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COLLOCATION FLUTTER ANALYSIS STUDY II

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VOLUME III
STRUCTURAL ANALYSIS PROGRAM FLUENC-100
COMPONENT MODE SYNTHESIS PROGRAM - COMSYN
AND
MODAL FLUTTER ANALYSIS PROGRAM

APRIL 1970



MISSILE SYSTEMS DIVISION

HUGHES

HUGHES AIRCRAFT COMPANY

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COFA II
COLLOCATION FLUTTER ANALYSIS STUDY II

VOLUME III
STRUCTURAL ANALYSIS PROGRAM ~ FLUENC-100C
COMPONENT MODE SYNTHESIS PROGRAM ~ COMSYN
and
MODAL FLUTTER ANALYSIS PROGRAM

PREPARED BY DYNAMICS & ENVIRONMENTS SECTION PERSONNEL, HUGHES
AIRCRAFT COMPANY, MISSILE SYSTEMS DIVISION, CONTRACT NO.
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I.0 INTRODUCTION

In order to determine the flutter characteristics of an aerodynamic surface, it is necessary to know the unsteady aerodynamic forces, the elastic properties, and the mass distribution of the structure. This volume contains a set of three programs that calculate the mass and stiffness distributions and the flutter speeds. The programs are FLUENC-100C, COMSYN, and MOFA.

FLUENC-100C is a structural analysis program that uses the direct stiffness method to generate stiffness, flexibility and mass matrices, and then to perform vibration analyses. In addition, there is an option to generate special structural parameters for use in the program COMSYN. FLUENC-100C is essentially the same as FLUENC except that the capability has been expanded to analyze lumped parameter systems that contain up to 200 nodes of which up to 100 may be free. The program COMSYN uses the component mode synthesis technique to analyze large structures. The structure is divided into component parts; the component modes and frequencies are obtained from FLUENC-100C and then entered into COMSYN where the analysis for the combined structure is performed. In addition, COMSYN calculates generalized aerodynamic forces and generalized masses for use in MOFA, the Modal Flutter Analysis Program. MOFA accepts data from FLUENC/FLUENC-100C and COMSYN and/or comparable data and performs flutter analyses using the normal mode (modal) method.

Both FLUENC-100C and COMSYN are tailored for use in flutter analyses. As such, only a capability to analyze planar structures is presented. The analysis includes displacements normal to the plane of the structure and approximates the two orthogonal rotations in the plane of the structure.

The FLUENC-100C and COMSYN programs have not been completely checked out for eigenvalue problems requiring more than fifty degrees of freedom. When exceeding fifty degrees of freedom, the user should check results carefully and if errors are suspected, the program should be rewritten in double precision for problems requiring degrees of freedom exceeding fifty. It should also be noted that the triangular plate elements are directional dependent which may cause small differences in deflections in symmetrical vibration modes. This problem can be eliminated by using a more refined and more complicated triangular plate element.

2.0 FLUENC-100C STRUCTURAL ANALYSIS PROGRAM

2.1 Theoretical Derivation

The theoretical derivation of the formulation for the FLUENC-100C Program is identical to that of the FLUENC Program presented in Volume II of Collocation Flutter Analysis Study, Reference 1; therefore, no new presentation of the derivation will be presented here. The additional capabilities added to the FLUENC-100C Program involved only computing changes associated with increasing the size of the program, and collecting certain structural data for use in COMSYN.

2.2 Program Description

The purpose of the computer program FLUENC-100C is twofold; namely, to provide structural influence coefficients and mass matrices for use in the Collocation Flutter Program and to provide stiffness and mass matrices, mode shapes, and frequencies for use in the Component Mode Synthesis Program. When using FLUENC-100C, a decision must be made whether to analyze a structure as one complete unit or to divide the structure into several components. When this is done, the analysis of the structure or the component is handled in essentially the same manner. Only special attention must be given to nodes that are common to two or more components when the structure is divided. Briefly, the program which is written in FORTRAN IV performs a structural analysis by the direct stiffness method. The structure is assumed to be representable by a planar network of beams and triangular plate elements connected at discrete joints. At each joint, if there are no restraints, the program assumes three degrees of freedom; that is, one displacement normal to the plane of the structure and two rotations. The program first synthesizes the stiffness and mass matrices for the entire structure, including all degrees of freedom from the data input for the beam and triangular plate elements and from the restraint information input for the joints. It then reduces the stiffness and mass matrices by solving for the rotational degrees of freedom in terms of the normal displacements by using static deflection relationships. As a final step, the program inverts the reduced stiffness matrix to obtain the influence coefficients. The dynamical matrix is then set up and a vibration analysis is performed.

If the option to generate data for COMSYN is used, a node or set of nodes are designated as common joints. Common joints are those structural points which exist on more than one component. The analysis is performed first with the common joints (junction nodes) restrained which yields the K_{FF} and M_{FF} matrices and an eigenvalue solution. Then new mass and stiffness matrices are generated based on an analysis with all common joints free. It is from these matrices that K_{FJ} , K_{JJ} , M_{FJ} are obtained. It is to be noted that in the second analysis, the rotational degrees of freedom for the junction nodes remain in order to insure slope compatibility, while those associated with the free joints (other than common joints) are reduced out of the system.

The FLUENC-100C Program allows a maximum of 200 nodal points in a structural idealization; of these 200 nodal points up to 100 nodal points may be allowed translational freedom. The remaining nodal points must be constrained in translation. Previously, the program FLUENC allowed a maximum of 50 points all of which could be free in translation; thus, the maximum size of the eigen value problem has increased; also, additional latitude is allowed in developing structural idealizations. The above change creates the following program restriction: The number of joints minus the number of joints restrained in translation must equal or be less than one hundred ($NJTS - NR \leq 100$)

Other features of the program include the option to input lumped masses or to compute the consistent mass matrices for the beam and triangular plate elements or both. The triangular plate elements may have either isotropic or orthotropic properties.

A series of problems was run to establish computer computation time. The results of this study are shown in Figure 2.2.1. The results are based upon the analysis of a flat plate using plate elements and the consistent mass matrix option. Five modes were requested for the analysis. As a result, the graph is only indicative of the computing time required, as the actual time not only depends on the number of degrees of freedom but also on the type of structural element, mass matrix, and number of modes requested.

2.2.1 Processing Information

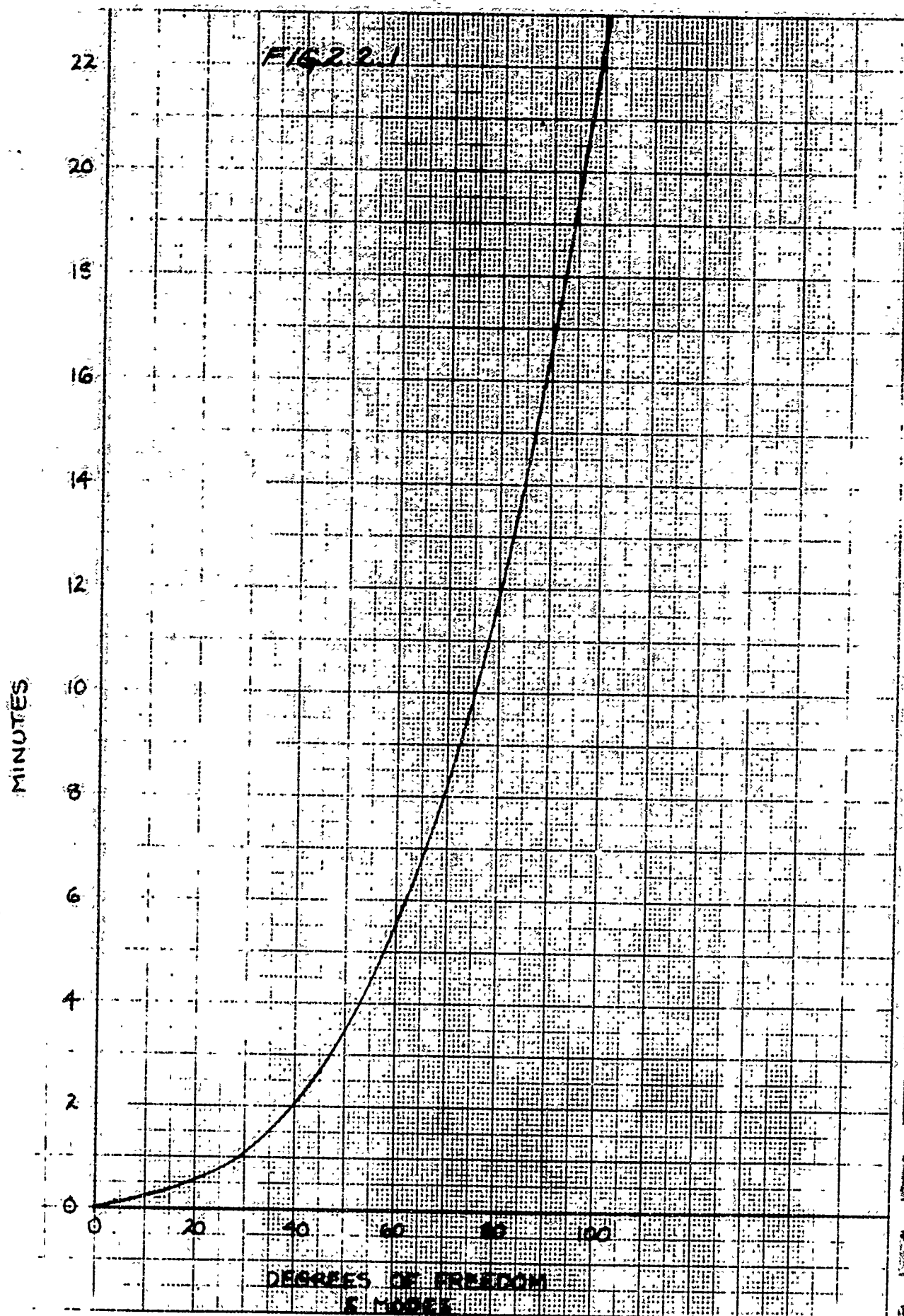
- A. Operation -- Standard FORTRAN IV processor system. Operable on the GE635 computer.
- B. Core Storage -- The program FLUENC-100C requires a minimum of 54,000 memory units for execution.
- C. Tape Units -- Standard input, output, and punch tape units, and 9 scratch tape units.

2.3 Description of Program Input

The following instructions describe the input data, their physical units, and their input FORTRAN format. The input quantities' names, in all capitals, are their FORTRAN names.

1.0 Title Card, format (12A6) two cards always

Column	1---72
Name	Any alphanumeric statement
Column	1---72
Name	Any alphanumeric statement



2.0 Problem Size and Control Information Format (1615)

Column	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45
Name	NJTS	NR	NBE	NPE	NMODE	MKEY	NLUMP	NCJT	NPUNJ

NJTS = Number of joints in structure (200 maximum).

NR = Number of joints with one or more restraints

NBE = Number of beam elements in structure

NPE = Number of plate elements in structure

NMODE = Number of eigenvalues and eigenvectors desired (9 maximum)

MKEY = 1. Do not compute consistent mass terms for beam and/or triangular plate elements

2. Compute consistent mass terms for beam and/or triangular plate elements

NLUMP = Number of lumped masses input. Only lumped masses corresponding to the normal displacement at each joint may be input.

NCJT = Number of common joints on the component (12 maximum)

= 0, if the complete structure is to be analyzed (no common joints involved).

NOTE: NPUNJ = 0 when NCJT > 0

NPUNJ = -1 No Punched Output

= 0 Both Mass and Flexibility Matrices Punched Out

= 1 Only Mass Matrix and ILOW, IHIGH Code Punched Out

= 2 Only Flexibility Matrix Punched Out

3.0 Material Properties

(a) Number of Materials, format (I5)

Column	1 - 5
Name	NMAT

NMAT = number of materials for which properties are input (10 max.)

(b) Properties, format (4E10.3)

Input NMAT number of cards, one for each material.

Column	1 - 10	11 - 20	21 - 30	31 - 40
Name	YM (1)	PR (1)	GE (1)	DENS (1)

YM (1) = Young's modulus of elasticity divided by 10^6 ; psi

PR (1) = Poisson's ratio

GE (1) = modulus of rigidity; psi. If input as 0, it will be computed from the following formula:

$$GE (1) = \frac{YM (1)}{2 [1 + PR (1)]}$$

DENS (1) = material density; lb/in³. Not required if MKEY = 1

4.0 Joint Coordinate Cards, format (10X, 2E10.3)

Input NJTS number of cards, one for each joint. Also, the structure is assumed to lie in the x-y plane.

Column	1 - 10	11 - 20	21 - 30
Name	m	X(m)	Y(m)

m = joint number (must be input consecutively starting with 1).
May be placed anywhere between columns 1 and 10

X(m) = x coordinate of joint m; inches

Y(m) = y coordinate of joint m; inches

NOTE: If NCJT > 0, the common joints must be numbered last.

Example: If NJTS = 10 and NCJT = 3

Then joints 8, 9 and 10 are the common joints.

When reference is made to these joints in the program COMSYN, common joint 1 should be joint 8, common joint 2 - joint 9, common joint 3 - joint 10.

5.0 Joint Restraint Information, format (4I5)

Input NR number of cards, one for each joint with one or more restraints.

Column	1 - 5	6 - 10	11 - 15	16 - 20
Name	JT	M1	M2	M3

JT = number of joint having one or more restraints

M1 = 0 free in the z direction

= 1 fixed in the z direction

M2 = 0 free to rotate about the x axis

= 1 fixed about the x axis

M3 = 0 free to rotate about the y axis

= 1 fixed about the y axis

NOTE: If NCJT > 0 then M1=M2=M3=1 for all common joints.

6.0 Lumped Masses, format (15, 5X, E10.3)

Input NLUMP number of cards, one for each lumped mass.

Column	1 - 5	6 - 10	11 - 20
Name	JMASS	blank	RMASS

JMASS = number of joint for which lumped mass is input

RMASS = lumped mass, lb.

If more than one lumped mass is input for a particular joint, the program will sum the masses.

7.0 Beam Element Properties, format (3E10.3, 3I5)

Input NBE number of cards, one for each beam element.

Column	1 - 10	11 - 20	21 - 30	31 - 35	36 - 40	41 - 45
Name	AR	XI	YJ	MAT	JTNR	JTFR

AR = area of beam cross section, in²

XI = moment of inertia of area, in⁴

YJ = effective torsional moment of inertia, in⁴

MAT = material code corresponding to one of the materials input under paragraph 4.1.3.

JTNR, JTFR = joint numbers at the ends of the beam element

8.0 Triangular Plate Element Properties, format (E10.3, 5I5)

Input NPE number of cards, one for each triangular plate element.

Column	1 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 35
Name	PTH	MAT	JT1	JT2	JT3	NDX

PTH = plate thickness, in.

MAT = material code corresponding to one of the materials input under Item 3,

JT1, JT2, JT3 = joint numbers at the three corners of the triangular plate

Restrictions:

- a) The order of the joint numbers must be given in a clockwise manner as follows:



- b) The angle formed by the edges of the triangular plate at JT1 must not be 90°.

- c) The angle that the directed line defined by JT1 and JT2 makes with the global or system y-axis must be acute (<90°).

NDX = 0 the plate has isotropic properties and the flexural rigidity terms are computed from

$$DX = DY = \frac{YM(MAT) \times PTH^3}{12 \left\{ 1 - [PR(MAT)]^2 \right\}}$$

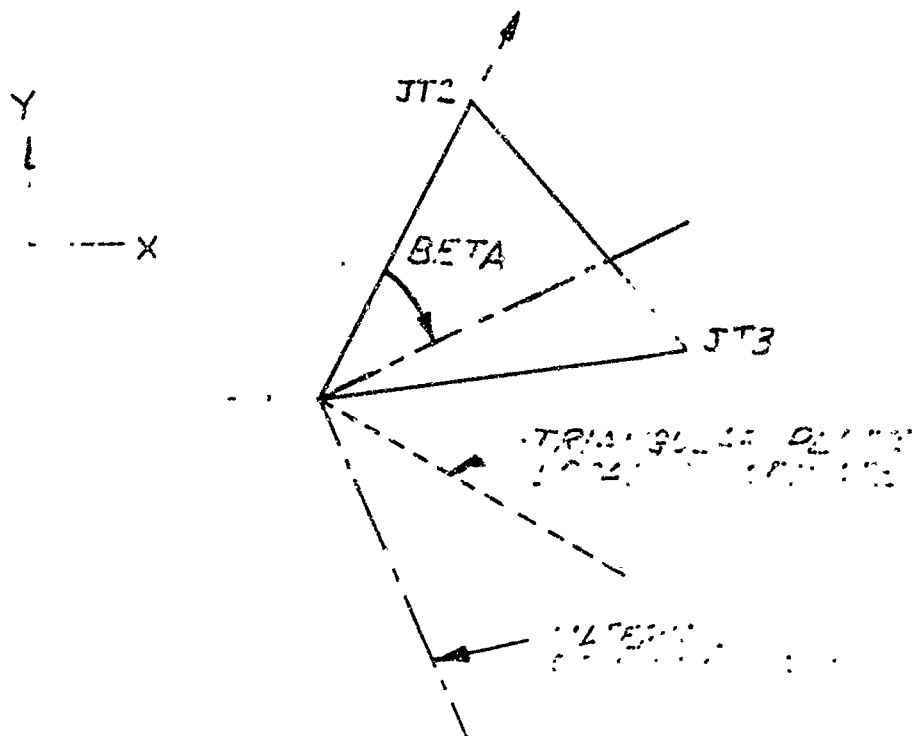
$$D1 = [PR(MAT)] \times DX$$

NDX = 1 the plate has orthotropic properties and the flexural rigidity terms are input by the next card [format (4E10.3)]

Column	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50
Name	DX	DY	D1	DXY	BETA

DX, DY, D1, DXY = flexural rigidity terms, in.lb.

BETA = angle between material principal axes and the triangular plate local coordinates as shown below



All the components to be considered subsequently in the Component Mode Synthesis Analysis may be analyzed on one computer run of FLUENC-100C. Repeat the input requirements for each additional component.

2.4 Description of Program Output

I. Analysis of Complete Structure with No Common Joints Involved (NCJT=0)

A. Printed

1. Input Data
2. Coordinate numbers assigned by the program to the normal displacements at each unrestrained joint.
3. Results of the analysis
 - a. Reduced stiffness matrix (lb./in.)
 - b. Flexibility matrix (in./lb.)
 - c. Reduced weight matrix (lb.)

(NOTE: Since the above matrices are symmetric, only the upper triangle is printed.)

 - d. Eigenvalues and eigenvectors (normalized to the largest element) for each mode requested.
 - e. Natural frequencies for each mode (CPS)

- B. Punched - all matrices are punched in their entirety in Fortran Format (1P6E12.5). Each row starts on a new card. The cards for each matrix are sequenced and identified as follows:

<u>Matrix</u>	<u>I.D.</u>
1. Flexibility	FLEX
2. Weight	WGHT

NOTE: The above punched output is compatible with the input required for COFA, the Collocation Flutter Program

II. Analysis of a Component with Common Joints (NCJT=0)

A. Printed Output

1. Common joints restrained.
Same as indicated in I-A.
2. Common joints free.
 - a. New list of coordinate numbers with the common joints added.
 - b. CKFJ Matrix (Stiffness) and CMFJ Matrix (MASS) - relates common joints to free joints.
 - c. Upper triangles of CKJJ Matrix (Stiffness) and CMJJ Matrix (MASS) - relates common joints to common joints.

B. Punched Output - Full Matrices are punched for all items

<u>Matrix</u>	<u>I.D.</u>	<u>*Theory Reference</u>
1. Common Joints Restrained		
Stiffness	CKFF	$\bar{K}_{FF}$
Flexibility	FLEX	$\bar{K}_{FF}^{-1}$
Weight (lbs.)	WGHT	386 ($\bar{M}_{FF}$)
Frequencies (Cps)	FREQ	$\omega/2\pi$
Mode Shapes (Eigenvectors) MODE		ϕ
2. Common Joints Free		
CKFJ	CKFJ	$\bar{K}_{FJ}$
CKJJ	CKJJ	$\bar{K}_{JJ}$
CMFJ	CMFJ	$\bar{M}_{FJ}$
CMJJ	CMJJ	$\bar{M}_{JJ}$

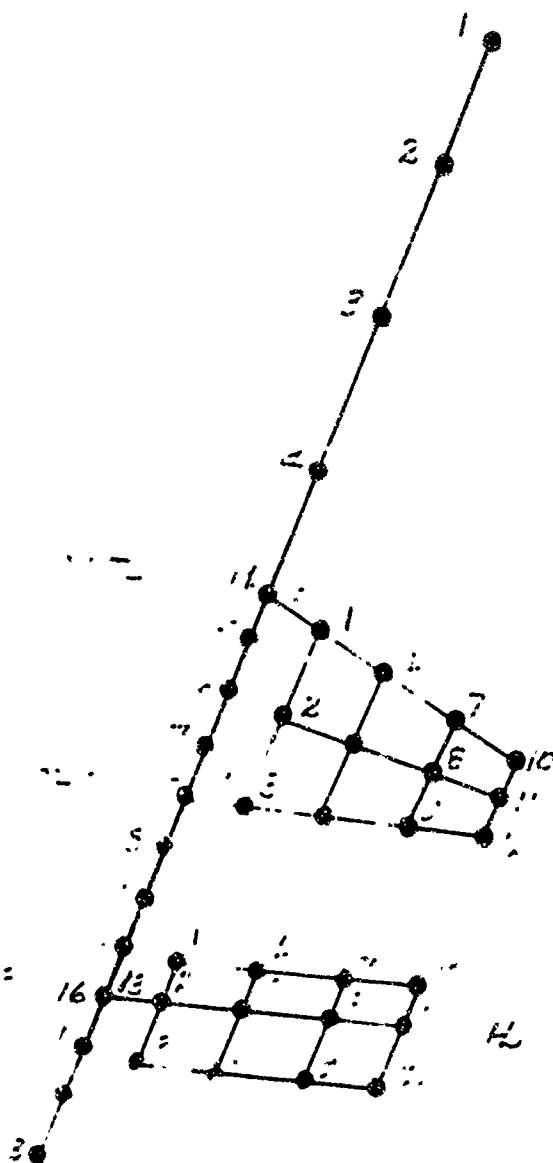
NOTE: The above punched output is compatible with the input required for the Component Mode Synthesis Program.

* Section 3.2, Volume III.

2.5 Sample Problems

The sample problems presented in Volume II of Reference 1 will demonstrate the operation of this program for the case when $NCJT=0$. To demonstrate the case for $NCJT>0$ a typical missile is analyzed.

The analysis will be performed for the missile being divided into three components the fuselage, the wing, and the control surface. There are three common joints; two attach the wing to the fuselage (Joints 1 and 2) and one attaches the control surface to the fuselage (Joint 3).



$\sigma = .3$

```

NPTS = 16
NR = 16
NRE = 15
NPE = 0
NMODE = 7
MKEY = 1
NLUMP = 16
HC_I = 3
NPUNJ = 0

```

M A T E R I A L P R O P E R T I E S				
NO.	YOUNG'S MODULUS	POISSON RATIO	MODULUS OF RIGIDITY	DENSITY
1	0.1000E 08	0.3000	0.3846E 07	0.

JOINT COORDINATES

JOINT NO.	X COORD.	Y COORD.
1	0.	0.
2	15.0000	0.
3	25.0000	0.
4	35.0000	0.
5	50.0000	0.
6	55.0000	0.
7	60.0000	0.
8	70.0000	0.
9	75.0000	0.
10	80.0000	0.
11	90.0000	0.
12	95.0000	0.
13	100.0000	0.
14	45.0000	0.
15	65.0000	0.
16	85.0000	0.

JOINT NO.	JOINT NO.	ROTATION ABOUT X	ROTATION ABOUT Y
1	1	0.000000	0.000000
2	2	0.000000	0.000000
3	3	0.000000	0.000000
4	4	0.000000	0.000000
5	5	0.000000	0.000000
6	6	0.000000	0.000000
7	7	0.000000	0.000000
8	8	0.000000	0.000000
9	9	0.000000	0.000000
10	10	0.000000	0.000000
11	11	0.000000	0.000000
12	12	0.000000	0.000000
13	13	0.000000	0.000000
14	14	0.000000	0.000000
15	15	0.000000	0.000000
16	16	0.000000	0.000000
17	17	0.000000	0.000000
18	18	0.000000	0.000000
19	19	0.000000	0.000000
20	20	0.000000	0.000000
21	21	0.000000	0.000000
22	22	0.000000	0.000000
23	23	0.000000	0.000000
24	24	0.000000	0.000000
25	25	0.000000	0.000000
26	26	0.000000	0.000000
27	27	0.000000	0.000000
28	28	0.000000	0.000000
29	29	0.000000	0.000000
30	30	0.000000	0.000000
31	31	0.000000	0.000000
32	32	0.000000	0.000000
33	33	0.000000	0.000000
34	34	0.000000	0.000000
35	35	0.000000	0.000000
36	36	0.000000	0.000000
37	37	0.000000	0.000000
38	38	0.000000	0.000000
39	39	0.000000	0.000000
40	40	0.000000	0.000000
41	41	0.000000	0.000000
42	42	0.000000	0.000000
43	43	0.000000	0.000000
44	44	0.000000	0.000000
45	45	0.000000	0.000000
46	46	0.000000	0.000000
47	47	0.000000	0.000000
48	48	0.000000	0.000000
49	49	0.000000	0.000000
50	50	0.000000	0.000000
51	51	0.000000	0.000000
52	52	0.000000	0.000000
53	53	0.000000	0.000000
54	54	0.000000	0.000000
55	55	0.000000	0.000000
56	56	0.000000	0.000000
57	57	0.000000	0.000000
58	58	0.000000	0.000000
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61	61	0.000000	0.000000
62	62	0.000000	0.000000
63	63	0.000000	0.000000
64	64	0.000000	0.000000
65	65	0.000000	0.000000
66	66	0.000000	0.000000
67	67	0.000000	0.000000
68	68	0.000000	0.000000
69	69	0.000000	0.000000
70	70	0.000000	0.000000
71	71	0.000000	0.000000
72	72	0.000000	0.000000
73	73	0.000000	0.000000
74	74	0.000000	0.000000
75	75	0.000000	0.000000
76	76	0.000000	0.000000
77	77	0.000000	0.000000
78	78	0.000000	0.000000
79	79	0.000000	0.000000
80	80	0.0	

JOINT NO.	Z DISPLACEMENT	ROTATION ABOUT X	ROTATION ABOUT Y
1	0	1	0
2	0	1	0
3	0	1	0
4	0	1	0
5	0	1	0
6	0	1	0
7	0	1	0
8	0	1	0
9	0	1	0
10	0	1	0
11	0	1	0
12	0	1	0
13	0	1	0
14	0	1	0
15	0	1	0
16	0	1	0
17	0	1	0
18	0	1	0
19	0	1	0
20	0	1	0
21	0	1	0
22	0	1	0
23	0	1	0
24	0	1	0
25	0	1	0
26	0	1	0
27	0	1	0
28	0	1	0
29	0	1	0
30	0	1	0
31	0	1	0
32	0	1	0
33	0	1	0
34	0	1	0
35	0	1	0
36	0	1	0
37	0	1	0
38	0	1	0
39	0	1	0
40	0	1	0
41	0	1	0
42	0	1	0
43	0	1	0
44	0	1	0
45	0	1	0
46	0	1	0
47	0	1	0
48	0	1	0
49	0	1	0
50	0	1	0
51	0	1	0
52	0	1	0
53	0	1	0
54	0	1	0
55	0	1	0
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59	0	1	0
60	0	1	0
61	0	1	0
62	0	1	0
63	0	1	0
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66	0	1	0
67	0	1	0
68	0	1	0
69	0	1	0
70	0	1	0
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73	0	1	0
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77	0	1	0
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79	0	1	0
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84	0	1	0
85	0	1	0
86	0	1	0
87	0	1	0
88	0	1	0
89	0	1	0
90	0	1	0
91	0	1	0
92	0	1	0
93	0	1	0
94	0	1	0
95	0	1	0
96	0	1	0
97	0	1	0
98	0	1	0
99	0	1	0
100	0	1	0

5 16,6010
 6 16,7810
 7 16,6600
 8 25,0000
 9 25,0000
 10 25,0000
 11 5,0000
 12 5,0000
 13 15,0000
 14 49,5000
 15 74,5000
 16 74,5000

BEAM ELEMENT PROPERTIES		MAT JOINT 1 JOINT 2												
ELEMENT NO.	A	I	J											
1	1.5000	35.0000	70.0000	1	2	3	4	5	6	7	8	9	10	11
2	1.5000	35.0000	70.0000	1	2	3	4	5	6	7	8	9	10	11
3	1.5000	35.0000	70.0000	1	2	3	4	5	6	7	8	9	10	11
4	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
5	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
6	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
7	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
8	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
9	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
10	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
11	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
12	3.0000	70.0000	140.0000	1	2	3	4	5	6	7	8	9	10	11
13	1.5000	35.0000	70.0000	1	2	3	4	5	6	7	8	9	10	11
14	1.5000	35.0000	70.0000	1	2	3	4	5	6	7	8	9	10	11
15	1.5000	35.0000	70.0000	1	2	3	4	5	6	7	8	9	10	11

COMMON JOINTS CONSTRAINED

COORDINATE NUMBERS FOR EACH Z DISPLACEMENT AT EACH UNRESTRAINED JOINT

JOINT NO.	COORD. NO.
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13

THE TIME ELAPSED FOR MATRIX INVERSION = 0.9844E-01 SECONDS

REDUCED UPPER TRIANGULAR STIFFNESS MATRIX

END :

0.19753E 06	-0.57511E 06	0.48689E 06	-0.15556E 06	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 2	0.22531E 07	-0.27889E 07	0.15556E 07	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 3	0.52000E 07	-0.49000E 07	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 4	0.91000E 07	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 5	0.10560E 09	-0.67200E 08	0.28800E 08	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 6	0.84000E 08	-0.67200E 08	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 7	0.10560E 09	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 8	0.10560E 09	-0.67200E 08	0.28800E 08	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 9	0.84000E 08	-0.67200E 08	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 10	0.10560E 09	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 11	0.51692E 08	-0.29733E 08	0.77538E 07	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 12	0.28431E 08	-0.10386E 08	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 13	0.5231E 07	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.

THE TIME ELAPSED FOR MATRIX INVERSION = 0.1018E 00 SECONDS

REDUCED UPPER TRIANGULAR FLEXIBILITY MATRIX

ROW 1	0.63809E-04	0.30505E-04	0.13214E-04	0.29762E-05	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 2	0.56667E-04	0.73514E-05	0.19748E-05	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
ROW 3	0.2857E-05	0.11905E-05	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.

0.

ROW 5

0.25112E-07 0.29742E-07 0.12091E-07 0. 0. 0. 0. 0.

ROW 6

0.59594E-07 0.20742E-07 0. 0. 0. 0. 0.

ROW 7

0.25112E-07 0. 0. 0. 0. 0.

ROW 8

0.25112E-07 0.29742E-07 0.12091E-07 0. 0. 0.

ROW 9

0.59594E-07 0.29742E-07 0. 0. 0.

ROW 10

0.25112E-07 0. 0. 0.

ROW 11

0.11905E-06 0.29742E-06 0.47019E-06

ROW 12

0.95239E-06 0.16667E-05

ROW 13

0.32143E-05

15

REDUCED UPPER TRIANGULAR WEIGHT MATRIX

ROW 1

0.25000E 02 0. 0. 0. 0. 0. 0. 0.

ROW 2

0.25000E 02 0. 0. 0. 0. 0. 0.

ROW 3

0.50000E 02 0. 0. 0. 0. 0. 0.

ROW 4

0.50000E 02 0. 0. 0. 0. 0. 0.

ROW 5

0.66000E 02 0. 0. 0. 0. 0. 0.

ROW 6

0.57000E 02 0. 0. 0. 0. 0.

ROW 7

0.50000E 02 0. 0. 0. 0. 0.

ROW 8

0.25000E 02 0. 0. 0. 0. 0.

ROW 9

0.25000E 02 0. 0. 0. 0.

ROW 13

0.25000E 02 0. 0. 0. 0.

ROW 11

0.50000E 01 0. 0. 0. 0.

ROW 12

0.50000E 01 0. 0. 0. 0.

ROW 13

0.10000E 02

HERE ARE THE EIGENVALUES AND EIGENVECTORS.

EIGENVECTOR NUMBER 1
CORRESPONDING TO 1.802636E-05
1.000000E-00 4.997767E-01 2.248700E-01 5.2882-05E-02 1.404284E-21 2.639210E-21
1.525798E-21 2.561998E-21 4.516382E-21 2.806369E-21 9.799122E-19 3.358238E-18
6.472933E-18

EIGENVECTOR NUMBER 2
CORRESPONDING TO 3.8120826E-06
-9.114038E-01 3.174319E-01 1.000000E-00 4.053143E-01 3.273132E-20 6.148695E-20
2.549379E-20 6.112478E-20 1.147755E-19 6.624105E-20 9.247833E-17 3.199652E-16
6.112638E-16

EIGENVECTOR NUMBER 3
CORRESPONDING TO 7.293206E-06
-7.941667E-15 2.967122E-15 3.074794E-15 1.696991E-15 4.911398E-19 9.222183E-19
5.315958E-19 9.314516E-19 1.747825E-18 1.006590E-18 1.513490E-01 5.236044E-01
1.000000E-00

EIGENVECTOR NUMBER 4
CORRESPONDING TO 3.4206412E-07
-5.036697E-01 1.000000E-00 -2.847090E-01 -6.435291E-01 -1.066150E-18 -1.995166E-18
-1.137839E-18 -2.327253E-18 -4.345035E-18 -2.463433E-18 -3.735575E-17 -1.316196E-16
-2.525801E-16

EIGENVECTOR NUMBER 5
CORRESPONDING TO 1.699779E-08
-1.442618E-01 7.919875E-01 -7.937264E-01 1.000000E-00 -4.549914E-18 -8.440637E-18
-1.692424E-18 -2.288757E-17 -4.227766E-17 -2.317809E-17 -3.806953E-18 -1.500437E-17
-3.159315E-17

EIGENVECTOR NUMBER 6
CORRESPONDING TO 1.663335E-08
1.928581E-15 -1.662732E-15 -3.366597E-17 3.267530E-15 2.331629E-15 4.302280E-15
2.359175E-15 5.440437E-01 1.000000E-00 5.440437E-01 1.424937E-16 8.973732E-16
2.339045E-15

EIGENVECTOR NUMBER 7
CORRESPONDING TO 2.5210840E-08
7.514691E-16 -8.782432E-16 3.935468E-16 9.018543E-16 5.438831E-01 1.000000E-00
5.438831E-01 1.954459E-15 3.641889E-15 2.028041E-15 -1.278879E-16 1.093893E-16
1.006666E-15

HERE ARE THE NATURAL FREQUENCIES

THE NATURAL FREQUENCY NUMBER	1 IS	67.697 CPS
THE NATURAL FREQUENCY NUMBER	2 IS	310.743 CPS
THE NATURAL FREQUENCY NUMBER	3 IS	420.313 CPS
THE NATURAL FREQUENCY NUMBER	4 IS	932.061 CPS
THE NATURAL FREQUENCY NUMBER	5 IS	1659.043 CPS
THE NATURAL FREQUENCY NUMBER	6 IS	2083.098 CPS
THE NATURAL FREQUENCY NUMBER	7 IS	2527.050 CPS

COMMON JOINTS FREE

COORDINATE NUMBERS FOR EACH Z DISPLACEMENT AT EACH UNRESTRAINED JOINT

JOINT NO.	COORD. NO.
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16

TIME ELAPSED FOR MATRIX INVERSION = 0.1014E 00 SECONDS

GKJ MATRIX (STIFFNESS) - RELATES COMMON JOINTS TO FREE JOINTS - FOR COMPONENT NODE SYNTHESIS PROGRAM

ROW 1	0.4444E 05	0.	0.	0.	0.	0.14815E 06	0.	0.
ROW 2	-0.4444E 06	0.	0.	0.	0.	-0.14815E 07	0.	0.
ROW 3	0.20000E 07	0.	0.	0.	0.	0.66667E 07	0.	0.
ROW 4	-0.56000E 07	0.	0.	0.	0.	-0.32667E 08	0.	0.
ROW 5	-0.50000E 08	-0.72000E 07	0.	0.	0.	0.15000E 09	-0.12000E 08	0.
ROW 6	0.25200E 08	0.25200E 08	0.	0.	0.	-0.42000E 08	0.42000E 08	0.
ROW 7	-0.72000E 07	-0.60000E 08	0.	0.	0.	0.12000E 08	-0.15600E 09	0.
ROW 8	-0.60000E 08	-0.72000E 07	0.	0.	0.	0.	0.15600E 09	-0.12000E 08
ROW 9	0.25200E 08	0.25200E 08	0.	0.	0.	0.	-0.42000E 08	0.42000E 08
ROW 10	-0.72000E 07	-0.60000E 08	0.	0.	0.	0.	0.12000E 08	-0.15600E 09
ROW 11	0.	-0.29723E 08	0.	0.	0.	0.	0.	0.77538E 08
ROW 12								

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0. 0. 0.11631E 08 0. 0. 0. -0.19385E 08

ROW 13

0. 0. -0.19385E 07 0. 0. 0. 0. 0.32308E 07

UPPER TRIANGLE OF CKIJ MATRIX (STIFFNESS) - COMMON JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1

0.44200E 08 0.15000E 07 0. 0. 0. -0.95667E 09 0.30000E 07 0.

ROW 2

0.30400E 08 0.18000E 07 0. 0. 0. -0.30000E 07 -0.46770E-01 0.30000E 07

ROW 3

0.60231E 08 0. 0. 0. 0. -0.30000E 07 0.61615E 08

ROW 4

0.16154E 09 0. 0. 0. 0. 0.

ROW 5

0.21538E 09 0. 0. 0. 0.

ROW 6

0.16154E 09 0. 0. 0.

ROW 7

0.71611E 09 -0.50000E 07 0.

ROW 8

0.97000E 09 -0.50000E 07

ROW 9

0.72731E 09

CMFJ MATRIX (MASS) - RELATES COMMON JOINTS TO FREE JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1

0. 0. 0. 0. 0. 0. 0. 0.

ROW 2

0. 0. 0. 0. 0. 0. 0. 0.

ROW 3

0. 0. 0. 0. 0. 0. 0. 0.

ROW 4

0. 0. 0. 0. 0. 0. 0. 0.

ROW 5

0. 0. 0. 0. 0. 0. 0. 0.

ROW 6

0. 0. 0. 0. 0. 0. 0. 0.

ROW 7

0. 0. 0. 0. 0. 0. 0. 0.

ROW 8

SAMPLE PROBLEM-TYPICAL MISSILE

COEFFICIENT P - 1.0

MJYS = 14 MR = 2 ARE = 19. ARE = 0 NYODE = 7 HKEY = 1 NLUMP = 14 NG-I = 2 NEURJ = 0

MATERIAL PROPERTIES
 NO. YOUNG'S MODULUS POISSON RATIO MODULUS OF RIGIDITY DENSITY
 1 0.40000E 03 0.30000 0.15305E 08 0.1

JOINT COORDINATES
 JOINT NO. X COORD. Y COORD.
 1 40.00000 5.00000
 2 55.00000 5.00000
 3 65.00000 5.00000
 4 48.13200 15.00000
 5 58.87200 15.00000
 6 65.00000 15.00000
 7 50.00000 25.00000
 8 58.12500 25.00000
 9 66.04000 25.00000
 10 52.29000 35.00000
 11 59.37500 35.00000
 12 66.45000 35.00000
 13 45.00000 0.
 14 65.00000 0.

JOINT RESTRAINT CODE
 JOINT NO. Z DISPLACEMENT ROTATION ABOUT X ROTATION ABOUT Y
 1 1 1
 2 1 1
 3 1 1
 4 1 1

LOADS
 LOAD NO. HEIGHT
 1 0.00000
 2 0.00000
 3 0.00000
 4 0.00000
 5 0.00000
 6 0.00000
 7 0.00000
 8 0.00000
 9 0.00000
 10 0.00000
 11 0.00000
 12 0.00000
 13 0.00000
 14 0.00000

ELEMENT PROPERTIES
 ELEMENT NO. AREA I-XX I-YY J 4AT JOINT 1 JOINT 2
 1 1.00000 0.00000 0.00000 1 0.00000 1 13

C.20294E 06 -0.30666E 15 0.16150E 04 -0.91493E 05 0.20116E 04 0.25457E 02 0.23271E 05 -0.19754E 03

ROW 6 C.19377E 06 -0.77737E 02 0.15971E 04 -0.10705E 06 -0.65444E 02 0.10472E 02 0.28272E 05

ROW 7 C.13639E 06 -0.69129E 05 0.32645E 05 -0.39569E 05 0.34129E 04 -0.46724E 03

ROW 8 C.26796E 06 -0.58975E 05 0.27417E 04 -0.43167E 05 0.29665E 04

ROW 9 0.14224E 06 -0.10793E 03 0.25542E 04 -0.41321E 05

ROW 10 C.54224E 05 -0.93279E 05 0.45294E 05

ROW 11 C.20261E 06 -0.92802E 05

ROW 12 C.64573E 05

THE TIME ELAPSED FOR MATRIX INVERSION = 0.7583E-01 SECONDS

REDUCED UPPER TRIANGULAR FLEXIBILITY MATRIX

ROW 1 C.38826E-05 0.21241E-05 0.26275E-06 0.14362E-04 0.82639E-05 0.21415E-05 0.23472E-04 0.14374E-04 -0.52743E-05
C.31827E-04 C.20443E-04 0.90737E-05

ROW 2 C.13693E-04 0.19535E-05 0.78914E-05 0.94071E-05 0.72820E-05 0.10932E-04 0.10152E-04 0.10150E-04 0.13050E-04
0.12609E-04 0.12276E-04

ROW 3 C.56745E-05 0.21700E-05 0.79273E-05 0.13698E-04 0.93572E-05 0.13939E-04 0.22526E-04 0.22540E-05 0.19985E-04
C.50722E-04

ROW 4 0.92429E-04 0.55947E-04 0.17267E-04 0.17358E-03 0.10740E-03 0.41799E-04 0.24730E-03 0.15954E-03 0.71765E-04

ROW 5 C.52720E-04 0.53777E-04 0.11329E-03 0.11291E-03 0.10932E-03 0.10886E-03 0.16596E-03 0.16364E-03

ROW 6 C.86679E-04 0.41942E-04 0.10416E-03 0.16701E-03 0.72517E-04 0.15581E-03 0.23921E-03

ROW 7 C.57969E-05 0.23759E-03 0.9757E-04 0.57656E-03 0.37121E-03 0.16459E-03

ROW 8 C.23800E-03 0.23093E-03 0.27344E-03 0.36801E-03 0.36355E-03

ROW 9 C.36790E-03 0.25574E-03 0.36309E-03 0.56148E-03

ROW 10 C.95542E-03 0.61244E-03 0.27338E-03

ROW 11

0.60934E-03 0.599A1E-03

ROW 12

0.53068E-03

REDUCED UPPER TRIANGULAR WEIGHT MATRIX

ROW 1

0.33300E 00 0. 0. 0. 0. 0. 0. 0.

ROW 2

0.33300E 00 0. 0. 0. 0. 0. 0. 0.

ROW 3

0.33300E 00 0. 0. 0. 0. 0. 0. 0.

ROW 4

0.26800E 00 0. 0. 0. 0. 0. 0. 0.

ROW 5

0.26800E 00 0. 0. 0. 0. 0. 0. 0.

ROW 6

0.26800E 00 0. 0. 0. 0. 0. 0. 0.

ROW 7

0.25500E 00 0. 0. 0. 0. 0. 0. 0.

ROW 8

0.25500E 00 0. 0. 0. 0. 0. 0. 0.

ROW 9

0.25500E 00 0. 0. 0. 0. 0. 0. 0.

ROW 10

0.22000E 00 0. 0. 0. 0. 0. 0. 0.

ROW 11

0.22000E 00 0. 0. 0. 0. 0. 0. 0.

ROW 12

0.22000E 00 0. 0. 0. 0. 0. 0. 0.

HERE ARE THE EIGENVALUES AND EIGENVECTORS.

EIGENVECTOR NUMBER 1
 CORRESPONDING TO 6.2632084E 05
 3.6002336E-02 2.4659071E-02 2.7338783E-01 2.8253907E-01 2.6247168E-01
 6.1943952E-01 6.0959623E-01 5.8517104E-01 1.0000000E 00 9.6182712E-01 9.6469735E-01

EIGENVECTOR NUMBER 2
 CORRESPONDING TO 1.698201E 06
 7.7886679E-02 7.3243095E-04 3.7986951E-02 -2.7866540E-01 7.8618528E-04 2.8181170E-01
 -6.2672194E-01 5.4320210E-03 8.3263302E-01 -9.7104231E-01 1.3908816E-02 1.0000000E 00

EIGENVECTOR NUMBER 3
 CORRESPONDING TO 2.6766513E 07
 2.4163401E-01 5.2206473E-01 1.9927914E-01 9.9041310E-01 1.0000000E 00 8.1744462E-01
 6.295426E-01 5.674090E-01 5.1752926E-01 -8.5026886E-01 -7.690823E-01 -6.8941854E-01

EIGENVECTOR NUMBER 4
 CORRESPONDING TO 3.5934503E 07
 -1.9679316E-01 3.0623353E-02 2.2448987E-01 -8.8301271E-01 6.6308938E-02 1.0000000E 00
 -5.7593627E-01 4.2697872E-02 5.5235907E-01 7.6300822E-01 -4.9530195E-02 -6.664830E-01

EIGENVECTOR NUMBER 5
 CORRESPONDING TO 9.8298457E 07
 6.3768959E-02 1.0600000E 00 5.4463697E-02 -6.7735487E-02 7.4186013E-02 -7.4186263E-02
 -2.1020006E-01 -2.3342149E-01 -1.9486479E-01 1.5229280E-01 1.4124142E-01 1.4325635E-01

EIGENVECTOR NUMBER 6
 CORRESPONDING TO 2.4897992E 08
 4.3259953E-01 -7.7543808E-02 1.7257104E-01 1.0000000E 00 -8.5281674E-01 5.1388778E-01
 -2.7532252E-01 -9.3619429E-01 3.8302056E-01 2.7441027E-01 8.959699E-02 -1.4511385E-02

EIGENVECTOR NUMBER 7
 CORRESPONDING TO 2.5916587E 08
 -3.1868037E-01 7.8847805E-02 4.7207745E-01 -1.1742049E-01 -3.7010275E-01 7.8017075E-01
 1.0000000E 00 -2.951236E-01 -6.5307367E-01 -3.433023E-01 -3.6937620E-02 3.4933783E-01

HERE ARE THE NATURAL FREQUENCIES

THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	CPS
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	126.157
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	207.478
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	821.417
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	954.061
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	1953.668
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	2511.321
THE NATURAL FREQUENCY NUMBER	1	2	3	4	5	6	7	2562.275

COMMON JOINTS FREE

COORDINATE NUMBERS FOR EACH Z DISPLACEMENT AT EACH UNRESTRAINED JOINT

JOINT NO. COORD. NO.

1 1

2 2

3 3

4 4

5 5

6 6

7 7

8 8

9 9

10 10

11 11

12 12

13 13

14 14

THE TIME ELAPSED FOR MATRIX INVERSION = 0.5062E 00 SECONDS

CKFJ MATRIX (STIFFNESS) - RELATES COMMON JOINTS TO FREE JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1

-0.55124E 06 0.75664E 02 -0.17192E 07 0.21142E 03 0.34779E 06 0.21282E 04

ROW 2

0.35965E 03 -0.90842E 03 0.32339E 04 -0.20121E 04 0.12080E 05 -0.12391E 05

ROW 3

-0.25990E 03 -0.58494E 06 -0.36423E 03 -0.18237E 07 -0.19617E 04 0.82749E 05

ROW 4

0.11587E 06 -0.40859E 02 0.19294E 06 -0.67104E 02 -0.41419E 05 0.27574E 02

ROW 5

0.79401E 03 0.15147E 04 0.13391E 04 0.25185E 04 -0.20309E 03 -0.25073E 03

ROW 6

0.11264E 03 0.12246E 06 0.18421E 03 0.20442E 06 -0.56176E 02 -0.82026E 04

ROW 7

-0.28825E 05 0.10144E 02 -0.46005E 05 0.16809E 02 0.10265E 05 -0.31253E 01

ROW 8

-0.30027E 03 -0.50145E 03 -0.49714E 03 -0.03612E 03 0.12088E 03 0.40965E 02

ROW 9

-0.34461E 02 -0.30540E 05 -0.57766E 02 -0.50699E 05 0.10648E 02 0.20663E 04

ROW 10

0.48708E 04 -0.65727E 01 0.90324E 04 -0.10605E 02 -0.17102E 04 0.89347E 00

ROW 11

0.15645E 02 0.87471E 02 0.25613E 02 0.14573E 03 -0.76734E 01 -0.72663E 01

ROW 12

0.12094E 02 0.30907E 04 0.21528E 02 0.84842E 04 -0.43339E 01 -0.34424E 03

UPPER TRIANGLE OF CKIJ MATRIX (STIFFNESS) - COMMON JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1	0.45865E 06	-0.27458E 02	0.15629E 07	-0.47025E 02	-0.32491E 06	-0.29727E 02
ROW 2	0.48753E 06	-0.46647E 02	0.16617E 07	0.53972E 01	-0.45764E 05	
ROW 3	0.65985E 07	-0.81749E 02	-0.13637E 07	-0.97478E 02		
ROW 4	0.70155E 07	0.29548E 00	-0.27628E 06			
ROW 5	0.36360E 06	-0.21745E 03				
ROW 6	0.91084E 05					

CMFJ MATRIX (MASS) - RELATES COMMON JOINTS TO FREE JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1	0.	0.	0.	0.	0.	0.
ROW 2	0.	0.	0.	0.	0.	0.
ROW 3	0.	0.	0.	0.	0.	0.
ROW 4	0.	0.	0.	0.	0.	0.
ROW 5	0.	0.	0.	0.	0.	0.
ROW 6	0.	0.	0.	0.	0.	0.
ROW 7	0.	0.	0.	0.	0.	0.
ROW 8	0.	0.	0.	0.	0.	0.
ROW 9	0.	0.	0.	0.	0.	0.
ROW 10	0.	0.	0.	0.	0.	0.
ROW 11	0.	0.	0.	0.	0.	0.
ROW 12	0.	0.	0.	0.	0.	0.

RCM 1	0.12950E-02	0.	0.	0.	0.	0.
RCM 2	0.12950E-02	0.	0.	0.	0.	0.
RCM 3	0.	0.	0.	0.	0.	0.
RCM 4	0.	0.	0.	0.	0.	0.
RCM 5	0.	0.	0.	0.	0.	0.
RCM 6	0.	0.	0.	0.	0.	0.

0.12950E-02

0

5

3.

C.12950E-02 0.

5

Q

0.0

10

0.

1

0.0

Abstract

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11

SAMPLE PROBLEM-TYPICAL MISSILE
COMPONENT 3-CONTROL SURFACE

NJTS = 13 NR = 1 NRE = 18 APE = 0 NMODE = 7 MKEY = 1 NLUMP = 13 NGT = 1 NPUNJ = 0

MATERIAL PROPERTIES

NO. YOUNG'S MODULUS POISSON RATIO MODULUS OF RIGIDITY DENSITY
1 0.10000E 03 0.30000 0.38462E 07 0.

JOINT COORDINATES

JOINT NO.	X COORD.	Y COORD.
1	81.6600	5.0000
2	85.0000	5.0000
3	91.6600	5.0000
4	81.6600	15.0000
5	85.0000	15.0000
6	91.6600	15.0000
7	81.6600	25.0000
8	85.0000	25.0000
9	91.6600	25.0000
10	81.6600	35.0000
11	85.0000	35.0000
12	91.6600	35.0000
13	85.0000	0.

JOINT RESTRAINT CODE

JOINT NO. Z DISPLACEMENT ROTATION ABOUT X ROTATION ABOUT Y
13 1 1

LUMPED HEIGHTS

JOINT NO.	HEIGHT
1	0.0840
2	0.1250
3	0.0410
4	0.0840
5	0.1250
6	0.0410
7	0.0840
8	0.1250
9	0.0410
10	0.0840
11	0.1250
12	0.0410
13	0.5000

BEM ELEMENT PROPERTIES

BEM ELEMENT NO.	A	I	J	SAT	JOINT 1	JOINT 2
1	0.5000	0.2660	0.0266	1	1	4
2	0.5000	0.2660	0.0266	1	4	7
3	0.5000	0.2660	0.0266	1	7	13
4	0.5000	0.2660	0.0266	1	13	2

ROW 7 0.10154E-06 -0.11219E-06 0.36234E-05 -0.11916E-05 0.25108E-04 -0.17785E-03

ROW 8 0.19431E-06 -0.55578E-05 0.25107E-04 -0.13170E-05 0.91639E-03

ROW 9 0.44903E-05 -0.17785E-03 0.91647E-03 -0.10318E-05

ROW 10 0.78076E-05 -0.10547E-06 0.36056E-05

ROW 11 0.16902E-06 -0.54789E-05

ROW 12 0.22960E-05

THE TIME ELAPSED FOR MATRIX INVERSION = 0.7552E-01 SECONDS

REDUCED UPPER TRIANGULAR FLEXIBILITY MATRIX

ROW 1 0.56546E-03 0.15643E-04 -0.10716E-02 0.60939E-03 0.62344E-04 -0.10282E-02 0.65434E-03 0.10228E-03 -0.98373E-03
0.69533E-03 0.35203E-03 -0.9327E-03

ROW 2 0.15664E-04 0.15646E-04 0.62655E-04 0.62656E-04 0.62658E-04 0.10965E-03 0.10965E-03 0.10965E-03 0.15664E-03
0.15664E-03 0.15644E-03

ROW 3 0.22195E-02 -0.10346E-02 0.61611E-04 0.22529E-02 -0.99763E-03 0.10032E-03 0.22822E-02 -0.25853E-03 0.13856E-03
0.23262E-02

ROW 4 0.10738E-02 0.40721E-03 -0.90075E-03 0.15152E-02 0.77511E-03 -0.70252E-03 0.19322E-02 0.11309E-02 -0.46779E-03

ROW 5 0.40757E-03 0.41303E-03 0.77207E-03 0.77779E-03 0.77797E-03 0.11460E-02 0.11454E-02 0.11444E-02

ROW 6 0.25536E-02 -0.66772E-03 0.81239E-03 0.37623E-02 -0.37688E-03 0.12196E-02 0.44052E-02

ROW 7 0.24975E-02 0.55846E-02 -0.22738E-03 0.34606E-02 0.24022E-02 0.20968E-03

ROW 8 0.15977E-02 0.16049E-02 0.24203E-02 0.24264E-02 0.24201E-02

ROW 9 0.52567E-02 0.36715E-03 0.24679E-02 0.66623E-02

ROW 10 0.51435E-02 0.03035E-02 0.12146E-02

ROW 11 0.35287E-02 0.8139E-02

ROW 12

REDUCED UPPER TRIANGULAR WEIGHT MATRIX

0.84000E-01	0.	0.	0.	0.
0.	0.	0.	0.	0.

0.12500E 00	0.	0.	0.	0.
0.	0.	0.	0.	0.

0.41000E-01	5.	.	0.	0.	0.	0.
0.						

0.84000E-01	0.	0.	0.	0.	0.
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16

1	7	0.	0.	0.	0.	0.
0.84000E-01	0.	0.	0.	0.	0.	0.

C.12500E 00	0.	0.	0.
	3.	0.	0.

4 10

0.12500E 00 3.

0.41000E+01

NOT REPRODUCIBLE

SEE: 20310383 "YENLU, ZHI BAO ZHANG THE ACTUAL"

TIME	NATURAL FREQUENCY	NUMBER	1	15	35	477	635
THE	NATURAL FREQUENCY	NUMBER	2	15	35	477	635
THE	NATURAL FREQUENCY	NUMBER	3	15	35	477	635
THE	NATURAL FREQUENCY	NUMBER	4	15	35	477	635
THE	NATURAL FREQUENCY	NUMBER	5	15	35	477	635
THE	NATURAL FREQUENCY	NUMBER	6	15	35	477	635
THE	NATURAL FREQUENCY	NUMBER	7	15	35	477	635

COMMON JOINTS FREE

COORDINATE NUMBERS FOR EACH 7 DISPLACEMENT AT EACH UNRESTRAINED JOINT

JOINT NO. COORD. NO.

1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13

THE TIME ELAPSED FOR MATRIX INVERSION = 0.5021E 03 SECONDS

CPFFJ MATRIX (STIFFNESS) - RELATES COMMON JOINTS TO FREE JOINTS - FOR COMPONENT MCDE SYNTHESIS PROGRAM

ROW 1
-0.69170E 03 -0.11526E 04 -0.40527E 04ROW 2
-0.14801E 06 -0.45948E 06 0.30303E 04ROW 3
-0.35255E 03 -0.58749E 03 0.10224E 04ROW 4
0.96467E 03 0.16078E 04 -1.43125E 01ROW 5
0.30499E 05 0.50832E 05 0.63536E 01ROW 6
0.49191E 03 0.61945E 03 -0.20213E 01ROW 7
-0.32931E 03 -0.54845E 03 -0.41756E 02ROW 8
-0.74917E 04 -0.12446E 05 0.26206E 01ROW 9
-0.16704E 03 -0.27900E 03 -0.42030E 01ROW 10
0.55336E 02 0.93664E 02 -0.57795E 04ROW 11
0.12466E 04 0.2074E 04 0.4749E 03ROW 12
0.24543E 02 0.37636E 02 -0.41765E 03

UPPER TRIANGLE OF CKIJ MATRIX (STIFFNESS) - COMMON JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1
C.12376E 06 0.41906E 06 0.

ROW 2
C.17624E 07 0.

ROW 3
C.20346E 05

CNEJ MATRIX (MASS) - RELATES COMMON JOINTS TO FREE JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1
0. 0. 0.

ROW 2
0. 0. 0.

ROW 3
0. 0. 0.

ROW 4
0. 0. 0.

ROW 5
0. 0. 0.

ROW 6
0. 0. 0.

ROW 7
0. 0. 0.

ROW 8
0. 0. 0.

ROW 9
0. 0. 0.

ROW 10
0. 0. 0.

ROW 11
0. 0. 0.

ROW 12
0. 0. 0.

UPPER TRIANGLE OF CUIJ MATRIX (MASS) - COMMON JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM

ROW 1
C.12908E 02 0.

ROW 2
0. 0.

ROW 3
0. 0.

2.6 Program Listing

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*      FORTRAN DECK
CMAIN  PROGRAM FLUENG=FOR GENERATING STIFFNESS,FLEXIBILITY AND MASS
C      MATRICES FROM PLANE GRID BEAM AND TRIANG. PLATE ELEMENTS
C      FLUENG-100 C FOR 100 DEGREES OF FREEDOM OR LESS. GENERATES PUNCHED
C      OUTPUT TO BE USED IN THE COMPONENT MODE SYNTHESIS PROGRAM.
C
      DIMENSION TITF(24),YM(10),FR(10),GF(10),DENS(10),X(200),Y(200),
      1NR1(200),NR2(200),NR3(200),N1(200),N2(200),N3(200),NOSC(9),DCS(2),
      2STM(6,6),SMH(6,6),PI TK(9,9),PLTM(9,9),SSTF(25050),SH(25050),
      3RSMAS(300),A(25050),VALU(9),TEMP(100),R(300),C(200),DUM3(300),
      4F(300,3),IDUM4(100),JHASS(300),JTN(100)
      INTEGER OUT
      EQUIVALENCE(SSTF(1),SH(1),A(1)),(STM(1,1),SMH(1,1),PI TK(1,1),
      1PI TM(1,1))
1000  FORMAT(12A6)
1001  FORMAT(16I5)
1002  FORMAT(8F10.3)
1003  FORMAT(1EX,2F10.3)
1004  FORMAT(3I10.3,3I5)
1005  FORMAT(F10.3,5I5)
1006  FORMAT(I5,5X,F10.3)
5000  FORMAT(14I1,12A6/1X,12A6)
5001  FORMAT(///6HNJTS =14,5X,6H NR =14,5X,6H NRE =14,5X,6H NPE =14,5X,
      17HNMDF =13,5X,6HMKFY =13,5X,7H LUMP =13,
      25X,6HNCJT =13,5X,7HNPUNJ =12)
5002  FORMAT(///73HMA T F P I A I      P R O P E R T I E S *****
      1*****/73HNO.      YOUNG*S MODULUS      POISSON RATIO
      1 MODULUS OF RIGIDITY      DENSITY,10(/12,6X,E12.5,9X,F7.5,10X,E12.5,
      16X,112.5))
5004  FORMAT(///34HJ O I N T      C O O R D I N A T E S/35HJOINT NO.      X
      1 COORD.      Y COORD.)
5004  FORMAT(15,7X,F10.5,3X,110.5)
5006  FORMAT(///67HJ O I N T      R E S T R A I N T      C O D E *****
      1*****/67HJOINT NO.      7 DISPLACEMENT      ROTATION ABOUT X
      1 ROTATION ABOUT Y)
5007  FORMAT(15,116,119,120)
5008  FORMAT(///75HNR I A M      E L E M E N T      P R O P E R T I E S *****
      1*****/75HELEMENT NO.      A      I
      1      I      MAT      JOINT 1      JOINT 2)
5009  FORMAT(16,8X,F9.4,4X,F9.4,4X,F9.4,2X,12,6X,13,9X,13)
5010  FORMAT(///122HTRI A NG U L A R      P L A T E      E L E M E N T
      1 P R O P E R T I E S *****
      1****/122ELEMENT NO.      1      MAT      JOINT 1      JOINT 2      JOINT
      13      DX      DY      D1      DXY      BETA)
5011  FORMAT(16,8X,F8.4,3X,12,6X,13,8X,13,8X,13,6X,F11.5,3X,F11.5,3X,
      1F11.5,3X,E11.5,3X,F6.2)
5020  FORMAT(///69HCOORDINATE NUMBERS FOR EACH 2 DISPLACEMENT AT EACH UN
      1RESTRAINED JOINT/25HJOINT NO.      COORD. NO.)
5021  FORMAT(15,116)
5022  FORMAT(///28H I M P E D      W E I G H T S/23HJOINT NO.      WFIG
      1HT)
5023  FORMAT(15,6X,F10.4)
C      DISC ASSIGNMENTS
      IN=5
      OUT=6
      MDISC=7
      NDISC=8
      IDISC=9
      JDISC=10
      KDISC=11

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      MMODISC=12
      ANODISC=13
      IODISC=14
      JIODISC=15
C     BEGIN INPUT OF DATA
100  READ(IN,1000) (TITLE(I),I=1,24)
      REWIND MDISC
      REWIND NDISC
      REWIND IDISC
      REWIND JIDISC
      REWIND KDISC
      REWIND MMODISC
      REWIND ANODISC
      REWIND IODISC
      REWIND JIODISC
      WRITE(OUT,5000) (TITLE(I),I=1,24)
      READ(IN,1001) NJTS,NR,NRE,NPE,NMODE,MKEY,NLUMP,NCJT,NPUNJ
C
C     NJTS=NO. OF JOINTS, NR=NO. OF JOINTS WITH RESTRAINTS
C     NRE=NO. OF BEAM ELEMENTS, NPE=NO. OF TRIANGULAR PLATE ELEMENTS
C     NMODE=NO. OF EIGENVALUES AND EIGENVECTORS DESIRED
C     MKEY = 1 DO NOT COMPUTE ELEMENTAL CONSISTENT MASS TERMS
C     MKEY = 2 COMPUTE ELEMENTAL CONSISTENT MASS TERMS
C     NLUMP = NO. OF LUMPED MASSES INPUT
C     NCJT = 0 IF ONLY ONE COMPONENT IS CONSIDERED.
C     NCJT = NO. OF COMMON JOINTS IF MORE THAN ONE COMPONENT IS CONSIDERED.
C     THE COMMON JOINTS MUST BE NUMBERED LAST.
C     NPUNJ = 0, BOTH MASS AND FLEXIBILITY MATRICES PUNCHED OUT
C     NPUNJ = -1, NO PUNCHED OUTPUT
C     NPUNJ = 1, ONLY MASS MATRIX AND IICW, IICW CODE PUNCHED OUT
C     NPUNJ = 2, ONLY REDUCED FLEXIBILITY MATRIX PUNCHED OUT
C     IF NCJT IS GREATER THAN 0, NPUNJ MUST BE 0 SO THAT ALL OUTPUT WILL
C     BE PUNCHED INCLUDING THE STIFFNESS MATRIX, MODE SHAPES AND FREQ.
C     FOR THE COMPONENT MODE SYNTHESIS PROGRAM.
C
      WRITE(OUT,5001) NJTS,NR,NRE,NPE,NMODE,MKEY,NLUMP,NCJT,NPUNJ
C     INPUT MATERIAL PROPERTIES
      READ(IN,1001) NMAT
      DO 10 I=1,NMAT
        READ(IN,1002) YM(I),PR(I),GE(I),DENS(I)
C     YM=YOUNG'S MOD./10**6, PR=POISSON RATIO, GE=MOD. OF RIGIDITY
C     DENS=DENSITY
        IF(GE(I).EQ.0.) GE(I)=YM(I)/(2.*(1.+PR(I)))
        YM(I)=YM(I)*1.E6
10    GE(I)=GE(I)*1.E6
      WRITE(OUT,5002) (I,YM(I),PR(I),GE(I),DENS(I),I=1,NMAT)
      DO 256 I=1,NMAT
256  DENS(I)=DENS(I)/(32.174*12.)
C     INPUT JOINT COORDINATES
      READ(IN,1003) (X(M),Y(M),M=1,NJTS)
      WRITE(OUT,5003)
      WRITE(OUT,5004) (M,X(M),Y(M),M=1,NJTS)
      NNJTS=NJTS-1
      DO 400 I=1,NNJTS
        XCOR=X(I)
        YOP=1+I
        DO 499 II=MOR,NJTS
          XMOP=X(II)
          IF(XMOP-XCOR)499,495,499
495  YCOR=Y(I)

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      YMRP=Y(I1)
      IF(YMRP-YCOR)499,485,499
485  WRITE(OUT,5099) I,I1
5999  FORMAT(1H1,5X,31HA DATA ERROR HAS BEEN DETECTED./6X,34HTHE X AND Y
      1 COORDINATES OF JOINTS 13,1X,4HAND 13,1X,13HARE THE SAME./6X,30HP
      2ROGRAM ENDED AND JOB DELETED.)
      CALL EXIT
499  CONTINUE
500  CONTINUE
C     INPUT JOINT RESTRAINT CODE
C     0=FREE
C     1=CLAMPED
      DO 12 I=1,NJTS
      NR1(I)=0
      NR2(I)=0
      NR3(I)=0
      N1(I)=0
      N2(I)=0
12  N3(I)=0
      IF(NP.EQ.0) GO TO 80
      WRITE(OUT,5006)
      DO 11 I=1,NP
      READ(IN,1001) JT,M1,M2,M3
      NR1(JT)=M1
      NR2(JT)=M2
      NR3(JT)=M3
      WRITE(OUT,5007) JT,M1,M2,M3
      JTN(I)=JT
11  CONTINUE
      IF(NP.EQ.1) GO TO 80
      ANR=NR-1
      DO 600 J=1,NNR
      JTT=JTN(I)
      JOT=J+1
      DO 599 JJ=JOT,NR
      JCT=JTN(JJ)
      IF(JCT-JTT)599,595,599
595  WRITE(OUT,6999)JCT
6999  FORMAT(1H1,5X,31HA DATA ERROR HAS BEEN DETECTED./6X,38HIN THE JOIN
      1T PESTRAINT LISTING, JOINT 13,1X,14HAPPEARS TWICE./6X,30HPROGRAM
      2ENDED AND JOB DELETED.)
      CALL EXIT
599  CONTINUE
600  CONTINUE
80  CONTINUE
C     INPUT LUMPED MASSES
      IF(NLUMP.EQ.0) GO TO 250
      READ(IN,1006) ((JMASS(I),RSPASS(I)),I=1,NLUMP)
      WRITE(OUT,5022)
      DO 251 I=1,NLUMP
      WRITE(OUT,5023) JMASS(I),RSMASS(I)
      RSMASS(I)=RSMASS(I)/(32.174*12.)
251  CONTINUE
250  CONTINUE
      IF(NRF.EQ.0) GO TO 202
      WRITE(OUT,5008)
      DO 650 NR=1,NRF
C     INPUT BEAM ELEMENT PROPERTIES
      READ(IN,1004) AR,XI,YJ,MAI,JTNR,JTFR
C     AR=AREA OF BEAM CROSS SECTION. XI=AREA MOMENT OF INERTIA,

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C      YJ=EFFECTIVE TORSIONAL MOMENT OF INERTIA, MAT=MATERIAL CODE
C      JTNR,JTFR=JOINT NUMBERS AT ENDS
      WRITE(OUT,5009) NM,AR,XI,YJ,MAT,JTNR,JTFR
      IF(AR.EQ.0.0.OR.XI.EQ.0.0.OR.YJ.EQ.0.0.OR.MAT.EQ.0) GO TO 795
      IF(JTNR.EQ.JTFR) GO TO 796
      GO TO 790
795  WRITE(OUT,7999)NM
7990  FORMAT(1H1,5X,29HDATA ERROR HAS BEEN DETECTED./6X,39HA BEAM PROPE
      RTY IS MISSING FOR ELEMENT 13,1X,1H.//6X,30HPROGRAM ENDED AND JO
      2R DELETED.)
      CALL EXIT
796  WRITE(OUT,7998)NM
7998  FORMAT(1H1,5X,31HA DATA ERROR HAS BEEN DETECTED./6X,36HJOINT 1 AND
      1 JOINT 2 OF BEAM ELEMENT 13,1X,1HARE THE SAME.//6X,30HPROGRAM END
      2ED AND JO2 DELETED.)
      CALL EXIT
799  CONTINUE
      WRITE(IIDISC) AR,XI,YJ,MAT,JTNR,JTFR
650  CONTINUE
202  CONTINUE
      IF(NPF.EQ.0) GO TO 302
      WRITE(OUT,5010)
      DO 655 NM=1,NPF
C      INPUT TRIANGULAR PLATE ELEMENT PROPERTIES
      READ(IN,1005) PTH,MAT, JT1,JT2,JT3,NDX
C      PTH=PLATE THICKNESS, MAT=MATERIAL CODE,
C      JT1, JT2, JT3=JOINT NUMBERS AT CORNERS, ANGLE AT JT1 MUST NOT BE
C      90 DEGREES
C      DX,DY,D1,DXY,RETA - FLEXURAL RIGIDITY TERMS AND ANGLE OF MATERIAL
C      PRINCIPAL AXES W/O TRIANGLE LOCAL AXES
      IF(NDX.EQ.1) READ(IN,1002) PX,DY,D1,DXY,RETA
      IF(NDX.EQ.1) GO TO 18
      RETA=0.
      DX=(YM(MAT)*PTH**3)/(12.*(1.-PR(MAT)**2))
      DY=DY
      D1=PR(MAT)*DX
      DXY=((1.-PR(MAT))/2.)*DX
18  RETA=RETA/57.2958
      WRITE(OUT,5011) NM,PTH,MAT, JT1,JT2,JT3,DX,DY,D1,DXY,RETA
      IF(PTH.EQ.0.0.OR.PTH.EQ.0) GO TO 895
      IF(JT1.EQ.JT2.OR.JT1.EQ.JT3.OR.JT2.EQ.JT3) GO TO 896
      GO TO 890
895  WRITE(OUT,8999)NM
8990  FORMAT(1H1,5X,29HDATA ERROR HAS BEEN DETECTED./6X,51HA TRIANGULAR
      1PLATE PROPERTY IS MISSING FOR ELEMENT 13,1X,1H.//6X,30HPROGRAM END
      2ED AND JO2 DELETED.)
      CALL EXIT
896  WRITE(OUT,8998)NM
8998  FORMAT(1H1,5X,31HA DATA ERROR HAS BEEN DETECTED./6X,94HEITHER JOIN
      ITS 1 AND 2, OR JOINTS 1 AND 3, OR JOINTS 2 AND 3 DEFINING TRIANGUL
      2AR PLATE ELEMENT 13,1X,1HARE THE SAME.//6X,30HPROGRAM ENDED AND J
      3OR DELETED.)
      CALL EXIT
899  CONTINUE
      WRITE(IIDISC) DX,DY,D1,DXY,RETA
      WRITE(IIDISC) PTH,MAT, JT1,JT2,JT3
655  CONTINUE
302  CONTINUE
      IF(NCJT) 657,656,657
656  NK 1

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```

GO TO 658
657 NK-2
NNGJT = NJTS-NCJT+1
658 DO 350 KKK=1,NK
IF(KKK.EQ.1) GO TO 670
REWIND IDISC
REWIND MDISC
REWIND MMDISC
REWIND NDISC
REWIND NMDISC
DO 669 JI=NNGJT,NJTS
NR1(JI)=0
NR2(JI)=0
NR3(JI)=0
669 CONTINUE
WRITE(OUT,659)
659 FORMAT(10I 41X,18HCOMMON JOINTS FREE)
C GENERATE COORDINATE NUMBERS FOR EACH DEGREE OF FREEDOM, 0 IF
C CLAMPED, NORMAL DISPLACEMENTS ARE NUMBERED FIRST
C N1, N2, N3 CONTAIN COORD. NUMBERS FOR EACH JOINT
C NREDU = NO. OF NORMAL DISPLACEMENTS
C NDI = NO. OF DEGREES OF FREEDOM INCLUDING ROTATIONS
670 CALL COORDN(NR1,NR2,NR3,N1,N2,N3,NJTS,NREDU,NDF,KKK,NNGJT)
NOMASS=NDF-NREDU
MM1=NREDU*NOMASS+(NREDU*(NREDU+1)/2)
IF(NCJT.EQ.0) GO TO 671
IF(KKK.EQ.2) GO TO 671
WRITE(OUT,672)
672 FORMAT(/// 25HCOMMON JOINTS CON-TRAINED)
671 WRITE(OUT,5020)
DO 50 I=1,NJTS
IF(NR1(I).EQ.1) GO TO 50
WRITE(OUT,5021) I,N1(I)
50 CONTINUE
NSSI=NDF*(NDF+1)/2
DO 13 I=1,MM1
13 SSTF(I)=0.
IK22=0
REWIND IDISC
IF(NRF.EQ.0) GO TO 200
C BEGIN TO GENERATE BEAM STIFFNESS TERMS
C SET UP CODE NUMBERS FOR BEAM JOINTS
DO 14 NM=1,NRF
READ(IDISC) AR,XI,YJ,MAT,JTNR,JTFR
NOSC(1)=N1(JTNR)
NOSC(2)=N2(JTNR)
NOSC(3)=N3(JTNR)
NOSC(4)=N1(JTFR)
NOSC(5)=N2(JTFR)
NOSC(6)=N3(JTFR)
IF(MKEY.EQ.1) GO TO 253
C STORE INFO. FOR LATER USE
WRITE(IDISC) AR,XI,YJ,MAT,JTNR,JTFR,(NOSC(I),I=1,6)
253 CONTINUE
X1=X(JTNR)
X2=X(JTFR)
Y1=Y(JTNR)
Y2=Y(JTFR)
FLNTH=SQRT((X2-X1)**2+(Y2-Y1)**2)
CALL TRANS(X1,X2,Y1,Y2,FLNTH,DCS)

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F=YH(MAT)
G=G(MAT)
CALL RFAMK(FINTH,E,G,XI,YJ,STM,DCS)
DO 15 K=1,6
IF(NOSC(K).EQ.0) GO TO 15
I=NOSC(K)
DO 16 N=1,6
IF(NOSC(N).EQ.0) GO TO 16
J=NOSC(N)
IF(J.LT.1) GO TO 16
MM=(2*I+(1-1)*(2*NDF-1))/2
MM2=MM-MM1
IF(MM2)186,186,187
186 SSTF(MM)=SSTF(MM)+STM(K,N)
GO TO 16
187 AS=STM(K,N)
WRITE (MHDISC) MM2,AS
IK22=IK22+1
16 CONTINUE
15 CONTINUE
14 CONTINUE
200 CONTINUE
IF(NPF.EQ.0) GO TO 300
C BEGIN TO GENERATE TRIANGULAR PLATE STIFFNESS TERMS
C SET UP CODE NUMBERS FOR TRIANGULAR PLATE JOINTS
REWIND JIDISC
DO 17 NM=1,NPF
READ(JIDISC) PTH,MAT,JT1,JT2,JT3
READ(JIDISC) DX,DY,D1,DXY,BETA
NOSC(1)=N1(JT1)
NOSC(2)=N2(JT1)
NOSC(3)=N3(JT1)
NOSC(4)=N1(JT2)
NOSC(5)=N2(JT2)
NOSC(6)=N3(JT2)
NOSC(7)=N1(JT3)
NOSC(8)=N2(JT3)
NOSC(9)=N3(JT3)
IF(NKEY.EQ.1) GO TO 254
C STOP INFO. FOR LATER USE
WRITE(IDISC) PTH,MAT,JT1,JT2,JT3,(NOSC(I),I=1,9)
254 CONTINUE
RX1=X(JT1)
RX2=X(JT2)
RY1=Y(JT1)
RY2=Y(JT2)
Y2=SQRT((RX2-RX1)**2+(RY2-RY1)**2)
CALL TRANS(RX1,PX2,RY1,BY2,Y2,DCS)
X3=DCS(2)*(X(JT3)-RX1)+DCS(1)*(Y(JT3)-RY1)
Y3=DCS(1)*(X(JT3)-RX1)+DCS(2)*(Y(JT3)-RY1)
CALL PLATEK(Y2,X3,Y3,DX,DY,D1,DXY,BETA,DCS,PLTK)
DO 19 K=1,9
IF(NOSC(K).EQ.0) GO TO 19
I=NOSC(K)
DO 20 N=1,9
IF(NOSC(N).EQ.0) GO TO 20
J=NOSC(N)
IF(J.LT.1) GO TO 20
MM=(2*I+(1-1)*(2*NDF-1))/2
MM2=MM-MM1

```

```

      IF (MM2) 108, 108, 109
108  SSTF(MM) = SSTF(MM) + PLTK(K,N)
      GO TO 20
109  AS = PLTK(K,N)
      WRITE (MMDISC) MM2, AS
      IM22 = IM22 + 1
20   CONTINUE
19   CONTINUE
17   CONTINUE
300  CONTINUE
C    STOP FOR REDUCTION
      DO 21 I = 1, NDFH
      NS = (2*I + (I-1)*(2*NDF-1))/2
      NE = (2*NDF + (I-1)*(2*NDF-1))/2
21   WRITE (MMDISC) (SSTF(J), I=NS, NE)
      REWIND MDISC
      DO 22 I = 1, MM1
22   SM(I) = 0.
      IM22 = 0
      IF (MKEY.EQ.1) GO TO 255
      IF (NPF.EQ.0) GO TO 201
C    GENERATE BEAM MASS MATRICES
      DO 23 NM = 1, NBI
      READ (MDISC) AP, XI, YJ, MAT, J1R, J1F, (NOSC(I), I=1, 6)
      X1 = X(J1F)
      X2 = X(J1R)
      Y1 = Y(J1F)
      Y2 = Y(J1R)
      FLNTH = SQRT((X2-X1)**2 + (Y2-Y1)**2)
      CALL TRANS(X1, X2, Y1, Y2, FLNTH, DCS)
      RHO = PENS(MAT)
      CALL BEAM3(FLNTH, RHO, AP, XI, YJ, SPM, DCS)
      DO 24 K = 1, 6
      IF (NOSC(K).EQ.0) GO TO 24
      I = NOSC(K)
      DO 25 N = 1, 6
      IF (NOSC(N).EQ.0) GO TO 25
      J = NOSC(N)
      IF (J.LT.1) GO TO 25
      MM = (2*I + (I-1)*(2*NDF-1))/2
      MM2 = MM - MM1
      IF (MM2) 100, 100, 101
100  SM(MM) = SM(MM) + SMM(K,N)
      GO TO 25
101  AS = SMM(K,N)
      WRITE (MMDISC) MM2, AS
      IM22 = IM22 + 1
25   CONTINUE
24   CONTINUE
23   CONTINUE
201  CONTINUE
      IF (NPF.EQ.0) GO TO 301
C    GENERATE TRIANGULAR PLATE MASS MATRICES
      DO 26 NM = 1, NPI
      READ (MDISC) PIH, MAT, JT1, JT2, JT3, (NOSC(I), I=1, 9)
      RX1 = X(JT1)
      RX2 = X(JT2)
      RY1 = Y(JT1)
      RY2 = Y(JT2)
      Y2 = SQRT((RX2-RX1)**2 + (RY2-RY1)**2)

```

```

CALL TRANS(RX1,RX2,RY1,RY2,Y2,DCS)
X3=DCS(2)*(Y(JT3)-RX1)-DCS(1)*(Y(JT3)-RY1)
Y3=DCS(1)*(Y(JT3)-RX1)+DCS(2)*(Y(JT3)-RY1)
PRHO=DEMS(MAT)
CALL PLATEM(Y2,X3,Y3,PRHO,PTH,DCS,PLTM)
DO 27 K=1,9
IF(NOSC(K).EQ.0) GO TO 27
I=NOSC(K)
DO 28 N=1,9
IF(NOSC(N).EQ.0) GO TO 28
J=NOSC(N)
IF(J.LT.I) GO TO 28
MM=(2*I+(J-1)*(2*NDF-1))/2
MM2=MM-MM1
IF(MM2)192,192,193
192 SM(MM)=SM(MM)+PITM(K,N)
GO TO 28
193 AS=PITM(I,N)
WRITE (NPDISC)MM2,AS
IM22=IM22+1
20 CONTINUE
27 CONTINUE
26 CONTINUE
301 CONTINUE
C STOP FOR REDUCTION
254 CONTINUE
IF(NLUMP.EQ.0) GO TO 259
DO 258 I=1,NLUMP
NN=JMASS(I)
IF(N1(NN).EQ.0) GO TO 258
NNN=N1(NN)
NS=(2*NNN+(NNN-1)*(2*NDF-1))/2
SM(NS)=SM(NS)+PSMASS(I)
258 CONTINUE
259 CONTINUE
DO 29 I=1,NPDFH
NS=(2*I+(I-1)*(2*NDF-1))/2
NF=(2*NDF+(I-1)*(2*NDF-1))/2
29 WRITE (NPDISC) (SM(J),J=NS,NF)
IF(MKEY.EQ.1) GO TO 305
GO TO 324
305 PM3=JMASS*(NOMASS+1)/2
AS=0.0
DO 310 MM2=1,MM3
WRITE (NPDISC)MM2,AS
IM22=IM22+1
310 CONTINUE
324 IF(KKK.EQ.1) GO TO 325
CALL DIVID (NPEDH,NOMASS,MDISC,IDISC,IDISC,A,H,MMDISC,IK22)
CALL ZROPAK(A,B,C,DUM3,NREDU,NOMASS,IDISC,JDISC,MDISC,KDISC,KKK)
CALL ZROPAK(A,B,C,DUM3,NREDU,NOMASS,IDISC,JDISC,MDISC,KDISC)
CALL DIVID (NREDU,NOMASS,NDISC,IDISC,IDISC,A,H,NNDISC,IM22)
CALL ZROPAK(A,B,C,DUM3,NREDU,NOMASS,IDISC,JDISC,NDISC,KDISC)
CALL COMS (NREDU,NCJT,MDISC,A,B,1)
CALL COMS (NREDU,NCJT,NDISC,A,B,2)
GO TO 350
325 CALL FGEN(A,VALU,TEMP,B,C,DUM3,F,TRUP4,IDISC,JDISC,KDISC,NDISC,
1PDISC,NDF,NMDF,NMDF,NREDU,NOMASS,MMDISC,NNDISC,IK22,IM22,NPUNJ,
2NCJT,KKK)
350 CONTINUE

```

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GO TO 100
END
FORTRAN DECK
FORMS, PRINTS, PUNCHES MASS OR STIFFNESS KJ AND JJ MATRICES
FOR THE COMPONENT MODE SYNTHESIS PROGRAM
MDISC CONTAINS REDUCED MASS OR STIFFNESS MATRIX - COMMON JOINTS
FREE (INCLUDES ROTATION), ROTATION OF OTHER JOINTS ELIMINATED.
NP=PRINT AND PUNCH CODE, NP=1 FOR STIFFNESS, NP=2 FOR MASS

SUBROUTINE COMS (NREDU,NCJT,MDISC,A,R,NP)

DIMENSION A(1),R(1),CJ(1296)

3 FORMAT(/2X,3HROW,14/(9F14.5))
4 FORMAT(///2X,10HCKFJ MATRIX (STIFFNESS) - RELATES COMMON JOINTS TO
10 FREE JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM )
8 FORMAT(/// 2X,96HCMFJ MATRIX (MASS) - RELATES COMMON JOINTS TO FREE
16 JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM )
50 FORMAT(/// 2X,96HUPPER TRIANGLE OF CKJJ MATRIX (STIFFNESS) - COMMON
16 JOINTS - FOR COMPONENT MODE SYNTHESIS PROGRAM )
51 FORMAT(/// 2X,91HUPPER TRIANGLE OF CMJJ MATRIX (MASS) - COMMON JOI
16 NTS - FOR COMPONENT MODE SYNTHESIS PROGRAM )
REWIND MDISC
DATA 01/4HCKFJ/,02/4HCKJJ/,03/4HCMFJ/,04/4HCMJJ/
MAX=NREDU*(NREDU+1)/2
READ(MDISC)(A(I),I=1,MAX)
IF(NP.EQ.2) GO TO 7
WRITE(6,1)
GO TO 11
7 WRITE(6,8)
11 IC=0
N3=3*NCJT
N=NREDU-3*NCJT
DO 20 I=1,N
NS=(2*I+(I-1)*(2*NREDU-1))/2
NF=(2*NREDU+(I-1)*(2*NREDU-1))/2
I=0
NR=NC+N-1+1
DO 15 K=NR,NF
L=I+1
15 R(I)=A(K)
WRITE(6,3)I,(R(J),J=1,N3)
IF(NP.EQ.2) GO TO 16
CALL PUNC (R,1,N3,01,IC)
GO TO 20
16 CALL PUNC (R,1,N3,03,IC)
20 CONTINUE
IF(NP.EQ.2) GO TO 23
WRITE(6,50)
GO TO 24
23 WRITE(6,51)
24 IC=0
N2=N+1
I=0
DO 30 I=N2,NREDU
NS=(2*I+(I-1)*(2*NREDU-1))/2
NF=(2*NREDU+(I-1)*(2*NREDU-1))/2
N1=I-N
WRITE(6,3)N1,(A(J),J=NS,NF)
DO 25 K=NS,NF

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      I=I+1
25  C.J.I(1)=A(K)
30  CONTINUE
      DO 40 I=1,N3
          II=I-1
          IF(II.EQ.0) GO TO 32
          DO 31 J=1,II
              NU=(2*I+(J-1)*(2*I-J))/2+(J-1)*(N3-1)
31      R(I)=CJJ(NU)
32  CONTINUE
          NS=(2*I+(I-1)*(2*N3-1))/2
          NF=(2*N3*(I-1)+(2*N3-1))/2
          J=1
          DO 33 JJ=NS,NF
              R(I)=CJJ(JJ)
33      J=J+1
          IF(NF.EQ.2) GO TO 35
          CALL PHNC (R,I,N3,02,IC)
          GO TO 40
35  CALL PHNC (R,I,N3,04,IC)
40  CONTINUE
      RETURN
      END

```

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*      FORTRAN DECK
C7ROMAK      GENERATES REDUCED STIFFNESS MATRIX FOR FLOFNC-100 C
C
C      D IS A DUMMY VECTOR WITH STORAGE N OR M (LARGER)
C      A IS A DUMMY VECTOR WITH STORAGE N*(N+1)/2 OR M*(M+1)/2 (LARGER)
C      R IS A DUMMY VECTOR WITH STORAGE N OR M (LARGER)
C      C IS A DUMMY VECTOR WITH STORAGE N OR M (LARGER)
C      N=NO. OF NORMAL DISPLACEMENTS
C      M=NO. OF ROTATIONAL D.O.F.
C      N1PE CONTAINS K11 MATRIX
C      M1PE CONTAINS K12 MATRIX
C      I1PE SCRATCH TAPE
C      K1PE STORES K12*K22**(-1)
C      A INITIALLY CONTAINS K22
C*** REDUCED STIFFNESS MATRIX IS STORED ON I1PE
SUBROUTINE 7ROMAK(A,R,C,D,N,M,N1PE,M1PE,I1PE,K1PE,KKK)
DIMENSION A(1),R(1),C(1),D(1)
DOUBLE PRECISION SUM,DP1,DP2
NMAX=N*(N+1)/2
MMAX=M*(M+1)/2
IF(KKK.EQ.1) GO TO 5
REWIND I1PE
WRITE(I1PE) (A(I),I=1,MMAX)
5 CALL SYMINV(A,M)
REWIND M1PE
REWIND I1PE
REWIND M1PE
REWIND K1PE
DO 10 IK=1,N
READ(M1PE) (R(I),I=1,M)
ICNT=0
DO 1000 IK=1,M
JJ=IK
JK=IK
DO 20 I=J,I,M
ICNT=ICNT+1
20 C(I)=A(ICNT)
JJ=JJ+1
JA=M
ID=IK
DO 30 J=1,JJ
IF(JJ.EQ.0) GO TO 30
C(I)=A(ID)
JA=JA-1
ID=ID+JA
30 CONTINUE
SUM=0.000
DO 50 J=1,M
DP1=R(J)
DP2=C(J)
50 SUM=SUM+DP1*DP2
D(IK)=SUM
1000 CONTINUE
IF(KKK.EQ.2) GO TO 11
WRITE(I1PE) (D(J),J=1,M)
11 WRITE(K1PE) (D(I),I=1,M)
10 CONTINUE
IF(KKK.EQ.1) GO TO 12
READ(I1PE) (A(I),I=1,MMAX)
GO TO 100

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12 REWIND ITPF
   REWIND MTPF
   REWIND NTPF
   REWIND KTPF
   READ (NTPF) (A(J),J=1,NMAX)
   ICNT=0
   DO 60 KK=1,N
     READ (ITPF) (D(J),J=1,M)
     KI=KK
     DO 70 KJ=1,N
       READ(MTPF)(C(J),J=1,M)
       KP=KJ
       IF(KP.IT.KI) GO TO 70
       SUM=0.000
       DO 80 R=1,M
         DP1=D(KR)
         DP2=C(KP)
80    SUM=SUM +DP1*DP2
       ICNT=ICNT+1
       SM=SUM
       A(ICNT)=A(ICNT)-SM
70    CONTINUE
   REWIND MTPF
60    CONTINUE
   REWIND NTPF
   REWIND MTPF
   REWIND ITPF
   WRITE(ITPF) (A(I),I=1,NMAX)
   REWIND ITPF
100 RETURN
END

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C      FORTRAN DECK
C      EIGEN      REDUCES STIFFNESS MATRIX AND INVERTS IT, REDUCES MASS MATRIX
C                  DETERMINES EIGENVALUES AND EIGENVECTORS FOR FLUENC-100 C
C      THE ARGUMENTS ARE=
C      A - VECTOR OF LENGTH NRDF*(NRDF+1)/2
C      VALU - VECTOR OF LENGTH NEIG
C      TEMP,B,C,DUM3, - VECTORS OF LENGTH NRDF OR NMASS (SMALLER)
C      F - MATRIX OF DIMENSION (NRDF,3)
C      IDUM4 - VECTOR OF LENGTH NRDF OR NMASS (SMALLER)
C      ITAPE,JTAPE,NTAPE,MTAPE, - THESE ARE VARIOUS TAPES
C      NRDF - NUMBER OF DEGREES OF FREEDOM OF THE SYSTEM
C      NEIG - NUMBER OF EIGENVALUES DESIRED
C      NVEC - NUMBER OF EIGENVECTORS DESIRED
C      NMASS=NO. OF NORMAL DISPLACEMENTS
C      NOMASS=NO. OF ROTATIONAL DEGREES OF FREEDOM
C      STIFF IS ON MTAPE IN COMPACT FORM
C      MASS IS ON NTAPE IN COMPACT FORM
C      SUBROUTINE EIGEN(A,VALU,TEMP,B,C,DUM3,F,IDUM4,ITAPE,JTAPE,KTAPE,
1      INTAPE,MTAPE,NRDF,NEIG,NVEC,NMASS,NOMASS,MNTAPE,NNTAPE,IK22,IM22,
2      NPUN1,NCIT,KKK)
C      DIMENSION DUM3(NRDF),IDUM4(1),A(1),VALU(1),B(1),C(1),F(NRDF,3),
1      TEMP(1)
C      DIMENSION ILOW(100),IHIGH(100)
C      INTEGER OUT
C      DATA Q5/1HCKE1/,Q6/4HFE1EX/,Q7/4HWGHT/,Q8/4HFREQ/
C      DO 56 I=1,NMASS
C      ILOW(I)=1
56      IHIGH(I)=NMASS
C      OUT=6
C      REWIND MTAPE
C      REWIND NTAPE
C      NTEMP=NMASS
C      CALL DIVID(NMASS,NOMASS,MTAPE,JTAPE,ITAPE,A,B,MNTAPE,IK22)
C      CALL ZROPAK(A,B,C,DUM3,NMASS,NOMASS,ITAPE,JTAPE,MTAPE,KTAPE,KKK)
C      CALL DIVID(NMASS,NOMASS,NTAPE,JTAPE,ITAPE,A,B,NNTAPE,IM22)
C      CALL ZROPAK(A,B,C,DUM3,NMASS,NOMASS,ITAPE,JTAPE,NTAPE,KTAPE)
345      CONTINUE
C      REWIND MTAPE
C      REWIND NTAPE
C      NREDO=NMASS
C      NRMX=NRDO*(NRDO+1)/2
C      READ IN THE STIFFNESS MATRIX
C      READ(MTAPE) (A(I),I=1,NRMX)
C      WRITE(OUT,5500)
5500      FORMAT(///85HREDUCED UPPER TRIANGULAR
1      STIFFNESS MATRIX)
C      DO 5501 I=1,NREDO
C      NS=(2*I+(I-1)*(2*NREDO-1))/2
C      NE=(2*NREDO+(I-1)*(2*NREDO-1))/2
C      WRITE(OUT,5502) I,(A(J),J=NS,NE)
5502      FORMAT(/3HROW,14/(9F14.5))
5501      CONTINUE
C      IF(NCIT.EQ.0) GO TO 375
C      IC=0
C      DO 370 I=1,NREDO
C      II=I-1
C      IF(II.EQ.0) GO TO 368
C      DO 367 J=1,II
C      NU=(2*I+(J-1)*(2*I-1))/2+(J-1)*(NREDO-1)
367      R(1)=A(NU)

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369 CONTINUE
  NS=(2*I+(I-1)*(2*NREDU-1))/2
  NF=(2*NREDU+(I-1)*(2*NREDU-1))/2
  J=1
  DO 369 JJ=NS,NF
    R(I)=A(J,I)
369 J=I+1
    CALL PUNCH (R,I,NREDU,05,IC)
370 CONTINUE
375 CONTINUE
    CALL SYMINV(A,NREDU)
    WRITE(OUT,5503)
5503 FORMAT(///80HR REDUCED UPPER TRIANGULAR
1 IF I C U I M A T R I X)
C PUNCH OPTION
  IF(NCJT.EQ.0) GO TO 8003
  IF(NPUNJ.EQ.0) GO TO 8000
  IF(NPUNJ) 8001,8002,8002
8001 GO TO 8003
8002 IF(NPUNJ.EQ.1) GO TO 8000
  GO TO 8003
8000 PUNCH 5502,((LOW(K),HIGH(Y)),K=1,NREDU)
8003 CONTINUE
5502 FORMAT (18I4)
  DO 5504 I=1,NREDU
    NS=(2*I+(I-1)*(2*NREDU-1))/2
    NF=(2*NREDU+(I-1)*(2*NREDU-1))/2
5504 WRITE(OUT,5502) I,(A(J),J=NS,NF)
  IF(NPUNJ) 803,802,802
  802 IF (NPUNJ.EQ.1) GO TO 803
  IC=0
  DO 5507 I=1,NREDU
    II=I-1
    IF(II.EQ.0) GO TO 5508
    DO 5509 J=1,II
      NU=(2*I+(J-1)*(2*I-1))/2+(J-1)*(NREDU-1)
5509 R(I)=A(NU)
5509 CONTINUE
      NS=(2*I+(I-1)*(2*NREDU-1))/2
      NF=(2*NREDU+(I-1)*(2*NREDU-1))/2
      J=1
      DO 5510 JJ=NS,NF
        R(J)=A(J,I)
5510 J=I+1
        CALL PUNCH (R,I,NREDU,06,IC)
5507 CONTINUE
  803 CONTINUE
C READ IN THE MASS MATRIX
  READ(NTAPE) (A(I),I=1,NRMX)
  DO 6012 I=1,NRMX
6012 A(I)=A(I)*32.174*12.
    WRITE(OUT,5505)
5505 FORMAT(///79HR REDUCED UPPER TRIANGULAR
1 IF I C U I M A T R I X)
  DO 5506 I=1,NREDU
    NS=(2*I+(I-1)*(2*NREDU-1))/2
    NF=(2*NREDU+(I-1)*(2*NREDU-1))/2
5506 WRITE(OUT,5502) I,(A(J),J=NS,NF)
  IF(NPUNJ.EQ.0) GO TO 700
  IF(NPUNJ) 701,702,702

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```

701 GO TO 703
702 IF(NPUNJ.EQ.1)GO TO 700
GO TO 703
700 IC=0
DO 5511 I=1,NREDU
II=I-1
IF(II.F0.0) GO TO 5512
DO 5513 J=1,II
NH=(2*I+(J-1)*(2*I-J))/2+(J-1)*(NREDU-1)
5513 R(I)=A(NH)
5512 CONTINUE
NS=(2*I+(I-1)*(2*NREDU-1))/2
NE=(2*NREDU+(I-1)*(2*NREDU-1))/2
J=I
DO 5514 JJ=NS,NE
R(I)=A(JJ)
5514 J=J+1
CALL PUNC (R,I,NREDU,07,IC)
5511 CONTINUE
703 CONTINUE
IF(NF1G.F0.0) RETURN
CALL EIGMAT(NTMP,A,VAIU,TEMP,B,C,DUM3,E,TDUM4,MTAPE,NTAPE,JTAPF,
1TAPF,NF1G,NVEC,NCJT)
DO 60 I=1,NF1G
IF(VAIU(I).LT.0.0) GO TO 59
DUM3(I)=SQRT(VAIU(I))/6.2831853
GO TO 60
50 DUM3(I)=0.0
60 CONTINUE
WRITE(OUT,9009)
WRITE(OUT,9005) (I,DUM3(I),I=1,FIG)
IF(NCJT.F0.0) GO TO 380
IC=0
CALL PUNC (DUM3,1,NF1G,08,IC)
380 CONTINUE
9009 FORMAT(/// 43X,33HHERE ARE THE NATURAL FREQUENCIES ///)
9005 FORMAT(35X,29HTHE NATURAL FREQUENCY NUMBER 13.2X,2HIS 12.3,2X,
13HCPS)
RETURN
END

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*      FORTRAN DECK
CCCOORDN  ASSIGNS A COORD. NO. TO EACH DEGREE OF FREEDOM AT EACH JOINT
C          FOR ELUENG = 100 C
C      NR1,NR2,NR3 = ARRAYS CONTAINING RESTRAINT INFO. FOR EACH DEGREE
C      OF FREEDOM AT EACH JOINT (FREE=0, CLAPPED=1)
C      N1,N2,N3 = COORD. NO. FOR EACH DEGREE OF FREEDOM (NORMAL
C      DISPLACEMENTS ARE NUMBERED FIRST)
C      NJTS = NO. OF JOINTS
C      NREFD = NO. OF NORMAL DISPLACEMENTS
C      NDF = TOTAL NO. OF DEGREES OF FREEDOM (INCLUDING ROTATIONS)
SUBROUTINE COORDN(NR1,NR2,NR3,N1,N2,N3,NJTS,NREFD,NDF,NT,NNCJT)
DIMENSION NR1(1),NR2(1),NR3(1),N1(1),N2(1),N3(1)
NO=1
DO 10 I=1,NJTS
  IF(NR1(I).EQ.1) GO TO 10
  N1(I)=NO
  NO=NO+1
10 CONTINUE
  IF(N1(EQ.2) GO TO 36
  NREFD=NO-1
  DO 30 I=1,NJTS
    IF(NR2(I).EQ.1) GO TO 30
    N2(I)=NO
    NO=NO+1
30 CONTINUE
    IF(NR3(I).EQ.1) GO TO 35
    N3(I)=NO
    NO=NO+1
35 CONTINUE
    GO TO 50
36 DO 37 I=1,NCJT,NJTS
    N2(I)=NO
    NO=NO+1
37 CONTINUE
    DO 38 I=1,NCJT,NJTS
    N3(I)=NO
    NO=NO+1
38 CONTINUE
    NREFD=NO-1
    NN=NCJT-1
    DO 39 I=1,NN
    IF(NR2(I).EQ.1) GO TO 39
    N2(I)=NO
    NO=NO+1
39 CONTINUE
    DO 40 I=1,NN
    IF(NR3(I).EQ.1) GO TO 40
    N3(I)=NO
    NO=NO+1
40 CONTINUE
50 NDF=NO-1
  RETURN
END

```

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*   FORTRAN DECK
C   PROGRAM FOR EIGENC - 100 C
C   THIS SUBROUTINE FINDS THE EIGENVALUES AND EIGENVECTORS FOR
C   SYMMETRIC MASS AND STIFFNESS MATRICES.
C   THE ARGUMENTS ARE--
C   N= ORDER OF MATRICES.
C   A= DUMMY VECTOR WITH DIMENSION IN MAIN PROGRAM OF N*(N+1)/2
C   VALU= STORAGE FOR EIGENVALUES. MUST BE DIMENSIONED IN THE MAIN
C   PROGRAM AS A VECTOR OF LENGTH NEIG.
C   TEMP,R,C,D,E= DUMMY VECTORS WITH DIMENSION OF N IN MAIN PROGRAM.
C   I= DUMMY ARRAY WITH DIMENSIONS OF (N,3) IN MAIN PROGRAM.
C   IDUM= DUMMY INTEGER VECTOR WITH DIMENSION OF N IN MAIN PROGRAM.
C   NTAP= TAPE WHERE STIFFNESS MATRIX IS STORED IN COMPACT FORM.
C   MTAP= TAPE WHERE MASS MATRIX IS STORED IN COMPACT FORM.
C   ITAPE, JTAPE= SCRATCH TAPES.
C   NEIG= NUMBER OF EIGENVALUES DESIRED.
C   NVEC= NUMBER OF EIGENVECTORS DESIRED. MUST BE EQUAL TO OR LESS
C   THAN NEIG.
C   THE MASS AND STIFFNESS MATRICES ARE STORED IN COMPACT FORM AS
C   VECTORS. ONLY THE UPPER TRIANGLE OF THESE MATRICES (BY ROWS) IS
C   STORED.
C   SUBROUTINE EIGMAT(N,A,VALU,TEMP,R,C,D,E,IDUM,NTAPE,MTAPE,JTAPE,
1  JTAPE,NEIG,NVEC,NCJT)
C   DIMENSION A(1),TEMP(1),VALU(1),R(1),C(1),D(1),E(N,3),IDUM(1)
C   DOUBLE PRECISION SUM,SUM1
C   INTEGER OUT
C   OUT=6
C   REWIND JTAPE
C   REWIND MTAPE
C   REWIND NTAPE
C   M=2*N
C   NMAX=N*(N+1)/2
C   * * * * *
C   STEP 1
C   READ IN M BY ROWS IN COMPACTED FORM
C   REPLACE " BY (1) TRANSPOSE, WHERE M=L*(L) TRANSPOSE
C   CALCULATE FIRST ROW
C   READ (NTAPE) (A(I),I=1,NMAX)
C   REWIND NTAPE
C   5 CONTINUE
C   A(1)=SORT(A(1))
C   DO 10 I=2,N
C   10 A(I)=A(1)/A(1)
C   CALCULATE ALL THE OTHER ROWS
C   IND=N
C   DO 101 I=2,N
C   IND=IND+1
C   SUM=0.00
C   K1=I-1
C   DO 50 JJ=1,K1
C   MJ=(M-JJ)*(JJ-1)/2+1
C   50 SUM=SUM+A(MJ)*A(MJ)
C   A(IND)=DSORT(A(IND)-SUM)
C   IF(IND.EQ.NMAX) GO TO 100
C   SUM1=A(IND)
C   K1=I+1
C   DO 40 J=I+1,N
C   IND=IND+1
C   SUM=0.00

```

```

      II=I-1
      DO 60 JJ=1,II
      K=(M-JJ)*(JJ-1)/2
      KI=K+I
      KJ=K+J
60    SUM=SUM+A(KI)*A(KJ)
      A(IND)=(A(IND)-SUM)/SUM1
90    CONTINUE
100   CONTINUE
101   CONTINUE
C     CHECK FOR SINGULAR MASS MATRIX
      DO 102 I=1,N
      KI=(M-I)*(I-1)/2+1
      IF(A(KI).EQ.0.) GO TO 1090
102   CONTINUE
C     THIS COMPLETES STEP 1
C* * * * *
C     STEP 2
C     WRITE (I) TRANSPOSE ON TAPE BY COLUMNS
C     PUT (I) TRANSPOSE INTO TEMPORARY STORAGE (TEMP--A VECTOR)
C     AND THEN WRITE TEMP ON TAPE
      KTAPE=NTAPE
300   IND=0
      DO 320 J=1,N
      DO 330 I=1,J
      IND=IND+1
      M1=(M-I)*(I-1)/2+J
      TEMP(IND)=A(M1)
330   CONTINUE
      WRITE(KTAPE) (TEMP(JJ),JJ=1,IND)
      IND=0
340   CONTINUE
C     THIS COMPLETES STEP 2
C* * * * *
C     STEP 3
C     ((I) TRANSPOSE) INVERSE REPLACES (I) TRANSPOSE IN CORE
C     REPLACEMENT IS DONE BY LAST COLUMN FIRST--WORKING UP THE COLUMN
      DO 410 I=1,N
      IND=(I*(M+3-I))/2-N
410   A(IND)=1./A(IND)
      DO 499 J=2,N
      JJ=(M+2)-J
      DO 490 I=2,JJ
      IND=(N+J+I-3)*(JJ-1)/2
      SUM=0.00
      K1=JJ-I+2
      DO 450 K=K1,JJ
      IND=IND+K
      MK=(M-K)*(K-1)/2+JJ
450   SUM=SUM+A(IND)*A(MK)
      IND=IND+J
      IND=IND-I+1
490   A(IND)=-SUM/A(IND)
499   CONTINUE
C     END OF STEP 3
C* * * * *
C     STEP 4
C     U=((I) TRANSPOSE) INVERSE
C     WRITE U ON TAPE BY ROWS
      WRITE(KTAPE) (A(I),I=1,NMAX)

```

```

C      FINISHED WITH STEP 4
C* * * * *
C      STEP 5
C      WRITE U ON TAPE BY COLUMNS STARTING WITH THE LAST COLUMN FIRST
C      PUT U (LAST COLUMN FIRST) INTO TEMP AND THEN WRITE ON TAPE
      IND=0
      DO 555 K=1,N
      J=N-K+1
      DO 550 I=1,J
      IND=IND+1
      M12=(M-1)*(I-1)/2+J
      TEMP(IND)=A(M12)
550 CONTINUE
      WRITE(JTAPF) (TEMP(JJ),JJ=1,IND)
      IND=0
555 CONTINUE
C      END OF STEP 5
C* * * * *
C      STEP 6
C      FORM KU
C      READ K INTO CORE
C      READ U INTO CORE A COLUMN AT A TIME IN REVERSE ORDER
C      REPLACE K BY KU COLUMN BY COLUMN STARTING WITH THE LAST COLUMN
C      AND WORKING UP THE COLUMN
      READ(MTAPF) (A(I),I=1,NMAX)
      REWIND JTAPF
      DO 690 JJ=1,N
      J=N+1-JJ
      READ(JTAPF) (TEMP(I),I=1,J)
      DO 600 II=1,I
      I=I+1-II
      SUM=0.00
      DO 650 K=1,I
      MK1=(M-K)*(K-1)/2+I
650 SUM=SUM+A(MK1)*TEMP(K)
      IND=(M-1)*(I-1)/2+J
      IF(I.EQ.1) GO TO 680
      K1=(M-1)*(I-1)/2
      I=I+1
      DO 660 K=1,J
      K1K=K1+K
660 SUM=SUM+A(K1K)*TEMP(K)
680 CONTINUE
      A(IND)=SUM
690 CONTINUE
C      END OF STEP 6
C* * * * *
C      STEP 7
C      FORM ((L)INVERSE)*KU
C      KU IS IN CORE
C      READ IN L COLUMN BY COLUMN AND CALCULATE ((L)INVERSE)*KU
C      ROW BY ROW
C      CALCULATE THE FIRST ROW
      REWIND MTAPF
      READ(MTAPF) TEMP(1)
      DO 710 I=1,N
710 A(I)=A(I)/TEMP(1)
C      NOW CALCULATE THE REST OF THE ROWS
      IND=N
      DO 700 I=2,N

```

```

      READ (MTAPE) (TEMP(JJ),JJ=1,I)
      DO 700 J=1,N
      INQ=IND+1
      JJ=J-1
      SUM=0.00
      DO 750 K=1,JJ
      MK2=(M-K)*(K-1)/2+J
      750 SUM=SUM+TEMP(K)*A(MK2)
      700 A(IND)=(A(IND)-SUM)/TEMP(I)
C     STEP 7 IS COMPLETE
C* * * * *
C     STEP 8
C     DETERMINE EIGENVALUES AND EIGENVECTORS OF THE NEW MATRIX
C     CHANGE THE SIGN OF A IN ORDER TO OBTAIN THE SMALLEST
C     EIGENVALUE FIRST
      DO 800 I=1,NMAX
      800 A(I)=-A(I)
      CALL RICHAT(A,VALU,TEMP,R,C,D,F,INDUP,N,NFIG,NVFC,MTAPE)
C     CHANGE VALU BACK
      DO 850 I=1,NFIG
      850 VALU(I)=-VALU(I)
C     STEP 8 IS COMPLETE
C* * * * *
C     STEP 9
C     CHANGE EIGENVECTORS BACK
C     READ U INTO CORE BY ROWS
C     READ UNCHANGED EIGENVECTORS INTO CORE ONE AT A TIME
C     CHANGE AND PRINT EIGENVECTORS
      IF(NVFC.EQ.0) GO TO 2000
      WRITE(OUT,4001)
      REWIND MTAPF
      READ(MTAPF) (A(I),I=1,NMAX)
      REWIND MTAPF
      IF(NCJT.EQ.0) GO TO 860
      DATA Q26/4HMODE/
      IC=0
      860 CONTINUE
      DO 900 J=1,NVFC
      READ(MTAPF) (TEMP(I),I=1,N)
      INQ=0
      DO 910 I=1,N
      SUM=0.00
      DO 900 J=1,N
      INQ=IND+1
      900 SUM=SUM+A(IND)*TEMP(J)
      910 TEMP(I)=SUM
C     NORMALIZE THE EIGENVECTOR
      SUM=TEMP(1)
      DO 930 II=2,N
      IF(ABS(SUM)-ABS(TEMP(II))) 038,939,939
      938 SUM=TEMP(II)
      939 CONTINUE
      IF(SUM) 040,947,940
      940 CONTINUE
      DO 941 II=1,N
      TEMP(II)=TEMP(II)/SUM
      941 CONTINUE
      947 CONTINUE
      IF(NCJT.EQ.0) GO TO 990
      CALL PUNC (TEMP,1,N,Q26,IC)

```

```

999 WRITE(OUT,4000) JJ,VALH(JJ),(TEMP(I),I=1,N)
C STEP 0 IS COMPLETE
C * * * * *
GO TO 2000
4000 FORMAT (1H0,19H EIGENVECTOR NUMBER 15/12X,17H CORRESPONDING TO
11P15.7/(1H 1P6F15.7))
4001 FORMAT(1H1,38X,43HHERE ARE THE EIGENVALUES AND EIGENVECTORS ///)
4002 FORMAT(1H1,38X,27HTHE MASS MATRIX IS SINGULAR ///)
1090 WRITE(OUT,4002)
2000 RETURN
END

```

1 FORTRAN DECK

2 CCMAT

3 THIS SUBROUTINE FORMS THE C MATRIX RELATING THE CORNER
4 DISPLACEMENTS TO THE POLYNOMIAL DEFLECTION COEFFICIENTS
5 FOR THE TRIANGULAR PLATE ELEMENT

6 Y2,X3,Y3 = COORDS. OF PLATE CORNERS IN LOCAL COORDINATES

7 C = C MATRIX

8 SUBROUTINE CMAT(Y2,X3,Y3,C)

9 DIMENSION C(9,9)

10 DO 10 I=1,9

11 DO 10 J=1,9

12 C(I,J)=0.

13 C(1,1)=1.

14 C(2,3)=1.

15 C(3,2)=-1.

16 C(4,1)=1.

17 C(4,3)=Y2

18 C(4,6)=Y2**2

19 C(4,9)=Y2**3

20 C(5,3)=1.

21 C(5,6)=2.*Y2

22 C(5,9)=3.*Y2**2

23 C(6,2)=-1.

24 C(6,5)=-Y2

25 C(6,8)=-Y2**2

26 C(7,1)=1.

27 C(7,2)=X3

28 C(7,5)=Y3

29 C(7,4)=X3**2

30 C(7,6)=X3*Y3

31 C(7,6)=Y3**2

32 C(7,7)=X3**3

33 C(7,8)=X3*Y3**2+Y3*X3**2

34 C(7,9)=Y3**3

35 C(8,3)=1.

36 C(8,5)=X3

37 C(8,6)=2.*Y3

38 C(8,8)=2.*X3*Y3+X3**2

39 C(8,9)=3.*Y3**2

40 C(9,2)=-1.

41 C(9,4)=-2.*Y3

42 C(9,5)=-Y3

43 C(9,7)=-3.*Y3**2

44 C(9,8)=-Y3**2+2.*X3*Y3

45 RETURN

46 END

```

$      FORTRAN DECK
CDIVID
C      N=NO. OF NORMAL DISPLACEMENTS
C      M=NO. OF ROTATIONAL D.O.F.
C      NTPF=CONTAINS STIFFNESS (OR MASS) MATRIX
C      NNTPF=CONTAINS K22 (OR M22)
C      NTPF=K12 (M12) STORED
C      ITPF=K11 (M11) STORED
C      A= DUMMY STORAGE VECTOR, LARGER OF (N*(N+1)/2 OR M*(M+1)/2)
SUBROUTINE DIVID (N,M,NTPF,ITPF,A,B,NNTPF,122)
DIMENSION A(1),R(1)
REWIND ITPF
REWIND NTPF
REWIND MTPF
REWIND NNTPF
NMAX=N*(N+1)/2
MMAX=M*(M+1)/2
NM=N+M
ICNT=0
DO 10 J=1,N
  II=NM-I+1
  READ(NTPF) (R(J),J=1,II)
  IU=II-M
  DO 20 J=1,IU
    ICNT=ICNT+1
20  A(ICNT)=R(J)
    IU=IU+1
    JCNT=0
    DO 30 J=IU,I
      JCNT=JCNT+1
30  R(JCNT)=R(J)
  WRITE(MTPF) (R(J),J=1,M)
10  CONTINUE
  WRITE(ITPF) (A(J),J=1,NMAX)
  REWIND MTPF
  REWIND ITPF
  DO 45 I=1,NMAX
45  A(I)=0.0
  DO 50 I=1,122
  READ (NNTPF)MM2,AS
  A(MM2)=A(MM2)+AS
50  CONTINUE
  RETURN
END

```

```

$      FORTRAN DECK
CREAMK      PLANE GRID BEAM ELEMENT STIFFNESS MATRIX IN SYSTEM COORDS.
C      FL = BEAM LENGTH
C      E = YOUNG'S MODULUS
C      G = MODULUS OF RIGIDITY
C      XI = AREA MOMENT OF INERTIA
C      YJ = EFFECTIVE TORSIONAL MOMENT OF INERTIA
C      STM = STIFFNESS MATRIX
C      DCS = DIRECTION COSINES
SUBROUTINE BEAMK(FL,E,G,XI,YJ,STM,DCS)
DIMENSION STM(6,6),DCS(2)
Z1=E*XI/FL
Z2=G*YJ/FL
STM(1,1)=12.*Z1/(FL*FL)
STM(2,1)=6.*Z1*DCS(2)/FL
STM(2,2)=4.*Z1*DCS(2)*DCS(2)+Z2*DCS(1)*DCS(1)

```

```

STM(3,1)=-6.*Z1*DCS(1)/FL
STM(3,2)=(-4.*Z1+Z2)*DCS(1)*DCS(2)
STM(3,3)=4.*Z1*DCS(1)*DCS(1)+Z2*DCS(2)*DCS(2)
STM(4,1)=-STM(1,1)
STM(4,2)=-STM(2,1)
STM(4,3)=-STM(3,1)
STM(4,4)=STM(1,1)
STM(5,1)=STM(2,1)
STM(5,2)=2.*Z1*DCS(2)*DCS(2)-Z2*DCS(1)*DCS(1)
STM(5,3)=-(2.*Z1+Z2)*DCS(1)*DCS(2)
STM(5,4)=-STM(2,1)
STM(5,5)=STM(2,2)
STM(6,1)=STM(3,1)
STM(6,2)=STM(5,3)
STM(6,3)=2.*Z1*DCS(1)*DCS(1)-Z2*DCS(2)*DCS(2)
STM(6,4)=-STM(3,1)
STM(6,5)=STM(4,2)
STM(6,6)=STM(5,3)
DO 10 I=2,6
  N=I-1
  DO 10 J=1,N
10 STM(I,J,1)=STM(I,J)
  RETURN
END

```

```

$      FORTRAN DECK
CBEAEM  PLANE GRID BEAM ELEMENT MASS MATRIX IN SYSTEM COORDS.
C      FL = BEAM LENGTH
C      RHO = DENSITY
C      A = CROSS SECTIONAL AREA
C      XI = AREA MOMENT OF INERTIA
C      YI = EFFECTIVE TORSIONAL MOMENT OF INERTIA
C      SMM = MASS MATRIX
C      DCS = DIRECTION COSINES
SUBROUTINE BEAEM(FL,RHO,A,XI,YI,SMM,DCS)
DIMENSION SMM(6,6),DCS(2)
Z1=RHO*A*FL
Z2=FL**2
Z3=XI/A
DD=Z1*(17./35.+(6.*Z3)/(5.*Z2))
CC=Z1*(11.*FL/210.+Z3/(10.*FL))
AA=Z1*(22/105.+2.*Z3/15.)
TT=Z1*YI/(3.*A)
RR=Z1*(9./70.-(6.*Z3)/(5.*Z2))
QQ=Z1*(11.*FL/420.-Z3/(10.*FL))
SS=-Z1*(72/140.+73/30.)
PP=Z1*YI/(6.*A)
SMM(1,1)=DD
SMM(2,1)=CC*DCS(2)
SMM(2,2)=AA*DCS(2)*DCS(2)+TT*DCS(1)*DCS(1)
SMM(3,1)=-CC*DCS(1)
SMM(3,2)=(-AA+TT)*DCS(1)*DCS(2)
SMM(3,3)=AA*DCS(1)*DCS(1)+TT*DCS(2)*DCS(2)
SMM(4,1)=RR
SMM(4,2)=QQ*DCS(2)
SMM(4,3)=-QQ*DCS(1)
SMM(4,4)=SMM(1,1)
SMM(5,1)=-SMM(4,2)
SMM(5,2)=SS*DCS(2)*DCS(2)+PP*DCS(1)*DCS(1)
SMM(5,3)=(-SS+PP)*DCS(1)*DCS(2)
SMM(5,4)=-SMM(2,1)
SMM(5,5)=SMM(2,2)
SMM(6,1)=-SMM(4,3)
SMM(6,2)=SMM(5,3)
SMM(6,3)=SS*DCS(1)*DCS(1)+PP*DCS(2)*DCS(2)
SMM(6,4)=-SMM(3,1)
SMM(6,5)=SMM(3,2)
SMM(6,6)=SMM(3,3)
DO 10 I=1,6
N=I-1
DO 10 J=1,N
10 SMM(J,I)=SMM(I,J)
RETURN
END

```

```

$      FORTRAN DECK
CPLATEK
C      THIS SUBROUTINE DETERMINES THE STIFFNESS MATRIX OF A
C      TRIANGLE PLATE ELEMENT IN SYSTEM COORDS.
C      Y2,X3,Y3 = COORDS. OF PLATE CORNERS IN LOCAL COORDINATES
C      DX,DY,D1,DXY,BETA = FLEXURAL RIGIDITY TERMS AND ANGLE OF MATERIAL
C      PRINCIPAL AXES W/O TRIANGLE LOCAL AXES
C      DCS = DIRECTION COSINES
C      PLTK = STIFFNESS MATRIX
SUBROUTINE PLATEK(Y2,X3,Y3,DX,DY,D1,DXY,BETA,DCS,PLTK)
DIMENSION PLTK(9,9),C(9,9),CINV(9,9),P(9,9),R(9,9)

```

```

DIMENSION T(9,9),STIFF(9,9),DCS(2)
EQUIVALENCE(P(1,1),STIFF(1,1)), (R(1,1),T(1,1))
CALL CMAT(Y2,X3,Y3,C)
CALL MINV(C,CINV,9)
CALL DINMAT(Y2,X3,Y3,DY,DY,D1,D1Y,RETA,P)
CALL MATMPY(P,CINV,R,9)
DO 10 I=2,9
N=I-1
DO 10 J=1,N
ZZ1=CINV(I,J)
ZZ2=CINV(J,I)
CINV(I,J)=ZZ2
CINV(J,I)=ZZ1
10 CONTINUE
CALL MATMPY(CINV,R,STIFF,9)
DO 400 I=1,9
DO 400 J=1,9
400 T(I,J)=0.
T(1,1)=1.
T(4,4)=1.
T(7,7)=1.
T(2,2)=DCS(2)
T(3,3)=DCS(2)
T(5,5)=DCS(2)
T(6,6)=DCS(2)
T(8,8)=DCS(2)
T(9,9)=DCS(2)
T(2,3)=-DCS(1)
T(5,6)=-DCS(1)
T(8,9)=-DCS(1)
T(3,2)=DCS(1)
T(6,5)=DCS(1)
T(9,8)=DCS(1)
CALL MATMPY(STIFF,T,C,9)
T(2,3)=DCS(1)
T(5,6)=DCS(1)
T(8,9)=DCS(1)
T(3,2)=-DCS(1)
T(6,5)=-DCS(1)
T(9,8)=-DCS(1)
CALL MATMPY(T,C,PLTK,9)
RETURN
END

```

FORTRAN DECK
MATRIX INVERSION SUBROUTINE

```

C      A = MATRIX TO BE INVERTED
C      U = INVERTED MATRIX
C      NM = ORDER OF MATRIX (MAX. 9)
SUBROUTINE MINV(A,U,NM)
  DIMENSION A(9,9),U(9,9)
  DO 9001 I=1,NM
    DO 9002 J=1,NM
      U(I,J)=0.0
      IF (I.EQ.J) U(I,J)=1.0
    9001 CONTINUE
    EPS=0.00000001
    DO 9015 I=1,NM
      K=I
      IF (I-NM) 9021,9007,9021
    9021 IF (A(I,I)-EPS) 9005,9006,9007
    9005 IF (-A(I,I)-EPS) 9006,9006,9007
    9006 K=K+1
    DO 9023 J=1,NM
      U(I,J)=U(I,J)+U(K,J)
    9023 A(I,J)=A(I,J)+A(K,J)
    GO TO 9021
    9007 DIV=A(I,I)
    DO 9009 I=1,NM
      U(I,J)=U(I,J)/DIV
    9009 A(I,J)=A(I,J)/DIV
    DO 9015 MM=1,NM
      DELT=A(MM,I)
      IF (ABS(DELT)-EPS) 9015,9015,9016
    9016 IF (MM-I) 9010,9015,9010
    9010 DO 9011 J=1,NM
      U(MM,J)=U(MM,J)-U(I,J)*DELT
    9011 A(MM,J)=A(MM,J)-A(I,J)*DELT
    9015 CONTINUE
    DO 9033 J=1,NM
      DO 9033 I=1,NM
    9033 A(I,J)=U(I,J)
  RETURN
  END

```

```

*      FORTRAN DECK
CDINMAT
C      THIS SUBROUTINE DETERMINES THE DOUBLE INTEGRAL MATRIX FOR
C      THE K EQUATION FOR THE TRIANGULAR PLATE ELEMENT
C      Y2,X3,Y3 = COORDS. OF PLATE CORNERS IN LOCAL COORDINATES
C      DX,DY,D1,DXY,BETA = FLEXURAL RIGIDITY TERMS AND ANGLE OF MATERIAL
C      PRINCIPAL AXES W/O TRIANGLE LOCAL AXES
C      P = DOUBLE INTEGRAL MATRIX
      SUBROUTINE CDINMAT(Y2,X3,Y3,DX,DY,D1,DXY,BETA,P)
      DIMENSION P(9,9),D(3,3)
      DO 10 I=1,3
      DO 10 J=1,9
10  P(I,J)=0.
      CALL DMAT(DX,DY,D1,DXY,BETA,D)
      A1=DDIINT(Y2,X3,Y3,0,0)
      A2=DDIINT(Y2,X3,Y3,1,0)
      A3=DDIINT(Y2,X3,Y3,2,0)
      A4=DDIINT(Y2,X3,Y3,0,1)
      A5=DDIINT(Y2,X3,Y3,0,2)
      A6=DDIINT(Y2,X3,Y3,1,1)
      P(4,4)=4.*D(1,1)*A1
      P(4,5)= 4.*D(1,3)*A1
      P(4,6)=4.*D(1,2)*A1
      P(4,7)=12.*D(1,1)*A2
      P(4,8)=4.*(D(1,1)*A4+D(1,2)*A2+2.*D(1,3)*(A2+A4))
      P(4,9)=12.*D(1,2)*A4
      P(5,5)=4.*D(3,3)*A1
      P(5,6)= 4.*D(3,2)*A1
      P(5,7)= 12.*D(3,1)*A2
      P(5,8)= 4.*(D(3,1)*A4+D(3,2)*A2+2.*D(3,3)*(A2+A4))
      P(5,9)= 12.*D(3,2)*A4
      P(6,6)=4.*D(2,2)*A1
      P(6,7)=12.*D(2,1)*A2
      P(6,8)=4.*(D(2,1)*A4+D(2,2)*A2+2.*D(2,3)*(A2+A4))
      P(6,9)=12.*D(2,2)*A4
      P(7,7)=36.*D(1,1)*A3
      P(7,8)=12.*(D(1,1)*A6+D(1,2)*A3+2.*D(1,3)*(A3+A6))
      P(7,9)=36.*D(1,2)*A6
      P(8,8)=4.*(D(1,1)*A5+D(1,2)*A6+2.*D(1,3)*(A6+A5))
1      +4.*(D(2,1)*A6+D(2,2)*A3+2.*D(2,3)*(A3+A6))
1      +8.*(D(3,1)*A6+D(3,2)*A3+2.*D(3,3)*(A3+A6))
1      +8.*(D(3,1)*A5+D(3,2)*A6+2.*D(3,3)*(A6+A5))
      P(8,9)=12.*(D(1,2)*A5+D(2,2)*A6+2.*D(3,2)*(A6+A5))
      P(9,9)=36.*D(2,2)*A5
      DO 20 I=1,8
      A=I+1
      DO 20 J=I+1,9
20  P(I,J)=P(J,I)
      RETURN
      END

```

* FORTRAN DECK

CHAMPY

C MULTIPLIES MATRICES A AND B TO GET C, ALL OF ORDER N*N

SUBROUTINE CHAMPY(A,B,C,N)

DIMENSION A(9,9),B(9,9),C(9,9)

DO 10 I=1,N

DO 10 J=1,N

C(I,J)=0

DO 10 K=1,N

10 C(I,J)=C(I,J)+A(I,K)*B(K,J)

RETURN

END

```

S      FORTRAN DECK
C      CDMAT
C      THIS SUBROUTINE DETERMINES THE FLEXURAL RIGIDITY MATRIX IN
C      TRIANGLE LOCAL COORDINATES
C      DX,DY,D1,DXY,BETA = FLEXURAL RIGIDITY TERMS AND ANGLE OF MATERIAL
C      PRINCIPAL AXES W/O TRIANGLE LOCAL AXES
C      D = FLEXURAL RIGIDITY MATRIX IN TRIANGLE LOCAL COORDS.
C      SUBROUTINE DMAT(DX,DY,D1,DXY,BETA,D)
      DIMENSION D(3,3)
      T11=(COS(BETA))**2
      T12=(SIN(BETA))**2
      T13=SIN(BETA)*COS(BETA)
      T21=T12
      T22=T11
      T23=-T13
      T31=-2.*SIN(BETA)*COS(BETA)
      T32=-T31
      T33=T11-T12
      Z11=DX*T11+D1*T12
      Z12=DX*T21+D1*T22
      Z13=DX*T31+D1*T32
      Z21=DY*T11+D1*T12
      Z22=DY*T21+D1*T22
      Z23=DY*T31+D1*T32
      Z31=DXY*T13
      Z32=DXY*T23
      Z33=DXY*T33
      D(1,1)=T11*Z11+T12*Z21+T13*Z31
      D(1,2)=T11*Z12+T12*Z22+T13*Z32
      D(1,3)=T11*Z13+T12*Z23+T13*Z33
      D(2,1)=T21*Z11+T22*Z21+T23*Z31
      D(2,2)=T21*Z12+T22*Z22+T23*Z32
      D(2,3)=T21*Z13+T22*Z23+T23*Z33
      D(3,1)=T31*Z11+T32*Z21+T33*Z31
      D(3,2)=T31*Z12+T32*Z22+T33*Z32
      D(3,3)=T31*Z13+T32*Z23+T33*Z33
      RETURN
      END

```

\$ FORTRAN DECK

```

CDBLINT     THIS SUBROUTINE EVALUATES THE DOUBLE INTEGRALS APPEARING IN THE
C     EQUATIONS FOR K AND M FOR THE TRIANGULAR PLATE ELEMENT
C     Y2,X3,Y3 = COORDS. OF PLATE CORNERS IN LOCAL COORDINATES
C     M,N = POWER OF X-AND Y, RESPECTIVELY, PRZEMIANIECKI, PAGE 305
C     FUNCTION DBLINT(Y2,X3,Y3,M,N)
C     DIMENSION A1(2),R1(7),P1(7),P2(7),P3(7)
C     EQUIVALENCE(R1(1),P3(1))
C     IF(M-1) 40,41,42
40     P1(1)=1.0
C     N1=0
C     GO TO 43
41     P1(1)=-1.0
C     P1(2)=1.0
C     N1=1
C     GO TO 43
42     CONTINUE
C     A1(1)=-1.0
C     A1(2)=1.0
C     R1(1)=-1.0
C     R1(2)=1.0
C     M1=1
C     MM=M-1
C     DO 10 J=1,MM
C     CALL PLYP(A1,1,R1,M1,P1,N1)
C     NN1=N1+1
C     DO 10 I=1,NN1
C     R1(I)=P1(I)
C     M1=N1
10     CONTINUE
43     CONTINUE
C     IF(N-1) 50,51,52
50     P2(1)=1.0
C     N2=0
C     GO TO 53
51     P2(1)=-Y3+Y2
C     P2(2)=Y3
C     N2=1
C     GO TO 53
52     CONTINUE
C     A1(1)=-Y3+Y2
C     A1(2)=Y3
C     R1(1)=-Y3+Y2
C     R1(2)=Y3
C     M1=1
C     NN=N-1
C     DO 20 J=1,NN
C     CALL PLYP(A1,1,R1,M1,P2,N2)
C     NN2=N2+1
C     DO 20 I=1,NN2
C     R1(I)=P2(I)
C     M1=N2
20     CONTINUE
53     CONTINUE
C     CALL PLY P(P1,N1,P2,N2,P3,N3)
C     NN3=N3+1
C     S01=0.
C     DO 30 I=1,NN3
C     S01=S01+(X3**M)*Y2*(1./FLOAT(M+N+2))+ P3(I)*(1./FLOAT(N3+2-1))

```

30 CONTINUE
PRINT=SOL
RETURN
END


```

N1=N2+1
10 N2=N2+6
   IF (NT.EQ.NC) GO TO 50
20 NO=NT-NC
   IC=IC+1
   GO TO (21,22,23,24,25),NO
21 PUNCH 1, (A(I), I=N1,NE),Q,IC
   GO TO 50
22 PUNCH 2, (A(I), I=N1,NE),Q,IC
   GO TO 50
23 PUNCH 3, (A(I), I=N1,NE),Q,IC
   GO TO 50
24 PUNCH 4, (A(I), I=N1,NE),Q,IC
   GO TO 50
25 PUNCH 5, (A(I), I=N1,NE),Q,IC
50 RETURN
END

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* FORTRAN DECK

CPLATEM

```

C       THIS SUBROUTINE DETERMINES THE MASS MATRIX OF A
C       TRIANGULAR PLATE ELEMENT IN SYSTEM COORDS.
C       Y2,X3,Y3 = COORDS. OF PLATE CORNERS IN LOCAL COORDINATES
C       PRHO = DENSITY
C       PTH = PLATE THICKNESS
C       DCS = DIRECTION COSINES
C       PLTM = MASS MATRIX
C       SUBROUTINE PLATEM(Y2,X3,Y3,PRHO,PTH,DCS,PLTM)
C       DIMENSION PLTM(9,9),C(9,9),CINV(9,9),P(9,9),R(9,9)
C       DIMENSION T(9,9),FMASS(9,9),DCS(2)
C       EQUIVALENCE(P(1,1),FMASS(1,1)),       (R(1,1),T(1,1))
C       CALL CHAT(Y2,X3,Y3,C)
C       CALL MINV(C,CINV,9)
C       CALL DINVTM(Y2,X3,Y3,PRHO,PTH,P)
C       CALL MATMPY(P,CINV,R,9)
C       DO 10 I=2,9
C       N=I-1
C       DO 10 J=1,N
C       ZZ1=CINV(1,J)
C       ZZ2=CINV(J,1)
C       CINV(1,J)=772
C       CINV(J,1)=771
10       CONTINUE
C       CALL MATMPY(CINV,R,FMASS,9)
C       DO 400 I=1,9
C       DO 400 J=1,9
400       T(1,J)=0.
C       T(1,1)=1.
C       T(4,4)=1.
C       T(7,7)=1.
C       T(2,2)=DCS(2)
C       T(3,3)=DCS(2)
C       T(5,5)=DCS(2)
C       T(6,6)=DCS(2)
C       T(8,8)=DCS(2)
C       T(9,9)=DCS(2)
C       T(2,3)=-DCS(1)
C       T(5,6)=-DCS(1)
C       T(8,9)=-DCS(1)
C       T(7,2)=DCS(1)
C       T(6,5)=DCS(1)
C       T(9,8)=DCS(1)
C       CALL MATMPY(FMASS,T,C,9)
C       T(2,3)=DCS(1)
C       T(5,6)=DCS(1)
C       T(8,9)=DCS(1)
C       T(3,2)=-DCS(1)
C       T(6,5)=-DCS(1)
C       T(9,8)=-DCS(1)
C       CALL MATMPY(T,C,PLTM,9)
C       RETURN
C       END

```

* FORTRAN DECK

CINMTM

```

C       THIS SUBROUTINE DETERMINES THE DOUBLE INTEGRAL MATRIX FOR
C       THE TRIANGULAR PLATE M MATRIX - PRZEMIENIECKI, PAGE 304
C       Y2,X3,Y3 = COORDS. OF PLATE CORNERS IN LOCAL COORDINATES

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```

C      PRHO = DENSITY
C      PTH = PLATE THICKNESS
C      P = DOUBLE INTEGRAL MATRIX
SUBROUTINE DIMINT(Y2,X3,Y3,PRHO,PTH,P)
  DIMENSION P(9,9)
  P(1,1)=DBLINT(Y2,X3,Y3,0,0)
  P(2,1)=DBLINT(Y2,X3,Y3,1,0)
  P(2,2)=DBLINT(Y2,X3,Y3,2,0)
  P(3,1)=DBLINT(Y2,X3,Y3,0,1)
  P(3,2)=DBLINT(Y2,X3,Y3,1,1)
  P(3,3)=DBLINT(Y2,X3,Y3,0,2)
  P(4,1)=P(2,2)
  P(4,2)=DBLINT(Y2,X3,Y3,3,0)
  P(4,3)=DBLINT(Y2,X3,Y3,2,1)
  P(4,4)=DBLINT(Y2,X3,Y3,4,0)
  P(5,1)=P(3,2)
  P(5,2)=P(4,3)
  P(5,3)=DBLINT(Y2,X3,Y3,1,2)
  P(5,4)=DBLINT(Y2,X3,Y3,3,1)
  P(5,5)=DBLINT(Y2,X3,Y3,2,2)
  P(6,1)=P(3,3)
  P(6,2)=P(5,3)
  P(6,3)=DBLINT(Y2,X3,Y3,0,3)
  P(6,4)=P(5,5)
  P(6,5)=DBLINT(Y2,X3,Y3,1,3)
  P(6,6)=DBLINT(Y2,X3,Y3,0,4)
  P(7,1)=P(4,2)
  P(7,2)=P(4,4)
  P(7,3)=P(5,4)
  P(7,4)=DBLINT(Y2,X3,Y3,5,0)
  P(7,5)=DBLINT(Y2,X3,Y3,4,1)
  P(7,6)=DBLINT(Y2,X3,Y3,3,2)
  P(7,7)=DBLINT(Y2,X3,Y3,6,0)
  P(8,1)=P(5,3)+P(4,3)
  P(8,2)=P(6,4)+P(5,4)
  P(8,3)=P(6,5)+P(5,5)
  P(8,4)=P(7,6)+P(7,5)
  P(8,5)=DBLINT(Y2,X3,Y3,2,3)+P(7,6)
  P(8,6)=DBLINT(Y2,X3,Y3,1,4)+DBLINT(Y2,X3,Y3,2,3)
  P(8,7)=DBLINT(Y2,X3,Y3,4,2)+DBLINT(Y2,X3,Y3,5,1)
  P(8,8)=DBLINT(Y2,X3,Y3,2,4)+DBLINT(Y2,X3,Y3,4,2)
  1  P(8,9)=DBLINT(Y2,X3,Y3,3,3)
  P(9,1)=P(6,3)
  P(9,2)=P(6,5)
  P(9,3)=P(6,6)
  P(9,4)=DBLINT(Y2,X3,Y3,2,5)
  P(9,5)=DBLINT(Y2,X3,Y3,1,4)
  P(9,6)=DBLINT(Y2,X3,Y3,0,5)
  P(9,7)=DBLINT(Y2,X3,Y3,3,3)
  P(9,8)=DBLINT(Y2,X3,Y3,1,5)+DBLINT(Y2,X3,Y3,2,4)
  P(9,9)=DBLINT(Y2,X3,Y3,0,6)
  DO 10 I=1,9
    DO 10 J=1,1
  10 P(I,J)=P(I,J)*PRHO*PTH
  DO 20 I=2,9
    N=I-1
    DO 20 J=1,N
  20 CONTINUE
  RETURN

```

```

*      FORTRAN DECK
C7ROMAM
C      N=NO. OF NORMAL DISPLACEMENTS
C      M=NO. OF ROTATIONAL D.O.F.
C      NTPF CONTAINS M11 MATRIX
C      MTPF CONTAINS M12 MATRIX
C      ITPE SCRATCH TAPE
C      KTFE CONTAINS K12*K22**(-1)
C***  REDUCED MASS MATRIX IS STORED ON ITPE
      SUBROUTINE ZROMAM(A,R,C,D,N,M,NTPF,MTPF,ITPE,KTFE)
      DIMENSION A(1),R(1),C(1),D(1)
      DOUBLE PRECISION SUM1,SUM2,DP1,DP2,DP3
      KMASS=M
      REWIND MTPF
      REWIND ITPE
      REWIND NTPF
      REWIND KTFE
      NMAX=N*(N+1)/2
      DO 10 KK=1,M
      READ(KTFE) (R(I),I=1,M)
      ICNT=0
      DO 1000 IK=1,M
      JJ=IK
      JK=IK
      DO 20 JJ=JJ,M
      ICNT=ICNT+1
20  C(ICNT)=A(ICNT)
      JJ=JJ-1
      JA=M
      ID=JK
      DO 30 J=1,JJ
      IF(JJ.EQ.0) GO TO 30
      C(J)=A(ID)
      JA=JA-1
      ID=ID+JA
30  CONTINUE
      SUM1=0.00
      DO 50 J=1,M
      DP1=R(J)
      DP2=C(J)
50  SUM1=SUM1+DP1*DP2
      D(IK)=SUM1
1000 CONTINUE
      WRITE(ITPE) (D(J),J=1,M)
10  CONTINUE
      REWIND ITPE
      REWIND MTPF
      REWIND NTPF
      REWIND KTFE
      READ(NTPF) (A(J),J=1,NMAX)
      DO 60 KK=1,N
      READ(MTPF) (R(J),J=1,M)
      READ(ITPE) (D(J),J=1,M)
      DO 70 KJ=1,N
      READ(KTFE) (C(J),J=1,M)
      SUM1=0.00
      SUM2=0.00
      DO 80 KP=1,M
      DP1=R(KP)
      DP2=D(KP)

```

```

DP3=C(KR)
SUM1=SUM1+DP1*DP3
80 SUM2=SUM2+DP2*DP3
SM1=SUM1
SM2=SUM2
IF (K.I.GF.KK) MM=(2*KJ+(KK-1)*(2*NHASS-KK))/2
IF (F.I.GF.KK) A(MM)=A(MM)-SM1*SM
IF (F.I.IF.KK) MM=(2*KK+(KJ-1)*(2*NHASS-KJ))/2
IF (F.I.IF.KK) A(MM)=A(MM)-SM1
70 CONTINUE
REWIND K1PF
60 CONTINUE
REWIND N1PF
REWIND M1PF
REWIND I1PF
REWIND K1PF
WRITE (I1PF) (A(I),I=1,NHMAX)
REWIND I1PF
REWIND N
END

```

* FORTRAN DECK

CRIGMAT

C PROG. AUTHORS M. FISON AND R.E. FUNDER: IC, CENTRAL DATA PROCESSING, 4.1.65 RIGMO

SUBROUTINE RIGMAT(A, VALU, VALL, UPPERD, DIAG, V, T, INTER, NN, NEIG, NVEC,

1 MTAPF)

DIMENSION A(1), VALU(1), VALL(1), UPPERD(1), DIAG(1), V(1), T(NN,3),

1 INTER(1)

REWIND MTAPF

N7=0

N=NN

IF(N.LE.2)GO TO 49

NP1=N+1

NM1=N-1

NM2=N-2

ATOP1=N**2+1

IX=0

DO 10 I=1,NM2

SIGMA2=0.

IP1=I+1

DO 1 J=IP1,N

IJ=IX+J

1 SIGMA2=SIGMA2+A(IJ)**2

SIGMA=SQRT(SIGMA2)

II=IX+I

DIAG(I)=A(II)

IIP1=IX+I+1

UPPERD(I)=-SIGN(SIGMA,A(IIP1))

T(1,2)=SIGMA2

IF(ABS(SIGMA).GT.ABS(A(IIP1)))GO TO 2

IIP1=IIP1

A(IIP1)=0.

GO TO 10

2 A(IIP1)=SQRT(1.+ABS(A(IIP1))/SIGMA)

SOTGAM=-SIGN(SIGMA*A(IIP1),UPPERD(I))

IP2=I+2

DO 3 J=IP2,N

IJ=IX+J

3 A(IJ)=A(IJ)/SOTGAM

JK1=1*(2*N-I-1)/2

JX=JK1

IIV=JK1

DO 5 J=IP1,N

VALL(J)=0.

JK=JK1+J

DO 4 K=IP1,J

IK=IX+K

VALL(J)=VALL(J)+A(JK)*A(IK)

4 JK=JK+N-2

IF(J.EQ.N)GO TO 6

CALL LOOP1(J+2,IP1,VALL(J),A(JX),A(IX))

5 JX=IX+N-1

6 DELGAM=0.

DO 7 J=IP1,N

IJ=IX+J

7 DELGAM=DELGAM+A(IJ)*VALL(J)

DG02=.5*DELGAM

DO 8 J=IP1,N

IJ=IX+J

8 T(1,1)=VALL(J)-DG02*A(IJ)

DO 9 I=IP1,N	RIGNO
III=IX+II	RIGNO
CALL LOOP2(A(IX),A(IX),T(NZ,1),T(II,1),A(III),II+1,NP1)	
9 IY=IIX+N-1	RIGNO
10 IX=IY+N-1	RIGNO
M=N*(N+1)/2	RIGNO
UPPERD(NM1)=A(M-1)	RIGNO
T(NM1,2)=UPPERD(NM1)*2	
DIAG(NM1)=A(M-2)	RIGNO
DIAG(N)=A(M)	RIGNO
ENORM=AMAX1(ABS(DIAG)+ABS(UPPERD),ABS(DIAG(N))+ABS(UPPERD(NM1)))	RIGNO
DO 11 I=2,NM1	RIGNO
ENRIMP=ABS(DIAG(I))+ABS(UPPERD(I))+ABS(UPPERD(I-1))	RIGNO
11 IF(ENRIMP.GT.ENORM)ENORM=ENRIMP	RIGNO
DO 12 I=1,NF16	RIGNO
VALU(I)=ENORM	RIGNO
12 VALI(I)=-ENORM	RIGNO
DO 24 I=1,NF16	RIGNO
13 ROOT=.5*(VALU(I)+VALI(I))	RIGNO
IF(ROOT.EQ.VALI(I).OR.ROOT.EQ.VALU(I))GO TO 24	RIGNO
NAGREE=0	RIGNO
PM2=0.	RIGNO
PM1=1.	RIGNO
DO 21 J=1,N	RIGNO
IF(PM2.NE.0.)GO TO 15	RIGNO
14 PM1=SIGN(1.,PM1)	RIGNO
GO TO 17	RIGNO
15 IF(PM1.NE.0.0) GO TO 17	
16 P=-SIGN(1.,PM2)	RIGNO
PM2=0.	RIGNO
IF(T(J-1,2)) 18,14,18	
17 P=DIAG(J)-ROOT-T(J-1,2)*PM2/PM1	
PM2=1.	RIGNO
18 IF(P)21,19,20	RIGNO
19 PM2=PM1	RIGNO
IF(PM2)21,20,20	RIGNO
20 NAGREE=NAGREE+1	RIGNO
21 PM1=P	RIGNO
DO 23 J=1,NF16	RIGNO
IF(J.IF.NAGREE)GO TO 22	RIGNO
IF(VALU(I).IF.ROOT)GO TO 13	RIGNO
VALU(J)=ROOT	RIGNO
GO TO 23	RIGNO
22 VALI(I)=ROOT	RIGNO
23 CONTINUE	RIGNO
GO TO 13	RIGNO
24 CONTINUE	RIGNO
IF(NVEC.IE.0)GO TO 49	
EPSIEN=ENORM*1.E-8	RIGNO
COMPI1=COMPI(1)	RIGNO
DO 48 I=1,NVEC	
DO 25 J=1,N	RIGNO
V(J)=1.	RIGNO
T(I,2)=DIAG(J)-VALU(I)	RIGNO
IF(J.EQ.N)GO TO 26	RIGNO
T(J,4)=UPPERD(J)	RIGNO
25 T(I+1,1)=UPPERD(J)	RIGNO
26 T(I,3)=0.	RIGNO
DO 29 J=1,N	RIGNO
IF(ABS(T(J,2)).LT.1.E-17)T(J,2)=EPSIEN	RIGNO

* FORTRAN DECK

CICOP1

```

SUBROUTINE LOOP1(JP2,NP1,SGAMPJ,AJX,AIX)
  DIMENSION AJX(1), AIX(1)
  DO 1 L=JP2,NP1
    1 SGAMPJ=SGAMPJ+AJX(L)*AIX(L)
  RETURN
END

```

RIGMO
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* FORTRAN DECK

CICOP2

```

SUBROUTINE LOOP2(AIIX,AIX,S,SI,AIII,IP1,NP1)
  DIMENSION AIIX(1),AIX(1),S(1)
  DO 2 JJ=IP1,NP1
    2 AIIX(JJ)=AIIX(JJ)-AIII*S(JJ)-SI*AIX(JJ)
  RETURN
END

```

RIGMO
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* FORTRAN DECK

CICOP3

```

SUBROUTINE LOOP3(UTV,AIIX,V,IIP2,NP1)
  DIMENSION AIIX(1), V(1)
  DO 3 J=IIP2,NP1
    3 UTV=UTV+AIIX(J)*V(J)
  RETURN
END

```

RIGMO
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* FORTRAN DECK

CICOP4

```

SUBROUTINE LOOP4(AIIX,V,NP1,IIP2,UTV)
  DIMENSION AIIX(1),V(1)
  DO 4 K=IIP2,NP1
    4 V(K)=V(K)-AIIX(K)*UTV
  RETURN
END

```

RIGMO
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RIGMO

* FORTRAN DECK

CTRANS TRANSFORMATION DIRECTION COSINES

C X1,Y1 = COORDS. OF POINT 1

C X2,Y2 = COORDS. OF POINT 2

C F1 = DISTANCE BETWEEN POINTS 1 AND 2

C DCS = DIRECTION COSINES OF VECTOR FROM POINT 1 TO POINT 2

 SUBROUTINE TRANS(X1,X2 Y1,Y2,F1,DCS)

 DIMENSION DCS(2)

 DCS(1)=(Y2-X1)/F1

 DCS(2)=(Y2-Y1)/F1

 RETURN

 END

500	JJ=J+N-1+1	SYMV
	IF(I-N)600,900,900	SYMV
600	JP1=I+1	SYMV
	II=II	
	DO 700 J=JP1,N	SYMV
	JJ=J+1	SYMV
700	A(I,J)=A(I,J)/A(II)	SYMV
900	A(II)=1.0/A(II)	SYMV
1000	IM1=I	SYMV
	II=I	SYMV
	DO 2000 I=1,N	SYMV
	JJ=II	SYMV
	II=II	SYMV
	DO 1400 I=1,N	SYMV
	A(I,J)=A(I,J)*A(J,J)	SYMV
	JP1=I+1	SYMV
	IF(JP1-N)1100,1100,1400	SYMV
1100	II=II	SYMV
	JL=JJ	SYMV
	DO 1200 I=JP1,N	SYMV
	II=II+1	SYMV
	JJ=JJ+1	SYMV
1200	A(I,J)=A(I,J)+A(II)*A(JL)	SYMV
	JJ=JJ+1	SYMV
1400	II=II+1	SYMV
2000	II=II	SYMV
	CALL FCLK(II2)	
	TIME = FLOAT(IT2-IT1)/64000.	
	WRITE(6,4000) TIME	
3000	FORMAT(100 39TIME TIME ELAPSED FOR MATRIX INVERSION = F12.4,IX,7HS	
	1ECONDS)	
	RETURN	SYMV
	END	

3.0

COMSYN ~ COMPONENT MODE SYNTHESIS PROGRAM

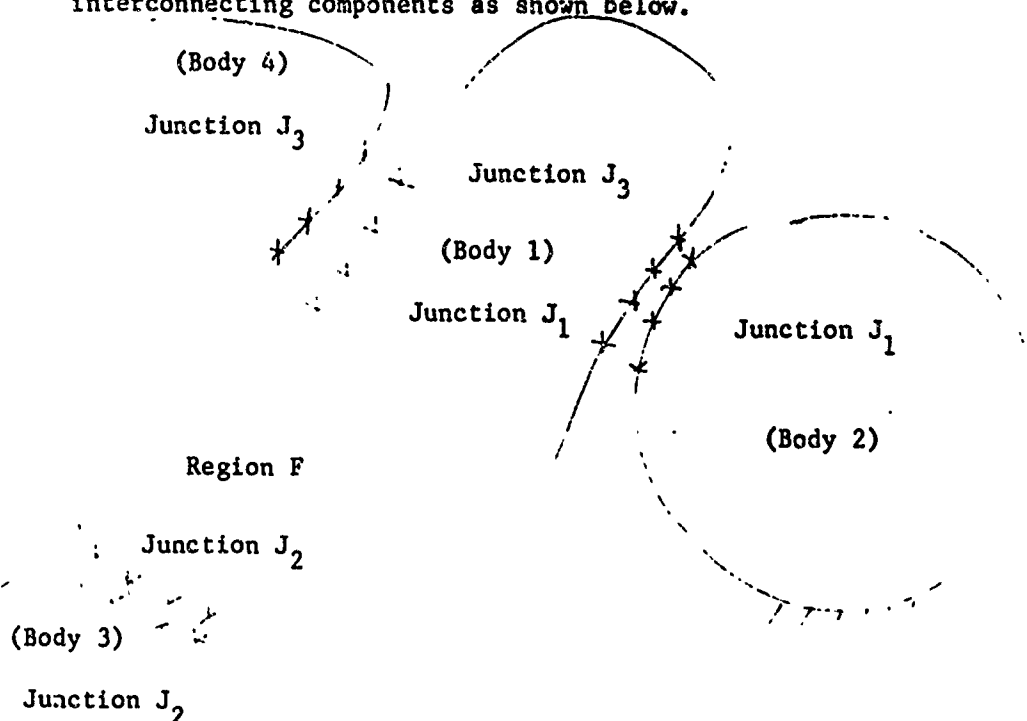
3.1 Introduction

The component mode synthesis technique provides the structural engineer with a valuable analytical tool for obtaining the dynamic response of large complex structures. The basic approach requires that the structure be divided into a number of smaller interconnected components each of which can be analyzed using a small number of degrees of freedom. The total system response is then obtained by coupling the component modal data. The principal advantage of the approach is that the order of the final system of equations to be solved is substantially smaller than the total number of degrees of freedom of the system. The order of the final system matrix depends on the number of component modes selected, and the number of common joints.

The program presented here is orientated for use in flutter analyses. As such, only planar structures may be analyzed. Consequently, only three degrees of freedom are used in the analysis; they are the translation normal to the plane of the structure and the two rotations in the plane of the structure. The program yields the natural vibration modes and frequencies for the composite structure, and generalized mass values for each mode. In addition, there is an option to calculate generalized aerodynamic forces when AICs are entered into the program. Note: When the generalized aerodynamic forces calculated by COMSYN are used in a flutter analysis, it is necessary to use the mode shapes and generalized masses calculated by COMSYN in order that the magnitude of all the parameters be consistent.

3.2 Theoretical Derivation

Assume that the structure under consideration is subdivided into interconnecting components as shown below.



Each component may be attached to one or more components by junction nodes. Junction nodes (common joints) are structural points that exist on two or more components. The components may also contain physically restrained nodes (boundary attach points), and nodes that are free to move. It is noted, that when dividing a structure into components, common joints cannot be boundary attach points.

The basic approach to the solution is as follows:

1. The structure is divided into components.
2. The stiffness and mass matrices are derived for each component with the common joints restrained; also a vibration analysis is performed for this condition.
3. The stiffness and mass matrices are derived for each component with the common joints free.
4. The absolute displacements of each component is expanded in terms of the fixed modes, and the rigid body and constraint modes. The fixed modes are calculated in Step 2 above. The rigid body and constraint modes are derived from information calculated in Step 3 above. These modes are defined as the displacements, X_F , in Region F, due to motion of the junction displacements, X_J 's, individually, when no external forces are applied in Region F.
5. Using Step 4 a transformation is established that takes the component from physical coordinates (absolute displacements) to the system component mode coordinates (the generalized coordinates and junction displacements).
6. The transformation matrix derived in Step 5 is used to transform the component stiffness and mass matrices to the system component mode coordinates.
7. The dynamical matrix for the entire structure in system component mode coordinates is assembled by combining the component stiffness and mass matrices of Step 6.
8. A vibration analysis is performed for the entire structure in system component mode coordinates.
9. The system component modes are transformed to the absolute displacements which are the mode shapes for the entire structure.
10. Using the mode shapes the generalized mass and generalized aerodynamic forces are calculated.

Steps 1 through 3 are performed by the program FLUENG-100C. Steps 4 through 10 are performed by the program COMSYN.

The equilibrium equation for a typical component can be written in the form

$$\begin{Bmatrix} P_F \\ P_J \\ 0 \end{Bmatrix} = \begin{bmatrix} K_{FF} & K_{FJ} & K_{F\theta} \\ K_{JF} & K_{JJ} & K_{J\theta} \\ K_{\theta F} & K_{\theta J} & K_{\theta\theta} \end{bmatrix} \begin{Bmatrix} X_F \\ X_J \\ \theta \end{Bmatrix} \quad (1)$$

where the matrices have been partitioned such that P_F and X_F refer to the forces and displacements in region F, P_J and X_J refer to the forces and displacements of the nodes in junctions J, and θ refers to the rotations in region F. If the common joint normal displacements are restrained, the above matrix equation can be written as

$$\begin{Bmatrix} P_F \\ 0 \\ P_J \end{Bmatrix} = \begin{bmatrix} K_{FF} & K_{F\theta} & K_{FJ} \\ K_{\theta F} & K_{\theta\theta} & K_{\theta J} \\ K_{JF} & K_{J\theta} & K_{JJ} \end{bmatrix} \begin{Bmatrix} X_F \\ \theta \\ 0 \end{Bmatrix} \quad (2)$$

which is equivalent to the partitioned matrix equation

$$\begin{Bmatrix} P_F \\ 0 \end{Bmatrix} = \begin{bmatrix} K_{FF} & K_{F\theta} \\ K_{\theta F} & K_{\theta\theta} \end{bmatrix} \begin{Bmatrix} X_F \\ \theta \end{Bmatrix} \quad (3a)$$

and

$$\begin{Bmatrix} P_J \end{Bmatrix} = \begin{bmatrix} K_{JF} & K_{J\theta} \end{bmatrix} \begin{Bmatrix} X_F \\ \theta \end{Bmatrix} \quad (3b)$$

The second row of Eq (3a) can be written as

$$0 = K_{\theta F} X_F + K_{\theta\theta} \theta$$

$$\text{or } \theta = -K_{\theta\theta}^{-1} K_{\theta F} X_F \quad (4)$$

Substituting back into the first row of Eq (2) yields

$$P_F = \left[K_{FF} - K_{F\theta} K_{\theta\theta}^{-1} K_{\theta F} \right] \{X_F\} \quad (5)$$

The reduced component stiffness matrix with joint nodes restrained
is

$$[K]_R = \left[K_{FF} - K_{F\theta} K_{\theta\theta}^{-1} K_{\theta F} \right] \quad (6)$$

The component consistent mass matrix can be written as

$$\begin{bmatrix} M_{FF} & M_{FJ} & M_{F\theta} \\ M_{JF} & M_{JJ} & M_{J\theta} \\ M_{\theta F} & M_{\theta J} & M_{\theta\theta} \end{bmatrix} \quad (7)$$

If the common joint normal displacements are restrained, Eq (7)
becomes

$$\begin{bmatrix} M_{FF} & M_{F\theta} \\ M_{\theta F} & M_{\theta\theta} \end{bmatrix} \quad (8)$$

Using Eq (4) we can write

$$\begin{Bmatrix} X_F \\ \theta \end{Bmatrix} = \begin{bmatrix} I \\ -K_{\theta\theta}^{-1} K_{\theta F} \end{bmatrix} \{X_F\} \quad (9)$$

and the reduced mass matrix becomes

$$[M]_R = [R_1]^T \begin{bmatrix} M_{FF} & M_{FO} \\ M_{OF} & M_{OO} \end{bmatrix} [R_1] \quad (10)$$

where

$$[R_1] = \begin{bmatrix} I \\ -K_{OO}^{-1} K_{OF} \end{bmatrix} \quad (11)$$

In order to perform a component mode synthesis analysis, it is necessary to expand the absolute displacements of each component in terms of the fixed modes and the rigid body and constraint modes. The fixed modes, $\bar{X}$, are given in the form

$$[\bar{X}_F] = [\phi] [q] \quad (12)$$

where $[q]$ are generalized coordinates and the modes $[\phi]$, stored columnwise in the modal matrix $[\phi]$ satisfy the following equations of motion

$$[K]_R [y] - \omega^2 [M]_R [y] = [0] \quad (13)$$

Equation (13) gives the modes of the component with the junction nodes fixed.

The rigid body and constraint modes are determined simultaneously from Eq (3) by defining these modes as the displacements in region F, X_F , due to the motion of the junction displacements, X_J , when no external forces are applied in region F. This condition is represented by the equations

$$\begin{Bmatrix} 0 \\ P_J \\ 0 \end{Bmatrix} = \begin{bmatrix} K_{FF} & K_{FJ} & K_{FO} \\ K_{JF} & K_{JJ} & K_{JO} \\ K_{OF} & K_{OJ} & K_{OO} \end{bmatrix} \begin{Bmatrix} X_F \\ X_J \\ \theta \end{Bmatrix} \quad (14)$$

where X_J are the junction displacements including the rotational degrees of freedom. The third equation of matrix Eq (13) yields

$$\begin{bmatrix} K_{\theta F} & K_{\theta J} \end{bmatrix} \begin{Bmatrix} X_F \\ X_J \end{Bmatrix} + \begin{bmatrix} K_{\theta\theta} \end{bmatrix} \begin{Bmatrix} \theta \end{Bmatrix} = \begin{Bmatrix} 0 \end{Bmatrix}$$

or $\theta = - \begin{bmatrix} K_{\theta\theta} \end{bmatrix}^{-1} \begin{bmatrix} K_{\theta F} & K_{\theta J} \end{bmatrix} \begin{Bmatrix} X_F \\ X_J \end{Bmatrix}$ (15)

Substituting into the first two equations of Eq (14) yields

$$\begin{Bmatrix} 0 \\ P_J \end{Bmatrix} = \begin{bmatrix} (K_{FF} - K_{F\theta} K_{\theta\theta}^{-1} K_{\theta F}) & (K_{FJ} - K_{F\theta} K_{\theta\theta}^{-1} K_{\theta J}) \\ (K_{JF} - K_{J\theta} K_{\theta\theta}^{-1} K_{\theta F}) & (K_{JJ} - K_{J\theta} K_{\theta\theta}^{-1} K_{\theta J}) \end{bmatrix} \begin{Bmatrix} X_F \\ X_J \end{Bmatrix}$$

or $\begin{Bmatrix} 0 \\ P_J \end{Bmatrix} = \begin{bmatrix} \bar{K}_{FF} & \bar{K}_{FJ} \\ \bar{K}_{JF} & \bar{K}_{JJ} \end{bmatrix} \begin{Bmatrix} \bar{X}_F \\ X_J \end{Bmatrix}$ (16)

it is noted $\begin{bmatrix} \bar{K}_{FF} \end{bmatrix} = \begin{bmatrix} K \end{bmatrix}_R$

where

$$\begin{aligned} \bar{K}_{FF} &= K_{FF} - K_{F\theta} K_{\theta\theta}^{-1} K_{\theta F} \\ \bar{K}_{FJ} &= K_{FJ} - K_{F\theta} K_{\theta\theta}^{-1} K_{\theta J} \\ \bar{K}_{JF} &= K_{JF} - K_{J\theta} K_{\theta\theta}^{-1} K_{\theta F} \\ \bar{K}_{JJ} &= K_{JJ} - K_{J\theta} K_{\theta\theta}^{-1} K_{\theta J} \end{aligned} \quad (17)$$

$\bar{X}_F$ = displacements in region F due to motion of joint displacements

The first equation of Eq (16) yields

$$\begin{aligned} & \left[\bar{K}_{FF} \right] \left\{ \bar{X}_F \right\} + \left[K_{FJ} \right] \left\{ X_J \right\} = 0 \\ \text{or} \quad & \left\{ \bar{X}_F \right\} = - \left[K_{FF} \right]^{-1} \left[K_{FJ} \right] \left\{ X_J \right\} \\ \text{or} \quad & \left\{ \bar{X}_F \right\} = \left[T \right] \left\{ X_J \right\} \end{aligned} \quad (18)$$

where

$$\left[T \right] = - \left[K_{FF} \right]^{-1} \left[K_{FJ} \right]$$

The absolute displacements of each component may be written in the form

$$\left\{ X \right\} = \left\{ \bar{X} \right\} + \left\{ \bar{X} \right\} \quad (19)$$

or

$$\begin{Bmatrix} X_F \\ X_J \end{Bmatrix} = \begin{bmatrix} \phi & T \\ 0 & I \end{bmatrix} \begin{Bmatrix} q \\ X_J \end{Bmatrix} \quad (20)$$

Let

$$\left[\beta \right] = \begin{bmatrix} \phi & T \\ 0 & I \end{bmatrix} \quad (21)$$

which is the transformation matrix which takes the component from physical coordinates (absolute displacements) to system component mode coordinates (generalized coordinates and junction displacements). The transformation matrix is exact if the modal matrix $\left[\phi \right]$ is complete; however, for a component mode synthesis analysis the modal matrix is truncated to reduce the number of degrees of freedom. To this extent the $\left[\beta \right]$ matrix is approximate.

The $\left[\beta \right]$ matrix is now used to obtain the transformed stiffness in the following manner

$$[\bar{K}_C] = [\beta]^T [K_C] [\beta] \quad (22)$$

where

$$[K_C] = \begin{bmatrix} \bar{K}_{FF} & \bar{K}_{FJ} \\ \bar{K}_{JF} & \bar{K}_{JJ} \end{bmatrix}$$

The mass matrix for a typical component is given by Eq (7). Likewise, using the transformation matrix

$$[R_2] = \begin{bmatrix} I & \\ [-K_{\theta\theta}]^{-1} [K_{\theta F} \ K_{\theta J}] \end{bmatrix} \quad (23)$$

The rotational degrees of freedom can be eliminated in the free region

$$[M_C] = [R_2]^T \begin{bmatrix} M_{FF} & M_{FJ} & M_{F\theta} \\ M_{JF} & M_{JJ} & M_{J\theta} \\ M_{\theta F} & M_{\theta J} & M_{\theta\theta} \end{bmatrix} [R_2] \quad (24)$$

$$[M_C] = \begin{bmatrix} \bar{M}_{FF} & \bar{M}_{FJ} \\ \bar{M}_{JF} & \bar{M}_{JJ} \end{bmatrix}$$

The $[\beta]$ matrix can again be used to obtain the transformed mass matrix

$$[\bar{M}_C] = [\beta]^T [M_C] [\beta] \quad (25)$$

Combining the system component stiffness matrix (Eq 22) and system component mass matrix (Eq 25) for all the components, one finally forms an overall stiffness and mass matrix

$$\begin{bmatrix} K_{qq} & K_{qJ} & K_{q\theta} \\ K_{Jq} & K_{JJ} & K_{J\theta} \\ K_{\theta q} & K_{\theta J} & K_{\theta\theta} \end{bmatrix} \begin{Bmatrix} q \\ \omega_J \\ \theta_J \end{Bmatrix} = \omega_S^2 \begin{bmatrix} M_{qq} & M_{qJ} & M_{q\theta} \\ M_{Jq} & M_{JJ} & M_{J\theta} \\ M_{\theta q} & M_{\theta J} & M_{\theta\theta} \end{bmatrix} \begin{Bmatrix} q \\ \omega_J \\ \theta_J \end{Bmatrix} \quad (26)$$

or

$$[K_S] \{X_S\} = \omega_S^2 [M_S] \{X_S\}$$

where q - component modes
 ω_J - junction normal displacements
 θ_J - junction rotations

The system stiffness and mass matrices can be reduced by eliminating the joint rotational degrees of freedom. This can be done by using the transformation matrix

$$\begin{bmatrix} R_3 \end{bmatrix} = \begin{bmatrix} \begin{bmatrix} I \end{bmatrix} \\ - \begin{bmatrix} K_{\theta\theta} \end{bmatrix}^{-1} \begin{bmatrix} K_{\theta q} & K_{\theta J} \end{bmatrix} \end{bmatrix} \quad (27)$$

in the following way

$$\begin{bmatrix} \bar{K}_S \end{bmatrix} = \begin{bmatrix} R_3 \end{bmatrix}^T \begin{bmatrix} K_S \end{bmatrix} \begin{bmatrix} R_3 \end{bmatrix} \quad (28)$$

$$\begin{bmatrix} \bar{M}_S \end{bmatrix} = \begin{bmatrix} R_3 \end{bmatrix}^T \begin{bmatrix} M_S \end{bmatrix} \begin{bmatrix} R_3 \end{bmatrix} \quad (29)$$

and the frequencies and mode shapes $\begin{bmatrix} \gamma \end{bmatrix}$ of the entire structural system is given by

$$\begin{bmatrix} \bar{K}_S \end{bmatrix} \begin{Bmatrix} X_S \end{Bmatrix} = \omega_S^2 \begin{bmatrix} \bar{M}_S \end{bmatrix} \begin{Bmatrix} X_S \end{Bmatrix}$$

where

$$\begin{Bmatrix} X_S \end{Bmatrix} = \begin{Bmatrix} q \\ \omega_J \end{Bmatrix}$$

The deflections in each component can be calculated by using $\begin{bmatrix} X_S \end{bmatrix}$ in conjunction with Eq (12) for each component.

Generalized Mass and Aerodynamic Forces

The generalized mass matrix is formed by utilizing the system modal matrix $[\bar{\gamma}]$, which is composed of the system modal shapes $\{X_S\}$ stored column-wise, as a transformation matrix. This can be written in matrix form as follows

$$[M]_G = [\bar{\gamma}]^T [\bar{M}_S] [\bar{\gamma}] \quad (30)$$

The aerodynamic forces are computed from the AIC matrix. For the uncoupled aero case the AIC matrix is in the form

$$[C_h] = \begin{bmatrix} [C_{h1}] & & 0 \\ & [C_{h2}] & \\ 0 & & [C_{h3}] \end{bmatrix} \quad (31)$$

where the diagonal terms are the AIC matrices for each component. The displacements $\{X_F\}$ must be computed for each component by using Eq (19) and the system modal matrix $[\bar{\gamma}]$. The modal matrix $[\bar{\gamma}]$ was reduced by eliminating any unnecessary degrees of freedom when X_F was determined for an individual component. The $[X_F]$ for a particular component is computed from

$$[X_F]_i = \begin{bmatrix} \emptyset \\ q \end{bmatrix} + \begin{bmatrix} T \end{bmatrix} [X_S]_i \quad (32)$$

where $[q]$ is the upper partition of the reduced modal matrix and $[X_S]_i$ is the junction displacement (translations and rotations) matrix for component i . Once $[X_F]_i$ is known for a particular component the equation

$$[Q]_{unc} = \sum_{i=1}^N [X_F]_i [C_{h_i}] [X_F]_i \quad (33)$$

yields the aerodynamic forces for N components. If the AIC matrix is coupled between components a and b , then

$$[C_h]_{a,b} = \begin{bmatrix} C_{haa} & C_{hab} \\ C_{hba} & C_{hbb} \end{bmatrix} \quad (34)$$

then for a two component system the generalized forces are computed from the matrix equation

$$\begin{aligned}
 [Q]_{\text{coupled}} &= [X_{F_a}]^T [C_{h_{aa}}] [X_{F_a}] \\
 &+ [X_{F_a}]^T [C_{h_{ab}}] [X_{F_b}] \\
 &+ [X_{F_b}]^T [C_{h_{ba}}] [X_{F_a}] + [X_{F_b}]^T [C_{h_{bb}}] [X_{F_b}]
 \end{aligned} \tag{35}$$

The final aerodynamic force matrix is obtained by adding $[Q]_{\text{uncoupled}}$ and $[Q]_{\text{coupled}}$

$$[Q] = [Q]_{\text{uncoupled components}} + [Q]_{\text{coupled components}} \tag{36}$$

The aerodynamic generalized forces as calculated have not been multiplied by any nondimensionalizing factors used in calculating $[C_h]$.

3.3 Program Description

The computer program COMSYN written in Fortran IV performs a vibration analysis for a planar structural system using the component mode synthesis technique. A complex structure can be divided into as many as five components; each component may have as many as 12 common joints. The order of the system eigenvalue solution is determined by the number of components times the number of component modes plus the number of unique common joints times three. Common joints may exist in two or more components; however, they are counted once

in determining the order of the system eigenvalue solution. The input requirements of COMSYN are a modal representation of each component and related data concerning the junction points (common joints). This input data is available as punched output from the FLUENC-100C program.

The program as such is oriented to facilitate flutter analyses by the normal mode (modal) method. A modal flutter analysis requires the vibration frequencies, the generalized masses, and the generalized aerodynamic forces. The vibration frequencies and generalized masses are the normal output of a component mode synthesis vibration analysis. A subroutine was added to the program to calculate generalized aerodynamic forces when aerodynamic influence coefficients are supplied. The aerodynamic influence coefficients may be uncoupled for each component or any two of the five components may be coupled. The only restriction being that the two coupled components must be entered serially as input data.

3.3.1 Processing Information

- A. Operation -- Standard FORTRAN IV processor system.
Operable on the GE635 computer.
- B. Core Storage -- The program COMSY requires a minimum of 65,000 memory units for execution.
- C. Tape Units -- Standard input, output, and punch tape units, and 11 scratch tape units.

3.4 Input Instructions

1. Title Cards, Format (12A6) Two cards required.

Column	1 - - - - -	72
Name	Any Alphanumeric Statement	

Column	1 - - - - -	72
Name	Any Alphanumeric Statement	

2. Control Card, Format (6I5) NCOUP = NAT = NV = 0 for vibration analysis only.

Column	1-5	6-10	11-15	16-20	21-25	26-30
Name	NCOMP	MODE	NCOM	NCOUP	NAT	NV

- NCOMP = Number of components used in the analysis ≤ 5 .
- MODE = Number of Modes requested for total system ≤ 9 .
- NCOM = Number of rows in the matrix that relates the common joints between two components (See instruction No. 6) ≤ 48 .
- NCOUP = 0, no aerodynamic coupling exists between components.
 = The lowest number of the two components which are aerodynamically coupled (coupled components must be in sequence).
- NAT = 1, AICs are entered as non-zero partitions (strip or piston theories).
 = 2 AICs are full matrices (kernel function or Mach box)
- NV = Number of reduced velocities (1/k's)
- NOTE: When NAT=1 then it is required that NCOUP=0; and when NAT=2 then it is required that NCOUP $\geq 0 < 5$

3. Information Card, Format (9I5)

Column	1-5	6-10	11-15	
	NREDU(1)	NREDU(2)	NREDU(3)	NREDU(4)

- NREDU(1) = Number of translational degrees of freedom for component "1" when the common joints are restrained.

4. Information Card, Format (9I5)

Column	1-5	6-10	11-15	
Name	NMODE(1)	NMODE(2)	NMODE(3)	NMODE(4)

- NMODE(1) = Number of modes for component "1" used in the analysis.

5. Information Card, Format (9I5)

Column	1-5	6-10	11-15	
Name	NCJT(1)	NCJT(2)	NCJT(3)	NCJT(4)

NCJT(1) = Number of common joints for component "1" used in the analysis ≤ 12 .

6. Information Card, Format (36I2) enter data continuously used as many cards as required. This card/series of cards describes a correlation matrix that relates the common joints of each component to the overall structure. Four numbers describe each row of the matrix as follows:

Common Joint No. of Component No. is the same as Common Joint No. of Component No.
 1st No. 2nd No. 3rd No. 4th No.

EXAMPLE: If the third junction point of Component 1 is common to the fifth junction point of Component 2, then the set of four numbers are:

Column	1	2	3	4	5	6	7	8
	3		1		5			2

Restrictions

1. Correlation must always be made to a lower numbered component; i.e., in each set, the 2nd number must always be smaller than the 4th number.
2. If a joint is common to more than two components, all possible correlations must be made to the lowest numbered component in which it appears. Additional correlations may be made to higher numbered components but are unnecessary.

7. Information Card, Format (6E12.8). If NV = 0 omit this card/s.

Column	1-12	13-24	25-36	
Name	VEL(1)	VEL(2)	VEL(3)	VEL(NV)

VEL(i) = Reduced velocity series, $i = 1, NV$

NV ≤ 20 (continue on next card if necessary)

8. The following input is available as punched output from the program FLUENC or can be derived from any other structural analysis computer program. The output from FLUENC is punched in Format (1P6E12.5), but any card than can be read in Format (6E12.8) can be used. All data is presented as full matrices, and each row begins on a new card.

The data is stacked in the following order by component:

1. Mode Shapes
 2. Frequencies, Hz
 3. CKFF - Stiffness Matrix
 4. CKFJ
 5. CKJJ
 6. Flexibility Matrix
 7. Weight Matrix
 8. CMFJ
 9. CMJJ
9. When generalized aerodynamic forces are desired, $NV > 0$, aerodynamic influence coefficients, AICs, are required input. The AIC matrix or partition is entered by row; each row begins on a new card. Format (6E12.8) is used.

When $NAT = 1$ the AICs are entered as non-zero partitions. The punched output from the computer programs STRIP and PISTON (Vol.I) are compatible input for this option. Repeat the following information for each component.

9a. Control Card, Format (2I4)

Column	1-4	5-8	
Name	NSIZE	NPART	

NSIZE = Size of complete AIC matrix for component "i"

NPART = Number of non-zero partitions for component "i" (number of strips)

Repeat the following instructions NPART times

9b. Control Card, Format (I4)

Column	1-4	
Name	NS	

NS = Size of partition

9c. Data Card Format (6E12.8) Start each row on a new card.

Column	1-12	13-24	25-36	37-48
Name	$ARE_{1,1}$	$AIM_{1,1}$	$ARE_{1,2}$	$AIM_{1,2}$

ARE - Real part of $AIC_{i,j}$

AIM - Imaginary part of $AIC_{i,j}$

Repeat data items 9a, 9b, and 9c for each $1/k$ value.

When $NAT = 2$, the AICs are entered as full matrices for each component. The punched output from the AIC computer programs subsonic, sonic, and supersonic (Vol. III, Ref. 1) are compatible input for this option. Stack the matrices for each component sequentially as they are entered in Items 4 through 8. Enter each matrix as follows:

9d. Data Card Format (6E12.5) Start each row on a new card.

Column	1-12	13-24	25-36	37-48
Name	$ARE_{1,1}$	$AIM_{1,1}$	$ARE_{1,2}$	$AIM_{1,2}$

ARE ~ Real part of $AIC_{i,j}$

AIM ~ Imaginary part of $AIC_{i,j}$

When two components are coupled, the coupled matrix is inserted in its proper sequence in the stack of AIC matrices. The maximum size for any AIC matrix is 40×80 .

Repeat data item 9d for each $1/k$ value.

NOTE: For all input, reference to the common joints, free joints, and components must be consistent between the structural analysis program and the aerodynamic influence coefficient programs. The sequence order of the above must be maintained when input into COMSYN.

3.5 DESCRIPTION OF PROGRAM OUTPUT

I. Printed Output

A. For each component

1. All input data except flexibility matrix
2. Transformed stiffness and mass matrices (component mode coordinates - generalized coordinates and junction displacements)
3. Normalized mode shapes (for orthogonality)
4. Mass matrix for orthogonality check (diagonal elements = 1.0)

B. Results for the total system

1. Relative locations of the degrees of freedom of each component when combined to form the system matrix by the NCODE METHOD.
2. Reduced stiffness and mass matrices (rotational degrees of freedom eliminated)
3. Eigenvalues and eigenvectors
4. Natural frequencies (CPS)
5. Mode shapes representing free joints on each component - printed columnwise.
6. Generalized mass matrix
7. Generalized aerodynamic forces for each $1/k$ if $NV > 0$.

II. Punched Output

A. Generalized mass matrix, GENM

B. Generalized aerodynamic force matrix for each $1/k$, GENA

In both cases full matrices are punched out. Format (1P6E12.5) is used. The cards, which are sequenced and identified with the names given above, are compatible with the input requirements for MOFA, the Modal Flutter Analysis Program.

3.6 SAMPLE PROBLEM

The sample problem of Section 2.5 will be used to demonstrate COMSYM. The structure is divided into three components, the fuselage, the wing, and the control surface. There are three common joints: two attach the wing to the fuselage and one attaches the control surface to the fuselage. The punched output from FLUENC-100C is used as input to the program.

COMPONENT MODE SYNTHESIS ANALYSIS
3 COMPONENTS CONSIDERED

TYPICAL MISSILE

COMSYN CHECK CASE 1

INPUT DATA FOR COMPONENT 1

13 DEGREES OF FREEDOM
7 MODES
3 COMMON JOINTS

NOT REPRODUCIBLE

MODE SHAPES

MODE 1 - FREQUENCY = 67.607 CPS

1.00000E-01	4.00777E-01	2.24870E-01	5.28821E-02	1.40420E-21	2.63921E-21	1.52560E-21	2.58288E-21
4.85164E-21	2.80610E-21	9.79013E-19	3.38824E-18	6.47293E-18			

MODE 2 - FREQUENCY = 310.743 CPS

-9.01140E-03	8.17440E-01	1.00000E-00	4.05314E-01	3.27313E-20	6.14870E-20	3.54938E-20	6.11248E-20
1.14776E-19	6.62411E-20	9.24783E-17	3.19065E-16	6.11126E-16			

MODE 3 - FREQUENCY = 420.813 CPS

-3.94167E-15	2.96710E-15	3.07470E-15	1.69609E-15	4.91140E-19	9.27218E-19	5.31596E-19	9.31452E-19
1.74785E-19	1.00650E-19	1.51340E-01	5.23604E-01	1.60000E-00			

MODE 4 - FREQUENCY = 832.061 CPS

-3.03670E-01	1.00000E-00	-2.84708E-01	-6.43520E-01	-1.06615E-18	-1.99517E-18	-1.13784E-18	-2.32728E-18
-4.34504E-18	-2.46343E-18	-3.78158E-17	-1.31628E-16	-2.52580E-16			

MODE 5 - FREQUENCY = 1669.060 CPS

-1.44262E-01	7.01290E-01	-7.93726E-01	1.00000E-00	-4.54091E-18	-8.44006E-18	-4.69242E-18	-2.28676E-17
-4.22278E-17	-2.31778E-17	-3.40605E-18	-1.50044E-17	-3.13432E-17			

MODE 6 - FREQUENCY = 2063.090 CPS

1.82850E-15	-1.86274E-15	-3.46040E-17	3.08753E-15	2.33168E-15	4.30228E-15	2.35918E-15	5.44044E-01
1.00000E-00	5.44044E-01	1.42494E-16	8.07373E-16	2.30905E-16			

MODE 7 - FREQUENCY = 2627.050 CPS

7.51409E-16	-5.76243E-16	3.03547E-16	9.01854E-16	5.43863E-03	1.00000E-00	5.43863E-01	1.95646E-15
3.64100E-15	-0.02904E-15	-1.27000E-16	1.00340E-16	1.00667E-16			

MODED RELATIONS OF DEGREES OF FREEDOM DIFFERENCE MATRIX FOR COMPONENT (COMMON JOINTS RESTRAINED) K-FE

ROW 1	1.07511E 05	-5.75330E 05	4.88880E 05	-1.55556E 05	0.	0.	0.
ROW 2	2.25330E 06	-2.78880E 06	1.55556E 06	0.	0.	0.	0.
ROW 3	5.20000E 06	-4.90000E 06	0.	0.	0.	0.	0.
ROW 4	9.10000E 06	0.	0.	0.	0.	0.	0.
ROW 5	1.05600E 08	-6.72000E 07	2.88000E 07	0.	0.	0.	0.
ROW 6	8.40000E 07	-6.72000E 07	0.	0.	0.	0.	0.
ROW 7	1.05600E 08	0.	0.	0.	0.	0.	0.
ROW 8	1.05600E 08	-6.72000E 07	2.88000E 07	0.	0.	0.	0.
ROW 9	8.40000E 07	-6.72000E 07	0.	0.	0.	0.	0.
ROW 10	1.05600E 08	0.	0.	0.	0.	0.	0.
ROW 11	5.16023E 07	-2.97231E 07	7.75385E 06	0.	0.	0.	0.
ROW 12	2.84300E 07	-1.03345E 07	0.	0.	0.	0.	0.
ROW 13	4.52300E 06	0.	0.	0.	0.	0.	0.

STIFFNESS MATRIX - RELATES COMMON JOINTS TO REF JOINTS (COMMON JOINTS FREE) K-FJ

ROW 1	4.44444E 04	0.	0.	0.	0.	1.48140E 05	0.
ROW 2	-4.44444E 04	0.	0.	0.	0.	-1.48140E 05	0.
ROW 3	0.	0.	0.	0.	0.	0.	0.

2.00000E 06	0.	0.	0.	0.	6.66667E 06	0.
ROW 4	-5.60000E 06	0.	0.	0.	-3.26667E 07	0.
ROW 5	-6.00000E 07	-7.20000E 06	0.	0.	1.56000E 08	-1.20000E 07
ROW 6	2.52000E 07	2.52000E 07	0.	0.	-4.20000E 07	4.20000E 07
ROW 7	-7.20000E 06	-6.00000E 07	0.	0.	1.20000E 07	-1.56000E 08
ROW 8	-6.00000E 07	-7.20000E 06	0.	0.	0.	1.56000E 08
ROW 9	2.52000E 07	2.52000E 07	0.	0.	0.	-4.20000E 07
ROW 10	-7.20000E 06	-6.00000E 07	0.	0.	0.	1.20000E 07
ROW 11	0.	-2.97231E 07	0.	0.	0.	0.
ROW 12	0.	1.16308E 07	0.	0.	0.	0.
ROW 13	0.	-1.93846E 06	0.	0.	0.	0.

UPPER TRIANGLE OF STIFFNESS MATRIX - COMMON JOINTS K-J

ROW 1	4.20000E 07	1.80000E 06	0.	0.	-9.56667E 07	3.00000E 06
ROW 2	8.04000E 07	1.80000E 06	0.	0.	-3.00000E 06	-5.02404E-01
ROW 3	6.02308E 07	0.	0.	0.	-3.00000E 06	6.16154E 07
ROW 4	1.61518E 08	0.	0.	0.	0.	0.

ROW 5	2.15305E 08	0.	0.	0.
ROW 6	1.61538E 08	0.	0.	0.
ROW 7	7.16111E 08	-5.00000E 06	0.	0.
ROW 8	9.70000E 08	-5.00000E 06	0.	0.
ROW 9	7.27308E 08	0.	0.	0.

UPPER TRIANGLE OF TRANSFORMED STIFFNESS MATRIX FOR COMPONENT 1

ROW 1	1.80927E 05	0.	0.	0.	0.	0.	0.	0.	
ROW 2	3.61208E 06	0.	0.	0.	0.	0.	0.	0.	
ROW 3	7.29321E 06	0.	0.	0.	0.	0.	0.	0.	
ROW 4	3.42964E 07	0.	0.	0.	0.	0.	0.	0.	
ROW 5	1.09977E 08	0.	0.	0.	0.	0.	0.	0.	
ROW 6	1.68034E 08	0.	0.	0.	0.	0.	0.	0.	
ROW 7	2.52108E 08	0.	0.	0.	0.	0.	0.	0.	
ROW 8	1.04988E 06	-1.05003E 07	0.	0.	0.	0.	-1.05003E 07	-1.05003E 07	
ROW 9	2.09900E 06	-1.05010E 06	0.	0.	0.	0.	1.05003E 07	1.06925E 00	-1.05003E 07
ROW 10	1.04986E 06	0.	0.	0.	0.	0.	1.05003E 07	1.05003E 07	0.
ROW 11									

POW 11	1.61538E 08	0.	0.	0.	0.
POW 12	2.15385E 08	0.	0.	0.	0.
POW 13	1.61538E 08	0.	0.	0.	0.
POW 14	1.39997E 08	7.00007E 07	0.	0.	0.
POW 15	2.80000E 08	7.00007E 07	0.	0.	0.
POW 16	1.39998E 08	0.	0.	0.	0.

UPPER TRIANGLE OF REDUCED WEIGHT MATRIX FOR COMPONENT (COMMON JOINTS RESTRAINED) M-FF

ROW 1	2.50000E 01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 2	2.50000E 01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 3	5.00000E 01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 4	5.00000E 01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 5	1.66000E 01	0.	0.	0.	0.	0.	0.	0.	0.
POW 6	1.67000E 01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 7	1.66000E 01	0.	0.	0.	0.	0.	0.	0.	0.
POW 8	2.50000E 01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 9	2.50000E 01	0.	0.	0.	0.	0.	0.	0.	0.
POW 10	2.50000E 01	0.	0.	0.	0.	0.	0.	0.	0.
POW 11	5.00000E 01	0.	0.	0.	0.	0.	0.	0.	0.

ROW 12

5.00000E 00 0.

ROW 13

1.50000E 01

MASS MATRIX - RELATES COMMON JOINTS TO FREE JOINTS (COMMON JOINTS FREE) M-FJ

ROW 1

0.

0.

0.

0.

0.

0.

0.

0.

ROW 2

0.

0.

0.

0.

0.

0.

0.

0.

ROW 3

0.

0.

0.

0.

0.

0.

0.

0.

ROW 4

0.

0.

0.

0.

0.

0.

0.

0.

ROW 5

0.

0.

0.

0.

0.

0.

0.

0.

ROW 6

0.

0.

0.

0.

0.

0.

0.

0.

ROW 7

0.

0.

0.

0.

0.

0.

0.

0.

ROW 8

0.

0.

0.

0.

0.

0.

0.

0.

ROW 9

0.

0.

0.

0.

0.

0.

0.

0.

ROW 10

0.

0.

0.

0.

0.

0.

0.

0.

ROW 11

0.

0.

0.

0.

0.

0.

0.

0.

ROW 12

0.

0.

0.

0.

0.

0.

0.

0.

ROW 13

0.

0.

0.

0.

0.

0.

0.

0.

UPPER TRIANGLE OF MASS MATRIX - COMMON JOINTS P-JJ

ROW 1	1.28209E-01	0.	0.	0.	0.	0.	0.
ROW 2	1.92941E-01	0.	0.	0.	0.	0.	0.
ROW 3	1.92941E-01	0.	0.	0.	0.	0.	0.
ROW 4	0.	0.	0.	0.	0.	0.	0.
ROW 5	0.	0.	0.	0.	0.	0.	0.
ROW 6	0.	0.	0.	0.	0.	0.	0.
ROW 7	0.	0.	0.	0.	0.	0.	0.
ROW 8	0.	0.	0.	0.	0.	0.	0.
ROW 9	0.	0.	0.	0.	0.	0.	0.

NORMALIZED MODE SHAPES FOR ORTHOGONALITY

MODE 1 - FREQUENCY = 67.607 CPS							
3.37414E-01	1.68632E-01	7.58742E-01	1.78431E-01	4.73823E-21	8.98586E-21	5.14826E-21	8.71702E-21
1.63701E-20	0.46015E-21	3.38332E-18	1.14324E-17	2.18488E-17			
MODE 2 - FREQUENCY = 310.743 CPS							
-1.81456E-01	1.44608E-01	2.01345E-01	8.16151E-01	6.59884E-20	1.23881E-19	7.14712E-20	1.23882E-19
2.31116E-10	1.33345E-10	1.86217E-16	6.44290E-16	1.23058E-15			
MODE 3 - FREQUENCY = 420.813 CPS							
-1.08754E-14	1.45501E-14	1.92357E-14	8.21248E-15	2.37884E-18	4.46301E-18	2.57262E-18	4.50720E-18
8.45888E-18	4.87112E-18	7.32443E-01	2.51394E-01	4.83943E-01			
MODE 4 - FREQUENCY = 942.861 CPS							
-8.24038E-01	2.72315E-01	-7.75302E-01	-1.75242E-01	-2.98328E-18	-5.43314E-18	-3.09851E-18	-6.33744E-18
-1.19355E-17	-6.78828E-18	-1.02078E-16	-3.58421E-16	-6.87812E-16			

MODE 5 - FREQUENCY = 1669.050 CPS

-2.86818E-01	1.5732E 00	-1.57806E 00	1.08817E 00	-9.04601E-18	-1.67803E-17	-9.32934E-18	-4.55045E-17
-8.39541E-17	-4.60815E-17	-7.56887E-18	-2.08313E-17	-6.24151E-17			

MODE 6 - FREQUENCY = 2063.090 CPS

5.69538E-15	-5.80174E-15	-1.07779E-16	1.24197E-14	7.26231E-15	1.34000E-14	7.34797E-15	1.69449E 00
3.11463E 00	1.60440E 00	4.43816E-16	2.79498E-15	7.19183E-15			

MODE 7 - FREQUENCY = 2527.050 CPS

2.86726E-15	-3.34334E-15	1.50159E-15	3.44105E-15	2.07513E 00	3.81553E 00	2.07513E 00	7.46494E-15
1.38958E-14	7.73806E-15	-4.87961E-16	4.17377E-16	3.84098E-15			

CHECK FOR ORTHOGONALITY

UPPER TRIANGLE OF THE GENERALIZED MASS MATRIX IS NOW

ROW 1 1.00000E 00 1.89236E-07 -5.15354E-16 5.72974E-08 1.79013E-07 8.87237E-16 4.88442E-16

ROW 2 1.00000E 00 9.91016E-15 2.00079E-07 1.19888E-07 -2.80159E-18 6.20782E-17

ROW 3 1.00000E 00 -3.83866E-16 -1.23738E-17 1.45086E-15 7.52420E-16

ROW 4 1.00000E 00 1.16364E-07 -4.13957E-15 -1.67619E-15

ROW 5 1.00000E 00 2.49602E-15 1.40874E-16

ROW 6 1.00000E 00 7.92564E-15

ROW 7 1.00000E 00

UPPER TRIANGLE OF TRANSFORMED MASS MATRIX FOR COMPONENT 1

ROW 1 1.00000E 00 0. 0. 0. 0. 0. 0. 4.49028E-01
1.51297E-21 1.04042E-18 0. 0. 0. 1.53037E 01 -3.03492E-21 -1.44175E-17

ROW 2 1.00000E 00 0. 0. 0. 0. 0. 0. 3.55549E-01 2.12700E-20
5.85765E-17 0. 0. 0. 4.18240E 00 -4.82377E-20 -8.12568E-16

ROW 3 1.00000E 00 0. 0. 0. 0. 0. 0. 3.24943E-15 7.75236E-19 2.30301E-01
0. 0. 0. 3.27670E-14 -1.59640E-18 -3.19505E 00

ROW 4	1.00000E 00	0.	0.	-1.39723E 00	0.	2.39754E-18	-2.04566E-01	-1.04661E-18	-3.35089E-17	0.
	0.	0.	0.	0.	0.	0.	4.50398E-16	0.	0.	0.
ROW 5	1.00000E 00	0.	0.	7.07828E-01	0.	2.13680E-17	1.36416E-01	-6.43265E-18	-8.60523E-18	0.
	0.	0.	0.	0.	0.	0.	1.79815E-17	0.	0.	0.
ROW 6	1.00000E 00	0.	0.	2.10018E-15	0.	2.10561E-01	2.10561E-01	0.	0.	0.
	1.85067E-14	-9.15654E-01	0.	0.15654E-01	0.	0.	0.	0.	0.	0.
ROW 7	1.00000E 00	1.71740E-01	0.	1.71740E-01	0.	1.09648E-15	0.	0.	0.	-7.47175E-01
	7.47175E-01	1.85097E-15	0.	0.	0.	0.	0.	0.	0.	0.
ROW 8	5.59177E-01	2.21504E-02	0.	0.	0.	0.	0.	0.	8.57883E 00	1.06973E-01
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 9	2.99300E-01	3.32615E-02	0.	0.	0.	0.	0.	-1.06973E-01	-8.16888E-02	1.60616E-01
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 10	3.21572E-01	0.	0.	0.	0.	0.	0.	-1.60616E-01	-5.32884E-01	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 14	2.54708E 02	-4.97074E-01	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 15	1.62204E 00	-7.46168E-01	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 16	1.13341E 01	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

INPUT DATA FOR COMPONENT 2

12 DEGREES OF FREEDOM
7 MODES
2 COMMON JOINTS

MODE SHAPES

MODE 1 - FREQUENCY = 126.157 CPS

3.60023E-02 2.46501E-02 3.45409E-02 2.73308E-01 2.82589E-01 2.62472E-01 6.19440E-01 6.89906E-01
5.96171E-01 1.00000E 00 9.81427E-01 0.54697E-01

MODE 2 - FREQUENCY = 207.478 CPS

-3.78860E-02 -7.32831E-04 3.79890E-02 -2.78605E-01 7.86185E-04 2.81802E-01 -6.20722E-01 5.43402E-03
6.32633E-01 -9.71042E-01 1.39889E-02 1.90000E 00

MODE 3 - FREQUENCY = 823.410 CPS

2.41634E-01 5.22065E-01 1.99279E-01 9.99413E-01 1.00000E 00 8.17415E-01 6.29004E-01 5.67109E-01
5.17529E-01 -8.58269E-01 -7.69806E-01 -6.80410E-01

MODE 4 - FREQUENCY = 954.161 CPS

-1.96793E-01 3.06234E-02 2.24483E-01 -8.83013E-01 6.63081E-02 1.00000E 00 -5.75936E-01 4.26279E-02
6.52360E-01 7.63081E-01 -4.95307E-02 -8.66648E-01

MODE 5 - FREQUENCY = 1553.690 CPS

6.37696E-02 1.00000E 00 5.44835E-02 -6.77355E-02 7.41860E-02 -7.41835E-02 -2.10200E-01 -2.33321E-01
-1.94895E-01 1.52203E-01 1.41241E-01 1.43256E-01

MODE 6 - FREQUENCY = 2511.320 CPS

4.32600E-01 -7.75638E-02 1.32571E-01 1.00000E 00 -8.52817E-01 5.13808E-01 -2.75323E-01 -9.36194E-01
3.83021E-01 2.74410E-01 8.95007E-02 -1.46114E-02

MODE 7 - FREQUENCY = 2562.280 CPS

-3.16680E-01 7.69478E-02 4.12877E-01 -4.17428E-01 -4.70103E-01 7.80171E-01 1.00000E 00 -2.95102E-01
-6.03074E-01 -3.43330E-01 -3.40376E-02 3.49338E-01

UPPER TRIANGLE OF REDUCED STIFFNESS MATRIX FOR COMPONENT (COMMON JOINTS RESTRAINED) K-FF

ROW 1

7.19297E 05 -4.00747E 04 1.01324E 04 -2.01988E 05 8.89914E 02 -4.03173E 02 6.49635E 04 1.77801E 02
8.77746E 01 -1.00703E 04 4.03252E 01 -3.12795E 01

ROW 2

0.66117E 04 -1.81510E 04 1.03528E 03 -4.11915E 04 1.63782E 03 1.71266E 02 2.51283E 04 -7.52511E 01
-2.25030E 01 -4.20566E 03 2.42634E 01

ROW 3	-5.39748E 01	-4.04133E 02	-2.14028E 05	-5.34760E 01	6.99542E 02	6.80133E 04	1.88368E 01
	-1.23204E 02	-1.14305E 04					
ROW 4	-5.10494E 04	2.42436E 04	-1.01075E 05	2.29922E 03	-3.42962E 02	2.67977E 04	-4.37147E 02
	1.84366E 05						
	7.45661E 01						
ROW 5	-5.06656E 04	1.60505E 03	-0.14928E 04	2.01162E 03	2.54565E 01	2.52710E 04	-1.97542E 02
	2.02939E 05						
ROW 6	-7.77366E 01	1.59706E 03	-1.07054E 05	-6.54436E 01	1.04716E 01	2.82717E 04	
	1.93765E 05						
ROW 7	-6.91280E 04	3.26452E 04	-3.05600E 04	3.41291E 03	-4.67244E 02		
	1.36388E 05						
ROW 8	-6.89752E 04	2.74167E 03	-4.31669E 04	2.96646E 03			
	2.37957E 05						
ROW 9	-1.07932E 02	2.55424E 03	-4.13208E 04				
	1.42219E 05						
ROW 10	-0.32779E 04	4.52939E 04					
	6.42241E 04						
ROW 11	-9.28015E 04						
	2.02609E 05						
ROW 12	6.45728E 04						

STIFFNESS MATRIX - RELATES COMMON JOINTS TO FREE JOINTS (COMMON JOINTS FREE) K-FJ

ROW 1	-5.51237E 05	7.56539E 01	-1.71924E 06	2.11420E 02	3.47788E 05	2.12022E 03
	3.99647E 02	-0.08418E 02	3.23300E 03	-2.01208E 03	1.20874E 04	-1.23900E 04
ROW 2	-2.50004E 02	-5.84937E 05	-8.64233E 02	-1.82366E 06	-1.96170E 03	8.27486E 04
	1.15871E 05	-4.02586E 01	1.92036E 05	-6.71036E 01	-4.14194E 04	2.75737E 01
ROW 3	7.94014E 02	1.51468E 03	1.33007E 03	2.51848E 03	-2.03000E 02	-2.50720E 02
	1.12616E 02	1.22655E 05	1.84200E 02	2.04425E 05	-5.61756E 01	-8.20262E 03
ROW 4	-2.88251E 04	1.01441E 01	-4.80049E 04	1.68088E 01	1.02051E 04	-3.12535E 00

ROW 8

ROW 9	-3.00275E 02	-5.01851E 02	-4.07143E 02	-8.36118E 02	1.20883E 02	4.09649E 01
ROW 10	-3.44807E 01	-3.05400E 04	-5.77662E 01	-5.08987E 04	1.06477E 01	2.06634E 03
ROW 11	4.82680E 03	-6.37270E 00	8.03041E 03	-1.06053E 01	-1.71920E 03	8.21345E 01
ROW 12	1.56446E 01	2.74708E 01	2.56128E 01	1.45727E 02	-7.67339E 00	-7.26627E 00
ROW 13	1.26943E 01	5.00067E 03	2.15280E 01	8.40425E 03	-4.33302E 00	-3.44263E 02

UPPER TRIANGLE OF STIFFNESS MATRIX - COMMON JOINTS K-JJ

ROW 1	4.50651E 05	-2.74576E 01	1.56293E 06	-4.70249E 01	-3.24906E 05	-2.97270E 01
ROW 2	4.87528E 05	-4.66473E 01	1.66173E 06	5.39717E 00	-6.57840E 04	
ROW 3	6.59853E 06	-8.17691E 01	-1.36372E 06	-9.74784E 01		
ROW 4	7.01554E 06	2.95689E 01	-2.76276E 05			
ROW 5	3.63602E 05	-2.17850E 02				
ROW 6	9.10844E 04					

UPPER TRIANGLE OF TRANSFORMED STIFFNESS MATRIX FOR COMPONENT 2

ROW 1	6.28322E 05	0.	0.	0.	0.	0.
ROW 2	1.69943E 06	0.	0.	0.	0.	0.
ROW 3	2.67665E 07	0.	0.	0.	0.	0.
ROW 4	3.59345E 07	0.	0.	0.	0.	0.
ROW 5	9.52990E 07	0.	0.	0.	0.	0.

ROW 6	2.40980E 08	0.	0.	0.	0.	0.	0.	0.	0.
ROW 7	2.59187E 08	0.	0.	0.	0.	0.	0.	0.	0.
ROW 8	4.44707E 02	-4.47645E 02	3.40453E 03	-3.50216E 03	-4.93587E 03	-4.01242E 03			
ROW 9	4.42832E 02	-3.50338E 03	3.48564E 03	4.03750E 03	4.01320E 03				
ROW 10	1.90796E 05	-1.00837E 05	-5.70520E 04	-1.20631E 04					
ROW 11	1.90880E 05	5.79827E 04	1.20623E 04						
ROW 12	9.55068E 04	3.24085E 03							
ROW 13	7.70080E 04								

UPPER TRIANGLE OF REDUCED WEIGHT MATRIX FOR COMPONENT (COMMON JOINTS RESTRAINED) M-FF

ROW 1	3.33000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 2	3.33000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 3	3.33000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 4	2.88000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 5	2.88000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 6	2.88000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 7	2.55000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 8	2.55000E-01	0.	0.	0.	0.	0.	0.	0.	0.
ROW 9									

2.55000E-01 0. 0. 0.

ROW 10 2.20000E-01 0. 0. 0.

ROW 11 2.20000E-01 0. 0. 0.

ROW 12 2.20000E-01 0. 0. 0.

MASS MATRIX - RELATES COMMON JOINTS TO FREE JOINTS (COMMON JOINTS FREE) M-FJ

ROW 1 0. 0. 0. 0. 0. 0.

ROW 2 0. 0. 0. 0. 0. 0.

ROW 3 0. 0. 0. 0. 0. 0.

ROW 4 0. 0. 0. 0. 0. 0.

ROW 5 0. 0. 0. 0. 0. 0.

ROW 6 0. 0. 0. 0. 0. 0.

ROW 7 0. 0. 0. 0. 0. 0.

ROW 8 0. 0. 0. 0. 0. 0.

ROW 9 0. 0. 0. 0. 0. 0.

ROW 10 0. 0. 0. 0. 0. 0.

ROW 11 0. 0. 0. 0. 0. 0.

ROW 12 0. 0. 0. 0. 0. 0.

UPPER TRIANGLE OF MASS MATRIX - COMMON JOINTS M-JJ

ROW 1 1.29500E-03 0. 0. 0. 0. 0.

ROW 2	1.29504E-03	0.	0.	0.
ROW 3	0.	0.	0.	0.
ROW 4	0.	0.	0.	0.
ROW 5	0.	0.	0.	0.
ROW 6	0.	0.	0.	0.

NORMALIZED MODE SHAPES FOR ORTHOGONALITY

MODE 1 - FREQUENCY = 126.157 CPS				
7.12582E-01	4.88070E-01	6.83657E-01	5.41108E 00	5.59319E 00
1.17908E 01	1.07927E 01	1.04330E 01	1.00939E 01	1.22604E 01
MODE 2 - FREQUENCY = 207.478 CPS				
-9.06784E-01	-1.75396E-02	9.00228E-01	-6.66956E 00	1.88165E-02
1.51414E 01	-2.32409E 01	3.34807E-01	2.39340E 01	-1.48563E 01
MODE 3 - FREQUENCY = 823.410 CPS				
3.83378E 00	8.28312E 00	3.10177E 00	1.50568E 01	1.58861E 01
8.21115E 00	-1.34904E 01	-1.22011E 01	-1.07956E 01	9.97982E 00
MODE 4 - FREQUENCY = 954.061 CPS				
-3.80779E 00	5.92539E-01	4.34357E 00	-1.70856E 01	1.28301E 00
1.26227E 01	1.47636E 01	-9.58371E-01	-1.67690E 01	1.93492E 01
MODE 5 - FREQUENCY = 1563.600 CPS				
2.00982E 00	3.15174E 01	1.71712E 00	-2.13485E 00	2.33815E 00
-6.14227E 00	4.79988E 00	4.45155E 00	4.51506E 00	-2.33759E 00
MODE 6 - FREQUENCY = 2511.320 CPS				
4.75667E 00	-1.57004E 00	2.68357E 00	2.92420E 01	-1.72697E 01
7.75309E 00	5.55459E 00	1.81149E 00	-2.05763E-01	1.04005E 01
MODE 7 - FREQUENCY = 2502.280 CPS				
-6.93920E 00	1.66301E 00	9.02957E 00	-9.14682E 00	-1.03011E 01
-1.32148E 01	-7.52316E 00	-8.53214E-01	7.65481E 00	1.70954E 01
MODE 8 - FREQUENCY = 2502.280 CPS				
-6.93920E 00	1.66301E 00	9.02957E 00	-9.14682E 00	-1.03011E 01
-1.32148E 01	-7.52316E 00	-8.53214E-01	7.65481E 00	1.70954E 01

CHECK FOR ORTHOGONALITY

UPPER TRIANGLE OF THE GENERALIZED MASS MATRIX IS NON

ROW 1	1.00000E+00	2.97555E-07	5.36412E-08	1.35301E-07	-1.80098E-07	9.62603E-08	3.29607E-07
ROW 2	1.00000E+00	8.14212E-08	2.21995E-07	-2.97788E-07	4.75223E-07	-1.10137E-07	
ROW 3	1.00000E+00	3.43849E-07	3.33876E-07	3.48765E-08	7.30441E-08		
ROW 4	1.00000E+00	6.73325E-08	6.32044E-08	-7.24075E-09			
ROW 5	1.00000E+00	-2.70145E-07	-1.09436E-07				
ROW 6	1.00000E+00	3.51801E-08					
ROW 7	1.00000E+00						

UPPER TRIANGLE OF TRANSFORMED MASS MATRIX FOR COMPONENT 2

ROW 1	1.00000E+00	0.	0.	0.	0.	0.	3.52117E-02
	3.55963E-02	9.65917E-01	9.83159E-01	-1.91009E-03	-4.18817E-02		
ROW 2	1.00000E+00	0.	0.	0.	0.	-2.55277E-02	2.64476E-02
	-4.69888E-01	4.98221E-01	9.80024E-02	-2.41790E-02			
ROW 3	1.00000E+00	0.	0.	0.	0.	2.29964E-02	2.06855E-02
	1.34800E-01	-3.33809E-02	-2.92657E-03				1.52324E-01
ROW 4	1.00000E+00	0.	0.	0.	-1.42799E-02	-1.08688E-01	1.32165E-01
	2.11141E-02	-6.02240E-03					
ROW 5	1.00000E+00	0.	0.	1.18032E-02	1.15579E-02	3.57115E-02	3.47199E-02
	2.52073E-03						-1.14106E-02
ROW 6	1.00000E+00	0.	9.24745E-03	2.19908E-03	4.36038E-02	1.28064E-02	-8.50144E-03
							-7.83479E-04
ROW 7	1.00000E+00	-8.07169E-03	1.06337E-02	-3.48948E-02	4.72971E-02	6.92110E-03	-2.09644E-03
ROW 8	4.62535E-03	8.84911E-04	5.44367E-02	2.33402E-02	-1.06327E-02	-8.95818E-04	
ROW 9	4.71324E-03	2.32034E-02	5.56057E-01	-4.88866E-03	-2.36153E-03		

ORW 10

1.19711E 00 7.22341F-01 -2.86256F-01 -2.87870F-02

ORW 11

1.25895E 00 -1.44613E-01 -5.46648F-02

ORW 12

4.61616E-02 5.74829F-03

RQW 13

2.48617E-03

INPUT DATA FOR COMPONENT 3

12 DEGREES OF FREEDOM
7 MODES
1 COMMON JOINTS

MODE SHAPES

MODE 1 - FREQUENCY = 82.477 CPS

4.37633E-02	4.27628E-02	3.48499E-02	3.07082E-01	3.06922E-01	3.18474E-01	6.38228E-01	6.39841E-01
6.41116E-01	1.00000E 00	9.94571E-01	9.83305E-01				

MODE 2 - FREQUENCY = 112.979 CPS

-2.75355E-01	7.66566E-05	5.52478E-01	-3.55707E-01	8.32325E-04	7.11989E-01	-4.27924E-01	3.91599E-03
8.62180E-01	-4.89719E-01	7.52720E-03	1.00000E 00				

MODE 3 - FREQUENCY = 361.113 CPS

-4.97534E-01	-1.25534E-03	1.00000E 00	-2.30311E-01	-5.52473E-03	4.42450E-01	6.96038E-02	-4.10120E-03
-1.50834E-01	3.74848E-01	6.25066E-04	-7.49210E-01				

MODE 4 - FREQUENCY = 681.826 CPS

1.65815E-01	2.44339E-01	5.36194E-01	1.00000E 00	9.09780E-03	7.20624E-01	6.76938E-01	5.84728E-01
3.76553E-01	-7.57196E-01	-6.68056E-01	-4.70477E-01				

MODE 5 - FREQUENCY = 1279.880 CPS

5.71372E-01	7.35543E-02	-8.29162E-01	-3.25084E-01	1.27944E-01	1.00000E 00	-4.34102E-01	2.78281E-02
9.36749E-01	3.90245E-01	-6.75696E-02	-9.61883E-01				

MODE 6 - FREQUENCY = 1801.950 CPS

7.36647E-01	5.50714E-01	1.00000E 00	5.10095E-01	4.29582E-01	6.88228E-02	-6.96970E-01	-6.89002E-01
-5.10580E-01	2.55403E-01	2.95712E-01	2.81553E-01				

MODE 7 - FREQUENCY = 2781.080 CPS

1.00000E 00	4.63241E-01	7.05656E-01	-9.08685E-01	-4.58104E-01	1.38029E-01	6.43519E-01	3.29389E-01
-3.65825E-01	-2.05103E-01	-8.81096E-02	1.60157E-01				

UPPER TRIANGLE OF PENDED STIFFNESS MATRIX FOR COMPONENT (COMMON JOINTS RESTRAINED) K-FF

ROW 1	7.88907E 04	-1.00507E 05	3.58562E 04	-1.10263E 04	2.16435E 03	-1.82966E 02	6.45244E 03	2.64544E 01
	-2.66948E 00	-1.07517E 03	-4.62009E 00	4.15884E-01				

ROW 2	3.51425E 05	-5.41123E 04	1.16190E 03	-5.50576E 04	2.28026E 02	4.02588E 02	1.69988E 04	2.05353E 02
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-6.93702E 01	-2.83023F 03	-3.48611F 01			
ROW 3					
2.30135E 04	-1.83587E 02	7.40F25F 02	-1.03213F 04	-2.67917E 00	1.75188E 01
-2.04333F 00	-1.07021F 03				
					6.42017E 03
					4.14279E-01

R0W 4
J.01554E 05 -1.11744F 05 3.62407E 04 -2.45424F 04 2.24874E 03 -1.70984E 02 6.44955E 03 -3.99523E 01
-4.15644E 00

[illegible]

	RW	6	-2-30136E 04	-4-15490E 00	-2-03304E 01	6-41942E 03
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ROW	7	62337E 04	-1.19163E 04	2.51095E 03	-1.77851E 02
1	1.2104E 05				

ROW	A
E E700E 04	-1.31895F 04
E E700E 03	9.16389E 02

[illegible]

ROW	IN	OUT	DATE	TIME	STATUS
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
13	13	13	13	13	13
14	14	14	14	14	14
15	15	15	15	15	15
16	16	16	16	16	16
17	17	17	17	17	17
18	18	18	18	18	18
19	19	19	19	19	19
20	20	20	20	20	20
21	21	21	21	21	21
22	22	22	22	22	22
23	23	23	23	23	23
24	24	24	24	24	24
25	25	25	25	25	25
26	26	26	26	26	26
27	27	27	27	27	27
28	28	28	28	28	28
29	29	29	29	29	29
30	30	30	30	30	30
31	31	31	31	31	31
32	32	32	32	32	32
33	33	33	33	33	33
34	34	34	34	34	34
35	35	35	35	35	35
36	36	36	36	36	36
37	37	37	37	37	37
38	38	38	38	38	38
39	39	39	39	39	39
40	40	40	40	40	40
41	41	41	41	41	41
42	42	42	42	42	42
43	43	43	43	43	43
44	44	44	44	44	44
45	45	45	45	45	45
46	46	46	46	46	46
47	47	47	47	47	47
48	48	48	48	48	48
49	49	49	49	49	49
50	50	50	50	50	50
51	51	51	51	51	51
52	52	52	52	52	52
53	53	53	53	53	53
54	54	54	54	54	54
55	55	55	55	55	55
56	56	56	56	56	56
57	57	57	57	57	57
58	58	58	58	58	58
59	59	59	59	59	59
60	60	60	60	60	60
61	61	61	61	61	61
62	62	62	62	62	62
63	63	63	63	63	63
64	64	64	64	64	64
65	65	65	65	65	65
66	66	66	66	66	66
67	67	67	67	67	67
68	68	68	68	68	68
69	69	69	69	69	69
70	70	70	70	70	70
71	71	71	71	71	71
72	72	72	72	72	72
73	73	73	73	73	73
74	74	74	74	74	74
75	75				

ROW 11

RW 12

RELATES COMMON JOINTS TO FREE JOINTS (COMMON JOINTS FREE) K-FJ

RGW J 000000Z 01 05201E 01 -A 05270E 03

ROW 2 . 50485E 05 3-03126E 03

[illegible]

ROW 4 1 10778E 03 -4 31283E 00

PCW 5 03401 04 6 15361E 20

ROW	6
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
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93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

004 7 175595-03

ROW 8
-7.49147E 03 -1.24861E 04 4.62050E-02

ROW 9
-1.67942E 02 -2.79903E 02 -4.20302E-02

ROW 10
5.63343E 01 2.38930E 01 -5.77948E-05

ROW 11
1.24657E 03 2.07761E 03 4.70394E-04

ROW 12
2.85825E 01 4.76375E 01 -4.12604E-04

UPPER TRIANGLE OF STIFFNESS MATRIX - COMMON JOINTS K-JJ

ROW 1
1.23757E 05 4.19041E 05 0.

ROW 2
1.76244E 06 0.

ROW 3
2.03460E 04

UPPER TRIANGLE OF TRANSFORMED STIFFNESS MATRIX FOR COMPONENT 3

ROW 1
2.68549E 05 0. 0. 0. 0. 0.

ROW 2
5.03913E 05 0. 0. 0. 0. 0.

ROW 3
5.14809E 06 0. 0. 0. 0. 0.

ROW 4
1.83530E 07 0. 0. 0. 0. 0.

ROW 5
6.46603E 07 0. 0. 0. 0. 0.

ROW 6
1.41312E 08 0. 0. 0. 0.

ROW 7
3.05540E 08 0. 0. 0.

ROW 8
1.52051E 07 7.73437E 07 5.87563E-04

ROW 9 2.00210E-01 9.56703E-01

ROW 10 5.29297E-01

UPPER TRIANGLE OF REDUCED STIFFNESS MATRIX FOR COMPONENT (COMMON JOINTS RESTRAINED) M-FF

ROW 1 8.40000E-02 0. 0. 0. 0. 0. 0.

ROW 2 1.25000E-01 0. 0. 0. 0. 0. 0.

ROW 3 4.10000E-02 0. 0. 0. 0. 0. 0.

ROW 4 8.40000E-02 0. 0. 0. 0. 0. 0.

ROW 5 1.25000E-01 0. 0. 0. 0. 0. 0.

ROW 6 4.10000E-02 0. 0. 0. 0. 0. 0.

ROW 7 8.40000E-02 0. 0. 0. 0. 0. 0.

ROW 8 1.25000E-01 0. 0. 0. 0. 0. 0.

ROW 9 4.10000E-02 0. 0. 0. 0. 0. 0.

ROW 10 8.40000E-02 0. 0. 0. 0. 0. 0.

ROW 11 1.25000E-01 0. 0. 0. 0. 0. 0.

ROW 12 4.10000E-02 0. 0. 0. 0. 0. 0.

ROW 1 0. 0. 0. 0. 0. 0.

ROW 2 0. 0. 0. 0. 0. 0.

0.	0.	0.
ROW 3	0.	0.
ROW 4	0.	0.
ROW 5	0.	0.
ROW 6	0.	0.
ROW 7	0.	0.
ROW 8	0.	0.
ROW 9	0.	0.
ROW 10	0.	0.
ROW 11	0.	0.
ROW 12	0.	0.

UPPER TRIANGLE OF MASS MATRIX - COMMON JOINTS P-JJ

ROW 1	1.29584E-03	0.	0.
ROW 2	0.	0.	0.
ROW 3	0.	0.	0.

NORMALIZED MODE SHAPES FOR OPTIMUM/LITY

MODE 1 - FREQUENCY = 2.477 CPS							
1.40643E 00	1.37428E 00	1.10700E 00	9.86878E 00	9.46364E 00	1.02349F 01	2.05109E 01	2.05628E 01
2.06837E 01	3.21373F 01	3.10628E 01	3.15008E 01				
MODE 2 - FREQUENCY = 112.979 CPS							
-1.36406E 01	3.79745E-03	2.73888E 01	-1.76212E 01	4.12320E-02	3.52708F 01	-2.11987E 01	1.49407E-01
4.27110E 01	-2.42500F 01	3.72805E-01	4.95384F 01				

MODE 3 - FREQUENCY = 361.113 CPS

-2.04176E 01 -7.42742E-02 5.91267E 01 -1.36175E 01 -3.26659E-01 2.61606E 01 4.11545E 00 -2.42491E-01
-8.91832E 00 2.21635E 01 3.59581E-02 -4.42983E 01

MODE 4 - FREQUENCY = 681.826 CPS

4.96610E 00 7.33698E 00 1.60562E 01 2.09460E 01 2.72445E 01 2.15798E 01 2.02716E 01 1.75103E 01
1.12743E 01 -2.26750E 01 -2.00326E 01 -1.40880E 01

MODE 5 - FREQUENCY = 1279.880 CPS

2.44882E 01 3.14214E 00 -3.54206E 01 -1.38871E 01 5.46559E 00 4.27186E 01 -1.85442E 01 1.18878E 00
4.00166E 01 1.66707E 01 -2.88648E 00 -4.11757E 01

MODE 6 - FREQUENCY = 1801.050 CPS

2.63506E 01 2.00291E 01 3.57832E 01 1.84675E 01 1.53718E 01 2.46270E 00 -2.49398E 01 -2.46547E 01
-1.85925E 01 9.13914E 00 1.02237E 01 1.00749E 01

MODE 7 - FREQUENCY = 2781.080 CPS

3.76352E 01 1.74342E 01 2.65575E 01 -3.04350E 01 -1.72408E 01 5.19475E 00 2.42189E 01 1.23966E 01
-1.37679E 01 -7.72247E 00 -3.31041E 00 6.02754E 00

CHECK FOR ORTHOGONALITY

UPPER TRIANGLE OF THE GENERALIZED MASS MATRIX IS NOW

ROW 1 1.00000E 00 -6.53587E-08 2.92860E-07 4.42412E-07 -1.75067E-08 -5.74257E-08 -1.59785E-07

ROW 2 1.00000E 00 2.31455E-08 5.50551E-08 -3.10518E-07 -2.47876E-07 -7.91508E-08

ROW 3 1.00000E 00 3.12898E-08 -1.25820E-08 2.38010E-07 -2.32745E-08

ROW 4 1.00000E 00 -3.65153E-08 -1.06387E-07 -2.37192E-08

ROW 5 1.00000E 00 -5.36930E-08 -1.89469E-08

ROW 6 1.00000E 00 -9.30489E-08

ROW 7 1.00000E 00

UPPER TRIANGLE OF TRANSFORMED MASS MATRIX FOR COMPONENT 3

ROW 1

[illegible]

COMPONENT 1

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523</
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[illegible][illegible][illegible][illegible][illegible][illegible][illegible]

[illegible]

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.168855E 02	-0.418128E 01	-0.100709E 02	0.431332E 01	0.203425E 01	-0.109589E 01	-0.401291E 01	0.216736E 01		
0.332615E 02	-0.409272E 01	-0.202018E 02	0.478158E 00	0.170408E 02	-0.272991E 01	-0.190001E 02	0.250934E 01		
0.186192E 01	-0.507616E 00	0.700056E 00	-0.1502949E 00	-0.123172E 01	0.199711E 00	0.540086E 00	-0.545471E 01		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.130454E 01	-0.152078E 01	0.140613E 02	-0.940007E 00	-0.175687E 02	0.122913E 01	-0.416257E 02	0.223986E 01		
0.868191E 02	0.136299E 00	-0.40536E 02	-0.252026E 01	0.136908E 01	-0.115448E 01	0.14072E 02	-0.472751E 00		
-0.155394E 02	0.714178E 00	0.315446E 01	-0.642883E 00	-0.435310E 01	0.675036E 00	0.117929E 01	-0.126366E 00		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.452191E 01	-0.128340E 01	-0.319832E 01	0.570416E 00	-0.142337E 01	0.285208E 00	-0.125925E 02	0.297766E 01		
0.123335E 02	-0.217565E 01	0.420268E 00	0.562223E 01	0.573327E 02	-0.465575E 01	-0.785286E 02	0.321727E 01		
0.130902E 02	-0.953061E 00	0.643023E 01	-0.409490E 00	-0.884009E 01	0.396327E 00	0.240225E 01	-0.175724E 00		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.100075E 01	-0.951616E 00	-0.402569E 01	0.153886E 01	0.210928E 01	-0.577768E 00	0.670689E 01	-0.101672E 01		
-0.182909E 01	0.370506E 00	-0.203523E 01	0.771456E 01	-0.518329E 01	0.966797E 00	0.362163E 02	-0.251808E 01		
-0.310444E 02	0.196552E 00	-0.272816E 00	0.160440E 00	0.440275E 01	-0.490136E 00	-0.421167E 01	0.860971E 01		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.106445E 02	-0.384639E 01	-0.154224E 02	0.505143E 01	0.466596E 01	-0.159339E 01	-0.149577E 01	0.322897E 00		
0.161363E 02	-0.252612E 01	-0.147337E 02	0.142310E 01	-0.510498E 02	0.311102E 01	0.113539E 03	-0.245698E 01		
-0.624165E 02	-0.123253E 01	-0.741605E 01	0.598761E 00	0.170024E 02	-0.723109E 00	-0.957855E 01	0.184664E 01		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.243334E 01	-0.146361E 00	-0.272576E 01	0.207330E 00	0.279849E 00	-0.628608E 01	-0.741922E 01	0.631087E 00		
0.868031E 01	-0.435127E 00	-0.115904E 01	0.147331E 00	0.194062E 02	-0.120409E 01	-0.234113E 02	0.730467E 00		
0.309231E 01	-0.316081E 00	0.291521E 01	-0.543143E 01	-0.245496E 01	-0.126525E 00	-0.460743E 00	0.118761E 01		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.804467E 00	-0.248829E 00	-0.533334E 00	0.191138E 00	-0.286645E 00	-0.773407E 03	0.110278E 01	-0.324231E 01		
-0.337689E 01	0.171909E 00	0.273442E 01	-0.653443E 01	-0.241754E 01	0.301808E 00	0.138168E 02	-0.925784E 00		
-0.114124E 02	0.144252E 00	-0.262234E 01	0.301001E 00	0.634654E 01	-0.353244E 00	-0.381615E 01	-0.104397E 01		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
0.	0.	0.	0.	0.	0.	0.	0.		
-0.230373E 01	0.503576E 00	0.144372E 00	0.144372E 00	0.939305E 00	-0.428580E 00	0.106946E 02	-0.230105E 01		

-0.129149E 02	0.156103E 01	0.204862E 01	0.204730E 00	-0.200053E 02	0.202712E 01	0.420825E 02	-0.170197E 01
-0.212110E 02	-0.242586E 00	-0.402382E 01	0.103975E 00	0.102301E 02	0.209361E 00	-0.529779E 01	-0.334110E 00
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.507538E 00	-0.200502E-01	-0.154879E 02	0.373353E 01	0.151917E 02	-0.276436E 01	-0.585934E 01	0.197317E 01
0.172382E 02	-0.407545E 01	-0.114579E 02	0.264336E 01	0.204515E 01	-0.158024E 01	-0.114520E 00	0.439236E 00
-0.285938E 01	0.075411E 00	0.647521E 00	0.326170E 00	-0.347101E 00	0.278273E 00	-0.337556E 00	0.705746E-01
0.129658E 02	0.206705E 00	0.500621E 01	0.936155E 00	-0.184336E 02	0.585500E-02	0.210288E 01	-0.446357E-01
-0.550266E 01	0.140558E 00	0.340260E 01	0.325272E-02	0.187303E 01	-0.262483E 00	0.265448E-01	0.134954E 00
-0.190668E 01	0.113200E-02	-0.204114E 00	0.201647E-01	-0.294059E-02	-0.149949E-01	0.211876E 00	-0.125787E-03
0.849194E 00	-0.294488E-01	-0.254194E 02	0.565289E 01	0.247873E 02	-0.407674E 01	-0.950980E 01	0.384883E 01
0.282041E 02	-0.762203E 01	-0.184732E 02	0.308700E 01	0.465957E 01	-0.251049E 01	-0.203752E 00	0.714433E 00
-0.468381E 01	0.136645E 01	0.109170E 01	-0.512769E 00	-0.571472E 00	0.320694E 00	-0.551176E 00	0.105471E 00
0.212051E 02	-0.300715E 01	0.934400E 01	0.168574E 01	-0.306682E 02	-0.513061E 00	0.341907E 01	-0.141409E-01
-0.910463E 01	0.823028E-01	0.568716E 01	0.102209E 00	0.306078E 01	-0.375545E 00	0.359697E-01	0.220513E 00
-0.310514E 01	-0.510688E-01	-0.344086E 00	0.417272E-01	-0.309092E-02	-0.245014E-01	0.345010E 00	0.567430E-02
0.102292E 01	-0.253184E-01	-0.204264E 02	0.573621E 01	0.287193E 02	-0.391965E 01	-0.111658E 02	0.321615E 01
0.328226E 02	-0.701404E 01	-0.217757E 02	0.401555E 01	0.552038E 01	-0.275870E 01	-0.267392E 00	0.823613E 00
-0.546080E 01	0.140824E 01	0.127799E 01	-0.558114E 00	-0.671632E 00	0.352853E 00	-0.639366E 00	0.104268E 00
0.246610E 02	-0.280670E 01	0.167367E 02	0.224650E 01	-0.354196E 02	-0.3156307E 01	0.393910E 01	0.924897E-01
-0.105108E 02	-0.106307E 00	0.654803E 01	0.298023E 00	0.355499E 01	-0.337388E 00	0.280685E-01	0.256081E 00
-0.358624E 01	-0.157245E 00	-0.394908E 00	0.374875E-01	-0.311903E-02	-0.284534E-01	0.398471E 00	0.174717E-01
0.867103E 01	0.346027E 01	0.175654E 02	-0.604380E 01	-0.927260E 01	0.254603E 01	0.843327E 01	-0.332424E 01
-0.263200E 02	0.746045E 01	0.174474E 02	-0.359159E 01	-0.619437E 01	0.221457E 01	0.114488E 02	-0.354132E 01
-0.522550E 01	0.138451E 01	-0.047105E 00	0.329207E 00	0.264413E 01	-0.770451E 00	-0.170406E 01	0.404324E 00
0.656700E 01	-0.663072E 00	-0.567007E 01	0.471155E 00	-0.911247E 00	-0.600048E-02	0.340511E 01	-0.990072E 00
0.117152E 02	0.249412E 00	-0.151565E 02	-0.205407E-02	0.701864E 01	-0.714750E 00	-0.504505E 01	0.503598E 00
-0.108913E 01	0.637264E-02	-0.257103E 00	0.297856E-01	0.137041E 00	-0.184821E-01	0.120880E 00	-0.205038E-03
-0.141962E 02	0.540000E 01	0.204005E 02	-0.933645E 01	-0.151775E 02	0.388877E 01	0.138299E 02	-0.518031E 01
-0.430568E 02	0.114164E 02	0.203100E 02	-0.534804E 01	-0.101351E 02	0.342953E 01	0.187350E 02	-0.544599E 01
-0.855475E 01	0.213020E 01	-0.150001E 01	0.509647E 00	0.432659E 01	-0.118117E 01	-0.278627E 01	0.611169E 00
0.107136E 02	-0.800000E 00	-0.024773E 01	0.008831E 00	-0.144801E 01	-0.155143E-01	0.560032E 01	-0.152830E 01
0.190410E 02	0.771382E 00	-0.246864E 02	-0.423008E 00	0.114508E 02	-0.969171E 00	-0.969671E 01	0.655083E 00
-0.177369E 01	-0.198441E-01	-0.410855E 00	0.413714E-01	0.223888E 00	-0.262942E-01	0.196843E 00	0.302031E-02
-0.165376E 02	0.577301E 01	0.342535E 02	-0.984481E 01	-0.174742E 02	0.401373E 01	0.161533E 02	-0.555051E 01
-0.500941E 02	0.118245E 02	0.346083E 02	-0.524722E 01	-0.117951E 02	0.363283E 01	0.218086E 02	-0.569426E 01
-0.096481E 01	0.216031E 01	-0.184701E 01	0.535528E 00	0.503586E 01	-0.122781E 01	-0.323913E 01	0.618157E 00
0.124102E 02	-0.660941E 00	-0.167077E 02	0.432174E 00	-0.371422E 01	-0.648759E-01	0.657105E 01	-0.159109E 01
0.219271E 02	0.144874E 01	-0.208037E 02	-0.127962E 01	0.132652E 02	-0.757715E 00	-0.112286E 02	0.450211E 00
-0.204870E 01	-0.700420E-01	-0.404945E 00	0.345342E-01	0.259038E 00	-0.233078E-01	0.227348E 00	0.971737E-02
-0.310044E-01	-0.315478E 00	0.650000E 00	-0.200708E 01	-0.671805E 01	0.108450E 01	-0.306047E 01	0.945063E 00
0.418214E 01	-0.002610E 00	-0.1072543E 01	0.160606E 00	-0.108928E 01	0.420370E 00	-0.145844E 02	-0.359244E 01
0.150000E 02	-0.34251E 01	-0.207341E 00	0.106762E 00	-0.232089E 01	0.619166E 00	0.262166E 01	-0.582964E 00
-0.259181E 00	0.273140E-01	0.150954E 00	-0.380040E-01	0.609425E-01	-0.228037E-03	0.729615E 01	-0.728886E 00
-0.440770E 01	0.523400E 00	-0.543090E 00	0.675624E-02	0.401045E 01	-0.110952E 01	0.121195E 02	0.298847E 00

NOT REPRODUCIBLE

-0.162486E 02	-0.177952E-02	0.813461E 00	-0.167225E 00	0.120834E 01	0.590273E-01	-0.202732E 01	0.698360E-04
-0.362576E-01	-0.510250E 00	0.107764E 02	-0.322905E 01	-0.104941E 02	0.304463E 01	-0.500612E 01	0.145291E 01
0.684214E 01	-0.146220E 01	-0.176467E 01	0.233133E 00	-0.177562E 01	0.074083E 00	-0.238458E 02	0.512109E 01
0.250416E 02	-0.467461E 01	-0.424604E 00	0.165902E 00	-0.379742E 01	0.044055E 00	0.428396E 01	0.876366E 00
-0.422915E 00	0.372883E-01	0.324437E 00	-0.247766E-01	0.992432E-01	0.131970E-02	0.119026E 02	-0.984474E 00
-0.105967E 02	0.671989E 00	-0.132565E 01	-0.116167E-01	0.671904E 01	-0.169411E 01	0.196968E 02	0.823126E 00
-0.264586E 02	-0.453736E 00	0.133209E 01	-0.240840E 00	0.196226E 01	0.129472E 00	-0.330124E 01	-0.561485E-01
-0.640695E-02	-0.609008E 00	0.125835E 02	-0.338156E 01	-0.127987E 02	0.316925E 01	-0.582353E 01	0.151827E 01
0.796165E 01	-0.147505E 01	-0.206306E 01	0.216308E 00	-0.205265E 01	0.106064E 01	-0.277202E 02	0.516591E 01
0.300972E 02	-0.457689E 01	-0.407620E 00	0.177085E 00	-0.441940E 01	0.071122E 00	0.497535E 01	-0.677171E 00
-0.490048E 00	0.207140E-01	0.375364E 00	-0.183683E-01	0.114629E 00	0.466462E-02	0.137868E 02	-0.761059E 00
-0.122689E 02	0.441248E 00	-0.153136E 01	-0.553622E-01	0.787358E 01	-0.174743E 01	-0.226772E 02	0.157556E 01
-0.305574E 02	-0.136138E 01	0.155534E 01	-0.244325E 00	0.221627E 01	0.212074E 00	-0.381266E 01	-0.169309E 00
0.804804E 00	-0.386486E 00	-0.192819E-01	0.554305E-02	-0.427999E 00	0.275767E 00	-0.132279E 01	0.335491E 00
0.399572E 01	-0.074704E 00	-0.260224E 01	0.565233E 00	-0.512686E 00	0.155832E 00	-0.379902E 01	0.104908E 01
0.437500E 01	-0.954266E 00	-0.150265E 00	-0.117018E-01	-0.683556E 00	0.294900E-00	0.845719E 00	-0.233892E 00
-0.178325E 00	0.109110E-01	0.314036E 00	-0.127384E-01	-0.135636E 00	-0.219359E-03	0.160492E 01	-0.981991E-01
-0.282632E 01	0.114645E 00	0.122073E 01	0.197423E-02	0.111113E 01	-0.345973E 00	0.429366E 01	0.815470E 01
-0.541752E 01	-0.836219E-03	-0.209096E 01	0.101350E 00	0.424007E 01	-0.149156E 00	-0.218941E 01	-0.278202E-02
0.132391E 01	-0.608319E 00	-0.345402E-01	0.981327E-02	-0.135556E 01	0.425013E 00	-0.216342E 01	0.509796E 00
0.653556E 01	-0.147604E 01	-0.440154E 01	0.846057E 00	-0.833953E 00	0.238018E 00	-0.621893E 01	0.160350E 01
0.714759E 01	-0.143207E 01	-0.243231E 00	-0.234349E-01	-0.112267E 01	0.461398E 00	0.138390E 01	-0.357395E 00
-0.200432E 00	0.128114E-01	0.511470E 00	-0.126268E-01	-0.220860E 00	-0.412084E-02	0.261388E 01	-0.115302E 00
-0.460321E 01	0.108242E 00	0.198774E 01	0.370875E-01	0.182891E 01	-0.532827E 00	0.697943E 01	0.251997E 00
-0.882171E 01	-0.151687E 00	-0.340363E 01	0.306803E 00	0.696965E 01	-0.124086E 00	-0.355509E 01	-0.652833E-01
0.155387E 01	-0.663515E 00	-0.459602E-01	0.127026E-01	-0.157905E 01	0.448922E 00	-0.251608E 01	0.520972E 00
0.760199E 01	-0.156103E 01	-0.511606E 01	0.639029E 00	-0.561495E 00	0.245650E 00	-0.724069E 01	0.165728E 01
0.820846E 01	-0.142767E 01	-0.273206E 00	-0.351076E-01	-0.131439E 01	0.497947E 00	0.161003E 01	-0.369164E 00
-0.335521E 00	0.559254E-02	0.590898E 00	0.229604E-02	-0.117484E-01	-0.301979E 01	0.301979E 01	-0.583320E-01
-0.531808E 01	-0.206698E-01	0.229597E 01	0.105739E 00	0.214859E 01	-0.558651E 00	0.003793E 01	0.512421E 00
-0.101883E 02	-0.454360E 00	-0.332865E 01	0.154759E-01	0.804956E 01	0.773091E-01	-0.411724E 01	-0.188221E 00

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ROW 9	1.69243E 06	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 10	2.67665E 07	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 11	3.59345E 07	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 12	9.52990E 07	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 13	2.48980E 08	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 14	2.52187E 08	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 15	2.68549E 05	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 16	5.03913E 05	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 17	5.14809E 06	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 18	1.83530E 07	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 19	6.46693E 07	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 20	1.41312E 08	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 21	3.05540E 08	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 22	1.31103E 05	-2.62648E 05	1.31306E 05						
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 23	5.25122E 05	-2.62654E 05							
	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROW 24	1.31091E 05								
	0.	0.	0.	0.	0.	0.	0.	0.	0.

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3.86088E 02	0.	3.35768E 00	0.	1.09594E 00	0.	-3.33915E-02	0.	0.	0.
ROW 14									
3.86088E 02	0.	3.05388E 00	0.	5.35206E-02	0.	0.	0.	0.	0.
-2.96973E-00									
ROW 15									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	-7.26649E-03
4.35809E-02									
ROW 16									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	7.98140E-01
3.96753E-00									-4.78754E-00
ROW 17									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	6.72725E-01
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	1.68309E-01
ROW 18									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	8.18710E-00
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	4.85764E-03
ROW 19									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	1.79474E 00
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	5.62544E-02
ROW 20									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	6.27712E 00
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	1.05437E-03
ROW 21									
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	4.12801E 00
3.86088E 02	0.	0.	0.	0.	0.	0.	0.	0.	6.87408E-03
ROW 22									
1.01809E 03	-7.08720E 02	1.21714E 02							
ROW 23									
7.10939E 02	-1.18692E 02								
ROW 24									
1.86565E-02									

EIGENVALUES AND EIGENVECTORS OF THE SYSTEM

EIGENVECTOR NUMBER 1

CORRESPONDING TO 6.3258670E-02

-3.7200169E-05	-1.8709638E-05	-2.3470081E-05	1.4724591E-06	-3.0600923E-07	-1.3784224E-06
-5.2504174E-07	-4.7527122E-05	-2.6302303E-06	-6.3205580E-07	-9.9830752E-08	-9.8329654E-08
-1.4745202E-08	-1.0910310E-08	-9.6802141E-05	-2.6179724E-06	-3.336147E-09	-7.2484729E-07
-4.8184085E-06	-7.3507301E-08	-1.9169041E-08	4.7204854E-01	7.3851303E-01	1.0000000E-00

EIGENVECTOR NUMBER 2

CORRESPONDING TO 1.5689355E-02

-9.2144612E-04	-2.1485534E-05	5.6684500E-06	1.1973125E-06	-2.3356066E-07	8.2029550E-08
-1.2797515E-07	-6.7024921E-06	1.8454090E-06	-1.7987434E-07	5.03108674E-08	-2.2353880E-08
-4.0493505E-09	4.4363803E-00	1.4750180E-05	2.1408526E-06	3.8433833E-08	1.1788144E-07
3.3589408E-00	1.2202844E-08	4.6424112E-10	1.0000000E-00	1.0740885E-03	-6.0608661E-01

EIGENVECTOR NUMBER 3

CORRESPONDING TO 2.6765938E-05

2.2182124E-01	-5.1423549E-03	2.6433347E-03	3.1935046E-04	-6.6826148E-05	-4.54444503E-05
-7.7465255E-05	-1.0135206E-02	1.6570637E-04	-8.5936646E-05	-9.3562335E-07	-1.2634755E-05
-2.5089466E-06	-2.0230314E-07	1.0000000E-00	2.0674900E-03	2.0401699E-05	2.5507809E-05
1.4835243E-06	2.5000664E-06	7.5751750E-07	-2.0809082E-01	-1.7874054E-01	8.1066148E-02

EIGENVECTOR NUMBER 4

CORRESPONDING TO 3.0084021E-05

1.0000000E-00	-2.6111626E-02	1.7164690E-02	1.5394537E-03	-3.1736843E-04	-1.4398041E-03
-3.0200041E-04	-4.4042016E-02	1.550927E-03	-3.5154289E-04	1.6086132E-05	-5.2471706E-05
-1.872807E-05	9.5521260E-07	-2.6458071E-01	1.8364347E-02	1.4404671E-04	2.4449739E-04
1.4712188E-05	2.3043836E-05	7.2708834E-06	-8.4106243E-01	-5.6779247E-01	6.9037414E-01

EIGENVECTOR NUMBER 5

CORRESPONDING TO 5.0404044E-05

-4.246503E-02	2.1240036E-03	-7.4831078E-04	-1.0514532E-04	2.0651792E-05	-9.0760390E-06
1.2335295E-05	3.9905379E-03	-2.0148686E-04	1.4286858E-05	-3.7978661E-06	2.1178601E-06
5.3440947E-07	-2.0204080E-07	1.9648195E-03	1.0000000E-00	-4.8001054E-06	-1.3354815E-05
-6.0683172E-07	-1.2978063E-06	-3.9388795E-07	2.7886958E-02	6.6955203E-03	-2.2295621E-02

EIGENVECTOR NUMBER 6

CORRESPONDING TO 6.3252272E-05

1.4288496E-01	-1.1652481E-02	6.9465195E-04	5.8021741E-04	-1.1549133E-04	-6.9855285E-05
-9.0545538E-05	1.0000000E-00	7.1663607E-04	-1.0824931E-04	9.2813400E-06	-1.6009387E-05
-3.4572550E-06	6.3568001E-07	8.9405924E-04	-2.8868053E-03	1.6283239E-05	-9.2013557E-06
-6.4584620E-07	-9.0241689E-07	-2.7106330E-07	-1.3183919E-01	-7.4626703E-02	-1.2339023E-02

EIGENVECTOR NUMBER 7

CORRESPONDING TO 1.4263243E-06

1.0000000E-00	-1.5707811E-01	-5.3109510E-02	4.1941144E-03	-6.0799205E-04	1.2406296E-03
7.0002405E-04	-5.045177E-02	7.1006300E-02	6.7440529E-04	4.5084480E-04	9.7527725E-05
4.8216252E-06	3.8282244E-05	8.0605882E-03	1.4520377E-02	-7.3319500E-04	-2.9075512E-04
-1.4771717E-05	-2.6572500E-05	-7.0078015E-06	-1.0353612E-01	6.0743568E-01	-1.6049711E-01

NATURAL FREQUENCIES OF THE SYSTEM

THE NATURAL FREQUENCY NUMBER 1 IS	0.	CPS
THE NATURAL FREQUENCY NUMBER 2 IS	0.	CPS

THE NATURAL FREQUENCY NUMBER 3 IS 82.340 CPS
 THE NATURAL FREQUENCY NUMBER 4 IS 87.205 CPS
 THE NATURAL FREQUENCY NUMBER 5 IS 112.003 CPS
 THE NATURAL FREQUENCY NUMBER 6 IS 126.578 CPS
 THE NATURAL FREQUENCY NUMBER 7 IS 190.877 CPS

SYSTEM MODE SHAPES FOR FREE JOINTS ON COMPONENT 1

MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6	MODE 7	MODE 8	MODE 9
-0.12022E 00	0.28024E 01	0.61284E 00	0.25178E 01	-0.76007E-01	0.24500E 00	0.11216E 01		
0.77483E-01	0.22021E 01	0.20053E 00	0.76494E 00	-0.11682E-01	0.74004E-02	-0.28594E 00		
0.20999E 00	0.18017E 01	-0.22105E-01	-0.16292E 00	0.19206E-01	-0.10311E 00	-0.74350E 00		
0.34114E 00	0.14011E 01	-0.15032E 00	-0.70006E 00	0.31805E-01	-0.14500E 00	-0.60220E 00		
0.33864E 00	0.17993E 00	-0.21441E 00	-0.83107E 00	0.23071E-01	-0.11802E 00	0.16231E 00		
0.60474E 00	0.59877E 00	-0.21530E 00	-0.79792E 00	0.16069E-01	-0.10405E 00	0.39320E 00		
0.67063E 00	0.30812E 00	-0.20513E 00	-0.71752E 00	0.12658E-01	-0.80531E-01	0.55245E 00		
0.80239E 00	-0.13278E 00	-0.13278E 00	-0.33411E 00	0.72599E-04	-0.50590E-01	0.53893E 00		
0.86825E 00	-0.20425E 00	-0.70506E-01	-0.31144E-01	-0.70964E-02	-0.44177E-01	0.36605E 00		
0.93413E 00	-0.40515E 00	0.25256E-02	0.31806E 00	-0.14606E-01	-0.28327E-01	0.12029E 00		
0.10659E 01	-0.80703E 00	0.16237E 00	0.10791E 01	-0.33580E-01	0.40599E-02	-0.48393E 00		
0.11317E 01	-0.10079E 01	0.24650E 00	0.14862E 01	-0.39664E-01	0.21202E-01	-0.80427E 00		
0.11974E 01	-0.12088E 01	0.33105E 00	0.17019E 01	-0.49123E-01	0.30694E-01	-0.12713E 01		

SYSTEM MODE SHAPES FOR FREE JOINTS ON COMPONENT 2

MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6	MODE 7	MODE 8	MODE 9
0.48678E 00	0.95787E 00	-0.21712E 00	-0.82320E 00	0.20974E-01	0.58252E 00	-0.14055E 00		
0.61294E 00	0.57362E 00	-0.20075E 00	-0.73129E 00	-0.18836E-01	0.38510E 00	-0.27129E 00		
0.73912E 00	0.18937E 00	-0.18454E 00	-0.52045E 00	0.90260E-02	0.60994E 00	0.64376E 00		
0.51305E 00	0.87435E 00	-0.26817E 00	-0.10845E 01	0.48056E-01	0.52013E 01	-0.69585E 00		
0.62918E 00	0.52342E 00	-0.25151E 00	-0.94271E 00	0.37036E-01	0.54936E 01	0.66746E-01		
0.74450E 00	0.17229E 00	-0.22833E 00	-0.77258E 00	0.25439E-01	0.51259E 01	-0.87233E 00		
0.54090E 00	0.70609E 00	-0.33861E 00	-0.13822E 01	0.74812E-01	0.12132E 02	-0.15363E 01		
0.64540E 00	0.47325E 00	-0.31574E 00	-0.12128E 01	0.62362E-01	0.11977E 02	-0.20614E 00		
0.74068E 00	0.15562E 00	-0.29222E 00	-0.19404E 01	0.49602E-01	0.11738E 02	-0.11316E 01		
0.56815E 00	0.70727E 00	-0.41418E 00	-0.17024E 01	0.10405E 00	0.10666E 02	-0.24323E 01		
0.66155E 00	0.42305E 00	-0.38815E 00	-0.15187E 01	0.20154E-01	0.19344E 02	-0.52381E 00		
0.75480E 00	0.13302E 00	-0.36233E 00	-0.13360E 01	0.76343E-01	0.10042E 02	0.13853E 01		

SYSTEM MODE SHAPES FOR FREE JOINTS ON COMPONENT 3

MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6	MODE 7	MODE 8	MODE 9
0.95589E 00	-0.47187E 00	0.13034E 01	-0.18524E 00	-0.13655E 02	0.13017E-01	-0.13855E 00		
0.90085E 00	-0.40066E 00	0.14556E 01	0.32028E 01	-0.15200E-01	-0.11213E-01	-0.15215E 00		
0.10876E 01	-0.87347E 00	0.13773E 01	-0.14144E 01	0.27357E 02	-0.60237E-01	-0.18123E 00		
0.95040E 00	-0.47174E 00	0.98460E 01	-0.24962E 01	-0.17619E 02	0.30958E-01	-0.14570E 00		
0.90001E 00	-0.60503E 00	0.90456E 01	-0.10117E 01	0.37947E-01	-0.31955E-02	-0.88425E-01		
0.10867E 01	-0.87351E 00	0.10528E 02	-0.85906E 00	0.35258E 02	-0.73069E-01	0.29332E-01		

0.95400E 00	-0.47157E 00	0.20477E 02	-0.53722E 01	-0.21176E 02	0.50133E-01	-0.12129E 00
0.90794E 00	-0.60575E 00	0.20645E 02	-0.47437E 01	0.16733E 00	0.55128E-02	0.30525E-02
0.10856E 01	-0.87332E 00	0.20917E 02	-0.34741E 01	0.42719E 02	-0.83496E-01	0.25048E 00
0.95294E 00	-0.47143E 00	0.32003E 02	-0.85113E 01	-0.24214E 02	0.6001F-01	-0.73979E-01
0.99702E 00	-0.60568E 00	0.32045E 02	-0.77642E 01	0.41368E 00	0.15450E-01	0.10813E 00
0.10847E 01	-0.87323E 00	0.31033E 02	-0.62699E 01	0.49568E 02	-0.91649E-01	0.47189E 00

GENERALIZED MASS MATRIX FOR THE TOTAL SYSTEM

6.38403E-01	-1.54503F-06	-1.41649E-09	3.17956E-09	1.07419F-08	-9.54038E-09	-5.99877E-09
-1.56183E-06	1.45001F-00	-8.34970F-07	1.06865E-08	-5.34498E-08	-5.34498E-08	-2.93679E-07
-9.31323F-09	-2.45025F-08	1.06343F-00	1.61252F-06	4.27862E-09	2.37922E-08	2.20675E-08
2.60770E-08	-8.39026E-07	1.49186E-06	1.10718F-00	-6.56597F-09	1.77566E-08	1.92939E-07
1.88848E-08	1.17178F-08	4.6432E-09	-7.18208E-09	1.00047E-08	1.06992E-08	-5.45822E-09
-7.77072E-09	-5.70089F-08	2.39628E-08	1.99978F-08	1.00085E-08	3.10984E-08	3.10984E-08
1.67638F-08	-2.54159F-07	1.72297F-08	1.49520F-07	-4.23197E-09	2.54165F-08	4.16718E-01

GENERALIZED AERODYNAMIC FORCES FOR 1/K = 1.0000F 01

-8.47111833F 02	-0.21968463E 02	0.14384303E 03	0.89207724F 01	-0.04685180E 02	-0.19839139E 03	-0.46236642E 03	0.51130739E 02
-8.13671253F 05	0.21562985F 03	0.64124125F 02	-0.11282143F 02	-0.11182205E 03	-0.23611818E 02		
-8.11039279F 02	0.26916291F 01	0.32244561E 02	-0.21655729F 02	0.48166780E 02	0.13898841E 03	0.25158353E 03	-0.11399768E 02
8.91751227F 04	-8.11502524F 03	0.65813721F 02	-0.12168104F 03	-0.24987570E 03	0.19053188E 02		
-8.17134386F 03	-0.15608943E 03	0.54969952E 03	0.25825900F 03	-0.12344269E 04	-0.36633762E 04	-0.52933951E 04	0.64779885E 03
-8.18678106F 06	0.21700455F 04	-0.23056684E 03	0.21579465F 04	0.29505081E 04	-0.677319611E 03		
8.73529346F 02	0.40605642E 02	-0.22821368E 03	-0.32045514F 02	0.25269205E 03	0.74117373E 03	0.18163469E 04	-0.16132885E 03
8.3479794F 05	-0.51331863E 03	-0.53472567F 02	-0.31632940F 03	-0.25492326E 03	0.17973287E 03		
-8.19837149F 03	-0.15276039F 03	0.60348285E 03	0.22326951F 03	-0.84949744E 03	-0.25264967E 04	-0.46784853E 04	0.29479513E 03
-8.15415803F 06	-0.30892515E 04	-0.47654415E 02	0.10904352F 04	0.15857917E 04	-0.29934659E 03		
-8.29459288F 03	-0.87568346F 02	0.88325631F 03	-0.92717748F 02	-0.58574428E 02	0.47866358E 02	-0.44131865E 03	0.16832638E 02
8.34638491F 03	-0.28894733F 01	0.72953255F 03	-0.14281087F 04	-0.31544211E 04	-0.66987806E 01		
8.14983499F 01	-0.65069821F 00	-0.43387116F 01	0.36982146E 01	-0.54134724E 00	-0.11367333E 02	0.11633192E 02	-0.35948813E 01
8.58883664F 02	-0.34588222F 02	-8.10878286E 02	0.67488508F 02	0.10552976E 03	-0.26879910E 02		

3.7 PROGRAM LISTINGS

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S      FORTRAN DECK
CCOMSYN      COMPONENT MODE SYNTHESIS PROGRAM

C
C      NCOMP = NO. OF COMPONENTS IN THE TOTAL SYSTEM (LIMITED TO 5).
C      MODE = NO. OF MODES DESIRED IN THE ANALYSIS OF THE TOTAL SYSTEM.
C      NCOM = NO. OF SETS OF COMMON JOINTS AMONG COMPONENTS IN SYSTEM.
C      NREDU = SIZE OF REDUCED MASS AND STIFFNESS MATRICES - NUMBER OF
C      DEGREES OF FREEDOM IN THE ANALYSIS OF EACH COMPONENT.
C      NMODE = NO. OF MODES IN EIGENVALUE SOLUTION OF EACH COMPONENT.
C      NCJT = NO. OF COMMON JOINTS ON EACH COMPONENT (LIMITED TO 12).
C      THE FOLLOWING INFORMATION IS NEEDED IF THERE IS AERODYNAMIC INPUT.
C      NCOUP = 0 IF NO AERODYNAMIC COUPLING EXISTS BETWEEN THE COMPONENTS
C      NCOUP = THE LOWER NUMBERED OF THE TWO COMPONENTS FOR WHICH THERE
C      IS AERODYNAMIC COUPLING (COUPLE COMPONENTS MUST BE IN SEQUENCE)
C      NAT = AERODYNAMIC THEORY USED IN THE COMPONENT ANALYSIS
C      NAT = 1, AIC-S ARE FORMED BY NON-ZERO PARTITIONS (STRIP OR PISTON)
C      NAT = 2, AIC-S ARE FULL MATRICES (KERNEL FUNCTION OR MACH BOX)
C      NV = NO. OF REDUCED VELOCITIES CONSIDERED FOR THE AERODYNAMICS.
C
C      DIMENSION TITLE(24),NREDU(5),NCJT(5),NMODE(5),CKFF(97,97),
1CKFF(97,97),CK12(97,36),CM12(97,36),CK22(36,36),CM22(36,36),
2XMODE(97,9),XMODEN(97,9),T(97,36),XM(9,97),XMX(9,9),TTK1(36,36),
3XKC(1035),TTM1(36,36),XMC(1035),W1(9,97),PMT(9,36),PM12(9,36),
4TH(36,97),TMT(36,36),NCODE(4,45),XKS(9180),XMS(9180),A(9180),
5ROOT(9),VALU(9),TEMP(75),B(97),C(97),DUM3(135),F(135,3),
6IDUM4(75),PKT(9,36),W2(9,9),CKFFI(97,97),CMT(36,36)
7,FREQ(9),ONE(9),GM(9,9),
8AP(4,8),AIC(40,80),XF(97,9),XFT(9,97),VEL(20)
C      INTEGER COM(48,4)

C      EQUIVALENCE (CKFF(1,1),CKFFI(1,1),CMFF(1,1)),(CK12(1,1),CM12(1,1))
1,(CK22(1,1),CM22(1,1)),(XMODE(1,1),XMODEN(1,1),XF(1,1)),
2(TTK1(1,1),TTM1(1,1)),(XKS(1),XMS(1),A(1)),AIC(1,1)
3,(PKT(1,1),PMT(1,1)),(XKC(1),XMC(1)),(XMX(1,1),W2(1,1),GM(1,1))
4,(XM(1,1),W1(1,1),XFT(1,1))

C      FORMAT
1 FORMAT(1H0 25X,12A6//26X,12A6//)
2 FORMAT(9I5)
3 FORMAT(1H1 42X,33HCOMPONENT MODE SYNTHESIS ANALYSIS//48X,11,22H CO
1MPONENTS CONSIDERED//)
4 FORMAT(1H0 46X,24HINPUT DATA FOR COMPONENT,12///49X,12,19H DEGREES
1 OF FREEDOM/50X,11,6H MODES/49X,12,14H COMMON JOINTS//)
5 FORMAT(1H0 2X,11HMODE SHAPES//)
6 FORMAT(1H0 2X,4HMODE,12,14H - F EQUENCY = F12,3,4H CPS//(3X,
11P8E15.5))
7 FORMAT(/// 3X,90HUPPER TRIANGLE OF REDUCED STIFFNESS MATRIX FOR CO
1MPONENT (COMMON JOINTS RESTRAINED) K-FF//)
8 FORMAT(1H0 2X,3HROW 13 /(3X,1P8E15.5))
11 FORMAT(/// 3X,83HSTIFFNESS MATRIX - RELATES COMMON JOINTS TO FREE
1JOINTS (COMMON JOINTS FREE) K-FJ//)
13 FORMAT(/// 3X,57HUPPER TRIANGLE OF STIFFNESS MATRIX - COMMON JOINT
1S K-JJ//)
14 FORMAT(/// 3X,87HUPPER TRIANGLE OF REDUCED WEIGHT MATRIX FOR COMPO
1NENT (COMMON JOINTS RESTRAINED) M-FF//)
18 FORMAT(/// 3X,78HMASS MATRIX - RELATES COMMON JOINTS TO FREE JOINT
1S (COMMON JOINTS FREE) M-FJ//)
21 FORMAT(/// 3X,52HUPPER TRIANGLE OF MASS MATRIX - COMMON JOINTS M
1-JJ//)
23 FORMAT(/// 3X,40HNORMALIZED MODE SHAPES FOR ORTHOGONALITY//)

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25	FORMAT(/// 3X,23HCHECK FOR ORTHOGONALITY//3X,52HUPPER TRIANGLE OF	165
	1THF GENERALIZED MASS MATRIX IS NOW//)	166
27	FORMAT(/// 3X,60HUPPER TRIANGLE OF TRANSFORMED STIFFNESS MATRIX FO	170
	1R COMPONENT I2//)	171
29	FORMAT(/// 3X,55HUPPER TRIANGLE OF TRANSFORMED MASS MATRIX FOR COM	175
	1PONENT I2//)	176
30	FORMAT(6F12.8)	180
33	FORMAT(12A6)	181
34	FORMAT(1H1)	182
37	FORMAT (36I2)	183
38	FORMAT(1H1 40X,22HAIC MATRICES FOR 1/K = 1P1E11.4)	184
39	FORMAT(2I4)	185
40	FORMAT(/// 9HCOMPONENT I2 //)	186
41	FORMAT(1H0 5HSTRIP I3 //)	187
42	FORMAT(1H0 /(3X,2E14.6,2X,2E14.6,2X,2E14.6,2X,2E14.6))	188
45	FORMAT(/// 33HCOUPLED AIC MATRIX FOR COMPONENTS I2,4H AND I2 //)	189
	DISC ASSIGNMENTS	200
	KDISC=7	205
	MDISC=8	210
	IDISC=9	215
	JDISC=10	220
	KKDISC=11	225
	IKDISC=12	226
	IMDISC=13	227
	NMDISC=14	228
	MCDISC=15	229
	MTDISC=16	230
	MADISC=17	231
	READ INPUT DATA AND PRINT	234
1000	READ(5,33)(TITLE(I),I=1,24)	235
	REWIND KDISC	240
	REWIND MDISC	245
	REWIND IDISC	250
	REWIND JDISC	255
	REWIND KKDISC	260
	REWIND IKDISC	261
	REWIND IMDISC	262
	REWIND NMDISC	263
	REWIND MCDISC	264
	REWIND MTDISC	265
	REWIND MADISC	266
	READ(5,2) NCOMP,MODE,NCOM,NCoup,NAT,NV	269
	READ(5,2) (NREDU(I),I=1,NCOMP)	270
	READ(5,2) (NMODE(I),I=1,NCOMP)	275
	READ(5,2) (NCJT(I),I=1,NCOMP)	280
	READ(5,37)((COM(I,J),J=1,4),I=1,NCOM)	281
	IF(NV.F0.0) GO TO 199	282
	READ(5,30)(VEL(I),I=1,NV)	283
199	WRITE(6,3) NCOMP	285
	WRITE(6,1) (TITLE(I),I=1,24)	290
	DO 100 I=1,NCOMP	295
	N=NREDU(I)	300
	NC=NCJT(I)*3	305
	NM=NMODE(I)	310
	DO 200 K=1,NM	314
200	READ(5,30) (XMODE(J,K),J=1,N)	315
	READ(5,30)(FREQ(L),L=1,NM)	320
	DO 210 J=1,N	324
210	READ(5,30) (CKFF(J,K),K=1,N)	325
	DO 220 J=1,N	329

220	READ(5,30) (CK12(J,K),K=1,NC)	330
	DO 230 J=1,NC	334
230	READ(5,30) (CK22(J,K),K=1,NC)	335
	IF(1.E0.1)GO TO 231	336
	WRITE(6,34)	337
231	WRITE(6,4) I,N,NH,NCJT(I)	340
	WRITE(6,5)	344
	DO 9 K=1,NH	345
9	WRITE(6,6)K,FREQ(K),(XMODE(J,K),J=1,N)	350
	WRITE(6,7)	355
	DO 12 L=1,N	360
12	WRITE(6,8)L,(CKFF(L,J),J=L,N)	365
	WRITE(6,11)	370
	DO 14 L=1,N	375
14	WRITE(6,8) L,(CK12(L,J),J=1,NC)	380
	WRITE(6,13)	385
	DO 15 L=1,NC	390
15	WRITE(6,8) L,(CK22(L,J),J=L,NC)	395
	DO 240 J=1,N	399
240	READ(5,30) (CKFFI(J,K),K=1,N)	400
C	GENERATE TRANSFORMED STIFFNESS MATRIX	404
	CALL MATMPL(CKFFI,CK12,T,97,97,97,36,97,36,N,NC,N,1)	405
	DO 46 J=1,N	410
	DO 10 K=1,NC	415
10	T(J,K)=-1.*T(J,K)	420
46	WRITE(MTDISC) (T(J,K),K=1,NC)	421
	CALL MATMPL(T,CK12,TTK1,97,36,97,36,36,36,NC,NC,N,2)	425
	DO 35 J=1,NC	430
	DO 35 K=1,NC	435
35	TTK1(J,K)=TTK1(J,K)+CK22(J,K)	440
	NMC=NH+NC	445
	DO 32 I=1,NH	450
32	ROOT(L)=(FREQ(L)*6.2831853)**2	455
	DO 36 J=1,NH	460
	DO 36 K=1,NC	465
36	PKT(J,K)=0.0	470
	CALL GENC(NH,NMC,NC,XKC,TTK1,PKT,ROOT,[KDISC])	475
C	PRINT TRANSFORMED STIFFNESS MATRIX	476
	WRITE(6,27) I	477
	DO 28 I=1,NMC	478
	NS=(2*I+(I-1)*(2*NMC-L))/2	479
	NE=(2*NMC+(I-1)*(2*NMC-L))/2	480
28	WRITE(6,8)L,(XKC(J),J=NS,NE)	481
	DO 250 J=1,N	484
250	READ(5,30) (CMFF(J,K),K=1,N)	485
	DO 260 J=1,N	489
260	READ(5,30) (CM12(J,K),K=1,NC)	490
	DO 270 J=1,NC	494
270	READ(5,30) (CM22(J,K),K=1,NC)	495
	WRITE(6,16)	496
	DO 17 I=1,N	497
17	WRITE(6,8)I,(CMFF(I,J),J=L,N)	498
	WRITE(6,18)	499
	DO 19 I=1,N	500
19	WRITE(6,8)L,(CM12(I,J),J=1,NC)	501
	WRITE(6,21)	502
	DO 22 I=1,NC	503
22	WRITE(6,8) L,(CM22(I,J),J=L,NC)	504
C	NORMALIZE MODE SHAPES FOR ORTHOGONALITY	505
	DO 51 K=1,N	506

DO 51 J=1,N	507
51 CMFF(K,J)=CMFF(K,J)/(32.174*12.)	508
CALL MATMPL(XMODE,CMFF,XM,97,9,97,97,9,97,NM,N,N,2)	509
CALL MATMPL(XM,XMODE,XMX,9,97,97,9,9,9,NM,NM,N,1)	510
DO 47 J=1,N	515
DO 20 K=1,NM	520
20 XMODEN(J,K)=XMODE(J,K)/SQRT(XMX(K,K))	525
47 WRITE(MCDISC) (XMODEN(J,K),K=1,NM)	526
CALL MATMPL(XMODEN,CMFF,W1,97,9,97,97,9,97,NM,N,N,2)	530
CALL MATMPL(W1,XMODEN,W2,9,97,97,9,9,9,NM,NM,N,1)	535
WRITE(6,23)	540
DO 24 K=1,NM	545
24 WRITE(6,6) K,FRFQ(K),(XMODEN(J,K),J=1,N)	550
WRITE(6,25)	555
DO 26 L=1,NM	560
26 WRITE(6,8) L,(W2(L,J),J=L,NM)	565
GENERATE TRANSFORMED MASS MATRIX	570
CALL MATMPL(W1,T,PMT,9,97,97,36,9,36,NM,NC,N,1)	575
CALL MATMPL(XMODEN,CM12,PM12,97,9,97,36,9,36,NM,NC,N,2)	580
DO 55 J=1,NM	585
DO 55 K=1,NC	590
55 PMT(J,K)=PMT(J,K)+PM12(J,K)	595
CALL MATMPL(T,CMFF,TH,97,36,97,97,36,97,NC,N,N,2)	600
CALL MATMPL(TH,T,TMT,36,97,97,36,36,36,NC,NC,N,1)	605
CALL MATMPL(T,CM12,TTM1,97,36,97,36,36,36,NC,NC,N,2)	610
CALL MATMPI(CM12,T,CMT,97,36,97,36,36,36,NC,NC,N,2)	615
DO 60 J=1,NC	620
DO 60 K=1,NC	625
60 TTM1(J,K)=TMT(J,K)+CM22(J,K)+TTM1(J,K)+CMT(J,K)	630
DO 65 M=1,NM	635
65 ONE(M)=1.0	640
CALL GFNC(NM,NMC,NC,XMC,TTM1,PMT,ONE,INDISC)	645
PRINT TRANSFORMED MASS MATRIX	649
WRITE(6,29) I	675
DO 31 I=1,NMC	680
NS=(2*I+(L-1)*(2*NMC-L))/2	685
NF=(2*NMC+(L-1)*(2*NMC-L))/2	690
31 WRITE(6,8)L,(XMC(J),J=NS,NF)	695
100 CONTINUE	700
IF(NV.EQ.0) GO TO 101	701
FOR EACH REDUCED VFLOCITY, READ AIC MATRIX FOR EACH COMPONENT	702
DO 109 K=1,NV	
WRITE(MADISC) VFI(K)	
WRITE(6,38) VFI(K)	
II=0	
DO 108 I=1,NCOMP	
IF(II.EQ.1) GO TO 108	
N=NRDU(I)	
N2=2*N	
IF(NAT.EQ.2) GO TO 105	
READ(5,39) NSIZE,NPART	
WRITE(MADISC) NPART	
WRITE(6,40) I	
DO 104 J=1,NPART	
READ(5,39) NS	
NS2=2*NS	
WRITE(6,41) J	
DO 103 JI=1,NS	
READ(5,30)(AP(JJ,KK),KK=1,NS2)	
103 WRITE(6,42)(AP(JJ,KK),KK=1,NS2)	

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WRITE(MADISC)NS,NS2
104 WRITE(MADISC)((AP(JJ,KK),KK*1,NS2),JJ=1,NS)
GO TO 108
105 IF(NCOUP.NE.1) GO TO 107
II=I+1
N=NREDU(I)+NREDU(II)
N2=2*N
WRITE(6,45) I,II
GO TO 121
107 WRITE(6,40) I
121 DO 106 JA=1,N
READ(5,30)(AIC(JA,KA),KA=1,N2)
WRITE(MADISC)(AIC(JA,KA),KA=1,N2)
106 WRITE(6,42)(AIC(JA,KA),KA=1,N2)
104 CONTINUE
109 CONTINUE
C GENEPATE THE NCODE MATRIX
101 KK=0
DO 110 I=1,NCOMP
NM=NMODE(I)
DO 110 J=1,NM
KK=KK+1
110 NCODE(I,1)=KK
NTM=KK
DO 120 I=1,NCOMP
JM=NMODE(I)+1
NCC=NMODE(I)+NCJT(I)
DO 119 J=JM,NCC
IF(I.EQ.1) GO TO 118
DO 117 K=1,NCOM
L=COM(K,4)
IF(L.EQ.1) GO TO 115
GO TO 117
115 JC=J-JM+1
LI=COM(K,3)
IF(LI.EQ.JC) GO TO 116
GO TO 117
116 II=COM(K,2)
JJ=COM(K,1)+NMODE(II)
NCODE(I,1)=NCODE(II,JJ)
GO TO 119
117 CONTINUE
118 KK=KK+1
NCODE(I,1)=KK
119 CONTINUE
120 CONTINUE
DO 130 I=1,NCOMP
JM=NMODE(I)+NCJT(I)+1
NCC=NMODE(I)+2*NCJT(I)
DO 129 J=JM,NCC
IF(I.EQ.1) GO TO 128
DO 127 K=1,NCOM
L=COM(K,4)
IF(L.EQ.1) GO TO 125
GO TO 127
125 JC=J-JM+1
LI=COM(K,3)
IF(LI.EQ.JC) GO TO 126
GO TO 127
126 II=COM(K,2)

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	JJ=COM(K,1)+NMODE(11)+NCJT(11)	787
	NCODE(1,J)=NCODE(11,JJ)	788
	GO TO 129	789
127	CONTINUE	790
128	KK=KK+1	791
	NCODE(1,J)=KK	792
129	CONTINUE	793
130	CONTINUE	794
	WRITE(6,131)	
131	FORMAT(1H1 2X,59HEFFECTIVE LOCATION OF COMPONENT D.O.F. IN THE SYS	
	ITEM MATRIX//)	
	DO 140 I=1,NCOMP	795
	JM=NMODE(1)+2*NCJT(1)+1	800
	NCC=NMODE(1)+3*NCJT(1)	805
	DO 139 J=JM,NCC	806
	IF(I.EQ.1) GO TO 138	807
	DO 137 K=1,NCOM	808
	L=COM(K,4)	809
	IF(L.EQ.1) GO TO 135	810
	GO TO 137	811
135	JC=J-JM+1	812
	LL=COM(K,3)	813
	IF(LL.FQ.JC) GO TO 136	814
	GO TO 137	815
136	II=COM(K,2)	816
	JJ=COM(K,1)+NMODE(11)+2*NCJT(11)	817
	NCODE(1,J)=NCODE(11,JJ)	818
	GO TO 139	819
137	CONTINUE	820
138	KK=KK+1	821
	NCODE(1,J)=KK	822
139	CONTINUE	823
	WRITE(6,150) I,(NCODE(1,J),J=1,NCC)	
150	FORMAT(1H0 2X,19HNCODE FOR COMPONENT 12//(25I5))	
140	CONTINUE	824
C	THE FINAL KK BECOMES THE ORDER OF THE SYSTEM MATRICES-XKS AND XMS	825
C	GENERATE AND REDUCE SYSTEM MATRICES AND SOLVE EIGENVALUE PROBLEM	830
	CALL GENM(KK,NCOMP,NMODE,NCJT,NCODE,XKS,XKC,KDISC,1KDISC)	835
	CALL GENM(KK,NCOMP,NMODE,NCJT,NCODE,XMS,XMC,MDISC,1MDISC)	840
	NTOT=KK-NTM	845
	NREDUS=NTM+NTOT/3	850
	NROT=KK-NREDUS	860
	CALL EIGEN(A,VALU,TEMP,B,C,DUM3,F,1DUM4,1DISC,1JDISC,KKDISC,MDISC,	865
	1KDISC,KK,MODE,MODE,NREDUS,NROT,NMDISC)	866
C	TRANSFORM SYSTEM MODE SHAPES BACK TO COMPONENTS	
	CALL TMODE(KKDISC,MCDISC,MTDISC,1DISC,NMODE,NCJT,NREDU,NCOMP,	
	1MODE,NV,NCODE,NTM,NREDUS,NROT,XF,B,C,DUM3)	
C	GENERATE GENERALIZED MASS MATRIX FOR SYSTEM	
	CALL GENM(1DISC,NMDISC,NREDUS,MODE,A,B,C,1JDISC,DUM3,GM)	867
	IF(NV.EQ.0) GO TO 999	
C	GENERATE GENERALIZED AERODYNAMIC FORCES FROM AIC MATRICES IF INPUT	
	CALL GENA(KKDISC,MADISC,MTDISC,VEL,NCOMP,MODE,NCOU,NAT,NV,NREDU,	
	1AP,AIC,XF,XFT,B)	
999	GO TO 1000	
	END	875

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S      FORTRAN DECK
CEIGEN  REDUCES STIFFNESS MATRIX AND INVERTS IT, REDUCES MASS MATRIX
C      DETERMINES EIGENVALUES AND EIGENVECTORS FOR CONSYN
C      THE ARGUMENTS ARE=
C      A - VECTOR OF LENGTH NRDF*(NRDF+1)/2
C      VALU - VECTOR OF LENGTH NEIG
C      TEMP,B,C,DUM3, - VECTORS OF LENGTH NRDF OR NMASS (SMALLER)
C      E - MATRIX OF DIMENSION (NRDF,3)
C      IDUM4 - VECTOR OF LENGTH NRDF OR NMASS (SMALLER)
C      ITAPE,JTAPE, NTAPE, MTAPE, - THESE ARE VARIOUS TAPES
C      NRDF - NUMBER OF DEGREES OF FREEDOM OF THE SYSTEM
C      NEIG - NUMBER OF EIGENVALUES DESIRED
C      NVEC - NUMBER OF EIGENVECTORS DESIRED
C      NMASS=NO. OF NORMAL DISPLACEMENTS
C      NOMASS=NO. OF ROTATIONAL DEGREES OF FREEDOM
C      STIFF IS ON MTAPE IN COMPACT FORM
C      MASS IS ON NTAPE IN COMPACT FORM
C      SUBROUTINE EIGEN(A,VALU,TEMP,B,C,DUM3,E,IDUM4,ITAPE,JTAPE,KTAPE,
1NTAPE,MTAPE,NRDF,NEIG,NVEC,NMASS,NOMASS,NMTAPE)
C      DIMENSION DUM3(NRDF),IDUM4(1),A(1),VALU(1),B(1),C(1),E(NRDF,3),
1TEMP(1)
C      INTEGER OUT
C      OUT=6
C      REWIND MTAPE
C      REWIND NTAPE
C      NTEMP=NMASS
C      CALL DIVID(NMASS,NOMASS,MTAPE,JTAPE,ITAPE,A,B)
C      CALL ZROMAX(A,B,C,DUM3,NMASS,NOMASS,ITAPE,JTAPE,MTAPE,KTAPE)
C      CALL DIVID(NMASS,NOMASS,NTAPE,JTAPE,ITAPE,A,B)
C      CALL ZROMAX(A,B,C,DUM3,NMASS,NOMASS,ITAPE,JTAPE,NTAPE,KTAPE)
C      REWIND MTAPE
C      REWIND NTAPE
C      NREDU=NMASS
C      NRMX=NREDU*(NREDU+1)/2
C      READ IN STIFFNESS MATRIX
C      READ(MTAPE) (A(I),I=1,NRMX)
C      WRITE(OUT,5500)
5500  FORMAT(/// 3X,63HUPPER TRIANGLE OF REDUCED STIFFNESS MATRIX FOR TH
1E TOTAL SYSTEM//)
C      DO 5501 I=1,NREDU
C      NS=(2*I+(I-1)*(2*NREDU-1))/2
C      NE=(2*NREDU+(I-1)*(2*NREDU-1))/2
C      WRITE(OUT,5502) I,(A(J),J=NS,NE)
5502  FORMAT(1H0 2X,3HROW 14 /(3X,1P8E15.5))
5501  CONTINUE
C      READ IN THE MASS MATRIX
C      READ(NTAPE) (A(I),I=1,NRMX)
C      DO 6012 I=1,NRMX
6012  A(I)=A(I)*32.174*12.
C      WRITE(OUT,5505)
5505  FORMAT(/// 3X,60HUPPER TRIANGLE OF REDUCED WEIGHT MATRIX FOR THE T
1OTAL SYSTEM//)
C      DO 5506 I=1,NREDU
C      NS=(2*I+(I-1)*(2*NREDU-1))/2
C      NE=(2*NREDU+(I-1)*(2*NREDU-1))/2
5506  WRITE(OUT,5502) I,(A(J),J=NS,NE)
C      IF(NEIG.EQ.0) RETURN
C      CALL EIGMAT(NTAPE,A,VALU,TEMP,B,C,DUM3,E,IDUM4,MTAPE,NTAPE,JTAPE,
1ITAPE,NEIG,NVEC,NMTAPE)
C      DO 60 I=1,NEIG

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IF(VALU(I).LT.0.0) GO TO 59
DUM3(I)=SORT(VALU(I))/6.2831853
GO TO 60
59 DUM3(I)=0.0
60 CONTINUE
WRITE(OUT,9009)
WRITE(OUT,9005) (I,DUM3(I),I=1,NEI8)
9009 FORMAT(/// 3X,33HNATURAL FREQUENCIES OF THE SYSTEM ///)
9005 FORMAT( 3X,29HTHE NATURAL FREQUENCY NUMBER 13,2X,2HIS F12.3,2X,
13HCPS)
RETURN
END

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*      FORTRAN DECK
CHAMPPL      MATRIX MULTIPLICATION (REAL AND TWO-DIMENSIONAL)
C
C      MATRIX A DIMENSION (MA,NA) IN MAIN PROGRAM
C      B      (MB,NB)
C      C      (MC,NC)
C      M = NO. OF ROWS IN PRODUCT MATRIX C
C      N = NO. OF COLUMNS IN C
C      L = COMMON DIMENSION OF A AND B
C      IOP = 1, A X B = C
C      2, A(TRANPOSE) X B = C
C      3, A X B(TRANPOSE) = C
C
C      SUBROUTINE MATMPL (A,B,C,MA,NA,MB,NB,MC,NC,M,N,L,IOP)
C      DIMENSION A(MA,NA),B(MB,NB),C(MC,NC)
C
C      GO TO (100,200,300),IOP
100  DO 175 I=1,M
    DO 150 J=1,N
      C(I,J)=0.0
      DO 125 K=1,L
        C(I,J)=C(I,J)+A(I,K)*B(K,J)
125  CONTINUE
150  CONTINUE
175  CONTINUE
    GO TO 400
200  DO 275 I=1,M
    DO 250 J=1,N
      C(I,J)=0.0
      DO 225 K=1,L
        C(I,J)=C(I,J)+A(K,I)*B(K,J)
225  CONTINUE
250  CONTINUE
275  CONTINUE
    GO TO 400
300  DO 375 I=1,M
    DO 350 J=1,N
      C(I,J)=0.0
      DO 325 K=1,L
        C(I,J)=C(I,J)+A(I,K)*B(J,K)
325  CONTINUE
350  CONTINUE
375  CONTINUE
400  RETURN
    END

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	FORTRAN DECK	9080
CCMULT	PRE AND POST MULTIPLIES A COMPLEX MATRIX BY REAL MATRICES	9085
C	A IS THE PRE-MULTIPLIER (REAL) OF SIZE NR X NC	9090
C	B IS THE COMPLEX MATRIX OF SIZE NC X NB IN REAL NOTATION	9095
C	C IS THE POST-MULTIPLIER (REAL) OF SIZE ND/2 X NR	9100
C	D IS RESULTANT (COMPLEX) OF SIZE NR X 2NR IN REAL NOTATION	9105
C	NR = NO. OF COLUMNS IN A AS DIMENSIONED IN MAIN PROGRAM	9110
C	NC = NO. OF ROWS IN C AS DIMENSIONED IN MAIN PROGRAM	9115
C	NA = NO. OF ROWS IN B AS DIMENSIONED IN MAIN PROGRAM	9120
C	NB = NO. OF COLUMNS IN B AS DIMENSIONED IN MAIN PROGRAM	9125
C		9130
C	SUBROUTINE CMULT(A,B,C,D,MR,MA,MB,NR,NC,ND)	9135
C		9140
C	DIMENSION A(9,MR),B(MA,MB),C(MR,9),D(9,18),E(9,80)	9145
C		9150
C	NR2=2*NR	9155
C	NDH=ND/2	9160
C	DO 20 K=1, NR	9165
C	DO 20 I=1, ND	9170
C	E(K,I)=0.0	9175
C	DO 20 J=1, NC	9180
20	E(K,I)=E(K,I)+A(K,J)*B(J,I)	9185
C	DO 30 K=1, NR	9190
C	DO 25 L=1, NR2, 2	9195
C	MM=(L+1)/2	9200
C	D(K,I)=0.0	9205
C	DO 25 J=1, NDH	9210
25	D(K,I)=D(K,I)+E(K,2*J-1)*C(J,MM)	9215
C	DO 30 L=2, NR2, 2	9220
C	MM=L/2	9225
C	D(K,I)=0.0	9230
C	DO 30 J=1, NDH	9235
30	D(K,I)=D(K,I)+E(K,2*J)*C(J,MM)	9240
C	RETURN	9245
C	END	9250

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C      FORTRAN DECK
C      GENC      GENERATES THE TRANSFORMED MASS OR STIFFNESS MATRIX
C                  FOR EACH COMPONENT
C      NMC = ORDER OF THE FINAL MATRIX (XC).
C      THE FINAL MATRIX IS STORED ON IDISC IN COMPACT FORM (BY ROWS)
C
C      SUBROUTINE GENC(NH,NMC,NC,XC,TT1,PT,DIAG,IDISC)
C      DIMENSION XC(1),      TT1(36,36),PT(9,36),DIAG(1)
C
C      NMCT=NMC*(NMC+1)/2
C      DO 40 J=1,NMCT
40  XC(J)=0.0
C      DO 45 M=1,NH
C      J=(2*M+(M-1)*(2*NMC-M))/2
C      NM=M-1
C      MMM=J+NM-NM
C      DO 44 K=1,NC
C      XC(MMM)=PT(M,K)
44  MMM=MMM+1
C      XC(J)=DIAG(M)
45  L=(2*(NH+1)+NM*(2*NMC-(NH+1)))/2
C      DO 50 J=1,NC
C      DO 50 K=J,NC
C      XC(L) = TT1(J,K)
C      L=L+1
50  CONTINUE
C      WRITE(IDISC) (XC(I),I=1,NMCT)
C      RETURN
C      END

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S	FORTRAN DECK	4000
CGENS	GENERATES THE MASS OR STIFFNESS MATRIX FOR THE TOTAL SYSTEM	4005
C	BY THE NCODE METHOD.	4010
C	KK = ORDER OF THE SYSTEM MATRIX (XS).	4015
C	IDISC CONTAINS THE COMPONENT MATRIX IN COMPACT FORM BY ROWS (XC).	4016
C	THE SYSTEM MATRIX IS STORED ON NDISC IN COMPACT FORM BY ROWS (XS).	4020
C		4025
	SUBROUTINE GENS (KK, NCOMP, NMODE, NCJT, NCODE, XS, XC, NDISC, IDISC)	4030
	DIMENSION NMODE(1), NCJT(1), NCODE(9, 49), XS(1), XC(1)	4035
		4040
	REWIND NDISC	4043
	REWIND IDISC	4044
	KKK=KK*(KK+1)/2	4045
200	DO 200 I=1, KKK	4050
	XS(I) = 0.0	4055
	DO 500 I=1, NCOMP	4060
	NMC=NMODE(I)+3*NCJT(I)	4065
	NMCT=NMC*(NMC+1)/2	4066
	READ(IDISC)(XC(K), K=1, NMCT)	4067
	DO 400 II=1, NMC	4070
	KI=NCODE(I, II)	4075
	DO 375 JJ=II, NMC	4080
	LI=NCODE(I, JJ)	4085
	KA=KI	
	LA=LI	
	IF(LI.OE.KI) GO TO 370	
	KI=LA	
	LI=KA	
370	MO=(2*JJ+(II-1)*(2*NMC-II))/2	
	NO=(2*II+(KI-1)*(2*KK-KI))/2	4095
	XS(NO)=XS(NO)+XC(MO)	4100
	KI=KA	
375	CONTINUE	4105
400	CONTINUE	4110
500	CONTINUE	4115
	DO 510 I=1, KKK	4120
	NS=(2*I+(I-1)*(2*KK-I))/2	4125
	NE=(2*KK+(I-1)*(2*KK-I))/2	4130
510	WRITE(NDISC)(XS(J), J=NS, NE)	4135
	RETURN	4140

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END
FORTRAN DECK
CGENM GENERATES THE GENERALIZED MASS MATRIX FOR THE TOTAL SYSTEM
      USED IN THE MODAL FLUTTER PROGRAM
C      N = SIZE OF REDUCED MASS MATRIX FOR THE SYSTEM
C      NVEC = NO. OF MODES
C      MSDISC - SYSTEM MODE SHAPES STORED
C      NDISC CONTAINS REDUCED MASS MATRIX OF THE SYSTEM
C      F = GENERALIZED MASS MATRIX - FORMED, PRINTED AND PUNCHED
C
      SUBROUTINE GENM (MSDISC,NDISC,N,NVEC,A,B,C,LLDISC,D,E)
      DIMENSION A(1),B(1),C(1),D(1),E(9,9),G(9)
C
10  FORMAT(1H1 2X,44HGENERALIZED MASS MATRIX FOR THE TOTAL SYSTEM //)
11  FORMAT (1H 1P9E14.5)
      REWIND NDISC
      REWIND MSDISC
      REWIND LLDISC
      NMAX = N*(N+1)/2
      READ(NDISC)(A(I),I=1,NMAX)
      DO 900 K=1,NVEC
      READ(MSDISC)(C(L),L=1,N)
      DO 800 I=1,N
      II=I-1
      IF(II.EQ.0) GO TO 600
      DO 595 J=1,II
      NU=(2*I+(J-1)*(2*I-J))/2+(J+1)*(N-I)
595  B(J)=A(NU)
600  CONTINUE
      NS=(2*I+(I-1)*(2*N-I))/2
      NE=(2*N+(I-1)*(2*N-I))/2
      J=I
      DO 650 JJ=NS,NE
      B(J)=A(JJ)
650  J=J+1
      D(I)=0.0
      DO 750 LL=1,N
750  D(I)=D(I)+C(LL)*B(LL)
800  CONTINUE
      WRITE(LLDISC)(D(I),I=1,N)
900  CONTINUE
      REWIND LLDISC
      DO 1000 K=1,NVEC
      REWIND MSDISC
      READ(LLDISC)(D(I),I=1,N)
      DO 950 KK=1,NVEC
      READ(MSDISC)(C(L),L=1,N)
      E(K,KK)=0.0
      DO 930 LI=1,N
930  E(K,KK)=F(K,KK)+D(LL)*C(LL)
950  CONTINUE
1000 CONTINUE
      WRITE(6,10)
      DATA Q1/4HGENM/
      IC=0
      DO 20 I=1,NVEC
      WRITE (6,11)(E(I,J),J=1,NVEC)
      DO 15 J=1,NVEC
15  G(I)=E(I,J)
      CALL PUNC (G,1,NVEC,Q1,IC)
20  CONTINUE

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RETURN
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*      FORTRAN DECK
CTMODE      TRANSFORMS SYSTEM MODE SHAPES TO EACH COMPONENT
C
C      KKDISC CONTAINS (K-NN) X (K-MM) INVERSE
C      MCDISC CONTAINS THE MODE SHAPES FOR EACH COMPONENT
C      MTDISC CONTAINS THE T MATRIX FOR EACH COMPONENT
C      MSDISC CONTAINS THE MODE SHAPES FOR THE TOTAL SYSTEM
C      SM MATRIX - SYSTEM MODE SHAPES INVOLVING MODAL DEGREES OF FREEDOM.
C      STP MATRIX - SYSTEM MODE SHAPES INVOLVING TRANSLATIONAL AND
C      ROTATIONAL DEGREES OF FREEDOM.
C      XF - TRANSFORMED SYSTEM MODE SHAPES FOR EACH COMPONENT.
C      XF STORED ON KKDISC FOR SUBROUTINE GENA IF AERO INPUT
C
C      SUBROUTINE TMODE (KKDISC,MCDISC,MTDISC,MSDISC,NMODE,NCJT,NREDU,
1NCOMP,MODE,NV,NCODE,NTM,NREDUS,NROT,XF,B,C,D)
C
C      DIMENSION NMODE(1),NCJT(1),NREDU(1),SM(45,9),STR(90,9),NCODE(5,45)
1,XF(97,9),B(1),C(1),D(1)
C
C      DATA Q5/4HSYSM/
300 FORMAT(/// 3X,47HSYSTEM MODE SHAPES FOR FREE JOINTS ON COMPONENT
112//)
301 FORMAT(1H 9E14.5)
302 FORMAT(// 6X,6HMODE 1,RX,6HMODE 2,8X,6HMODE 3,8X,6HMODE 4,8X,
16HMODE 5,8X,6HMODE 6,8X,6HMODE 7,8X,6HMODE 8,8X,6HMODE 9//)
REWIND KKDISC
REWIND MCDISC
REWIND MSDISC
REWIND MTDISC
C      GENERATE XF, TRANSFORMED SYSTEM MODE SHAPES TO EACH COMPONENT
NT=NTM+1
DO 20 J=1,MODE
READ(MSDISC)(B(K),K=1,NREDUS)
DO 11 K=1,NTM
11 SM(K,J)=B(K)
L=0
DO 12 K=NT,NREDUS
L=L+1
12 STR(L,J)=B(K)
DO 15 M=1,NROT
D(M)=0.0
DO 14 N=1,NREDUS
READ(KKDISC)(C(KK),KK=1,NROT)
14 D(M)=D(M)+B(N)*C(M)
REWIND KKDISC
L=L+1
STR(L,J)=-D(M)
15 CONTINUE
20 CONTINUE
REWIND KKDISC
NNM=0
DO 100 I=1,NCOMP
N=NREDU(I)
NM=NMODE(I)
NO=NNM+1
NNM=NO+NM-1
NC=3*NCJT(I)
JJ=NM+1
JK=NM+NC
DO 30 K=1,N

```

```

      READ(MCDISC)(B(KK),KK=1,NM)
      DO 26 I=1,MODE
        D(K)=0.0
        DO 25 J=NO,MM
          M=J-NO+1
25      D(K)=D(K)+B(M)*SM(J,L)
          XF(K,L)=D(K)
26      CONTINUE
      READ(MTDISC)(H(KK),KK=1,MC)
      DO 35 L=1,MODE
        C(K)=0.0
        DO 29 JL=JJ,JK
          M=JL-NM
          JM=NCODE(1,JL)-NTM
29      C(K)=C(K)+B(M)*STR(JM,L)
          XF(K,L)=XF(K,L)+C(K)
35      CONTINUE
30      CONTINUE
      IF(NV.F0.0) GO TO 39
      WRITE(KKDISC)((XF(K,L),L=1,MODE),K=1,N)
39      WRITE(6,300)I
      WRITE(6,302)
      DO 40 K=1,N
40      WRITE(6,301)(XF(K,L),L=1,MODE)
100 CONTINUE
      RETURN
      END

```

5 FORTRAN DECK

CSYHINV

C	A IS THE UPPER TRIANGLE OF THE SYMMETRIC MATRIX TO BE INVERTED.	SYHV	CC
C	ELEMENTS ARE STORED ROWWISE.		
C	N = ORDER OF MATRIX	SYHV	CC
C	PROGRAM INVERTS IN PLACE.	SYHV	CC
	SUBROUTINE SYHINV(A,N)	SYHV	00
	DIMENSION A(1)	SYHV	10
	CALL ECLOCK(IT1)		
	NMAX=N*(N+1)/2		
	IF(A(1).LT.0.0) GO TO 25		
	GO TO 99		
25	II=1		
26	WRITE(6,27)II		
27	FORMAT(1H1,5X,36HA NEGATIVE VALUE APPEARS IN ELEMENT ,15,1X, 125HOF VECTOR TO BE INVERTED,/6X 69HSINCE ELEMENT FALLS ON DIAGONAL 2, MATRIX IS NOT POSITIVE DEFINITE,/76X,30HPROGRAM ENDED AND JOB DE 3LETED.)		
	DO 45 I=1,N		
	NS=(2*I+(I-1)*(2*N-1))/2		
	NE=(2*N+(I-1)*(2*N-1))/2		
	WRITE(6,28)I,(A(J),J=NS,NE)		
28	FORMAT(/3HROW,14/(9F14.5))		
45	CONTINUE		
	CALL EXIT		
99	CONTINUE		
	A(1)=SQRT(A(1))		
	DO 100 IJ=2,N	SYHV	30
100	A(IJ)=A(IJ)/A(1)	SYHV	40
	A(1)=1.0/A(1)	SYHV	50
	IM1=1	SYHV	60
	IJ=N		
	DO 1000 I=2,N		
	II=IJ+1		
	IJ=II		
	DO 200 J=I,N		
	JM1=J-1		
	LI=I		
	LJ=J		
	DO 120 L=1,IM1		
	A(IJ)=A(IJ)-A(LI)*A(LJ)		
	LI=LI+N-1		
120	LJ=LJ+JM1		
200	IJ=IJ+1		
	IF(A(II).LT.0.0) GO TO 26		
	A(II)=SQRT(A(II))		
	J1=I		
	JJ=1		
	DO 500 J=1,IM1		
	A(JJ)=A(JJ)*A(J1)		
	IF(J-JM1)300,420,420		
300	JP1=J+1		
	JL=JJ		
	LI=J1		
	DO 400 L=JP1,IM1		
	JL=JL+1		
	LI=LI+N-1+1		
400	A(JJ)=A(JJ)+A(JL)*A(LI)		
420	A(JJ)=-A(JJ)/A(II)		

```

      JI=JI+N-1
500  JJ=JI+N-1+1
      IF(1-N)600,900,900
600  IP1=I+1
      IJ=II
      DO 700 J=IP1,N
      IJ=IJ+1
700  A(IJ)=A(IJ)/A(II)
900  A(II)=1.0/A(II)
1000 IM=I
      II=1
      DO 2000 I=1,N
      JJ=II
      IJ=II
      DO 1400 J=1,N
      A(IJ)=A(IJ)*A(JJ)
      JP1=J+1
      IF(JP1-N)1100,1100,1400
1100 II=IJ
      JL=JJ
      DO 1200 I=JP1,N
      IL=II+1
      JL=JI+1
1200 A(IJ)=A(IJ)+A(IL)*A(JL)
      JJ=JI+1
1400 IJ=I.I+1
2000 II=I.I
      CALL ECLOCK(IT2)
      TIME = FLOAT(IT2-IT1)/64000.
      WRITE(6,3000) TIME
3000 FORMAT(1H0 39H THE TIME ELAPSED FOR MATRIX INVERSION = E12.4,1X,7HS
1ECONDS)
      RETURN
      END

```

1 FORTRAN DECK

CDIVID

C N=NO. OF NORMAL DISPLACEMENTS

C M=NO. OF ROTATIONAL D.O.F.

C NTPE-CONTAINS STIFFNESS (OR MASS) MATRIX

C MTPE-K12 (M12) STORED

C ITPE-K11 (M11) STORED

C A- DUMMY STORAGE VECTOR, LARGER OF $(N*(N+1)/2$ OR $M*(M+1)/2$

SUBROUTINE DIVID (N,M,NTPE,MTPE,ITPE,A,B)

DIMENSION A(1),B(1)

REWIND ITPE

REWIND NTPE

REWIND MTPE

NMAX=N*(N+1)/2

MMAX=M*(M+1)/2

NM=N+M

ICNT=0

DO 10 I=1,N

II=NM-I+1

READ(NTPE) (B(J),J=1,II)

ID=II-M

DO 20 J=1,ID

ICNT=ICNT+1

20 A(ICNT)=B(J)

ID1=ID+1

JCNT=0

DO 30 J=ID1,II

JCNT=JCNT+1

30 B(JCNT)=B(J)

WRITE(MTPE) (B(J),J=1,M)

10 CONTINUE

WRITE(ITPE) (A(J),J=1,NMAX)

REWIND MTPE

REWIND ITPE

ID=0

ICNT=0

DO 50 I=1,M

II=M-ICNT

READ(NTPE) (B(J),J=1,II)

ICNT=ICNT+1

DO 60 J=1,II

ID=ID+1

60 A(ID)=B(J)

50 CONTINUE

RETURN

END

```

*      FORTRAN DECK
CFIGMAT      FOR CONSYN
C      THIS SUBROUTINE FINDS THE EIGENVALUES AND EIGENVECTORS FOR
C      SYMMETRIC MASS AND STIFFNESS MATRICES.
C      THE ARGUMENTS ARE--
C      N- ORDER OF MATRICES.
C      A- DUMMY VECTOR WITH DIMENSION IN MAIN PROGRAM OF  $N*(N+1)/2$ 
C      VALU- STORAGE FOR EIGENVALUES. MUST BE DIMENSIONED IN THE MAIN
C            PROGRAM AS A VECTOR OF LENGTH NEIG.
C      TEMP,B,C,D,- DUMMY VECTORS WITH DIMENSION OF N IN MAIN PROGRAM.
C      E- DUMMY ARRAY WITH DIMENSIONS OF (N,3) IN MAIN PROGRAM.
C      IDUM- DUMMY INTEGER VECTOR WITH DIMENSION OF N IN MAIN PROGRAM.
C      MTAPE- TAPE WHERE STIFFNESS MATRIX IS STORED IN COMPACT FORM.
C      NTAPE- TAPE WHERE MASS MATRIX IS STORED IN COMPACT FORM.
C      JTAPE,ITAPE- SCRATCH TAPES.
C      NEIG- NUMBER OF EIGENVALUES DESIRED.
C      NVEC- NUMBER OF EIGENVECTORS DESIRED. MUST BE EQUAL TO OR LESS
C            THAN NEIG.
C      THE MASS AND STIFFNESS MATRICES ARE STORED IN COMPACT FORM AS
C      VECTORS. ONLY THE UPPER TRIANGLE OF THESE MATRICES(BY ROWS) IS
C      STORED.
C      SUBROUTINE FIGMAT(N,A,VALU,TEMP,B,C,D,E,IDUM,MTAPE,NTAPE,JTAPE,
1 ITAPE,NEIG,NVEC,NMTAPE)
C      DIMENSION A(1),TEMP(1),VALU(1),R(1),C(1),D(1),E(N,3),IDUM(1)
C      DOUBLE PRECISION SUM,SUM1
C      INTEGER OUT
C      OUT=6
C      REWIND ITAPE
C      REWIND JTAPE
C      REWIND NTAPE
C      REWIND MTAPE
C      REWIND NMTAPE
C      M=2*N
C      NMAX=N*(N+1)/2
C * * * * *
C      STEP 1
C      READ IN M BY ROWS IN COMPACTED FORM
C      REPLACE M BY (L)TRANSPOSE, WHERE  $M=L*(L)TRANSPOSE$ , SAVE M ON NMTAPE
C      CALCULATE FIRST ROW
C      READ (NTAPE) (A(I),I=1,NMAX)
C      WRITE (NMTAPE)(A(I),I=1,NMAX)
C      REWIND NTAPE
5 CONTINUE
C      A(1)=SORT(A(1))
C      DO 10 I=2,N
10 A(I)=A(I)/A(1)
C      CALCULATE ALL THE OTHER ROWS
C      IND=N
C      DO 101 I=2,N
C      IND=IND+1
C      SUM=0.00
C      K1=I-1
C      DO 50 JJ=1,K1
C      MJ=(M-JJ)*(JJ-1)/2+I
50 SUM=SUM+A(MJ)*A(MJ)
C      A(IND)=DSORT(A(IND)-SUM)
C      IF(IND.EQ.NMAX) GO TO 100
C      SUM1=A(IND)
C      K1=I+1
C      DO 99 J=K1,N

```

```

      IND=IND+1
      SUM=0.00
      II=I-1
      DO 60 JJ=1,II
      K=(M-JJ)*(JJ-1)/2
      KI=K+I
      KJ=K+J
60    SUM=SUM+A(KI)*A(KJ)
      A(IND)=(A(IND)-SUM)/SUM1
99    CONTINUE
100   CONTINUE
101   CONTINUE
C     CHECK FOR SINGULAR MASS MATRIX
      DO 102 I=1,N
      KI=(M-I)*(I-1)/2+I
      IF(A(KI).EQ.0.) GO TO 1090
102  CONTINUE
C     THIS COMPLETES STEP 1
C* * * * *
C     STEP 2
C     WRITE (I) TRANSPOSE ON TAPE BY COLUMNS
C     PUT (I) TRANSPOSE INTO TEMPORARY STORAGE (TEMP--A VECTOR)
C     AND THEN WRITE TEMP ON TAPE
      KTAPE=NTAPE
300   IND=0
      DO 340 J=1,N
      DO 330 I=1,J
      IND=IND+1
      MI=(M-I)*(I-1)/2+J
      TEMP(IND)=A(MI)
330   CONTINUE
      WRITE(KTAPE) (TEMP(JJ),JJ=1,IND)
      IND=0
340   CONTINUE
C     THIS COMPLETES STEP 2
C* * * * *
C     STEP 3
C     ((L) TRANSPOSE) INVERSE REPLACES (L) TRANSPOSE IN CORE
C     REPLACEMENT IS DONE BY LAST COLUMN FIRST--WORKING UP THE COLUMN
      DO 410 I=1,N
      IND=(I*(M+3-I))/2-N
410   A(IND)=1./A(IND)
      DO 499 J=2,N
      JJ=(M+2)-J
      DO 490 I=2,JJ
      IND=(M+J+I-3)*(JJ-1)/2
      SUM=0.00
      K1=JJ-I+2
      DO 450 K=K1,JJ
      IDK=IND+K
      MK=(M-K)*(K-1)/2+JJ
450   SUM=SUM+A(IDK)*A(MK)
      IND=IND+JJ
      IDI=IND-I+1
490   A(IND)=-SUM*A(IDI)
499   CONTINUE
C     END OF STEP 3
C* * * * *
C     STEP 4
C     U=((L) TRANSPOSE) INVERSE

```

```

C      WRITE U ON TAPE BY ROWS
C      WRITE(JTAPE) (A(I),I=1,NMAX)
C      FINISHED WITH STEP 4
C * * * * *
C      STEP 5
C      WRITE U ON TAPE BY COLUMNS STARTING WITH THE LAST COLUMN FIRST
C      PUT U (LAST COLUMN FIRST) INTO TEMP AND THEN WRITE ON TAPE
C      IND=0
C      DO 555 K=1,N
C      J=N-K+1
C      DO 550 I=1,J
C      IND=IND+1
C      MI2=(M-I)*(I-1)/2+J
C      TEMP(IND)=A(MI2)
550 CONTINUE
C      WRITE(JTAPE) (TEMP(JJ),JJ=1,IND)
C      IND=0
555 CONTINUE
C      END OF STEP 5
C * * * * *
C      STEP 6
C      FORM KU
C      READ K INTO CORE
C      READ U INTO CORE A COLUMN AT A TIME IN REVERSE ORDER
C      REPLACE K BY KU COLUMN BY COLUMN STARTING WITH THE LAST COLUMN
C      AND WORKING UP THE COLUMN
C      READ(MTAPE) (A(I),I=1,NMAX)
C      REWIND JTAPE
C      DO 690 JJ=1,N
C      J=N+1-JJ
C      READ(JTAPE) (TEMP(IJ),IJ=1,J)
C      DO 690 IJ=1,J
C      I=I+1-IJ
C      SUM=0.00
C      DO 650 K=1,I
C      MK1=(M-K)*(K-1)/2+I
650 SUM=SUM+A(MK1)*TEMP(K)
C      IND=(M-I)*(I-1)/2+J
C      IF(I.EQ.1) GO TO 680
C      K1=(M-I)*(I-1)/2
C      I=I+1
C      DO 660 K=1,J
C      K1K=K1+K
660 SUM=SUM+A(K1K)*TEMP(K)
680 CONTINUE
C      A(IND)=SUM
690 CONTINUE
C      END OF STEP 6
C * * * * *
C      STEP 7
C      FORM((L)INVERSE)*KU
C      KU IS IN CORE
C      READ IN L COLUMN BY COLUMN AND CALCULATE ((L)INVERSE)*KU
C      ROW BY ROW
C      CALCULATE THE FIRST ROW
C      REWIND NTAPE
C      READ(MTAPE) TEMP(1)
C      DO 710 I=1,N
710 A(I)=A(I)/TEMP(1)
C      NOW CALCULATE THE REST OF THE ROWS

```

```

      IND=N
      DO 799 I=2,N
      READ (NTAPE) (TEMP(JJ),JJ=1,I)
      DO 799 J=1,N
      IND=IND+1
      JJ=I-1
      SUM=0.00
      DO 750 K=1,JJ
      MK2=(M-K)*(K-1)/2+J
750 SUM=SUM+TEMP(K)*A(MK2)
799 A(IND)=(A(IND)-SUM)/TEMP(I)
C   STEP 7 IS COMPLETE
C* * * * *
C   STEP 8
C   DETERMINE EIGENVALUES AND EIGENVECTORS OF THE NEW MATRIX
C   CHANGE THE SIGN OF A IN ORDER TO OBTAIN THE SMALLEST
C   EIGENVALUE FIRST
      DO 800 I=1,NMAX
800 A(I)=-A(I)
      CALL BIGMAT(A,VALU,TEMP,B,C,D,E,IDUM,N,NFIB,NVEC,MTAPE)
C   CHANGE VALU BACK
      DO 850 I=1,NFIB
850 VALU(I)=-VALU(I)
C   STEP 8 IS COMPLETE
C* * * * *
C   STEP 9
C   CHANGE EIGENVECTORS BACK
C   READ II INTO CORE BY ROWS
C   READ UNCHANGED EIGENVECTORS INTO CORE ONE AT A TIME
C   CHANGE AND PRINT EIGENVECTORS
      IF(NVEC.FQ.0) GO TO 2000
      WRITE(OUT,4001)
      REWIND ITAPE
      READ(ITAPE) (A(I),I=1,NMAX)
      REWIND MTAPE
      REWIND ITAPE
      DO 999 JJ=1,NVEC
      READ(MTAPE) (TEMP(I),I=1,N)
      IND=0
      DO 910 I=1,N
      SUM=0.00
      DO 909 J=1,N
      IND=IND+1
909 SUM=SUM+A(IND)*TEMP(J)
910 TEMP(I)=SUM
C   NORMALIZE THE EIGENVECTOR
      SUM=TEMP(1)
      DO 939 II=2,N
      IF(ABS(SUM)-ABS(TEMP(II))) 938,939,939
938 SUM=TEMP(II)
939 CONTINUE
      IF(SUM) 940,947,940
940 CONTINUE
      DO 941 II=1,N
      TEMP(II)=TEMP(II)/SUM
941 CONTINUE
947 CONTINUE
      WRITE (ITAPE)(TEMP(I),I=1,N)
999 WRITE(OUT,4000) JJ,VALU(JJ),(TEMP(I),I=1,N)
C   STEP 9 IS COMPLETE

```

```

C*****
GO TO 2000
4000 FORMAT(1H0 2X,18HEIGENVECTOR NUMBER 15/12X,17H CORRESPONDING TO
11PF15.7/(1H 2X,1P6E15.7))
4001 FORMAT(1H1 2X,42HEIGENVALUES AND EIGENVECTORS OF THE SYSTEM ///)
4002 FORMAT(1H1,38X,27HTHE MASS MATRIX IS SINGULAR ///)
1090 WRITE(OUT,4002)
2000 RETURN
END

```

```

$      FORTRAN DECK
CZROMAK      GENERATES REDUCED STIFFNESS MATRIX FOR CONSYM
C
C      D IS A DUMMY VECTOR WITH STORAGE N OR M (LARGER)
C      A IS A DUMMY VECTOR WITH STORAGE  $N*(N+1)/2$  OR  $M*(M+1)/2$  (LARGER)
C      B IS A DUMMY VECTOR WITH STORAGE N OR M (LARGER)
C      C IS A DUMMY VECTOR WITH STORAGE N OR M (LARGER)
C      N=NO. OF NORMAL DISPLACEMENTS
C      M=NO. OF ROTATIONAL D.O.F.
C      NTPE CONTAINS K11 MATRIX
C      MTPE CONTAINS K12 MATRIX
C      ITPE SCRATCH TAPE
C      KTPE STORES  $K12*K22*(-1)$ 
C      A INITIALLY CONTAINS K22
C*** REDUCED STIFFNESS MATRIX IS STORED ON ITPE
SUBROUTINE ZROMAK(A,B,C,D,N,M,NTPE,MTPE,ITPE,KTPE)
DIMENSION A(1),B(1),C(1),D(1)
DOUBLE PRECISION SUM,DP1,DP2
CALL SYMINV( A,M)
REWIND MTPE
REWIND ITPE
REWIND NTPE
REWIND KTPE
NMAX=N*(N+1)/2
MMAX=M*(M+1)/2
DO 10 KK=1,N
READ(MTPE) (B(I),I=1,M)
ICNT=0
DO 1000 IK=1,M
JJ=IK
JK=IK
DO 20 J=JJ,M
ICNT=ICNT+1
20 C(I)=A(ICNT)
JJ=J,I-1
JA=M
ID=IK
DO 30 J=1,JJ
IF(JJ.EQ.0) GO TO 30
C(I)=A(ID)
JA=JA-1
ID=ID+JA
30 CONTINUE
SUM=0.000
DO 50 J=1,M
DP1=R(J)
DP2=C(J)
50 SUM=SUM+DP1*DP2
D(JK)= SUM
1000 CONTINUE
WRITE (ITPE) (D(J),J=1,M)
WRITE (KTPE) (D(J),J=1,M)
10 CONTINUE
REWIND ITPE
REWIND MTPE
REWIND NTPE
REWIND KTPE
READ (NTPE) (A(J),J=1,NMAX)
ICNT=0
DO 60 KK=1,N

```

```

      READ (ITPE) (D(J),J=1,M)
      KI=KK
      DO 70 KJ=1,N
      READ(MTPE)(C(J),J=1,M)
      KP=KJ
      IF(KP.LT.KI) GO TO 70
      SUM=0.0D0
      DO 80 KR=1,M
      DP1=D(KR)
      DP2=C(KR)
80    SUM=SUM +DP1*DP2
      ICNT=ICNT+1
      SM=SUM
      A(ICNT)=A(ICNT)-SM
70    CONTINUE
      REWIND MTPE
60    CONTINUE
      REWIND NTPE
      REWIND MTPE
      REWIND ITPE
      WRITE(ITPE) (A(I),I=1,NMAX)
      REWIND ITPE
      RETURN
      END

```

```

S      FORTRAN DECK
CZROMAN
C      N=NO. OF NORMAL DISPLACEMENTS
C      M=NO. OF ROTATIONAL D.O.F.
C      NTPE CONTAINS M11 MATRIX
C      MTPE CONTAINS M12 MATRIX
C      ITPE SCRATCH TAPE
C      KTPE CONTAINS K12*K22**(*1)
C***   REDUCED MASS MATRIX IS STORED ON ITPE
        SUPROUTINE ZROMAN(A,B,C,D,N,M,NTPE,MTPE,ITPE,KTPE)
        DIMENSION A(1),B(1),C(1),D(1)
        DOUBLE PRECISION SUM1,SUM2,DP1,DP2,DP3
        NMASS=N
        REWIND MTPE
        REWIND ITPE
        REWIND NTPE
        REWIND KTPE
        NMAX=N*(N+1)/2
        DO 10 KK=1,N
        READ(KTPE) (B(I),I=1,M)
        ICNT=0
        DO 1000 IK=1,M
        JJ=IK
        JK=IK
        DO 20 J=JJ,M
        ICNT=ICNT+1
20      C(J)=A(ICNT)
        JJ=J,I-1
        JA=M
        ID=IK
        DO 30 J=1,JJ
        IF(JJ.EQ.0) GO TO 30
        C(J)=A(ID)
        JA=JA-1
        ID=ID+JA
30      CONTINUE
        SUM1=0.D0
        DO 50 J=1,M
        DP1=R(J)
        DP2=C(J)
50      SUM1=SUM1+DP1*DP2
        D(IK)=SUM1
1000     CONTINUE
        WRITE(ITPE) (D(J),J=1,M)
10      CONTINUE
        REWIND ITPE
        REWIND MTPE
        REWIND NTPE
        REWIND KTPE
        READ(NTPE) (A(J),J=1,NMAX)
        DO 60 KK=1,N
        READ(MTPE) (B(J),J=1,M)
        READ(ITPE) (D(J),J=1,M)
        DO 70 KJ=1,N
        READ(KTPE) (C(J),J=1,M)
        SUM1=0.D0
        SUM2=0.D0
        DO 80 KR=1,M
        DP1=R(KR)
        DP2=D(KR)

```

```

DP3=C(KR)
SUM1=SUM1+DP1+DP3
80 SUM2=SUM2+DP2+DP3
SM1=SUM1
SM2=SUM2
IF(KJ.GE.KK) MH=(2*KJ+(KK-1)*(2*NHASS-KK))/2
IF(KJ.GF.KK) A(MH)=A(MH)+SM1+SM2
IF(KJ.LE.KK) MH=(2*KK+(KJ-1)*(2*NHASS-KJ))/2
IF(KJ.LE.KK) A(MH)=A(MH)+SM1
70 CONTINUE
REWIND KTPE
60 CONTINUE
REWIND NTPE
REWIND MTPE
REWIND ITPE
REWIND KTPE
WRITE(ITPE) (A(I),I=1,NMAX)
REWIND ITPE
RETURN
END

```

```

S      FORTRAN DECK
CPUNC  PUNCHES FULL MATRIX IN (1P6E12.5) FORMAT AND SEQUENCES CARDS
C
C      THE CALL PUNC STATEMENT MUST BE IN A LOOP.
C      EACH ROW STARTS ON A NEW CARD.
C      A IS THE ROW VECTOR TO BE PUNCHED.
C      NS IS THE FIRST ELEMENT OF A TO BE PUNCHED.
C      NE IS THE LAST ELEMENT OF A TO BE PUNCHED.
C      Q IS THE ALPHANUMERIC IDENTIFICATION CODE FOR THE MATRIX.
C      IC IS THE SEQUENCE NUMBER FOR THE FIRST CARD LESS ONE.
C      IC = 0, IF THE FIRST CARD FOR THE MATRIX IS TO BE SEQUENCED 1.
C
C      SUBROUTINE PUNC (A,NS,NE,Q,IC)
C      DIMENSION A(1)
C
1  FORMAT(1P1E12.5,60X,1A4,14)
2  FORMAT(1P2E12.5,48X,1A4,14)
3  FORMAT(1P3E12.5,36X,1A4,14)
4  FORMAT(1P4E12.5,24X,1A4,14)
5  FORMAT(1P5E12.5,12X,1A4,14)
6  FORMAT(1P6E12.5,1A4,14)
C
      NT=NF-NS+1
      N6=NT/6
      NC=N6*6
      N1=NS
      N2=N1+5
      IF(NT.LT.6) GO TO 20
      DO 10 J=1,N6
      IC=IC+1
      PUNCH6,(A(I),I=N1,N2),Q,IC
      N1=N2+1
10  N2=N2+6
      IF(NT.EQ.NC) GO TO 50
20  NO=NT-NC
      IC=IC+1
      GO TO(21,22,23,24,25),NO
21  PUNCH 1,(A(I),I=N1,NE),Q,IC
      GO TO 50
22  PUNCH 2,(A(I),I=N1,NE),Q,IC
      GO TO 50
23  PUNCH 3,(A(I),I=N1,NE),Q,IC
      GO TO 50
24  PUNCH 4,(A(I),I=N1,NE),Q,IC
      GO TO 50
25  PUNCH 5,(A(I),I=N1,NE),Q,IC
50  RETURN
      END

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$      FORTRAN DECK
CRIGMAT
C PRG. AUTHORS M. ELSON AND R. E. FUNDERLIC, CENTRAL DATA PROCESSING, 4, 1, 65 BIGH0003
SUBROUTINE BIGHAT(A, VALU, VALL, UPPERD, DIAG, V, T, INTER, NN, NEIG, NVEC,
1MTAPE)
  DIMENSION A(1), VALU(1), VALL(1), UPPERD(1), DIAG(1), V(1), T(NN,3),
1INTER(1)
  REWIND MTAPE
  NZ=0
  N=NN
  IF(N.LE.2)GO TO 49
  NP1=N+1
  NM1=N-1
  NM2=N-2
  NT2P1=N*2+1
  IX=0
  DO 10 I=1,NM2
    SIGMA2=0.
    IP1=I+1
    DO 1 J=IP1,N
      IJ=IX+J
1 SIGMA2=SIGMA2+A(IJ)**2
    SIGMA=SQRT(SIGMA2)
    II=IX+I
    DIAG(I)=A(II)
    IIP1=IX+I+1
    UPPERD(I)=-SIGN(SIGMA,A(IIP1))
    T(I,2)=SIGMA2
    IF(ABS(SIGMA).GT.ABS(A(IIP1)))GO TO 2
    UPPERD(I)=A(IIP1)
    A(IIP1)=0.
    GO TO 10
2 A(IIP1)=SQRT(1.+ABS(A(IIP1))/SIGMA)
  SQTGAM=-SIGN(SIGMA*A(IIP1),UPPERD(I))
  IP2=I+2
  DO 3 J=IP2,N
    IJ=IX+J
3 A(IJ)=A(IJ)/SQTGAM
  JK1=I*(2*N-1-1)/2
  JX=JK1
  IIX=JK1
  DO 5 J=IP1,N
    VALL(J)=0.
    JK=JK1+J
    DO 4 K=IP1,J
      IK=IX+K
      VALL(J)=VALL(J)+A(JK)*A(IK)
4 JK=JK+N-K
    IF(J.EQ.N)GO TO 6
    CALL LOOP1(J+2,NP1,VALL(J),A(JX),A(IX))
5 JX=JX+N-J
6 DELGAM=0.
  DO 7 J=IP1,N
    IJ=IX+J
7 DELGAM=DELGAM+A(IJ)*VALL(J)
  DGO2=.5*DELGAM
  DO 8 J=IP1,N
    IJ=IX+J
8 T(J,1)=VALL(J)-DGO2*A(IJ)
  DO 9 II=IP1,N

```

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BIGH0055
BIGH0056

BIGH0058

III=IX+11	BIGH0059
CALL L00P2(A(III),A(IX),T(NZ,1),T(II,1),A(III),II+1,NP1)	
0 IIX=IIX+N-11	BIGH0061
10 IX=IX+N-1	BIGH0062
M=N*(N+1)/2	BIGH0063
UPPERD(NM1)=A(M-1)	BIGH0064
T(NM1,2)=UPPERD(NM1)**2	
DIAG(NM1)=A(M-2)	BIGH0066
DIAG(N)=A(M)	BIGH0067
FNORM=AMAX1(ABS(DIAG)+ABS(UPPERD),ABS(DIAG(N))+ABS(UPPERD(NM1)))	BIGH0068
DO 11 I=2,NM1	BIGH0069
FNRTMP=ABS(DIAG(I))+ABS(UPPERD(I))+ABS(UPPERD(I-1))	BIGH0070
11 IF(FNRTMP.GT.FNORM)FNORM=FNRTMP	BIGH0071
DO 12 I=1,NFIG	BIGH0072
VALU(I)=FNORM	BIGH0073
12 VALL(I)=-FNORM	BIGH0074
DO 24 I=1,NFIG	BIGH0075
13 ROOT=.5*(VALU(I)+VALL(I))	BIGH0076
IF(ROOT.EQ.VALL(I).OR.ROOT.EQ.VALU(I))GO TO 24	BIGH0077
NAGREE=0	BIGH0078
PM2=0.	BIGH0079
PM1=1.	BIGH0080
DO 21 J=1,N	BIGH0081
IF(PM2.NF.0.)GO TO 15	BIGH0082
14 PM1=SIGN(1.,PM1)	BIGH0083
GO TO 17	BIGH0084
15 IF(PM1.NF.0.0) GO TO 17	
16 P=-SIGN(1.,PM2)	BIGH0086
PM2=0.	BIGH0087
IF(T(J-1,2)) 18,14,18	
17 P=DIAG(J)-ROOT-T(J-1,2)*PM2/PM1	BIGH0090
PM2=1.	BIGH0091
18 IF(P)21,19,20	BIGH0092
19 PM2=PM1	BIGH0093
IF(PM2)21,20,20	BIGH0094
20 NAGREE=NAGREE+1	BIGH0095
21 PM1=P	BIGH0096
DO 23 J=1,NFIG	BIGH0097
IF(J.LE.NAGREE)GO TO 22	BIGH0098
IF(VALU(J).LE.ROOT)GO TO 13	BIGH0099
VALU(J)=ROOT	BIGH0100
GO TO 23	BIGH0101
22 VALL(J)=ROOT	BIGH0102
23 CONTINUE	BIGH0103
GO TO 13	BIGH0104
24 CONTINUE	
IF(NVEC.EQ.0)GO TO 49	BIGH0106
EPSLON=ENORM*1.E-8	BIGH0107
COMPL1=COMPL(1)	
DO 48 I=1,NVEC	BIGH0109
DO 25 J=1,N	BIGH0110
V(I)=1.	BIGH0111
T(I,2)=DIAG(J)-VALU(I)	BIGH0112
IF(J.EQ.N)GO TO 26	BIGH0113
T(I,3)=UPPERD(J)	BIGH0114
25 T(I+1,1)=UPPERD(J)	BIGH0115
26 T(N,3)=0.	BIGH0116
DO 29 J=1,N	BIGH0117
IF(ABS(T(J,2)).LT.1.E-17)T(J,2)=EPSLON	BIGH0118
T(I,1)=T(J,2)	

```

T(J,2)=T(J,3)
T(J,3)=0.
IF(J.EQ.N)GO TO 30
INTER(J)=0
JP1=J+1
IF(ABS(T(JP1,1)).LE.ABS(T(J,1)))GO TO 28
INTER(J)=1
DO 27 K=1,3
TEMP=T(J,K)
T(J,K)=T(JP1,K)
27 T(JP1,K)=TEMP
28 THULTP=T(JP1,1)/T(J,1)
VALL(J)=OR(INTER(J),AND(THULTP,COMPL1))
T(JP1,2)=T(JP1,2)-THULTP*T(J,2)
29 T(JP1,3)=T(JP1,3)-THULTP*T(J,3)
30 ITER=1
31 DO 32 J=1,N
L=N+1-J
32 V(I)=(V(L)-T(L,2)*V(L+1)-T(L,3)*V(L+2))/T(L,1)
VNORM=0.
DO 33 L=1,N
33 VNORM=VNORM+V(L)**2
VNORM=SQRT(VNORM)
DO 34 J=1,N
34 V(I)=V(J)/VNORM
IF(ITER.FQ.2)GO TO 36
ITER=2
DO 35 L=2,N
LM1=L-1
TRY=VALL(LM1)
IF(AND(TRY,1).EQ.0) GO TO 35
VTEMP=V(LM1)
V(LM1)=V(L)
V(L)=VTEMP
35 V(L)=V(L)-VALL(LM1)*V(LM1)
GO TO 31
36 IF(VNORM.EQ.0.)V(I)=1.
IIX=(N*N-N-6)/2
DO 37 KK=1,NM2
IIP1=N-KK
UTV=0.
CALL LOOP3(UTV,A(IIX),V(NZ),IIP1+1,NP1)
CALL LOOP4(A(IIX),V(NZ),NP1,IIP1+1,UTV)
37 IIX=IIX+IIP1-N-2
WRITE(MTAPE) (V(ICH),ICH=1,N)
48 CONTINUE
49 RETURN
END

```

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BIGM0123
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BIGM0125
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\$ FORTRAN DECK

CLOOP1

```
SUBROUTINE LOOP1(JP2, NP1, SGAMPJ, AJX, AIX)
  DIMENSION AJX(1), AIX(1)
  DO 1 L=JP2, NP1
1  SGAMPJ=SGAMPJ+AJX(L)*AIX(L)
  RETURN
END
```

BIGH0167
BIGH0168
BIGH0169
BIGH0170
BIGH0171

\$ FORTRAN DECK

CLOOP2

```
SUBROUTINE LOOP2(AIIX, AIX, S, SI, AIII, IIP1, NP1)
  DIMENSION AIIX(1), AIX(1), S(1)
  DO 2 JJ=IIP1, NP1
2  AIIX(JJ)=AIIX(JJ)-AIII*S(JJ)-SI*AIX(JJ)
  RETURN
END
```

BIGH0174
BIGH0175
BIGH0176
BIGH0177
BIGH0178

\$ FORTRAN DECK

CLOOP3

```
SUBROUTINE LOOP3(UTV, AIIX, V, IIP2, NP1)
  DIMENSION AIIX(1), V(1)
  DO 3 J=IIP2, NP1
3  UTV=UTV+AIIX(J)*V(J)
  RETURN
END
```

BIGH0181
BIGH0182
BIGH0183
BIGH0184
BIGH0185

\$ FORTRAN DECK

CLOOP4

```
SUBROUTINE LOOP4(AIIX, V, NP1, IIP2, UTV)
  DIMENSION AIIX(1), V(1)
  DO 4 K=IIP2, NP1
4  V(K)=V(K)-AIIX(K)*UTV
  RETURN
END
```

BIGH0188
BIGH0189
BIGH0190
BIGH0191
BIGH0192

```

*      FORTRAN DECK
CGENA      GENERATES THE GENERALIZED AERODYNAMIC FORCES
C           FOR THE SYSTEM FROM AIC MATRICES
C           KKDISE CONTAINS XF - TRANSFORMED SYSTEM MODE SHAPES FOR COMPONENTS
C           MADISC CONTAINS THE AIC MATRIX FOR EACH COMPONENT
C           MTDISC - SCRATCH TAPE
C           GAC - GENERALIZED AERODYNAMIC FORCES FOR EACH COMPONENT.
C           GA - GENERALIZED AERODYNAMIC FORCES FOR THE SYSTEM.
C
C           SUBROUTINE GENA (KKDISC,MADISC,MTDISC,VEL,NCOMP,MODE,NCUP,NAT,NV,
1NRFDU,AP,AIC,XF,XFT,B)
C
C           DIMENSION NRFDU(1),XFPT(9,4),XFP(4,9),XF(97,9),GAC(9,18),GA(9,18),
1B(1),VEL(1),XFA(9,18),AIC(40,80),XFT(9,97),AP(4,8),AC(40,80)
C
1  FORMAT(/// 1X,40HGENERALIZED AERODYNAMIC FORCES FOR 1/K = 1P1E11.4
1/)
2  FORMAT(1H0 /(2E16.8,1X,2E16.8,1X,2E16.8,1X,2E16.8))
M2=2*MODE
DATA Q1/4HGENA/
REWIND MADISC
DO 200 K=1,NV
REWIND KKDISE
READ(MADISC)VEL(K)
WRITE(6,1)VEL(K)
DO 175 JA=1,MODE
DO 175 KA=1,M2
175 GA(JA,KA)=0.0
DO 198 I=1,NCOMP
IF(I.EQ.NCUP+1)GO TO 198
N=NRFDU(I)
M2=2*N
DO 176 JA=1,MODE
DO 176 KA=1,M2
176 GAC(JA,KA)=0.0
READ(KKDISE)((XF(M,L),L=1,MODE),M=1,N)
IF(NAT.EQ.2) GO TO 191
C           PARTITIONED AIC MATRICES (FROM STRIP OR PISTON THEORIES)
READ(MADISC) NPART
NSF=0
NSS=1
DO 190 J=1,NPART
READ(MADISC) NS,NS2
READ(MADISC)((AP(JJ,KK),KK=1,NS ),JJ=1,NS)
NSF=NSF+NS
DO 185 NF=1,MODE
LF=0
DO 185 MF=NSS,NSF
LF=LF+1
185 XFP(LF,NF)=XF(MF,NF)
NSS=NSF+1
DO 186 JA=1,NS
DO 186 KA=1,MODE
186 XFPT(KA,JA)=XFP(JA,KA)
CALL CMULT(XFPT,AP,XFP,XFA,4,4,8,MODE,NS,NS2)
DO 180 JA=1,MODE
DO 180 KA=1,M2
180 GAC(JA,KA)=GAC(JA,KA)+XFA(JA,KA)
190 CONTINUE
GO TO 196

```

```

191 IF(NCOUP.EQ.1) GO TO 250
C FULL AIC MATRICES (FROM KERNEL FUNCTION OR MACH BOX THEORIES)
DO 193 JA=1,N
193 READ(MADISC)(AIC(JA,KA),KA=1,N2)
DO 194 JA=1,N
DO 194 KA=1,MODE
194 XFT(KA,JA)=XF(JA,KA)
CALL CMULT(XFT,AIC,XF,GAC,97,40,80,MODE,N,N2)
GO TO 196
C OPTION FOR AERODYNAMIC COUPLING BETWEEN TWO COMPONENTS
250 II=I+1
N=NREDU(I)+NREDU(II)
N2=2*N
DO 251 JA=1,N
251 READ(MADISC)(AIC(JA,KA),KA=1,N2)
NC=NREDU(I)
NC2=2*NC
NCC=NREDU(II)
NCC2=2*NCC
NCC3=NC2+1
NCC4=NC+1
REWIND MTDISC
DO 275 JK=1,4
GO TO(352,355,357,361),JK
352 DO 252 JA=1,NC
DO 252 KA=1,NC2
252 AC(JA,KA)=AIC(JA,KA)
DO 253 JA=1,NC
DO 253 KA=1,MODE
253 XFT(KA,JA)=XF(JA,KA)
CALL CMULT(XFT,AC,XF,XFA,97,40,80,MODE,NC,NC2)
WRITE(MTDISC)((XF(JA,KA),KA=1,MODE),JA=1,NC)
GO TO 362
355 DO 255 JA=1,NC
DO 255 KA=NCC3,N2
LA=KA-NCC3+1
255 AC(JA,LA)=AIC(JA,KA)
READ(KKDISC)((XF(M,L),L=1,MODE),M=1,NCC)
CALL CMULT(XFT,AC,XF,XFA,97,40,80,MODE,NC,NCC2)
WRITE(MTDISC)((XF(JA,KA),KA=1,MODE),JA=1,NCC)
GO TO 362
357 REWIND MTDISC
DO 258 JA=1,NCC
DO 258 KA=1,MODE
258 XFT(KA,JA)=XF(JA,KA)
READ(MTDISC)((XF(JA,KA),KA=1,MODE),JA=1,NC)
DO 259 JA=NCC4,N
LA=JA-NCC4+1
DO 259 KA=1,NC2
259 AC(LA,KA)=AIC(JA,KA)
CALL CMULT(XFT,AC,XF,XFA,97,40,80,MODE,NCC,NC2)
GO TO 362
361 READ(MTDISC)((XF(JA,KA),KA=1,MODE),JA=1,NCC)
DO 261 JA=NCC4,N
LA=JA-NCC4+1
DO 261 KA=NCC3,N2
LB=KA-NCC3+1
261 AC(LA,LR)=AIC(JA,KA)
CALL CMULT(XFT,AC,XF,XFA,97,40,80,MODE,NCC,NCC2)
362 DO 262 JA=1,MODE

```

```

      DO 262 KA=1,M2
262  GAC(JA,KA)=GAC(JA,KA)+XFA(JA,KA)
275  CONTINUE
196  DO 197 JA=1,MODE
      DO 197 KA=1,M2
197  GA(JA,KA)=GA(JA,KA)+GAC(JA,KA)
198  CONTINUE
      IC=0
      DO 199 JA=1,MODE
        WRITE(6,2)(GA(JA,KA),KA=1,M2)
        DO 192 KA=1,M2
192  R(KA)=GA(JA,KA)
        CALL PUNC (R,1,M2,Q1,IC)
199  CONTINUE
200  CONTINUE
      RETURN
      END

```

4.0

MOFA~ MODAL FLUTTER ANALYSIS PROGRAM

4.1

Theoretical Development

The flutter problem can be solved with either a collocation or normal-mode formulation. The collocation approach is attractive if an accurate stiffness and aerodynamic influence coefficient matrix can be generated for the system. The normal-mode method merits consideration when mode shapes and natural frequencies for the structure are known.

The equations of motion, in matrix notation, for a lumped parameter, linear system acted upon by aerodynamic forces is

$$[m] \ddot{\{h\}} + [k] \{h\} = \{F_a\} \quad (4.1.1)$$

where $[m]$ = symmetric mass matrix

$[k]$ = symmetric stiffness matrix

$\{h\}$ = control point deflection

$\{F_a\}$ = aerodynamic force

The aerodynamic force matrix can be defined as a complex matrix of oscillatory aerodynamic influence coefficients such that

$$\{F_a\} = \rho \omega^2 b_r^2 s [C_h] \{h\} \quad (4.1.2)$$

where ρ = air density

ω = oscillatory frequency, rad/sec

b_r = reference semi-chord

s = reference semi-span

$[C_h]$ = aerodynamic influence

coefficient matrix

Assuming harmonic motion, $\{h\} = \{\bar{h}\} e^{i\omega t}$, the equations of motion become

$$-\omega^2 [m] \{\bar{h}\} + [k] \{\bar{h}\} = \rho \omega^2 b_r^2 s [C_h] \{\bar{h}\} \quad (4.1.3)$$

The collocation method solves the flutter problem with the equations of motion cast in this form.

For the modal approach, the equations of motion can be uncoupled with the linear transformation

$$\{\bar{h}\} = [\phi] \{\psi\} \quad (4.1.4)$$

where $[\phi]$ is the modal matrix and $\{\psi\}$ the normal coordinates. Substituting Equation (4.1.4) into Equation (4.1.3) and premultiplying both sides of the resulting equation by $[\phi]^T$, we obtain

$$-\omega^2 [\phi]^T [m] [\phi] \{\psi\} + [\phi]^T [k] [\phi] \{\psi\} = \rho \omega^2 b_r^2 s [\phi]^T [C_h] [\phi] \{\psi\} \quad (4.1.5)$$

By virtue of the orthogonality of the modal matrix with respect to the mass and stiffness matrix, $[\phi]^T [m] [\phi]$ and $[\phi]^T [k] [\phi]$ become diagonal matrices. With the following definitions

$$\begin{aligned} [\bar{M}] &= [\phi]^T [m] [\phi] = \text{generalized mass matrix} \\ [\bar{K}] &= [\phi]^T [k] [\phi] = \text{generalized stiffness matrix} \\ [\bar{Q}] &= \rho \omega^2 b_r^2 s [\phi]^T [C_h] [\phi] = \text{generalized force matrix} \\ [\bar{Q}] &= \rho b_r^2 s [\phi]^T [C_h] [\phi] \end{aligned}$$

Equation (4.1.5) can be written as

$$([\bar{M}] + [\bar{Q}] - \frac{1}{\omega^2} [\bar{K}]) \{\psi\} = 0 \quad (4.1.6)$$

Equation (4.1.6) can be written in a slightly different form by noting the generalized stiffness matrix can be expressed in terms of the generalized masses and natural frequencies of the structure. If $[\omega_n^2]$ is a diagonal matrix of natural frequencies squared, $\text{rad}^2/\text{sec}^2$, then

$$[\bar{K}] = [\omega_n^2] [\bar{M}] \quad (4.1.7)$$

and equation (3.2.6) becomes

$$([\bar{M}] + [\bar{Q}] - \frac{1}{\omega^2} [\omega_n^2] [\bar{M}]) \{\psi\} = 0 \quad (4.1.8)$$

Adding artificial structural damping, g , to the system of equations, we arrive at the classical normal-mode formulation of the flutter problem:

$$([\bar{M}] + [\bar{Q}] - \frac{1+ig}{\omega^2} [\omega_n^2] [\bar{M}]) \{\psi\} = 0 \quad (4.1.9)$$

or

$$([\bar{M}] + [\bar{Q}] - \lambda [\omega_n^2] [\bar{M}]) \{\psi\} = 0 \quad (4.1.10)$$

Equation (4.1.10) can be solved for the complex eigenvalue λ and complex eigenvector $\{\psi\}$. From the complex eigenvalue ($\lambda = \lambda_{\text{real}} + i \lambda_{\text{imag}}$) the flutter frequency is

$$\omega_f = \frac{1}{\sqrt{\lambda_{\text{real}}}} \quad (4.1.11)$$

and the artificial structural damping is

$$g = \frac{\lambda_{\text{imag}}}{\lambda_{\text{real}}} \quad (4.1.12)$$

4.2 Program Description

The notation used in the computer program HOFA for Equation 4.1.9 or 4.1.10 is:

$$\left[M_{ij} + F B_{ij} - \lambda_i P_{ii} \right] \{ Q_i \} = 0 \quad 4.2.1$$

or

$$\left[A_{ij} - \lambda_i P_{ii} \right] \{ Q_i \} = 0 \quad 4.2.2$$

where:

- n = number of generalized coordinates (Max 20)
- i = row index, $1 \leq i \leq n$
- j = column index, $1 \leq j \leq n$
- M_{ij} = generalized mass matrix
- B_{ij} = generalized aerodynamic force matrix
- A_{ij} = sum of mass and aero-matrices
- P_{ii} = diagonal stiffness parameter matrix = $M_{ii} \left(\frac{W_i}{W_r} \right)^2$
- F = factor for aero matrix
- W_i = modal frequency
- W_r = reference frequency, usually W_1 or W_n

The sum of mass and aero-matrices, A_{ij} or the generalized mass M_{ij} , and the generalized force B_{ij} , must be input. The stiffness parameter P_{ii} may be input or computed by inputting ω_i , the modal frequencies and the diagonal generalized mass matrix M_{ii} (if the generalized mass M_{ij} is not input). In addition to the complex Eigenvalues, the program computes the following:

- λ = Eigenvalues = $\lambda_{\text{real}} + i \lambda_{\text{imag}}$
- ω_f = flutter frequencies = $W_r / \sqrt{(\lambda_{\text{real}})}$
- g = artificial structural damping = $\lambda_{\text{imag}} / \lambda_{\text{real}}$
- V = flutter velocity = $\omega_f \times \text{ref. chord} / \text{Strouhal No.}$

A vibration analysis may be performed by entering zero aerodynamic forces, and zeros for all parameters associated with determining the aerodynamic forces.

4.2.1 PROCESSING INFORMATION

- A. Operation~Standard FORTRAN IV Processor System operable on the GE 635 computer.
- B. Core Storage - The program MOFA requires a minimum of 20,000 memory units for execution.
- C. Tape Units - Standard input and output tapes.

4.3 Input Instructions

The following instructions describe the input data, the physical units and the input format to be used.

Title Cards - 2 title cards are required at beginning of each computer run.

Item 1 Control Card Format (15I3)

Column	1-3	4-6	7-9	10-12	13-15	16-18	19-21
Name	W_r	b_r	NDEGA	M_{ij}	M_{ii}	W_i	P_{ii}
Field	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Column	22-24	25-27	28-30	31-33	34-36	37-39	40-42	42-45
Name	NOK	F	B_{ij}	A_{ij}				
Field	(8)	(9)	(10)	(11)				

- (1) Input Reference Frequency
 $W_r = 1 \sim \text{Input}$
 $0 \sim \text{No Input}$
- (2) Input Reference Semi-Chord
 $b_r = 1 \sim \text{Input}$
 $0 \sim \text{No Input}$
- (3) NDEGA Number of modes to be used in the analysis, generalized coordinates (Max 20)
- (4) Input Coupled Generalized Mass
 $2 \sim \text{Input, all real elements}$
 $M_{ij} = 1 \sim \text{Input, both real and imaginary elements}$
 $0 \sim \text{No Input}$
- (5) Input Uncoupled Generalized Mass
 $2 \sim \text{Input, all real elements}$
 $M_{ii} = 1 \sim \text{Input, both real and imaginary elements}$
 $0 \sim \text{No Input}$
 M_{ii} must equal zero if $M_{ij} = 1$ or 2
- (6) Input Modal Frequencies
 $W_i = 1 \sim \text{Input}$
 $0 \sim \text{No Input}$
- (7) Input Stiffness Parameter
 $P_{ii} = 2 \sim \text{to be computed. In Item 1, (1), (4) or (5), and (6) must be input or available in core from previous problem}$
 $= 1 \sim \text{Input}$
 $= 0 \sim \text{No Input}$

- (8) Input Reduced Velocity
 NOK = 1~Input
 0~No Input (Vibration Analysis)
- (9) Input Factor for Aero Matrix
 F = 1~Input
 0~No Input
- (10) Input Aero Matrix
 2~Input, by rows loaded in a continuous manner (to accommodate the output from programs in Vol. II)
 B_{ij} = 1~Input, by rows - each row starts on a new card
 0~No Input
- (11) Input Sum of Mass & Aerodynamic Matrices
 2~to be computed. In Item 1, (4) or (5) (9), and (10) must be input of available in case from previous problem
 A_{ij} = 1~Input
 0~No Input

Item 2. Reference Frequency, ω_r , Format 1E12.8

Column	1-12	
Name	ω_r	
Field	(1)	

ω_r must equal the value used when computing the unsteady generalized aerodynamic forces (RAD/SEC).

Item 3. Reference semi-chord, b_r , Format 1E12.8

Column	1-12	
Name	b_r	
Field	(1)	

b_r must be same units used in calculating aerodynamics

Item 4. Coupled Generalized Mass Format 6E12.8

If in Item 1, $M_{ij} = 1$, use the following format

Column	1-12	13-24	25-36	37-48	49-60	61-72	
Name	$ReM_{1,1}$	$IM_{1,1}$	$ReM_{1,2}$	$IM_{1,2}$		$IM_{1,NDEGA}$	
Field	(1)	(2)	(3)	(4)	(5)	(6)	

Continued on next card if $NDEGA > 6$

Start each row on a new card

$ReM_{i,j}$ = The Real Part of $M_{i,j}$

$IM_{i,j}$ = The Imaginary Part of $M_{i,j}$ (pseudo-IM = 0.0 in all cases)

If in Item 1, $M_{ij} = 2$, use the following format

Column	1-12	13-24	25-36		61-72	
Name	$M_{1,1}$	$M_{1,2}$	$M_{1,3}$		$M_{1,NDEGA}$	

All mass elements are real numbers. Continue on next card
if $NDEGA > 6$. Start each row on a new card.

Item 5. Uncoupled Generalized Mass Format 6E12.8
If in Item 1 $M_{i,i} = 1$, use the following format

Column	1-12	13-24	25-36	37-48	49-60	61-72	
Name	$ReM_{1,1}$	$IM_{1,1}$	$ReM_{2,2}$	$IM_{2,2}$	'''	$IM_{1,i}$	
Field	(1)	(2)	(3)	(4)	(5)	(6)	

$i = 1, 2, \dots, NDEGA$

Continued on next card if necessary

$ReM_{i,i}$ = The Real Part of $M_{i,i}$

$IM_{i,i}$ = The Imaginary Part of $M_{i,i}$ (pseudo-IM = 0.0 in all cases)

If in Item 1, $M_{i,i} = 2$, use the following format

Column	1-12	13-24	25-36		61-72	
Name	$M_{1,i}$	$M_{2,2}$	$M_{3,3}$	'''	$M_{1,i}$	

Item 6. Modal Frequencies Format 6E12.8 (RAD/SEC)

Column	1-12	13-24	25-36	37-48	49-60	61-72	
Name	W_1	W_2	'''	'''	'''	W_{NDEGA}	
Field	(1)	(2)	(3)	(4)	(5)	(6)	

Continued on next card if necessary

Item 7.

Column	1-12	13-24	25-36	37-48	49-60	61-72	
Name	$ReP_{1,1}$	$IP_{1,1}$	$ReP_{2,2}$	$IP_{2,2}$	'''	IP_{ii}	
Field	(1)	(2)	(3)	(4)	(5)	(6)	

$ReP_{i,i}$ is the Real Part of $P_{i,i}$

$IP_{i,i}$ is the Imaginary Part of $P_{i,i}$ (pseudo-IP = 0.0 in all cases)

where $i = 1, 2, \dots, NDEGA$

Continue on next card if necessary until $IP_{1,NDEGA}$ is entered

Item 8. Reduced Velocity, Format 1E12.8

Column	1-12	
Name	1/K	
Field	(1)	

1/K = Reciprocal of reduced frequency used in calculating the unsteady aerodynamic generalized forces

Item 9. Aero Matrix Factor Format 1E12.8

F = Nondimensionalizing factor, $F \neq 0$

Column	1-12	
Name	F	
Field	(1)	

F depends on method used to calculate aerodynamics.

If the programs presented in Volume II are used, $F = 1/n\omega^{-2}$

where $n = 1$ when the generalized mass matrix is calculated for the entire vehicle (nonsymmetrical mode shapes)

$n = 2$ when the generalized mass matrix is calculated for one half the vehicle (symmetrical or anti-symmetrical mode shapes)

$n = 4$ when the generalized mass matrix is calculated for 1/4 the vehicle (anti-symmetrical mode shapes of cruciform planforms).

If the generalized aerodynamic forces are obtained from COMSYN, F = the non-dimensionalizing factor for the aerodynamics, equals

$b_r^2 s$, where s is the semi-span.

NOTE: The air density, ρ , should be included in F for altitude variation, if not already considered in the aerodynamics. (Length units should be consistent with b_r .)

Item 10. Generalized Aerodynamic Force Matrix Format 6E12.8
Input by Rows

Column	1-12	13-24	25-36	37-48	49-60	61-72	
Name	$ReB_{1,1}$	$IB_{1,1}$	$ReB_{1,2}$	$IB_{1,2}$	...	...	
Field	(1)	(2)	(3)	(4)	(5)	(6)	

$ReB_{i,j}$ = The Real Part of $B_{i,j}$

$IB_{i,j}$ = The Imaginary Part of $B_{i,j}$

Continue on next card if necessary until $IB_{1,NDEGA}$ is entered

Start each row on a new card if in item 1, $B_{ij} = 1$

Item 11. Sum of Mass and Aerodynamic Force Matrices Format 6E12.8
Input By Rows.

Column	1-12	13-24	25-36	37-48	49-60	61-72	
Name	ReA _{1,1}	IA _{1,1}	ReA _{1,2}	IA _{1,2}	...	...	
Field	(1)	(2)	(3)	(4)	(5)	(6)	

ReA_{i,j} = The Real Part of A_{i,j}

IA_{i,j} = The Imaginary Part of A_{i,j}

Continue on next card if necessary until IA_{1,NDEGA} is entered,
Start each row on a new card.

The basic use of the control card is to minimize input when stacking cases. Once program has been initialized, you may use information from previous case by entering a zero or leave blank on the control card the quantity you want to use from the previous case. Any new input, indicate input as such on the control card and input that quantity. Any number of cases may be stacked. A control card must be present for each and every case.

4.4 Program Output

All input, computed data and results are printed.

The complex eigenvalue problem is solved by the subroutine ALLMAT.

The flutter results are presented in tabular form, the units being consistent with the reference semi-chord used in the input. The output frequency is in radians per second (as required for input), and the velocity is in inches or feet per second depending upon the units of b_r.

4.5 Sample Problem

A sample problem is presented; the input data is presented on the first page of the computer output. The control card input is shown below:

1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27
W _r	b _r	NDEGA	M _{ij}	M _{ii}	W _i	P _{ii}	NOK	F
1	1	7	2	0	1	2	1	1

28-30	31-33	34-36	37-39	40-42	43-45
B _{ij}	A _{ij}				
1	2				

The punched output of the sample problem in Section 3.6 is used as input in MOFA.

MODAL FLUTTER PROGRAM MODIFICATION CHECK CASE FOR COFA II

TYPICAL MISSILE DIVIDER INTO THREE COMPONENTS

MODAL FLUTTER ANALYSIS

INPUT DATA

REFERENCE FREQUENCY = 0.10000000E-01 RPS

REFERENCE SEMI-CHORD = 0.15000000E-02

NUMBER OF MODES = 7

GENERALIZED MASS MATRIX

1	1	0.63840300E-00	0.
1	2	-0.15450300E-05	0.
1	3	-0.14164900E-08	0.
1	4	0.31295600E-08	0.
1	5	0.10741900E-07	0.
1	6	-0.95983800E-08	0.
1	7	-0.59987700E-08	0.
2	1	-0.15618300E-05	0.
2	2	0.18599100E-01	0.
2	3	-0.82449800E-08	0.
2	4	-0.83497000E-06	0.
2	5	0.10686500E-07	0.
2	6	-0.5344000E-07	0.
2	7	-0.29367900E-06	0.
3	1	-0.93132300E-08	0.
3	2	-0.24502500E-07	0.
3	3	0.10434300E-01	0.
3	4	0.15125800E-05	0.
3	5	0.42706200E-08	0.
3	6	0.25792200E-07	0.
3	7	0.22067500E-07	0.
4	1	0.26977000E-07	0.
4	2	-0.83902600E-06	0.
4	3	0.14918600E-05	0.
4	4	0.11071800E-01	0.
4	5	-0.65459700E-08	0.
4	6	0.17754600E-07	0.
4	7	0.19203000E-06	0.
5	1	0.10848800E-07	0.
5	2	0.11717000E-07	0.
5	3	0.46463200E-08	0.
5	4	-0.71920900E-08	0.
5	5	0.10004700E-01	0.
5	6	0.10002200E-07	0.
5	7	-0.254502200E-08	0.
6	1	-0.27707200E-08	0.
6	2	-0.57006900E-07	0.
6	3	0.23062400E-07	0.

6	4	0.19997800E-07	0.
6	5	0.18693700E-07	0.
6	6	0.10990500E 01	0.
6	7	0.31990400E-07	0.
7	1	0.16763800E-07	0.
7	2	-0.25415900E-06	0.
7	3	0.17229700E-07	0.
7	4	0.1452000E-06	0.
7	5	-0.42319700E-08	0.
7	6	0.25616500E-07	0.
7	7	0.41671800E 00	0.

MODAL FREQUENCIES (RPS)

0.	0.	0.51709500E 03	0.54821300E 03	0.70959600E 03	0.79491000E 03	0.11936888E 04
----	----	----------------	----------------	----------------	----------------	----------------

DIAGONAL STIFFNESS PARAMETER MATRIX

0.	0.	0.	0.	0.	0.28434761E 06	0.
0.33274910E 06	0.	0.50376314E 06	0.	0.	0.63191350E 06	0.
0.59376977E 06	0.	0.	0.	0.	0.	0.

1/K = 0.10000000E 02

FACTOR FOR AERODYNAMIC FORCES = 0.90247500E-03

GENERALIZED AERODYNAMIC FORCES

1	1	-0.47111800E 02	-0.21988500E 02
1	2	0.14384300E 03	0.89207700E 01
1	3	-0.83685200E 02	-0.19830100E 03
1	4	-0.46236500E 03	0.51138700E 02
1	5	-0.13671300E 05	0.21563000E 03
1	6	0.68124100E 02	-0.11202200E 02
1	7	-0.11102200E 03	-0.23611000E 02
2	1	-0.11039300E 02	0.26916300E 01
2	2	0.32244600E 02	-0.21655700E 02
2	3	0.48166800E 02	0.13890800E 03
2	4	0.25158400E 03	-0.11390800E 02
2	5	0.91751200E 04	-0.11502500E 03
2	6	0.65013700E 02	-0.12188100E 03
2	7	-0.24987600E 03	0.10853200E 02
3	1	-0.17134300E 03	-0.14608900E 03
3	2	0.54970000E 03	0.25826000E 03
3	3	-0.12344300E 04	-0.36633800E 04
3	4	-0.52634000E 04	0.64779100E 03
3	5	-0.18678100E 06	0.21700700E 04
3	6	-0.23556700E 03	0.21579500E 04
3	7	0.29505100E 04	-0.77310600E 03
4	1	0.73529300E 02	0.49605600E 02
4	2	-0.22821400E 03	-0.32045500E 02
4	3	0.25560200E 03	0.74117400E 03
4	4	0.10163500E 04	-0.16132900E 03
4	5	0.34749400E 05	-0.51331900E 03
4	6	-0.53172600E 02	-0.31639000E 03
4	7	-0.25192300E 03	0.17973300E 03
5	1	-0.10332100E 03	-0.15276900E 03
5	2	0.61483200E 03	0.22327800E 03
5	3	-0.84949700E 03	-0.25245000E 04

1	66704900E 04	0.29470500E 03
2	6.15415000E 06	-0.30802500E 04
3	6.47454400E 02	0.10904400E 04
4	2.15157900E 04	-0.29034700E 03
5	1.29459200E 03	-0.87568300E 02
6	6.88125600E 03	-0.92717700E 02
7	6.58574400E 02	0.47866400E 02
8	6.44131900E 03	0.16832600E 03
9	6.34430500E 03	-0.28094700E 01
10	6.72953300E 03	-0.14281000E 04
11	7.0.31544200E 04	-0.66987800E 01
12	7.1.0.14503500E 01	-0.65069800E 00
13	7.2.0.43187100E 01	-0.36982200E 01
14	7.3.0.54134700E 00	-0.11367400E 02
15	7.4.0.11603200E 02	-0.35940800E 01
16	7.5.0.58903200E 02	-0.34508200E 02
17	7.6.0.10078300E 02	-0.67400600E 02
18	7.7.0.10553000E 03	-0.26879900E 02

COMPUTED SUM OF MASS AND AERODYNAMIC MATRICES

5.9588578E-01	-1.9826022E-02	1.2991317E-01	8.0507720E-03	-7.5523803E-02	-1.7904292E-01	-4.1727376E-01	4.6151399E-02
-1.2336007E 01	1.9460068E-01	6.1480287E-02	-1.0109706E-02	-1.0019459E-01	-2.1308337E-02		
-9.9642541E-03	2.4291288E-03	1.8800099E 00	-1.95433728E-02	4.3469325E-02	1.2536100E-01	2.2704744E-01	-1.0288034E-02
8.2803165E 00	-1.0380719E-01	5.9395165E-02	-1.0981406E-01	-2.2250714E-01	1.7195032E-02		
-1.5463278E-01	-1.4086642E-01	4.0609048E-01	2.3307319E-01	-5.0612211E-02	-3.3061089E 00		
-1.6856518E 02	1.9584339E 00	-2.0808093E-01	1.9474959E 00	2.6627616E 00	-6.9779006E-01	-4.7771597E 00	5.8461539E-01
6.6358381E-02	3.6645539E-02	-2.0505827E-01	-2.8920263E-02	2.2804970E-01	6.6889101E-01	2.0244105E 00	-1.4559539E-01
3.1360826E 01	-4.6325757E-01	-4.8257667E-02	-2.854201E-01	-2.3006144E-01	1.6220454E-01		
-1.7175993E-01	-1.3787020E-01	5.4462834E-01	2.0149560E-01	-7.6664981E-01	-2.2801031E 00	-4.2150005E 00	2.6604512E-01
-1.3812327E 02	-2.7870709E 00	-4.5006894E-02	9.8409484E-01	1.3589378E 00	-2.7015318E-01		
-2.6586192E-01	-7.9028202E-02	7.0711440E-01	-8.3675407E-02	-5.2861908E-02	4.3198229E-02	-3.9827935E-01	1.5191001E-01
3.125312E-01	-2.5354744E-03	1.6584353E 00	-1.2888246E 00	-2.8462893E 00	-6.0454815E-03		
1.3080214E-03	-5.8723868E-04	-3.0158314E-03	3.3375511E-03	-4.8853490E-04	-1.0258794E-02	1.0552970E-02	-3.2443796E-03
5.3159113E-02	-3.1142788E-02	-9.0953882E-03	6.0827357E-02	5.1195619E-01	-2.4258438E-02		

REDUCED SUM OF MASS AND AERODYNAMIC MATRICES

-1.0597798E-02	-3.4007399E 00	-4.0955787E 00	4.6445660E-01	-1.7396934E 02	-2.1649887E 00	-2.2291091E-01	1.9819342E 00
2.7085352E 00	-6.9956306E-01						
2.2683113E-01	7.0853400E-01	2.0987933E 00	-1.1064862E-01	3.3662077E 01	4.8642254E-01	-4.6221413E-02	-2.9991025E-01
-2.4734406E-01	1.6816027E-01						
-7.4174740E-01	-2.3911354E 00	-4.4115158E 00	1.5280500E-01	-1.4410780E 02	-6.7196652E 00	-5.5958394E-02	1.0220785E 00
1.4078026E 00	-2.7610621E-01						
-2.255486E-02	-1.3130895E-01	-6.8885560E-01	1.2053894E-01	-8.8207973E 00	-1.4851908E 00	1.6627027E 00	-1.2325751E 00
-2.752458E 00	-4.4281195E-02						

1.5767918E-04 -9.7271201E-03 1.1922584E-02 -4.1425370E-03 9.8575315E-02 -5.7503633E-02 -9.2854379E-03 6.0548313E-02
5.1171678E-01 -2.3853809E-02

DYNAMICAL MATRIX

-6.8921969E-08 -1.1991440E-05 -1.7428624E-05 1.6334113E-06 -6.1181922E-04 -7.6138803E-06 -7.8393805E-07 6.9761101E-06
9.5254368E-06 -2.4602389E-06
6.0169420E-07 2.1293343E-06 6.3074350E-06 -3.5957608E-07 1.0116354E-04 1.4618298E-06 -1.3890770E-07 -9.0131048E-07
-7.433502E-07 5.0536659E-07
-1.4724130E-06 -4.7469430E-06 -8.7571229E-06 3.0332708E-07 -2.8606261E-04 -1.3338938E-05 -1.1108076E-07 2.0288870E-06
2.7945725E-06 -5.4866303E-07
-1.2085241E-07 -1.6046334E-07 -1.0901106E-06 1.9075227E-07 -1.3958868E-05 -2.3503072E-06 2.6312189E-06 -1.9505440E-06
-4.4076378E-06 -7.0074948E-08
2.6555608E-10 -1.6381972E-08 2.0079472E-08 -6.9766720E-09 1.6601605E-07 -9.6844999E-08 -1.5638111E-08 1.0197271E-07
8.6181009E-07 -4.0173498E-08

NUMBER OF EIGENVALUES AND EIGENVECTORS CALCULATED = 5

EIGENVECTOR CORRESPONDING TO EIGENVALUE = 7.2213784E-07 4.5314527E-08

3.9214671E-02 -1.6127506E-01 -6.8672888E-02 6.5037549E-02 1.9977601E-03 -3.452522E-04 9.9999999E-01 0.
4.2620574E-01 -4.752974F-01

EIGENVECTOR CORRESPONDING TO EIGENVALUE = 2.8087757E-04 -2.4446720E-06

0.9999908E-01 0.
3.7636015E-03 -9.5741354E-03 -2.1714868E-01 3.1638493E-02 2.7546624E-05 -1.8360252E-02 -8.4956662E-02 1.1154428E-01

EIGENVECTOR CORRESPONDING TO EIGENVALUE = 3.3482892E-04 -1.7909398E-07

8.8454745E-02 -4.2602004E-02 9.9999999E-01 0. -3.3833314E-02 1.2686323E-03 1.0256012E-02 3.4126832E-01
-8.2322250E-03 -4.1762769E-03

EIGENVECTOR CORRESPONDING TO EIGENVALUE = 3.1833040E-04 -1.7404286E-06

0.9999999E-01 0.
1.0878949E-03 -6.2904709E-05 -3.0652155E-01 4.0514051E-02 4.1752065E-03 -1.7193443E-02 1.2755683E-01 -1.8779222E-01

EIGENVECTOR CORRESPONDING TO EIGENVALUE = -2.8639364E-04 -2.3361805E-05

9.9999999E-01 0. -1.6574362E-01 -8.7316478E-04 4.7279767E-01 1.2542876E-02 2.2805268E-02 3.4255458E-03
-2.4669210E-04 2.1733336E-04

FLUTTER SOLUTION FOR $1/K = 1.000000E-01$

EIGENVALUE-R	EIGENVALUE-I	FREQUENCY	G	Y
-2.863936E-04	-2.336180E-05	IMAGINARY	ZERO.	ZERO
3.348289E-04	-1.790936E-07	5.464979E 02	-5.34809E-02	8.197469E 04
3.183304E-04	-1.740470E-06	5.604811E 02	-5.467365E-01	8.407216E 04
2.808776E-04	-2.444672E-06	5.966800E 02	-8.703692E-01	8.956200E 04
7.221378E-07	4.531453E-08	1.176766E 03	6.275052E-02	1.765148E 05

4.6 PROGRAM LISTINGS

```

1      FORTRAN DECK
2      MODAL FLUTTER ANALYSIS PROGRAM
3
4      TAPE DESIGNATIONS -- IPTAPE = STANDARD INPUT TAPE
5                          IWTAPE = STANDARD OUTPUT TAPE
6
7      NCONT(1) = REFERENCE TO INPUT WR
8      NCONT(2) = REFERENCE TO INPUT RR
9      NCONT(3) = REFERENCE TO INPUT DEGREE OF MATRIX A
10     NCONT(4) = REFERENCE TO INPUT MIJ(1,J)
11     NCONT(5) = REFERENCE TO INPUT MIJ(1,1)
12     NCONT(6) = REFERENCE TO INPUT WI(1)
13     NCONT(7) = REFERENCE TO INPUT PII(1,J)
14     NCONT(8) = REFERENCE TO INPUT 1/K
15     NCONT(9) = REFERENCE TO INPUT F, FACTOR FOR AERO MATRIX
16     NCONT(10) = REFERENCE TO INPUT RIJ(1,J)
17     NCONT(11) = REFERENCE TO INPUT AIJ(1,J)
18
19     COMMON/ALL/IPTAPE,IWTAPE
20     COMMON/IN12/AMTRX(20,40),ONEK,NFWA,WR,RR
21     DIMENSION NCONT(11),CMIJ(20,40),WI(20),PII(20,2),AIJ(20,40),
22             TEMP(6),T(20,40),PIISAV(20,2),TITLE(24),RIJ(20,40)
23
24     IPTAPE = 5
25     IWTAPE = 6
26     KKK=
27     READ(IPTAPE,5) (TITLE(I),I=1,24)
28     FORMAT(12A6)
29     WRITE(IWTAPE,10) (TITLE(I),I=1,24)
30     FORMAT(10I 25X,12A6// 25X,12A6////)
31     READ(IPTAPE,70) (NCONT(I),I=1,11)
32     FORMAT(70I 4)
33     IF (KKK.EQ.0) GO TO 75
34     WRITE(IWTAPE,74)
35     FORMAT(11I 1)
36     WRITE(IWTAPE,71)
37     FORMAT(10I 49X,22HMODAL FLUTTER ANALYSIS//55X,10HINPUT DATA//)
38
39     DO 100 I=1,9
40     IF (NCONT(I)) 80,300,80
41     GO TO (90,110,120,125,140,190,200,240,290),I
42     READ(IPTAPE,100) WR
43     WRITE(IWTAPE,91) WR
44     FORMAT(100 21HREFERENCE FREQUENCY = F16.8,4H RPS)
45     FORMAT(4E12.8)
46     GO TO 300
47     READ(IPTAPE,100) RR
48     WRITE(IWTAPE,111) RR
49     FORMAT(100 22HREFERENCE SEMI-CHORD = F16.8)
50     GO TO 310
51     N2A = NCONT(1)
52     N2A = 2*N2A
53     WRITE(IWTAPE,121) N2A
54     FORMAT(10I 17HNUMBER OF MODES = I3//)
55     GO TO 300
56     IF (NCONT(1).EQ.1) GO TO 129
57     DO 126 I=1,N2A
58     DO 126 J=1,N2A
59     CMIJ(I,J)=0.0
60     DO 129 I=1,N2A
61     READ(IPTAPE,100) (CMIJ(I,J),J=1,N2A,2)

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NOT REPRODUCIBLE

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      GO TO 131
120 DO 130 I=1,NDEGA
130 READ(10TAPF,100) (CMIJ(I,J),J=1,N2A)
131 WRITE(10TAPF,132)
132 FORMAT(100 23HGENERALIZED MASS MATRIX //)
      DO 134 I=1,NDEGA
      K = 1
      DO 134 J=1,N2A,2
      WRITE(10TAPF,133) I, K, CMIJ(I,J), CMIJ(I,J+1)
133 FORMAT(2I3,2F16.8)
134 K = K+1
      GO TO 300
140 CONTINUE
      DO 140 I=1,NDEGA
      DO 140 J=1,N2A
140 CMIJ(I,J) = 0
      IF(PCONT(I).EQ.1) GO TO 155
      READ(10TAPF,100) (CMIJ(I,2*I-1),I=1,NDEGA)
      GO TO 131
155 J = 1
      I1 = 1
      I2 = 3
160 READ(10TAPF,100) (TEMP(NT),NT=1,6)
      NT = 1
      DO 160 I=I1,I2
      CMIJ(I,J) = TEMP(NT)
      CMIJ(I,I+1) = TEMP(NT+1)
      IF(2A - (I+1)) 131,131,170
170 J = I+2
      NT = NT+2
180 CONTINUE
      I1 = I2+1
      I2 = I1+2
      GO TO 160
190 READ(10TAPF,100) (WI(I),I=1,NDEGA)
      WRITE(10TAPF,101) (WI(I),I=1,NDEGA)
191 FORMAT(100 23HMODAL FREQUENCIES (RPS) //(8F16.8))
      GO TO 300
200 I = NCONT(I)
      GO TO (210,220), I
210 READ(10TAPF,100) ((PII(I,J),J=1,2),I=1,NDEGA)
      WRITE(10TAPF,211) (I, I, (PII(I,J),J=1,2),I=1,NDEGA)
211 FORMAT(100 35HDIAGONAL STIFFNESS PARAMETER MATRIX //(3(I2,I3,2F16.
18,4Y)))
      GO TO 300
220 I1 = 1
      DO 230 I=1,NDEGA
      X = WI(I)/WR
      PII(I,1) = CMIJ(I,I1)*X*X
      PII(I,2) = CMIJ(I,I1+1)*X*X
      I1 = I1+2
230 CONTINUE
      WRITE(10TAPF,2230) ((PII(I,J),J=1,2),I=1,NDEGA)
2230 FORMAT(100 25HDIAGONAL STIFFNESS PARAMETER MATRIX //(3(2F16.8,4Y))
1)
      GO TO 300
240 READ(10TAPF,100) ONEK
      WRITE(10TAPF,241) ONEK
241 FORMAT(100 5H1/K = F16.8)
      GO TO 300

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200 READ (RTAPE,100) F
    WRITE (ITAPE,291) F
291 FORMAT(100 31HFACTOR FOR AERODYNAMIC FORCES = F16.8//)
300 CONTINUE

IF (NCONT(10)) 329,350,329
320 IF (NCONT(10).EQ.2) GO TO 339
    DO 330 I=1,NDEGA
330 READ (RTAPE,100) (RIJ(I,J),J=1,N2A)
    GO TO 340
330 READ (RTAPE,100) ((RIJ(I,J),J=1,N2A),I=1,NDEGA)
340 WRITE (ITAPE,331)
331 FORMAT(100 30HGENERALIZED AERODYNAMIC FORCES //)
    DO 333 I=1,NDEGA
        K = 1
        DO 333 J=1,N2A,2
            WRITE (ITAPE,332) I, K, RIJ(I,J), RIJ(I,J+1)
332 FORMAT (2I3,2F16.8)
333 K = K+1
350 IF (NCONT(11)) 370,410,370
370 IF (NCONT(11).EQ.2) GO TO 390
    DO 380 I=1,NDEGA
380 READ (RTAPE,100) (AIJ(I,J),J=1,N2A)
    WRITE (ITAPE,381)
381 FORMAT(100 36HSUM OF MASS AND AERODYNAMIC MATRICES)
    DO 383 I=1,NDEGA
        K = 1
        DO 383 J=1,N2A,2
            WRITE (ITAPE,382) I, K, AIJ(I,J), -AIJ(I,J+1)
382 FORMAT (2I3,2F16.8)
383 K = K+1
    GO TO 410
400 CONTINUE
    DO 404 I=1,NDEGA
        DO 404 J=1,N2A
404 I(I,I) = F*RIJ(I,I)
        CALL HYA3(CM11,T,20,40,AIJ)
        WRITE (ITAPE,2400)
2400 FORMAT(/// 1X,45HCOMPUTED SUM OF MASS AND AERODYNAMIC MATRICES)
        DO 405 I=1,NDEGA
405 WRITE (ITAPE,2405) (AIJ(I,J),J=1,N2A)
2405 FORMAT(10 7(1P2F15.7,2X,1P2F15.7,2X,1P2F15.7,2X,1P2F15.7))
410 K00A = NDEGA
    K00B = NDEGA
    K00C = N2A
    DO 415 I=1,NDEGA
        P11S/V(11,1) = P11(11,1)
415 P11S/V(11,2) = P11(11,2)
        K00B = 0
        DO 419 I=1,NDEGA
420 IF (P11S/V(11,1)) 510,430,510
430 IF (P11S/V(11,2)) 510,440,510
440 K = 2*I1 - 1
        K01 = K+1
        K00C = K+1
        DO 444 I=1,NDEGA
            DO 444 J=1,N00C,2
11 = AIJ(I,I)*AIJ(I1,J) - AIJ(I,K01)*AIJ(I1,J+1)
12 = AIJ(I,K)*AIJ(I1,J+1) + AIJ(I,K01)*AIJ(I1,J)

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NOT REPRODUCIBLE

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      T1      = A1J(I1,K)*A1J(I1,K) + A1J(I1,KP1)*A1J(I1,KP1)
      T(I,1)  = A1J(I,J) - (A1J(I1,K)*T1 + A1J(I1,KP1)*T2)/T3
      T(I,I+1) = A1J(I,J+1) - (A1J(I1,K)*T2 + A1J(I1,KP1)*T1)/T3
480 CONTINUE
      DO 483 I=1,NFWA
      DO 481 J=1,NFW2A
481 A1J(I,J) = T(I,J)
      NOLDA = NFWA
      NOLDA = 2*NOLDA
      NFWA = NFWA - 1
      NFW2A = 2*NFWA
      DO 480 I=1,NFWA
      PIISAV(I,1) = PIISAV(I+1,1)
      PIISAV(I,2) = PIISAV(I+1,2)
      DO 480 J=1,NOLDA
      A1J(I,J) = A1J(I+1,J)
490 CONTINUE
      DO 500 J=K,NFW2A
      DO 500 I=1,NFWA
500 A1J(I,J) = A1J(I,J+2)
      IF (11-NOLDA) 420,510,510
510 CONTINUE
      IF (K.EQ.0) GO TO 506
      WRITE(IWTAPE,504)
504 FORMAT(/// 1X,4'HREDUCED SUM OF MASS AND AERODYNAMIC MATRICES)
      DO 505 I=1,NFWA
505 WRITE(IWTAPE,2405) (A1J(I,J),J=1,NFW2A)
506 DO 520 I=1,NFWA
      T1 = PIISAV(I,1)*PIISAV(I,1) + PIISAV(I,2)*PIISAV(I,2)
      DO 520 J=1,NFW2A,2
      AMTRX(I,J) = (A1J(I,J)*PIISAV(I,1) + A1J(I,J+1)*PIISAV(I,2))/T1
      AMTRX(I,J+1) = (-A1J(I,J)*PIISAV(I,2) + A1J(I,J+1)*PIISAV(I,1))/T1
520 CONTINUE
      WRITE(IWTAPE,2520)
      DO 525 I=1,NFWA
525 WRITE(IWTAPE,2405) (AMTRX(I,J),J=1,NFW2A)
2520 FORMAT(/// 1X,16'DYNAMICAL MATRIX)
      CALL MAT12
      KKK=KKK+1
      GO TO 1000
      END

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NOT REPRODUCIBLE

COMPLEX EIGENVALUE SOLUTION AND FLUTTER RESULTS

```

      SUBROUTINE MAIN2
      COMMON/ALL/IPTAPE,IWTAPE
      COMMON/MAIN2/AMTRX(20,40),ONEK,NEWA,WR,RR
      DIMENSION FIGVAL(40)
      COMPLEX AMC(20,20),FIGC(20)

      DATA Q1/6HIMAGINE/,Q2/6HARY /,Q3/6HINFINI/,Q4/6HTE /,Q5/6HZIRO
      /
      N = 7*NEWA
      DO 10 I=1,NEWA
      DO 10 J=1,N,2
      II=(I+1)/2
10  AMC(I,II)=CMPLX(AMTRX(I,J),AMTRX(I,J+1))
      NCAI=NEWA
      CALL ALIQUAT(AMC,FIGC,NEWA,20,NCAI)
      IF(NCAI.II.NEWA) GO TO 12
      WRITE(IWTAPE,11) NCAI
11  FORMAT(10I 3X,51HNUMBER OF EIGENVALUES AND EIGENVECTORS CALCULATED
      / 13//)
      GO TO 14
12  WRITE(IPTAPE,13) NCAI
13  FORMAT(10I 3X,51HNUMBER OF EIGENVALUES AND EIGENVECTORS CALCULATED
      / 14//4X,72HCONVERGENCE DID NOT OCCUR WITHIN TEN ITERATIONS FOR I
      2HE NEXT EIGENVALUE.//)
      IF(NCAI.EQ.0) RETURN
14  DO 20 I=1,NCAI
      WRITE(IWTAPE,20) FIGC(I)
20  FORMAT(100 3X,41HEIGENVECTOR CORRESPONDING TO EIGENVALUE = 1P2E15.
      17//)
      WRITE(IWTAPE,21) (AMC(I,J),I=1,NCAI)
21  FORMAT(10 2X,112E15.,2X,1P2E15.7,2X,1P2E15.7,2X,1P2E15.7)
25  CONTINUE
      WRITE(IWTAPE,15) ONEK
15  FORMAT(/// 4X,26HFLUTTER SOLUTION FOR 1/K = 1P1E13.6 )
      WRITE(IWTAPE,16)
16  FORMAT(100 3X,12HEIGENVALUE-R,6X,12HEIGENVALUE-I,7X,9HFREQUENCY,13
      1X,100,17X,10V//)

      NCAI2=2*NCAI
      DO 30 I=1,NCAI2,2
      II=(I+1)/2
      FIGVAL(I)=REAL(-FIGC(II))
      FIGVAL(I+1)=AIMAG(FIGC(II))
30  CONTINUE
      DO 40 I=1,NCAI2,2
      DO 35 J=1,NCAI2,2
      SAX=FIGVAL(I)
      IF(ABS(SAX).GE.ABS(FIGVAL(J))) GO TO 35
      SAX=FIGVAL(J)
      SAXI=FIGVAL(I+1)
      FIGVAL(I)=FIGVAL(I)
      FIGVAL(I+1)=FIGVAL(I+1)
      FIGVAL(I)=SAX
      FIGVAL(I+1)=SAXI
35  CONTINUE
40  CONTINUE
      DO 170 I=1,NCAI2,2

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NOT REPRODUCIBLE

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      IF (FIGVAL(I)) 60,80,100
60  WRITE(IWTAPF,70) FIGVAL(I),FIGVAL(I+1),Q1,Q2,Q5,Q5
70  FORMAT(1H 1P15.6,1P18.6,7X,2A6,8X,1A6,12X,1A6)
      GO TO 170
80  WRITE(IWTAPF,90)FIGVAL(I),FIGVAL(I+1),Q3,Q4,Q3,Q4,Q3,Q4
90  FORMAT(1H 1P15.6,1P18.6,7X,2A6,6X,2A6,6X,2A6)
      GO TO 170
100  WF      = WR/SQR(FIGVAL(I))
120  G      = FIGVAL(I+1)/FIGVAL(I)
      V = WF*RR*ONEK
      WRITE(IWTAPF,130) FIGVAL(I),FIGVAL(I+1),WF,G,V
130  FORMAT(1H 1P15.6,1P4F18.6)
170  CONTINUE
      RETURN
      END

```

1 FORTRAN DECK

2 CALL MAT

3 SUBROUTINE ALLMAT(A,LAMBDA,M,IA,NCAI)

4 C PROGRAMMERS JOHN RINZEL, R.E. FUNDERLIC, UNION CARBIDE CORP.

5 C NUCLEAR DIVISION, CENTRAL DATA PROCESSING FACILITY,

6 C OAK RIDGE, TENNESSEE

7 C

8 COMPILE A(IA,1), H(30,30), HL(30,30), LAMBDA(1), VECT(30),

9 10001(30), SHIFT(3), TEMP, SIN, COS, TEMP1, TEMP2

10 LOGICAL INTN(30), TWICE

11 INTEGER INT(30), P, RP1, RP2

12 NVECT = NCAI

13 N = M

14 NCAI = N

15 IF (L.NE.1) GO TO 1

16 LAMBDA(1) = A(1,1)

17 A(1,1) = 1.

18 GO TO 67

19 1 DOUNT = 0

20 SHIFT(1) = 0.

21 IF (D.NE.2) GO TO 4

22 2 TEMP = (A(1,1) + A(2,2) + CSQRT((A(1,1) + A(2,2))**2 -

23 14. * ((A(2,2) * A(1,1) - A(2,1) * A(1,2)))**2) / 2.

24 IF (REAL(TEMP).NE.0.0. OR AIMAG(TEMP).NE.0.0) GO TO 3

25 LAMBDA(M) = SHIFT(1)

26 LAMBDA(M-1) = A(1,1) + A(2,2) + SHIFT(1)

27 GO TO 37

28 3 LAMBDA(M) = TEMP + SHIFT(1)

29 LAMBDA(M-1) = (A(2,2) * A(1,1) - A(2,1) * A(1,2)) / (LAMBDA(M) - SHIFT(1))

30 A + SHIFT(1)

31 GO TO 37

32 C

33 C

34 REDUCE MATRIX A TO HESSENBERG FORM

35 1 AMP = 1

36 DO 15 R = 1, M-2

37 RP1 = R+1

38 RP2 = R+2

39 ARIG = 0.

40 INT(1) = RP1

41 DO 5 I = RP1, R

42 ARIG = REAL(A(I,R))**2 + AIMAG(A(I,R))**2

43 IF (ARIG .EQ. 0.) GO TO 5

44 INT(1) = I

45 ARIG = ARIG

46 2 CONTINUE

47 INT(1) = INT(1)

48 IF (1.EP.EQ.0.) GO TO 8

49 IF (A(1,1).EQ.0.) GO TO 15

50 DO 6 I = R, M

51 TEMP = A(RP1, I)

52 A(RP1, I) = A(INT(1), I)

53 6 A(INT(1), I) = TEMP

54 DO 7 I = 1, M

55 TEMP = A(I, RP1)

56 A(I, RP1) = A(I, INT(1))

57 7 A(I, INT(1)) = TEMP

58 8 DO 9 I = RP2, M

59 MULT(1) = A(I, R) / A(RP1, R)

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NOT REPRODUCIBLE

[illegible]

[illegible]

```

10 CONTINUE
   TEMP1 = A(L,J)
   DO K=1,N
20 A(L,K) = A(L,K) / TEMP1
30 CONTINUE
40 RETURN
   END

```

```

A(L,M)?
A(L,M)?
A(L,M)?
A(L,M)?
A(L,M)?
A(L,M)?
A(L,M)?

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REFERENCES

1. Hughes Aircraft Co. MSD-P69-144, Collocation Flutter Analysis Program, Vol. I-IV, NASC Contract 00019-68-C-0274, dated April 1969.
2. Hughes Aircraft Co. SSD80319R, Research Report No. 32-MARS-COMOSY and DYNOPT Computer Programs, dated August 1968.
3. Hurty, W. C., "Dynamic Analysis of Structural Systems Using Component Modes" AIAA Journal, Vol. 3, No. 4, April 1965, pp 678-685.
4. TRW Inc. Project Appollo Interim Rpt Structural Dynamics Characteristics Document, Contract No. NAS 9-4810, MSC-TRW Task ASFO-17, dated 1 March 1966.
5. J.P.L. Tech Rpt. 32-530, Dynamic Analysis of Structural Systems by Component Mode Synthesis, date January 1964.

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13. ABSTRACT This study covers the development of a set of computer programs to perform flutter analysis. These programs supplement those of collocation flutter Analysis-Study I Contract No. 00019-68-C-0274. This study is presented in three volumes. Volume I contains a subsonic strip theory unsteady aerodynamics program and a supersonic piston theory unsteady aerodynamics program. Volume II contains unsteady aerodynamic generalized force programs for subsonic, transonic, and supersonic flight regimes. Volume III contains the structural analysis programs, FLUENC-100C and COMSYN, and the modal flutter analysis program.			

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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