(2)

structures library

UG-0017

HNCFRAME USER'S GUIDE

Version 1.0

THREE-DIMENSIONAL FRAME ANALYSIS FOR STATIC LOADS

by

Frank R. Johnson

Naval Civil Engineering Laboratory
Port Hueneme, California 93043-5003

July 1989

DISCLAIMER

This program is furnished by the Government and is accepted and used by the recipient with the express understanding that the United States Government makes no warranties, expressed or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the United States shall be under no liability whatsoever to any person by reason of any use made thereof. The program belongs to the Government. Therefore, the recipient further agrees not to assert any proprietary rights therein or to represent this program to anyone as other than a Government program.

PREFACE

The information contained in this report is technical in nature. It does not contain policy of the Naval Civil Engineering Laboratory, the Naval Facilities Engineering Command, the Assistant Commander of Engineering and Design, or the Director of the Engineering System Division. This report is one of a series which is designed to provide technical information and documentation for studies conducted in support of the Naval Facilities Engineering Command Graphics Engineering and Mapping Systems, Engineering Microcomputer Graphics, Computer-Aided Design, Cost Engineering System, and Guide Specifications System as they relate to the Naval Facilities System and life cycle facilities management.

CONTENTS

INTRODUCTION

HNCFRAME is a structural analysis program designed to analyze two- and three-dimensional truss and frame structures. The program only considers static loads and static loads due to temperature changes.

CAPABILITIES

The program has the following features and capabilities:

100 member types distinguishable by material property, section property, or orientation of the local member axis with respect to the global structure axis.

100 members defined by line segments between nodes.

100 joints or nodes.

A truss option to eliminate the computation of member end moments.

Engineering units must be consistent. Thus, to compute correct numerical results for moment, for example, in terms of in.-lbs one must use pounds and inches for all appropriate data values.

The member axes vectors A and B are defined by the cross products L x A = B and B x L = A where L is the axis along the length of the member, positive from end I to end J. The origin of the A and B axes is located at the cross section centroid. This local axis system is related to the global axis system by using direction cosines for the angles between the A axis and the global X, Y, or Z axis. Notice that the A axis vector initially only has to be defined in the plane defined by the A and L vectors, and they do not have to be orthogonal.

Gravity loads are defined for each member by considering the material unit weight, the cross section area, and the member length. Gravity multipliers are used to assign magnitude and direction of the load with respect to the global structure axis system. This feature also permits an equivalent static load analysis for dynamic loads.

Joint loads are defined with respect to the global structure axes. Forces and moments are permitted, however this is the only way concentrated loads can be applied to the structure.

Member loads must be in the planes of the member axes. However, the user defines the loads with respect to the global structure axis. The transformation to the member axis is done by the analysis algorithm. Up to seven member load conditions are permitted for each member where each load condition can be composed of uniform member loads, a temperature change, or both. Notice that only uniform member loads, including temperature change, are permitted.

Straight uniform section (prismatic) members are assumed. Nonprismatic members can be modeled using prismatic segments along the length of each nonprismatic member. The prismatic segment section properties are an average of the section properties of the two ends of the nonprismatic segment.

Principal area moments of inertia I_A and I_B are used. I_A and I_B are respectively computed about the member A and B axes. The torsional rigidity JG is used. The torsional inertia, J, depends on the form and shape of the cross section. For a circular cross section the torsional inertia is the polar moment of inertia; for other sections it is less than the polar moment of inertia and often much smaller. Common values for the torsional inertia have been tabulated in Reference 1*. The shear modulus, G, is computed:

$$G = \frac{E}{2(1 + \nu)}$$

where ν is the Poisson's ratio and E is the modulus of elasticity.

The computed deflection and reaction results are positive with respect to the global structural axes.

The computed axial force, average shear force, torsion, and bending moments follow standard beam theory sign conventions.

Positive axial force implies tension and negative compression.

*1. R.J. Roark. Formulas for stress and strain. New York, N.Y., McGraw-Hill, 1954.

Positive shear, the forces in the direction of the A or B axis on the left end of the member section, sum up to a positive resultant force with respect to the member axis causing the section to move in the positive A or B axis direction. This positive resultant is reacted by a shear force in the opposite direction, defined as positive shear. The positive shear force couple causes a clockwise rotation on a small differential element.

Positive bending moment causes the top of the beam to be in compression and the bottom of the beam to be in tension. The top of the beam is on the positive side of the member A or B axis.

Torque or twisting moment is positive when it follows the right hand rule about the member centroidal axis, L, in the I end to J end direction.

SOLUTION METHOD

The program uses the stiffness method of analysis. This method assumes the external or applied loads and the stiffness properties determined from the member section properties and the member length are known quantities. The displacement of the end of each member, three translations and three rotations, are determined by solving the system of equations using the Choleski method for symmetric matrices. A bandwidth optimizer is used to reduce the stiffness matrix size and improve the computation speed. It is assumed that the user is familiar with the stiffness method of analysis.

PROBLEM DATA PREPARATION

The data file, HNCFRAME.DAT, is made up of lines of data that describe the structure and the loading conditions. The data input lines can be prepared using either a line or screen editor. Since the data lines use the fixed format style, the editor should have a right hand tab feature to facilitate preparing the data file. This will facilitate entering integer data, which must be right justified in the field.

The data that are entered must employ consistent engineering units. For example, if area is entered in inches, then the coordinates must be in inches also. The results will then be in the same engineering unit system.

Structure Description Lines

Title Line - (Line Type A)

<u>Columns</u>	<u>Description</u>
1 - 80	The title line allows one to define the problem or project title.

Problem Size Parameter Line - (Line Type B)

Columns	Description
1 - 5	Number of members in the member definition table, a zero will cause the program to stop.
6 - 10	Number of joints (100 maximum) in the joint coordinate and restraint table.
11 - 15	Blank
16 - 20	Exterior joint number to be used as the interior joint number one for bandwidth optimization. 0 = begin with joint 1.
21 - 25	Exterior joint number to be used as the interior joint number two for bandwidth optimization. 0 = begin with joint 2.
26 - 30	Number of member types (100 maximum) in the member property table.
31 - 35	Maximum number, up to seven on line type D, of member load conditions assigned to a member.
36 - 40	TRUSS if a truss structure is to be analyzed, otherwise this field is blank.
41	Blank
42 - 45	TIME if the real time clock is to be interrogated, otherwise this field is blank.

Member Property Table - (Line Type C)

One line is required for each member type (maximum 100).

Columns	Description
1 - 3	Member type identifier number (1, 2, etc.)
4 - 10	Cross section area
11 - 20	Modulus of elasticity
21 - 30	Thermal expansion empirical coefficient
31 - 40	Area moment of inertia about the member local A axis.
41 - 50	Area moment of inertia about the member local B axis.
51 - 60	Torsional rigidity, the torsion constant (J) multiplied by the shear modulus (G).
61 - 65	Material unit weight
66 - 70	Direction cosine (A axis to X axis)
71 - 75	Direction cosine (A axis to Y axis)
76 - 80	Direction cosine (A axis to Z axis)

Member Definition Table - (Line Type D)

One line is required for each member (maximum 100).

Columns	Description
1 - 5	Joint number at the I end of the member
6 - 10	Joint number at the J end of the member
11 - 15	Member type identification number
16 - 20	1st member load condition identification number defined on line type G.
21 - 25	2nd member load condition identification number
26 - 30	3rd member load condition identification number
31 - 35	4th member load condition identification number
36 - 40	5th member load condition identification number
41 - 45	6th member load condition identification number
46 - 50	7th member load condition identification number

Joint Coordinate and Restraint Table - (Line Type E)

One line for each joint (maximum 100).

Columns	Description
1 - 5	Joint number
6 - 7	Blank
8 - 10	FIX if the joint is to be fixed for a frame or pinned for a truss (if FIX then ignore columns 41 thru 70)
11 - 20	X coordinate
21 - 30	Y coordinate
31 - 40	Z coordinate
41 - 45	Displacement constraint X direction if 1, free if 0
46 - 50	Displacement constraint Y direction if 1, free if 0
51 - 55	Displacement constraint Z direction if 1, free if 0
56 - 60	Rotation constraint about X axis if 1, free if 0
61 - 65	Rotation constraint about Y axis if 1, free if 0
66 - 70	Rotation constraint about Z axis if 1, free if 0

Loading Description Lines

Load System Title Line - (Line Type F)

Columns	Description
1 - 80	The load system or load case title

Load Definition Table - (Line Type G)

Columns	Description
1 - 5	Loading type Gravity load = 1 Joint loads = 2 Member loads = 3 Terminate loading input = 0
	GRAVITY LOAD
6 - 20	Blank
21 - 30	Gravity load in X direction, "Gs" This load is based upon the material unit weight (line type C) for each member
31 - 40	Gravity load in Y direction, "Gs"
41 - 50	Gravity load in Z direction, "Gs"
	JOINT LOADS
6 - 10	Joint number
11 - 20	Blank
21 - 30	Force applied in the X direction
31 - 40	Force applied in the Y direction
41 - 50	Force applied in the Z direction
51 - 60	Moment applied about the X axis
61 - 70	Moment applied about the Y axis
71 - 80	Moment applied about the Z axis
	MEMBER LOADS
All members	
6 - 20	Blank, the load applies to all members
Member load condition identification	
6 - 10	Member load condition identification number This load condition only applies to members assigned on line type D
11 - 20	Blank
Single member	
6 - 10	Joint number for the I end of the member
11 - 15	Joint number for the J end of the member
16 - 20	Blank
Uniform load definition	
21 - 30	Distributed load per unit length in the X direction
31 - 40	Distributed load per unit length in the Y direction
41 - 50	Distributed load per unit length in the Z direction
51 - 60	Temperature change from the unstressed condition

Program Termination

Columns	Description
1 - 80	Load system title (e.g., END LOADING) (Line Type F)
1 - 5	Loading type: Terminate loading input = 0 (Line Type G)
1 - 80	Title line (e.g., END PROBLEM) (Line Type A)
1 - 5	Number of numbers = 0 (Line Type B)

EXECUTION INSTRUCTIONS

The program is designed to run on an IBM-PC compatible personal computer having at least 512K memory and a math coprocessor. There are a number of ways to execute the program, each will be discussed.

Installation

The HNCFRAME program is provided on a single diskette. The diskette contains:

HNCFRAME.EXE	The executable program.
RUNHNC.BAT	The batch execute file.
RMFORT.ERR	The execution error message file

Sample problems found in Appendix A through E:

MMTRUSS.DAT	Plane truss
W2DFRAME.DAT	Plane frame
MPKFRAME.DAT	Gable plane frame
W3DFRAME.DAT	Space frame
GNTRUSS.DAT	Temperature

These files should be copied to the hard disk or to another floppy disk before the program is used. The standard DOS COPY Command can be used:

COPY A:*.* C:	For the hard disk
COPY A:*.* B:	For the floppy disk

The program is now ready to run using one of the methods described below.

Standard Execution

The standard way of executing the program involves preparing an input file and running the program with the print output going to a file. The program assumes the input data is contained in the file HNCFRAME.DAT. The data can be prepared using a line editor program, such as the DOS EDLIN program, or a screen editor program. The screen editor is recommended. The user can prepare this file using the HNCFRAME.DAT file name, or the input can be prepared using any file name then copying the prepared file to HNCFRAME.DAT by using the standard DOS COPY Command.

The program HNCFRAME.EXE is executed by typing HNCFRAME.

The program will write the print output to HNCFRAME.OUT. The HNCFRAME.OUT file can be printed using the standard DOS PRINT Command. However, set the printer to compressed print mode (i.e. at least 16 characters per inch) to accommodate the 132 character output lines on a standard 8.5-inch wide paper. This printing feature can be evoked using a hardware switch or by printing a string of control characters instructing the printer to change to the appropriate mode. These control characters can be sent to the printer via a simple BASIC program, or they can be stored in a file and sent to the printer using the DOS PRINT command. Consult your printer instruction manual for particular instructions.

Input and Output Redirection

The user can use the DOS SET Command to redirect the input, output, or both. The default input and output file names can be changed by:

```
SET HNCFRAME.DAT= your input file name
SET HNCFRAME.OUT= your output file name
```

Then the program can be run by the HNCFRAME command. CAUTION! The DOS redirection mechanism is active for the duration of the run of the program. The SET Command stays set until the connection is broken in the following manner or through a system restart:

```
SET HNCFRAME.DAT=
SET HNCFRAME.OUT=
```

Batch File Execution

The program can be run with a batch file. For example, the batch file might be called RUNHNC.BAT as it is on the supplied diskette. This file could contain the following DOS commands:

```
SET HNCFRAME.DAT=%1
SET HNCFRAME.OUT=LPT1
HNCFRAME
SET HNCFRAME.DAT=
SET HNCFRAME.OUT=
ERASE FORT7
ERASE FORT8
```

The program would then be executed by the command:

```
RUNHNC <your data file name>
```

For example:

```
RUNHNC MMTRUSS.DAT
```

SAMPLE PROBLEMS

The sample problem input files and the associated output files are listed in Appendixes A through E. These problems have been selected to demonstrate features of HNCFRAME which are discussed in each appendix. They also demonstrate the program is computing correctly, because the HNCFRAME results agree with the documented result found in the applicable structural engineering literature reference. Solving documented problems is recommended to insure the program is being used correctly.

ACKNOWLEDGMENTS

HNCFRAME was originally written by Dr. Henry N. Christensen of Brigham Young University. Appreciation is expressed for his continued assistance and furthering of the finite element method, especially in the pre- and post-processing arena. Troy E. Gillum and Steve M. Davis prepared and validated the test problems.

Appendix A

PLANE TRUSS SAMPLE PROBLEM

PLANE TRUSS PROBLEM DEFINITION

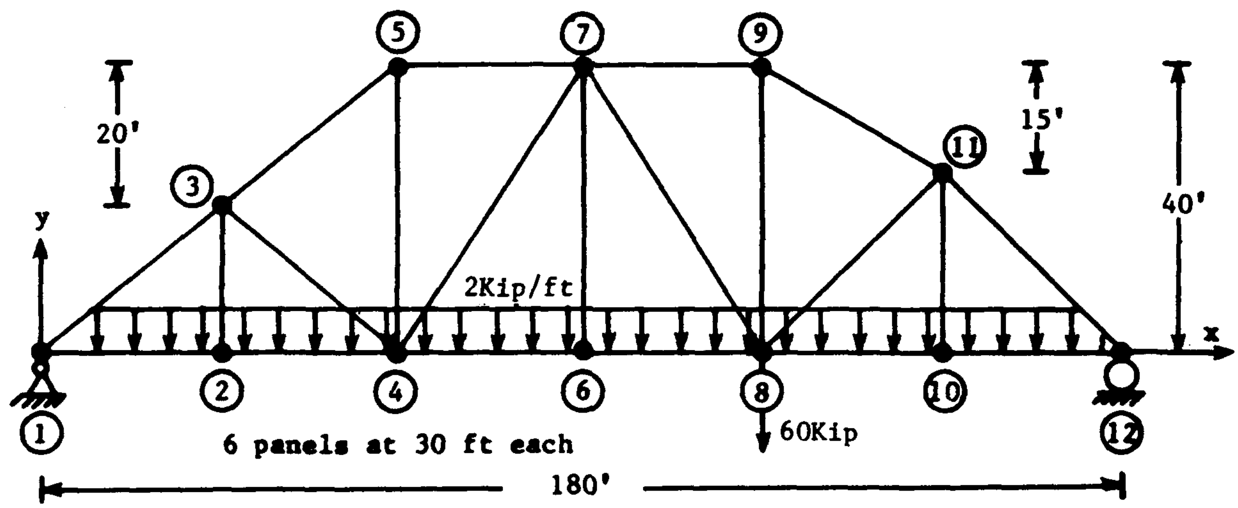
The intent of this sample problem is to demonstrate the plane truss features of HNCFRAME. Furthermore, the problem demonstrates how to handle uniform distributed loads in a truss system. Consistent engineering units are used so the problem is solved in terms of feet and kips.

Section Properties:

Area	20.59 $in.^2$
Major moment of inertia	N/A
Minor moment of inertia	N/A
Torsion constant	N/A

Material Properties:

Modulus of Elasticity	29,000,000 $lb/in.^2$
Shear modulus	N/A
Thermal expansion coefficient	0.0 $in./in./^{\circ}F$
Unit weight	490 lb/ft^3

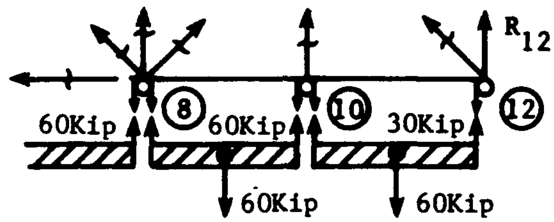


Mantell and Marron example 3-9 and 3-15*

*Mantell, M.I., and Marron, J.F., "Structural Analysis," The Ronald Press Company, New York, NY, 1962, pages 84, 92, 93.

Uniform distributed loads:

Uniform distributed loads can not be applied to a truss member because analysis theory does not permit a truss member to support bending. Therefore, such loads are usually applied through collector beams, simply supported by truss joints. In this problem, the uniform load (Kip/ft^2) covering the bridge deck has been converted to a uniform line load (2 Kip/ft^2) by considering an appropriate tributary area width. The interior joints receive a full panel load and each end joint receives a half panel load as shown below:



DATA INPUT FILE

```
      |                                      COLUMN
LINE  |         1         2         3         4         5         6         7         8
TYPE  |12345678901234567890123456789012345678901234567890123456789012345678901234567890
------|--------------------------------------------------------------------------------
A     |PLANE TRUSS: MANTELL AND MARRON PAGE 84 EXAMPLE 3-9
B     |   21   12    0    0    0    1    1TRUSS
C-1   |  1  0.143     4.2E6               0.000     0.0000       0.0 .490    0    0    0
D-1   |    1    2    1    1
D-2   |    1    3    1    1
D-3   |    2    3    1    1
D-4   |    2    4    1    1
D-5   |    3    4    1    1
D-6   |    3    5    1    1
D-7   |    4    5    1    1
D-8   |    4    6    1    1
D-9   |    4    7    1    1
D-10  |    5    7    1    1
D-11  |    6    7    1    1
D-12  |    6    8    1    1
D-13  |    7    8    1    1
D-14  |    7    9    1    1
D-15  |    8    9    1    1
D-16  |    8   10    1    1
D-17  |    8   11    1    1
D-18  |    9   11    1    1
D-19  |   10   11    1    1
D-20  |   10   12    1    1
D-21  |   11   12    1    1
E-1   |    1            0.0       0.0       0.0    1    1    1    1    1    0
E-2   |    2           30.0       0.0       0.0    0    0    1    1    1    0
E-3   |    3           30.0      20.0       0.0    0    0    1    1    1    0
E-4   |    4           60.0       0.0       0.0    0    0    1    1    1    0
E-5   |    5           60.0      40.0       0.0    0    0    1    1    1    0
E-6   |    6           90.0       0.0       0.0    0    0    1    1    1    0
E-7   |    7           90.0      40.0       0.0    0    0    1    1    1    0
E-8   |    8          120.0       0.0       0.0    0    0    1    1    1    0
E-9   |    9          120.0      40.0       0.0    0    0    1    1    1    0
E-10  |   10          150.0       0.0       0.0    0    0    1    1    1    0
E-11  |   11          150.0      25.0       0.0    0    0    1    1    1    0
E-12  |   12          180.0       0.0       0.0    0    1    1    1    1    0
F     |UNIFORM DECK LOAD APPLIED AS CONCENTRATED LOADS AT LOWER CHORD NODES
G-1   |    2    1                 0.0     -30.0       0.0
G-2   |    2    2                 0.0     -60.0       0.0
G-3   |    2    4                 0.0     -60.0       0.0
G-4   |    2    6                 0.0     -60.0       0.0
G-5   |    2    8                 0.0    -120.0       0.0
G-6   |    2   10                 0.0     -60.0       0.0
G-7   |    2   12                 0.0     -30.0       0.0
G-8   |    0
F     |END LOADING
G-1   |    0
A     |END PROBLEM
B     |    0
```

PRINTED OUTPUT

PLANE TRUSS: MANTELL AND MARRON PAGE 84 EXAMPLE 3-9

JOINT	COORDINATES			DISPLACEMENT	- RESTRAINTS	-	ROTATIONS		
NUMBER	X	Y	Z	X	Y	Z	X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	30.000	0.000	0.000			FIXED	FIXED	FIXED	FIXED
3	30.000	20.000	0.000			FIXED	FIXED	FIXED	FIXED
4	60.000	0.000	0.000			FIXED	FIXED	FIXED	FIXED
5	60.000	40.000	0.000			FIXED	FIXED	FIXED	FIXED
6	90.000	0.000	0.000			FIXED	FIXED	FIXED	FIXED
7	90.000	40.000	0.000			FIXED	FIXED	FIXED	FIXED
8	120.000	0.000	0.000			FIXED	FIXED	FIXED	FIXED
9	120.000	40.000	0.000			FIXED	FIXED	FIXED	FIXED
1C	150.000	0.000	0.000			FIXED	FIXED	FIXED	FIXED
11	150.000	25.000	0.000			FIXED	FIXED	FIXED	FIXED
12	180.000	0.000	0.000		FIXED	FIXED	FIXED	FIXED	FIXED

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	0.1430	0.420E+07	0.000E+00				0.4900	T R U S S	E L E M E N T	

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	1	30.000	2.102	1	3	1	36.056	2.526	2	3	1	20.000	1.401
2	4	1	30.000	2.102	3	4	1	36.056	2.526	3	5	1	36.056	2.526
4	5	1	40.000	2.803	4	6	1	30.000	2.102	4	7	1	50.000	3.503
5	7	1	30.000	2.102	6	7	1	40.000	2.803	6	8	1	30.000	2.102
7	8	1	50.000	3.503	7	9	1	30.000	2.102	8	9	1	40.000	2.803
8	10	1	30.000	2.102	8	11	1	39.051	2.736	9	11	1	33.541	2.350
10	11	1	25.000	1.752	10	12	1	30.000	2.102	11	12	1	39.051	2.736

TOTAL STRUCTURAL WEIGHT 50.787 CENTER OF GRAVITY X = 90.75376, Y = 15.42699, Z = 0.00000

THE STIFFNESS MATRIX FOR 21 EQUATIONS REQUIRES 111 STORAGE LOCATIONS

PRINTED OUTPUT

UNIFORM DECK LOAD APPLIED AS CONCENTRATED LOADS AT LOWER CHORD NODES

C O N C E N T R A T E D   L O A D S

JOINT	F O R C E S A P P L I E D I N T H E X DIRECTION	Y DIRECTION	Z DIRECTION	M O M E N T A P P L I E D A B O U T T H E X AXIS	Y AXIS	Z AXIS
1	0.0000E+00	-0.3000E+02	0.0000E+00			
2	0.0000E+00	-0.6000E+02	0.0000E+00			
4	0.0000E+00	-0.6000E+02	0.0000E+00			
6	0.0000E+00	-0.6000E+02	0.0000E+00			
8	0.0000E+00	-0.1200E+03	0.0000E+00			
10	0.0000E+00	-0.6000E+02	0.0000E+00			
12	0.0000E+00	-0.3000E+02	0.0000E+00			

J O I N T   D I S P L A C E M E N T S

JOINT	D I R E C T I O N X	Y	Z	JOINT	D I R E C T I O N X	Y	Z	JOINT	D I R E C T I O N X	Y	Z
1	0.0000E+00	0.0000E+00	0.0000E+00	2	0.1274E-01	-0.1081E+00	0.0000E+00	3	0.4862E-01	-0.1061E+00	0.0000E+00
4	0.2547E-01	-0.1350E+00	0.0000E+00	5	0.4344E-01	-0.1256E+00	0.0000E+00	6	0.3784E-01	-0.1511E+00	0.0000E+00
7	0.3295E-01	-0.1471E+00	0.0000E+00	8	0.5020E-01	-0.1328E+00	0.0000E+00	9	0.2097E-01	-0.1249E+00	0.0000E+00
10	0.6159E-01	-0.9687E-01	0.0000E+00	11	0.1946E-01	-0.9437E-01	0.0000E+00	12	0.7298E-01	0.0000E+00	0.0000E+00

M E M B E R I	J	A X I A L F O R C E I E N D	J E N D	A X I A L S T R E S S I E N D	J E N D
1	2	0.2550E+03	0.2550E+03	0.1783E+04	0.1783E+04
1	3	-0.3065E+03	-0.3065E+03	-0.2143E+04	-0.2143E+04
2	3	0.6000E+02	0.6000E+02	0.4196E+03	0.4196E+03
2	4	0.2550E+03	0.2550E+03	0.1783E+04	0.1783E+04
3	4	-0.5408E+02	-0.5408E+02	-0.3782E+03	-0.3782E+03
3	5	-0.2524E+03	-0.2524E+03	-0.1765E+04	-0.1765E+04
4	5	0.1400E+03	0.1400E+03	0.9790E+03	0.9790E+03
4	6	0.2475E+03	0.2475E+03	0.1731E+04	0.1731E+04
4	7	-0.6250E+02	-0.6250E+02	-0.4371E+03	-0.4371E+03
5	7	-0.2100E+03	-0.2100E+03	-0.1469E+04	-0.1469E+04
6	7	0.6000E+02	0.6000E+02	0.4196E+03	0.4196E+03
6	8	0.2475E+03	0.2475E+03	0.1731E+04	0.1731E+04
7	8	-0.1250E+02	-0.1250E+02	-0.8741E+02	-0.8741E+02
7	9	-0.2400E+03	-0.2400E+03	-0.1678E+04	-0.1678E+04
8	9	0.1200E+03	0.1200E+03	0.8392E+03	0.8392E+03
8	10	0.2280E+03	0.2280E+03	0.1594E+04	0.1594E+04
8	11	0.1562E+02	0.1562E+02	0.1092E+03	0.1092E+03
9	11	-0.2683E+03	-0.2683E+03	-0.1876E+04	-0.1876E+04
10	11	0.6000E+02	0.6000E+02	0.4196E+03	0.4196E+03
10	12	0.2280E+03	0.2280E+03	0.1594E+04	0.1594E+04
11	12	-0.2968E+03	-0.2968E+03	-0.2075E+04	-0.2075E+04

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	0.1727E-11
1	DISPLACEMENT IN THE Y DIRECTION	0.2000E+03
12	DISPLACEMENT IN THE Y DIRECTION	0.2200E+03

Appendix B

PLANE FRAME SAMPLE PROBLEM

PLANE FRAME PROBLEM DEFINITION

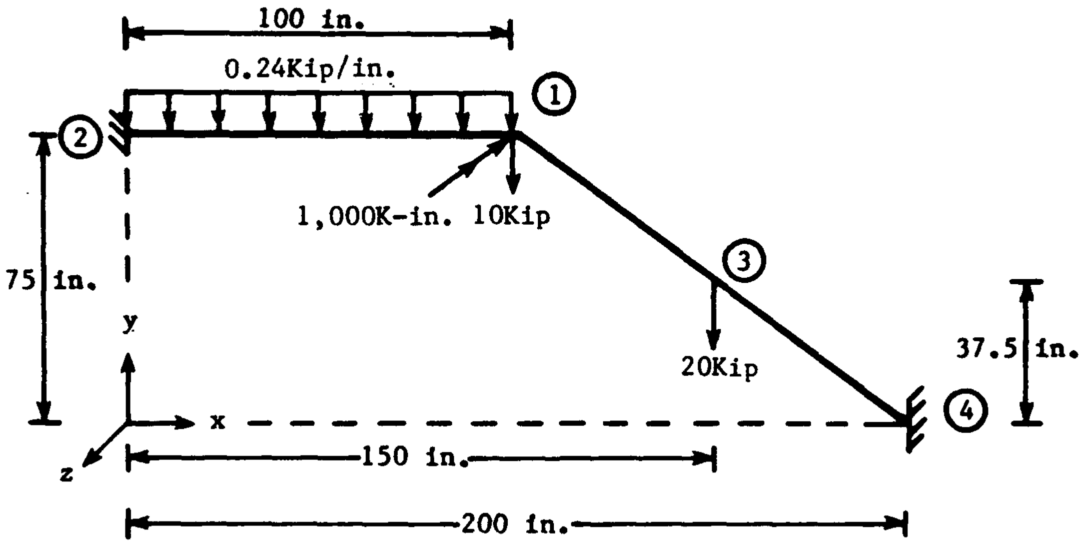
The intent of this sample problem is to demonstrate the plane frame features of HNCFRAME. Furthermore, the problem demonstrates how to handle loads applied along the length of a member and at joints. Consistent engineering units are employed so the results are in terms of inches and kips.

Section properties:

Area	10.0 $in.^2$
Major moment of inertia	1000.0 $in.^4$
Minor moment of inertia	N/A
Torsion constant	N/A

Material properties:

Modulus of elasticity	10000.0 Ksi
Shear modulus	N/A
Thermal expansion coefficient	0.0 in./in./$^{\circ}$F
Unit weight	0.0 lb/ft^3



Weaver plane frame example 3*

*Weaver, William, Jr., "Computer Programs for Structural Analysis," D. Van Nostrand Company, Inc., Princeton, NJ, 1967, pp 129, 134, 138, 139.

DATA INPUT FILE

```
      |                                  COLUMN
LINE  |         1         2         3         4         5         6         7         8
TYPE  |12345678901234567890123456789012345678901234567890123456789012345678901234567890
------+--------------------------------------------------------------------------------
A     |PLANE FRAME: WEAVER PAGES 134, 138, FIGURE 3-3 PAGE 129
B     |    3    4         0    0    1    0
C-1   |  1   10.0   10000.0         0         0    1000.0         0    0  0.0  1.0  0.0
D-1   |    2    1    1
D-2   |    1    3    1
D-3   |    3    4    1
E-1   |    1          100.0      75.0       0.0    0    0    1    1    1    0
E-2   |    2  FIX       0.0      75.0       0.0
E-3   |    3          150.0      37.5       0.0    0    0    1    1    1    0
E-4   |    4  FIX     200.0       0.0       0.0
F     |LOAD CASE 1
G-1   |    3    2    1            0.0     -0.24       0.0       0.0
G-2   |    2    1                 0.0     -10.0       0.0       0.0       0.0   -1000.0
G-3   |    2    3                 0.0     -20.0       0.0       0.0       0.0       0.0
G-4   |    0
F     |END LOADING
G-1   |    0
A     |END PROBLEM
B     |    0
```

PRINTED OUTPUT

PLANE FRAME: WEAVER PAGES 134, 138, FIGURE 3-3 PAGE 129

JOINT NUMBER	COORDINATES X	Y	Z	DISPLACEMENT X	Y	Z	RESTRAINTS - ROTATIONS X	Y	Z
1	100.000	75.000	0.000			FIXED	FIXED	FIXED	
2	0.000	75.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
3	150.000	37.500	0.000			FIXED	FIXED	FIXED	
4	200.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	10.0000	0.100E+05	0.000E+00	0.0000	1000.0000	0.000E+00	0.0000	0.0000	1.0000	0.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
2	1	1	100.000	0.280	1	3	1	62.500	0.175	3	4	1	62.500	0.175

TOTAL STRUCTURAL WEIGHT 0.630 CENTER OF GRAVITY X = 105.55556, Y = 54.16667, Z = 0.00000

THE STIFFNESS MATRIX FOR 6 EQUATIONS REQUIRES 21 STORAGE LOCATIONS

PRINTED OUTPUT

LOAD CASE 1

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	FORCES APPLIED IN THE Y DIRECTION	FORCES APPLIED IN THE Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	MOMENT APPLIED ABOUT THE Y AXIS	MOMENT APPLIED ABOUT THE Z AXIS
1	0.0000E+00	-0.1000E+02	0.0000E+00	0.0000E+00	0.0000E+00	-0.1000E+04
3	0.0000E+00	-0.2000E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	DISTRIBUTED LOADING PER UNIT LENGTH Y DIRECTION	DISTRIBUTED LOADING PER UNIT LENGTH Z DIRECTION	TEMPERATURE CHANGE	MEMBER	DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	DISTRIBUTED LOADING PER UNIT LENGTH Y DIRECTION	DISTRIBUTED LOADING PER UNIT LENGTH Z DIRECTION	TEMPERATURE CHANGE
2	1	0.000	-0.240	0.000	0.000					

JOINT	DISPLACEMENTS IN THE X DIRECTION	DISPLACEMENTS IN THE Y DIRECTION	DISPLACEMENTS IN THE Z DIRECTION	ROTATIONS ABOUT THE X AXIS	ROTATIONS ABOUT THE Y AXIS	ROTATIONS ABOUT THE Z AXIS
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1	-0.2026E-01	-0.9936E-01	0.0000E+00	0.0000E+00	0.0000E+00	-0.1798E-02
3	-0.3375E-01	-0.8742E-01	0.0000E+00	0.0000E+00	0.0000E+00	0 1549E-02
4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

MEMBER I	MEMBER J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	AVERAGE SHEAR FORCE B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	BENDING MOMENTS ABOUT THE A AXIS J END	BENDING MOMENTS ABOUT THE B AXIS I END	BENDING MOMENTS ABOUT THE B AXIS J END
2	1	-0.2026E+02	0.1138E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.4366E+03	-0.3229E+03
1	3	-0.2873E+02	-0.4533E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.6771E+03	0.3938E+03
3	4	-0.4073E+02	-0.2053E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.3938E+03	-0.8895E+03

JOINT NUMBER	RESTRAINT CONDITION	REACTION
2	DISPLACEMENT IN THE X DIRECTION	0.2026E+02
2	DISPLACEMENT IN THE Y DIRECTION	0.1314E+02
2	ROTATION ABOUT THE Z AXIS	0.4366E+03
4	DISPLACEMENT IN THE X DIRECTION	-0.2026E+02
4	DISPLACEMENT IN THE Y DIRECTION	0.4086E+02
4	ROTATION ABOUT THE Z AXIS	-0.8895E+03

Appendix C

GABLE PLANE FRAME SAMPLE PROBLEM

GABLE PLANE FRAME PROBLEM DEFINITION

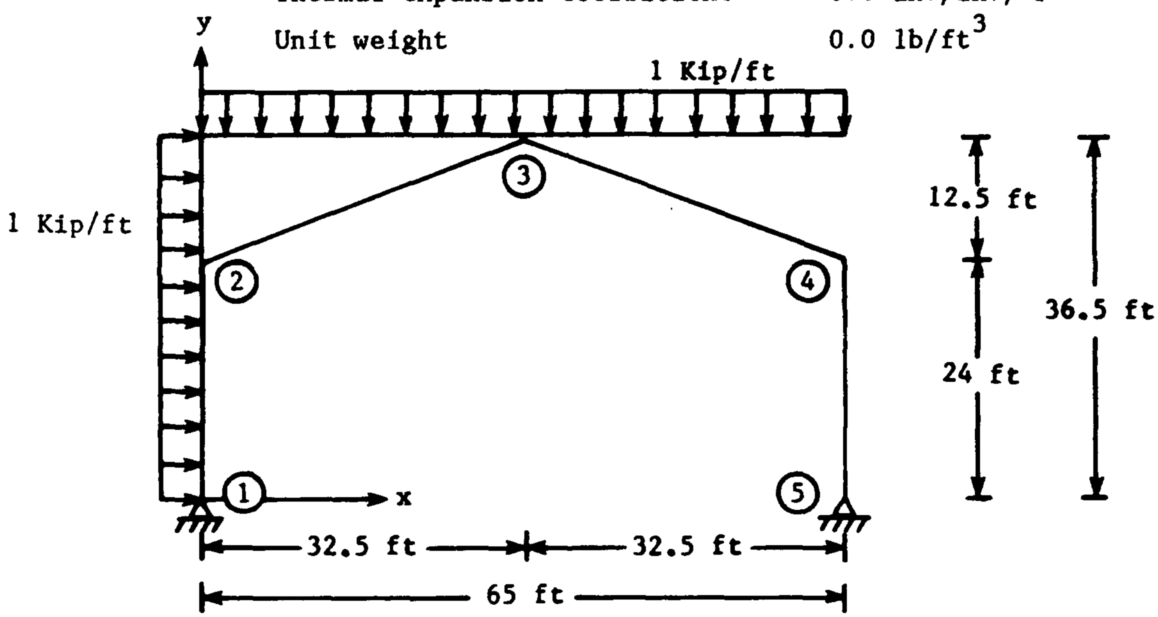
The intent of this sample problem is to demonstrate how member loads are applied to sloping members. Consistent engineering units are used so the problem is solved in terms of feet and kips.

Section Properties:

Area	17.0 in.^{2}
Major moment of inertia	475.0 in.^{4}
Minor moment of inertia	N/A
Torsion constant	N/A

Material Properties:

Modulus of Elasticity	29,000,000 lb/in.^{2}
Shear modulus	N/A
Thermal expansion coefficient	0.0 in./in./^{o}F
Unit weight	0.0 lb/ft^3



Martin P. Korn single span rigid frame design tables*

Two methods for computing the fixed end reactions for the sloping members are demonstrated in this sample problem. HNCFRAME uses the true member length of the sloping member to compute the fixed end reactions, which produces larger moment and shear results than shown in most handbook solutions for this problem. The handbook solutions (e.g. M.P. Korn) usually apply the uniform load to the horizontal and vertical projections of the sloping member which produces the smaller values. The second set of loading conditions in the sample problem have the uniform load reduced by the appropriate trigonometric multiplier to match the handbook results.

*Martin P. Korn, "Steel Rigid Frames Design and Construction Manual," J.W. Edwards, Inc., Ann Arbor, MI, 1953, pp 34 and 35.

DATA INPUT FILE

```
LINE    |                                     COLUMN
        |         1         2         3         4         5         6         7         8
TYPE    |12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------+--------------------------------------------------------------------------------
A       |GABLE PLANE FRAME: MARTIN P KORN, PAGE 34 L=65 H=24 F=12.5
B       |    4    5         1    2    2    4FRAME TIME
C-1     |  1   .118   4.176E6         0         0    0.0229         0  0.0  0.0  1.0  0.0
C-2     |  2   .118   4.176E6         0         0    0.0229         0  0.0 -1.0  0.0  0.0
D-1     |    1    2    2    0    2    0    4
D-2     |    2    3    1    1    2    3    5
D-3     |    3    4    1    1    0    3    0
D-4     |    4    5    2    0    0    0    0
E-1     |    1            0.0       0.0       0.0    1    1    1    1    1    0
E-2     |    2            0.0      24.0       0.0    0    0    1    1    1    0
E-3     |    3          32.50     36.50       0.0    0    0    1    1    1    0
E-4     |    4          65.00     24.00       0.0    0    0    1    1    1    0
E-5     |    5          65.00       0.0       0.0    1    1    1    1    1    0
F       |UNIFORM ROOF LOADING - SLOPING MEMBER LENGTH
G-1     |    3    1                 0.0      -1.0       0.0
G-2     |    0
F       |UNIFORM LOAD ON ONE SIDE - SLOPING MEMBER LENGTH
G-1     |    3    2                 1.0       0.0       0.0
G-2     |    0
F       |UNIFORM ROOF LOADING - HORIZONTAL PROJECTION CORRECTION
G-1     |    3    3                 0.0    -0.933       0.0
G-2     |    0
F       |UNIFORM LOAD ON ONE SIDE - VERTICAL PROJECTION CORRECTION
G-1     |    3    4                 1.0       0.0       0.0
G-2     |    3    5               0.359       0.0       0.0
G-3     |    0
F       |END LOADING
G-1     |    0
A       |END PROBLEM
B       |    0
```

PRINTED OUTPUT

GABLE PLANE FRAME: MARTIN P KORN, PAGE 34 L=65 H=24 F=12.5

REAL TIME CLOCK INTERROGATED AT 10:31:38:31

JOINT	COORDINATES			DISPLACEMENT - RESTRAINTS - ROTATIONS					
NUMBER	X	Y	Z	X	Y	Z	X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	
2	0.000	24.000	0.000			FIXED	FIXED	FIXED	
3	32.500	36.500	0.000			FIXED	FIXED	FIXED	
4	65.000	24.000	0.000			FIXED	FIXED	FIXED	
5	65.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	AREA MOMENT OF INERTIA B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	0.1180	0.418E+07	0.000E+00	0.0000	0.0229	0.000E+00	0.0000	0.0000	1.0000	0.0000
2	0.1180	0.418E+07	0.000E+00	0.0000	0.0229	0.000E+00	0.0000	-1.0000	0.0000	0.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	2	24.000	0.000	2	3	1	34.821	0.000	3	4	1	34.821	0.000
4	5	2	24.000	0.000										

THE STIFFNESS MATRIX FOR 11 EQUATIONS REQUIRES 44 STORAGE LOCATIONS

REAL TIME CLOCK INTERROGATED AT 10:31:38:97

REAL TIME CLOCK INTERROGATED AT 10:31:39: 2

PRINTED OUTPUT

UNIFORM ROOF LOADING - SLOPING MEMBER LENGTH

MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE	MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE
2	3	0.000	-1.000	0.000	0.000	3	4	0.000	-1.000	0.000	0.000

	DISPLACEMENTS IN THE			ROTATIONS ABOUT THE		
JOINT	X DIRECTION	Y DIRECTION	Z DIRECTION	X AXIS	Y AXIS	Z AXIS
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2134E-01
2	-0.2395E+00	-0.1696E-02	0.0000E+00	0.0000E+00	0.0000E+00	-0.1274E-01
3	0.4480E-13	-0.6276E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5520E-15
4	0.2395E+00	-0.1696E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.1274E-01
5	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.2134E-01

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	J END	B AXIS I END	J END
1	2	-0.3482E+02	-0.1131E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2765E-13	-0.2715E+03
2	3	-0.1681E+02	0.1219E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.2715E+03	0.1529E+03
3	4	-0.1681E+02	-0.1219E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1529E+03	-0.2715E+03
4	5	-0.3482E+02	-0.1131E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2715E+03	0.2842E-13

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	0.1131E+02
1	DISPLACEMENT IN THE Y DIRECTION	0.3482E+02
5	DISPLACEMENT IN THE X DIRECTION	-0.1131E+02
5	DISPLACEMENT IN THE Y DIRECTION	0.3482E+02

PRINTED OUTPUT

UNIFORM LOAD ON ONE SIDE - SLOPING MEMBER LENGTH

MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE	MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE
1	2	1.000	0.000	0.000	0.000	2	3	1.000	0.000	0.000	0.000

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.1567E+00
2	0.3001E+01	0.1005E-02	0.0000E+00	0.0000E+00	0.0000E+00	-0.6781E-01
3	0.2919E+01	0.2157E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.3736E-01
4	0.2833E+01	-0.1005E-02	0.0000E+00	0.0000E+00	0.0000E+00	-0.7527E-01
5	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.1395E+00

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	A AXIS J END	B AXIS I END	B AXIS J END
1	2	0.2064E+02	0.2551E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.7105E-14	0.6122E+03
2	3	0.3768E+01	-0.2066E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.6122E+03	-0.1072E+03
3	4	-0.2730E+02	-0.1161E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.1072E+03	-0.5115E+03
4	5	-0.2064E+02	-0.2131E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5115E+03	0.3979E-12

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-0.3751E+02
1	DISPLACEMENT IN THE Y DIRECTION	-0.2064E+02
5	DISPLACEMENT IN THE X DIRECTION	-0.2131E+02
5	DISPLACEMENT IN THE Y DIRECTION	0.2064E+02

PRINTED OUTPUT

UNIFORM ROOF LOADING - HORIZONTAL PROJECTION CORRECTION

MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH			TEMPERATURE	MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH			TEMPERATURE
		X DIRECTION	Y DIRECTION	Z DIRECTION	CHANGE			X DIRECTION	Y DIRECTION	Z DIRECTION	CHANGE
2	3	0.000	-0.933	0.000	0.000	3	4	0.000	-0.933	0.000	0.000

	DISPLACEMENTS IN THE			ROTATIONS ABOUT THE		
JOINT	X DIRECTION	Y DIRECTION	Z DIRECTION	X AXIS	Y AXIS	Z AXIS
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1991E-01
2	-0.2234E+00	-0.1582E-02	0.0000E+00	0.0000E+00	0.0000E+00	-0.1188E-01
3	0.4173E-13	-0.5856E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5145E-15
4	0.2234E+00	-0.1582E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.1188E-01
5	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.1991E-01

MEMBER		AVERAGE	AVERAGE SHEAR FORCE		TORSION	BENDING MOMENTS ABOUT THE			
I	J	AXIAL FORCE	A AXIS	B AXIS		A AXIS		B AXIS	
						I END	J END	I END	J END
1	2	-0.3249E+02	-0.1056E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.2765E-13	-0.2533E+03
2	3	-0.1568E+02	0.1137E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.2533E+03	0.1426E+03
3	4	-0.1568E+02	-0.1137E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1426E+03	-0.2533E+03
4	5	-0.3249E+02	-0.1056E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2533E+03	0.4263E-13

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	0.1056E+02
1	DISPLACEMENT IN THE Y DIRECTION	0.3249E+02
5	DISPLACEMENT IN THE X DIRECTION	-0.1056E+02
5	DISPLACEMENT IN THE Y DIRECTION	0.3249E+02

PRINTED OUTPUT

UNIFORM LOAD ON ONE SIDE - VERTICAL PROJECTION CORRECTION

MEMBER	DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE	MEMBER	DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE
1 2	1.000	0.000	0.000	0.000	2 3	0.359	0.000	0.000	0.000

	DISPLACEMENTS IN THE			ROTATIONS ABOUT THE		
JOINT	X DIRECTION	Y DIRECTION	Z DIRECTION	X AXIS	Y AXIS	Z AXIS
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.8661E-01
2	0.1606E+01	0.4991E-03	0.0000E+00	0.0000E+00	0.0000E+00	-0.3356E-01
3	0.1549E+01	0.1497E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1901E-01
4	0.1490E+01	-0.4991E-03	0.0000E+00	0.0000E+00	0.0000E+00	-0.4023E-01
5	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.7300E-01

MEMBER		AVERAGE	AVERAGE SHEAR FORCE		TORSION	BENDING MOMENTS ABOUT THE			
I	J	AXIAL FORCE	A AXIS	B AXIS		A AXIS		B AXIS	
						I END	J END	I END	J END
1	2	0.1025E+02	0.1362E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.7105E-14	0.3268E+03
2	3	-0.6449E+00	-0.1123E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.3268E+03	-0.6416E+02
3	4	-0.1384E+02	-0.5659E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	-0.6416E+02	-0.2612E+03
4	5	-0.1025E+02	-0.1088E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.2612E+03	0.2132E-12

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-0.2562E+02
1	DISPLACEMENT IN THE Y DIRECTION	-0.1025E+02
5	DISPLACEMENT IN THE X DIRECTION	-0.1088E+02
5	DISPLACEMENT IN THE Y DIRECTION	0.1025E+02

Appendix D

SPACE FRAME SAMPLE PROBLEM

SPACE FRAME PROBLEM DEFINITION

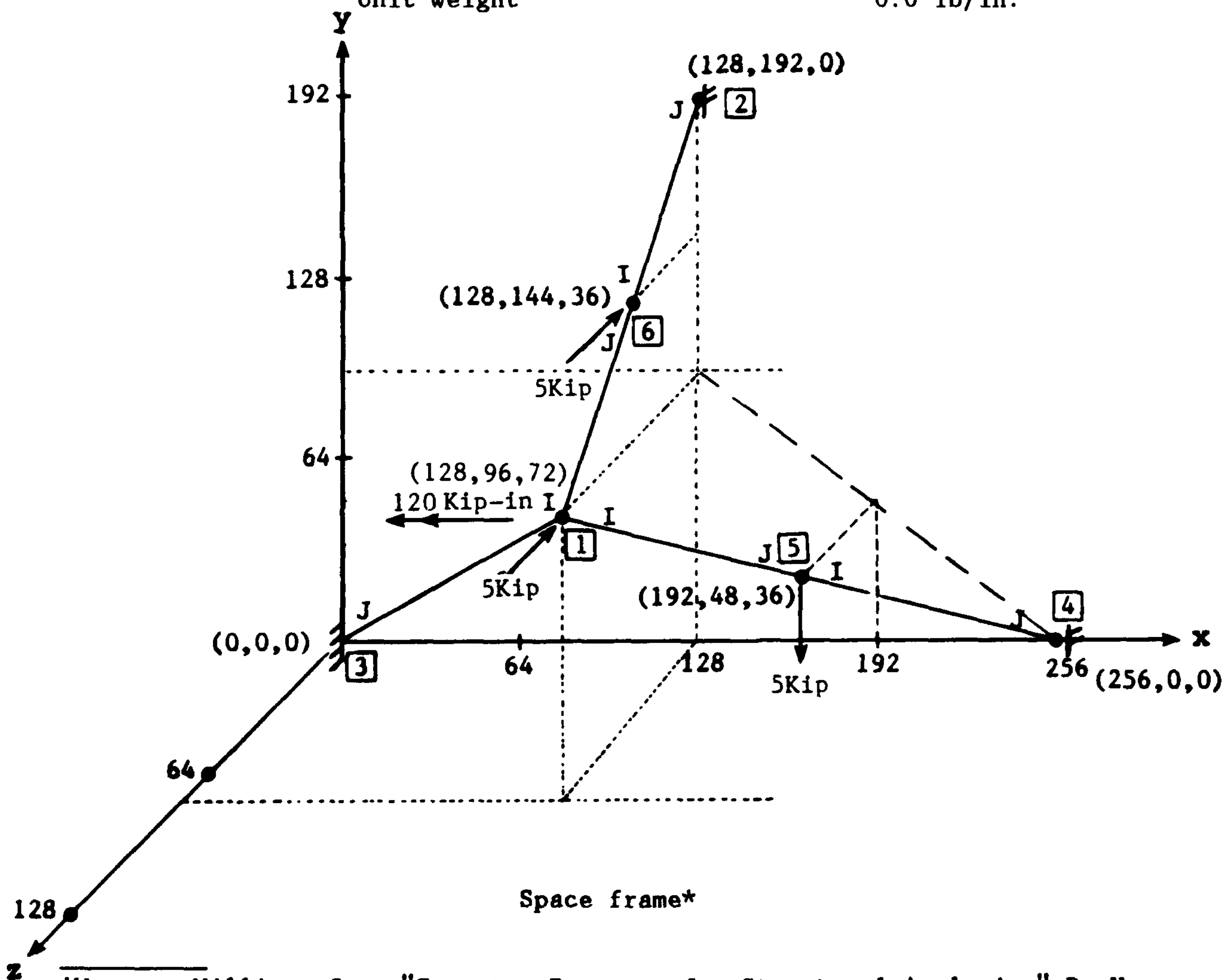
The intent of this sample problem is to demonstrate the space frame features of HNCFRAME. Consistent engineering units are used so the problem is solved in terms of inches and kips.

Section Properties:

Area	9.0 in.^{2}
Major moment of inertia	80.0 in.^{4}
Minor moment of inertia	28.0 in.^{4}
Torsion constant	64.0 in.^{4}

Material Properties:

Modulus of Elasticity	10,000,000 lb/in.^{2}
Shear modulus	4,000,000 lb/in.^{2}
Thermal expansion coefficient	0.0 in./in./^{o}F
Unit weight	0.0 lb/in.^{3}



Space frame*

*Weaver, William, Jr., "Computer Programs for Structural Analysis," D. Van Nostrand Company, Inc. Princton, N.J. 1967, pp 133, 134, 148, 149.

DATA INPUT FILE

```
      |                                     COLUMN
LINE  |          1         2         3         4         5         6         7         8
TYPE  | 12345678901234567890123456789012345678901234567890123456789012345678901234567890
------+---------------------------------------------------------------------------------
A     | SPACE FRAME:  WEAVER, PAGES 134, 148, 149, FIGURE 3-9, PAGE 133
B     |     5    6         0    0    1    1
C-1   |   1    9.0   10000.0       0.0      28.0      80.0   256000.    0    0    0   -1
D-1   |     6    2    1    1
D-2   |     1    6    1    1
D-3   |     3    1    1    1
D-4   |     1    5    1    1
D-5   |     5    4    1    1
E-1   |     1         128.0      96.0      72.0
E-2   |     2  FIX    128.0     192.0       0.0
E-3   |     3  FIX      0.0       0.0       0.0
E-4   |     4  FIX    256.0       0.0       0.0
E-5   |     5         192.0      48.0      36.0
E-6   |     6         128.0     144.0      36.0
F     | LOAD CASE 1
G-1   |     2    1                 0.0       0.0     -5.00    -120.0       0.0       0.0
G-2   |     0
F     | LOAD CASE 2
G-1   |     2    5                 0.0      -5.0       0.0       0.0       0.0       0.0
G-2   |     2    6                 0.0       0.0      -5.0       0.0       0.0       0.0
G-3   |     0
F     | END LOADING
G-1   |     0
A     | END PROBLEM
B     |     0
```

PRINTED OUTPUT

SPACE FRAME: WEAVER, PAGES 134, 148, 149, FIGURE 3-9, PAGE 133

JOINT	COORDINATES			DISPLACEMENT	- RESTRAINTS	-	ROTATIONS		
NUMBER	X	Y	Z	X	Y	Z	X	Y	Z
1	128.000	96.000	72.000						
2	128.000	192.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
3	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
4	256.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
5	192.000	48.000	36.000						
6	128.000	144.000	36.000						

MEMBER	SECTION	MODULUS OF	THERMAL EXP.	AREA MOMENT OF INERTIA		TORSIONAL	UNIT	REFERENCE VECTOR FOR A AXIS		
TYPE	AREA	ELASTICITY	COEFFICIENT	A AXIS	B AXIS	RIGIDITY	WEIGHT	A1	A2	A3
1	9.0000	0.100E+05	0.000E+00	28.0000	80.0000	0.256E+06	0.0000	0.0000	0.0000	-1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
6	2	1	60.000	0.000	6	1	1	60.000	0.000	1	3	1	175.454	0.000
1	5	1	87.727	0.000	5	4	1	87.727	0.000					

THE STIFFNESS MATRIX FOR 18 EQUATIONS REQUIRES 135 STORAGE LOCATIONS

PRINTED OUTPUT

LOAD CASE 1

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	FORCES APPLIED IN THE Y DIRECTION	FORCES APPLIED IN THE Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	MOMENT APPLIED ABOUT THE Y AXIS	MOMENT APPLIED ABOUT THE Z AXIS
1	0.0000E+00	0.0000E+00	-0.5000E+01	-0.1200E+03	0.0000E+00	0.0000E+00

JOINT	DISPLACEMENTS IN THE X DIRECTION	DISPLACEMENTS IN THE Y DIRECTION	DISPLACEMENTS IN THE Z DIRECTION	ROTATIONS ABOUT THE X AXIS	ROTATIONS ABOUT THE Y AXIS	ROTATIONS ABOUT THE Z AXIS
6	-0.2401E-16	-0.2540E-01	-0.3873E-01	0.8082E-03	-0.2636E-18	-0.3021E-18
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1	0.5927E-19	-0.7729E-03	-0.1075E-01	-0.2779E-02	0.9141E-18	0.1317E-17
3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	0.6119E-16	-0.2540E-01	0.2797E-01	-0.4622E-03	0.7650E-03	0.6289E-03
4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

MEMBER I	MEMBER J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	AVERAGE SHEAR FORCE B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	A AXIS J END	B AXIS I END	B AXIS J END
6	2	-0.4376E+01	0.9768E+00	-0.1868E-15	0.1263E-15	-0.3739E-14	0.7471E-14	-0.1853E+02	0.4008E+02
6	1	-0.4376E+01	-0.9768E+00	-0.1868E-15	0.1263E-15	0.3739E-14	0.1495E-13	-0.1853E+02	-0.7714E+02
1	3	-0.2481E+01	-0.2429E+00	-0.5018E-01	-0.2958E+01	-0.5858E+01	0.2946E+01	0.2892E+02	-0.1371E+02
1	5	-0.2481E+01	-0.2429E+00	0.5018E-01	0.2958E+01	0.5858E+01	0.1456E+01	0.2892E+02	0.7604E+01
5	4	-0.2481E+01	-0.2429E+00	0.5018E-01	0.2958E+01	0.1456E+01	-0.2946E+01	0.7604E+01	-0.1371E+02

JOINT NUMBER	RESTRAINT CONDITION	REACTION
2	DISPLACEMENT IN THE X DIRECTION	0.1868E-15
2	DISPLACEMENT IN THE Y DIRECTION	-0.2915E+01
2	DISPLACEMENT IN THE Z DIRECTION	0.3407E+01
2	ROTATION ABOUT THE X AXIS	-0.4008E+02
2	ROTATION ABOUT THE Y AXIS	0.4584E-14
2	ROTATION ABOUT THE Z AXIS	0.5901E-14
3	DISPLACEMENT IN THE X DIRECTION	0.1859E+01
3	DISPLACEMENT IN THE Y DIRECTION	0.1457E+01
3	DISPLACEMENT IN THE Z DIRECTION	0.7965E+00
3	ROTATION ABOUT THE X AXIS	-0.7033E+01
3	ROTATION ABOUT THE Y AXIS	0.1186E+02
3	ROTATION ABOUT THE Z AXIS	0.3901E+01
4	DISPLACEMENT IN THE X DIRECTION	-0.1859E+01
4	DISPLACEMENT IN THE Y DIRECTION	0.1457E+01
4	DISPLACEMENT IN THE Z DIRECTION	0.7965E+00
4	ROTATION ABOUT THE X AXIS	-0.7033E+01
4	ROTATION ABOUT THE Y AXIS	-0.1186E+02
4	ROTATION ABOUT THE Z AXIS	-0.3901E+01

PRINTED OUTPUT

LOAD CASE 2

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
5	0.0000E+00	-0.5000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	0.0000E+00	0.0000E+00	-0.5000E+01	0.0000E+00	0.0000E+00	0.0000E+00

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
6	0.5215E-01	-0.4965E-01	-0.6867E-01	0.6902E-03	0.1660E-02	-0.1594E-03
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1	-0.2181E-03	-0.3289E-02	-0.5982E-02	-0.2423E-02	0.1870E-03	-0.4495E-02
3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	-0.2817E+00	-0.4283E+00	0.6202E-01	0.5755E-03	-0.7450E-04	0.1153E-02
4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	A AXIS J END	B AXIS I END	B AXIS J END
6	2	-0.2219E+01	0.2845E+01	0.4060E+00	-0.6073E+01	0.8129E+01	-0.1623E+02	-0.7615E+02	0.9456E+02
6	1	0.7814E+00	0.1155E+01	0.4060E+00	-0.6073E+01	-0.8129E+01	-0.3249E+02	-0.7615E+02	-0.6862E+01
1	3	-0.2264E+01	-0.2419E+00	0.1813E+00	-0.5121E+01	0.2125E+02	-0.1056E+02	0.2853E+02	-0.1391E+02
1	5	-0.7328E+00	0.4206E+00	-0.1729E+01	0.3673E-01	-0.5604E+02	0.9561E+02	-0.3951E+01	0.3295E+02
5	4	-0.3469E+01	-0.8105E+00	0.2271E+01	0.3673E-01	0.9561E+02	-0.1036E+03	0.3295E+02	-0.3816E+02

JOINT NUMBER	RESTRAINT CONDITION	REACTION
2	DISPLACEMENT IN THE X DIRECTION	-0.4060E+00
2	DISPLACEMENT IN THE Y DIRECTION	-0.6774E-01
2	DISPLACEMENT IN THE Z DIRECTION	0.3607E+01
2	ROTATION ABOUT THE X AXIS	-0.9456E+02
2	ROTATION ABOUT THE Y AXIS	-0.1460E+02
2	ROTATION ABOUT THE Z AXIS	-0.9343E+01
3	DISPLACEMENT IN THE X DIRECTION	0.1840E+01
3	DISPLACEMENT IN THE Y DIRECTION	0.1153E+01
3	DISPLACEMENT IN THE Z DIRECTION	0.7085E+00
3	ROTATION ABOUT THE X AXIS	-0.1143E+01
3	ROTATION ABOUT THE Y AXIS	0.1653E+02
3	ROTATION ABOUT THE Z AXIS	-0.7525E+01
4	DISPLACEMENT IN THE X DIRECTION	-0.1434E+01
4	DISPLACEMENT IN THE Y DIRECTION	0.3914E+01
4	DISPLACEMENT IN THE Z DIRECTION	0.6843E+00
4	ROTATION ABOUT THE X AXIS	-0.5689E+02
4	ROTATION ABOUT THE Y AXIS	-0.5026E+01
4	ROTATION ABOUT THE Z AXIS	-0.9453E+02

Appendix E

PLANE TRUSS TEMPERATURE SAMPLE PROBLEM

PLANE TRUSS TEMPERATURE PROBLEM DEFINITION

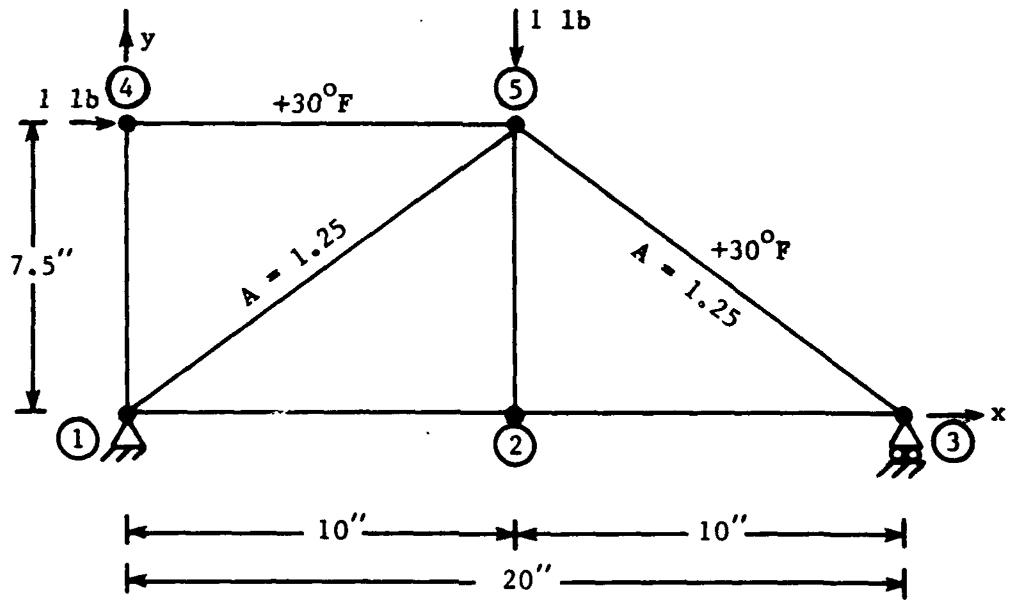
The intent of this problem is to demonstrate the temperature load features of HNCFRAME. It also demonstrates how to handle a problem with two sets of section properties.

Section Properties:

Area	1.00 $in.^2$
	1.25 $in.^2$
Major moment of inertia	N/A
Minor moment of inertia	N/A
Torsion constant	N/A

Material Properties:

Modulus of Elasticity	10,000,000 $lb/in.^2$
Shear modulus	N/A
Thermal expansion coefficient	0.000006 in./in./^{o}F
Unit weight	0.0 lb/ft^3



Plane truss with temperature loading*

*Ghali, A. and Neville, A.M., "Structural Analysis a Unified Classical and Matrix Approach," Halsted Press, New York, NY 1972, pp 119-122.

DATA INPUT FILE

```
LINE |                                  COLUMN
     |         1         2         3         4         5         6         7         8
TYPE |12345678901234567890123456789012345678901234567890123456789012345678901234567890
-----+--------------------------------------------------------------------------------
A    |PLANE TRUSS: GHALI & NEVILLE TEMPERATURE CHANGE EXAMPLE 6-2, PAGES 119-122
B    |    7    5         0    0    2    1TRUSS
C-1  |  1    1.0      .1E8     .6E-5       0.0       0.0       0.0  0.0    0    0    0
C-2  |  2   1.25      .1E8     .6E-5       0.0       0.0       0.0  0.0    0    0    0
D-1  |    1    2    1
D-2  |    2    3    1
D-3  |    1    4    1
D-4  |    2    5    1
D-5  |    4    5    1    1
D-6  |    5    3    2    1
D-7  |    1    5    2
E-1  |    1           0.0       0.0       0.0    1    1    1    1    1    0
E-2  |    2          10.0       0.0       0.0    0    0    1    1    1    0
E-3  |    3          20.0       0.0       0.0    0    1    1    1    1    0
E-4  |    4           0.0       7.5       0.0    0    0    1    1    1    0
E-5  |    5          10.0       7.5       0.0    0    0    1    1    1    0
F    |LOAD CASE ONE
G-1  |    2    4                 1.0
G-2  |    2    5                          -1.0
G-3  |    0
F    |LOAD CASE ONE TEMPERATURE LOAD (CHANGE OF 30 DEGREES ON TWO MEMBERS)
G-1  |    3    1                 0.0       0.0       0.0      30.0
G-2  |    0
F    |END LOAD CASES
G-1  |    0
A    |END PROBLEM
B    |    0
```

PRINTED OUTPUT

PLANE TRUSS: GHALI & NEVILLE TEMPERATURE CHANGE EXAMPLE 6-2, PAGES 119-122

JOINT	COORDINATES			DISPLACEMENT	- RESTRAINTS	-	ROTATIONS		
NUMBER	X	Y	Z	X	Y	Z	X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	10.000	0.000	0.000			FIXED	FIXED	FIXED	FIXED
3	20.000	0.000	0.000		FIXED	FIXED	FIXED	FIXED	FIXED
4	0.000	7.500	0.000			FIXED	FIXED	FIXED	FIXED
5	10.000	7.500	0.000			FIXED	FIXED	FIXED	FIXED

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	1.0000	0.100E+08	0.600E-05				0.0000	T R U S S	E L E M E N T	
2	1.2500	0.100E+08	0.600E-05				0.0000	T R U S S	E L E M E N T	

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	1	10.000	0.000	1	4	1	7.500	0.000	1	5	2	12.500	0.000
2	5	1	7.500	0.000	2	3	1	10.000	0.000	4	5	1	10.000	0.000
5	3	2	12.500	0.000										

THE STIFFNESS MATRIX FOR 7 EQUATIONS REQUIRES 28 STORAGE LOCATIONS

PRINTED OUTPUT

LOAD CASE ONE

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
4	0.1000E+01	0.0000E+00	0.0000E+00			
5	0.0000E+00	-0.1000E+01	0.0000E+00			

JOINT DISPLACEMENTS

JOINT	DIRECTION X	Y	Z	JOINT	DIRECTION X	Y	Z	JOINT	DIRECTION X	Y	Z
1	0.0000E+00	0.0000E+00	0.0000E+00	2	0.1167E-05	-0.2944E-05	0.0000E+00	4	0.2948E-05	0.0000E+00	0.0000E+00
5	0.1948E-05	-0.2944E-05	0.0000E+00	3	0.2333E-05	0.0000E+00	0.0000E+00				

MEMBER I	J	AXIAL FORCE I END	J END	AXIAL STRESS I END	J END
1	2	0.1167E+01	0.1167E+01	0.1167E+01	0.1167E+01
1	4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1	5	-0.2083E+00	-0.2083E+00	-0.1667E+00	-0.1667E+00
2	5	0.1129E-14	0.1129E-14	0.1129E-14	0.1129E-14
2	3	0.1167E+01	0.1167E+01	0.1167E+01	0.1167E+01
4	5	-0.1000E+01	-0.1000E+01	-0.1000E+01	-0.1000E+01
5	3	-0.1458E+01	-0.1458E+01	-0.1167E+01	-0.1167E+01

JOINT NUMBER	*RESTRAINT CONDITION*	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-0.1000E+01
1	DISPLACEMENT IN THE Y DIRECTION	0.1250E+00
3	DISPLACEMENT IN THE Y DIRECTION	0.8750E+00

PRINTED OUTPUT

LOAD CASE ONE TEMPERATURE LOAD (CHANGE OF 30 DEGREES ON TWO MEMBERS)

MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE	MEMBER		DISTRIBUTED LOADING PER UNIT LENGTH X DIRECTION	Y DIRECTION	Z DIRECTION	TEMPERATURE CHANGE
4	5	0.000	0.000	0.000	30.000	5	3	0.000	0.000	0.000	30.000

JOINT DISPLACEMENTS

JOINT	DIRECTION X	Y	Z	JOINT	DIRECTION X	Y	Z	JOINT	DIRECTION X	Y	Z
1	0.0000E+00	0.0000E+00	0.0000E+00	2	-0.2556E-18	0.1875E-02	0.0000E+00	4	-0.3206E-02	0.0000E+00	0.0000E+00
5	-0.1406E-02	0.1875E-02	0.0000E+00	3	-0.5111E-18	0.0000E+00	0.0000E+00				

MEMBER I	J	AXIAL FORCE I END	J END	AXIAL STRESS I END	J END
1	2	-0.2556E-12	-0.2556E-12	-0.2556E-12	-0.2556E-12
1	4	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1	5	-0.6067E-13	-0.6067E-13	-0.4853E-13	-0.4853E-13
2	5	-0.2891E-12	-0.2891E-12	-0.2891E-12	-0.2891E-12
2	3	-0.2556E-12	-0.2556E-12	-0.2556E-12	-0.2556E-12
4	5	0.1800E+04	0.1800E+04	0.1800E+04	0.1800E+04
5	3	0.2250E+04	0.2250E+04	0.1800E+04	0.1800E+04

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	0.3041E-12
1	DISPLACEMENT IN THE Y DIRECTION	0.3640E-13
3	DISPLACEMENT IN THE Y DIRECTION	-0.2274E-12

HNCFRAME - VERSION 1.0

FEEDBACK REPORT

The Naval Civil Engineering Laboratory is fully dedicated to supporting GEMS users. A primary requirement for this task is to establish a priority listing of user requirements. It would be of great value to the development of new software if you, the user, would complete the feedback questions below. Since each individual user may have specific requirements, please reproduce this page as many times as necessary.

Please circle the number that best applies in questions 1 through 4, complete the other questions, fold at tic marks, and mail to NCEL with franked label on reverse side or to address at bottom of page.

1. Was the software beneficial (productive)?

   No benefit 0 1 2 3 4 5 6 7 8 9 10 Very beneficial

2. Was it easy to use (user friendly)?

   Difficult 0 1 2 3 4 5 6 7 8 9 10 Very easy

3. Does this software make decisions more reliable?

   No 0 1 2 3 4 5 6 7 8 9 10 Yes

4. Does it better document the design?

   No 0 1 2 3 4 5 6 7 8 9 10 Yes

5. Did it save time?

   Yes___ No___ Estimated percent saved______

6. What would make future software more user friendly?

7. What further support would you like to have on the GEMS system?

8. What other comments or remarks would you like to add?

Activity ____

Telephone ____

Mail address is:
NAVFAC GEMS Support Group
Naval Civil Engineering Laboratory
Code L54
Port Hueneme, CA 93043-5003

DEPARTMENT OF THE NAVY

Naval Civil Engineering Laboratory
Port Hueneme, CA 93043-5003

Official Business
Penalty for Private Use, $300

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY CARD

FIRST CLASS PERMIT NO. 69

POSTAGE WILL BE PAID BY ADDRESSE

Commanding Officer
Code L54 (NAVFAC GEMS Support Group)
Naval Civil Engineering Laboratory
Port Hueneme, California 93043-5003