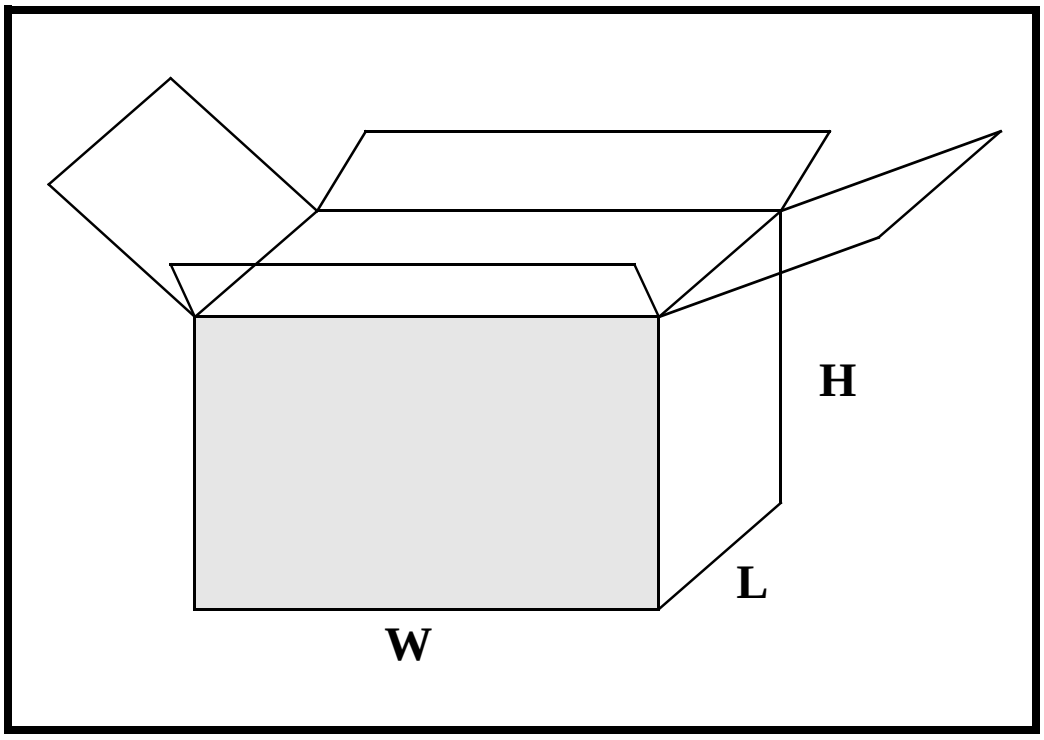
WORKSHOP 2

Objectives:

- Minimize the amount of material used for constructing the following box. This workshop also illustrates the use of equation writing capabilities in optimization.



Model Description:

- Objective Function: Minimize the material surface area.

$$S = 2 \times (W \times H + L \times H + 2.0 \times W \times L)$$

- Design Variables: W (Width), H (Height), L (Length)
- Constraints:

Volume: $V = H \times W \times L \geq 2.0$

- Initial Design: Optimum Design:

Initial Design	Optimum Design
H = 1.5	H = 2.0
W = 1.5	W = 1.0
L = 1.5	L = 1.0
S = 18.0	S = 12.0
V = 3.375	V = 2.0

Generating an input file for MSC.Nastran Users:

1. Generate an input file using the data from pages 2-1 through 2-3. Use the following input file as a starting point.

```
$
$   wkshp2.dat
$
ID MSC, D200X8 $
TIME 5
SOL 200
CEND
TITLE    = BOX MATERIAL MINIMIZATION WITH A VOLUME CONSTRAINT  D200X8
DESOBJ =
DESSUB = 1
SUBTITLE = INITIAL DESIGN: W=1.5, L=1.5, AND H=1.5
$DISPLACEMENT = ALL
STRESS       = NONE
SPC          = 1
ANALYSIS =  STATICS
LOAD         = 1
BEGIN BULK
param,post,-1
$
$ ------------------------------------------------------------
$
$  DUMMY STRUCTURAL MODEL (NOT USED)
FORCE   1       2               1.0E7   1.0     0.0     0.0
GRID    1               0.0     0.0     0.0
GRID    2               1.0     0.0     0.0
CROD    1       1       1       2
MAT1    1       1.0E7           0.3     0.1
PROD    1       1       1.0
SPC1    1       23456   2
SPC1    1       123456  1
$
$ DUMMY STRUCTURAL OPTIMIZATION STATEMENTS
$
DESVAR  4       DUM     1.0     0.1     10.0
DVPREL1 10      PROD    1       4
        4       1.0
DRESP1  10      DISPL   DISP                    1               2
DCONSTR 1       10      1.0     1.0
$
$ ------------------------------------------------------------
$
$  BOX DESIGN PROBLEM DEFINITION
$
$ Define three design variables
$
DESVAR  1       W       1.5     0.1     10.0
DESVAR  2       L       1.5     0.1     10.0
DESVAR  3       H       1.5     0.1     10.0
$
$ Define the Objective function using DRESP2 and DEQATN
$ the DRESP2 should be referenced by DESOBJ in Subcase level.
$
DRESP2...
DEQATN...
$
$ Define a Volume response function using DRESP2 and DEQATN
$ The box must be able to hold a minimum volume of 2.0
$
DEQATN...
DRESP2...
DCONSTR...
$
$ define the screen entry for equation
DSCREEN EQUA    -100.0  1
doptprm           p1   1    p2   15
ENDDATA
```

2. The completed MSC.Nastran input file is shown below:

```
$
$    soln2.dat
$
ID MSC, D200X8 $
TIME 5
SOL 200
CEND
TITLE    = BOX MATERIAL MINIMIZATION WITH A VOLUME CONSTRAINT  D200X8
DESOBJ = 2
DESSUB = 1
SUBTITLE = INITIAL DESIGN: W=1.5, L=1.5, AND H=1.5
$DISPLACEMENT = ALL
STRESS       = NONE
SPC          = 1
ANALYSIS =  STATICS
LOAD         = 1
BEGIN BULK
$
param,post,-1
$
$------------------------------------------------------------------------
$
$  DUMMY STRUCTURAL MODEL (NOT USED)
FORCE   1       2               1.0E7   1.0     0.0     0.0
GRID    1               0.0     0.0     0.0
GRID    2               1.0     0.0     0.0
CROD    1       1       1       2
MAT1    1       1.0E7           0.3     0.1
PROD    1       1       1.0
SPC1    1       23456   2
SPC1    1       123456  1
$
$ DUMMY STRUCTURAL OPTIMIZATION STATEMENTS
$
DESVAR  4       DUM     1.0     0.1     10.0
DVPREL1 10      PROD    1       4
        4       1.0
DRESP1  10      DISPL   DISP                    1               2
DCONSTR 1       10      1.0     1.0
$
$------------------------------------------------------------------------
$
$  BOX DESIGN PROBLEM DEFINITION
$
$ Define three design variables
$
DESVAR  1       W       1.5     0.1     10.0
DESVAR  2       L       1.5     0.1     10.0
DESVAR  3       H       1.5     0.1     10.0
$
$ Define the Objective function
$
DRESP2  2       SURFACE 2
        DESVAR  1       2       3
DEQATN  2       F(W,L,H)=2.0*(W*H+L*H+2.0*W*L)
$
$ Define a Volume constraint function
$
DCONSTR 1       1       2.0     1.0E35
DEQATN  1       F(W,L,H)=W*L*H
DRESP2  1       VOLUME  1
        DESVAR  1       2       3
$ define the screen entry for equation
DSCREEN EQUA    -100.0  1
doptprm p1      1       p2      15
ENDDATA
```

3. Submit the input file to MSC.Nastran for analysis.

   To submit the MSC.Nastran **.dat** file, find an available UNIX shell window and at the command prompt enter **nastran wkshp2 scr=yes**. Monitor the run using the UNIX **ps** command.

4. When the run is completed, edit the **wkshp2.f06** file and search for the word **FATAL**. If no matches exist, search for the word **WARNING**. Determine whether existing WARNING messages indicate modeling errors.

   4a. While still editing **wkshp2.f06**, search for the word:

   H I S T O R Y

Comparison of Results:

Compare the results obtained in the **.f06** file with the following:

```
                    ***************************************************************
                    S U M M A R Y   O F   D E S I G N   C Y C L E   H I S T O R Y
                    ***************************************************************

                                  (HARD CONVERGENCE ACHIEVED)

                                  (SOFT CONVERGENCE ACHIEVED)

                        NUMBER OF FINITE ELEMENT ANALYSES COMPLETED          3
                        NUMBER OF OPTIMIZATIONS W.R.T. APPROXIMATE MODELS    2

                               OBJECTIVE AND MAXIMUM CONSTRAINT HISTORY
         ---------------------------------------------------------------------------------------------------------------
                     OBJECTIVE FROM           OBJECTIVE FROM          FRACTIONAL ERROR          MAXIMUM VALUE
          CYCLE        APPROXIMATE                 EXACT                     OF                      OF
          NUMBER      OPTIMIZATION               ANALYSIS              APPROXIMATION             CONSTRAINT
         ---------------------------------------------------------------------------------------------------------------

          INITIAL                               1.800000E+01                                     0.000000E+00

                1        1.199244E+01           1.199244E+01              0.000000E+00           9.940267E-04

                2        1.198192E+01           1.198192E+01              0.000000E+00           2.773523E-03
         ---------------------------------------------------------------------------------------------------------------
1    BOX MATERIAL MINIMIZATION WITH A VOLUME CONSTRAINT  D200X8         NOVEMBER  10, 1997  MSC/NASTRAN  7/17/97 PAGE 30
      INITIAL DESIGN: W=1.5, L=1.5, AND H=1.5
0
                                          DESIGN VARIABLE HISTORY
 ---------------------------------------------------------------------------------------------------------------------
  INTERNAL |   EXTERNAL   |             |
   DV. ID. |    DV. ID.   |    LABEL    |   INITIAL    :      1       :      2       :     3      :     4      :     5
 ---------------------------------------------------------------------------------------------------------------------
         1 |            1 |  W          |   1.5000E+00 :   1.0054E+00 :   9.8065E-01 :
         2 |            2 |  L          |   1.5000E+00 :   1.0054E+00 :   9.8065E-01 :
         3 |            3 |  H          |   1.5000E+00 :   1.9767E+00 :   2.0739E+00 :
         4 |            4 |  DUM        |   1.0000E+00 :   1.0000E+00 :   1.0000E+00 :
 ---------------------------------------------------------------------------------------------------------------------
```

X-Y Plots of Design Results:

Figure 2.1 - Objective Function

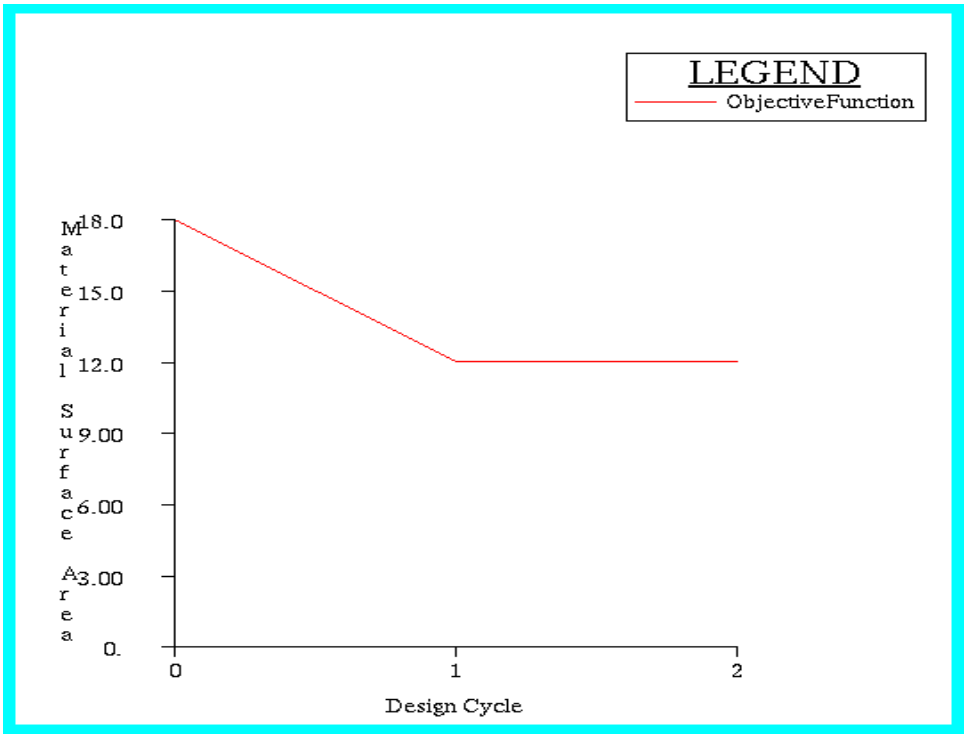


Figure 2.2 - Design Variables

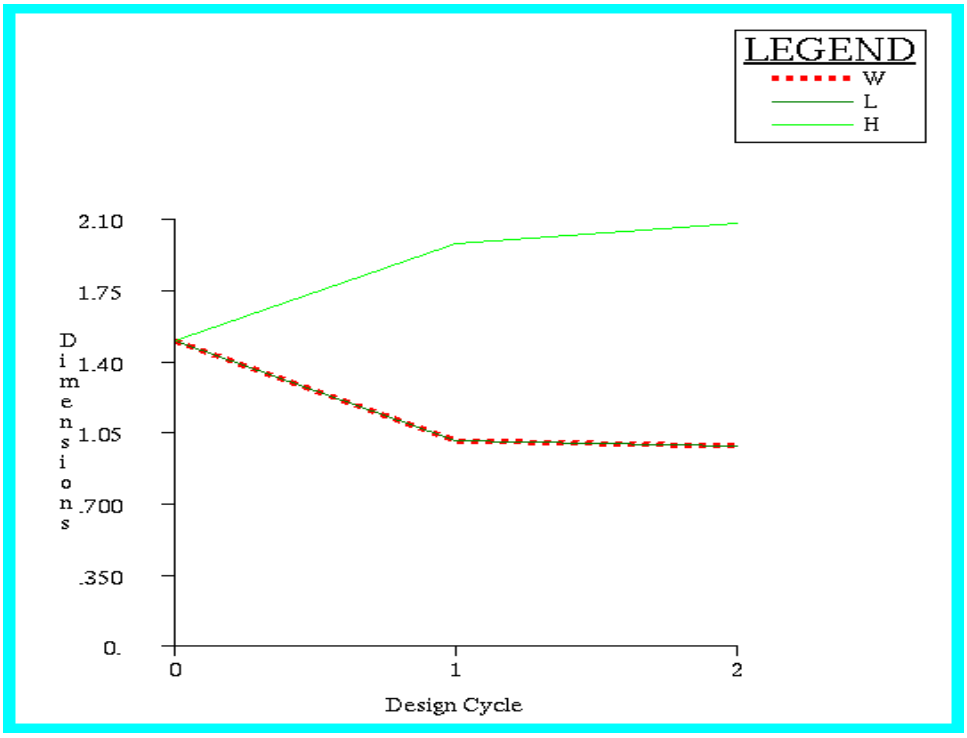


Figure 2.3 - Maximum Constraint