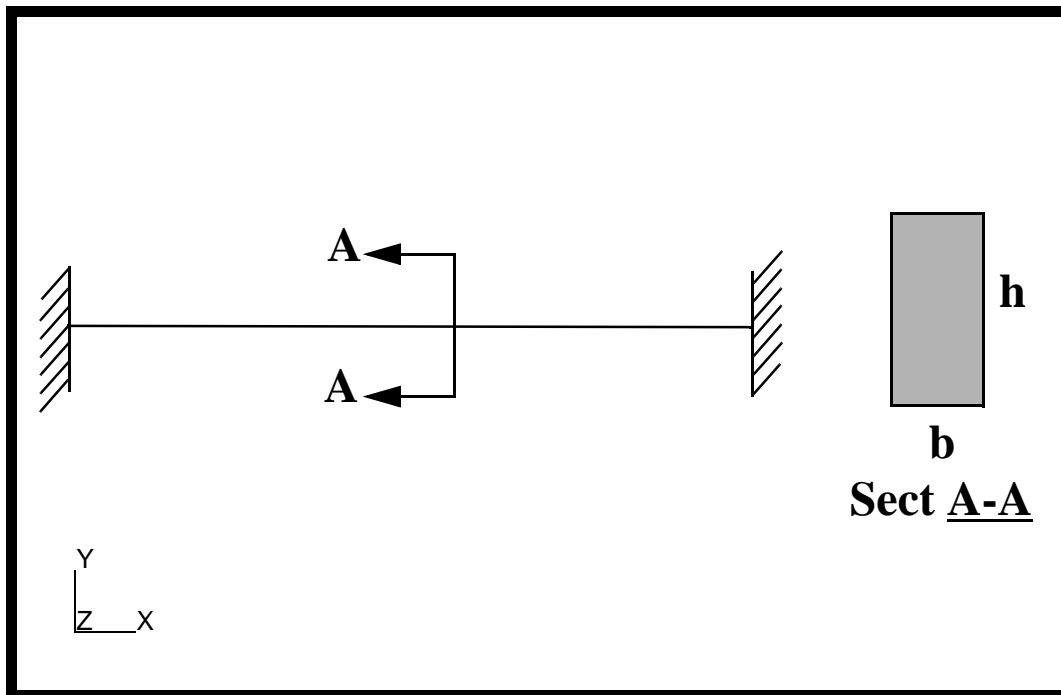


WORKSHOP 5

Objectives:

- Mode Tracking Exercise: Keep track of the mode shapes for the first ten modes of the following fixed-fixed beam.





Model Description:

- Objective Function - Weight Minimization.
- Design Variables = B, H
- Constraints:

$$\text{Eigenvalue Allowable:} \quad 9.8696 < \lambda_1 < 11.942$$

$$39.4784 < \lambda_2 < 43.525$$

Exercise Procedure:

PART A

For this exercise, define the BAR property using the PBAR entry and specify the constraints using eigenvalues. Keep track of the mode shapes for the first ten modes. The design variables are width (b) and height (h). The properties on the PBAR entries are defined using the area (A) and moment of inertia (I). They are related by the following equations:

$$A = b \times h \qquad I = \frac{b \times h^3}{12}$$

Use DVPREL2 to relate A , I , b and h by writing the equations given.

PART B

Redo the previous exercise defining the BAR property using the PBARL entry. Specify the constraints using the frequencies shown below.

Eigenvalue allowable: $0.50 < f1 < 0.55$

$$1.0 < f2 < 1.05$$

Generating an input file for MSC.Nastran Users:

1. Generate an input file for PART A using the data from pages 5-1 through 5-4. Use the following input file as a starting point.

```

$
$   wkshp5a.dat
$
TIME 10
SOL 200
CEND
$
$   INPUT CASE CONTROL
$
.
.
.
$
BEGIN BULK
param,post,-1
$
$-----
$ ANALYSIS MODEL:
$-----
$
$...FIXED-FIXED CANTILEVER, TWO PLANES OF MOTION:
GRID, 10, , 0., 0., 0., , 123456
GRID, 11, , 10., 0., 0., , 4
GRID, 12, , 20., 0., 0., , 4
GRID, 13, , 30., 0., 0., , 4
GRID, 14, , 40., 0., 0., , 4
GRID, 15, , 50., 0., 0., , 4
GRID, 16, , 60., 0., 0., , 4
GRID, 17, , 70., 0., 0., , 4
GRID, 18, , 80., 0., 0., , 4
GRID, 19, , 90., 0., 0., , 4
GRID, 20, , 100., 0., 0., , 123456
GRID, 21, , 0., 1., 0., , 123456
$
CBAR, 1, 30, 10, 11, 21
CBAR, 2, 30, 11, 12, 21
CBAR, 3, 30, 12, 13, 21
CBAR, 4, 30, 13, 14, 21
CBAR, 5, 30, 14, 15, 21
CBAR, 6, 30, 15, 16, 21
CBAR, 7, 30, 16, 17, 21
CBAR, 8, 30, 17, 18, 21
CBAR, 9, 30, 18, 19, 21
CBAR, 10, 30, 19, 20, 21
$
PBAR, 30, 40, 0.5, 1.042E-2,4.167E-2
$
MAT1, 40, 1.0E+7, , 0.33, 0.1
$
$IGRL SID V1 V2 ND
EIGRL, 50, , , 10
$
$-----
$ DESIGN MODEL:
$-----
$
$   INPUT DESIGN MODEL
$
.
.
.
$
ENDDATA

```

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

```

$
$ soln5a.dat
$
TIME 10
SOL 200
CEND
  analysis = MODES
  dssub = 100
  desobj(min) = 203
  METHOD = 50
  DISPL = ALL
  MODTRAK=10
BEGIN BULK
PARAM,POST,-1
PARAM,  NASPRT,  1
$
$-----
$ ANALYSIS MODEL:
$-----
$
$...FIXED-FIXED BEAM , TWO PLANES OF MOTION:
GRID,  10,  ,  0.,  0.,  0.,  ,  123456
GRID,  11,  ,  10.,  0.,  0.,  ,  4
GRID,  12,  ,  20.,  0.,  0.,  ,  4
GRID,  13,  ,  30.,  0.,  0.,  ,  4
GRID,  14,  ,  40.,  0.,  0.,  ,  4
GRID,  15,  ,  50.,  0.,  0.,  ,  4
GRID,  16,  ,  60.,  0.,  0.,  ,  4
GRID,  17,  ,  70.,  0.,  0.,  ,  4
GRID,  18,  ,  80.,  0.,  0.,  ,  4
GRID,  19,  ,  90.,  0.,  0.,  ,  4
GRID,  20,  ,  100.,  0.,  0.,  ,  123456
GRID,  21,  ,  0.,  1.,  0.,  ,  123456
$
CBAR,  1,  30,  10,  11,  21
CBAR,  2,  30,  11,  12,  21
CBAR,  3,  30,  12,  13,  21
CBAR,  4,  30,  13,  14,  21
CBAR,  5,  30,  14,  15,  21
CBAR,  6,  30,  15,  16,  21
CBAR,  7,  30,  16,  17,  21
CBAR,  8,  30,  17,  18,  21
CBAR,  9,  30,  18,  19,  21
CBAR,  10,  30,  19,  20,  21
$
PBAR,  30,  40,  0.5,  1.042E-2,4.167E-2
$
MAT1,  40,  1.0E+7,  ,  0.33,  0.1
$
$IGRL  SID  V1  V2  ND
EIGRL,  50,  ,  ,  10
$
$-----
$ DESIGN MODEL:
$-----
$
$ MODE TRACKING INPUT DATA:
$
$
MODTRAK 10      1      10      0.8
$
$...design variables, b & h (cross-sectional dimensions):
DESVAR, 101,  B,  0.5,  0.1,  2.0
DESVAR, 102,  H,  1.0,  0.1,  2.0
$
$...relate to changes in cross-sectional properties:
DVPREL2,110,  PBAR,  30,  4,  1.E-3,  ,  121,  ,  +
+,  DESVAR,  101,  102
DVPREL2,111,  PBAR,  30,  5,  1.E-3,  ,  122,  ,  +
+,  DESVAR,  102,  101
DVPREL2,112,  PBAR,  30,  6,  1.E-3,  ,  122,  ,  +
+,  DESVAR,  101,  102

```

WORKSHOP 5

```
DEQATN 121      A(B,H) = B*H          $ ...equations for
DEQATN 122      I(B,H) = B*H**3/12.  $ rectangular sections
$
$...specify first two eigenvalues as design responses:
DRESP1, 201,    LAMBDA1,EIGN,        ,          ,          1
DRESP1, 202,    LAMBDA2,EIGN,        ,          ,          2
$
$...and constrain them.
DCONSTR,100,    202,    9.8696 11.942 $
DCONSTR,100,    201,    39.4784 43.525 $
$
$...define weight minimization as the objective
DRESP1, 203,    W,          WEIGHT
$
doptprm,desmax, 10, 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 wkshp5a scr=yes**. Monitor the run using the UNIX **ps** command.

4. When the run is completed, edit the **wkshp5a.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 **wkshp5a.f06**, search for the words:

T R A C K I N G

H I S T O R Y

Comparison of Results:

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

```
*****  
*****  
***** REPORT ON MODE TRACKING ACTIVITY *****  
***** FOR DESIGN CYCLE:      6 *****  
*****  
*****
```

```
*** USER WARNING MESSAGE 6678 (MTI1RD)  
FOLLOWING ARE THE CORRESPONDING NEW POSITIONS OF THE SWITCHING DESIGNED MODES:  
INITIAL ORDER: MODE NUMBERS FROM INITIAL, OR PREVIOUS DESIGN CYCLE, THAT ARE TO BE TRACKED.  
TRACKED AS    : CORRESPONDING POSITION, IN CURRENT DESIGN CYCLE, OF SUCCESSFULLY TRACKED MODES.
```

INITIAL ORDER	1	2
TRACKED AS	2	1

 SUMMARY OF DESIGN CYCLE HISTORY

(HARD CONVERGENCE ACHIEVED)

(SOFT CONVERGENCE ACHIEVED)

NUMBER OF FINITE ELEMENT ANALYSES COMPLETED 7
 NUMBER OF OPTIMIZATIONS W.R.T. APPROXIMATE MODELS 6

OBJECTIVE AND MAXIMUM CONSTRAINT HISTORY

CYCLE NUMBER	OBJECTIVE FROM APPROXIMATE OPTIMIZATION	OBJECTIVE FROM EXACT ANALYSIS	FRACTIONAL ERROR OF APPROXIMATION	MAXIMUM VALUE OF CONSTRAINT
INITIAL		5.000000E+00		2.492728E+00
1	5.056348E+00	5.056242E+00	2.093607E-05	2.417018E-01
2	4.064205E+00	4.063976E+00	5.631968E-05	3.783900E-01
3	5.073577E+00	5.074127E+00	-1.084462E-04	1.583846E-02
4	4.838595E+00	4.838535E+00	1.231874E-05	-1.867615E-03
5	4.742812E+00	4.742828E+00	-3.418312E-06	-1.854281E-03
6	4.742828E+00	4.742828E+00	0.000000E+00	-1.854281E-03

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0

DESIGN VARIABLE HISTORY

INTERNAL DV. ID.	EXTERNAL DV. ID.	LABEL	INITIAL	1	2	3	4	5
1	101	B	5.0000E-01	8.4801E-01	1.0597E+00	1.0296E+00	9.9376E-01	9.741
2	102	H	1.0000E+00	5.9625E-01	3.8352E-01	4.9283E-01	4.8689E-01	4.868

INTERNAL DV. ID.	EXTERNAL DV. ID.	LABEL	6	7	8	9	10
1	101	B	9.7411E-01				
2	102	H	4.8689E-01				

X-Y Plots of Design Results:

Figure 5.1 - Objective Function

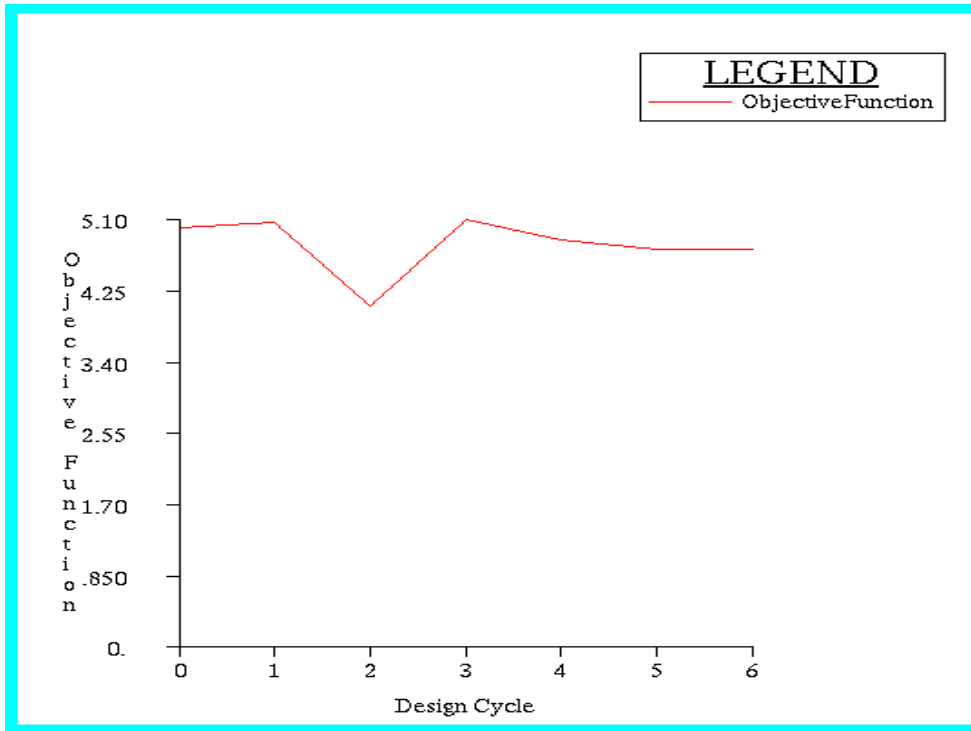


Figure 5.2 - Design Variables

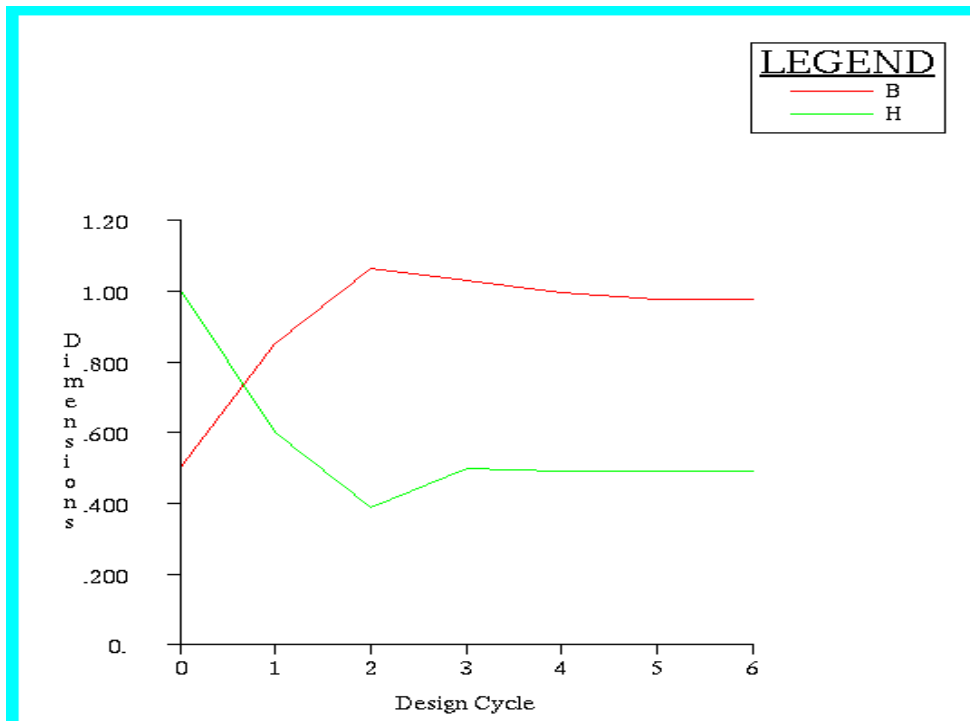
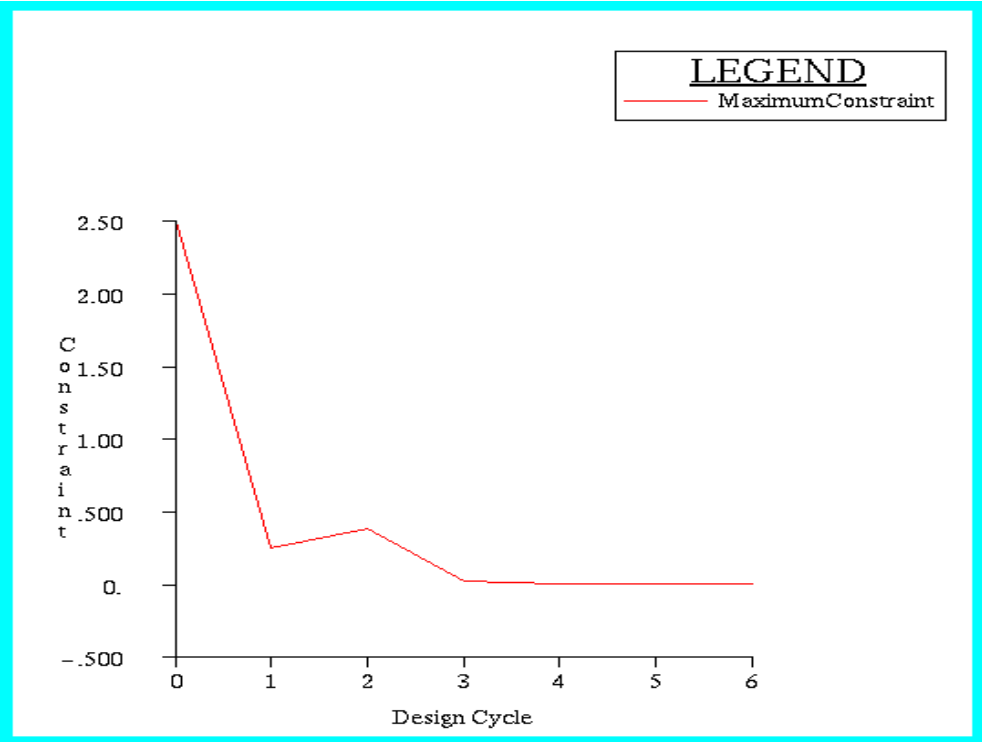


Figure 5.3 - Maximum Constraint



7. The completed MSC.Nastran input file for PART B is shown below:

```

$
$   soln5b.dat
$
TIME 10
SOL 200
CEND
  analysis = MODES
  dssub = 100
  desobj(min) = 203
  METHOD = 50
  DISPL = ALL
  MODTRAK=10
BEGIN BULK
PARAM,POST,-1
PARAM,  NASPRT,  1
$
$-----
$ ANALYSIS MODEL:
$-----
$
$...FIXED-FIXED BEAM, TWO PLANES OF MOTION:
GRID,  10,  ,  0.,  0.,  0.,  ,  123456
GRID,  11,  ,  10.,  0.,  0.,  ,  4
GRID,  12,  ,  20.,  0.,  0.,  ,  4
GRID,  13,  ,  30.,  0.,  0.,  ,  4
GRID,  14,  ,  40.,  0.,  0.,  ,  4
GRID,  15,  ,  50.,  0.,  0.,  ,  4
GRID,  16,  ,  60.,  0.,  0.,  ,  4
GRID,  17,  ,  70.,  0.,  0.,  ,  4
GRID,  18,  ,  80.,  0.,  0.,  ,  4
GRID,  19,  ,  90.,  0.,  0.,  ,  4
GRID,  20,  ,  100.,  0.,  0.,  ,  123456
GRID,  21,  ,  0.,  1.,  0.,  ,  123456
$
CBAR,  1,  30,  10,  11,  21
CBAR,  2,  30,  11,  12,  21
CBAR,  3,  30,  12,  13,  21
CBAR,  4,  30,  13,  14,  21
CBAR,  5,  30,  14,  15,  21
CBAR,  6,  30,  15,  16,  21
CBAR,  7,  30,  16,  17,  21
CBAR,  8,  30,  17,  18,  21
CBAR,  9,  30,  18,  19,  21
CBAR, 10,  30,  19,  20,  21
$
PBARL  30  40  BAR
      0.5  1.0
$
MAT1,  40,  1.0E+7,  ,  0.33,  0.1
$
$IGRL  SID  V1  V2  ND
EIGRL,  50,  ,  ,  10
$
$-----
$ DESIGN MODEL:
$-----
$
$ MODE TRACKING INPUT DATA:
$
$
MODTRAK 10  1  10  0.8
$
$...design variables, b & h (cross-sectional dimensions):
DESVAR, 101,  B,  1.0,  0.1,  2.0
DESVAR, 102,  H,  0.5,  0.1,  2.0
$
$...relate to changes in cross-sectional properties:
DVPREL1 110  PBARL  30  12
      101  1.0
DVPREL1 120  PBARL  30  13
      102  1.0
$

```


-
8. 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 wkshp5b scr=yes**. Monitor the run using the UNIX **ps** command.

9. When the run is completed, edit the **wkshp5b.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.

- 9a. While still editing **wkshp5b.f06**, search for the words:

T R A C K I N G

H I S T O R Y

Comparison of Results:

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

```
*****
*****
*****      REPORT ON MODE TRACKING ACTIVITY      *****
*****      FOR DESIGN CYCLE:          6          *****
*****
*****
```

```
*** USER WARNING MESSAGE 6678 (MTI1RD)
    FOLLOWING ARE THE CORRESPONDING NEW POSITIONS OF THE SWITCHING DESIGNED MODES:
    INITIAL ORDER: MODE NUMBERS FROM INITIAL, OR PREVIOUS DESIGN CYCLE, THAT ARE TO BE TRACKED.
    TRACKED AS    : CORRESPONDING POSITION, IN CURRENT DESIGN CYCLE, OF SUCCESSFULLY TRACKED MODES.
```

INITIAL ORDER	1	2
TRACKED AS	2	1

THE SWITCHING DESIGNED MODES WILL BE PLACED BACK INTO THEIR ORIGINAL ORDER.

 SUMMARY OF DESIGN CYCLE HISTORY

(HARD CONVERGENCE ACHIEVED)
 (SOFT CONVERGENCE ACHIEVED)

NUMBER OF FINITE ELEMENT ANALYSES COMPLETED 7
 NUMBER OF OPTIMIZATIONS W.R.T. APPROXIMATE MODELS 6

OBJECTIVE AND MAXIMUM CONSTRAINT HISTORY

CYCLE NUMBER	OBJECTIVE FROM APPROXIMATE OPTIMIZATION	OBJECTIVE FROM EXACT ANALYSIS	FRACTIONAL ERROR OF APPROXIMATION	MAXIMUM VALUE OF CONSTRAINT
INITIAL		5.000000E+00		8.676274E-01
1	5.395522E+00	5.395318E+00	3.791494E-05	4.900323E-01
2	5.297136E+00	5.297260E+00	-2.340411E-05	1.557503E-01
3	5.153106E+00	5.153164E+00	-1.138154E-05	-1.957631E-02
4	4.793719E+00	4.793677E+00	8.853018E-06	-2.434134E-03
5	4.748835E+00	4.748810E+00	5.221420E-06	-2.259016E-04
6	4.748810E+00	4.748810E+00	0.000000E+00	-2.259016E-04

1
 0

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DESIGN VARIABLE HISTORY

INTERNAL DV. ID.	EXTERNAL DV. ID.	LABEL	INITIAL	1	2	3	4	5
1	101	B	1.0000E+00	7.9763E-01	6.1858E-01	5.1917E-01	4.9122E-01	4.8663E
2	102	H	5.0000E-01	6.7642E-01	8.5636E-01	9.9257E-01	9.7586E-01	9.7586E

INTERNAL DV. ID.	EXTERNAL DV. ID.	LABEL	6	7	8	9	10	11
1	101	B	4.8663E-01					
2	102	H	9.7586E-01					

0*** USER INFORMATION MESSAGE 6464 (DOM12E)
 RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 6.

X-Y Plots of Design Results:

Figure 5.4 - Objective Function

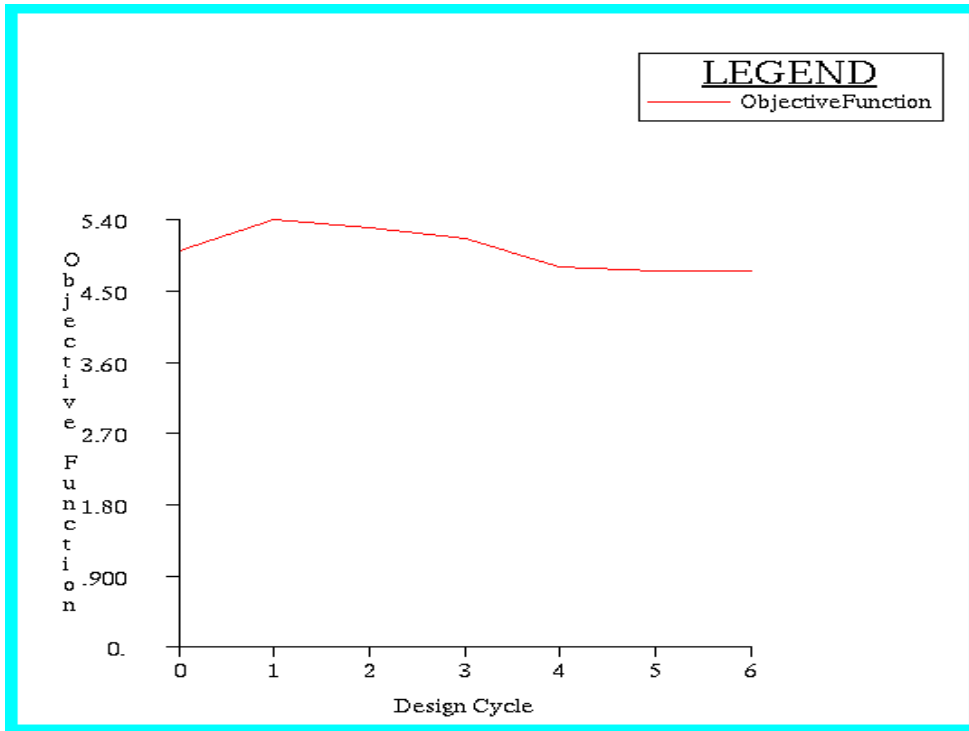


Figure 5.5 - Design Variables

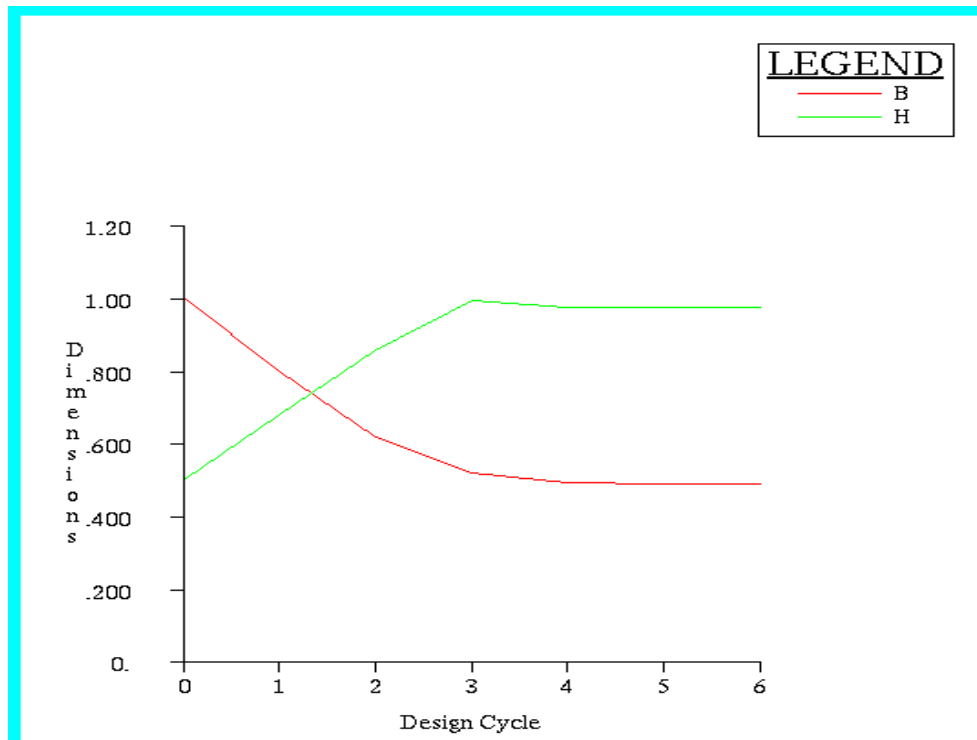


Figure 5.6 - Maximum Constraint

