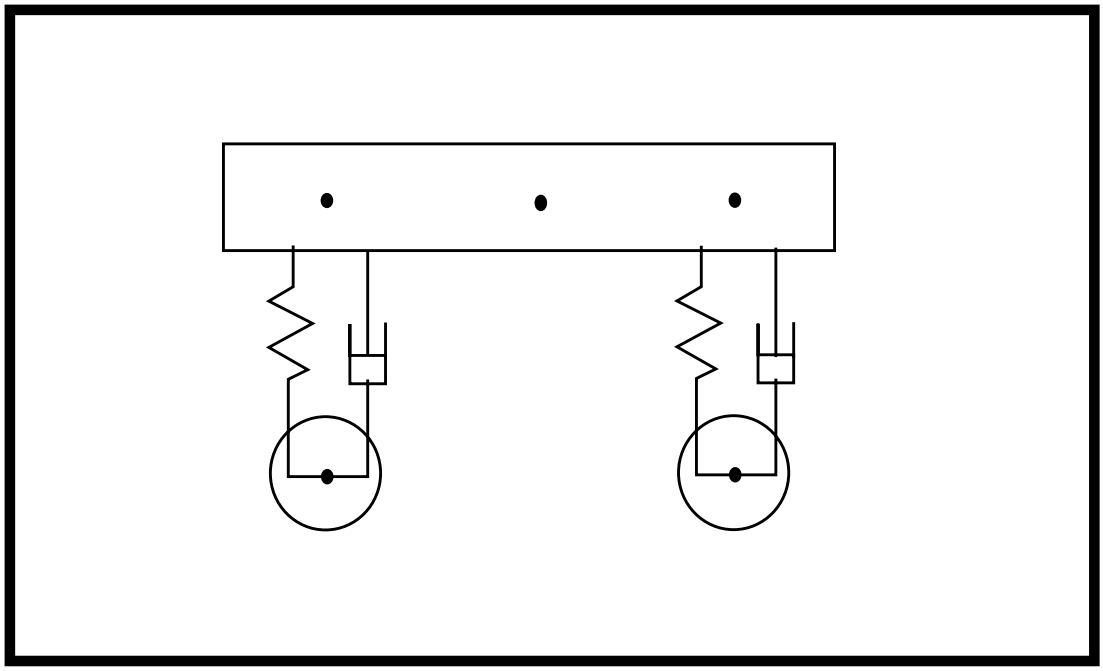
WORKSHOP PROBLEM 13

Nolins in Linear Transient

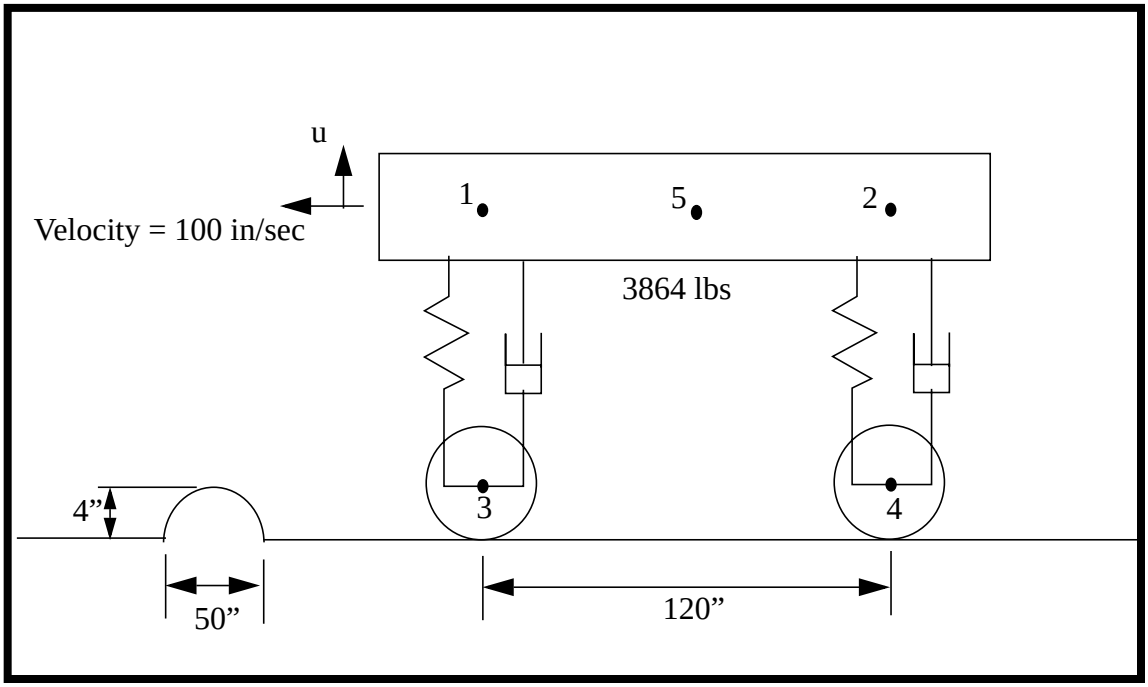


Objectives:

- Represent non-structural variables using non-structural DOFs.
- Define dynamic functions with transfer functions.
- Create a nonlinear transient force.
- Prepare a MSC/NASTRAN input file for a transient analysis.
- Visualize analysis results.

Model Description:

Figure 13.1-Car traveling over a speed bump



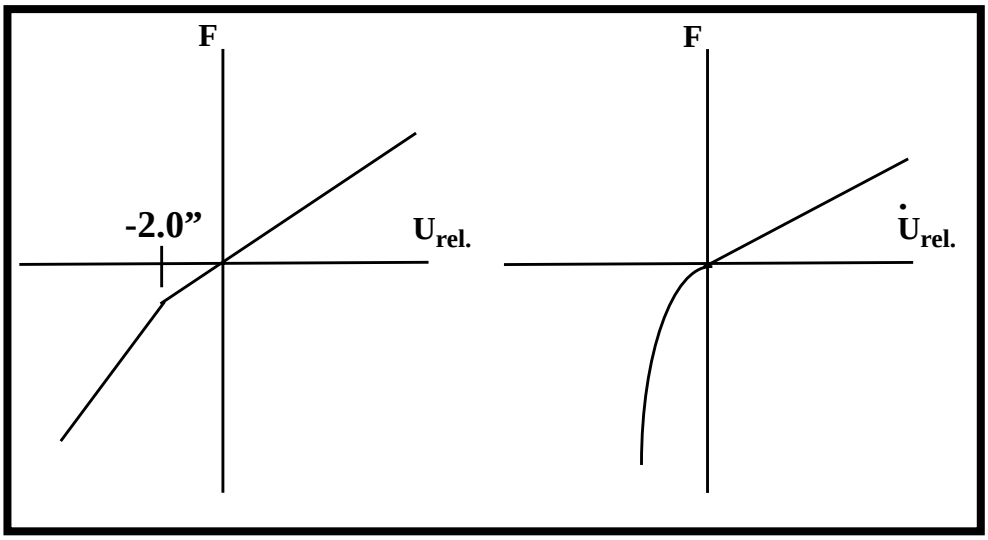
k : $u \geq -2.0 in$ **197.4 lb/in**

$u < -2.0 in$ **394.8 lb/in**

c : $\dot{u} \geq 0$ **1.88 lb/(in/sec)**

$\dot{u} \leq 0$ **1.88 lb/(in/sec) + 0.3 lb/(in/sec)^2**

Figure 13.2-Force vs Relative Velocity



Suggested Exercise Steps:

- Generate a finite element representation of the model using (GRID), (CBAR), and (CELAS2) elements.
- Define material (MAT1) and element (PBAR) properties.
- Constraints to eliminate rigid-body modes (SPC1).
- Define non-structural variables (CONM2).
- Specify scalar damper property and connection (CDAMP2).
- Define extra points (EPOINT).
- Define dynamic transfer functions (TF).
- Add nonlinear portion of the spring (NOLIN1).
- Add nonlinear portion of the damper (NOLIN4).
- Define the time-varying load (DAREA & TLOAD2).
- Define time delay (DELAY).
- Specify integration time step.
- Prepare the model for a direct transient analysis (SOL109).
- Request response in terms of nodal displacement and nonlinear load output.
- Generate an input file and submit it to the MSC/NASTRAN solver for direct transient analysis.
- Review the results, specially the xy plot of nodal displacements and nonlinear load.

```
ID SEMINAR,PROB13
```

```
CEND
```

```
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

ENDDATA

Generating an input file for MSC/NASTRAN Users:

1. MSC/NASTRAN users can generate an input file using the data from pages 13-3 and 13-4 (general model description). The result should be similar to the output below (**prob13.dat**):

```
ASSIGN OUTPUT2 = 'prob13.op2', UNIT=12
ID NAS102, WORKSHOP13
SOL 109
TIME 100
CEND
TITLE= SIMPLE CAR MODEL WITH NOLINEAR
SUBTITLE= SPRINGS AND DAMPERS RUNNING OVER A BUMP
LABEL= SOL 109, CONSTANT DELTA TIME
SEALL= ALL
SPC= 100
TFL= 100
NONLINEAR = 100
DLOAD = 100
TSTEP = 100
DISPLACEMENT(PLOT)= ALL
NLLOAD(PLOT)= ALL
$
OUTPUT(XYPLOT)
CSCALE=1.3
XAXIS= YES
YAXIS= YES
XGRID LINES= YES
YGRID LINES= YES
XTITLE= TIME (SEC)
YTITLE= VERTICAL DISPLACEMENT OF POINT 1
XYPLOT DISP/1(T2)
YTITLE= VERTICAL DISPLACEMENT OF POINT 2
XYPLOT DISP/2(T2)
YTITLE= VERTICAL DISPLACEMENT OF POINT 3
XYPLOT DISP/3(T2)
YTITLE= VERTICAL DISPLACEMENT OF POINT 4
XYPLOT DISP/4(T2)
YTITLE= VERTICAL DISPLACEMENT OF POINT 5
XYPLOT DISP/5(T2)
YTITLE= NONLINEAR FORCES AT POINT 1
XYPLOT NONLINEAR/1(T2)
```

```
YTITLE= NONLINEAR FORCES AT POINT 2
XYPLOT NONLINEAR/2(T2)
$
BEGIN BULK
PARAM,POST,-1
PARAM,PATVER,3.0
$
$ CARRIAGE POINTS
$
GRID, 1, , 0., 0., 0.
GRID, 2, , 120., 0., 0.
GRID, 5, , 60., 0., 0.
$
$ WHEEL POINTS
$
GRID, 3, , 0., -10., 0.
GRID, 4, , 120., -10., 0.
$
$ CAR CARRIAGE
$
CBAR, 5, 11, 1, 5, 0., 1., 0.
CBAR, 6, 11, 5, 2, 0., 1., 0.
PBAR, 11, 12, 10., 10., 10.
MAT1, 12, 3.0E+7, , .33
$
$ CONSTRAINTS TO ELIMINATE RIGID-BODY MODES
$
SPC1, 100, 1345, 1, 2, 5
SPC1, 100, 13456, 3, 4
$
$ SYSTEM WILL HAVE A NATURAL FREQUENCY OF 1 HZ
$ WITH CRITICAL DAMPING OF 1 PERCENT
$
CONM2, 10, 1, ,2.5
CONM2, 15, 2, ,2.5
CONM2, 20, 5, ,5.
$
CELAS2, 30, 197.4, 1, 2, 3, 2
CELAS2, 40, 197.4, 2, 2, 4, 2
$
CDAMP2, 50, 1.88, 1, 2, 3, 2
CDAMP2, 60, 1.88, 2, 2, 4, 2
$
$ DEFINE EXTRA POINTS TO HOLD DIFFERENCES
$ BETWEEN WHEELS AND CARRIAGE
```

```
$
EPOINT, 101, 102
$
$ USE TRANSFER FUNCTIONS TO TRACK DIFFERENCES
$ 101= V1 - V3
$ 102= V2 - V4
$
TF, 100, 101, 0, 1., 0., 0.,
, 1, 2, -1., 0., 0.,
, 3, 2, 1., 0., 0.
$
TF, 100, 102, 0, 1., 0., 0.,
, 2, 2, -1., 0., 0.,
, 4, 2, 1., 0., 0.
$
$ ADD NONLINEAR PORTION OF SPRINGS
$
NOLIN1, 100, 1, 2, 197.4, 101, 0, 111
NOLIN1, 100, 2, 2, 197.4, 102, 0, 111
TABLED2, 111, -2.0,
, -1., 1., 0., 0., 1., 0.,ENDT
$
$ ADD NONLINEAR PORTION OF DAMPERS
$
NOLIN4, 100, 1, 2, -0.3, 101, 10, 2.
NOLIN4, 100, 2, 2, -0.3, 102, 10, 2.
$
$ USE LAGRANGE MULTIPLIERS TO IMPOSE WHEEL DISPLACEMENT
$ 103= V3
$ 104= V4
$
EPOINT, 103, 104
$
TF, 100, 103, 0, 0., 0., 0.,
, 3, 2, 1., 0., 0.
TF, 100, 3, 2, 0., 0., 0.,
, 103, 0, 1., 0., 0.
$
TF, 100, 104, 0, 0., 0., 0.,
, 4, 2, 1., 0., 0.
TF, 100, 4, 2, 0., 0., 0.,
, 104, 0, 1., 0., 0.
$
```

```
$ MOVE WHEELS OVER BUMP
$
TLOAD2, 100, 222, 333, 0, 0., 0.5, 1., -90.
DAREA, 222, 103, 0, 4.
DAREA, 222, 104, 0, 4.
DELAY, 333, 104, 0, 1.2
$
$ INTEGRATION INFORMATION
TSTEP, 100, 200, .05, 1
$
ENDDATA
```

Submitting the input file for analysis

2. 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 prob13 scr=yes**. Monitor the run using the UNIX **ps** command.

3. When the run is completed, use **plotps** utility to create a postscript file, **prob13.ps**, from the binary plot file **prob13.plt**. The nonlinear force and displacement plots are shown in figures 13.3 to 13.9.

4. When the run is completed, edit the **prob13.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.

5. While still editing **prob13.f06**, search for the word:

   X Y - O U T P U T S U M M A R Y (spaces are necessary).

Comparison of Results

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

X Y - O U T P U T S U M M A R Y (R E S P O N S E)

SUBCASE ID	CURVE TYPE	FRAME NO.	CURVE ID.	XMIN-FRAME/ ALL DATA	XMAX-FRAME/ ALL DATA	YMIN-FRAME/ ALL DATA	X FOR YMIN	YMAX-FRAME/ ALL DATA	X FOR YMAX
1	NONLIN	1	1(4)	0.000000E+00	1.000002E+01	0.000000E+00	0.000000E+00	2.975151E+02	6.000001E-01
				0.000000E+00	1.000002E+01	0.000000E+00	0.000000E+00	2.975151E+02	6.000001E-01
1	NONLIN	2	2(4)	0.000000E+00	1.000002E+01	0.000000E+00	0.000000E+00	4.661461E+02	1.749999E+00
				0.000000E+00	1.000002E+01	0.000000E+00	0.000000E+00	4.661461E+02	1.749999E+00
1	DISP	3	1(4)	0.000000E+00	1.000002E+01	-2.836541E+00	2.199999E+00	5.942877E+00	4.500000E-01
				0.000000E+00	1.000002E+01	-2.836541E+00	2.199999E+00	5.942877E+00	4.500000E-01
1	DISP	4	2(4)	0.000000E+00	1.000002E+01	-2.671688E+00	1.999999E+00	7.464218E+00	1.600000E+00
				0.000000E+00	1.000002E+01	-2.671688E+00	1.999999E+00	7.464218E+00	1.600000E+00
1	DISP	5	3(4)	0.000000E+00	1.000002E+01	-4.440892E-16	5.000001E-01	4.000000E+00	2.500000E-01
				0.000000E+00	1.000002E+01	-4.440892E-16	5.000001E-01	4.000000E+00	2.500000E-01
1	DISP	6	4(4)	0.000000E+00	1.000002E+01	-1.332268E-15	1.749999E+00	4.000000E+00	1.450000E+00
				0.000000E+00	1.000002E+01	-1.332268E-15	1.749999E+00	4.000000E+00	1.450000E+00
1	DISP	7	5(4)	0.000000E+00	1.000002E+01	-2.150819E+00	2.149999E+00	3.963917E+00	1.600000E+00
				0.000000E+00	1.000002E+01	-2.150819E+00	2.149999E+00	3.963917E+00	1.600000E+00

7. MSC/NASTRAN Users have finished this exercise. MSC/PATRAN Users should proceed to the next step.

8. Proceed with the Reverse Translation process, that is importing the **prob13.op2** results file into MSC/PATRAN. To do this, return to the Analysis form and proceed as follows.

◆ **Analysis**

Action:	**Read Output2**
Object:	**Both**
Method:	**Translate**

Select Results File...

Select Available Files	**prob13.op2**

OK

Apply

9. Plot the results in xy plots.

The first plot is to make the Displacement versus Frequency plot at Node 1.

◆ **Results**

Form Type:	**Advanced**
Select Result Cases	**(highlight all cases)**

Get Results

Select Result	**1.1-Nonlinear Applied Load**
Plot Type:	**XY Plot**

Plot Type Options...

Result XY Plot Types	**Results Versus Global Variables**

Global Var...

Global Variables:	**1-Time**

Apply

Result (Y)...

Results: **1.1-Nonlinear Applied Loads, Translational**

Vector Component ● **Mag.**

OK

Node Ids **Node 1**

Apply

New Title or Title Filter **Nonlinear Forces at Point 1**

Rename

Apply

Figure 13.3-Nonlinear Forces at Point 1

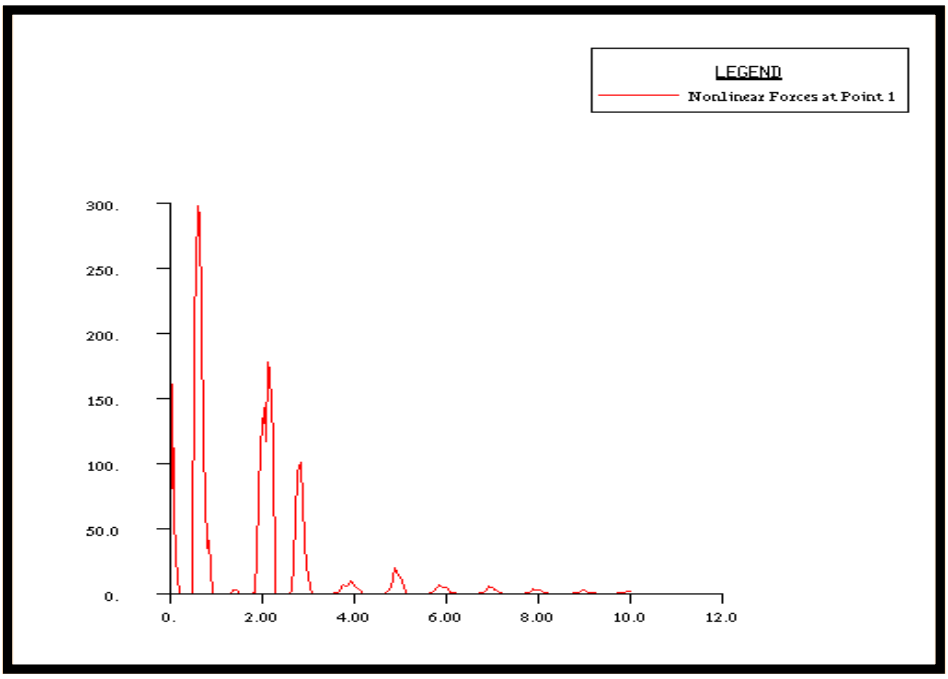
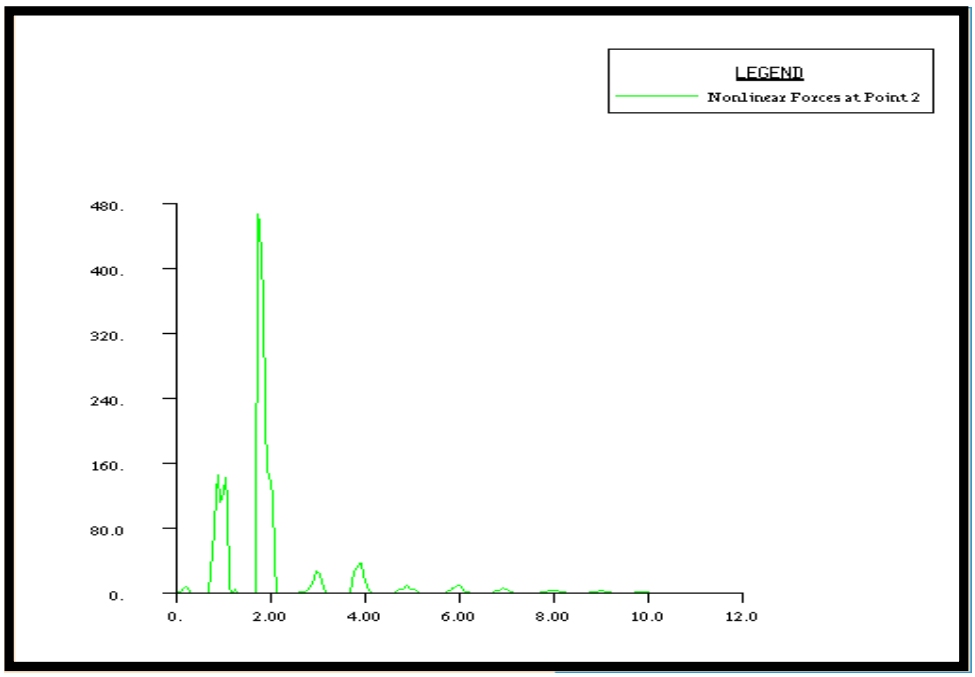


Figure 13.4-Nonlinear Forces at Point 2



To get the displacement results, go all the way back to the ***Result menu***.

Select Result **2.1 - Displacement, Translational**

Plot Type: **XY Plot**

Plot Type Options...

Result XY Plot Types **Results Versus Global Variables**

Global Var...

Global Variable: **1-time**

Apply

Result (Y)...

Results: **2.1-Displacement, Translational**

Vector Component ● **Component**
❒ **X** ■ **Y** ❒ **Z**

OK

Node IDs **Node 1**

Apply

New Title or Title Filter **Vertical Displacement of Point 1**

Rename

Apply

Figure 13.5-Vertical Displacement of Point 1

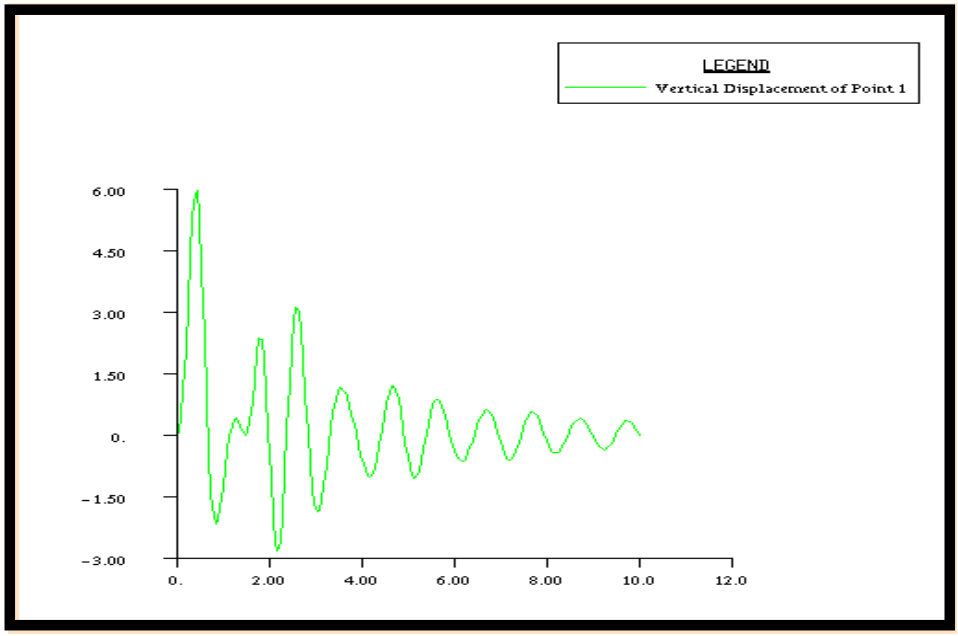


Figure 13.6-Vertical Displacement of Point 2

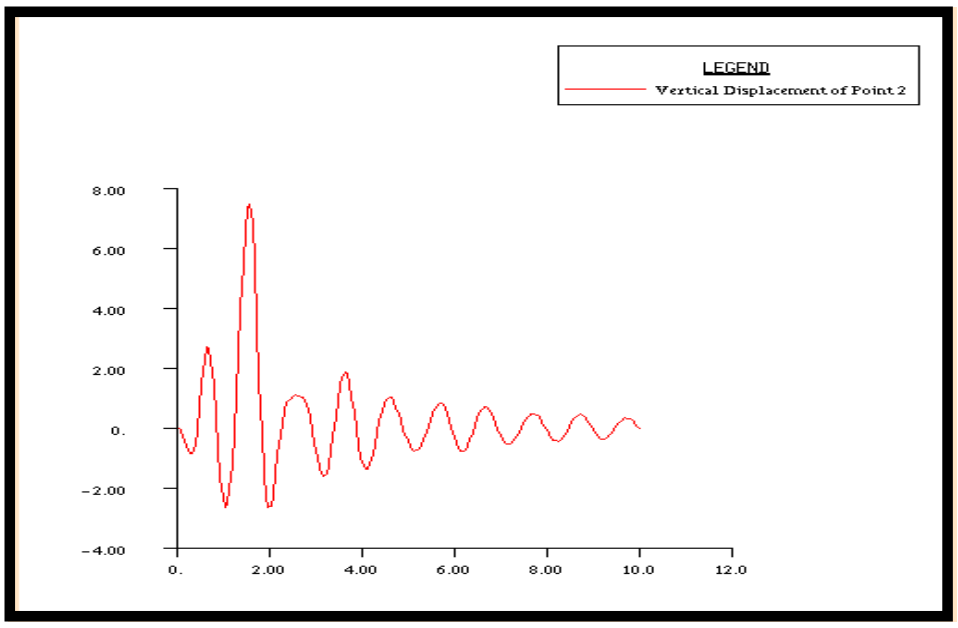


Figure 13.7-Vertical Displacement of Point 3

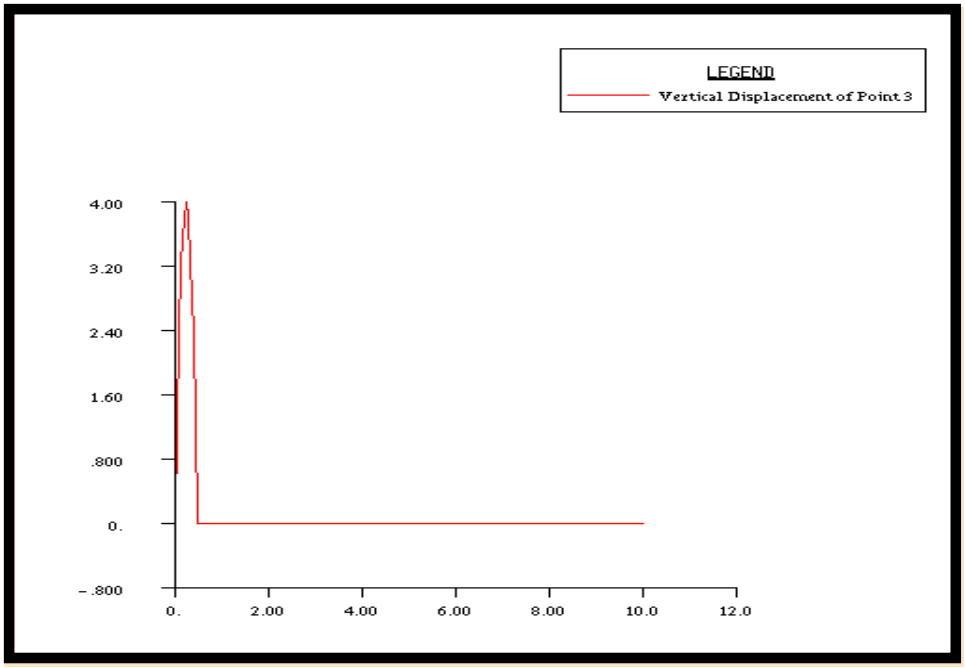


Figure 13.8-Vertical Displacement of Point 4

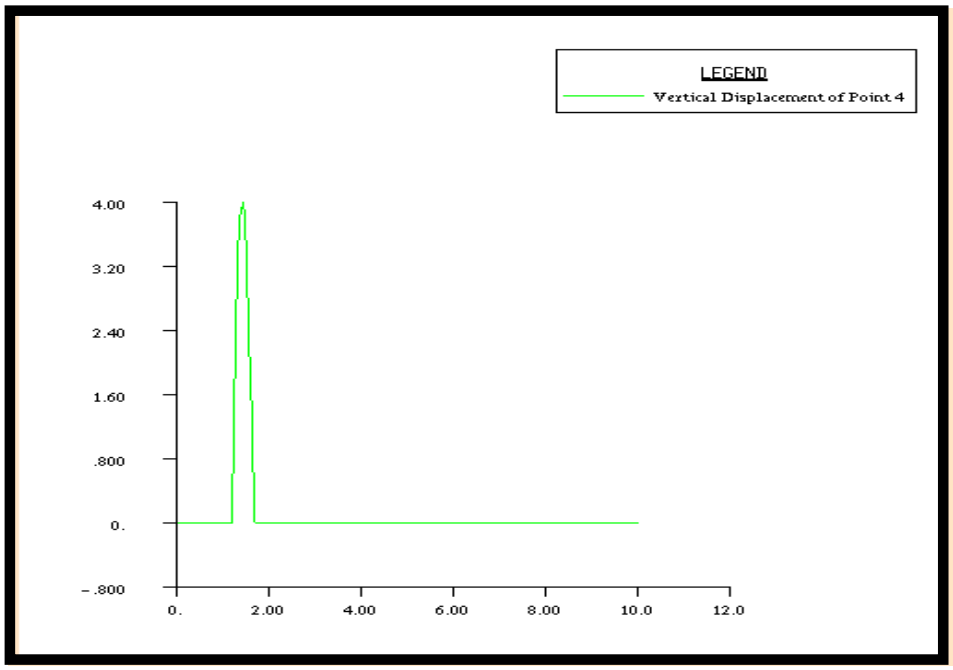


Figure 13.9-Vertical Displacement of Point 5