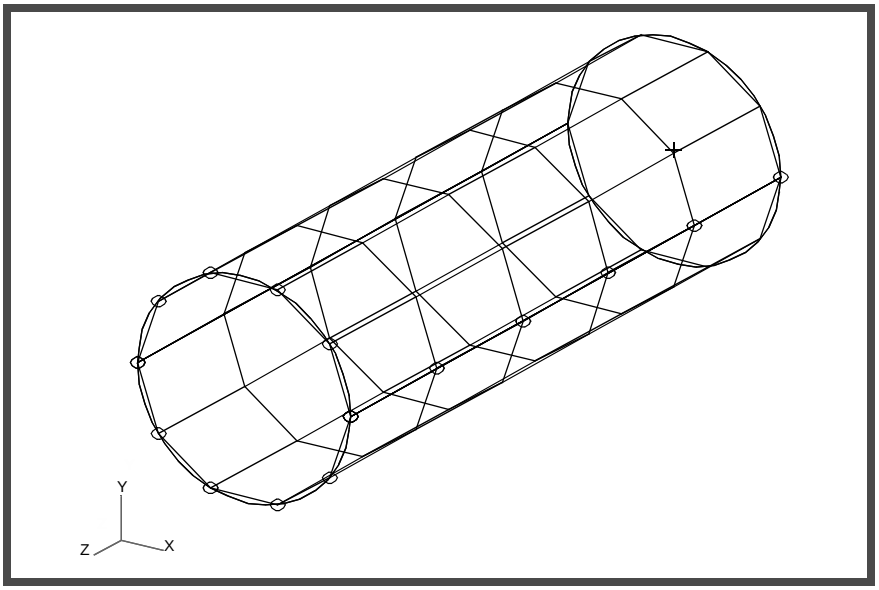
APPENDIX F

Modal Analysis of Interpolation Constraint Elements and Concentrated Mass (SI)



Objectives:

- Utilize the analysis model created in a previous exercise.
- Run an MSC.Nastran modal analysis with interpolation constraint elements.
- Visualize analysis results.
- Modify the existing model. Replace interpolation constraint elements with rigid elements.
- Run an MSC.Nastran modal analysis again.
- Visualize analysis results.

Model Description:

The goal of this example is to examine the effect of rigid and interpolation constraint elements. The rigid element, RBE2, will maintain a circular cross section at the rigid end of the tube, while the interpolation constraint elements, RBE3, are used to distribute either loading or mass.

Figure F.1 - Grid Coordinates and Element Connectivities.

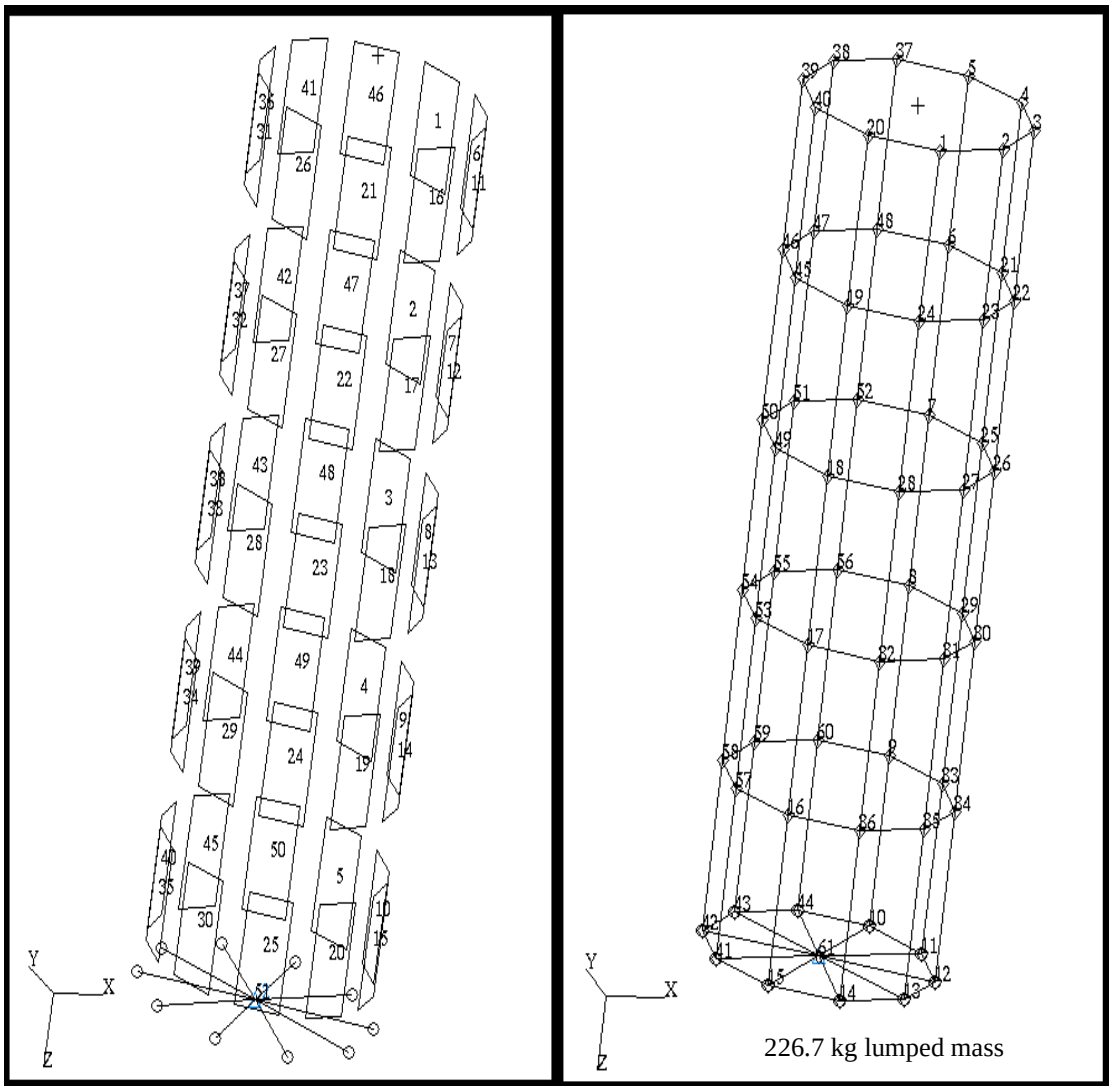


Figure F.2 - Loads and Boundary Conditions.

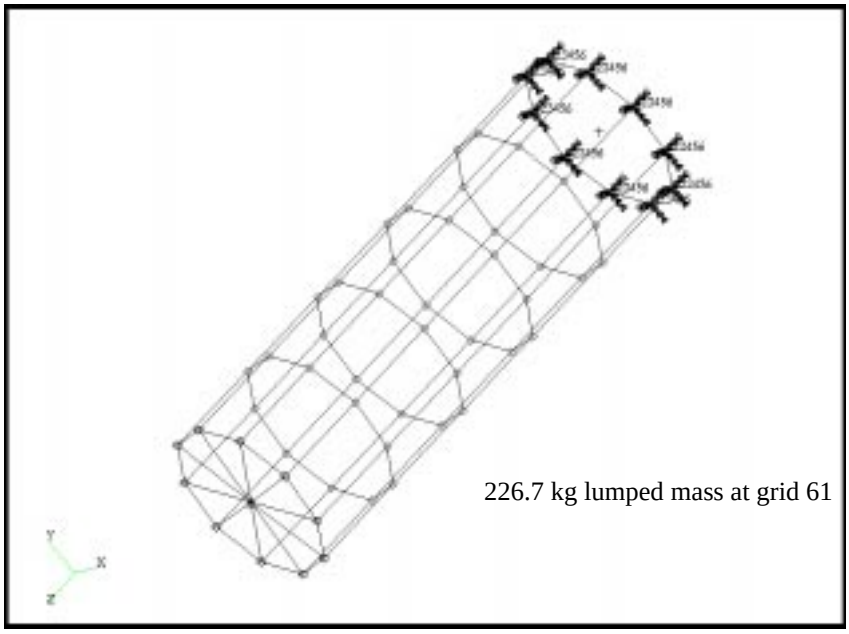


Table F.1 - Model Properties

Radius:	**381 mm**
Thickness:	**3.175 mm**
Length:	**2,286 mm**
Elastic Modulus:	**69 GPa**
Poisson Ratio:	**0.3**
Density:	**2796 kg/m^3**

Suggested Exercise Steps:

- Generate a finite element representation of the cylinder structure (i.e., The nodes (GRID) and element connectivities (CQUAD4)).
- Define material (MAT1) and element (PSHELL) properties.
- Create grid point 61 at the center of the top enclosure. This point is to serve as the load application point, as well as the connection point for the interpolation constraint element.
- Idealize the top enclosure with interpolation constraint elements (RBE3).
- Apply the fixed boundary constraints (SPC1).
- Apply a concentrated mass at the center of the top enclosure, grid 61 (CONM2).
- Prepare the model for normal modal analysis (SOL 103).
- Generate an input file and submit it to the MSC.Nastran solver for normal modal analysis.
- Review the results.

Generating an Input File for MSC.Nastran Users:

MSC.Nastran users can generate an input file using the data from Table F.1. The result should be similar to the output below.

1. MSC.Nastran input file: **ex05interp.dat**

```
ID  MODAL AN,CATIAFEM
SOL     103
CEND
$..
$-------------------------------------------------------------------------------
$..
$..                   CASE CONTROL DECK
$..
TITLE = MODAL ANALYSIS OF INTERPOLATION CONSTRAINT ELEMENT
METHOD  =       1
MPC     =       1
$..
SUBCASE =        1
$ CATIA RESTRAINT SET NAME :
$ FIX TO WALL
   SPC  =        1
$ CATIA LOAD SET NAME :
$ 2.7G VERTICAL LOAD
   LOAD =        1
$..
$-------------------------------------------------------------------------------
$..
$..                   BULK DATA CARDS
$..
BEGIN BULK
EIGRL,1,,,10
PARAM   POST    0
PARAM   AUTOSPC YES
$..
$-------------------------------------------------------------------------------
$..
$..                   RESTRAINTS
$..
$ NASTRAN ID =        1 / RESTRAINT SET NAME :
$ FIX TO WALL
SPC1    1       123456  1       2       3       4       5       20              1
+      137      38      39      40
$..
$-------------------------------------------------------------------------------
$..
$..                   LOADS
$..
$ NASTRAN ID =        1 / LOAD SET NAME :
$ 2.7G VERTICAL LOAD
GRAV    1               9810.   0.      0.      2.7
$..
$-------------------------------------------------------------------------------
$..
$..                   MATERIALS
```

```
$..
$ MATERIAL NAME : ALUM
MAT1    1       69000.01        .03     .2796-8
$..
$------------------------------------------------------------------------------
$..
$..                   NODES
$..
GRID    1               -59.6016-376.309.365-14
GRID    2               172.9703-339.473-.106-13
GRID    3               339.4734-172.97 -.208-13
GRID    4               376.309459.60159-.23-13
GRID    5               269.4077269.4077-.165-13
GRID    6               269.4077269.4077457.2
GRID    7               269.4077269.4077914.4
GRID    8               269.4077269.40771371.6
GRID    9               269.4077269.40771828.8
GRID    10              269.4077269.40772286.
GRID    11              376.309459.601592286.
GRID    12              339.4734-172.97 2286.
GRID    13              172.9703-339.4732286.
GRID    14              -59.6016-376.3092286.
GRID    15              -269.408-269.4082286.
GRID    16              -269.408-269.4081828.8
GRID    17              -269.408-269.4081371.6
GRID    18              -269.408-269.408914.4
GRID    19              -269.408-269.408457.2
GRID    20              -269.408-269.408.165-13
GRID    21              376.309459.60167457.2
GRID    22              339.4735-172.97 457.2
GRID    23              172.9703-339.473457.2
GRID    24              -59.6017-376.309457.2
GRID    25              376.309459.60169914.4
GRID    26              339.4735-172.97 914.4
GRID    27              172.9703-339.473914.4
GRID    28              -59.6017-376.309914.4
GRID    29              376.309459.601691371.6
GRID    30              339.4735-172.97 1371.6
GRID    31              172.9703-339.4731371.6
GRID    32              -59.6017-376.3091371.6
GRID    33              376.309459.601671828.8
GRID    34              339.4735-172.97 1828.8
GRID    35              172.9703-339.4731828.8
GRID    36              -59.6017-376.3091828.8
GRID    37              59.60159376.3094-.365-14
GRID    38              -172.97 339.4734.1059-13
GRID    39              -339.473172.9703.2079-13
GRID    40              -376.309-59.6016.2304-13
GRID    41              -376.309-59.60162286.
GRID    42              -339.473172.97032286.
GRID    43              -172.97 339.47342286.
GRID    44              59.60159376.30942286.
GRID    45              -376.309-59.6017457.2
GRID    46              -339.473172.9703457.2
GRID    47              -172.97 339.4735457.2
GRID    48              59.60167376.3094457.2
GRID    49              -376.309-59.6017914.4
```

```
GRID    50              -339.473172.9703914.4
GRID    51              -172.97 339.4735914.4
GRID    52              59.60169376.3094914.4
GRID    53              -376.309-59.60171371.6
GRID    54              -339.473172.97031371.6
GRID    55              -172.97 339.47351371.6
GRID    56              59.60169376.30941371.6
GRID    57              -376.309-59.60171828.8
GRID    58              -339.473172.97031828.8
GRID    59              -172.97 339.47351828.8
GRID    60              59.60167376.30941828.8
GRID    61              .4121-14-.124-122286.
$..
$-------------------------------------------------------------------------------
$..
$..                   ELEMENTS
$..
CQUAD4  1       1       5       6       21      4
CQUAD4  2       1       6       7       25      21
CQUAD4  3       1       7       8       29      25
CQUAD4  4       1       8       9       33      29
CQUAD4  5       1       9       10      11      33
CQUAD4  6       1       4       21      22      3
CQUAD4  7       1       21      25      26      22
CQUAD4  8       1       25      29      30      26
CQUAD4  9       1       29      33      34      30
CQUAD4  10      1       33      11      12      34
CQUAD4  11      1       3       22      23      2
CQUAD4  12      1       22      26      27      23
CQUAD4  13      1       26      30      31      27
CQUAD4  14      1       30      34      35      31
CQUAD4  15      1       34      12      13      35
CQUAD4  16      1       2       23      24      1
CQUAD4  17      1       23      27      28      24
CQUAD4  18      1       27      31      32      28
CQUAD4  19      1       31      35      36      32
CQUAD4  20      1       35      13      14      36
CQUAD4  21      1       1       24      19      20
CQUAD4  22      1       24      28      18      19
CQUAD4  23      1       28      32      17      18
CQUAD4  24      1       32      36      16      17
CQUAD4  25      1       36      14      15      16
CQUAD4  26      1       20      19      45      40
CQUAD4  27      1       19      18      49      45
CQUAD4  28      1       18      17      53      49
CQUAD4  29      1       17      16      57      53
CQUAD4  30      1       16      15      41      57
CQUAD4  31      1       40      45      46      39
CQUAD4  32      1       45      49      50      46
CQUAD4  33      1       49      53      54      50
CQUAD4  34      1       53      57      58      54
CQUAD4  35      1       57      41      42      58
CQUAD4  36      1       39      46      47      38
CQUAD4  37      1       46      50      51      47
CQUAD4  38      1       50      54      55      51
CQUAD4  39      1       54      58      59      55
CQUAD4  40      1       58      42      43      59
```

```
CQUAD4  41      1       38      47      48      37
CQUAD4  42      1       47      51      52      48
CQUAD4  43      1       51      55      56      52
CQUAD4  44      1       55      59      60      56
CQUAD4  45      1       59      43      44      60
CQUAD4  46      1       37      48      6       5
CQUAD4  47      1       48      52      7       6
CQUAD4  48      1       52      56      8       7
CQUAD4  49      1       56      60      9       8
CQUAD4  50      1       60      44      10      9
CONM2   51      61              .2267
RBE3    52              61      123     1.      123     10      1.              2
+       2123    11      1.      123     12      1.      123     13              3
+       31.     123     14      1.      123     15      1.      123             4
+       441     1.      123     42      1.      123     43      1.              5
+       5123    44                                                              6
+       6UM
$..
$-------------------------------------------------------------------------------
$..
$..                     PROPERTIES
$..
PSHELL  1       1       3.175   1       1.      1       .83333
$..
ENDDATA
```

Submitting the Input File for Analysis:

2. When the run is completed, edit the **ex05interp.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.

3. While still editing **ex05interp.f06**, search for the word:

   E I G E N (spaces are necessary)

   What are the first five modes?

   Mode 1 = _____ Hz

   Mode 2 = _____ Hz

   Mode 3 = _____ Hz

   Mode 4 = _____ Hz

   Mode 5 = _____ Hz

Comparison of Results:

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

R E A L   E I G E N V A L U E S

MODE NO.	EXTRACTION ORDER	EIGENVALUE	RADIANS	CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	1	3.103987E+04	1.761814E+02	2.804013E+01	1.000000E+00	3.103987E+04
2	2	3.103987E+04	1.761814E+02	2.804013E+01	1.000000E+00	3.103987E+04
3	3	8.292659E+04	2.879698E+02	4.583181E+01	1.000000E+00	8.292659E+04
4	4	8.292659E+04	2.879698E+02	4.583181E+01	1.000000E+00	8.292659E+04
5	5	8.778574E+04	2.962866E+02	4.715548E+01	1.000000E+00	8.778574E+04
6	6	8.778574E+04	2.962866E+02	4.715548E+01	1.000000E+00	8.778574E+04
7	7	2.342735E+05	4.840181E+02	7.703387E+01	1.000000E+00	2.342735E+05
8	8	2.342735E+05	4.840181E+02	7.703387E+01	1.000000E+00	2.342735E+05
9	9	3.580046E+05	5.983348E+02	9.522794E+01	1.000000E+00	3.580046E+05
10	10	5.473325E+05	7.398192E+02	1.177459E+02	1.000000E+00	5.473325E+05