  7.071068E-01  0.000000E+00 *
                                        *  0.000000E+00  0.000000E+00  1.000000E+00 *

1    EXAMPLE 2D TRUSS                                                      AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE     6
      LINEAR STATICS         $
0
1    EXAMPLE 2D TRUSS                                                      AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE     7
      LINEAR STATICS         $
0
0 RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.

0                                              OLOAD    RESULTANT
   SUBCASE/    LOAD
   DAREA ID    TYPE       T1            T2            T3            R1            R2            R3
0        1      FX    1.000000E+02      ----          ----          ----      0.000000E+00 -1.000000E+04
                FY        ----      -2.000000E+02     ----      0.000000E+00      ----      -2.000000E+04
                FZ        ----          ----      0.000000E+00  0.000000E+00  0.000000E+00      ----
                MX        ----          ----          ----      0.000000E+00      ----          ----
                MY        ----          ----          ----          ----      0.000000E+00      ----
                MZ        ----          ----          ----          ----          ----      0.000000E+00
              TOTALS  1.000000E+02 -2.000000E+02  0.000000E+00  0.000000E+00  0.000000E+00 -3.000000E+04
0        2      FX    2.000000E+02      ----          ----          ----      0.000000E+00 -2.000000E+04
                FY        ----      0.000000E+00      ----      0.000000E+00      ----      0.000000E+00
                FZ        ----          ----      0.000000E+00  0.000000E+00  0.000000E+00      ----
                MX        ----          ----          ----      0.000000E+00      ----          ----
                MY        ----          ----          ----          ----      0.000000E+00      ----
                MZ        ----          ----          ----          ----          ----      0.000000E+00
              TOTALS  2.000000E+02  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00 -2.000000E+04
```

6x6 mass matrix

S=Transformation to Principal Mass

CG

I about S

I about Q

Q=Transformation to Principal Inertia

```
1   EXAMPLE 2D TRUSS                                                    AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07
PAGE      8
     LINEAR STATICS          $
0    FIRST LOAD SET                                                                                    SUBCASE
1
0                                        G R I D   P O I N T   S I N G U L A R I T Y   T A B L E
0                                 POINT    TYPE   FAILED      STIFFNESS       OLD USET          NEW USET
                                    ID           DIRECTION      RATIO     EXCLUSIVE  UNION   EXCLUSIVE  UNION
                                    11        G      3         0.00E+00          B        F         SB       S    *
                                    11        G      4         0.00E+00          B        F         SB       S    *
                                    11        G      5         0.00E+00          B        F         SB       S    *
                                    11        G      6         0.00E+00          B        F         SB       S    *
                                    12        G      3         0.00E+00          B        F         SB       S    *
                                    12        G      4         0.00E+00          B        F         SB       S    *
                                    12        G      5         0.00E+00          B        F         SB       S    *
                                    12        G      6         0.00E+00          B        F         SB       S    *
                                    13        G      3         0.00E+00          B        F         SB       S    *
                                    13        G      4         0.00E+00          B        F         SB       S    *
                                    13        G      5         0.00E+00          B        F         SB       S    *
                                    13        G      6         0.00E+00          B        F         SB       S    *
1   EXAMPLE 2D TRUSS                                                    AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07
PAGE      9
     LINEAR STATICS          $
0    FIRST LOAD SET                                                                                    SUBCASE
1
 *** SYSTEM INFORMATION MESSAGE 6916 (MREORDR)
     DECOMP ORDERING METHOD CHOSEN: DEFAULT, ORDERING METHOD USED: BEND

 *** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
     THE DECOMPOSITION OF KLL       YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF    1.353553E+00
 *** USER INFORMATION MESSAGE 5293 (SSG3A)
    FOR DATA BLOCK KLL
    LOAD SEQ. NO.             EPSILON              EXTERNAL WORK      EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH
ASTERISKS
                  1         -1.4210854E-16          5.9142137E-01
                  2          0.0000000E+00          7.6568544E-01
```

Grid Numbers

Component

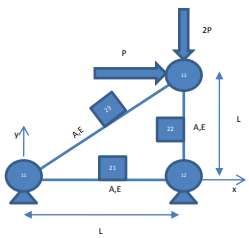
Stiffness

AutoSPC

Numerical Ill Conditioning? – Stiffness matrix

Results

```
1   EXAMPLE 2D TRUSS                                                    AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    10
     LINEAR STATICS          $
0
0 RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0                                                SPCFORCE RESULTANT
  SUBCASE/     LOAD
  DAREA ID     TYPE          T1              T2              T3              R1              R2              R3
0        1     FX   -1.000000E+02            ----            ----            ----     0.000000E+00    0.000000E+00
               FY            ----     2.000000E+02            ----     0.000000E+00            ----    3.000000E+04
               FZ            ----            ----     0.000000E+00    0.000000E+00    0.000000E+00            ----
               MX            ----            ----            ----    0.000000E+00            ----            ----
               MY            ----            ----            ----            ----    0.000000E+00            ----
               MZ            ----            ----            ----            ----            ----    0.000000E+00
          TOTALS -1.000000E+02  2.000000E+02  0.000000E+00  0.000000E+00  0.000000E+00  3.000000E+04
0        2     FX   -2.000000E+02            ----            ----            ----     0.000000E+00    0.000000E+00
               FY            ----    -2.842171E-14            ----     0.000000E+00            ----    2.000000E+04
               FZ            ----            ----     0.000000E+00    0.000000E+00    0.000000E+00            ----
               MX            ----            ----            ----    0.000000E+00            ----            ----
               MY            ----            ----            ----            ----    0.000000E+00            ----
               MZ            ----            ----            ----            ----            ----    0.000000E+00
          TOTALS -2.000000E+02 -2.842171E-14  0.000000E+00  0.000000E+00  0.000000E+00  2.000000E+04
1   EXAMPLE 2D TRUSS                                                    AUGUST  14, 2007  MSC.NASTRAN  4/ 3/07   PAGE    11
     LINEAR STATICS          $
0
0                                              MAXIMUM  SPCFORCES
  SUBCASE/
  DAREA ID        T1              T2              T3              R1              R2              R3
0        1   1.0000000E+02   3.0000000E+02   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
0        2   2.0000000E+02   2.0000000E+02   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
1   EXAMPLE 2D TRUSS                                                    AUGUST  14, 2007  MSC.NASTRAN  4/ 3/07   PAGE    12
     LINEAR STATICS          $
0
0                                              MAXIMUM  DISPLACEMENTS
  SUBCASE/
  DAREA ID        T1              T2              T3              R1              R2              R3
0        1   5.8284272E-03   3.0000000E-03   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
0        2   7.6568541E-03   2.0000001E-03   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
1   EXAMPLE 2D TRUSS                                                    AUGUST  14, 2007  MSC.NASTRAN  4/ 3/07   PAGE    13
     LINEAR STATICS          $
0
0                                              MAXIMUM  APPLIED LOADS
  SUBCASE/
  DAREA ID        T1              T2              T3              R1              R2              R3
0        1   1.0000000E+02   2.0000000E+02   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
0        2   2.0000000E+02   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
```



Results

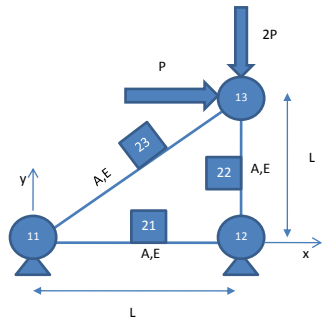
```
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    10
2   1   EXAMPLE 2D TRUSS                                               AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    11
     LINEAR STATICS        $
0    FIRST LOAD SET                                                                                    SUBCASE 1

                                    D I S P L A C E M E N T   V E C T O R

      POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
            11      G      0.0            0.0            0.0            0.0            0.0            0.0
            12      G      0.0            0.0            0.0            0.0            0.0            0.0
            13      G      5.828427E-03  -3.000000E-03   0.0            0.0            0.0            0.0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    12
     LINEAR STATICS        $
0    SECOND LOAD SET                                                                                   SUBCASE 2

                                    D I S P L A C E M E N T   V E C T O R

      POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
            11      G      0.0            0.0            0.0            0.0            0.0            0.0
            12      G      0.0            0.0            0.0            0.0            0.0            0.0
            13      G      7.656854E-03  -2.000000E-03   0.0            0.0            0.0            0.0
```




```
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    13
     LINEAR STATICS        $
0    FIRST LOAD SET                                                                                    SUBCASE 1

                                F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
            11      G     -1.000000E+02  -1.000000E+02   0.0            0.0            0.0            0.0
            12      G      0.0            3.000000E+02   0.0            0.0            0.0            0.0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    14
     LINEAR STATICS        $
0    SECOND LOAD SET                                                                                   SUBCASE 2

                                F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
            11      G     -2.000000E+02  -2.000000E+02   0.0            0.0            0.0            0.0
            12      G      0.0            2.000000E+02   0.0            0.0            0.0            0.0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    15
     LINEAR STATICS        $
0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    16
     LINEAR STATICS        $
0    FIRST LOAD SET                                                                                    SUBCASE 1

                                    F O R C E S   I N   R O D   E L E M E N T S   ( C R O D )

        ELEMENT          AXIAL                                    ELEMENT          AXIAL
          ID.            FORCE          TORQUE                      ID.            FORCE          TORQUE
            21        0.0            0.0                            22       -3.000000E+02   0.0
            23        1.414214E+02   0.0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    17
     LINEAR STATICS        $
0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    18
     LINEAR STATICS        $
0    FIRST LOAD SET                                                                                    SUBCASE 1

                                S T R E S S E S   I N   R O D   E L E M E N T S   ( C R O D )

        ELEMENT       AXIAL       SAFETY      TORSIONAL     SAFETY       ELEMENT       AXIAL       SAFETY      TORSIONAL     SAFETY
          ID.         STRESS      MARGIN        STRESS      MARGIN         ID.         STRESS      MARGIN        STRESS      MARGIN
            21    0.0                       0.0                            22    -3.000000E+02   5.7E+00    0.0
            23    1.414214E+02   1.3E+01    0.0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    19
     LINEAR STATICS        $
0
1   EXAMPLE 2D TRUSS                                                AUGUST  13, 2007  MSC.NASTRAN  4/ 3/07   PAGE    20
```

Did not ask for 2

Did not ask for 2

$$MS = FS - 1 = \frac{\sigma_{Limit}}{\sigma} - 1 = \frac{2000}{141.4} - 1 = 13$$

$$MS > 0 \Rightarrow \sigma < \sigma_{Limit}$$

Nastran Session

- Get truss.dat from web site
  - http://www.me.rochester.edu/courses/ME204/
  - Schedule link, select truss.dat from lecture 4 line (right side of text)
- Open truss.dat in text editor, modify to get new model, save under different name
  - **Real data must have decimal, integer data no decimal**
  - Keep keywords: cend, begin bulk, enddata
  - Turn on SPC and LOAD in case control
  - Ask for output in case control: DISP=all, FORCE=all
- Run Nastran on file (icon on desktop or start menu)
- Examine output in f06 file:
  - Search for FATAL, fix any problems
  - Check Epsilon should be < 10E-6
  - Look at Maximum displacement, reasonable?
  - Search for Message, read them

Rules for Homework

- For Each problem
  1. Cover page on Engineering Paper
     - Name, date, problem set
     - Conclusions drawn from results
  2. Full listing of .dat file (Nastran input)
     - Place your name in title (title=name)
     - Place problem number in subtitle (subtitle=Logan p 3.1)
  3. Print ***Selected*** portions of f06 file
     - Edit it down with an editor, sed, etc.
     - Highlight key results
  4. If problem is done with Patran
     - Un-deformed plot with grid and element labels
     - Deformed plot