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FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES
IN NASTRAN

(NAS3-CR-165429) FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES IN NASTRAN
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by

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NASA Lewis Research Center
Cleveland, Ohio 44135

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### Abstract

A new capability has been added to the general purpose finite element program NASTRAN Level 17.7 to conduct forced vibration analysis of tuned cyclic structures rotating about their axis of symmetry. The effects of Coriolis and centripetal accelerations together with those due to linear acceleration of the axis of rotation have been included.

This report presents the Theoretical, User’s, Programmer’s and Demonstration manuals for this new capability. The work was conducted under Contract NAS3-22533 from NASA Lewis Research Center, Cleveland, Ohio, with Mr. Richard E. Norris as the Technical Monitor.

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### Key Words (Suggested by Author(s))

- Forced Vibrations
- Rotating Cyclic Structures
- NASTRAN
- Finite Elements
- Turbomachines
- Propellers
- Base Excitation

### Distribution Statement

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FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

1.1 Introduction

A new capability has been developed and implemented in NASTRAN Level 17.7 to perform forced vibration analysis of cyclic structures rotating about their axis of symmetry. Fans, propellers, and bladed shrouded disks of turbomachines are some examples of such structures. The capability includes the effects of Coriolis and centripetal accelerations on the rotating structure which can be loaded with:

1) directly applied loads moving with the structure and
2) inertial loads due to the translational acceleration of the axis of rotation ('base' acceleration).

One rotationally cyclic sector of the N-sectorced structure is modeled and analyzed. Steady-state sinusoidal or general periodic loads are specified to represent:

1) the physical loads on various segments of the complete structure, or
2) the circumferential harmonic components of the loads in (1).

The sinusoidal loads are specified as functions of frequency and the general periodic loads are specified as functions of time.

The translational acceleration of the axis of rotation may be specified as a function of frequency in an inertial coordinate system.

The details of the User's, Programmer's and Demonstration manuals are presented in Sections 2, 3 and 4, respectively. The following sections present the salient points in the theoretical development.

1.2 Theory

The theoretical development of Reference 1 to conduct forced vibration analysis of rotating cyclic structures in conjunction with the theory of rotational cyclic symmetry as presented in Section 4.5.1 of the NASTRAN Theoretical Manual (Reference 2) is summarized in this section.

1.2.1 Equations of Motion

The complete structure consists of N identical sectors. The displacement at any grid point in any sector can be expressed in any body-fixed coordinate system as a combination of:

1) the steady displacement due to the steady rotation of the structure, and
2) the vibratory displacement (superposed on the steady displacement) due to the vibratory excitation provided by the directly applied loads and base acceleration.
The vibratory response of rotating cyclic structures may be determined by this new capability.

As shown in Reference 1, the equations of forced response can be written as

\[ M^n u^n + B^n u^n + K^n u^n = p^n - M_2^n R, \quad n = 1, 2, ..., N. \]  

(1)

For the \( n \)th cyclic sector, \( u^n \) represents the vibratory degrees of freedom; \( M^n, B^n \) and \( K^n \) represent its mass, damping and stiffness matrices respectively; \( p^n \) represents the directly applied loads on \( u^n \), and \( -M_2^n R \) represents the inertial loads on \( u^n \) due to base acceleration \( \ddot{R} \). The damping matrix \( B^n \) consists of the viscous and structural damping, and the contribution due to the Coriolis acceleration, i.e.,

\[ B^n = B^n_{viscous} + 2\Omega B^n_{Coriolis}, \]  

(2)

with \( \Omega \) as the (constant) rotational speed. The stiffness matrix \( K^n \) consists of elastic and differential stiffness together with the contribution due to the centripetal acceleration, i.e.,

\[ K^n = K^n_{elastic} + K^n_{differential} - \Omega^2 M^n_{centripetal}. \]  

(3)

The derivation of the coefficient matrices \( B^n_{Coriolis}, M^n_{centripetal} \) and \( M^n_2 \) is given in Reference 1.

Equations (1) supplemented by the inter-segment boundary compatibility conditions (Section 4.5.1, Reference 2),

\[ u^{n+1}_{side 1} = u^n_{side 2}, \quad n = 1, 2, ..., N, \]  

(4)

completely describe the vibratory forced motion of the rotating cyclic structure.

1.2.2 Method of Solution

The method of solution of equations (1) consists of four principal steps:

1) Transformation of applied loads to frequency-dependent circumferential harmonic components.

2) Application of circumferential harmonic-dependent inter-segment compatibility constraints.

3) Solution of frequency-dependent circumferential harmonic components of displacements.
4) Recovery of frequency-dependent response (displacements, stresses, loads, etc.) in various segments of the total structure.

An overall flowchart outlining the solution algorithm is shown in Figure 1.

1. Transformation of Applied Loads

The transformation to frequency-dependent circumferential harmonic components depends on the form in which the excitation is specified by the user. The following options are made available in the present capability to specify the form of excitation due to the directly applied loads and base acceleration loads:

- Directly applied loads specified as:
  - periodic functions of time on various segments
  - periodic functions of time for various circumferential harmonic indices
  - functions of frequency on various segments
  - functions of frequency for various circumferential harmonic indices.

- Base acceleration specified as:
  - function of frequency for circumferential harmonic indices 0 (axial) and 1 (lateral).

Details of each of the above five loading conditions are as follows.

Directly applied loads (segment-dependent and periodic in time)

If $P^n$ represents a general periodic load on sector $n$ specified as a function of time at $M$ equally spaced instances of time per period (Figure 2), the load at $m^{th}$ time instant can be written as

$$p^n = p^n + \sum_{l=1}^{M} p^n \cos(m-1 \xi_c) + p^n \sin(m-1 \xi_s) + (-1)^{m-1} p^n,$$

where $b = 2m/M$, $\xi_c = (M-1)/2$ for odd $M$, $\xi_s = (M-2)/2$ for even $M$. The last term in equation (5) exists only when $M$ is even. The coefficients $p^n$ for $\xi = 0; \xi_c, \xi_s, \xi = 1, 2, ..., \xi; M/2$ in equation (5) are independent of time, and are defined by the relations

$$p^n = \frac{1}{M} \sum_{m=1}^{M} p^n,$$

for $\xi = 0$ part of (6)
Each of the coefficient vectors \( \mathbf{p}^n \) on the left hand sides of equations (6) can further be expanded in a circumferential (truncated) Fourier series

\[
\mathbf{p}^n = \frac{1}{M} \sum_{m=1}^{M} \left( \mathbf{p}^n \cos(\overline{m-1}ka) + \mathbf{p}^n \sin(\overline{m-1}ka) \right) + (-1)^{n-1} \mathbf{p}^{n/2},
\]

where \( n = 1, 2, \ldots, N \),

\( \overline{x} = 0; \overline{k} = 1, 2, \ldots, k_L; M/2 \)

\( a = 2\pi/N \)

\( k_L = (N-1)/2 \) for \( N \) odd

\( k_L = (N-2)/2 \) for \( N \) even.

The last term in equation (7) exists only when \( N \) is even. The Fourier coefficients \( \mathbf{p}^n \) (\( \overline{k} = 0; \overline{k} = 1, 2, \ldots, k_L; N/2 \)) in equation (7) do not vary from sector to sector, and are defined by

\[
\mathbf{p}^0 = \frac{1}{N} \sum_{n=1}^{N} \mathbf{p}^n \quad (k = 0)
\]

\[
\mathbf{p}^{kc} = \frac{2}{N} \sum_{n=1}^{N} \mathbf{p}^n \cos(\overline{n-1}ka), \quad (k = 1, 2, \ldots, k_L)
\]

\[
\mathbf{p}^{ks} = \frac{2}{N} \sum_{n=1}^{N} \mathbf{p}^n \sin(\overline{n-1}ka), \quad \text{and}
\]

\[
\mathbf{p}^{n/2} = \frac{1}{N} \sum_{n=1}^{N} (-1)^{n-1} \mathbf{p}^n \quad (N \text{ even only}) \quad (k = N/2).
\]
The terms $\bar{P}^m_k$ ($m = 0; \ldots, L; n = 0, 1, 2, \ldots, N/2$ and $k = 0; \ldots, L; n = 0, 1, 2, \ldots, N/2$) are the transformed frequency-dependent circumferential harmonic components of the directly applied loads $\bar{p}^m_n$ ($m = 1, 2, \ldots, M$ and $n = 1, 2, \ldots, N$).

**Directly applied loads (Circumferential harmonic-dependent and periodic in time).**

Such loads can be represented as

$$\bar{p}^m_k = \bar{p}^m_k + \sum_{1}^{L} \left[ -\frac{\bar{p}^m_k \cos(m-nb)}{P^m_k} + \frac{\bar{p}^m_k \sin(m-nb)}{P^m_k} \right] + (-1)^{m-1} \bar{p}^m_k, \quad (10)$$

where $m = 1, 2, \ldots, M$ represent the time instances at which harmonic components $\bar{p}^m_k$ ($m = 0; \ldots, L; n = 0, 1, 2, \ldots, N/2$ of directly applied loads are specified.

The coefficients $\bar{p}^m_k$ on the right hand side of equation (10) are obtained using equations (6) with sector number $n$ replaced by harmonic number $k$.

**Directly applied loads (frequency-and segment-dependent).**

This type of loads can be represented as

$$\bar{p}^m_n = \bar{p}^m_0 + \sum_{1}^{L} \left[ \frac{\bar{p}^m_k \cos(n-ka)}{P^m_k} + \frac{\bar{p}^m_k \sin(n-ka)}{P^m_k} \right] + (-1)^{n-1} \bar{p}^m_n, \quad (11)$$

where $n (=1, 2, \ldots, F)$ now represents the frequencies at which excitation is specified. The transformed frequency-dependent circumferential harmonic components $\bar{p}^m_k$ ($m = 0; \ldots, L; n = 0, 1, 2, \ldots, N/2$ are obtained using equations (9) with $\bar{p}^m_n$ as defined above.

**Directly applied loads (frequency-and circumferential harmonic-dependent).**

These loads are the transformed frequency-dependent circumferential harmonic components $\bar{p}^m_k$ ($m = 0; \ldots, L; n = 0, 1, 2, \ldots, N/2$ with $k (=1, 2, \ldots, F$) representing the various frequencies at which the directly applied loads are specified.

**Base acceleration (frequency- and circumferential harmonic-dependent).**

In Reference 1, it is shown that the components of the translational base acceleration contribute to inertial loads on the rotating structure in the following manner:
1. Axial component contributes to \( P^{''k} \) where "k" = 0, and "z" represents the specified excitation frequencies.

2. Lateral components contribute to \( P^{''k} \) where "k" = 1 or 1, and "z" represents the effective excitation frequencies which are shifted from the specified frequencies by \( z \), the rotational frequency.

The user specifies the components of the base acceleration vector \( \ddot{R} \) as functions of frequency. The program computes the inertial loads \(-M_2^{''k} \) and transforms them to appropriate frequency-dependent circumferential harmonic components.

2. Application of Inter-Segment Compatibility Constraints

As shown in Section 4.5.1 of Reference 2, equations (4) are used to derive the compatibility conditions relating the circumferential harmonic component degrees of freedom on the two sides of a rotationally cyclic sector:

\[
\begin{align*}
\bar{u}_2^0 &= \bar{u}_1^0 \\
\bar{u}_2^k &= \bar{u}_1^k \cos(ka) + \bar{u}_1^l \sin(ka) \\
\bar{u}_2^{N/2} &= -\bar{u}_1^{N/2}.
\end{align*}
\]

(12)

In order to apply these constraint relationships for any given harmonic \( k \), an independent set \( \bar{u}^k \) consisting of the circumferential harmonic component (cosine and sine) degrees of freedom from the interior and side 1 of the cyclic sector is defined. \( \bar{u}^k \) is selected from the 'analysis' set degrees of freedom, and is defined as

\[
\begin{align*}
\bar{u}_2^{kc} &= G_{ck}(k) \bar{u}^k, \quad \text{and} \\
\bar{u}_2^{ks} &= G_{sk}(k) \bar{u}^k.
\end{align*}
\]

(13)

\( \bar{u}_2^{kc} \) and \( \bar{u}_2^{ks} \) each contain all (and only) the 'analysis' set degrees of freedom from the interior and both sides of the cyclic sector. Equations (12) are used to define some of the elements of the transformation matrices \( G_{ck} \) and \( G_{sk} \). For \( k = 0 \) and \( N/2 \), the matrix \( G_{sk} \) is null.
3. **Solution of Frequency-Dependent Harmonic Displacements**

For a given harmonic $k$, the introduction of $\ddot{u}^K$ in the equations of motion, (1), results in the transformed equations of motion (Reference 3)

$$[\bar{M}^K] \ddot{u}^K + [\bar{B}^K] \dot{u}^K + [\bar{K}^K] u^K = \bar{p}^K \quad (14)$$

where

$$\bar{M}^K = \bar{g}^T_{ck} \bar{h}^n g_{ck} + \bar{g}^T_{sk} \bar{h}^n g_{sk},$$

$$\bar{B}^K = \bar{g}^T_{ck} \bar{b}^n g_{ck} + \bar{g}^T_{sk} \bar{b}^n g_{sk},$$

$$\bar{K}^K = \bar{g}^T_{ck} \bar{k}^n g_{ck} + \bar{g}^T_{sk} \bar{k}^n g_{sk},$$

and

$$\bar{p}^K = \bar{g}^T_{ck} \bar{p}^c + \bar{g}^T_{sk} \bar{p}^s.$$

As discussed in subsection 1 of Section 1.2.2, $\bar{p}^c$ and $\bar{p}^s$ are the transformed frequency-dependent circumferential harmonic components of the directly applied and base acceleration loads.

At any excitation frequency $\omega^*$, let

$$\bar{p}^K = \bar{p}^c e^{i \omega^* t} \quad \text{and accordingly,} \quad \bar{u}^K = \bar{u}^c e^{i \omega^* t} \quad (16)$$

where $\bar{p}^K$ and $\bar{u}^K$ are complex quantities. Equation (14) can be rewritten as

$$[-\omega^*]^2 \bar{M}^K + i \omega^* \bar{B}^K + \bar{K}^K \bar{u}^K = \bar{p}^K \quad (17)$$

The excitation frequency $\omega^*$ is given by

$$\omega^* = \omega \text{ for all directly applied and axial true acceleration loads, and}$$

$$\omega^* = \omega^2 \text{ for lateral base acceleration loads.} \quad (18)$$

Equation (17) is solved for $\bar{u}^K$ for all excitation frequencies and all harmonics as specified by the user. The cosine and sine harmonic components of displacements are recovered using equations (13).

4. **Recovery of Frequency-Dependent Displacements in Various Segments**

This step is carried out only when the applied loads are specified on the various segments of the complete structure.
For loads specified as functions of time, equation (7) is used to obtain the displacements $u_n(k)$ in various segments with $"k" = 0, \xi c, \xi s, \xi = 1, 2, ..., \xi_{max}$. The circumferential harmonic $k$ is varied from $k_{min}$ to $k_{max}$. The user specifies $k_{max}, k_{min}$ and $k_{max}$.

For loads specified as functions of frequency, equation (11) is used to obtain the displacements $u_n$ in various segments with $"\nu"$ representing the excitation frequencies. The circumferential harmonic is varied from user specified $k_{min}$ to $k_{max}$.

The recovery of other responses such as stresses, internal forces, etc., is identical to that currently existent in NASTRAN.
1.3 References


FIGURE 1: Overall Flowchart of Forced Vibration Analysis of Rotating Cyclic Structures
Application of inter-segment compatibility constraints to stiffness, mass, damping and load matrices

Solution of independent harmonic displacements

Increment $k$ by 1.

$k > k_{\text{max}}$?

Yes

Recovery of segment-dependent independent displacements (Inverse Phase 2, if necessary)

Recovery of dependent displacements

Output requests for displacements, stresses, loads, plots, etc.

Exit

FIGURE 1. (Concluded)
Figure 2: Directly Applied Periodic Loads Specified as Functions of Time
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

2.1 Introduction

Forced vibration analysis of cyclic structures rotating about their axis of symmetry can be conducted using this capability. An extensive package of ALTERs including new Functional Modules and PARAMETERS has been developed and used to modify the existing Displacement Approach Rigid Format 8 (Direct Frequency and Random Response), Series R, in NASTRAN Level 17.7. Example 2 of the Demonstration Manual (Section 4) illustrates the use of this ALTER package. The Theoretical and Programmer's Manuals are described in Sections 1 and 3, respectively.

2.2 NASTRAN Model

The user models one rotationally cyclic sector (segment) of the entire structure as shown by the 12-bladed disc example in Figure 1. All NASTRAN coordinate systems (basic, location and displacement) are considered fixed to the rotating structure. The only additional requirement is that the X-axis of the basic coordinate system be coincident with the axis of rotation. A positive value of the rotational speed (PARAM RPS) indicates a clockwise sense of rotation when the structure is viewed at in the positive basic X direction.

Except for the special features discussed in this section, the general rules of modelling rotationally cyclic structures in NASTRAN (e.g. CYJOIN, NSEGS, etc.) have been maintained.

The rotating structure can be loaded with steady-state sinusoidal or general periodic loads classified as:

1. directly applied loads moving with the structure, and
2. inertial loads due to the translational acceleration of the axis of rotation ('base' acceleration).

The sinusoidal loads are specified as functions of frequency using the RLOADI bulk data cards. The general periodic loads are specified as functions of time using the TLOADI bulk data cards.

The following notes apply when using TLOADI bulk data cards:

1. Time delay \( t \) must be set to zero.
2. In conjunction with the TSTEP bulk data card, TLOADI information is used to discretely define \( P(t) \) at \( M \) time instances as \( P_m^R \) or \( P_m^W \) (\( m = 1, 2, \ldots, M \)), as discussed in Section 1.2.2 of the Theoretical
Manual.

\[ N(1) \text{ of TSTEP bulk data card} = M-2 \]
\[ DT(1) \text{ of TSTEP bulk data card} = \frac{(T2 - T1)}{M} \]

3. \(P(t)\) is defined in the interval \([T1, T2]\) with \((T2 - T1)\) as the period.

4. Only one physical TSTEP bulk data card is allowed, i.e. continuation of the TSTEP card is not permitted.

The following options are provided to specify the form of excitation:

Directly applied loads specified as:
- periodic functions of time on various segments \((\text{PARAM CYCIO} = +1)\)
- periodic functions of time for various circumferential harmonic indices \((\text{PARAM CYCIO} = -1)\)
- functions of frequency on various segments \((\text{PARAM CYCIO} = +1)\)
- functions of frequency for various circumferential harmonic indices \((\text{PARAM CYCIO} = -1)\)

Base acceleration specified as:
- function of frequency for circumferential harmonic indices 0 (axial)
  and 1 (lateral) \((\text{PARAM CYCIO} = -1)\)

The base acceleration refers to the translational acceleration of the axis of rotation, and is specified in an inertial coordinate system. The user defines a rectangular inertial coordinate system with its X-axis parallel to and in the direction of the basic X axis, as shown in Figure 1. The definition of this inertial system, otherwise, is arbitrary. The user specifies the X, Y, Z components (magnitude and phase) of the base acceleration vector as functions of frequency on TABLEDi bulk data cards. The use of these tables is activated by the PARAMs BXTID, BXPTID, SYTID, BYPTID, BZTID and BZPTID.

The user is provided with two options to include damping by specifying the form of the matrices \(K_{dd}, B_{dd}\) and \(M_{dd}\) in the Functional module GKAD as per equations 16 through 21, pages 9.3-7 and 9.3-9, Section 9.3.3 of the NASTRAN Level 17.7 Theoretical Manual. The PARAMETERS GKAD and LGKAD have been defined for this purpose.

Section 2.4.4 of this manual describes all the PARAMETERS applicable with this new capability.
2.3 Subcase Definitions

The parameters CYCIO (±1) and KMAX (≥0, ≤NSEGS/2 for even NSEGS, ≤(NSEGS-1)/2 for odd NSEGS) determine the number, order and meaning of subcases as follows:

**CYCIO=±1**

The number of subcases is equal to NSEGS, independent of KMAX.

- **SUBCASE 1** (SEGMENT NO. 1)
- **SUBCASE 2** (SEGMENT NO. 2)
- ...
- **SUBCASE NSEGS** (SEGMENT NO. NSEGS)

**CYCIO=-1**

The number of subcases is equal to FKMAX, where

- \( FKMAX = 1 \), if \( KMAX = 0 \),
- \( = 1 + 2 \cdot KMAX \), if \( 0 < KMAX \leq (NSEGS-1)/2 \), NSEGS odd,
- \( = 1 + 2 \cdot KMAX \), if \( 0 < KMAX \leq (NSEGS-2)/2 \) NSEGS even, and
- \( \geq NSEGS \), if \( KMAX = NSEGS/2 \), NSEGS even.

- **SUBCASE 1** ('\( k' = 0 \))
- **SUBCASE 2** ('\( k' = 1c \))
- **SUBCASE 3** ('\( k' = 1s \))
- **SUBCASE 4** ('\( k' = 2c \))
- **SUBCASE 5** ('\( k' = 2s \))
- ...
- **SUBCASE FKMAX** ('\( k' = KMAXs \))

In the event that NSEGS is even and KMAX = NSEGS/2, Subcase FKMAX will represent '\( k' = KMAXc \) as KMAXs does not exist.

Directly applied loads on various segments (CYCIO=±1) or their circumferential harmonic components (CYCIO=-1) are specified under the appropriate subcases.

With RLOADi bulk data cards, null loads need not be specified by the user. With TLOADi bulk data cards, the user is required to provide information to generate null loads where applicable.

2.3
Base acceleration is included only when CYCLO=1. Based on the activating parameters BXTID etc., the corresponding inertial loads are internally calculated and assigned to 'k' = 0, 1c and 1s as applicable.
Figure 1: NASTRAN Model of the 12-Bladed Disc
2.4 Rigid Format Description

2.4.1 Rigid Format Alters to Displacement SOL 8

EXECUTIVE DECK INPUT -
1. SOL 8
2. R.F. ALTERS

CASE CONTROL DECK INPUT -
1. ALL SPC AND MPC CONSTRAINTS MUST BE ABOVE THE SUBCASE LEVEL.
2. EITHER FREQUENCY OR TSTEP MUST BE SELECTED AND MUST BE ABOVE
   THE SUBCASE LEVEL.
3. IF SELECTED, FREQUENCY MUST BE USED TO SELECT ONE AND ONLY
   ONE FREQUENCY CARD FROM THE BULK DATA DECK AND
   MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
4. IF SELECTED, TSTEP MUST BE USED TO SELECT THE TIME-STEPS TO BE
   USED FOR LOCAL DEFINITION AND MUST BE DEFINED ABOVE THE SUBCASE
   LEVEL.
5. DIRECT INPUT MATRICES ARE NOT ALLOWED.
6. OFREQUENCY MUST NOT BE USED.
7. A SEPARATE GROUP OF SUBCASES MUST BE DEFINED FOR EACH SYMMETRIC
   SEMENT.
8. DLOAD MUST BE USED TO DEFINE A FREQUENCY OR TIME-DEPENDENT
   LOADING CONDITION FOR EACH SUBCASE.
   FOR FREQUENCY-DEPENDENT LOADS, SUBCASES WITHOUT LOADS NEED NOT
   REFER TO A DLOAD CARD.
   FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO
   A DLOAD CARD THAT GENERATES A NULL LOAD.
9. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF
   SUBCASES FOR EACH HARMONIC INDEX. K. THE PARAMETER CYCLO IS
   INCLUDED AND THE LOAD COMPONENTS FOR EACH INDEX ARE DEFINED
   DIRECTLY WITHIN EACH GROUP FOR THE VARIOUS LOADING CONDITIONS.

BULK DATA DECK INPUT -
1. SUPORTI BULK DATA CARDS ARE NOT ALLOWED.
2. EPOINT BULK DATA CARDS ARE NOT ALLOWED.
3. SPOINL BULK DATA CARDS ARE NOT ALLOWED.
4. CYCJO IN BULK DATA CARDS ARE REQUIRED.
5. IF A TSTEP CARD IS USED THEN IT MUST NOT BE CONTINUED SINCE
   ONLY ONE UNIFORM TIME STEP INTERVAL MUST BE SPECIFIED.
6. THE SKIP FACTOR FOR OUTPUT, NO, OR THE TSTEP CARD MUST BE 1.

PARAMETERS USED ARE:

A. NSEGS - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   IS THE NUMBER OF IDENTICAL SEGMENTS IN THE
   STRUCTURAL MODEL.

B. CYCJO - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE FORM OF THE INPUT AND OUTPUT DATA.
   A VALUE OF 61 IS USED TO SPECIFY PHYSICAL SEGMENT
   REPRESENTATION. A VALUE OF -1 IS USED TO SPECIFY
   CYCLIC TRANSFORMATION REPRESENTATION. THERE IS NO
   DEFAULT, A VALUE MUST BE INPUT.

C. CYCSED - FIXED - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE PROCEDURE FOR SEQUENCING THE
   EQUATIONS IN THE SOLUTION SET. THE VALUE OF THIS
   PARAMETER HAS BEEN SET TO -1 TO SPECIFY
   ALTERNATING COSINE AND SINE TERMS.

D. CATPE - FIXED - THE BCD VALUE OF THIS PARAMETER
   DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE
   OF THIS PARAMETER HAS BEEN SET TO NOT- FOR
   ROTATIONAL SYMMETRY.

E. KMAX - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE MAXIMUM VALUE OF THE HARMONIC
   INDEX. THERE IS NO DEFAULT FOR THIS PARAMETER.
   THE MAXIMUM VALUE THAT CAN BE SPECIFIED IS NSEGS/2

F. KMIN - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE MINIMUM VALUE OF THE HARMONIC
   INDEX TO BE USED IN THE SOLUTION LOOP. KMIN CAN
   EQUAL KMAX. THE DEFAULT VALUE IS 0.

G. LMAX - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE MAXIMUM TIME HARMONIC INDEX. THE
   DEFAULT VALUE IS NTSTEPS/2, WHERE NTSTEPS EQUALS
   N (FROM TSTEP CARD) PLUS 2.

H. NLOAD - FIXED - THE INTEGER VALUE OF THIS PARAMETER
   IS THE NUMBER OF LOADING CONDITIONS. THE VALUE
   OF THIS PARAMETER IS INTERNALLY CALCULATED.

I. RPS - OPTIONAL - THE REAL VALUE OF THIS PARAMETER
   DEFINES THE ROTATIONAL SPEED OF THE STRUCTURE
   IN REVOLUTIONS PER UNIT TIME. THE DEFAULT VALUE
   IS 0.

J. bxtid - OPTIONAL - THE POSITIVE INTEGER VALUES OF THESE
   BYTID PARAMETERS DEFINE THE SET IDENTIFICATION NUMBERS
   OF THE TABLED BULK DATA CARDS WHICH DEFINE THE
   COMPONENTS OF THE BASE ACCELERATION VECTOR.
BYPTID  TABLES REFERRED TO BY BXITD, BYPTO AND BXITD
BXPTO  DEFINE MAGNITUDE (LT-2) AND THE TABLES REFERRED TO
BY BXITD, BYPTO AND BXITD DEFINE PHASE (DEGREE).
THE DEFAULT VALUES ARE -1 WHICH MEANS THAT THE
RESPECTIVE TERMS ARE IGNORED.

K. NOKPRT - AN INTEGER VALUE OF 61 FOR THIS
PARAMETER WILL CAUSE THE CURRENT HARMONIC INDEX,
KINDLX, TO BE PRINTED AT THE TOP OF THE HARMONIC
LOOP. THE DEFAULT VALUE IS 61.

L. GRUPNI - OPTIONAL - A POSITIVE INTEGER VALUE OF THIS
PARAMETER WILL CAUSE THE GRID POINT WEIGHT
GENERATOR TO BE EXECUTED AND THE RESULTING WEIGHT
BALANCE INFORMATION TO BE PRINTED. DEFAULT IS -1.

M. NMASS - OPTIONAL - THE TERMS OF THE STRUCTURAL MASS
MATRIX ARE MULTIPLIED BY THE REAL VALUE OF THIS
PARAMETER WHEN THEY ARE GENERATED IN EBG. THE
DEFAULT IS 1.0.

N. GPUPMAS - FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.

O. GRAD - OPTIONAL - THE BCD VALUE OF THIS PARAMETER IS
USED TO TELL THE GRAD MODULE THE DESIRED FORM OF
MATRICES KUP, BUD AND MOU. THE BCD VALUE CAN BE
FREQESP OR TRANRESP. THE DEFAULT IS TRANRESP.
SEE SECTION 9.1.3 (DIRECT DYNAMIC MATRIX
ASSEMBLY) PAGES 9.3-7 AND 9.3-8 OF THE
NASTRAN THEORETICAL MANUAL.

P. LGRAV - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
IS USED IN CONJUNCTION WITH PARAMETER GRAD. IF
GRAD=FREQESP THEN SET LGRAV=1. IF GRAD=TRANRESP
THEN SET LGRAV=-1. THE DEFAULT VALUE IS -1.

Q. G - OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A UNIFORM STRUCTURAL DAMPING COEFFICIENT
IN THE DIRECT FORMULATION OF DYNAMICS PROBLEMS.

R. W3 - OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A PIVOTAL FREQUENCY FOR UNIFORM STRUCTURAL
DAMPING IF PARAMETER GRAD=TRANRESP. IN THIS CASE
W3 IS REQUIRED IF UNIFORM STRUCTURAL DAMPING IS
DESIRED. THE DEFAULT VALUE IS 0.0.

S. W4 - OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A PIVOTAL FREQUENCY FOR ELEMENT STRUCTURAL
DAMPING IF PARAMETER GRAD=TRANRESP. IN THIS CASE
W4 IS REQUIRED IF STRUCTURAL DAMPING IS DESIRED FOR
ANY OF THE STRUCTURAL ELEMENTS. DEFAULT IS 0.0.

REMARKS -
1. THE ANALYSIS WILL LOOP THRU A RANGE OF THE CYCLIC INDEX,
   KINDLX = KMIX TO KMAX.
2.8
NASTRAN EXECUTIVE CONTROL DECK ECH

<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ALTER 3 $</td>
</tr>
<tr>
<td>2</td>
<td>FILE UXF=APPEND/PDI=APPEND/PD=APPEND $</td>
</tr>
<tr>
<td>3</td>
<td>$ PERFORM INITIAL ERRORS CHECKS ON NSEGS AND KMAX.</td>
</tr>
<tr>
<td>4</td>
<td>CCOND ERROR C1,NSG $ IF USER HAS NOT SPECIFIED NSEG.</td>
</tr>
<tr>
<td>5</td>
<td>CNDN ERROR C1,MAX $ IF USER HAS NOT SPECIFIED KMAX.</td>
</tr>
<tr>
<td>6</td>
<td>PARAM /C/N,EQ /V/N,CYCLOERR /V/Y,LYCIU=O /N,O $</td>
</tr>
<tr>
<td>7</td>
<td>CCOND ERROR C1,LYCLOERR $ IF USER HAS NOT SPECIFIED CYCLO.</td>
</tr>
<tr>
<td>8</td>
<td>PARAM /C/N,DIV /V/N,NSEG2 /V/Y,NSEGS /C/N,2 $ NSEG2 = NSEGS/2</td>
</tr>
<tr>
<td>9</td>
<td>PARAM /C/N,SUB /V/N,KMAXERR /V/N,NSEG2 /V/Y,KMAX $</td>
</tr>
<tr>
<td>10</td>
<td>CNDN ERROR C1,KMAXERR $ IF KMAX GT NSEGS/2</td>
</tr>
<tr>
<td>11</td>
<td>$ SET DEFAULTS FOR PARAMETERS.</td>
</tr>
<tr>
<td>12</td>
<td>PARAM /C/N,NOP /V/Y,NCPRT=61 /V/Y,NGKAD=-1 $</td>
</tr>
<tr>
<td>13</td>
<td>$ CALCULATE OMEGA, 2<em>OMEGA AND OMEGA</em>2 FROM RPS. SET DEFAULT RPS.</td>
</tr>
<tr>
<td>14</td>
<td>PARAM /C/N,NMPY /V/N,OMEGA /V/Y,RPS=0.0 /C/N,0.283185 $</td>
</tr>
<tr>
<td>15</td>
<td>PARAM /C/N,NMPY /V/N,OMEGA2 /C/N,2.0 /V/N,OMEGA $</td>
</tr>
<tr>
<td>16</td>
<td>PARAM /C/N,NMPY /V/N,OMEGASQ /V/N,OMEGA /V/N,OMEGA $</td>
</tr>
<tr>
<td>17</td>
<td>$ GENERATE NUNPS FLAG IF RPS IS ZERO.</td>
</tr>
<tr>
<td>18</td>
<td>PARAM /C/N,NWU /V/Y,RPS /C/N,0.0 ///V/N,NORPS $</td>
</tr>
<tr>
<td>19</td>
<td>$ MAKE SURE COUPLED PASS HAS NOT BEEN REQUESTED.</td>
</tr>
<tr>
<td>20</td>
<td>PARAM /C/N,NUT /V/N,NLUMP /V/Y,CCUPMASS=-1 $</td>
</tr>
<tr>
<td>21</td>
<td>CNDN ERROR C2,NLUMP $</td>
</tr>
<tr>
<td>22</td>
<td>ALTEN 21,21 $ ADD SLT TO OUTPUT FOR TRLE.</td>
</tr>
<tr>
<td>23</td>
<td>GP3 G3M3,EUELX=UNLUM2 / SLT,GPTT / V/N,NOGRAV $</td>
</tr>
<tr>
<td>24</td>
<td>CHKPT SLT,GPT $</td>
</tr>
<tr>
<td>25</td>
<td>ALTEN 23 $</td>
</tr>
<tr>
<td>26</td>
<td>$ SINCE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NUM SO THAT</td>
</tr>
<tr>
<td>27</td>
<td>$ MORE ERRORS CHECKS CAN BE MADE BEFORE ELEMENT GENERATION.</td>
</tr>
<tr>
<td>28</td>
<td>$ AUXYS NEEDED FOR PSF RECOVERY IN SSG2.</td>
</tr>
<tr>
<td>29</td>
<td>PARAM /C/N,NMPY /V/N,NSKIP /C/N,0 /C/N,0 $</td>
</tr>
<tr>
<td>30</td>
<td>GP4 CASECC,GE4XN,EUEXN,SLT,BMPT,BTSL,GSLT/RT/GYS,USET,ASET/V/N,LUSET/</td>
</tr>
<tr>
<td>31</td>
<td>S/N,MPCF2/SN,MPCF/SN,SINGLE/S/N,OPIT/SN,S,REACT/S/N,NSKIP/</td>
</tr>
<tr>
<td>33</td>
<td>PURG GM,NMU/NPCF1/GY,CURVTP/KP5,PSF,OPC/SINGLE $</td>
</tr>
<tr>
<td>34</td>
<td>CHKPT UMDU,UGU,GDC,PEF,PSF,USF/PC,GSF $</td>
</tr>
<tr>
<td>35</td>
<td>$ SUPPORT BULK DATA IS NOT ALLOWED.</td>
</tr>
<tr>
<td>36</td>
<td>PARAM /C/N,NUT /V/N,REACDATA /V/N,REAC $</td>
</tr>
<tr>
<td>37</td>
<td>CNDN ERROR C3,REACDATA $</td>
</tr>
<tr>
<td>38</td>
<td>$ EXECUTE GP4 NUM SO CHECKS CAN BE MADE. ADD TRLE TO OUTPUT DATA BLOCKS.</td>
</tr>
<tr>
<td>39</td>
<td>DPL DYN,MIC,DPL,SLT,SET / GPLD,SILU,USET,TFPGD,DLT,PSQL,FRX,</td>
</tr>
<tr>
<td>40</td>
<td>TDL,CEL/YN / V/N,USET/S/N,NSET1/V/N,NGRFL/S/N,NOULT/</td>
</tr>
<tr>
<td>41</td>
<td>S/N,MPQL/S/N,MPFL/V/N,NGDFLT/S/N,NUKFL/V/N,NGDFL/V/N,NGDGP/L,N/</td>
</tr>
<tr>
<td>42</td>
<td>S/N,NOUDE $</td>
</tr>
<tr>
<td>43</td>
<td>$ MUST HAVE EITHER FREQ OR TSTEP BULK DATA.</td>
</tr>
<tr>
<td>44</td>
<td>PARAM /C/N,AND/V/N,FTK /V/N,NOFRL /V/N,NOHTL $</td>
</tr>
<tr>
<td>45</td>
<td>CNDN ERROR C5,FTK $ NO FREQ OR TSTEP BULK DATA.</td>
</tr>
<tr>
<td>46</td>
<td>$ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL.</td>
</tr>
<tr>
<td>47</td>
<td>PARAM /C/N,FTK /V/N,FTK /V/N,FREQU SET $</td>
</tr>
<tr>
<td>48</td>
<td>PARAM /C/N,FTK /V/N,FREQUET /V/N,FREGSET /V/N,TIMSET $</td>
</tr>
<tr>
<td>49</td>
<td>PARAM /C/N,NMPY /V/N,FREQUET /V/N,FREGSET /V/N,TIMSET $</td>
</tr>
</tbody>
</table>
NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //C,N,NUT /V,N,TERML /V,N,FREQTIME $
PARAM //C,N,LE /V,N,FREQUE /V,N,FREQSET /C,N,O $
PARAM //C,N,LE /V,N,NUTIME /V,N,TIMESET /C,N,O $
COND ERRORC0+TERML $ BOTH FREQ AND TSTEP IN CASE CONTROL DECK.
% EPOLL DATA NOT ALLOWED
PARAM //C,N,NUT /V,N,EXTRA/N /V,N,NOUE $
COND ERRORC0+EXTRAPTS $  
$ GENERATE DATA FOR CYC2 MODULE.
GPYCYL = GEOM4,EUQNY,USEUD /CYCDE /V,N,CTYPERG1 /Sc,NGGG $  
LCUPN ERRORC0+NOOG $  
CHKPT CYCDE $  
ALTER 32 $  
$ PRE-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED
PARAM //C,N,UR /V,N,NUBMI /V,N,NUMGG /V,N,NUKPS $  
PURGL .B1GG,M1GG /NUBMI $  
PURGL .M2GG,M2BASEG0 /NOOG $  
ALTER 35 $  
$ CLINLKATE DATA BLOCKS FRLX, B1GG, M1GG, M2GG AND BASLGX.  
$ GENERATE PARAMETERS FKMAX AND NBASEX.
LUKMOD1 CASLLE,GPDTL,CLTH,IHALF,FRLX,OR, / FRLX,B1GG,M1GG,  
M2GG,M2SLAV,PO2KGG, /V,N,NUMGG/V,Y,LYCIC/V,Y,NSEG$  
V,Y,NMAX/S,N,NMAX/V,Y,BXID=I/V,Y,BYPID=I/V,Y,GRPID=1/V,Y,GRPID=I/V,Y,BXPT=I/V,Y,BXPT=1  
V,Y,CMAX/S,N,NMAX/V,Y,NFREQ/V,Y,OMEGA $  
PARAM FRLX //C,N,PRESENT " //V,N,NOFRLX $  
COND LBLFRLX,NUFRLX $  
EQUIV FRLX,FRL $  
LABEL LBLFRLX $  
CHKPT FRLX,B1GG,M1GG,M2GG,BASEG0 $  
ALTER 42 $  
PARAM //C,N,ADDU /V,N,NUBBG /V,N,NUBMI /C,N,O $  
ALTER 52 $  
$ RLLE1 IN B1GG AND KG0.  
COND LBL11A,NUBMI $  
PARAM //C,N,COMPLEX //V,N,OMEGA2 /C,N,O / V,N,CMPLX2 $  
PARAM //C,N,SCV /V,N,MCMEGA $ /C,N,SCV /V,N,OMEGASQ $  
PARAM //C,N,COMPLEX /V,N,COMPLEX /C,N,NL0 / V,N,COMPLEX2 $  
ADD B1GG,B1GG / B1GG / C,N,(1.0,0.0) / V,N,CMPLX $  
EQUIV B1GG,B1GG $  
ADD KG0,M1GG / KG0 / C,N,(1.0,0.0) / V,N,CMPLX2 $  
EQUIV KG0,KG0 $  
CHKPT KG0,KG0 $  
LABEL LBL11A $  
ALTER 53,55 $ GI+ HAS BEEN MOVE UP.  
ALTER 55 $ GI+ HAS BEEN MOVE UP.  
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LUKAD FOR FREQ OR TRAN.  
PARAM //C,N,ANDU/V,N,LUKAD/V,N,NUBBG $  
COND LUKAD=LUKAD / BRANCH IN NOT FREQESP.  
ALTER 114 $ SEE ALTER 114 COMMENT.  
JUMP LUKAD2 $  

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None of the text in the image is clear enough to be read accurately. The document appears to be a computer program or code, but the content is unrecognizable due to the image quality.
NASTRAN EXECUTIVE CONTROL DECK ECHO

FRLG CASExx,USExD,DLT1,FLR1,GRD1,OF1T1 / PPF,PSF,PDF,FOL,PFETHAM / C,N,DIRED1/V,N,FREQU1,N,FREQ $ 
LCRD LBLFRLX1,NORFRLX5 ZEROCUTLOADCOLUMNSIFFRLXWASGENERATED. 
MPYAD PPF,PODEKU / PPFX /C,N,0 $ 
LQIV PPFX,PF $ 
LABEL LBLFRLX1 $ 
$ FOR NEW LOADS. 
LCRD LBLFRL1,NOBASEX $ 
MPYAD M2G,BASEXG / M2BASEXG/C,N,0 $ 
ACC PPF,M2BASEXG / PPF1/C,N,(-1.0,0.0) /C,N,(-1.0,0.0) $ 
EQLIV PPF1,PF $ 
LCRD LBLBASE1,NOSET $ 
SSEG USE10,UMO,YS,KFS,GOO,PPF /,PDDUM1,PSF1,PDF $ 
EQLIV PSF1,PS / PDF1,PDF $ 
LABEL LBLBASE1 $ 
LABEL LBLFRL1 $ 
EQLIV PPF,PDF/NOS1 $ 
CHPVNT PPF,PSF,PDF,FOL $ 
$ LOADS ARE FREQUENCY-DEPENDENT 
$ PLRFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIC=61. 
PARAM PPF //C,N,TH11ER1 /C,N,1 /V,N,PDFCOLS $ 
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1. 
PARAM //C,N,01V /V,N,NO1AD /V,N,PDFCOLS /V,N,FKMAX $ NLOAD = NF/FKMAX 
EQLIV PPF,PPF/1CYCIC $ 
LCRD LBLPOONE,CYCIC $ 
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1. 
PARAM //C,N,01V /V,N,NO1AD /V,N,PDFCOLS /V,N,FKMAX $ NLOAD = NF/NSEGS 
CYC1 PPF / PPF,GCY1 /V,N,CTYPE /C,N,FORE /V,N,NSEGS $ / 
V,Y,NMAX = 0 / V,N,NOLOAD /S,N,NSEGS 
CGN4 ERROR!1,NOGO $ 
CHPVNT PPF $ 
JUMP LBLPGONE $ 
LABEL LBLFRL2 $ 
$ LOADS ARE TIME-DEPENDENT 
PARAM //C,N,01T /V,N,NOTE1CYCIC /V,Y,CYCI $ 
$ CYCIC-DEPENDING ON VALUE OF CYCIC 
CGND LBLTR12,NOTE1CYCIC $ 
$ CYCIC=1 
EQLIV PPF,PDTR21/N0KU1 $ 
LCRD LBLRCIA,NORC1 $ 
MPYAD PPF,REORJER1, / PDTR21 /C,N,0 $ 
LABEL LBLRCIA $ 
CYC1 PDTR21 / PXTR21,GCY1F2 /V,N,CTYPE/C,N,FORE/V,N,NSTEPS/ 
V,Y,NMAX /V,N,FKMAX /S,N,NGO $ 
CGN4 ERR0RC1,NOGO $ 
CHPVNT PXTR21 $ 
JUMP PXTR21,STOP1/N0K02 $ 
CGND LBLRO2A,NORC2 $ 
MPYAD PXTR21,KLRDELK2, / PXF21 /C,N,0 $ 
LABEL LBLK02A $
EQUIV  PXFZ2, PXF1 $  
CHKPNT  PXF1 $  
JUMP  LBLTRL3 $  
LABEL  LBLTRL2 $  
$ CYCIC  =  61  
MPYAD  PDRKORDER1, / PDRZ2 / CN=0 $  
CYC1  PDRZ2 / PXTRZ2,6GCF3 / VN,CTYPE/CN,FORE/VN,NTSTEPS/V,Y,LMAX/  
        V,Y,NSEGS/S,N,NGGC $  
CGND  ERRGCL1,NGGC $  
CHKPNT  PXTRZ2 $  
EQUIV  PXTRZ2,PXTR/NURO2 $  
COIN  LBLKRO2,NURO2 $  
MPYAD  PXTRZ2,KORDER1, / PXTR2 / CN=0 $  
LABEL  LBLKR02 $  
CYC1  PXTR2 / PXFZ2,6GCF4 / VN,CTYPE/CN;FORE/V,Y,NSEGS/V,Y,KMAX/  
        V,Y,FLMAX/S,N,NGGC $  
CGND  ERRURC1,NGGC $  
EQUIV  PXFZ2,PXF1 $  
CHKPNT  PXF1 $  
LABEL  LBLTRL3 $  
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND  
$ TO FREQUENCY DEPENDENT LOADS. ALSO SUR2 EXPECTS LOADS TO BE COMPLEX  
$ IN FREQUENCY DEPENDENT PROBLEMS.  
COPY  PXF1 / PXF2 $  CONVET REAL PXF1 TO COMPLEX PXF.  
AJE  PXF1,PXF2 / PXF / CN,(0.5,1.0) / CN,(0.5,-1.0) $  
$ LDEF1NY NLAD FCG CYC1.  
PARAM  //CN,AUD / VN,NLAD / V,Y,FLMAX /CH,0 $  NLCAU = FLMAX  
LABEL  LBLPDO1E $  
PARAM  //CN,AUD / V,Y,KINDEX /V,Y,KMIN=0 /CN,0 $  INITIALIZE KINDEX.  
$ INITIALIZE UXVF IF KMIN IS NOT ZERO.  
$  
PARAM  //CN,AUD / V,Y,KMINL /V,Y,KMIN /CN,-1 $  
CGND  NUKMINL,KMINL $  
PARAM  //CN,AUD / V,N,KMINV /CN,0 /CN,0 $  
JUMP  KMINLJUP $  
LABEL  KMINLJUP $  
CYC2  CYCUD,*,PKF2, / CN,FORE/V,Y,NSEGS/  
        V,N,KMINV/V,N,CGC/L/V,N,NLCAU/S,N,NGGC $  
CGND  ERRRCL1,NGGC $  
ADC  PKF2, / UXVFZ / CH,(0.0,0.0) $  
CYC2  CYCUD,*,KVFLZ, / UXVF, / CN,BACK/V,Y,NSEGS/  
        V,N,KMINV/V,N,CGC/L/V,N,NLCAU/S,N,NGGC $  
CGND  ERRRCL1,NGGC $  
PARAM  //CN,AUD / V,N,KMINV /V,N,KMINV /CN,1 $  
REPT  KMINLJUP,KMINL $  
LABEL  KMINLJUP $  
$  
JUMP  TOPCYC $  
LABEL  TOPCYC $  LREP CN KINDEX  

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NASTRAN EXECUTIVE CONTROL DECK ECHO

CCND  NDKPR,NDKPR $  
PKTPARM //CN,0/CN,KINDEX $  
LABEL  NDKPR $  
CYCT2  CYCDU,KDU,MDU... /KKF,MKF... /CN,FORE/V,Y,NSEGS/  
       V,N,KINDEX/V,N,CYSEU=-1/V,Y,NLOAD/S,N,NGCC $  
COND  ERKRL1,NGCC $  
CHAMPNT  KKF,MKF $  
PARAM  //CN,SYT/CN,56/CN,2 $ METHOD 3T IN CYCT2 PRODUCES  
       UNDERFLOWS FOR PXF, USE METHOD 2.  
CYCT2  CYCDU,KDU,MDU... /KKF,MKF... /CN,FORE/V,Y,NSEGS/  
       V,N,KINDEX/V,N,CYSEU/V,N,NLOAD/S,N,NGCC $  
PARAM  //CN,SYT/CN,56/CN,0 $ RESET MPYAD METHOD CONTROL.  
COND  ERKRL1,NGCC $  
CHAMPNT  KKF,MKF $  
$ SOLUTION  
FRKD2  KKF,MKF,MKF...PKF,FDL / UKVF /CN,0.0/CN,0.0/CN,-1.0 $  
CHAMPNT  UKVF $  
CYCT2  CYCDU,KDU,MDU... /UKVF... /CN,BACK/V,Y,NSEGS/V,N,KINDEX/  
       V,N,CYSEU/V,N,NLOAD/S,N,NGCC $  
COND  ERKRL1,NGCC $  
CHAMPNT  UKVF $  
PARAM  //CN,ADD/V,N,KINDEX/V,N,KINDEX/CN,1 $ KINDEX = KINDEX + 1  
PARAM  //CN,SLU/V,Y,DONE / V,Y,KMAX / V,Y,KINDEX $  
COND  LCY2,DONE $ IF KINDEX .GT. KMAX THEN EXIT  
KEEP  TLPCYL,1CC $  
JUMP  ERRNO3 $  
LABEL  LCY2 $  
EQUIV  UVF,UDVF / CYCLO $  
CHAMPNT  UDVF $  
COND  LCY3,LCY3 $ IF CYCLO .GE. 0 THEN TRANSFORM TO PHYSICAL.  
CYCT1  UVF / UDVF...LCY3 / V,N,CTYPE/CN,BACK/V,Y,NSEGS/V,Y,KMAX/  
       V,Y,NLOAD $  
CHAMPNT  UDVF $  
LABEL  LCY3 $  
COND  LLTR4,NOTIME $  
EQUIV  PXF,PXF2 / CYCIC $  
COND  LCY4,LCY4 $ IF CYCLO .GE. 0 THEN TRANSFORM TO PHYSICAL.  
CYCT1  PXF / PXF2,LCY4 / V,N,CTYPE/CN,BACK/V,Y,NSEGS/V,Y,KMAX/  
       V,Y,NLOAD $  
LABEL  LCY4 $  
$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PXF.  
SDK1  USEDU,PPFZ/PPFZ,OPUDOM... / PPFS... /CN,1/CN,DYNAMICS $  
SDK2  USED0,OMS,YS,MS,SLD...PPFZ.../PCDOM,PSFZ,PLDOM $  
EQUIV  PPFS,PPF / PSFZ,PSF $  
CHAMPNT  PPF,PSF $  
LABEL  LLTR4 $  
ALTER 124,129 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  
VOR  CASEXX,EDYN,USEDU,UDVF,FDL,XYCDU/UVDVCY/CN,FRE租3/CN,  
       DIREC3/V,Y,NOSE1/2/S,N,XD/S,N,NGC/CN,0 $  
ALTER 14C,14O $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  

2.14
NASTRAN EXECUTIVE CONTROL DECK ECHO

SUR2  CASEXX,CSTM,MPT,JIT,EDYK,SILD,EGPDP,FLL,UPC,UPVC,EST,XYCOB,
PPF/UPPC1,UPC1,UPVCL,DESC,DEPL,UPVCL/CG,N,FREORSP/
S,N,FOSURT2 $
ALTER 160 $ ADD LABEL FOR ERROR3.
LABEL ERROR3 $
ALTER 103,166 $ REMOVE ERROR1 AND ERROR2.
ALTER 168 $ FORCED VIBRATION ERRORS.
LABEL ERRORC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.
PRTPARM //C,N,-7 //C,N,LYCSTATICS $
LABEL ERRORC2 $ COUPLED MASS NOT ALLOWED.
PRTPARM //C,N,0 //C,Y,COUPMASS $
JUMP FINIS $
LABEL ERRORC3 $ SUPPORT BULK DATA NOT ALLOWED.
PRTPARM //C,N,-6 //C,N,LYCSTATICS $
LABEL ERRORC4 $ EPOINT BULK DATA NOT ALLOWED.
PRTPARM //C,N,0 //C,N,INGUE $
JUMP FINIS $
LABEL ERRORC5 $ NEITHER FREQ OR TSTEP WERE IN BULK DATA DECK.
PRTPARM //C,N,0 //C,N,INGFRL $
PRTPARM //C,N,0 //C,N,NOTRL $
JUMP FINIS $
LABEL ERRORC6 $ BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.
PRTPARM //C,N,0 //C,N,NOFREQ $ PRTPARM //C,N,0 //C,N,NOTIME $
JUMP FINIS $
ENDALTER
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

2.4.2 DMAP Sequence for Forced Vibration Analysis of Rotating Cyclic Structures

OPTIONS IN EFFECT GO ERR=2 NOUUT NODECK NOREF NOOSCAR

1 BEGIN NO.8 FORCED VIBRATIONS OF ROTATING CYCLIC STRUCTURES - SERIES R
2 PKLCHK ALL $
3 $ FILE KGGX=TAPE/KGG=TAPE/GMD=SAVE/GMD=SAVE/MDD=SAVE/BDU=SAVE $
4 $ FILE UXVF=APPEND/PDT=APPEND/PD=APPEND $
5 CUND ERRURCL,NSEGS IF USER HAS NOT SPECIFIED NSEGS.
6 CUND ERRURCL,KMAX IF USER HAS NOT SPECIFIED KMAX.
7 PARAM V/C/N,E2/V/N,CYCIO=0/C/N,0 $
8 CUND ERRURCL,CYCIO=0 IF USER HAS NOT SPECIFIED CYCIO.
9 PARAM V/C,N,DIV/V,N,NSEG2/V,Y,NSEGS/C,N,2 NSEG2 = NSEGS/2
10 PARAM V/C,N,SUB/V,N,KMAXERR/V,N,NSEG2/V,Y,KMAX $
11 CUND ERRURCL,KMAXERR IF KMAX .GT. NSEG/2
12 PARAM V/C,N,NUP/V,Y,NOKPT=11/V,Y,LGKAD=-L $
13 PARAM V/C,N,MPY/V,N,OMEGA/V,Y,RPS=0/C,N,6.283185 $
14 PARAM V/C,N,MPY/V,N,CMEGA/V,Y,CMEGA $
15 PARAM V/C,N,MPY/V,N,CMEGASUP/V,N,CMEGA $
16 PARAM V/C,N,EQ/V,Y,RPS/C,N,0.0 ////V,N,NURPS. $
17 PARAM V/C,N,NUT/V,N,NOLUMP/V,Y,COUPMASS=-L $
18 CUND ERRURC2,NOLUMP $
19 PARAM V/*MPY*/CARDN=0/C $
20 GPL GEOM1,GEOM2/GPL,EXEXIN,GPD,GPSTP,BGPDOT,SIL/S,N,LUSET/ S,N, NUGDOT $
21 PLTRAN BGPDOT,SIL/HUSTP,SIP/LUSET/S,N,LUSEP $
22 PURGE USET,GM,GO,KA3,RAA,MAA,KAA,KFS,PSF,QQC,EST,ECT,PLTSETX,PLTPAR, GPSETS,ELSETS/NUGDOT $

2.16
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

23 CDNU LBL5,NOGPDT 
24 GP2 GEOM2,EQEXIN/ECT 
25 PARAM PCDB/*PRES==/**NOPCDB 
26 PURGE PLTSETX,PLTPAR,GPSETS,ELSETS/HOMCDB 
27 CDNU P1,NOPCDB 
28 PLTSET PLCUH,EQEXIN/ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,NSIL/ S,N, JUMPPLUT=1 $ 
29 PRTHSG PLTSETX// $ 
30 PARAM //*MPY*/PLTFLG/L/1 $ 
31 PARAM //*MPY*/PFILE/O/O $ 
32 CDNU P1,JUMPPLUT $ 
33 PLTJ PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,ECT,/*PLTXL/ NSIL/LUSET/S,N,JUMPPLUT/S,N,PLTFLG/S,N,PFILE $ 
34 PRTHSG PLTXL// $ 
35 LABEL P1 $ 
36 GP3 GEOM3,EQEXIN,GEOM2 / SLT,GP1T / V,N,NOGRAV $ 
37 CHKPI T SLT,GP1T $ 
38 TA1 ECT,GP1T,BGPDT,SIL,GPIT,CMST/EST,GEI,GPECT,/*LUSET/S,N,NGSIMP= -L/L,S,N,NGGENL=-L/S,N,GENEL $ 
39 PURGE K4GG,GPST,UGPST,MGG,BGG,K4NN,K4FF,K4AA,1NN,MFF,MAA,BNN,BFF,BAA, KGGX/NGSIMP/CPST/GENEL $ 
40 PARAM //C,N,MPY /V,N,NSKIP /C,N,O /C,N,O $ 
42 PURGE GM,GMDF/MPCLF/GO,GOCD/OMIT/KFS,PSF,PC/SINGLE $ 
43 CHKPI T GM,GMDF,GO,GOCD,KFS,PSF,PC,USET,YS $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

44 PARAM //C,N,NOT /V,N,REALDATA /V,N,REAL $  
45 COND  ERRORC3,REALDATA $  
46 UPD  DYNAMICS;GPL,SIL,USET /GPL,SIL,USET,TFPGOL,OLT,PSDL,FRL,  
TRL,EQDYN /V,N,LUSET/S,N,LUSETU/V,N,NUTFL/S,N,NODLT/  
S,N,NGPSDL/S,N,NOFRSL/V,N,NONLFT/S,N,NOTRL/V,N,NODEED/C,N/  
S,N,NOUE $  
47 PARAM //C,N,AND /V,N,FTRR /V,N,NCFRRL /V,N,NOTRL $  
48 COND  ERRORC9,FTRRR $  NC FREQ OR TSTEP BULK DATA.  
49 PARAML CASECC //C,N,D1 /C,N,1 /C,N,14 /V,N,FREQSET $  
50 PARAML CASECC //C,N,D1 /C,N,1 /C,N,38 /V,N,TIMESET $  
51 PARAM //C,N,MPY /V,N,FREQTIME /V,N,FREQSET /V,N,TIMESET $  
52 PARAM //C,N,NOT /V,N,FTRRL /V,N,FRECTIME $  
53 PARAM //C,N,LE /V,N,NOFREQ /V,N,FREQSET /C,N,0 $  
54 PARAM //C,N,LE /V,N,NOTIME /V,N,TIMESET /C,N,0 $  
55 COND  ERRORC6,FTRRL $  BOTH FREQ AND TSTEP IN CASF CONTROL DECK.  
56 PARAM //C,N,NOT /V,N,EXTRAPTS /V,N,NCUE $  
57 COND  ERRORC4,EXTRAPTS $  
58 GPCYC GEUM4,EQDYN,USETD /CYCDO /V,N,CTYPE=ROU /S,N,NOGG $  
59 COND  ERRORC1,NOGG $  
60 CHKPT CYCDO $  
61 COND  LAB1,NUSIMP $  
62 PARAM //ADD*/NUKGGX/1/0 $  
63 PARAM //ADD*/NOGU/1/0 $  
64 PARAM //ADD*/NUBG=1/1/0 $  
65 PARAM //ADD*/NOKGG/1/0. $  
66 E4G  EST,CSTM,MPT,DIT,GEUM2//KELM,KUICT,HELM,MDICT,BELM,EDICT/  
S,N,NOKGGX/S,N,NOGG/S,N,NOGU/S,N,NOKGG/ //C,Y,COUPMASS/C,Y,  
CPBAR/C,Y,CPRUD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIAL/C,Y,  
2.18
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


67 COND LBLKGGX,NOKGGX $
68 EMA GPECT,KDICT,KELM/KGGX,GPST $
69 LABEL LBLKGGX $
70 PARAM //C,N,OF /V,N,NDBMI /V,N,NOMGG /V,N,NOKPS $
71 PURGE BIGG,HIGG /NDBMI $
72 PURGE H2GG,H2BASEXG /NOMGG $
73 COND LBLMGG,NUMGG $
74 EMA GPECT,KDICT,MELM/MGG,-1/C/Y,NTMASS=1.0 $
75 LABEL LBLMGG $
77 PARAM FRLX //C,N,PRESENCE ////V,N,NDFRLX $
78 COND LBLFRLX,NDFRLX $
79 EQUIV FRLX,FRL $
80 LABEL LBLFRLX $
81 CHKPNF FRL,B1GG,M1GG,M2GG,BASEXG $
82 COND LBLBGG,NUBCG $
83 EMA GPECT,KDICT,BELM/RGG, $
84 LABEL LBLBGG $
85 COND LBLK4GG,NOK4GG $
86 EMA GPECT,KDICT,KELM/K4GG,NOK4GG $
87 LABEL LBLK4GG $
88 PURGE MNN,MFF,MAA/NOMGG $

2.19
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

99 PARAM //C,N,ADD /V,N,NOBGG /V,N,NORMI /C,N,0 $, RESET NOBGG.$
90 PURGE BNN, OFF, BAA/NOBGG $
91 COND LBL1, GRDPNT $
92 COND ERROR4, NOBGG $
93 GPWG BDP,CSTH, EQEXIN, NMGG/GPWP/V,Y,GRDPNT=-1/C,Y,NT MASS $
94 DPP GPWP, , , , //S,N,CARDNO $
95 LABEL LBL1 $
96 EQUIV KGGX, KGG/NOGENL $
97 COND LBL11, NGENL $
98 SME3 GEI, KGGX/KGG/LUSET/NOGENL/NOSIMP $
99 LABEL LBL11 $
100 COND LBL11A, NORMI $
101 PARAM //C,N,COMPLX // V,N,OMEGA2 / C,N,0.0 / V,N,CMPLX1 $
102 PARAM //C,N,SUB / V,N,OMEGASQ / C,N,0.0 / V,N,CMEGASQ $
103 PARAM //C,N,COMPLEX / V,N,OMEGASG / C,N,0.0 / V,N,CMPLX2 $
104 ADD BGG, BGG / BGG1 / C,N,(1.0,0.0) / V,N,CMPLX1 $
105 EQUIV BGG1, BGG $
106 ADD KGG, M1GG / KGG1 / C,N,(1.0,0.0) / V,N,CMPLX2 $
107 EQUIV KGG1, KGG $
108 CHKPT BGG, KGG $
109 LABEL LBL11A
110 COND LBL4, GENEL $
111 COND LBL4, NOSIMP $
112 PARAM //EQ#/GPSFLG/AUTOSPC/O $
113 COND LBL4, GPSFLG $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

114 GPSP GPL,GPST,USE / S, N, NGPST $
115 COND LBL4,NGPST $
116 DFPS GPST,,/$, S, N, CARDAG $
117 LABEL LBL4 $
118 EQJ IV KGG, KNN/MPCF1/ MGG, MNN/MPCF1/ BGG, BNN/MPCF1/K4GG, K4NN/MPCF1 $
119 COND LBL2,MPCF1 $
120 MCE1 USET, RG/GM $
121 MCE2 USET, GM, KGG, MGG, BGG, K4GG/K4NN, BNN, K4NN $
122 LABEL LBL2 $
123 EQJ IV KNN, KFF/SINGLE/MNN, KFF/SINGLE/BNN, BFF/SINGLE/K4NN, K4FF/SINGLE $
124 COND LBL3,SINGLE $
125 SCE1 USET, KNN, MNN, BNN, K4NN/KFF, KFF, MFF, BFF, K4FF $
126 LABEL LBL3 $
127 EQUIV KFF, KAA/OMIT $
128 EQUIV MFF, MAA/OMIT $
129 EQJ IV BFF, BAA/OMIT $
130 EQUIV K4FF, K4AA/OMIT $
131 COND LBL5,OMIT $
132 SMP 1 USET, KFF,,/GO, KAA, KCC, LCO,,,$
133 COND LBLM, NOMGG $
134 SMP 2 USET, GO, MFF/MAA $
135 LABEL LBLM $
136 COND LBLB, NOBGG $
137 SMP 2 USET, GO, BFF/BAA $
138 LABEL LBLB $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

139 COND LBL5,NOK4GG $
140 \text{ SYM } 2 \text{ USE } 7,20,K4FL/K4AA $
141 \text{ LABEL } LBL5 $
142 \text{ EQIV } GO,God/NOUE/GM,GMD/NCLE $
143 \text{ PARAM } //\text{ADD*/NEVER/1/0}$
144 \text{ PARAM } //\text{MPY*/REPEATF/-1/1}$
145 \text{ BFG } MAPPOOL,BGPDT,EQEXIN,CSTH/8DFCCL/S,N,NCFL/S,N,NOABFL/S,N,FACT $
146 \text{ PARAM } //\text{AND*/NOFL/NCFL/NOKFL}$
147 \text{ PURGE } XBFL/NOKFL/ABFL/NCAFL $
148 \text{ COND } LBLFL3,NCFL $
149 \text{ MTRXIN } ,RPOOL,EQDYN,,/ABFL,KRFL,LUSETO/S,N,NOABFL/S,N,NOKFL/O $
150 \text{ LABEL } LBLFL3 $
151 \text{ JUMP } LBL13 $
152 \text{ LABEL } LBL13 $
153 \text{ PURGE } ODVC1,ODVC2,XYPLTF,UPPC1,UPPC1,UPVC1,CEC1,CEF1,UPPC$
154 \text{ CASE } \text{CASECC,PSDL/CASEXX/FREQ*/S,N,REPEATF/S,N,NOLOOP}$
155 \text{ MTRXIN } \text{CASEXX,MAPPOOL,EQDYN,,TFPCOL/K2PP,K2PP,K2PP,LUSETO/S,N,NOABFL/S,N,NOKFL}$
156 \text{ PARAM } //\text{AND*/NOK2PP/NOFL/NCFL}$
157 \text{ PARAM } //\text{AND*/NO2PP/NOFL/NCFL}$
158 \text{ EQIV } M2DP2,M2PP/NOABFL $
159 \text{ ADDS } ABFL,KBFL,K2DP2,,/K2PP/-1.0,0.0) $
160 \text{ COND } LBLFL2,NCAFL $
161 \text{ TKNSP } ABFL/AUFLT $

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LEVEL 2.0 NASTRAN MAP COMPILER − SOURC LISTING

162 ADD  ABFL,T,M2DDP/N2PP/IMPACT $
163 LABEL  LBLFL2 $
164 PARAM  //CNDT/BDEBA/NOQED/KC2PP $
165 PARAM  //CNDT/KDEK2/NOGED/NOSIMP $
166 PARAM  //CNDT/KDEMA/NOUE/KC2PP $
167 PURGE  K2DD/NOK2PP/K2DD/NOM2PP/K2DD/NG2PP $
168 PARAM  //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NCK2PP $
169 COVD  LGKAD1, LGKAD $ BRANCH IN NOT FREQRESP. 
171 JUMP  LGKAD2 $
172 LABEL  LGKAD1 $
174 CHKPT  K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,KDD,MDD $
175 LABEL  LGKAD2 $
176 COVD  LBL18, NOGPUT $
178 LABEL  LBL18 $
179 COVD  LGKAD3, LGKAD $ BRANCH IF NOT FREQRESP. 
180 EQIV  B2DD, BDD/NOBGG/ M2DD, MDD/NOSIMP/ K2DD, KDD/KDEK2 $
181 JUMP  LGKAD4 $
182 LABEL  LGKAD3 $
183 EQIV  B2DD, BDD/NOGPUT/M2DD, MDD/NOSIMP/K2DD, KDD/KDEK2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

184 LABEL LOKAD4 $
185 COND LBLTRL1:NOTIME $
186 PARAM //C,N,MPY /V,N,REPEAT /C,N,1 /C,N,-1 $
187 PARAM //C,N,ADD /V,N,APPFLG /C,N,0 /C,N,0 INITIALIZE FOR SDRI.
188 JUMP TRLGLOOP $
189 LABEL TRLGLOOP $
190 CASE CASECC/\ CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NCLGODP1 $
191 CHKPT CASEYY $
192 PARAM //C,N,MPY /V,N,NCOL /C,N,0 /C,N,1 $
193 TRLG CASEYY,USETO,DLT,SID,BGPDT,SIL,CSM,TRL,DIT,GMD,GOO,EST,MSG/ $
194 SDR1 TRL,PDT1,,,$ /,PDT,$ /V,N,APPFLG/C,N,DYNAMICS $
195 SDR1 TRL,PDT1,,,$ /,PDT,$ /V,N,APPFLG/C,N,DYNAMICS $
196 PARAM //C,N,ADD /V,N,APPFLG /V,N,APPFLG /C,N,1 $ APPFLG=APPFLG
197 CND TRLGDONE,REPEAT $ 100 $
198 JUMP ERROR 3 $
199 LABEL TRLGDONE $
200 CHKPT PDT,PDTIOL $
201 EQP IV PD,PDT/PDEPDC $
202 CHKPT PDT $
203 DUMMOD2 TUL,$ / FRLZ,FGLZ,REORDER1,REORDER2,$ / $V,Y,NSEQS/V,Y,CYCLIC/S,Y,LMAX=-1/V,N,FKMAX/$ $
204 S,N,FLMAX/S,N,NTSTEPS/S,N,NGRI/S,N,NGRI $ 2.24
205 EQP IV FRLZ,FRL / FOLZ,FCL $
206 CHKPT FRL,FOL,REORDER1,REORDER2 $
207 JUMP LULFLR2 $

2.24
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

208  LABEL  LBLTRL1 $  
209  FRLG  CASEXX, USETU, ULT, FRL, GMD, GDC, DIT, / PPF, PSF, PDF, FOL, PHFUM / C,N, DIRECT/V,N,FREQ/C,N,FREQ $  
210  COVD  LBLFRLX1, NOFRLX $  ZEROD LT LOAD COLUMNS IF FRLX HAS GENERATED.  
211  MPYAD  PPF, PDZERO, / PPFX /C,N,0 $  
212  EQJIV  PPFX, PPF $  
213  LABEL  LBLFRLX1 $  
214  COVD  LBLFRL1, NODBASEX $  
215  MPYAD  M2GG, BASEXG, / M2BASEXG /C,N,0 $  
216  ADD  PPF, M2BASEXG / PPF1 /C,N,(1.0,0.0) /C,N,(-1.0,0.0) $  
217  EQJIV  PPF1, PPF $  
218  COVD  LBLBASE1, NOSET $  
219  SSGZ  USETU, GMD, YS, KFS, GCD, PPF / , PHFUM, PSF1, PDF1 $  
220  EQJIV  PSF1, PSF // PDF1, PDF $  
221  LABEL  LBLBASE1 $  
222  LABEL  LBLFRL1 $  
223  EQJIV  PPF, PDF / NOSET $  
224  CHKPT  PPF, PSF, PDF, FOL $  
225  PARAML  PDF // C,N, TRAILFR /C,N,1 / V,N, PDFCGLS $  
226  PARAM  // C,N, DIV / V,N, NLOAD / V,N, PDFCGLS / V,N, FKMAX $ NLOAD = NF/FKMAX  
227  EQUIV  PDF, PXF, CYCIC $  
228  COVD  LBL?DUNE, CYCIO $  
229  PARAM  // C,N, DIV / V,N, NLOAD / V,N, PDFCGLS / V,Y, NSEGS $ NLOAD = NF/NSEGS  
230  CYCT1  PDF / PXF, GCYCF1 / V,N, CTYPE / C,N, FCRE / V,Y, NSEGS=-1 / V,Y, KM=1=1 / V,N, HLLAD / S,N, NGG $  
231  COVD  ERRORC1, NGG $  

2.25
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

232 CHKPNT PXF $  
233 JUMP LBLPDONE $  
234 LABEL LBLTRL2 $  
235 PARAM /C,N,KUT /V,N,NOTCYCIO /V,Y,CYCIO $  
236 COND LBLTRL2, NOTCYCIO $  
237 EQUIV POT, PDTRZ1/NCRO1 $  
238 COND LBLRO1A, NOGO $  
239 MPYAD POT, REORDER1, / PDTRZ1 / C,N,0 $  
240 LABEL LBLRO1A $  
241 CYCT1 PDTRZ1 / PXTRZ1, GCYCF2 /V,N,CTYPE/C,N,FORE/V,N,NTSTEPS/ V,Y,LMAX/V,N,FKMAX/S,N,NOGO $  
242 CYCTC ERRURC1, NOGO $  
243 CHKPNT PXTRZ1 $  
244 EQUIV PXTRZ1, PXFZ1/NCRO2 $  
245 COND LBLPD2A, NORL2 $  
246 MPYAD PXTRZ1, REORDER2, / PXFZ1 / C,N,0 $  
247 LABEL LBLPD2A $  
248 EQUIV PXFZ1, PXF1 $  
249 CHKPNT PXF1 $  
250 JUMP LBLTRL3 $  
251 LABEL LBLTRL2 $  
252 MPYAD POT, REORDER1, / PDTRZ2 / C,N,0 $  
253 CYCT1 PDTRZ2 / PXTPZ2, GCFYCF3 /V,N,CTYPE/C,N,FCRE/V,N,NTSTEPS/V,Y,LMAX/ V,Y,NSEG5/S,N,NOGO $  
254 COND ERRURC1, NOGO $  
255 CHKPNT PXTRZ2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

256 EQUIV PXTR2, PXTR2/NORO2 $ 
257 COND LBLRO28, NORO2 $ 
258 MPYAD PXTR2,REORDER2 / PXTR2 /C,N,0 $ 
259 LABEL LBLRO29 $ 
261 CONV ERRORC1, NOGO $ 
262 EQUIV PXF2, PXF1 $ 
263 CHKPT PXF1 $ 
264 LABEL LBLTRL3 $ 
265 CUPY PXF1 / PXF2 $ CONVERT REAL PXF1 TC COMPLEX PXF. 
266 ADD PXF1, PXF2 / PXF / C,N,(0.5,1.0) / C,N,(0.5,-1.0) $ 
267 PARAM / C,N,ADD / V,N,NLOAD / V,N,FLMAX / C,N,0 $ NLOAD = FLMAX 
268 LABEL LBLPDONE $ 
269 PARAM / C,N,ADD / V,N,KINDEX / V,Y,KMIN=0 / C,N,0 $ INITIALIZE KINDEX. 
270 PARAM / C,N,ADD / V,N,KMINL / V,Y,KMIN / C,N,-1 $ 
271 CONV NOKMINL,KMINL $ 
272 PARAM / C,N,ADD / V,N,KMINV / C,N,0 / C,N,0 $ 
273 JUMP KMINLOOP $ 
274 LABEL KMINLOOP $ 
275 CYCT2 CYCUD,...,PXF,... /,...,PKFZ,... / C,N,FORE/V,Y,NSEG5/ V,N,KMINV/V,N,CYCSEQ/V,N,NLOAD/S,N,NCGC $ 
276 CONV ERRORC1, NOGO $ 
277 ADD PKFZ, / LKVFZ / C,N,(0.0,0.0) $ 
278 CYCT2 CYCUD,...,LKVFZ,... /,...,UXVF,... / C,N,BACK/V,Y,NSEG5/ V,N,KMINV/V,N,CYCSEQ/V,N,NLOAD/S,N,NCGC $ 
279 CONV ERRORC1, NOGO $
LEVEL 2.0 NASTRAN DHAP COMPILER - SOURCE LISTING

280 PARAM /C,N,ADD /V,N,KMINV /V,N,KMINV /C,N,1 $
281 REPT KHINLOOP,KHINAL $
282 LABEL NOKMINL $
283 JMP TOPCYC $
284 LABEL TOPCYC $ LUOP ON KINDEX
285 COND NOKPRT,NOKPRT $
286 PRTPARM /C,N,O /C,N,KINDEX $
287 LABEL NOKPRT $
288 CYCT2 CYCODD,KDD,M0D,* /KKKF,MMKF,, /C,N,FORE/V,Y,NSEGS /
V,N,KINDEX/V,N,CYSEQ=-1/V,N,NLOAD/S,N,NCGC $
289 COND ERRCRC1,NOGU $
290 CHKPT1 KKKF,MMKF $
291 PARAM /C,N,SYST /C,N,58 /C,N,2 $ METHOD 37 IN CYCT2 PRODUCES
292 CYCT2 CYCODD,B0D,*,PKF,, /BBKF,PKF,, /C,N,FORE/V,Y,NSEGS/
V,N,KINDEX/V,N,CYSEQ/V,N,ALOAD/S,N,NOGO $
293 PARAM /C,N,SYST /C,N,58 /C,N,0 $ RESET MPYAD METHOD CONTROL.
294 COND ERRCRC1,NOGU $
295 CHKPT1 BBKF,PKF $
296 FR2D2 KKKF,BKKF,MMKF,,PKF,FCL / UKVF /C,N,0.0/C,N,0.0/C,N,1.0 $
297 CHKPT1 UKVF $
298 CYCT2 CYCJD,,LKV,*, /UXVF,, /C,N,BACK/V,Y,NSEGS/V,N,KINDEX/
V,N,CYSEQ/V,N,ALOAD/S,N,NCGC $
299 COND ERRCRC1,NOGU $
300 CHKPT1 UXVF $
301 PARAM /C,N,ADD /V,N,KINDEX/V,N,KINDEX/C,N,1 $ KINDEX = KINDEX + 1.
302 PARAM /C,N,SUB /V,N,DONE /V,Y,KFAX / V,N,KINDEX $
303 COND LCYC2,DONE $ IF KINDEX .GT. KMAX THEN EXIT

2.28
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

304 REPT TOPCYC,100 $
305 JUMP ERROR3 $
306 LABEL LCYC2 $
307 EQUIV UXVF,UDVF / CYC10 $
308 CHKPTN UDVF $
309 COND LCYC3,CYC10 IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL.
310 CYCT1 UXVF / UDVF,GCYCLH / V,N,CTYPE/C,N,BACK/V,Y,NSEG5/V,Y,KMAX/ V,N,NLOAD $
311 CHKPTN UDVF $
312 LABEL LCYC3 $
313 COND LBLTRL4,NOTIME $
314 EQUIV PXF,PDF2 / CYC10 $
315 COND LCYC4,CYC10 IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL.
316 CYCT1 PXF / PDF2,GCYCLH / V,N,CTYPE/C,N,BACK/V,Y,NSEG5/V,Y,KMAX/ V,N,NLOAD $
317 LABEL LCYC4 $
318 SDF1 USETD,PDF2,..GUD,GMD,... / PPFZ,... / C,N,1 / C,N,DYNAMICS $
319 SDF2 USETD,GMD,YS,KFS,GUD,...,PPFZ / PCDUP,PSFZ,PLDUM $
320 EQUIV PPFZ,PPF // PSFZ,PSF $
321 CHKPTN PPF,PSF $
322 LABEL LBLTRL4 $
323 VDF CASEXX,EQD,YI,USEDT,UDVF,FCL,XYCJ,H,/GUOVC1,C,N,FREQPES/C,N, DIRECT/S,N,NOSORT2/S,N,NOD/S,N,NCP/C,N,0 $
324 COND LBL15,NOD $
325 COND LBL15A,NOSORT2 $
326 SDF3 OUVVC1,...,/GUOVC2,... $
327 OEP OUVVC2,... / S,N,CARDNC $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

328 XYTRAN    XVCUB,OUVC2,/,/XYPLTF/*/FREQ*/OSET*/S,N,PFILA/S,N,CARDNO $
329 XYPLTT    XYPCTFA/ / $ 
330 JUMP      LBL15 $ 
331 LABEL      LBL15A $ 
332 QFP        OUDVC1,...,/,S,N,CARDNC $ 
333 LABEL      LBL15 $ 
334 COND       LBL20,NUP $ 
335 EQUIV      UDFV,UPVC/NOA $ 
336 COND       LBL19,NUA $ 
337 SDR1       USETO,UDVF,...,GUD,GM0,PSF,KFS,,UPVC,,QPC/1/*DYNAMICS* $ 
338 LABEL      LBL19 $ 
339 SDR2       CASEXX,LMST,MPT,0,T,EOYNE,,SBGQD,FOLE,QPC,JPVC,EST,XVCUB,
               PPF/QPPC1,QPC1,QUPVC1,GEFC1,GSFC1,PUPVC1/C,N,FREQ/FRESF/ 
               S,N,NSURT2 $ 
340 CLVD       LBL17,NSURT2 $ 
341 SDR3       QPPC1,UPPC1,CUPVC1,GEFC1,GSFC1,QPPC2,QPPC2,UPVC2,GEFC2, 
               QEF2, $ 
342 QFP        QPPC2,QPPC2,CUPVC2,GEFC2,GSFC2,,S,N,CARDNC $ 
343 XYTRAN     XVCUB,UPPC2,QPC2,UPVC2,GEFC2,GSFC2/XYPLTF/*/FREQ*/PSET*/ 
               S,N,PFILA/S,N,CARDNO $ 
344 XYPLTT     XYPLTF/ / $ 
345 COND       LBL16,NOPSOL $ 
346 RANDLM     XVCUB,DIT,PSOL,UPVC2,QPPC2,QPC2,GSFC2,GSFC2,CASEXX/PSDF, 
               AUTU/S,N,NORD $ 
347 CLVD       LBL16,NORD $ 
348 XYTRAN     XVCUB,PSET,AUTO,/,/XYPLTR/*RAND*/PSET*/S,A,PFILA/
               S,N,CARDNO $ 
349 XYPLTT     XYPLTR/ / $ 

2.30
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

350 JUMP LBL16 $
351 LABEL LBL17 $
352 JFP UUPVCI,OPPC1,OOPPC1,CEFC1,CESCI,THEA,CARDAC $
353 LABEL LBL16 $
354 CUD LBL20, JUMP PLOT $
355 PLOT PLTPAR,GPSETS,ELSETS,CASEXX,B6PDT,EQEXIN,SPU,PUPVCI, GPECT, DESC1/PLOTX2/NSIL/LUSEP/JUMP PLOT/PLTFLG/ $,N,PFILE $
356 PRTMSG PLOTX2/ $ $
357 LABEL LBL20 $
358 CUD FINISH REPEAT F $
359 KEEP LBL13,100 $
360 LABEL ERROR3 $
361 PRTPARM //3/*DIRFRAD* $
362 JUMP FINISH $
363 LABEL ERROR4 $
364 PRTPARM //4/*DIRFRAD* $
365 LABEL ERRURC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA. $
366 PRTPARM //C,N,-7 /C,N,CYCSTAS $ $
367 LABEL ERRURC2 $ COUPLED MASS NCT ALLOWED. $
368 PRTPARM //C,N,0 /C,Y,COUPPASS $ $
369 JUMP FINISH $
370 LABEL ERRURC3 $ SUPPORT BULK DATA NCT ALLOWED. $
371 PRTPARM //C,N,-6 /C,N,CYCSTAS $ $
372 LABEL ERRURC4 $ EPOINT BULK DATA NCT ALLOWED. $
373 PRTPARM //C,N,0 /C,N,NOUE $ $
374 JUMP FINISH $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

375 LABEL ERRORC5 $ NEITHER FREQ OR TSTEP WERE IN BULK DATA DECK.
376 PRTPARM //C,N,0 /C,N,NDFRL $
377 PRTPARM //C,N,0 /C,N,NCTRL $
378 JUMP FINIS $
379 LABEL ERRORC6 $ BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.
380 PRTPARM //C,N,0 /C,N,NOFREQ $
381 PRTPARM //C,N,0 /C,N,NOTIME $
382 JUMP FINIS $
383 LABEL FINIS $
384 END $
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

2.4.3 Description of DMAP Operations for Forced Vibration Analysis of Rotating Cyclic Structures

5. Go to DMAP No. 365 if user has not specified parameter NSEGS.
6. Go to DMAP No. 365 if user has not specified parameter KMAX.
8. Go to DMAP No. 365 if user has not specified parameter CYCIO.
11. Go to DMAP No. 365 if KMAX > NSEGS/2.
18. Go to DMAP No. 367 if user has requested consistent mass.
20. GPI generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.
23. Go to DMAP No. 141 if only Direct Matrix Input.
24. GP2 generates Element Connection Table with internal indices.
27. Go to DMAP No. 35 if no plot output is requested.
28. PLTSET transforms user input into a form used to drive structure plotter.
29. PRTMSG prints error messages associated with structure plotter.
32. Go to DMAP No. 35 if no undeformed structure plots are requested.
33. PLT generates all requested undeformed structure plots.
34. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
36. GP3 generates Grid Point Temperature Table.
38. TAI generates element tables for use in matrix assembly and stress recovery.
41. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations \([R_g][u_g] = 0\).
45. Go to DMAP No. 370 and print error message if free-body supports are present.
46. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Power Spectral Density List and Frequency Response List.
48. Go to DMAP No. 375 and print parameters NOFRL and NOTRL if there was no FREQ or TSTEP bulk data.
55. Go to DMAP No. 379 and print parameters NOFREQ and NOTIME if both FREQUENCY and TSTEP were requested in the Case Control deck.
57. Go to DMAP No. 372 and print parameter NOUE if extra points are present.
58. GPCYC prepares segment boundary table (CYCDD).
59. Go to DMAP No. 365 and print error message if CYJOIN data is inconsistent.
61. Go to DMAP No. 95 if there are no structural elements.
66. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.
67. Go to DMAP No. 69 if no stiffness matrix is to be assembled.
68. EMA assembles stiffness matrix \([K_{gg}^X]\) and Grid Point Singularity Table.
73. Go to DMAP No. 75 if no mass matrix is to be assembled.
74. EMA assembles mass matrix \([M_{gg}]\).
76. DUMMODI generates modified Frequency Response List, FRLX, Coriolis acceleration coefficient matrix \([B1GG_{gg}]\), centripetal coefficient matrix \([M1GG_{gg}]\), Base acceleration coefficient matrix \([M2GG_{gg}]\), Base acceleration matrix \([BASEXG_{gg}]\) and load modification matrix, \([PDZERO^F_g]\), for base acceleration problems.
79. Equivalence FRLX to FRL if FRLX was generated by DUMMODI.
82. Go to DMAP No. 84 if no viscous damping matrix is to be assembled.
83. EMA assembles viscous damping matrix \([B_{gg}]\).
85. Go to DMAP No. 87 if no structural damping matrix is to be assembled.
86. EMA assembles structural damping matrix \([K_{gg}^A]\).
91. Go to DMAP No. 95 if no weight and balance is requested.
92. Go to DMAP No. 363 and print error message if no mass matrix exists.
93. GPWG generates weight and balance information.
94. DFPP formats weight and balance information prepared by GPWG and places it on the system output file for printing.
96. Equivalence \([K_{gg}^X]\) to \([K_{gg}]\) if no general elements.
97. Go to DMAP No. 99 if no general elements.
98. SMA3 adds general elements to \([K_{gg}^X]\) to obtain stiffness matrix \([K_{gg}]\).
100. Go to DMAP No. 109 if parameter RPS = 0.0 or if no mass matrix is present.
104. ADD assembles the Coriolis acceleration matrix into the viscous damping matrix \([BGu'_{gg}] = [B_{gg}] + (4\pi \cdot \text{RPS}) [B1GG_{gg}]\)
105. Equivalence \([BGG]_{gg}\) to \([B_{gg}]\).

106. ADD assembles the centripetal acceleration matrix into the stiffness matrix.
\[
[KGG]_{gg} = [K_{gg}] - (2\pi \cdot \text{RPS})^2 [M_{16G}]_{gg}
\]

107. Equivalence \([KGG]_{gg}\) to \([K_{gg}]\).

108. Go to DMAP No. 117 if general elements present.

109. Go to DMAP No. 117 if no structural elements.

110. GPSP determines if possible grid point singularities remain.

111. Go to DMAP No. 117 if no grid point singularities exist.

112. DFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

113. Equivalence \([K_{gg}]\) to \([K_{nn}]\), \([M_{gg}]\) to \([M_{nn}]\), \([B_{gg}]\) to \([B_{nn}]\) and \([K_{4g}]\) to \([K_{nn}]\) if no multipoint constraints.

114. Go to DMAP No. 122 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

115. MCE1 partitions multipoint constraint equations \([R_{g}] = [K_{m}]^{-1}[R_{n}]\) and solves for multipoint constraint transformation matrix \([G_{m}] = -[R_{m}]^{-1}[R_{n}]\).

116. MCE2 partitions stiffness, mass and damping matrices
\[
[K_{gg}] = \begin{bmatrix} [K_{nn}] & [K_{mn}] \\ [K_{mn}] & [K_{mm}] \end{bmatrix}, \quad [M_{gg}] = \begin{bmatrix} [M_{nn}] & [M_{mn}] \\ [M_{mn}] & [M_{mm}] \end{bmatrix}, \quad [B_{gg}] = \begin{bmatrix} [B_{nn}] & [B_{mn}] \\ [B_{mn}] & [B_{mm}] \end{bmatrix}, \quad [K_{4g}] = \begin{bmatrix} [K_{nn}] & [K_{mn}] \\ [K_{mn}] & [K_{mm}] \end{bmatrix}
\]

and performs matrix reductions
\[
[K_{nn}] = [R_{nn}] + [G_{m}^{T}] [K_{nn}] + [K_{nn}] [G_{m}] + [G_{m}^{T}] [K_{nn}] [G_{m}],
\]
\[
[M_{nn}] = [R_{nn}] + [G_{m}^{T}] [M_{nn}] + [M_{nn}] [G_{m}] + [G_{m}^{T}] [M_{nn}] [G_{m}],
\]
\[
[B_{nn}] = [R_{nn}] + [G_{m}^{T}] [B_{nn}] + [B_{nn}] [G_{m}] + [G_{m}^{T}] [B_{nn}] [G_{m}],
\]
\[
[K_{4n}] = [R_{nn}] + [G_{m}^{T}] [K_{4n}] + [K_{nn}] [G_{m}] + [G_{m}^{T}] [K_{nn}] [G_{m}],
\]

117. Equivalence \([K_{nn}]\) to \([K_{ff}]\), \([M_{nn}]\) to \([M_{ff}]\), \([B_{nn}]\) to \([B_{ff}]\) and \([K_{4n}]\) to \([K_{ff}]\) if no singlepoint constraints.
124. Go to DMAP No. 126 if no single-point constraints.  

125. SCE partitions out single-point constraints:

\[
[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix}, \quad [U_{nn}] = \begin{bmatrix} U_{ff} & U_{fs} \\ U_{sf} & U_{ss} \end{bmatrix}, \quad [B_{nn}] = \begin{bmatrix} B_{ff} & B_{fs} \\ B_{sf} & B_{ss} \end{bmatrix}, \quad [K_{44}^4] = \begin{bmatrix} K_{44}^f & K_{44}^s \\ K_{44}^f & K_{44}^s \end{bmatrix}
\]

127. Equivalence \([K_{ff}]\) to \([K_{aa}]\) if no omitted coordinates.  

128. Equivalence \([M_{ff}]\) to \([M_{aa}]\) if no omitted coordinates.  

129. Equivalence \([B_{ff}]\) to \([B_{aa}]\) if no omitted coordinates.  

130. Equivalence \([K_{44}^4\)] to \([K_{44}^4\)] if no omitted coordinates.  

131. Go to DMAP No. 141 if no omitted coordinates.  

132. SMP1 partitions constrained stiffness matrix:

\[
[K_{ff}] = \begin{bmatrix} K_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}
\]

solves for transformation matrix \([G_o] = -[K_{oo}]^{-1}[K_{oa}]\) and performs matrix reduction \([K_{aa}^1] = [K_{aa}] + [K_{ao}][G_o]\).

133. Go to DMAP No. 135 if \(n\) mass matrix.  

134. SMP2 partitions constrained mass matrix:

\[
[M_{ff}] = \begin{bmatrix} M_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}
\]

and performs matrix reduction \([M_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}][G_o]^T + [G_o]^T [M_{oo}][G_o]\).

136. Go to DMAP No. 138 if no viscous damping matrix.
137. SMP2 partitions constrained viscous damping matrix

\[
[B_{ff}] = \begin{bmatrix}
B_{aa} & B_{ao} \\
B_{oa} & B_{oo}
\end{bmatrix}
\]

and performs reduction

\[
[B_{aa}^1] = [B_{aa}] + [B_{ao}][G_0]^{-1}[G_0^T][B_{ao}] + [G_0^T][B_{ao}]G_0
\]

139. Go to DMAP No. 141 if no structural damping matrix.

140 SMP2 partitions constrained structural damping matrix

\[
[K_{ff}] = \begin{bmatrix}
K_{aa}^4 & K_{ao}^4 \\
K_{oa}^4 & K_{oo}^4
\end{bmatrix}
\]

and performs matrix reduction

\[
[K_{aa}^4] = [K_{aa}^4] + [K_{ao}^4][G_0]^{-1}[G_0^T][K_{ao}^4] + [G_0^T][K_{oo}^4]G_0
\]

142. Equivalence \([G_0]\) to \([G_0^d]\) and \([G_m]\) to \([G_m^d]\) if no extra points introduced for dynamic analysis.

145. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

148. Go to DMAP No. 150 if no fluid structure interface is defined.

149. MTRXIN generates fluid boundary matrices \([A_{bfx}^d]\) and \([K_{bfx}^d]\) if a fluid structure interface is defined. The matrix \([K_{bfx}^d]\) is generated only for a nonzero gravity in the fluid.

151. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

152. Beginning of loop for additional sets of direct input matrices.

154. CASE extracts user requests from CASECC for current loop.

155. MTRXIN selects the direct input matrices for the current loop, \([K_{pp}^{2d}]\), \([M_{pp}^{2d}]\) and \([B_{pp}^2]\).

158. Equivalence \([M_{pp}^{2d}]\) to \([M_{pp}^2]\) if no \([A_{bfx}^d]\).

159. ADDS adds \([K_{bfx}^d]\) and \([K_{pp}^{2d}]\) and subtracts \([A_{bfx}^d]\) from them to form \([K_{pp}^2]\).

2.37
160. Go to DMAP No. 163 if for use in Direct Transient Response, if parameter GKAD = TRANRESP.

161. Transpose \([A_b, f_{22}]\) to obtain \([A_b, f_{22}]^T\).

162. ADD assembles input matrix \([M_{pp}^{2}] = \text{MFACT} [A_b, f_{22}]^T + [M_{dd}^{2}]\).

169. Go to DMAP No. 172 if transient type GKAD matrices are to be generated.

170. Equivalence \([H_{pp}^{2}]\) to \([M_{dd}^{2}], [B_{pp}^{2}]\) to \([B_{dd}^{2}]\) and \([K_{pp}^{2}]\) to \([K_{dd}^{2}]\) if no constraints applied, \([M_{aa}^{1}]\) to \([M_{dd}^{1}]\) if no direct input mass matrices and no extra points and \([B_{aa}^{1}]\) to \([B_{dd}^{1}]\) if no direct input damping matrices and no extra points.

172. Go to DMAP No. 175.

173. Equivalence \([H_{pp}^{2}]\) to \([M_{dd}^{2}], [B_{pp}^{2}]\) to \([B_{dd}^{2}]\) and \([K_{pp}^{2}]\) to \([K_{dd}^{2}]\) if no constraints applied, \([M_{aa}^{1}]\) to \([M_{dd}^{1}]\) if no direct input mass matrices and no extra points, and \([K_{aa}^{1}]\) to \([K_{dd}^{1}]\) if no direct input stiffness matrices and no extra points.

176. Go to DMAP No. 178 if only extra points are defined.

177. GKAD assembles stiffness, mass, and damping matrices for use in Direct Frequency Response, if parameter GKAD = FREQRESP.

\[
[K_{dd}^1] = (1 + i\omega)[K_{dd}^1] + [K_{dd}^2] + i[K_{dd}^4],
\]

\[
[M_{dd}^1] = [M_{dd}^1] + [M_{dd}^2] \quad \text{and}
\]

\[
[B_{dd}^1] = [B_{dd}^1] + [B_{dd}^2].
\]

Direct input matrices may be complex.

or

GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response if parameter GKAD = TRANRESP.

\[
[K_{dd}^1] = [K_{dd}^1] + [K_{dd}^2],
\]

\[
[M_{dd}^1] = [M_{dd}^1] + [M_{dd}^2],
\]

and \([B_{dd}^1] = [B_{dd}^1] + [B_{dd}^2] + \frac{b}{\omega_3}[K_{dd}^1] + \frac{1}{\omega_4}[K_{dd}^1]\).

where \[
\begin{bmatrix}
[K_{aa}^1] & 0 \\
0 & 0
\end{bmatrix} \Rightarrow [K_{dd}^1],
\]

\[
\begin{bmatrix}
[M_{aa}^1] & 0 \\
0 & 0
\end{bmatrix} \Rightarrow [M_{dd}^1],
\]

\[
\begin{bmatrix}
[B_{aa}^1] & 0 \\
0 & 0
\end{bmatrix} \Rightarrow [B_{dd}^1].
\]
\[
\begin{bmatrix}
B_{aa} & 0 \\
0 & 0
\end{bmatrix} \Rightarrow \begin{bmatrix}
B_{dd}^t \\
0
\end{bmatrix},
\]
and
\[
\begin{bmatrix}
K_{aa} & 0 \\
0 & 0
\end{bmatrix} \Rightarrow \begin{bmatrix}
K_{dd}^t \\
0
\end{bmatrix}.
\]
All matrices are real.

179. Go to DMAP No. 182 if transient type GKAD matrices were generated.

180. Equivalence \([K_{dd}^2]\) to \([K_{dd}]\) if all stiffness is Direct Matrix Input, \([M_{dd}^2]\) to \([M_{dd}]\) if all mass is Direct Matrix Input and \([B_{dd}^2]\) to \([B_{dd}]\) if all damping is Direct Matrix Input.

181. Go to DMAP No. 184.

183. Equivalence \([B_{dd}^2]\) to \([B_{dd}]\) if all damping is Direct Matrix Input, \([M_{dd}^2]\) to \([M_{dd}]\) if all mass is Direct Matrix Input and \([K_{dd}^2]\) to \([K_{dd}]\) is all stiffness is Direct Matrix Input.

185. Go to DMAP No. 203 if loading is frequency-dependent.

189. Beginning of loop for additional subcases for time-dependent loads.

190. CASE extracts user requests from CASECC for the current loop.

193. TRLG generates matrices of loads versus time. \([P_{d}^t]\) is generated with one column per output time step. \([P_{d}^t]\) is generated with one column per solution time step, and the Transient Output List (TOL) is a list of output time steps.

194. SDR1 appends \([P_{d}^t]\) to \([P_d]\).

195. SDR1 appends \([P_{d}^t]\) to \([P_d]\).

197. Go to DMAP No. 200 if no additional time-dependent loads need to be processed.

198. Go to DMAP No. 189 if additional time-dependent loads need to be processed.

199. Go to DMAP No. 360 and print message if more than 100 loops.

202. Equivalence \([P_d]\) to \([P_{d}^t]\) if the output times are the same as the solution times.

204. DUMMOD2 generates a Frequency Response List (FRLZ) and a Frequency Output List (FOL), from the Transient Output List (TOL). Load reordering matrices REORDER1 and REORDER2 are generated based on parameter values. This module, in effect, generates data blocks necessary to convert time-dependent loads into frequency dependent loads.

205. Equivalence FRLZ to FRL and FOLZ to FOL.
207. Go to DMAP No. 234.

209. FRLG forms the dynamic load vectors \( \{P_p^f\} \), \( \{P_s^f\} \), \( \{P_d^f\} \) and Frequency Output List (FOL) for frequency-dependent loads.

210. Go to DMAP No. 213 if FRLX was not generated by DUMMOD1.

211. MPYAD uses PDZERO from DUMMOD1 to zero out selected columns of \( \{P_p^f\} \) in base acceleration problems.

212. Equivalence \( \{P_x^f\} \) to \( \{P_p^f\} \).

214. Go to DMAP No. 222 if not a base acceleration problem.

215. MPYAD forms the complete base acceleration matrix, \( \{M2BASEXG_g^f\} = [M2GG_g] \cdot \{BASEXG_g^f\} \).
216. ADD assembles the freq. and loads due to base acceleration.
\[ \{P_{1f}^f\} = \{P_{p}^f\} - \{\text{H2BASEEX}_{0}^f\} \]

Note that the p-set and g-set are the same because no extra points are allowed.

217. Equivalence \( \{P_{1f}^f\} \) to \( \{P_{p}^f\} \).

218. Go to DMAP No. 221 if there are no SPC's, MPC's or OMITS.

219. SSG2 applies constraints to \( \{P_{p}^f\} \).

220. Go to DMAP No. 268 if parameter CYCIO = -1.

221. CYCT1 transforms loads on analyses points to symmetric components.

222. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

223. Go to DMAP No. 268.

224. Go to DMAP No. 251 if parameter CYCIO = +1.

225. Equivalence \( \{P_{1d}^t\} \) and \( \{\text{PDTRZ1}\} \) if REORDER1 was not generated by DUMMOD2.

226. Go to DMAP No. 240 if REORDER1 was not generated.

227. MPYAD reorders columns of \( \{P_{d}^t\} \).

228. CYCT1 transforms loads on analysis points to symmetric components, in time.

229. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

230. Equivalence \( \{\text{PXTRZ1}\} \) and \( \{\text{PXCTZ1}\} \) if REORDER2 was not generated by DUMMOD2.

231. MPYAD reorders columns of \( \{\text{PXTRZ1}\} \).

232. Equivalence \( \{\text{PXCTZ1}\} \) to \( \{\text{PXCT1}\} \).

233. Go to DMAP No. 264.

234. MPYAD reorders columns of \( \{P_{d}^t\} \).

235. CYCT1 transforms loads on analysis points to symmetric components, in time.

236. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

237. Equivalence \( \{\text{PXTRZ2}\} \) to \( \{\text{PXTR2}\} \) if REORDER2 was not generated.

238. Go to DMAP No. 259 if REORDER2 was not generated.

239. MPYAD reorders columns of \( \{\text{PXTRZ2}\} \).

240. CYCT1 transforms symmetric components, in time, to symmetric components.

241. Go to DMAP No. 365 and print error message if a CYCT1 error was found.

242. Equivalence \( \{\text{PXCFZ2}\} \) to \( \{\text{PXCF1}\} \).

243. COPY makes a physical copy of \( \{\text{PXCF1}\} \) called \( \{\text{PFX2}\} \).
266. ADD makes loads complex, since SCR2 expects complex loads in a frequency response problem. Time-dependent loads are real.

\[(PFX) = (0.5, 1.0) \cdot (PFX1) \cdot (0.5, -1.0) \cdot (PFX2)\]

271. Go to DMAP No. 282 if KMIN = 0.

274. Beginning of loop to create KMIN null columns of \((UVfX)\) for KINDEX = 0 to (KMIN-1). These leading null columns are necessary because CYCT1 expects columns for KINDEX = 0 to KMAX.

275. CYCT2 transforms loads from symmetric components to solution set for rotational symmetry. This operation is necessary to get a correct size matrix for generating null \((UVfX)\) columns.

276. Go to DMAP No. 365 and print error message if a CYCT2 error was found.

277. ADD generates a null vector \((UVf1) = (PZf1) \cdot 0.0\).

278. CYCT2 finds symmetric components of displacements from solution set data and appends it to \((UVfX)\).

279. Go to DMAP No. 365 and print error message if a CYCT2 error was found.

280. PARAM increments the value of KMINV=KMIN+1.

281. Go to DMAP No. 274 if more null vectors are to be generated for \((UVfX)\). If the initial \((UVfX)\) for KINDEX values 0 to (KMIN-1) has been completed then go to DMAP No. 282.

284. Beginning of loop for cyclic index value (KINDEX), for values KINDEX = KMIN to KMAX.

288. CYCT2 transforms stiffness and mass matrix from symmetric components to solution set for rotational symmetry by the equation:

\[
[K_{kk}] = [G^T_c][K_{aa}][G_c] + [G^T_s][K_{aa}][G_s]
\]

291. CYCT2 transforms damping and loads from symmetric components to solution set for rotational symmetry by the equations:

\[
[B_{kk}] = [G^T_c][B_{aa}][G_c] + [G^T_s][B_{aa}][G_s]
\]

\[
[P_k] = [G^T_c] \cdot \{P_c\} + [G^T_s] \cdot \{P_s\}
\]

294. Go to DMAP No. 365 and print error message if CYCT2 error was found.

296. FRRD2 solves for the displacements using the following equation:

\[
[-M_{dd}w^2 + iB_{dd}w + K_{dd}] \{U_d\} = \{P_d\}.
\]

298. CYCT2 finds symmetric components of displacement from solution set data and appends to output for each KINDEX.

299. Go to DMAP No. 365 and print error message if CYCT2 error was found.
301. PARAM increments the value of KINDEX = KINDEX + 1.
303. Go to DMAP No. 306 if all cyclic index values are complete.
304. Go to DMAP No. 284 if additional index values are needed.
305. Go to DMAP No. 360 and print error message if more than 100 loops on KINDEX.
307. Equivalence \( \{u_x^f\} \) to \( \{u_d^f\} \) if parameter CYCIO = -1.
309. Go to DMAP No. 312 if parameter CYCIO = -1.
310. CYCTI transforms displacements from symmetrical components to physical components.
313. Go to DMAP No. 322 if loads were frequency-dependent.
314. Equivalence \( \{p_x^f\} \) to \( \{p_d^f\} \) if parameter CYCIO = -1.
315. Go to DMAP No. 317 if parameter CYCIO = -1.
316. CYCTI transforms loads from symmetrical components to physical components if loads were time-dependent.
318. SDR1 recovers dependent loads \( \{p_d^f\} \).
319. SSG2 applies constraints to \( \{p_d^f\} \) to form \( \{p_d^f\} \).
320. Equivalence \( \{p_d^f\} \) to \( \{p_d^f\} \) and \( \{p_d^f\} \) to \( \{p_d^f\} \).
323. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.
324. Go to DMAP No. 333 if no output request for the independent degrees of freedom.
325. Go to DMAP No. 331 if no output request for independent displacements sorted by point number.
326. SDR3 sorts the independent displacements by point number.
327. OFP formats the requested independent displacements, sorted by point number, prepared by SDR3 and places them on the system output file for printing.
328. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.
329. XYPLOT prepares the requested X-Y plots of the independent displacements vs. frequency.
332. OFP formats the requested independent displacements, sorted by frequency, prepared by VDR and places them on the system output file for printing.
Go to DMAP No. 357 if no equations for involving dependent degrees of freedom for forces and stresses.

Equivalence \( \{u_d\} \) to \( \{u_p\} \) if no constraints applied.

Go to DMAP No. 338 if no constraints applied.

SDR1 recovers independent components of displacements

\[
\{u_o\} = [G_0^d] \{u_d\}, \quad \{\frac{u_f + u_e}{u_o}\} = \{u_f + u_e\},
\]

\[
\{\frac{u_n + u_e}{u_s}\} = \{u_n + u_e\}, \quad \{u_m\} = [G_m^d] \{uf + u_e\},
\]

and recovers single-point forces of constraining \( \{q_s\} = -\{P_s\} + [K_{fs}] \{uf\} \).

SDR2 calculates element forces (ΩEFC1) and stresses (ΩESC1) and prepares load vectors (ΩPPC1), displacement vectors (ΩUPVC1), and single-point forces of constraint (ΩQPC1) for output sorted by frequency.

Go to DMAP No. 351 if no output requests sorted by point number of element number.

SDR3 prepares requested output sorted by point number or element number.

DFP formats tables prepared by SDR3, sorted by point number or element number, and places them on the system output file for printing.

XYTRAN prepares the input for requested X-Y plots.

XYPL=T prepares the requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

Go to DMAP No. 353 if no Power Spectral Density List

RANDOM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTD) using the previously calculated frequency response.

Go to DMAP No. 353 if no RANDOM calculations requested.

XYTRAN prepares the input for requested X-Y plots of the RANDOM output.

XYPL=T prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.

Go to DMAP No. 353 if no frequency response output requests sorted by frequency.
352. UFIP formats frequency response output requests prepared by SDR2, sorted by frequency, and places them on the system output file for printing.

354. Go to DMAP No. 357 if no deformed structure plots are requested.

355. PLOT generates all requested deformed plots.

356. PRTEG prints plotter data and engineering data for each deformed plot generated.

358. Go to DMAP No. 383 if no additional sets of direct input matrices need to be processed.

359. Go to DMAP No. 152 if additional sets of direct input matrices need to be processed.

361. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

364. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 4 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

366. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 7 - CYCLIC SYMMETRY DATA ERROR.

368. Coupled mass is not allowed - Print parameter COUPMASS.

371. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 6 - FREE-BODY SUPPORTS NOT ALLOWED.

373. EPoint bulk data not allowed - Print parameter NOUE.

376. Neither FREQ or TSTEP were in bulk data - Print parameters NOFRL and NOTRL.

380. Both FREQ and TSTEP were selected in case control - Print parameters NOFREQ and NOTIME.

384. END of DMAP sequence.
2.4.4 CASE CONTROL DECK AND PARAMETERS FOR FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

The following items relate to subcase definition and data selection for Forced Vibration and Random Response of Rotating Cyclic Structures:

1. The SPC and MPC request must appear above the subcase level and may not be changed.

2. Either FREQUENCY or TSTEP must be selected and must be above the subcase level.

3. If selected, FREQUENCY must be used to select one and only one FREQ, FREQ1 or FREQ2 card from the Bulk Data deck.

4. If selected, TSTEP must be used to select the time-steps to be used for load definition via a TSTEP Bulk Data card and must be defined above the subcase level.

5. Direct input matrices are not allowed.

6. OFREQ must not be used.

7. A separate group of subcases must be defined for each symmetric segment.

8. DLOAD must be used to define a frequency or time-dependent loading condition for each subcase. For frequency-dependent loads, subcases without loads need not refer to a DLOAD card. For time-dependent loads, subcases without loads must refer to a DLOAD card that explicitly generates a null load.

9. An alternate loading method is to define a separate group of subcases for each harmonic index, k. The parameter CYCID is included and the load components for each index are defined directly within each group for the various loading conditions.

10. If Random Response calculations are desired, RANDOM must be used to select RANDPS and RANDTI cards from the Bulk Data Deck.

The following printed output, sorted by frequency (SORT1) or by point number or element number (SORT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SOLUTION points (points used in formulation of the general K system).

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements (ALL available only for SORT1).

The following plotter output is available for Frequency Response calculations:
1. Undeformed plot of the structural model.

2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SOLUTION point.

3. X-Y plot of any component of the applied load vector or single-point force of constraint.

4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing X-Y plots may be punched or printed in tabular form (see Section 4.3). This is the only form of printed output that is available for Random Response. Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following items relate to Bulk Data restrictions:

1. SUPPORT cards are not allowed.

2. EPOINT cards are not allowed.

3. SPOINT cards are not allowed.

4. CYJOIN cards are required.

5. If a TSTEP card is used then it must not be continued since only one uniform time step interval must be specified. The skip factor for output, NO, on the TSTEP card must be 1.

The following parameters are used in Forced Vibration and Random Response of Rotating Cyclic Structures:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WIMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. COUPMASS - fixed - Only lumped mass matrices must be used.
4. GKAD - optional - The BCD value of this parameter is used to tell the GKAD module the desired form of matrices KDD, BDD, and MDD. The BCD value can be FREQRESP or TRANRESP. The default is TRANRESP.

NOTE: Remember to define parameters G, W3, and W4. See Section 9.3.3 (DIRECT DYNAMIC MATRIX ASSEMBLY) Pages 9.3-7 and 9.3-8 of the NASTRAN theoretical manual for further details.

5. LGKAD - optional - The integer value of this parameter is used in conjunction with parameter GKAD. If GKAD = FREQRESP then set LGKAD = 1, if GKAD = TRANRESP set LGKAD = -1. The default value is -1.

6. G - optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems (use GE on MAT1).

7. W3 - optional - The real value of this parameter is used as a pivotal frequency for uniform structural damping if parameter GKAD = TRANRESP. In this case W3 is required if uniform structural damping is desired. The default value is 0.0.

8. W4 - optional - The real value of this parameter is used as a pivotal frequency for element structural damping if parameter GKAD = TRANRESP. In this case W4 is required if structural damping is desired for any of the structural elements. The default value is 0.0.

9. NSEGS - required - The integer value of this parameter is the number of identical segments in the structural model.

10. CYCLO - required - The integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. There is no default.

11. CYCSEQ - fixed - The integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The value of CYCSEQ has been set to -1.

12. CYTYPE - fixed - The BCD value of this parameter defines the type of cyclic symmetry as follows:

(1) R0T - rotational symmetry

13. KMAX - required - The integer value of this parameter specifies the maximum value of the harmonic index. There is no default for this parameter. The maximum value that can be specified is NSEGS/2.

14. KMIN - optional - The integer value of this parameter specifies the minimum value of the harmonic index to be used in the solution loop. KMIN can equal KMAX. The default is 0.

15. NL0AD - fixed - The integer value of this parameter is the number of static loading conditions. The value of NL0AD is internally computed.
16. **NOKPRT** - optional - An integer value of +1 for this parameter will cause the current harmonic index, KINDEX, to be printed at the top of the harmonic loop. The default is +1.

17. **LMAX** - optional - The integer value of this parameter specifies the maximum harmonic in the fourier decomposition of periodic, time-dependent loads. The default value is NTSTEPS/2, where NTSTEPS = N+2 where N is from the TSTEP bulk data card.

18. **RPS** - optional - The real value of this parameter defines the rotational speed of the structure in revolutions per unit time. The default is 0.0.

19. **BXTID, BYTID, BZTID, BXPTID, BYPTID, BZPTID** - optional - The positive integer values of these parameters define the set identification numbers of the TABLED bulk data cards which define the components of the base acceleration vector. The tables referred to by BXTID, BYTID and BZTID define magnitude (LT-2) and tables referred to by BXPTID, BYPTID and BZPTID define phase (degrees). The default values are -1, which means that the respective terms will be ignored.
3.1 DATA BLOCK AND TABLE DESCRIPTION

3.1.1 Data Blocks Output from Module BUADD

3.1.1.1 FRLX (TABLE)

Description

Frequency Response List

The FRLX contains one log. ca. record for each different set defined in the bulk data. Each record contains a sorted list of frequencies defined in the set.

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,2</td>
<td>BCD</td>
<td>Data block name</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td></td>
<td>Set ID1</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+n</td>
<td>I</td>
<td></td>
<td>Set IDn</td>
</tr>
<tr>
<td>1</td>
<td>1-m</td>
<td>R</td>
<td>Radian frequencies belonging to set ID1 ( (w = 2\pi F) )</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>1-k</td>
<td>R</td>
<td>Radian frequencies belonging to set IDn ( (w = 2\pi F) )</td>
</tr>
<tr>
<td>n+1</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>

Table Trailer

Word 1 = number of frequency sets
Word 2-6 = zero

3.1.1.2 BIGG (MATRIX)

Description

\([BIGG]_{gg}\) = Coriolis acceleration coefficient matrix - g set.

3.1.1.3 MIGG (MATRIX)

Description

\([MIGG]_{gg}\) = Centripetal acceleration coefficient matrix - g set.

3.1.1.4 M2GG (MATRIX)

Description

\([M2GG]_{gg}\) = Base acceleration coefficient matrix - g set.
3.1.1.5 BASEXG (MATRIX)

Description

\[
[BASEXG^F_g] \quad \text{- Base acceleration matrix} \quad g \quad \text{set.}
\]

3.1.1.6 PDZERO (MATRIX)

Description

\[
[PDZERO^F_g] \quad \text{- Load modification matrix in base acceleration problems} \quad g \quad \text{set.}
\]

3.1.2 Data Blocks Output from Module DUMMO2

3.1.2.1 FRL (TABLE)

Description

Frequency Response List

The FRL output by DUMMO2 contains one logical record. This logical record contains a sorted list of frequencies.

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,2</td>
<td>BCD</td>
<td>Data Block Name</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
<td>Set ID = 1</td>
</tr>
<tr>
<td>1</td>
<td>1-m</td>
<td>R</td>
<td>Radian frequencies ( w = 2\pi F )</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>

Table Trailer

Word 1 = 1
Word 2-6 = zero

3.1.2.2 FOL (TABLE)

Description

Frequency Response Output List

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-2</td>
<td>BCD</td>
<td>Table Name</td>
</tr>
<tr>
<td></td>
<td>3-NFREQ+2</td>
<td>R</td>
<td>Frequencies ( F = 2\pi F )</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>
Table Trailer

Word 1 = Number of frequencies (NFREQ)
Word 2 = Frequency set record number (=1)
Word 3-6 = zero

3.1.2.3 REORDER1 (MATRIX)

Description

[REORDER1] - Load reordering matrix in time-dependent frequency response problems
for cyclic structures.

Matrix Trailer

Number of columns = NTSTEPS*FKMAX, if CYCIO = -1
Number of rows = NTSTEPS*NSEGS, if CYCIO = +1
Form = square
Type = real single precision

3.1.2.4 REORDER2 (MATRIX)

Description

[REORDER2] - Load reordering matrix in time-dependent frequency response problems
for cyclic structures.

Matrix Trailer

Number of columns = FLMAX*FKMAX, if CYCIO = -1
Number of rows = FLMAX*NSEGS, if CYCIO = +1
Form = square
Type = real single precision
3.2 FUNCTIONAL MODULES

3.2.1 Functional Module DUMMOD1

3.2.1.1 Entry Point: DUMMOD1

3.2.1.2 Purpose

To generate the Coriolis, centripetal and base acceleration coefficient matrices and the base acceleration matrix for a forced vibration response analysis of rotating structures.

3.2.1.3 DMAP Calling Sequence


3.2.1.4 Input Data Blocks

CASECC - Case Control.
BGPDT - Basic Grid Point Definition Table.
CSTM - Coordinate System Transformation Matrices.
DIT - Direct Input Tables.
FRL - Frequency Response List (radians).
MGG - Partition of mass matrix (g-set).

Notes: 1. All input data blocks can be purged if only parameters FKMAX and NOBASEX are to be computed.
2. CASECC, DIT and FRL can be purged if output data blocks FRLX and BASEXG are purged.

3.2.1.5 Output Data Blocks

FRLX - Frequency Response List (modified)
B1GG - Coriolis acceleration coefficient matrix (g-set)
M1GG - Centripetal acceleration coefficient matrix (g-set)
M2GG - Base Acceleration coefficient matrix (g-set)
BASEXG - Base acceleration matrix (g-set x f).
PDZERO - Load modification matrix in base acceleration problems (g-set x f).

Notes: 1. All output data blocks can be purged if parameter NOMGG=-1.
2. B1GG and M1GG can be purged if NOMGG=-1 or if OMEGA=0.0.
3. FRLX and PDZERO can be purged if OMEGA=0.0.
4. FRLX, PDZERO, M2GG and BASEXG can be purged if NOMGG=-1 or if
   NOFREQ=-1 or if CYCIO=-1 or if all three parameters BXTID=BYTID=
   BZTID=-1.

3.2.1.6 Parameters

NOMGG  - Input-integer-no default. MGG was not generated if NOMGG=-1.

CYCIO  - Input-integer-no default. This parameter specifies the form of the
        input and output data from cyclic structures. A value of +1 is used
        to specify physical segment representation and a value of -1 for
        cyclic transformation representation.

NSEGS  - Input-integer-no default. The number of identical segments in the
        structural model.

KMAX  - Input-integer-no default. KMAX specifies the maximum value of the
        harmonic index. The maximum value that can be specified for KMAX
        is NSEGS/2.

FKMAX  - Output-integer-no default. FKMAX is a function of KMAX.

NOBASEX - Output-integer-no default. NOBASEX=-1 if data block BASEXG is not
          generated.

NOFREQ  - Input-integer-no default. NOFREQ=-1 if FREQUENCY was not selected
          in the Case Control deck.

OMEGA  - Input-real-no default. Rotational speed of the structure in radians.
          OMEGA = \(2\pi\cdot\text{RPS}\).

BXTID  - Input-integer-defaults. The values of these parameters define the
        set identification numbers of the TABLEDI Bulk Data cards which define
        the components of the base acceleration vector. The tables referred
        to by BXTID, BYTID and BZTID define magnitude (LT-2) and the tables
        referred to by BXPTID, BYPTID and BZPTID define phase (degrees). The
        default values are -1 which means that the respective terms are
        ignored.

3.2.1.7 Method

Parameters NOBASEX and FKMAX are computed depending on the values of various
input parameters. Parameter NOBASEX is set equal to -1 if parameters NOMGG=-1
or CYCIO=-1 or NOFREQ=-1 or if parameters BXTID=BYTID=BZTID=-1, otherwise NOBASEX
is set equal to +1 indicating that base acceleration data blocks are to be
generated.
If parameter CYCIO=-1, then parameter FKMAX is computed as follows. If NSEGS is odd then FKMAX=2*KMAX+1; if NSEGS is even and KMAX=NSEGS/2, then FKMAX=NSEGS, otherwise FKMAX=2*KMAX+1.

If parameter NOMGG=-1 then no data blocks are generated and an exit is made from module DUMMOD1, otherwise computations proceed in three phases. In the first phase B1GG and M1GG are generated unless parameter OMEGA=0.0. M2GG is generated if parameter NOBASEX=1. The second and third phases generate data blocks associated with base acceleration problems and are only executed if NOBASEX=1. In the second phase FRLX and PDZERO are generated unless parameter OMEGA=0.0. Data block BASEXG is generated and output in phase three.

3.2.1.7.1 Phase 1 - Generation of B1GG, M1GG and M2GG

Phase one begins with a request for open core and buffer allocation. If OMEGA=0.0 then B1GG and M1GG are not output and their buffers, IBUF3 and IBUF4, are not allocated and IBUF5 is set equal to IBUF3. If coordinate system transformations exist then the CSTM data block is open and the coordinate system information is placed in core and readied for use by subroutine PRETRD.

The primary loop in phase one is controlled by the number of grid points in the Basic Grid Point Definition Table (BGPDT), scalar points are not allowed by DUMMOD1. Each grid point in the BGPDT is considered in order and the corresponding columns of the mass matrix, MGG, are processed to form B1GG, M1GG and M2GG. When all grid points have been processed the necessary trailers are written. For the ith grid point in the BGPDT the corresponding translational terms of MGG are unpacked and the diagonal terms are isolated into a 3 x 3 matrix \([M_i]\). If the grid point is not in the basic system then subroutine TRANSD calculates the 3 x 3 transformation matrix \([T_i]\) from global coordinates to basic coordinates for the grid point and \([M_i]\) is transformed to the basic system to form \([\overline{M}_i]\). The average of the three diagonal terms of \([\overline{M}_i]\) is then used to form \([BT_i]\), \([MT_i]\) and \([M2_i]\). These three submatrices are then transformed back to the global coordinate system, if necessary. The 3 x 3 matrices \([BT_i]\), \([MT_i]\) and \([M2_i]\) are then packed into the B1GG, M1GG and M2GG matrices.

\[
[MGG]_{m\times n} = \begin{bmatrix}
[M_1] & [M_2] & 0 \\
0 & \cdots & [M_n]
\end{bmatrix}
\]

where \(n\) = the total number of grid points.

3.6
where 
\[ [M_i] = \begin{bmatrix} \vdots & \vdots & \vdots \\ [M_{i1}] & [M_{i2}] & \vdots \\ \vdots & \vdots & \vdots \end{bmatrix} \quad \text{for } i = 1, n \]

and 
\[ [M_i^T] = \begin{bmatrix} m_i^T1 & 0 & 0 \\ 0 & m_i^T2 & 0 \\ 0 & 0 & m_i^T3 \end{bmatrix} \]

(b) Transform \([M_i]\) from global to basic coordinate system 
\[ [M_i] = [T_i] [M_i] [T_i]^T \]

(c) Compute average of \([M_i]\) 
\[ \bar{m}_i = \frac{3}{2} \frac{m_i^K}{m_i} \quad \text{where } m_i^K \text{ is the mass (in the basic coordinate system) at the } i^{th} \text{ node point of the total of } 'n' \text{ nodes in the } k^{th} \text{ direction.} \]

(d) Form B1GG 
\[ [B1GG] = \begin{bmatrix} [B1_1] & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & [B1_n] \end{bmatrix} \]

where 
\[ [B1_i] = \begin{bmatrix} [B1_{i1}] & \vdots & \vdots \\ \vdots & \ddots & \vdots \\ \vdots & \vdots & [B1_{in}] \end{bmatrix} \]

and 
\[ [B1_i^T] = [T_i]^T \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -m_i^K \\ 0 & m_i & 0 \end{bmatrix} [T_i] \]

(e) Form M1GG 
\[ [M1GG] = \begin{bmatrix} [M1_1] & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & [M1_n] \end{bmatrix} \]
3.2.1.7.2 Phase 2 - Generation of FRLX and PDZERO

In this phase the FREQUENCY set selected in the Case Control deck is located in data block FRL and stored in core. If parameter OMEGA=0.0 or if parameters BYTID=-1 and BZTID=-1 then phase two is complete, otherwise phase two processing continues. The Frequency Response List must be modified to include an expanded set of frequencies. Read and copy from FRL to FRLX record 0 and all logical records up to the selected frequency set. The only set that will be modified in FRL is the selected frequency set. Once the set of selected frequencies have been found and stored in core a vector for FRLX and PDZERO are generated using the FRL frequencies stored in core and parameter OMEGA. Let \( \omega_i \) for \( i = 1, \text{NFREQ} \) be the frequencies (in radians) from FRL.

If \( \omega_i \neq 0.0 \), create 3 entries, 0.0, 1.0 and 0.0 for PDZERO and create 3 entries, \(|\omega_i-\text{OMEGA}|, \omega_i, \text{and} |\omega_i+\text{OMEGA}|\) for FRLX.
If \( \omega_1 = 0.0 \), create 2 entries, 1.0 and 0.0 for PDZERO and create 2 entries, 0.0 and \(|\text{OMEGA}|\) for FRLX.

After the expanded list of frequencies is generated call routine DUM01E to sort it in ascending order. DUM01E also returns a sorting index so other vectors may be sorted the same as FRLX. Sort PDZERO using this sorting index. Output this FRLX vector and continue copying the remaining records of FRL to FRLX. Output data block PDZERO by writing out the PDZERO vector FNUMAX times, thus creating FNMAX columns. The original unexpanded frequencies from FRL and the sorting index stored in core are retained for phase 3 processing.

3.2.7.3 Phase 3 - Generation of BASEXG.

If NOBASEX=-1 then this phase is skipped, otherwise processing continues.
A unique list of table IDs using parameters BXTID, BYTID, BZTID, BXPTID, BYPTID and BZPTID is generated and a call to PRETAB is made so that tables TABLED1, TABLED2, TABLED3 and TABLED4 can be interpolated by calls to TAB. Routines DUM01A, DUM01B, DUM01C and DUM01D are used to generate data block BASEXG. Routine DUM01A calls the routines to generate the BASE table and outputs the BASEXG matrix. The BASE table is used to generate up to three groups of NFREQX columns, where NFREQX is the number of expanded frequencies from phase two, in the BASEXG matrix. Routine DUM01B is called to generate the BASE table if the original FRL frequency list was not expanded, see phase two, otherwise routine DUM01C is called. Routine DUM01D sorts the columns of the BASE table so that they are arranged in the same order as the modified frequency set if FRLX was generated in phase two. The following is a mathematical description of matrix BASEXG.

(a) Let \(X_0(f_i), \theta_X(f_i), Y_0(f_i), \theta_Y(f_i), Z_0(f_i), \theta_Z(f_i)\) be input via frequency dependent tables TABLEDi where the table IDs are defined by parameters BXTID, BXPTID, BYTID, BYPTID, BZTID and BZPTID respectively. \(X_0, Y_0\) and \(Z_0\) are magnitudes in L7-2 units while \(\theta_X, \theta_Y\) and \(\theta_Z\) are phase angles in degrees.

(b) Define control flag MODFRL.

If parameter OMEGA=0.0 or parameters BYTID=-1 and BZTID=-1 then set MODFRL to false, otherwise MODFRL is true.

(c) Let FRL be a vector of NF frequencies (in radians).

\[ FRL = [\omega_1, \omega_2, \omega_3, \ldots, \omega_{NF}] \]

(d) If MODFRL is false then generate complex base table BASE of order 3xNF.

\[
\text{BASE} = [\text{Base}(f_1) \quad \cdots \quad \text{Base}(f_{NF})]_{3\times NF}^{3\times 1}
\]

\[
\text{BASE} = [\text{Base}(f_1) \quad \cdots \quad \text{Base}(f_{NF})]_{3\times NF}^{3\times 1}
\]

3.9
where \( f_i = \frac{\omega_i}{2\pi} \) for \( i = 1, 2, \ldots, \text{INF} \)
and

\[
\{\text{BASE}(f_i)\} = \begin{cases} 
\hat{X}_0(f_i) - e^{i\theta_x(f_i)} \\
\hat{Y}_0(f_i) - e^{i\theta_y(f_i)} \\
\hat{Z}_0(f_i) - e^{i\theta_z(f_i)}
\end{cases}
\]

\[3\times1\]

(e) If MODFRL is true then generate complex base table \text{BASE} of order \( 3 \times \text{NFX} \)
where NFX is an expanded number of frequencies as defined below.

\[
\text{BASE} = \begin{bmatrix} \text{BASE}(f_1) & \text{BASE}(f_2) & \ldots & \text{BASE}(f_{\text{NF}}) \end{bmatrix}
\]

where \( f_i = \frac{\omega_i}{2\pi} \) for \( i = 1, 2, \ldots, \text{INF} \)
and each \{\text{BASE}(f_i)\} is either \( 3 \times 2 \) if \( \omega_i = 0.0 \) or \( 3 \times 3 \) if \( \omega_i \neq 0.0 \).

(e.1) If \( \omega_i = 0.0 \), then \{\text{BASE}(f_i)\} is defined as follows:

\[
\text{BASE}(f_i) = \begin{bmatrix} A & 0 \\
0 & B \\
0 & C 
\end{bmatrix}
\]

where

\[
\begin{align*}
\text{SGN} &= 1.0 \text{ if parameter } \text{OMEGA} \geq 0.0, \text{ otherwise } \text{SGN} = -1.0 \\
A &= \hat{X}_0(f_i) \cdot e^{i\theta_x(f_i)} \\
B &= \hat{Y}_0(f_i) \cdot \cos(\theta_y(f_i)) - i \cdot \text{SGN} \cdot \hat{Z}_0(f_i) \cdot \cos(\theta_z(f_i)) \\
C &= \hat{Z}_0(f_i) \cdot \cos(\theta_z(f_i)) + i \cdot \text{SGN} \cdot \hat{Y}_0(f_i) \cdot \cos(\theta_y(f_i))
\end{align*}
\]

(e.2) If \( \omega_i \neq 0.0 \), then \{\text{BASE}(f_i)\} is defined as follows:

\[
\text{BASE}(f_i) = \begin{bmatrix} 0 & A & 0 \\
B & 0 & C \\
D & 0 & E 
\end{bmatrix}
\]

where

\[
\begin{align*}
\text{SGNA} &= 1.0 \text{ if } (\omega_i - \text{OMEGA}) \geq 0.0, \text{ otherwise } \text{SGNA} = -1.0 \\
\text{SGNB} &= 1.0 \text{ if } (\omega_i + \text{OMEGA}) \geq 0.0, \text{ otherwise } \text{SGNB} = -1.0 \\
A &= \hat{X}_0(f_i) \cdot e^{i\theta_x(f_i)} \\
B &= 0.5 \cdot \left[ \hat{Y}_0(f_i) \cdot e^{i\text{SGNA} \cdot \theta_y(f_i)} - \text{SGNA} \cdot \hat{Z}_0(f_i) \cdot e^{i\text{SGNA} \cdot \theta_z(f_i)} \right]
\end{align*}
\]

3.10
(f) Define the complex base acceleration matrix $\text{BASEXG}$ of order $G \times (NF \cdot \text{FKMAX})$ as follows:

Let $NF$ be the number of frequencies in the BASE matrix, i.e., let $NF = NF$ if MODFRL was false or $NF = NF \cdot \text{FKHAX}$ if MODFRL was true.

$$[\text{BASEXG}]_{gx(NF \cdot \text{FKHAX})} = [\text{BASEXG}]_{g \times NF} [\text{BASEXG}]_{g \times NF} [\text{BASEXG}]_{g \times NF} \ldots [\text{BASEXG}]_{g \times NF}$$

where

$$[\text{BASEXG}]_{g \times NF} = \begin{bmatrix} [\text{BASEXG}]_1 \end{bmatrix}_{6 \times NF} \begin{bmatrix} [\text{BASEXG}]_2 \end{bmatrix}_{6 \times NF} \begin{bmatrix} [\text{BASEXG}]_3 \end{bmatrix}_{6 \times NF} \ldots [\text{BASEXG}]_i_{6 \times NF} \ldots$$

and

$$[\text{BASEXG}]_{g \times NF} = [0] \text{ for } i = 4, 5, 6, \ldots, \text{FKMAX}$$

NOTE: $[\text{BASEXG}]_i$ is repeated $N$ times where $N = g/6$ and $g$ is the g-set size. Scalar points are not allowed so each node has 6 degrees of freedom.

$$[\text{BASEXG}]_{6 \times NF} = \begin{bmatrix} \text{BASE}(1,1) & \text{BASE}(1,2) & \ldots & \text{BASE}(1,NF) \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \end{bmatrix}$$
3.2.1.8 Subroutines

Utility subroutines GMATD, PRETRD, TRANSO, PRETAB and TAB are used. See subroutine descriptions, Section 3 of NASTRAN Programmer's Manual.

3.2.1.8.1 Subroutine Name: DUM01A

1. Entry Point: DUM01A

2. Purpose: To define and output the complex single precision base acceleration matrix BASEXG.

3. Calling Sequence: Call DUM01A (BASE, BASE1, Z, W, BUF, INDEX, MODFRL, BASEXG, NROW, NF, NFX, FKMAX, OMEGA)

BASE - Storage for BASE matrix - complex S.P. - input.
BASE1 - Storage for sorted BASE matrix - complex S.P. - input.
Z - Storage for one column of matrix BASEXG - complex S.P. - input.
W - Frequencies (radians) from data block FRL - real - input.
BUF - GINO buffer for BASEXG - real - input
INDEX - Sorting index - integer - input
MODFRL - Flag to indicate if frequency list was expanded - logical - input.
BASEXG - GINO file number of BASEXG - integer - input.
NROW - G-set size - integer - input.
NF - Number of frequencies in FRL data block - integer - input.
NFX - Expanded number of frequencies - integer - input.
FKMAX - Function of parameter KMAX - integer - input.
OMEGA - Rotational speed of structure in radians - real - input.
3.2.1.8.2 Subroutine Name: DUM01B

1. Entry Point: DUM01B

2. Purpose: To define the complex single precision BASE matrix used in generating the complete base acceleration matrix BASEXG. This routine is only called if MODFRL is false.

3. Calling Sequence: CALL DUM01B (BASE, W, NF)

   BASE - BASE matrix - complex S.P. - output
   W - Frequencies from data block FRL - real (radians) - input.
   NF - Number of frequencies in W - integer - input.

COMMON/CONDAS/PI, TWOP, RADEG, DEGRA, S4PISQ
COMMON/BLANK/DUM(5), BXPTID, BYPTID, BYPTID, BZPTID

3.2.1.8.3 Subroutine Name: DUM01C

1. Entry Point: DUM01C

2. Purpose: To define the complex single precision BASE matrix used in generating the complete base acceleration matrix BASEXG. This routine is only called if MODFRL is true.

3. Calling Sequence: CALL DUM01C (BASE, W, OMEGA, NF)

   BASE - BASE matrix - complex S.P. - output.
   W - Frequencies from data block FRL - real (radians) - input.
   OMEGA - Rotational speed of the structure in radians - real - input.
   NF - Number of frequencies in W - integer - input.

COMMON/CONDAS/PI, THOP, RADEG, DEGRA, S4PISQ
COMMON/BLANK/DUM(5), BXPTID, BYPTID, BYPTID, BZPTID

3.2.1.8.4 Subroutine Name: DUM01D

1. Entry Point: DUM01D

2. Purpose: To sort the columns of matrix BASE in the same order as the expanded frequencies in data block FRLX.

3. Calling Sequence: CALL DUM01D (BASE, BASE1, INDEX, NFX)

   BASE - BASE matrix - complex S.P. - input/output
   BASE1 - Temporary storage used for sorting matrix BASE - complex S.P. - input.
   INDEX - Sorting key - integer - input.

3.13
3.2.1.8.5 Subroutine Name: DUM01E

1. Entry Point: DUM01E

2. Purpose: To sort the list of expanded frequencies of data block FRLX and to supply an index key so these vectors can be sorted the same way.

3. Calling Sequence: CALL DUM01E(A,K,N)

A - Vector to be sorted - real - input/output.
K - Sort index key - integer - output
N - Length of A and K

3.2.1.9 Design Requirements

a) Open core is defined at /DUM1XX/
b) No scratch files are used
c) DUM01 resides in LINKNS07
d) Open core for five GINO buffers is needed.
e) The layout for open core is as follows:

**Phase I**

```plaintext
COMMON/DUM1XX/ Z

<table>
<thead>
<tr>
<th>Z(1)</th>
<th>Column of MGG</th>
<th>NTYPE*G-set</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREE</td>
<td></td>
</tr>
<tr>
<td>Z(ICSTM)</td>
<td>CSTM DATA</td>
<td>LCSTM</td>
</tr>
<tr>
<td>Z(IBUF5)</td>
<td>M2GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF4)</td>
<td>M1GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF3)</td>
<td>B1GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF2)</td>
<td>BGPDT</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>CSTM/MGG</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>
```

3.14
Phase II

COMMON/DUMIXX/Z

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL)</td>
<td>FRL DATA</td>
<td>NF</td>
</tr>
<tr>
<td>Z(INDEX)</td>
<td>SORT INDEX KEY</td>
<td>3*NF</td>
</tr>
<tr>
<td>Z(IFRLX)</td>
<td>FRLX DATA</td>
<td>3*NF</td>
</tr>
<tr>
<td>Z(IPDZ)</td>
<td>PDZERO DATA</td>
<td>5*NF</td>
</tr>
<tr>
<td></td>
<td>FREE</td>
<td></td>
</tr>
<tr>
<td>Z(IBUF3)</td>
<td>PDZERO</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF2)</td>
<td>CASELL/FRLX</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>FRL</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

Phase III

COMMON/DUMIXX/Z

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL)</td>
<td>FRL DATA</td>
<td>NFS</td>
</tr>
<tr>
<td>Z(INDEX)</td>
<td>SORT INDEX</td>
<td>3*NFSX</td>
</tr>
<tr>
<td>Z(ITAB)</td>
<td>PRETAB TABLE DATA</td>
<td>NTABL</td>
</tr>
<tr>
<td>Z(N1)</td>
<td>BASE MATRIX</td>
<td>(3*NFSX)*2</td>
</tr>
<tr>
<td>Z(N2)</td>
<td>BASE1 MATRIX</td>
<td>(3*NFSX)*2</td>
</tr>
<tr>
<td>Z(N3)</td>
<td>COLUMN OF BASEXG</td>
<td>(G-set)*2</td>
</tr>
<tr>
<td></td>
<td>FREE</td>
<td></td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>DIT/BASEXG</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

3.2.1.10 Diagnosis of Messages

The following fatal error messages may occur:
3091, 3002, 3003, 3008 and 3031.
3.2.2 Functional Module DUMMOD2

3.2.2.1 Entry Point: DUMMOD2

3.2.2.2 Purpose

To generate tables FRL and FOL and matrices REORDER1 and REORDER2 to be used in a forced vibration response analysis of rotating cyclic structures. Parameters LMAX, NTSTEPS, FLMAX, NOR01 and NOR02 are also computed.

3.2.2.3 DMAP Calling Sequence

DUMMOD2 TOL,....../FRL, FOL, REORDER1, REORDER2,.../V,Y,NSEGS/V,Y, CYCIO/V,Y,LMAX=-1/V,N,FKMAX/V,N,FLMAX/V,N,NTSTEPS/V,N,NOR01/V,N,NOR02 S

3.2.2.4 Input Data Blocks

TOL - Time output list.
NOTES: 1. TOL must be present

3.2.2.5 Output Data Blocks

FRL - Frequency Response List
FOL - Frequency Output List
REORDER1 - Load reordering matrix for time-dependent frequency response problems.
REORDER2 - Load reordering matrix for time-dependent frequency response problems.
NOTES: 1. FRL and FOL cannot be purged.

3.2.2.6 Parameters

NSEGS - Input-integer-no default. NSEGS is the number of identical segments in the structural model.

CYCIO - Input-integer-no default. The value of this parameter specifies the form of the input and output data for cyclic structures. A value of +1 is used to specify physical segment representation and a value of -1 for cyclic transformation representation.

LMAX - Input/output-integer-default. LMAX specifies the maximum time-harmonic index for cyclic structures. The default value is NTSTEPS/2, where NTSTEPS is defined below.

FKMAX - Input-integer-no default. FKMAX is a function of parameter KMAX.
FLMAX - Output-integer-no default. FLMAX is a function of parameter LMAX.
NTSTEPS - Output-integer-no default. The number of time steps from data block TOL.

NOR01 - Output-integer-no default. NOR01=-1 if matrix REORDER1 is not generated, +1 otherwise.

NOR02 - Output-integer-no default. NOR02=-1 if matrix REORDER2 is not generated, +1 otherwise.
3.2.2.7 Method

Computations proceed in three phases. Parameters NTSTEPS, LMAX and FLMAX are computed in Phase I. Data blocks FRL and FOL are generated and output in Phase II and matrix data blocks REORDER1 and REORDER2 and their respective parameters NOR01 and NOR02 are generated and output in Phase III.

3.2.2.7.1 Computation of Parameters NTSTEPS, LMAX and FLMAX

Data block TOL is open and the list of output times is read from the header record and stored for use by Phase II. Let NTIMES be the number of times read.

a) Parameter NTSTEPS

If CYCIO = -1, then NTSTEPS = (NTIMES * FLMAX) / FLMAX
If CYCIO = +1, then NTSTEPS = (NTIMES * NSEGS) / NSEGS

b) Parameter LMAX

If LMAX < 0, then the default value of LMAX is set equal to NTSTEPS / 2.

c) Parameter FLMAX

If NTSTEPS is even and LMAX = NTSTEPS / 2, then FLMAX = NTSTEPS, otherwise FLMAX = 2 * LMAX + 1.

3.2.2.7.2 Generation of tables FOL and FRL

The list of times read from TOL are now converted to the frequency domain. The number of frequencies, NFREQ, is set equal to FLMAX.

Let PERIOD = TIME(2) + TIME(NTSTEPS)

then, FOL(1) = 0.0
FOL(i) = (i - 1/2) * (1.0 / PERIOD) for i = 2, 4, 6, ..., NFREQ
and FOL(j) = FOL(j-1) for j = 3, 5, 7, ..., NFREQ-1

Data block FOL is then output and data block FRL is then generated from FOL by converting the FOL frequencies in hertz to FRL frequencies in rad / ns, FRL(i) = FOL(i) * 2π for i = 1, NFREQ.

3.2.2.7.3 Computation of parameters NOR01 and NOR02 and matrices REORDER1 and REORDER2.

REORDER1 and REORDER2 are used for reordering columns of a matrix by post-multiplying the matrix whose columns are to be reordered. Routine DUMOZA is called twice, once to generate and output REORDER1 and once to generate and output REORDER2. See the subroutine description of DUMOZA for details.
3.2.2.8 Subroutines

DUMOD2 uses standard NASTRAN GINO routines and utility routines.

3.2.2.8.1 Subroutine Name: DUM02A

1. Entry Point: DUM02A

2. Purpose: To generate and output column reordering matrices REORDER1 and REORDER2 and to compute parameters NORO1 and NORO2.

3. Calling Sequence: CALL DUM02A(FILE, KK1, KK2, NORO, BUFFER)

   FILE - GINO file number of REORDER1 or REORDER2 - integer - input.
   KK1 - Reordering row index - integer - input.
   KK2 - Reordering column index - integer - input.
   NORO - NORO=1 if reordering matrix was generated, -1 otherwise - integer - output.
   BUFFER - GINO buffer - real - input

4. Method: If KK1 = 1 or KK2 = 1 then set parameter NORO=-1, otherwise set parameter NORO=+1 to indicate that the reordering matrix was generated. If NORO=-1, then return otherwise continue processing.

Generate a real single precision reordering matrix of order KK1*KK2 by KK1*KK2. This matrix can be used to reorder columns of another matrix by post-multiplying the matrix whose columns are to be reordered.

Column i of the reordering matrix contains a 1.0 in row j if column j is to become column i of the reordered matrix. For example, if column 5 is to become column 1 of the new matrix then the reordering matrix contains a 1.0 in row 5 of column 1.

3.2.2.9 Design Requirements

a) Open core is defined at /DUM2XX/

b) DUMOD2 resides in LINKNS07

c) No scratch files are used
d) Open core for one BUFFER+1 is required.
The layout of open core is as follows:

```
COMMON/DUM2XX/
```

<table>
<thead>
<tr>
<th>Z(ITOL)</th>
<th>TOL TIME DATA</th>
<th>OLTIMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFOL)</td>
<td>FOL/FRL DATA</td>
<td>OLMAX</td>
</tr>
<tr>
<td></td>
<td>FREE</td>
<td></td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>TOL/FOL/FRL/REORDER</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

### 3.2.2.10 Diagnostic Messages

The following fatal error messages may occur: 3001, 3002, 3008, 3037
3.3 OVERLAY CHARTS

3.3.1 IBM OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
QUALIFIED EXISTING ROUTINES

LFP  SFPAR  SFPX  LSUPI  IFX.81B  IFX.81P  IFX.81DB  IFX.81BD  EFSUR

XCSA  YXKDD  XXYFDDD  XRODFM

NOTE - LINKEDIT CONTROL

CHANGE: CDBG_IUX(332), IUX(332), LDIY(332), LDIY(332)
Included NEW (ARCSM)

% - Denotes New Routines

3.22
NASTRAN L179 (IBM)
LINKNS07

Diagram of program flow:
- Root File
- Solution
- Input File
- Output File
- Switch
- Define
- Document

Region 1:
- Region 2 (cont.)
- Region 3
- Region 4

Legend:
- *New*
- + Existing

Section 2 (cont.):
- *New*
- + Existing

Hi-level Existing Routines:
- CYPE, DUMP, DUMFO
MODIFIED EXISTING ROUTINES: FAZ

ORIGIN: "-GE: OR- POOR QUALITY

OF POOR QUALITY
3.3.2 UNIVAC OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

Frequency Response of a 12-Bladed Disc
(Examples 1-6) by the Direct Method

A. General Description

Five inter-related examples are presented to illustrate various features of this new capability to conduct forced vibration analysis of rotating cyclic structures. A 12-bladed disc is used for demonstration.

The capability includes the effects of Coriolis and centripetal accelerations on the rotating structure which can be loaded with:

1. directly applied loads moving with the structure, and
2. inertial loads due to the translational acceleration of the axis of rotation ('base' acceleration).

Example 1 is conducted on a finite element model of the complete structure (Figure 1). Examples 2 through 5 use a finite element model of one rotationally cyclic sector (Figure 2). Results of example 1 are used to verify some of the results obtained in the remaining examples. Table 1 summarizes the principal features demonstrated by these examples.

Steady-state frequency-dependent (sinusoidal) or time-dependent (periodic) loads are applied to selected grid point degrees of freedom. The specified loads can represent either the physical loads on various segments or their circumferential harmonic components. For illustration purposes only, the frequency band of excitation, 1700-1920 Hz, due to directly applied loads and base acceleration is selected to include the second bending mode of the disc for a circumferential harmonic index \( k = 2 \). The 'blade-to-blade' distribution of the directly applied loads also corresponds to \( k = 2 \). Table 2 lists the first few natural frequencies of the bladed disc for \( k = 0, 1 \) and 2. Modes for \( k = 2 \) are shown in Figure 3.

B. General Input

1. Parameters:

\[ \text{Diameter at blade tip} = 19.4 \text{ in.} \]
\[ \text{Diameter at blade root} = 14.2 \text{ in.} \]
\[ \text{Shaft diameter} = 4.0 \text{ in.} \]
Disc thickness = 0.25 in.
Blade thickness = 0.125 in.
Young's modulus = $30.0 \times 10^6$ lbf/in$^2$
Poisson's ratio = 0.3
Material density = $7.4 \times 10^{-4}$ lbs-sec$^2$/in$^4$
Uniform structural damping (g) = 0.02

2. Constraints:

All constraints are applied in body-fixed global coordinate system(s). All grid points on the shaft diameter are completely fixed. Rotational degrees of freedom $\theta_z$ at remaining grid points are constrained to zero.
EXAMPLE 1

A. Description

This example uses the direct frequency response capability in NASTRAN, RF8, and forms the basis to verify some of the results of examples 2 through 5.

B. Input

1. Parameters:
   
   Same as general input parameters.

2. Constraints:

   Same as general input constraints.

3. Loads:

   \[ P(f;n) = A(f) \cos (n - T \cdot \frac{2\pi}{\Omega}) \]

   where \( n \) is the segment number,

   \( \Omega \) represents \( k = 2 \),

   and \( \Omega \) represents the total number of segments in the bladed disc.

   \( P \) is specified using RLOAD1 bulk data cards.

C. Results

Sample plots of grid point displacement and element stress response are shown in Figures 4 through 6. The expected behavior about a \( k = 2 \) natural frequency of the bladed disc can be seen in all these figures.
D. Driver Decks and Bulk Data

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FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)

INDEX 2C TYPE LOADS

CASE CONTROL DECK ECHO

CARD
COUNT

$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
3 SUBTITLE = BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)
4 LABEL = INDEX 2C TYPE LOADS

$ SPC = 30
7 FREQ = 1
8 DLOAD = 1
9
OUTPUT

10 SET 1 = 8,22,26,50,64,70,86,92,106,120,134,140,142
11   16,30,44,58,66,74,86,100,114,120,142,156,170
12   18,32,34,60,74,88,102,116,130,144,150,172
13
14 DLOAD = 1
15 DISP(SORT2, PHASE) = ALL
16 STRESS(SORT2, PHASE) = ALL
17
18 OUTPUT(XYPLOT)

19 PLOTTER NASPLOT, MODEL 0,0
20 XPAPER = 8.0
21 YPAPER = 10.5
22 XAXIS = YES
23 YAXIS = YES
24 XGRID LINES = YES
25 YGRID LINES = YES
26 CURVE1INESYMBOL = 1
27 VLOG = YES
28
29 XTITLE = FREQUENCY (HERTZ)
30 YTITLE = GRID POINT DISPLACEMENT ( MAGNITUDE, INCH )
31
32 XYPLOT, XPRINT DISP RESPONSE /14(T3RM), 18(T3RM), 95(T3RM)
33
34 YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI )
35
36 XYPLOT, XPRINT STRESS RESPONSE /11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
37
38 TCURVE = 119(3), 109(5), 109(7), 109(10), 109(12), 109(14)
39
40 XYPLOT, XPRINT STRESS RESPONSE /109(3), 109(5), 109(7),
41
42 TCURVE = 109(10), 109(12), 109(14)
43
44 BEGIN BULK

SER INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
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EXAMPLE 2

A. Description

This example uses the forced vibration capability with cyclic symmetry. The user input/output data for loads, displacements, stresses, etc., pertain to the physical representation of the various segments of the bladed disc. The frequency-dependent applied loads correspond to \( k = 2 \), and hence the solution loops on the circumferential harmonic index \( k \) are restricted to \( k = 2 \) only via parameters \( \text{KMIN} \) and \( \text{KMAX} \).

B. Input

1. Parameters:

   In addition to general input parameters,
   - \( \text{CYCIO} = +1 \) physical cyclic input/output data
   - \( \text{KMIN} = 2 \) minimum circumferential harmonic index
   - \( \text{KMAX} = 2 \) maximum circumferential harmonic index
   - \( \text{NSEGS} = 12 \) number of rotationally cyclic segments
   - \( \text{RPS} = 0.0 \) rotational speed
   - \( \text{GKAD} = \text{FREQRESP} \) Specify the form in which the damping parameters are used.
   - \( \text{LGKAD} = +1 \)

2. Constraints:

   Same as general input constraints.

3. Loads:

   \[ P^n(f) = A(f) \cos \left( \frac{n-1}{\text{NSEG}} \cdot \frac{2\pi}{12} \right) \]

   where
   - \( n \) is the segment number,
   - \( \cdot \) represents \( k = 2 \),
   - \( \cdot \) represents the total number of segments in the bladed disc.
   - \( P \) is specified using RLOADi bulk data cards.

C. Results

Displacement and stress output results for selected grid points and elements are presented in Figures 7 through 10. Agreement between results of Figures 7-8 and Figure 4, Figure 9 and Figure 5, and Figure 10 and Figure 6 is excellent.
D. Driver Decks and Bulk Data

NASTRAN EXECUTIVE CONTROL DECK ECHO

ID       NASA_EXAMPLE2
APP       DISP
SOL 8

BEGINNING OF RF ALTER 88:1 - RF 8 / SERIES R (1117.7) / 1-28-82 / M.G. 5

PURPOSE - TO MODIFY THE DIRECT FREQUENCY AND RANDOM RESPONSE RIGID
FORMAT TO ENABLE THE USER TO PERFORM A FORCED VIBRATION
RESPONSE ANALYSIS OF ROTATING CYCLIC STRUCTURES.

EXECUTIVE DECK INPUT -

1. SOL 8
2. R.F. ALTERS

CASE CONTROL DECK INPUT -

1. ALL SPC AND MPC CONSTRAINTS MUST BE ABOVE THE SUBCASE LEVEL.
2. EITHER FREQUENCY OR TSTEP MUST BE SELECTED AND MUST BE ABOVE
   THE SUBCASE LEVEL.
3. IF SELECTED, FREQUENCY MUST BE USED TO SELECT ONE AND ONLY
   ONE FREQ, FREQ1 OR FREQ2 CARD FROM THE BULK DATA DECK AND
   MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
4. IF SELECTED, TSTEP MUST BE USED TO SELECT THE TIME- STEPS TO BE
   USED FOR LOAD DEFINITION AND MUST BE DEFINED ABOVE THE SUBCASE
   LEVEL.
5. DIRECT INPUT MATRICES ARE NOT ALLOWED.
6. UPFREQUENC Y MUST NOT BE USED.
7. A SEPARATE GROUP OF SUBCASES MUST BE DEFINED FOR EACH SYMMETRIC
   SEGMENT.
8. ULOAD MUST BE USED TO DEFINE A FREQUENCY OR TIME-DEPENDENT
   LOADING CONDITION FOR EACH SUBCASE.
   FOR FREQUENCY-DEPENDENT LOADS, SUBCASES WITHOUT LOADS NEED NOT
   REFER TO A ULOAD CARD.
   FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO
   A ULOAD CARD THAT GENERATES A NULL LOAD.
9. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF
   SUBCASES FOR EACH HARMONIC INDEX, K. THE PARAMETER CYCLO IS
   INCLUDED AND THE LOAD COMPONENTS FOR EACH INDEX ARE DEFINED
   DIRECTLY WITHIN EACH GROUP FOR THE VARIOUS LOADING CONDITIONS.

BULK DATA DECK INPUT -

ORIGINAL PAGE OF POOR QUALITY.

4.15
1. SUPORT BULK DATA CARDS ARE NOT ALLOWED.
2. EPOINT BULK DATA CARDS ARE NOT ALLOWED.
3. SPOINT BULK DATA CARDS ARE NOT ALLOWED.
4. CYJOIN BULK DATA CARDS ARE REQUIRED.
5. IF A TSTEP CARD IS USED THEN IT MUST NOT BE CONTINUED SINCE
   ONLY ONE UNIFORM TIME STEP INTERVAL MUST BE SPECIFIED.
   THE SKIP FACTOR FOR OUTPUT, NO. ON THE TSTEP CARD MUST BE 1.
6. PARAMETERS USED ARE:

   A. NSEGS - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
      IS THE NUMBER OF IDENTICAL SEGMENTS IN THE
      STRUCTURAL MODEL.

   B. CYCLO - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
      SPECIFIES THE FORM OF THE INPUT AND OUTPUT DATA.
      A VALUE OF G1 IS USED TO SPECIFY PHYSICAL SEGMENT
      REPRESENTATION. A VALUE OF -1 IS USED TO SPECIFY
      CYCLIC TRANSFORMATION REPRESENTATION. THERE IS NO
      DEFAULT, A VALUE MUST BE INPUT.

   C. CYCSEG - FIXED - THE INTEGER VALUE OF THIS PARAMETER
      SPECIFIES THE PROCEDURE FOR SEQUENCING THE
      EQUATIONS IN THE SOLUTION SET. THE VALUE OF THIS
      PARAMETER HAS BEEN SET TO -1 TO SPECIFY
      ALTERNATING COSINE AND SINE TERMS.

   D. CTYPY - FIXED - THE GCD VALUE OF THIS PARAMETER
      DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE
      OF THIS PARAMETER HAS BEEN SET TO -rot- FOR
      ROTATION SYMMETRY.

   E. KMAX - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
      SPECIFIES THE MAXIMUM VALUE OF THE HARMONIC
      INDEX. THERE IS NO DEFAULT FOR THIS PARAMETER.
      THE MAXIMUM VALUE THAT CAN BE SPECIFIED IS NSEGS/2

   F. KMIN - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
      SPECIFIES THE MINIMUM VALUE OF THE HARMONIC
      INDEX TO BE USED IN THE SOLUTION LOOP. KMIN CAN
      EQUAL KMAX. THE DEFAULT VALUE IS 0.

   G. LMAX - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
      SPECIFIES THE MAXIMUM TIME HARMONIC INDEX. THE
      DEFAULT VALUE IS NTSTEPS/2, WHERE NTSTEPS EQUALS
      N (FROM TSTEP CARD) PLUS 2.

   H. NLOAD - FIXED - THE INTEGER VALUE OF THIS PARAMETER
      IS THE NUMBER OF LOADING CONDITIONS. THE VALUE
      OF THIS PARAMETER IS INTERNALLY CALCIULATED.

   I. RPS - OPTIONAL - THE REAL VALUE OF THIS PARAMETER
      DEFINES THE ROTATIONAL SPEED OF THE STRUCTURE
      IN REVOLUTIONS PER UNIT TIME. THE DEFAULT VALUE
      IS 0.0.

   J. BATID - OptionAl - THE POSITIVE INTEGER VALUES OF THESE
      PARAMETERS DEFINE THE SET IDENTIFICATION NUMBERS
      OF THE TABLED BULK DATA CARDS WHICH DEFINE THE
      COMPONENTS OF THE BASE ACCELERATION VECTOR.

   BYTID
   UZTID
   UXPTID

4.16
NASTRAN EXECUTIVE CONTROL DECK ECHO

D1YPTID TABLES REFERED TO BY D1XID, D1YID AND D1ZID
DEFINE MAGNITUDE (17=-2) AND THE TABLES REFERED TO
BY D1YID, D1YID AND D1ZPTID DEFINE PHASE (DEGREE).
THE DEFAULT VALUES ARE -1 WHICH MEANS THAT THE
RESPONSIVE TERMS ARE IGNORED.

K. NUKPRT - OPTIONAL - AN INTEGER VALUE OF 61 FOR THIS
PARAMETER WILL CAUSE THE CURRENT HARMONIC INDEX,
KINDEX, TO BE PRINTED AT THE TOP OF THE HARMONIC
LOOP. THE DEFAULT VALUE IS 61.

L. GRPNT - OPTIONAL - A POSITIVE INTEGER VALUE OF THIS
PARAMETER WILL CAUSE THE GRID POINT WEIGHT
GENERATOR TO BE EXECUTED AND THE RESULTING WEIGHT
BALANCE INFORMATION TO BE PRINTED. DEFAULT IS -1.

M. WTHASS - OPTIONAL - THE TERMS OF THE STRUCTURAL MASS
MATRIX ARE MULTIPLIED BY THE REAL VALUE OF THIS
PARAMETER WHEN THEY ARE GENERATED IN EMG. THE
DEFAULT IS 1.0.

N. COUPMASS - FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.

D. GKA - OPTIONAL - THE BCD VALUE OF THIS PARAMETER IS
USED TO TELL THE GKA MODULE THE DESIRED FORM OF
MATRICES KDD, BDD AND VDD. THE BCD VALUE CAN BE
FREQESP OR TRANRESP. THE DEFAULT IS TRANRESP.
NOTE - MEMBER TO DEFINE PARAMETERS G, W3 AND H4.
SL: SECTION 9.3.3 (DIRECT DYNAMIC MATRIX
ASSEMBLY) PAGES 9.3-7 AND 9.3-8 OF THE
NASTRAN THEORETICAL MANUAL.

P. LKG - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
IS USED IN CONJUNCTION WITH PARAMETER GKA. IF
GKA=FREQESP THEN SET LKG=1. IF GKA=TRANRESP
THEN SET LKG=-1. THE DEFAULT VALUE IS -1.

Q. U - OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A UNIFORM STRUCTURAL DAMPING COEFFICIENT
IN THE DIRECT FORMULATION OF DYNAMICAL PROBLEMS.

R. W3 - OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A PIVOTAL FREQUENCY FOR UNIFORM STRUCTURAL
DAMPING IF PARAMETER GKA=TRANRESP. IN THIS CASE
W3 IS REQUIRED IF UNIFORMED STRUCTURAL DAMPING IS
DESIRED. THE DEFAULT VALUE IS 0.0.

S. H4 - OPTIONAL - THE REAL VALUE OF THIS PARAMETER IS
USED AS A PIVOTAL FREQUENCY FOR ELEMENT STRUCTURAL
DAMPING IF PARAMETER GKA=TRANRESP. IN THIS CASE
H4 IS REQUIRED IF STRUCTURAL DAMPING IS DESIRED FOR
ANY OF THE STRUCTURAL ELEMENTS. DEFAULT IS 0.0.

REMARKS -
1. THE ANALYSIS WILL LOOP THRU A RANGE OF THE CYCLIC INDEX,
   KINDEX = KMIN TO KMAX.

4.17
NASTRAN EXECUTIVE CONTROL DECK ECHO

NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //C,N,NOT /V,N,FTEK1 /V,N,FREUTINE $
PARAM //C,N,LE /V,N,NUPREQ /V,N,FPRESET /C,N,O $
PARAM //C,N,LE /V,N,NOTINE /V,N,TIMESET /C,N,O $
COND ERRORC, FTEK1 $ BOTH FREQ AND STEP IN CASE CONTROL DECK.
$ LOQUII GULK DATA NOT ALLOWED
PARAM //C,N,NGT /V,N,EXTRAPTS /V,N,NOUE $
COND ERRORC, EXTRAPTS $
$ GENERATE DATA FOR CYCT2 MODULE.
CP5C GEM4,EQYN,USETO /CYCT2 /V,N,CTYPE=RUT /S,N,NOGU $
CCMD ERRORCl,NUGC $
CHPNT CYCT2 $
ALTER 32 $
$ PRI-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED
PARAM //C,N,OK /V,N,NOGU1 /V,N,NCMG2G /V,N,NUKPS $
PURGE B1GG,M1GG /NUCHI $
PURGE M2GG,M2BASExG /NUM2G $
ALTER 35 $
$ GENERATE DATA BLOCKS FRRLX, BILG, MLG2, M2GG AND BASFX.
$ GENERATE PARAMETERS FKMAX AND NCBASEX.
UMM001 CASECC, 0,UPUT,C3TM, BIT,FRXL,MUG $ / FRXL,B1GG,M1GG, M2GG,BASEXG, POZRC $, / V,N,NUMGG/V,Y,LYCI,C/V,Y,NSEG $/ V,Y,KMAX/S,N,FKMAX/V,Y,BX7TID=-1/V,Y,BX7TID=-1/ V,Y,0Y7TID=-1/V,Y,0Y7TID=-1/V,Y,0Z7TID=-1/ V,Y,0Z7TID=-1/S,N,NCBASEX/V,N,NOFREQ/V,N,LMG$ $
PARAML FRRLX //C,N,PRESENCE /// /V,N,NOFLRXL $
COND LBLFRXL,NUFLRLX $
EQUIV FRRLX,FRKL $
LABEL LBLFRXL $
CHPNT FRKL,B1GG,M1GG,M2GG,BASEXG $
ALTER 42 $
PARAM //C,N,ADD /V,N,NUBGG $ /V,N,NUCH1 /C,N,O $ RESET NUBGG.
ALTER 52 $
$ REDEFINE BGG AND KGG.
COND LBL1,IA,NUCH1 $
PARAM //C,N,COMPLEX /V,N,OMEGA2 /C,N,O $ / V,N,CMPLX1 $
PARAM //C,N,CONC /V,N,OMEGASU /C,N,UC $ / V,N,OMEGASUR $
PARAM //C,N,COMPLEX /V,N,OMEGASU /C,N,NO $ / V,N,CMPLX2 $
AGC BGG31OG / BGG1 / C,N,(L,0,0,0) / V,N,CMPLX1 $
EQUIV BGG1,BGG $
AGC KG1,KG2 / KG1 / C,N,(L,0,0,0) / V,N,CMPLX2 $
EQUIV KG1,KGG $
CHPNT BGG,KGG $
LABEL LBL1A $ ALTER 53,55 $ GP4 HAS BEEN MOVED-UP.
ALTER dB,61 $ GDP HAS BEEN MOVED-UP.
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LGKAD, FOR FREQ OR TRAN.
PARAM //C,N,AND /V,N,KULKA /V,N,NOUE /V,N,NGK2PP $
COND LGKAD, LGKAD $ BRANCH IN NOT FRERESP.
ALTER 115 $ SEE ALTER 114 COMMENT.
JUMP LGKAD2 $
LABEL LGKAD1 $
EQUIV M2PP,M2DD,NCA/B2PP,B2DD/K2PP,K2DD/NGA/HAAP,MD0/MDM$ 
CHKPNT K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDEK $ 
LABEL LGKAD2 $ 
ALTER 117,117 $ ADD PARAMETERS GKAU, n3 and m TO GKAU. $ 
GKAU USFD,G2G,GO,M4A,MAA,K2AA,K2PP,M2PP,B2PP,K2DD,B2DD,MD0,GMG$ 
C,Y,G=0.0/C,Y,N=3/G0/C,Y,H4=0.0/V,N,NOK2PP/V,N,NOM2PP/$ 
V,N,NGB2PP/V,N,MCFL/V,N,S1NL/E/V,N,SHIT/V,N,NGUE/V,N,NOK46G/ 
V,N,NGB00/V,N,KDEK/ $ 
ALTER 118 $ SEE ALTER 117 COMMENT. $ 
COND LGKAD3, LGKAD5 $ BRANCH IF NOT FRESRESP. $ 
ALTER 119 $ SEE ALTER 114 COMMENT. $ 
JUMP LGKAD4 $ 
LABEL LGKAD3 $ 
EQUIV B2DD,G2D/NOLPNT/M2DD,MD0/NOSIMP/K2DD,KDEK $ 
LABEL LGKAD4 $ 
ALTER 120,123 $ $ NEW SOLUTION LOGIC $ 
$ GENERATE TIME-DEPENDENT LOADS IF TSTEP WAS REQUESTED IN CASE CONTROL. $ 
COND LBLTRLI, NOTIME $ 
$ LOOP THROUGH ALL SUBCASES FOR TIME-DEPENDENT LOADS. $ 
PARAM /C,N,MPY/V,N,REPEAT/T,C,N,1/C,N,-1 $ 
PARAM /C,N,ADD/V,N,APPFLG/C,N,1/C,N,0 $ INITIALIZE FOR SUBS. $ 
JUMP TRLGLOOP $ 
LABEL TRLGLOOP $ 
CASE CASECC, /CASEYY/C,N,TRAN/S,N,REPEAT/T,C,N,NOLPNT $ 
CHKPNT CASEYY $ 
PARAM /C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $ 
TRLG CASEYY,USEDT/DLT,LST,BGPDT,SL,CSIM,TRL,UT,GMG,GO,EST,HGG/ 
**PDT1,PD1,TCL/V,N,NUSET/S,N,PDEPDV/V,N,NCOL $ 
SDRI TRL,PD1,............. /PD1 /V,N,APPFLG/C,N,DYNAMICS $ 
SDRI TRL,PD1,............. /PD /V,N,APPFLG/C,N,DYNAMICS $ 
PARAM /C,N,ADD/V,N,APPFLG/V,N,APPFLG/C,N,1 $ APPFLG=APPFLG1 $ 
COND TRLGONE,REPEAT $ 
KEEP TRLGONE,10G $ 
JUMP LKRDR3 $ 
LABEL TRLGONE $ 
CHKPNT PDT,PD,TCL $ 
EQUIV PD,PDT,PDEPD $ 
CHKPNT PST $ 
DUNJUD2 TDL,......... /FRLZ,FULZ,REGRDER1,REGRDER2,......... / 
V,N,NSEG/V,N,CYCLG/S,Y,LMAX=-1/V,N,FMAX/$ 
S,N,FMAX/S,N,NSTEPS/S,N,NORCL/S,N,NORC2 $ 
EQUIV FRLZ,FULZ/FULZ,FCL $ 
CHKPNT FRL,FCL,REGRDER1,REGRDER2 $ 
JUMP LBLTRL1 $ 
LABEL LBLTRL1 $ $ GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC. $
NAStRAN EXECUTIVE CONTROL DECK ECH

FRG
CASEXX, USEC, DLT, FRL, GHDr, G00, DIT, / PPF, PSF, PDF, PUL, PHFUM /
C,N, DIRECT / V., FREQ / C,N, FREQ $
COND.
LRLFRLlx, NOFRLX $ ZERO OUT LOAD COLUMNS IF FRLX WAS GENERATED.
MPYAD
PPF, PSFZERD, / PPFX / C,N, O $ 
EQUIV
PPFX, PPF $ 
LABEL
LRLFRLlx $ 
$ FORM NEW LOADS.
CCND
LRLFRLlx, NOBASEX $ 
MPYAD
M2G0, BASELG / M2BASEXG / C,N, O $ 
ADL
PPF, M2BASEXG / PPF1 / C,N, (-1, 0, 0, 0) / C,N, (1, 0, 0, 0) $ 
EQUIV
PPF1, PPF $ 
CCND
LRLBASE1, NOSET $ 
SSE2
USEC, G00, YS, ASG, GW $ PPF / / PPFUM1, PSF1, PDF1 $ 
EQUIV
PSF1, PSF / PDF1, PDF $ 
LABEL
LRLBASE1 $ 
LABEL
LRLFRLlx $ 
EQUIV
PPF, PDF/NNOSET $ 
CHKPNT
PPF, PSF, PDF, FGL $ 
$ LOADS ARE FREQUENCY-DEPENDENT
$ PERFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIC=1.
PARAM
PDF / C,N, ThINER / C,N, 1 / V,N, POFCOLS $ 
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1.
PARAM
// C,N, OIV / V,N, NLCAO / V,N, POFCOLS / V,N, FKMAX $ NLOAD = NF/FKMAX
EQUIV
PDF, PPF, CYCIC $ 
COND
LRLPD1GNE, CYCIC $ 
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1.
PARAM
// C,N, OIV / V,N, NLCAO / V,N, POFCOLS / V,N, NSEG $ NLOAD = NF/SEG $ 
CYC1
PDF / PPF, CYICL / V,N, LTYPE / C,N, FKME / V,Y, NKSEG =-1 $ 
V,Y, KMAX=-1 / V,N, NLOAD / S,N, NCOR $ 
COND
ERRRCL, NGGG $ 
CHKPNT
SFX $ 
JUMP
LRLPD1GNE $ 
LABEL
LRLFR2 $ 
$ LOADS ARE TIME-DEPENDENT
PARAM
// C,N, O1 / V,N, NOTCYCIG / V,Y, CYCIG $ 
$ BRANCH DEPENDING ON VALUE OF CYCIG
COND
LULTRL2, NOTCYCIG $ 
$ CYCIG=-1
EQUIV
PDT, PTK121/NORU1 $ 
COND
LRLR1A, NORU1 $ 
MPYAD
PDT, KEQDERR1, / PDTK21 / C,N, O $ 
LABEL
LRLR1A $ 
CYC1
PTK121 / PTK21, GYCF2 / V,N, LTYPE / C,N, FKE / V,N, NT3PE/S
V,Y, KMAX/V,N, FKMAX/S,N, NCOR $ 
COND
ERRRCL, NGGG $ 
CHKPNT
PXTK121 $ 
EQUIV
PXTK121, PTK21/NORU2 $ 
COND
LRLR2A, NORU2 $ 
MPYAD
PXTK121, KEQDERR2, / PTK21 / C,N, O $ 
LABEL
LRLR2A $ 

4.21
EQUIV  PXFL2,PXF1 $  
CHKPNT  PXF1 $  
JUMP  LBLTRL3 $  
LABEL  LBLTRL2 $  
$ CYC10 = C1  
MPYAD  PDTR,REORDER1, / PDTRZ2 / C,N,0 $  
COND  ERRORT1,NOGC $  
CHKPNT  PXTRZ2 $  
EQUIV  PXTRZ2,PXTR2/NOR2 $  
COND  LBLRZ2,NOR2 $  
MPYAD  PXTRZ2,REORDER2, / PXTR2 / C,R,0 $  
LABEL  LBLRZ2 $  
COND  ERRORT1,NOGC $  
EQUIV  PXFL2,PXF1 $  
CHKPNT  PXF1 $  
LABEL  LBLTRL3 $  
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND $ TO FREQUENCY DEPENDENT LOADS. ALSC SDR2 EXPECTS LOADS TO BE COMPLEX $ IN FREQUENCY PROBLEMS.  
COPY  PXF1 / PXF2 $  CONV REAL PXF1 TO COMPLEX PXF.  
ADJ  PXF1,PXF2 / PXF / C,N,(0.5,1.0) / C,N,(0.5,-1.0) $  
$ DEFINE LOAD FOR CYC2.  
PARAM  //C,N,ADD /V,N,LOAD /V,N,FLMAX /C,N,0 $  NLCAD = FLMAX  
LABEL  LULPJNE $  
PARAM  //C,N,ADD /V,N,KINDEX /V,Y,KMIN=0 /C,N,0 $  INITIALIZE KINDEX.  
$  $ INITIALIZE UXVF IF KMIN IS NOT ZERO.  
$  
PARAM  //C,N,ADD /V,N,KMINL /V,Y,KMIN /C,N,-1 $  
COND  NOKMINL,KMINL $  
PARAM  //C,N,ADD /V,N,KMINV /C,N,0 /C,N,0 $  
JUMP  KMINLUP $  
LABEL  KMINLUP $  
CYC2  CYCDD,...,XPF,...,,...,PKF2,..., / C,N,FORE/V,Y,NSEGS/ V,N,KMINV/V,N,CYC SEQ/V,N,NLCAD/S,N,NOGC $  
COND  ERRORT1,NOGC $  
ADJ  PKF2, / UXVFZ / C,N,(0.5,0.0) $  
CYC2  CYCDD,...,LKF2,...,,...,UXVF,..., / C,N,BACK/V,Y,NSEGS/ V,N,KMINV/V,Y,FLMAX/S,N,NOGC $  
COND  ERRORT1,NOGC $  
PARAM  //C,N,ADD /V,N,KMINV /V,N,KMINV /C,N,1 $  
REPT  KMINLUP,KMINL $  
LABEL  NOKMINL $  
$  
JUMP  TOPCYC $  
LABEL  TOPCYC $  LOCUP CN KINDEX  

4.22
CASE CONTROL DECK ECHO

CARD
COUNT
1 $ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
2 SUBTITLE = BLADED DISC EXAMPLE 2 (CYC MODEL; FREQ LOADS; PHYSICAL I/O)
3 $ SPC = 30
4 FREQ = 1
5 OUTPUT
6 SET 1 = 8,16,18
7 OLOAD = 1
8 DISP(SORT2, PHASE) = ALL
9 STRESS(SORT2, PHASE) = ALL
10 SUBCASE 1
11 LABEL = SEGMENT 1
12 OLOAD = 1 $ FREQ DEPENDENT LOADS
13 SUBCASE 2
14 LABEL = SEGMENT 2
15 OLOAD = 2 $ FREQ DEPENDENT LOADS
16 SUBCASE 3
17 LABEL = SEGMENT 3
18 OLOAD = 3 $ FREQ DEPENDENT LOADS
19 SUBCASE 4
20 LABEL = SEGMENT 4
21 OLOAD = 4 $ FREQ DEPENDENT LOADS
22 SUBCASE 5
23 LABEL = SEGMENT 5
24 OLOAD = 5 $ FREQ DEPENDENT LOADS
25 SUBCASE 6
26 LABEL = SEGMENT 6
27 OLOAD = 6 $ FREQ DEPENDENT LOADS
28 SUBCASE 7
29 LABEL = SEGMENT 7
30 OLOAD = 7 $ FREQ DEPENDENT LOADS
31 SUBCASE 8
32 LABEL = SEGMENT 8
33 OLOAD = 8 $ FREQ DEPENDENT LOADS
34 SUBCASE 9
35 LABEL = SEGMENT 9
36 OLOAD = 9 $ FREQ DEPENDENT LOADS
37 SUBCASE 10
38 LABEL = SEGMENT 10
39 OLOAD = 10 $ FREQ DEPENDENT LOADS
40 SUBCASE 11
41 LABEL = SEGMENT 11
42 OLOAD = 11 $ FREQ DEPENDENT LOADS
43 SUBCASE 12
44 LABEL = SEGMENT 12
45 OLOAD = 12 $ FREQ DEPENDENT LOADS
46 OUTPUT(XYPLOT)
47 PLOTTER NASTPLT, MODEL D*O
48 XPAPER = 8.0
49
50 4.25
CASE CONTROL DECK ECHO

CARD COUNT
YPAPER = 10.5
XAXIS = YES
YAXIS = YES
XGRID LINES = YES
YGRID LINES = YES
CURVELINESYMBOL = 1
YLOG = YES
XTITLE = FREQUENCY (HERTZ)
YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
TCURVE = 14(T3RH), 18(T3RH)
XYPLOT, XYPRINT DISP RESPONSE 1 / 14(T3RH), 18(T3RH)
XYPLOT, XYPRINT DISP RESPONSE 8 / 2(T3RH)
TCURVE = 2(T3RH)
XYPLOT, XYPRINT DISP RESPONSE 8 / 2(T3RH)
YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
TCURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
XYPLOT, XYPRINT STRESS RESPONSE 1 / 11(3), 14(5), 11(7),
11(10), 11(12), 11(14)
TCURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
XYPLOT, XYPRINT STRESS RESPONSE 10 / 11(3), 11(5), 11(7),
11(10), 11(12), 11(14)
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| P A R A M | KHIN | 2 |   |   |   |   |   |   |   |   |
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| P A R A M | NSEG5 | 12 |   |   |   |   |   |   |   |   |
| P A R A M | RPS | .0 |   |   |   |   |   |   |   |   |
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| PQUAD2 | 3 | 1 | .125 |   |   |   |   |   |   |   |
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| RLOAD1 | 3 | 3 | 100 |   |   |   |   |   |   |   |
| RLOAD1 | 4 | 4 | 100 |   |   |   |   |   |   |   |
| RLOAD1 | 5 | 5 | 100 |   |   |   |   |   |   |   |
| RLOAD1 | 6 | 6 | 100 |   |   |   |   |   |   |   |
| RLOAD1 | 7 | 7 | 100 |   |   |   |   |   |   |   |
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| RLOAD1 | 11 | 11 | 100 |   |   |   |   |   |   |   |
| RLOAD1 | 12 | 12 | 100 |   |   |   |   |   |   |   |
| SPC1 | 30 | 6 | 1 | THRU | 19 |   |   |   |   |   |
| SPC1 | 30 | 123456 | 1 | 10 |   |   |   |   |   |   |

4.28
SORTED BULK DATA ECHO

TABLED1 100
STBD1 0.0 1.0 1000.0 1.0 ENDT
EXAMPLE 3

A. Description

This example uses the forced vibration capability with cyclic symmetry. User input/output data pertain to harmonic representation. Frequency-dependent excitation is provided by both directly applied and base acceleration loads.

B. Input

1. Parameters:

   In addition to general input parameters,
   
   CYC10 = -1 harmonic cyclic input/output data
   KMIN = 0 minimum circumferential harmonic index
   KMAX = 2 maximum circumferential harmonic index
   NSEGS = 12 number of rotationally cyclic sectors
   RPS = 600.0 revolutions per second
   BXTID, BYTID, BZTID \ Refer to TABLEd bulk data cards to specify
   BAPTID, B YPTID, BZPTID\ magnitude and phase of base acceleration
   components.
   GKAD = FREQRESP\ Specify the form in which damping parameters are
   LGKAD = +1 \ used.

2. Constraints:

   Same as general input constraints.

3. Loads:

   a) p0,2c = A(f) specified on RLOADi bulk data cards.
   b) Base acceleration as shown in Figure 11.

C. Results

Results are shown in Figures 12 through 20.

Figures 12 and 13 present k = 0 results (subcase 1). The excitation consists of axial base acceleration and directly applied loads. The selected frequency band of excitation, 1700-1970 Hz, lies between the second out-of-plane disc bending mode frequency (1577 Hz, k = 0, Table 2) and the first in-plane shear mode frequency (1994 Hz, k = 0, Table 2). Since the excitation is parallel to the axis of rotation, only the former mode responds.
Figures 14 through 18 present $k = 1$ results (subcases 2 ($k = 1c$) and 3 ($k = 1s$)). The excitation is due to lateral base acceleration only. Although the frequency band of input base acceleration is 1700-1920 Hz, the rotation of the bladed disc at 600 Hz (parameter RPS) splits the input bandwidth into two effective bandwidths:

$$(1700 - 600) = 1100 \text{ Hz} \quad \text{to} \quad (1920 - 600) = 1320 \text{ Hz},$$

and

$$(1700 + 600) = 2300 \text{ Hz} \quad \text{to} \quad (1920 + 600) = 2520 \text{ Hz}.$$  

The only $k = 1$ mode in these effective bandwidths is the first torsional mode of the blade with the disc practically stationary (2460 Hz, $k = 1$, Table 2). This is shown by the out-of-plane displacement magnitudes of grid points 18 (blade) and 8 (disc) respectively (Figures 14 ($k = 1c$) and 17 ($k = 1s$)). The corresponding phase responses of these grid points are shown in Figure 16.

Figures 19 and 20 present $k = 2$ results (subcase 4 ($k = 2c$)). The excitation consists of directly applied $k = 2c$ loads. The out-of-plane displacement magnitude of grid point 18 (Figure 19) compares well with that obtained in example 2 (Figure 7). Table 3 lists the out-of-plane displacement response of grid point 18 as obtained in examples 2 and 3. The marginal difference in response in example 3 is due to the Coriolis and centripetal acceleration effects at a rotational speed of 600 revolutions per second.

No $k = 2s$ loads are applied in this example (subcase 5).
D. Driver Decks and Bulk Data

NASTRAN EXECUTIVE CONTROL DECK ECHO

ID      NASA, EXAMPLE3
APP     DISP
SOL     8
$       ALTER PACKAGE AS IN EXAMPLE2
$       TIME 12 $ IBM 370/3031
DIAG    14, 21
CEHD

4.32
CASE C 0 0 7 - G - B - G - C - B - E 0 - B

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C O U N T

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$ T I T L E = FORCED VIBRATION ANALYSIS OF ROTATING DISC STRUCTURES
$ SUBTITLE = BLADED DISC EXAMPLE 8 (CTC REGION FREEBASE ACCN LOAD, KARM 1/0)

SPC = 30
FREQ = 1

OUTPUT

SET 1 = 0, 14, 18
SET 2 = 11
DLOAD = 1
DISP(SORT2, PHASE) = 1
STRESS(SORT2, PHASE) = 2

SUBCASE 1
LABEL = KINEX 0
DLOAD = 1
$ FREQ DEPENDENT LOADS

SUBCASE 2
LABEL = KINEX 1C
$ LATERAL BASE ACCN LOADS VIA PARAH OYITID

SUBCASE 3
LABEL = KINEX 1S
$ LATERAL BASE ACCN LOADS VIA PARAH OYITID

SUBCASE 4
LABEL = KINEX 2C
DLOAD = 1
$ FREQ DEPENDENT LOADS

SUBCASE 5
LABEL = KINEX 2S

OUTPUT(XYPLOT)

PLOTTER NASTPLT, MODEL D, 0
XPAPER = 8.0
YPAPER = 10.5
XAXIS = YES
YAXIS = YES
XGRID LINES = YES
YGRID LINES = YES
CURVELINESYMBOL = 1

XTITLE = FREQUENCY (HERTZ)
YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
YLOG = YES
TCURVE = 8(T3RM), 18(T3RH)

XYPLOT, XYPRINT DISP RESPONSE 1 /8(T3RM), 18(T3RH)
XYPLOT, XYPRINT DISP RESPONSE 2 /8(T3RM), 18(T3RH)
XYPLOT, XYPRINT DISP RESPONSE 3 /8(T3RM), 10(T3RH)
XYPLOT, XYPRINT DISP RESPONSE 4 /8(T3RM), 10(T3RH)

YTITLE = GRID POINT DISPLACEMENTS (PHASE, DEGREE)
YLOG = NO
TCURVE = 8(T3IP), 18(T3IP)

XYPLOT, XYPRINT DISP RESPONSE 2 /8(T3IP), 10(T3IP)

YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
YLOG = YES

4.33
CASE CONTROL DECK E'GHO

CARD COUNT
51  CURVE = 114311451141124112611181101
52  XYPLOT,XYPRT STRESS RESPONSE 1 /1113112511171117
53  11(10),21(12),124141
54  XYPLOT,XYPRT STRESS RESPONSE 2 /1141112511171117
55  1113112511171117
56  XYPLOT,XYPRT STRESS RESPONSE 3 /1131112511171117
57  1113112511171117
58  XYPLOT,XYPRT STRESS RESPONSE 4 /1131112511171117
59  1113112511171117
60  BEGIN BULK

INFORMATION MESSAGE 207. BULK DATA NOT SORTED.XSORT WILL RE-ORDER DECKS.
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ENDATA

4.36
A. Description

This example uses the forced vibration capability with cyclic symmetry. The user input/output pertains to physical representation. Periodic loads are specified as functions of time on the segments of the bladed disc corresponding to \( k = 2 \). For clarity of illustration only, sinusoidal loads of varying amplitudes at a frequency of 1814 Hz are specified. The Fourier decomposition of these sine functions obviously contains contributions from first harmonic alone (\( \ell = 1 \))-- the parameter LMAX accordingly has been set at 1 (\( \ell = 0, 1c, 1s \)).

B. Input

1. Parameters:

   In addition to general input parameters,
   
   CYCIO = +1 physical cyclic input/output data
   
   \( KMIN = 2 \) minimum circumferential harmonic index
   
   \( KMAX = 2 \) maximum circumferential harmonic index
   
   LMAX = 1 maximum harmonic in the Fourier decomposition of periodic, time-dependent loads,
   
   NSEGS = 12 number of rotationally cyclic sectors
   
   RPS = 600.0 revolutions per second
   
   GKAD = FREQRESP Specify the form in which the damping parameters are used.
   
   LGKAD = +1

2. Constraints:

   Same as general input constraints.

3. Loads:

   \[ P^n(t) = A(t) \cos \left( n - 1 \cdot \oplus \cdot \frac{2\pi}{12} \right) \]

   where \( n \) is the segment number,

   \( \oplus \) represents \( k = 2 \),

   \( \oplus \) represents the total number of segments in the bladed disc,

   \( A(t) = A \cdot \sin (2\pi \cdot 1814 \cdot t) \).

   \( P \) is specified on TLOADi bulk data cards.
C. Results

Results are presented in Table 4 and are in good agreement with those from example 3.
D. Driver Decks and Bulk Data

NASTRAN EXECUTIVE CONTROL DECK ECHO

ID: NASA, EXAMPLE4
APP: DISP
SOL: 3
S:
ALERT PACKAGE AS IN EXAMPLE2
S:
TIME: 4 $ IBM 370/3031
DIAG: 8,14,21
CEND
CASE CONTROL DECK ECHO

CARD COUNT
1
2 $ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES
3 $ SUBTITLE = BLADED DISC EXAMPLE 4 (CYC MODEL, TIME DEP. LOAD, PHYS I/O)
4 $ TSTEP = 1
5 SPG = 30
6 $ OUTPUT
7 SET 1 = 8, 16, 10
8 SET 2 = 11
9 DLOAD = 1
10 DISP (SORT2, REAL) = 1
11 STRESS (SORT2, REAL) = 2
12 SUBCASE 1
13 LABEL = SEGMENT 1
14 DLOAD = 1 $ TIME DEPENDENT LOADS
15 SUBCASE 2
16 LABEL = SEGMENT 2
17 DLOAD = 2 $ TIME DEPENDENT LOADS
18 SUBCASE 3
19 LABEL = SEGMENT 3
20 DLOAD = 3 $ TIME DEPENDENT LOADS
21 SUBCASE 4
22 LABEL = SEGMENT 4
23 DLOAD = 4 $ TIME DEPENDENT LOADS
24 SUBCASE 5
25 LABEL = SEGMENT 5
26 DLOAD = 5 $ TIME DEPENDENT LOADS
27 SUBCASE 6
28 LABEL = SEGMENT 6
29 DLOAD = 6 $ TIME DEPENDENT LOADS
30 SUBCASE 7
31 LABEL = SEGMENT 7
32 DLOAD = 7 $ TIME DEPENDENT LOADS
33 SUBCASE 8
34 LABEL = SEGMENT 8
35 DLOAD = 8 $ TIME DEPENDENT LOADS
36 SUBCASE 9
37 LABEL = SEGMENT 9
38 DLOAD = 9 $ TIME DEPENDENT LOADS
39 SUBCASE 10
40 LABEL = SEGMENT 10
41 DLOAD = 10 $ TIME DEPENDENT LOADS
42 SUBCASE 11
43 LABEL = SEGMENT 11
44 DLOAD = 11 $ TIME DEPENDENT LOADS
45 SUBCASE 12
46 LABEL = SEGMENT 12
47 DLOAD = 12 $ TIME DEPENDENT LOADS
48 BEGIN BULK

FORMATTED MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.

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**4.42**
SORTED BULK DATA ECHO

ENDATA
EXAMPLE 5

A. Description

This example uses the forced vibration capability with cyclic symmetry. The user input/output pertains to harmonic representation. Periodic loads are specified as functions of time for the circumferential harmonic index \( k = 2 \). For clarity of illustration only, sinusoidal loads are selected.

B. Input

1. Parameters:

In addition to general input parameters,

- \( \text{CYCIO} = -1 \) harmonic cyclic input/output data
- \( \text{KNIN} = 2 \) minimum circumferential harmonic index
- \( \text{KMAX} = 2 \) maximum circumferential harmonic index
- \( \text{LMAX} = 1 \) maximum harmonic in the Fourier decomposition of periodic, time-dependent loads.
- \( \text{NSEGS} = 12 \) number of rotationally cyclic sectors
- \( \text{RPS} = 600.0 \) revolutions per second
- \( \text{GKAO} = \text{FREQRES} \) Specify the form in which the damping parameters
- \( \text{LGKAD} = +1 \) are used.

2. Constraints:

Same as general input constraints.

3. Loads:

\[ p^2_{C}(t) = A \cdot \sin(2\pi \cdot 1814 \cdot t), \]

specified on TLOADi bulk data cards.

C. Results

Results are presented in Table 4 and agree well with those from example 3.
**D. Driver Decks and Bulk Data**

**NASTRAN EXECUTIVE CONTROL DECK ECHO**

<table>
<thead>
<tr>
<th>ID</th>
<th>NASA, EXAMPLE5</th>
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<tbody>
<tr>
<td>APP</td>
<td>DISP</td>
</tr>
<tr>
<td>SOL</td>
<td>8</td>
</tr>
<tr>
<td>$</td>
<td>ALTER PACKAGE AS IN EXAMPLE2</td>
</tr>
<tr>
<td>$</td>
<td>TIME 3 $ IBM 370/3031</td>
</tr>
<tr>
<td>DIAG</td>
<td>8, 14, 21</td>
</tr>
<tr>
<td>CEND</td>
<td></td>
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</tbody>
</table>
CASE CONTROL DECK. ECHO

CARD
COUNT
$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
$ SUBTITLE = BLADED DISC EXAMPLE 5 (CYC MODEL, TIME DEP. LOAD, PARM I/O)
$ SPC = 30
$ STEP = 1
$ OUTPUT
$ SET 1 = 0, 16, 18
$ SET 2 = 11
$ SLLOAD = 1
$ DISP (SCRT2, REAL) = 1
$ STRESS (SCRT2, REAL) = 2
$ SLCASE 1
$ LABEL = KINDEX 0
$ DLOAD = 99 $ NULL LOAD
$ SLCASE 2
$ LABEL = KINDEX 1C
$ DLOAD = 99 $ NULL LOAD
$ SLCASE 3
$ LABEL = KINDEX 1S
$ DLOAD = 99 $ NULL LOAD
$ SLCASE 4
$ LABEL = KINDEX 2C
$ DLOAD = 1 $ TIME DEPENDENT LOADS
$ SLCASE 5
$ LABEL = KINDEX 2S
$ DLOAD = 99 $ NULL LOAD
$ BEGIN BULK

"L~"~HATION "S.CA3T' 207, BULK DATA NOT SCORTED, XSCRT WILL RE-ORDER DECK.

4.46
### Sorted Bulk Data Echo

<p>| | | | | | | | | | | |</p>
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<td>7</td>
<td></td>
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<td>8</td>
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<td>14</td>
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<td>13</td>
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<td>6</td>
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<tr>
<td>GRI2A</td>
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<td>1</td>
<td>2</td>
<td></td>
<td>6</td>
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<td>3</td>
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<td>11</td>
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<td>1</td>
<td>8</td>
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<td>15</td>
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</table>

### Additional Parameters
- **PARAM** CYCIC: -1
- **PARAM** G: .02
- **PARAM** GKAD: 00000000
- **PARAM** KMAX: 2
- **PARAM** KMIN: 2
- **PARAM** LKAD: 1
- **PARAM** LMAX: 1
- **PARAM** NSEG: 12
- **PARAM** EPS: 600.0
- **PGLOB**: 2.25

**CORR**: 4.47
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<th>0.125</th>
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<td>1</td>
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</table>

**ENDATA**
TABLE 1: PRINCIPAL FEATURES DEMONSTRATED BY EXAMPLE PROBLEMS

<table>
<thead>
<tr>
<th>Example No.</th>
<th>Finite Element Model of</th>
<th>Applied loads specified as functions of</th>
<th>Base Acceleration</th>
<th>Rotational Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Frequency (sinusoidal)</td>
<td>Time (periodic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physical Components</td>
<td>Circum.Harmonic Components</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Physical Components</td>
<td>Circum.Harmonic Components</td>
</tr>
<tr>
<td>1</td>
<td>Complete Structure</td>
<td>Yes</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Cyclic Sector</td>
<td>Yes</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Cyclic Sector</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
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<td>4</td>
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<td>5</td>
<td>Cyclic Sector</td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Frequency (Mode No.), Hz.</td>
<td>Mode Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k = 0</td>
<td>k = 1</td>
<td>k = 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>214 (1)</td>
<td>208 (1)</td>
<td>242 (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>591 (2)</td>
<td>594 (2)</td>
<td>622 (2)</td>
<td></td>
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</tr>
<tr>
<td>1577 (3)</td>
<td>1633 (3)</td>
<td>1814 (3)</td>
<td></td>
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<tr>
<td>2468 (5)**</td>
<td>2460 (4)</td>
<td>2433 (4)</td>
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<td></td>
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</tbody>
</table>

* k is the circumferential harmonic index

** Mode No. 4 for k = 0 at 1994 Hz represents an in-plane shear mode not excited by the applied forces.
TABLE 3: EFFECT OF CORIOLIS AND CENTRIPETAL ACCELERATIONS ON THE DISPLACEMENT RESPONSE OF GRID POINT 18 AT 600 RPS.

<table>
<thead>
<tr>
<th>Frequency Hz</th>
<th>Example 2</th>
<th>Example 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Segment 1 (subcase 1)</td>
<td>$k = 2c$ (subcase 4)</td>
</tr>
<tr>
<td></td>
<td>Mag. (in)/Phase (deg)</td>
<td>Mag. (in)/Phase (deg)</td>
</tr>
<tr>
<td>1700</td>
<td>7.2655 E-5/349.4</td>
<td>7.6132 E-5/354.3</td>
</tr>
<tr>
<td>1750</td>
<td>1.3071 E-4/343.1</td>
<td>1.3844 E-4/347.3</td>
</tr>
<tr>
<td>1778</td>
<td>2.1580 E-4/332.7</td>
<td>2.3252 E-4/335.8</td>
</tr>
<tr>
<td>1796</td>
<td>3.4139 E-4/314.6</td>
<td>3.7252 E-4/315.2</td>
</tr>
<tr>
<td>1814</td>
<td>4.8374 E-4/269.9</td>
<td>4.9177 E-4/266.8</td>
</tr>
<tr>
<td>1832</td>
<td>3.4146 E-4/224.9</td>
<td>3.2655 E-4/225.5</td>
</tr>
<tr>
<td>1850</td>
<td>2.1451 E-4/206.6</td>
<td>2.0742 E-4/209.3</td>
</tr>
<tr>
<td>1880</td>
<td>1.2433 E-4/195.6</td>
<td>1.2214 E-4/199.2</td>
</tr>
<tr>
<td>1920</td>
<td>7.6125 E-5/190.4</td>
<td>7.5397 E-5/194.3</td>
</tr>
</tbody>
</table>
TABLE 4: COMPARISON OF RESPONSE AT 1814 Hz

<table>
<thead>
<tr>
<th>Grid Pt. Disp. or Elem. Stresses</th>
<th>Example 3 k = 2c (subcase 4) Mag. (in)/Phase(deg)</th>
<th>Example 4 Segment 1 (subcase 1) Mag. (in)/Phase(deg)</th>
<th>Example 5 k = 2c (subcase 4) Mag. (in)/Phase(deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 (T3RM), u_x</td>
<td>5.4297 E-4/82.6</td>
<td>5.4299 E-4/82.6</td>
<td>5.4299 E-4/82.6</td>
</tr>
<tr>
<td>18 (T3RM), u_z</td>
<td>4.9177 E-4/266.8</td>
<td>4.9180 E-4/266.8</td>
<td>4.9180 E-4/266.8</td>
</tr>
<tr>
<td>11 (3), σ_{xx,1}</td>
<td>1.4841 E 3/84.7</td>
<td>1.4842 E 3/84.7</td>
<td>1.4842 E3/84.7</td>
</tr>
<tr>
<td>11 (5), σ_{yy,1}</td>
<td>2.0891 E 2/83.4</td>
<td>2.0892 E 2/83.4</td>
<td>2.0892 E2/83.4</td>
</tr>
<tr>
<td>11 (7), τ_{xy,1}</td>
<td>1.0774 E 2/64.7</td>
<td>1.0775 E 2/64.7</td>
<td>1.0775 E2/64.7</td>
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<tr>
<td>11 (10), σ_{xx,2}</td>
<td>1.4677 E 3/263.3</td>
<td>1.4678 E 3/263.3</td>
<td>1.4678 E3/263.3</td>
</tr>
<tr>
<td>11 (12), σ_{yy,2}</td>
<td>2.2489 E 2/260.3</td>
<td>2.2491 E 2/260.4</td>
<td>2.2491 E2/260.4</td>
</tr>
<tr>
<td>11 (14), τ_{xy,2}</td>
<td>1.8510 E 2/253.0</td>
<td>1.8511 E 2/253.0</td>
<td>1.8512 E2/253.0</td>
</tr>
</tbody>
</table>

* Fibre distances 1 and 2.
Figure 1: NASTRAN Model of the 12-Bladed Disc
Figure 2: NASTRAN Cyclic Model of the 12-Bladed Disc
Figure 3: $k=2$ Modes of Bladed Disc
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES.
BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)
KINDEX 2C TYPE LOADS

Figure 4
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)
KINDEX 2C TYPE LOADS

Figure 5
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FREQ LOADS, PHYSICAL 1/0)
SEGMENT 1
SUBCASE 1

Figure 7
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2  (CYC MODEL, FIXED LOADS, PHYSICAL 1/0)
SEGMENT B
SUBCASE B

Figure 8
Figurc 4.51
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FREQ LOADS, PHYSICAL)
SEGMENT 10  SUBCASE 10

Figure 10
Figure 11: Base Acceleration Data in an Inertial Coordinate System
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL), FIXED-DISC ACCUR LDCD, HARM 1/6
INDEX 0  SUBCASE 1

Figure 12
FORCED VIBRATION ANALYSIS OF Rotating Cyclic Structures

Figure 14

BOLTED DISC EXAMPLE 3 IC C MODEL FREQUENCY INDEX 1

SUBCASE 2

4.65
Figure 17

FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES
BLADED DISC EXAMPLE 3 IEC MODEL, FREQUENCY RATED LOAD, HARM 1/0
KINDEK 15
SUBCASE 3

BIT3AH 18173AH 1
Figure 18

FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQ=BASE ACCEL LOAD, HARM 1/0)
KINDEX 15
SUBCASE 3
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CTC MODEL, FREQ+BASE ACCN LOAD, MARR 1'0)
KINDX 2C
SUBCASE 4

Figure 19
Figure 20

Forced vibration analysis of rotating cyclic structures
Bladed disc example 3 (250 model, freq.-base mean 1700, Rank 1/0
K-index 26

Figure 20

4.72
End of Document