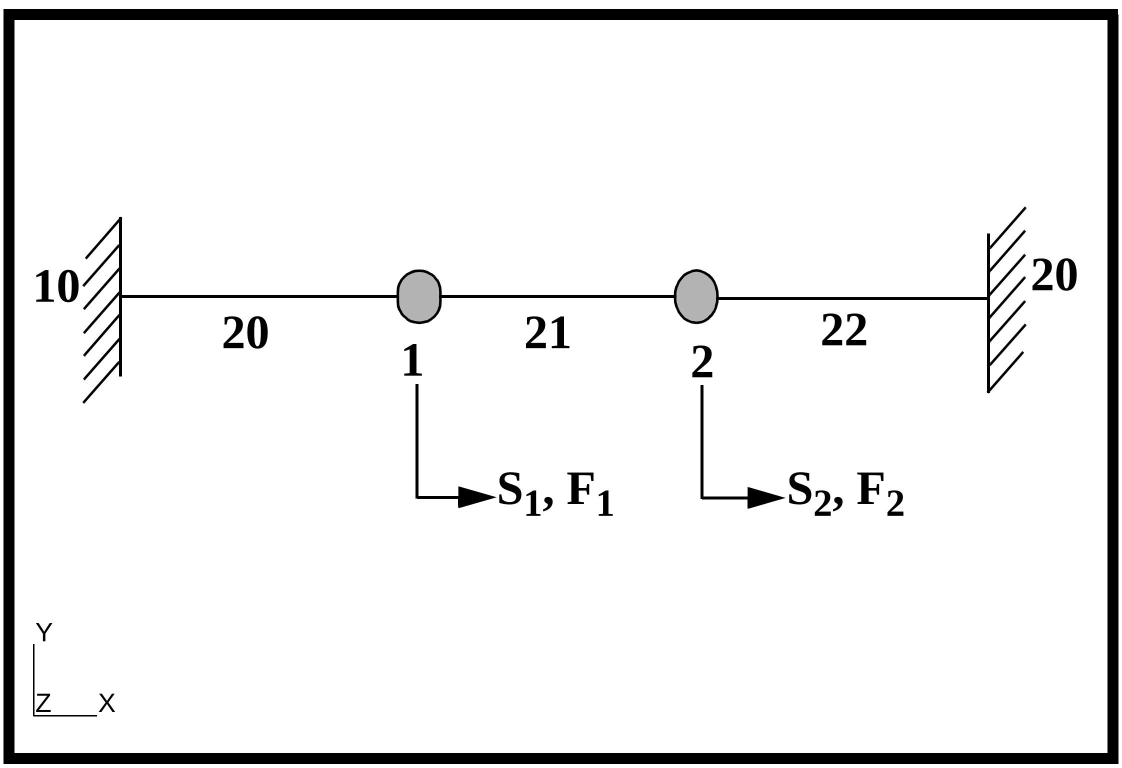
WORKSHOP 7

Objectives:

- Multi-disciplinary optimization problem subject to static, normal modes, and frequency response.



Model Description:

- Subject to:
  - Static loads of $S_1 = 30$ and $S_2 = 40$ pounds at Grid Points 1 and 2, respectively.
  - Normal modes analysis.
  - $F_1 = F_2 = 10$ pounds harmonic load at Grid Points 1 and 2.
- Objective Function - Minimize the SRSS response

$$\sqrt{(y_{f1}^2 + y_{f2}^2 + y_{f2}^2 + ...)}$$

of Grid Point 2 from 4 hz to 30 hz.

- Design Variables: cross-sectional area A1, A2, and A3
- Constraints:

  Static subcase: -20,000 < Elem stresses < +20,000

  Modal subcase: 17 hz < Freq1 < 20 hz

Generating an input file for MSC.Nastran Users:

1. Generate an input file using the data from pages 7-1 through 7-3. Use the following input file as a starting point.

```
$
$    wkshp7.dat
$
TIME 5
SOL 200 $
CEND
TITLE=TWO MASS OPTIMIZATION PROBLEM
DISPL = ALL
$
SUBCASE 1
 LABEL = STATIC
 ANALYSIS = ....
 LOAD = 101
 FORCE = ALL
 STRESS = ALL
 DESSUB = ....
$
SUBCASE 2
 LABEL = MODES
 ANALYSIS = ....
 METHOD = 201
 DESSUB = ....
$
SUBCASE 3
 LABEL = DIRECT FREQUENCY RESPONSE
 ANALYSIS = ....
 DISP(PHASE)=ALL
 FREQ = 100
 DLOAD = 200
DESOBJ(MIN) = ....
$
BEGIN BULK
$
param,post,-1
$
FORCE   101     1               30.     1.
FORCE   101     2               40.     1.
EIGRL   201                     2
$
CROD    20      20      10      1
CROD    21      21      1       2
CROD    22      22      2       20
CONM2   10      1               1.
CONM2   11      2               2.
DAREA   201     1       1       10.     2       1       10.
FREQ1   100     4.      .25     30
GRID    10              0.      0.      0.              123456
GRID    1               1.      0.      0.              23456
GRID    2               2.      0.      0.              23456
GRID    20              3.      0.      0.              123456
PROD    20      200     1.E-3
PROD    21      200     1.5E-3
PROD    22      200     2.E-3
MAT1,200,1.0E7,,0.3,1.0 $ DUMMY DENSITY
RLOAD1  200     201                     210
TABLED1 210
        1.      1.      10.     1.      ENDT
param,g,.10
$
$    design model
$
DOPTPRM P1      1       P2      15      DESMAX  10
   .
   .
   .
ENDDATA
```

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

```
$
$    soln7.dat
$
TIME 5
SOL 200 $
CEND
TITLE=TWO MASS OPTIMIZATION PROBLEM
DISPL = ALL
$
SUBCASE 1
 LABEL = STATIC
 ANALYSIS = STATICS
 LOAD = 101
 FORCE = ALL
 STRESS = ALL
 DESSUB = 100
$
SUBCASE 2
 LABEL = MODES
 ANALYSIS = MODES
 METHOD = 201
 DESSUB = 200
$
SUBCASE 3
 LABEL = DIRECT FREQUENCY RESPONSE
 ANALYSIS = DFREQ
 DISP(PHASE)=ALL
 FREQ = 100
 DLOAD = 200
DESOBJ(MIN) = 1000
$
BEGIN BULK
$
param,post,-1
$
FORCE   101     1               30.     1.
FORCE   101     2               40.     1.
EIGRL   201                     2
$
CROD    20      20      10      1
CROD    21      21      1       2
CROD    22      22      2       20
CONM2   10      1               1.
CONM2   11      2               2.
DAREA   201     1       1       10.     2       1       10.
FREQ1   100     4.      .25     104
GRID    10              0.      0.      0.              123456
GRID    1               1.      0.      0.              23456
GRID    2               2.      0.      0.              23456
GRID    20              3.      0.      0.              123456
PROD    20      200     1.E-3
PROD    21      200     1.5E-3
PROD    22      200     1.5E-3
MAT1,200,1.0E7,,0.3,1.0 $ DUMMY DENSITY
RLOAD1  200     201                     210
TABLED1 210
        1.      1.      10.     1.      ENDT
param,g,.10
$
$    design model
$
DOPTPRM P1      1       P2      15      DESMAX  10
DESVAR  1       A1      1.-3    1.-4    1.-2
DESVAR  2       A2      1.5-3   1.5-4   1.5-2
DESVAR  3       A3      2.-3    2.0-4   2.0-2
DVPREL1 1       PROD    20      4       1.0-3
        1       1.0
DVPREL1 2       PROD    21      4       1.5-3
        2       1.0
```

```
DVPREL1 3       PROD    22      4       2.0-3
        3       1.0
DCONSTR 100     101     -20000. 20000.
DCONSTR 100     102     -20000. 20000.
DCONSTR 100     103     -20000. 20000.
DCONSTR 200     200     17.     20.
$
DRESP1  101     STRELM1 STRESS  PROD            2               20
DRESP1  102     STRELM2 STRESS  PROD            2               21
DRESP1  103     STRELM3 STRESS  PROD            2               22
DRESP1  200     MODE1   FREQ                    1
$
dresp2,1000,srssg2c1,2000
,dresp1,1001,1002,1003,1004,1005,1006,1007
,,*7,*7,*7,*7,*7,*7,*7
=13
$
DRESP1,1001,GRID2C1,FRDISP,,,1,4.0,2
=,*1,=,=,=,=,=,*(.25),=
=103
$
deqatn  2000    srssg2c1(f1,f2,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f13,f14,
                         f15,f16,f17,f18,f19,f20,f21,f22,f23,f24,
                         f25,f26,f27,f28,f29,f30,f31,f32,f33,f34,
                         f35,f36,f37,f38,f39,f40,f41,f42,f43,f44,
                         f45,f46,f47,f48,f49,f50,f51,f52,f53,f54,
                         f55,f56,f57,f58,f59,f60,f61,f62,f63,f64,
                         f65,f66,f67,f68,f69,f70,f71,f72,f73,f74,
                         f75,f76,f77,f78,f79,f80,f81,f82,f83,f84,
                         f85,f86,f87,f88,f89,f90,f91,f92,f93,f94,
                         f95,f96,f97,f98,f99,f100,
                         f101,f102,f103,f104,f105) =
                         sqrt(f1**2+f2**2+f3**2+f4**2+f5**2+f6**2+f7**2+
                         f8**2+f9**2+f10**2+f11**2+f12**2+f13**2+f14**2+
                         f15**2+f16**2+f17**2+f18**2+f19**2+f20**2+
                         f21**2+f22**2+f23**2+f24**2+f25**2+f26**2+
                         f27**2+f28**2+f29**2+f30**2+f31**2+f32**2+
                         f33**2+f34**2+f35**2+f36**2+f37**2+f38**2+
                         f39**2+f40**2+f41**2+f42**2+f43**2+f44**2+
                         f45**2+f46**2+f47**2+f48**2+f49**2+f50**2+
                         f51**2+f52**2+f53**2+f54**2+f55**2+f56**2+
                         f57**2+f58**2+f59**2+f60**2+f61**2+f62**2+
                         f63**2+f64**2+f65**2+f66**2+f67**2+f68**2+
                         f69**2+f70**2+f71**2+f72**2+f73**2+f74**2+
                         f75**2+f76**2+f77**2+f78**2+f79**2+f80**2+
                         f81**2+f82**2+f83**2+f84**2+f85**2+f86**2+
                         f87**2+f88**2+f89**2+f90**2+f91**2+f92**2+
                         f93**2+f94**2+f95**2+f96**2+f97**2+f98**2+
                         f99**2+f100**2+
                         f101**2+f102**2+f103**2+f104**2+f105**2)
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 wkshp7 scr=yes**. Monitor the run using the UNIX **ps** command.

4. When the run is completed, edit the **wkshp7.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 **wkshp7.f06**, search for the word:

   H I S T O R Y

Comparison of Results:

5. 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          5
                          NUMBER OF OPTIMIZATIONS W.R.T. APPROXIMATE MODELS    4

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

      INITIAL                                 2.092793E-02                                    2.692307E-01

            1          2.326684E-02           1.880714E-02           2.371285E-01            -1.848973E-02

            2          1.865978E-02           1.833768E-02           1.756471E-02            -1.624980E-02

            3          1.790566E-02           1.744772E-02           2.624666E-02            -3.792715E-02

            4          1.744772E-02           1.744772E-02           0.000000E+00            -3.792715E-02
     ---------------------------------------------------------------------------------------------------------------
1    TWO MASS OPTIMIZATION PROBLEM                                   AUGUST  14, 1998  MSC/NASTRAN  4/28/98   PAGE   308

0                                                                                                     SUBCASE 2
                                             DESIGN VARIABLE HISTORY
 ----------------------------------------------------------------------------------------------------------------------------------
 INTERNAL |  EXTERNAL   |             |
  DV. ID. |   DV. ID.   |    LABEL    |   INITIAL    :     1       :     2       :     3       :     4       :     5       :
 ----------------------------------------------------------------------------------------------------------------------------------
        1 |           1 |  A1         |   1.0000E-03 :  1.5665E-03 :  1.4401E-03 :  1.2765E-03 :  1.2765E-03 :
        2 |           2 |  A2         |   1.5000E-03 :  1.5968E-03 :  1.7829E-03 :  4.6500E-03 :  4.6500E-03 :
        3 |           3 |  A3         |   2.0000E-03 :  2.0615E-03 :  2.2233E-03 :  2.5143E-03 :  2.5143E-03 :
```

X-Y Plots of Design Results:

Figure 7.1 - Objective Function

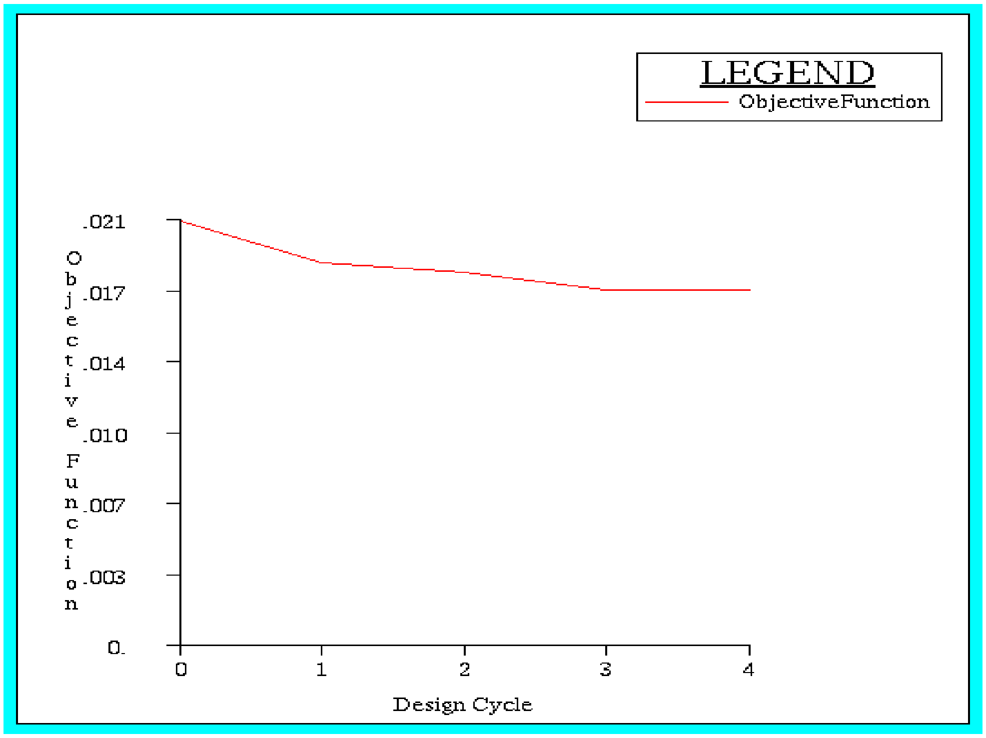


Figure 7.2 - Design Variables

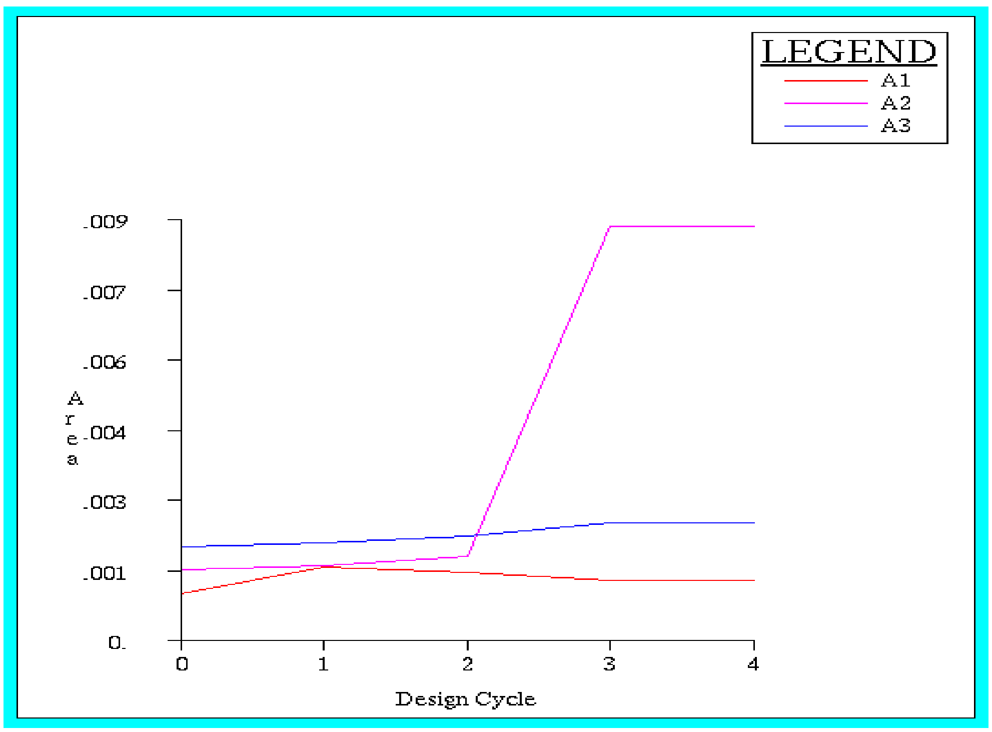


Figure 7.3 - Maximum Constraint