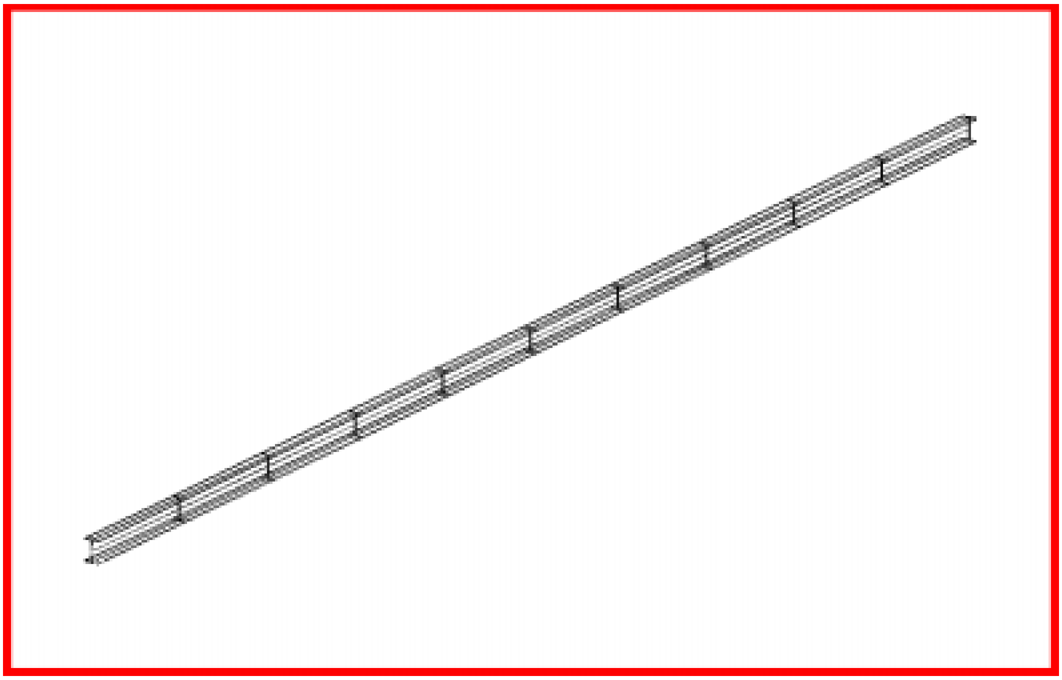
WORKSHOP PROBLEM 14b

Normal Modes with Differential Stiffness



Objectives

- Analyze a stiffened beam for normal modes.
- Produce an MSC/ NASTRAN input file that represent beam and load.
- Submit for analysis.
- Find normal modes (natural frequencies).

Model Description:

The goal of this example is to analyze a stiffened model. In this case, the beam from Problem 14a. with a 500 lb force applied.

Figure 14b.1 below is a finite element representation of the beam. This is no longer a simple normal modes analysis. Instead we will be using a nonlinear static solution (SOL 106) with (PARAM, NMLOOP and METHOD and EIGRL).

Below is a finite element representation of the beam. One end is pinned in 3 translations and one rotation. The other is pinned in 2 translations and one rotation with a 500 lb force applied.

Figure 14b.1-Grid Coordinates and Element Connectivities

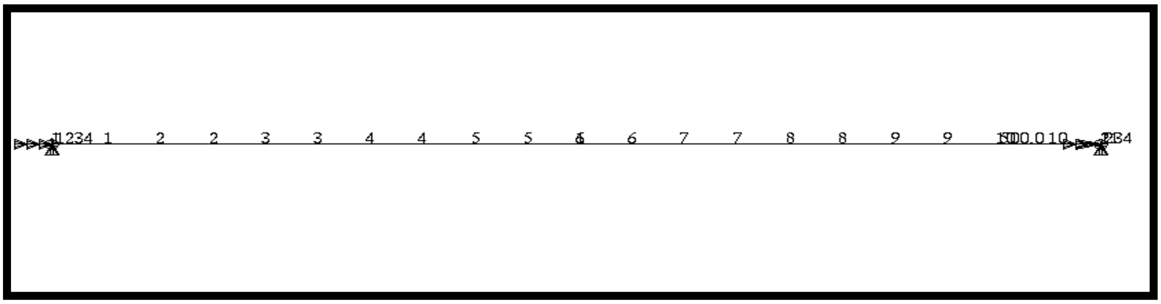


Figure 14b.2-Beam Cross Section

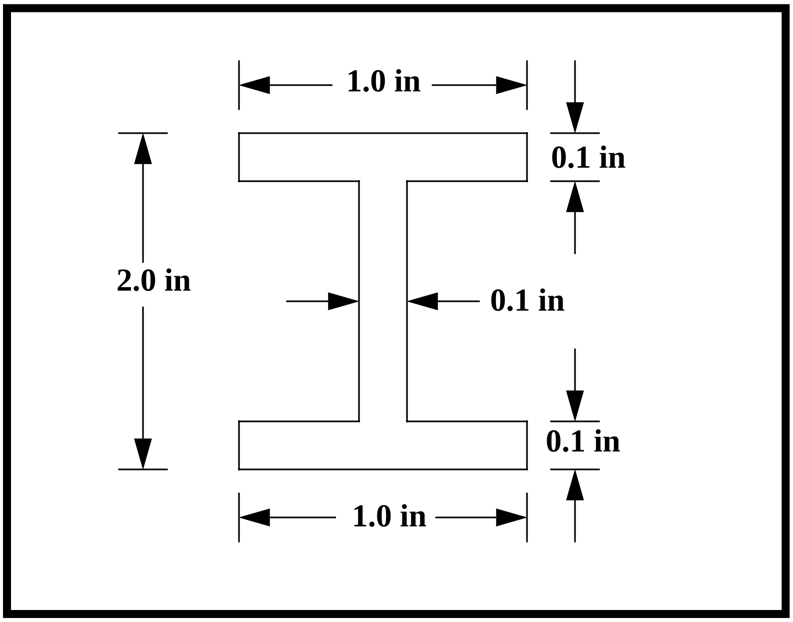


Table 14b.1

Length	**100 in**
Height	**2 in**
Width	**1 in**
Thickness	**0.100 in**
Area	**0.38 in^2**
I_1	**0.229 in^4**
I_2	**0.017 in^4**

Theoretical Solution

$$f_n = \frac{K_n}{2\pi}\left[\frac{EIg}{Wl^4}\left(1 + \frac{1}{Kr}\frac{Pl^2}{EI}\right)\right]^{1/2}$$

For Mode 1, Kr =9.87

$$f_n = \frac{9.87}{2\pi}\left[\frac{10\times10^6(0.229)(386.4)}{(0.38)(0.101)(100)^4}\text{x}\left(1 + \frac{1}{9.87}\frac{(500)(100)^2}{(10\times10^6)(0.229)}\right)\right]^{1/2}$$

$$f_n = 26.36Hz$$

For Static Load

$$\Delta = \frac{PL}{AE}$$

$$\Delta = \frac{500(100)}{0.38(10\times10^6)}$$

$$\Delta = 0.0132$$

Suggested Exercise Steps

- Open database created in Problem 1a in order to modify it, adding a load and reanalyze.
- Create 500 lb force applied at one end (FORCE).
- Make sure analysis is set to nonlinear static (SOL 106).
- Prepare nonlinear analysis to also analyze for normal mode (PARAM NMLOOP, EIGRL, LGDISP, NLPARM).
- Review the results, specifically the eigenvectors.

```
ID SEMINAR,PROB1
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
CEND
```

```
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

ENDDATA

Exercise Procedure:

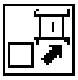
1. Users who are not utilizing MSC/PATRAN for generating an input file should go to Step 6, otherwise, proceed to step 2.

2. Open database created in Problem 14a named **prob14a.db**.

   File/Open Database

Existing Database Name	**prob14a**
OK	

3. Activate the entity labels by selecting the Show Labels icon on the tool-bar.

    **Show Labels**

4. Create force.

   ◆ **Loads/BCs**

Action:	**Create**
Object:	**Force**
Type:	**Nodal**
New Set Name	**pull**
Input Data...	
Force <F1 F2 F3>	**<500, , >**
OK	
Select Application Region...	
Select Geometry Entities	**Point 2**
Add	
OK	
Apply	

5. Now, you will generate the input file for analysis.

◆ **Analysis**

Action:	**Analyze**
Object:	**Entire Model**
Method	**Analysis Deck**
Job Name	**prob14b**
Solution Type...	
Solution Type:	◆ **NONLINEAR STATIC**
Solution Parameters ...	
<deselect Automatic Constraints>	❐ **Automatic Contraints**
Mass Calculation:	**Coupled**
Data Deck Echo:	**None**
Wt. -Mass Conversion =	**.00259**
OK	
OK	
Direct Text Input...	
◆ **Case Control Section**	**METHOD = 10**
◆ **Bulk Data Section**	**PARAM, NMLOOP, 5** **EIGRL, 10, , , 3**
OK	
Subcase Create...	
Available Subcases	**Default**
Subcase Parameters...	
Number of Load Increments =	**5**
OK	
Apply	
Cancel	
Apply	

An MSC/NASTRAN input file called **prob14b.bdf** will be generated. The process of translating your model into an input file is called Forward Translation. The Forward Translation is complete when the Heartbeat turns green. MSC/PATRAN Users should proceed to step 7.

Generating an input file for MSC/NASTRAN Users:

MSC/NASTRAN users can generate an input file using the data from Table 14b.1. The result should be similar to the output below.

6. MSC/NASTRAN Input File: **prob14b.dat**

```
SOL 106
TIME 600
CEND
$
TITLE = Normal Modes with Differential Stiffness
METHOD = 10
SUBCASE 1
   NLPARM = 1
   SPC = 1
   LOAD = 1
   DISPLACEMENT=ALL
$
BEGIN BULK
PARAM   COUPMASS 1
PARAM    WTMASS  .00259
PARAM    LGDISP  1
NLPARM   1       5               AUTO    5       25      PW      NO      +       A
+       A        .001    1.-7
PARAM,NMLOOP,5
$
EIGRL,10,,,3
PBARL    1       1               I                                       +       B
+       B 2.     1.      1.      .1      .1      .1
CBAR     1       1       1       2       0.      1.      0.
CBAR     2       1       2       3       0.      1.      0.
CBAR     3       1       3       4       0.      1.      0.
CBAR     4       1       4       5       0.      1.      0.
CBAR     5       1       5       6       0.      1.      0.
CBAR     6       1       6       7       0.      1.      0.
CBAR     7       1       7       8       0.      1.      0.
CBAR     8       1       8       9       0.      1.      0.
CBAR     9       1       9       10      0.      1.      0.
CBAR     10      1       10      11      0.      1.      0.
$
MAT1     1       1.+7            .3      .101
GRID     1               0.      0.      0.         345
GRID     2               10.     0.      0.         345
GRID     3               20.     0.      0.              345
GRID     4               30.     0.      0.              345
GRID     5               39.9999 0.      0.              345
GRID     6               49.9999 0.      0.              345
GRID     7               60.     0.      0.         345
GRID     8               70.     0.      0.         345
GRID     9               80.     0.      0.         345
GRID     10              90.     0.      0.              345
```

```
GRID    11              100.    0.      0.              345
LOAD    2       1.      1.      1
SPC1    1       1234    1
SPC1    1       234     11
FORCE   1       11      0       500.    1.      0.      0.
ENDDATA
```

Submit the input file for analysis

7. Submit the input file to MSC/NASTRAN for analysis.

   7a. To submit the MSC/PATRAN **.bdf** file for analysis, find an available UNIX shell window. At the command prompt enter: **nastran prob14b.bdf scr=yes**. Monitor the run using the UNIX **ps** command.

   7b. To submit the MSC/NASTRAN **.dat** file for analysis, find an available UNIX shell window. At the command prompt enter: **nastran prob14b scr=yes**. Monitor the run using the UNIX **ps** command.

8. When the run is completed, edit the **prob14b.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.

9. While still editing **prob14b.f06**, search for the word:

E I G E N (spaces are necessary)

What are the first three natural frequencies?

1st = ___________Hz

2nd = ___________Hz

3rd = ___________Hz

Comparison of Results

10. 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	2.735837E+04	1.654037E+02	2.632481E+01	1.000000E+00	2.735837E+04
2	2	3.748482E+05	6.122484E+02	9.744236E+01	1.000000E+00	3.748482E+05
3	3	1.816509E+06	1.347779E+03	2.145057E+02	1.000000E+00	1.816509E+06

11. MSC/NASTRAN Usershave finished this exercise. MSC/ PATRAN Users should proceed to the next step.

12. Proceed with the Reverse Translation process, that is importing the **prob14b.op2** results file into MSC/PATRAN. To do this, return to the Analysis form and proceed as follows:

◆ **Analysis**

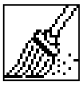
Action:	**Read Output2**
Object:	**Result Entities**
Method	**Translate**
Select Results File...	
Select Results File	**prob14b.op2**
OK	
Apply	

When the translation is complete bring up the **Results** form.

◆ **Results**

Form Type:	**Basic**
Select Results Cases	**1.1-Default, Mode 1:Freq=23.36**
Select Deformation Result	**1.1 Eigenvectors, Translational**
Apply	

To reset the graphics, click on this icon:



Reset Graphics

You can go back and select any *Results Case, Fringe Results or Deformation Results* you are interested in.

Quit MSC/PATRAN when you are finished with this exercise.