FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES
IN HOATRAN

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Contract NAS3-22533

NASA Lewis Research Center
Cleveland, Ohio 44135

December 1981
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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. Morris as the Technical Monitor.
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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 bi-axial shrouded discs 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-sectored structure is modelled 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

\[ M^n \ddot{u}^n + \theta^n u^n + k^n u^n = p^n - \frac{M_2}{2} \dot{R}^n, \quad n = 1, 2, ..., N. \]  

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 \(-M_2\ddot{R}^n\) 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.,

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

structural

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.,

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

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),

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

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

$$
p^n = p^n + \sum_{\ell=1}^{M} [p^n \cos(\ell b + \pi \ell M) + p^n \sin(\ell b + \pi \ell M)] + (-1)^{M/2} p^n, \quad (5)
$$

where $b = 2\pi/N$, $\ell_L = (M-1)/2$ for odd $M$, $\ell_L = (M-2)/2$ for even $M$. The last term in equation (5) exists only when $M$ is even. The coefficients $p^{n\ell}$ ($\ell = 0; \ell \leq \ell_L; M/2$) in equation (5) are independent of time, and are defined by the relations

$$
p^n = \sum_{m=1}^{M} p^{n\ell}, \quad (\ell = 0) \quad \text{part of (6)}
$$

1.3
Each of the coefficient vectors $p_n^m$ on the left hand sides of equations (6) can further be expanded in a circumferential (truncated) Fourier series

$$p_n^m = p_0^m + \sum_{k=1}^{k_L} \left[ p_{kC}^m \cos(n-1ka) + p_{kS}^m \sin(n-1ka) \right] + (-1)^{n-1} p^{N/2}_n$$

where $n = 1, 2, \ldots, N$

$k^m_C = 0$; $k^m_S, k = 1, 2, \ldots, k_L; M/2$

$a = 2\pi/N$

$k_L = (N-1)/2$ 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 $p_{kC}^m$ ("$k^m_C = 0$; $k^m_S, k = 1, 2, \ldots, k_L; N/2$) in equation (7) do not vary from sector to sector, and are defined by

$$p_0^m = \frac{1}{N} \sum_{n=1}^{N} p_n^m$$

(k = 0)

$$p_{kC}^m = \frac{2}{N} \sum_{n=1}^{N} p_n^m \cos(n-1ka)$$

(k = 1, 2, \ldots, $k_L$)

$$p_{kS}^m = \frac{2}{N} \sum_{n=1}^{N} p_n^m \sin(n-1ka), \text{ and}$$

$$p^{N/2}_n = \frac{1}{N} \sum_{n=1}^{N} (-1)^{n-1} p_n^m \quad (N \text{ even only}) \quad (k = N/2) \, .$$
The terms $p_k^m$ ($m = 0; k_c, k_s, k = 1, 2, \ldots, L; M/2$ and $k^m = 0; k_c, k_s, k = 1, 2, \ldots, L; N/2$) are the transformed frequency-dependent circumferential harmonic components of the directly applied loads $p_m^n$ ($m = 1, 2, \ldots, M$ and $n = 1, 2, \ldots, N$).

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

Such loads can be represented as

$$p_k^m = p_k^m + \sum_{m=1}^L \left[ p_{k_c}^m \cos(m-1\pi b) + p_{k_s}^m \sin(m-1\pi b) \right] + (-1)^{m-1} p_k^{m/2}, \quad (10)$$

where $m = 1, 2, \ldots, M$ represent the time instances at which harmonic components $m^m = 0; k_c, k_s, k = 1, 2, \ldots, L; N/2$ of directly applied loads are specified.

The coefficients $p_k^m$ 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

$$p_k^n = p_0^n + \sum_{k=1}^L \left[ p_{k_c}^n \cos(n-1\pi a) + p_{k_s}^n \sin(n-1\pi a) \right] + (-1)^{n-1} p_1^{n/2}, \quad (11)$$

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

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

These loads are the transformed frequency-dependent circumferential harmonic components $p_k^n$ ($m = 0; k_c, k_s, k = 1, 2, \ldots, L; N/2$) with $n^m = 1, 2, \ldots, F$ 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 $u''_k$ where ""k" = 0, and ""z" represents the specified excitation frequencies.

2. Lateral components contribute to $u''_k$ where ""k" = 1c and 1s, and ""z" represents the effective excitation frequencies which are shifted from the specified frequencies by $2\pi$, 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 $-M_2^0 R$ 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:

$$
\begin{align*}
\bar{u}_2^0 &= \bar{u}_1^0 \\
\bar{u}_2^{kc} &= \bar{u}_1^{kc} \cos(ka) + \bar{u}_1^{ks} \sin(ka) \\
\bar{u}_2^{ks} &= -\bar{u}_1^{kc} \sin(ka) + \bar{u}_1^{ks} \cos(ka)
\end{align*}
\right\} \quad (k = 1, 2, ..., k_L) \\
\text{and} \quad \bar{u}_2^{N/2} &= -\bar{u}_1^{N/2} \quad (k = N/2) 
\right\} 
$$

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

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

$\bar{u}_2^{kc}$ 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 \( \tilde{u}^K \) in the equations of motion, (1), results in the transformed equations of motion (Reference 3)

\[
\begin{align*}
\mathbf{K}^K u^K + \mathbf{B}^K u^K + \mathbf{R}^K u^K &= \mathbf{P}^K ,
\end{align*}
\]

(14)

where

\[
\begin{align*}
\mathbf{K}^K &= \mathbf{G}_{ck}^T \mathbf{M}^n \mathbf{G}_{ck} + \mathbf{G}_{sk}^T \mathbf{M}^n \mathbf{G}_{sk} , \\
\mathbf{B}^K &= \mathbf{G}_{ck}^T \mathbf{B}^n \mathbf{G}_{ck} + \mathbf{G}_{sk}^T \mathbf{B}^n \mathbf{G}_{sk} , \\
\mathbf{R}^K &= \mathbf{G}_{ck}^T \mathbf{K}^n \mathbf{G}_{ck} + \mathbf{G}_{sk}^T \mathbf{K}^n \mathbf{G}_{sk} , \\
\mathbf{P}^K &= \mathbf{G}_{ck} \mathbf{P}^K + \mathbf{G}_{sk} \mathbf{P}^K .
\end{align*}
\]

(15)

As discussed in subsection 1 of Section 1.2.2, \( \mathbf{P}^K \) and \( \mathbf{R}^K \) are the transformed frequency-dependent circumferential harmonic components of the directly applied and base acceleration loads.

At any excitation frequency \( \omega^* \), let

\[
\begin{align*}
\mathbf{P}^K &= \mathbf{P}^K e^{i \omega t} \quad \text{and accordingly,} \\
\mathbf{u}^K &= \mathbf{u}^K e^{i \omega t} ,
\end{align*}
\]

(16)

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

\[
\begin{align*}
[-\omega^* 2 \mathbf{K}^K + i \omega^* \mathbf{B}^K + \mathbf{R}^K] \mathbf{u}^K &= \mathbf{P}^K .
\end{align*}
\]

(17)

The excitation frequency \( \omega^* \) is given by

\[
\begin{align*}
\omega^* &= \omega \quad \text{for all directly applied and axial true acceleration loads, and} \\
&= \omega \Omega \quad \text{for lateral base acceleration loads.}
\end{align*}
\]

(18)

Equation (17) is solved for \( \mathbf{u}^K \) 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 $u_k^n$ in various segments with $\lambda^n = 0; \kappa_c, \kappa_s, \ell = 1, 2, ..., \ell_{\text{max}}$. The circumferential harmonic $k$ is varied from $k_{\text{min}}$ to $k_{\text{max}}$. The user specifies $\ell_{\text{max}}$, $k_{\text{min}}$ and $k_{\text{max}}$. For loads specified as functions of frequency, equation (11) is used to obtain the displacements $u_k^n$ in various segments with $\gamma^n$ representing the excitation frequencies. The circumferential harmonic is varied from user specified $k_{\text{min}}$ to $k_{\text{max}}$.

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


Finite Element Model of one Cyclic Sector, Rotational Speed, Constraints, Loads

Differential Stiffness Matrix

Generation of Stiffness, Mass and Damping Matrices

Application of Constraints and Partitioning to Stiffness, Mass and Damping Matrices

Frequency-dependent

Type of Applied Loads

General, periodic in time

Circumf. Harmonic Dependent

Type of Input/Output

Segment Dependent

Circumf. Harmonic Dependent

Type of Input/Output

Segment Dependent

Fourier decomposition Phase 1 (time), Equation (10)

Fourier decomposition Phase 2 (circumferential), Equation (11)

Application of Constraints and Partitioning to Load Matrices

FIGURE 1: Overall Flowchart of Forced Vibration Analysis of Rotating Cyclic Structures
Selection of Circumf. Harmonic Index \( k \)
\[ k_{\text{min}} \leq k \leq k_{\text{max}} \]

Application of inter-segment compatibility constraints to stiffness, mass, damping and load matrices

Solution of independent harmonic displacements

Increment \( k \) by 1.
\[ k > k_{\text{max}}? \]

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 φ^m or P^m, (m = 1, 2, ..., M), as discussed in Section 1.2.2 of the Theoretical Manual.
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 \( \text{PARAMs} \) \( \text{BXTID}, \text{BXPTID}, \text{SYTID}, \text{BYPTID}, \text{BZTID} \) and \( \text{SZPTID} \).

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 9.3-8, Section 9.3.3 of the NASTRAN Level 17.7 Theoretical Manual. The \( \text{PARAMeters} \) \( \text{GKAD} \) and \( \text{LGKAD} \) have been defined for this purpose.

Section 2.4.4 of this manual describes all the \( \text{PARAMeters} \) 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 • KMAX, if 0 < KMAX ≤ (NSEGS-1)/2, NSEGS odd,
= 1 + 2 • KMAX, if 0 < KMAX ≤ (NSEGS-2)/2 NSEGS even, and
= 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' = KMAX)

In the event that NSEGS is even and KMAX = NSEGS/2, Subcase FKMAX will represent 'k' = KMAX as KMAX 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. RF 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 FREU, FREU1 OR FREUZ 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 USLD.
7. A SEPARATE GROUP OF SUBCASES MUST BE DEFINED FOR EACH SYMMETRIC SEMENT.
8. ULCARD 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 ULCARD.
   FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO A ULCARD 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. SUPORT BULK DATA CARDS ARE NOT ALLOWED.
2. EPOINT BULK DATA CARDS ARE NOT ALLOWED.
3. SPPOINT 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, NG, OR 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 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. CYGSEQ - 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. CTYPE - FIXED - THE BCU VALUE OF THIS PARAMETER
   DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE
   OF THIS PARAMETER HAS BEEN SET TO -NO- 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. DXTID - 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
BYPTID  TABLES REFERED TO BY BXI1O, BXI10 AND BXI10
BYPT10  DEFINE MAGNITUDE(LT-2) AND THE TABLES REFERED TO
BY BX110, BYPT10 AND BYPT10 DEFINE PHASE(DEGREE).
THE DEFAULT VALUES ARE =1 WHICH MEANS THAT THE
RESPECTIVE TERMS ARE IGNORED.

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

L. GUPN1T  - 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. WIMASS  - OPTIONAL - THE TERMS OF THE STRUCTURAL MASS
MATRIX ARE MULTIPLIED BY THE REAL VALUE OF THIS
PARAMETER WHEN THEY ARE GENERATED IN ENQ. THE
DEFAULT IS 1.0.

N. GUPM1SS  - FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.

G. GRAD  - OPTIONAL - THE BCD VALUE OF THIS PARAMETER IS
USED TO TELL THE GRAD MODULE THE DESIRED FORM OF
MATRICES KO, BU0 AND BU0. THE BCD VALUE CAN BE
FREKREP OR TRANKESP. THE DEFAULT IS TRANKESP.
SEE SECTION 9.3.3 (DIRECT DYNAMIC MATRIX
ASSEMBLY) PAGES 9.3-7 AND 9.3-8 OF THE
NASTRAN THEORETICAL MANUAL.

P. LGRAH  - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
IS USED IN CONJUNCTION WITH PARAMETER GRAD. IF
GRAD=FREKREP THEN SET LGRAH=1. IF GRAD=TRANKESP
THEN SET LGRAH=-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=TRANKESP. 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=TRANKESP. 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:
   KINDX = KMIN TO KMAX.
NASTRAN EXECUTIVE CONTROL DECK ECH

FILE  UXVF=APPEND/PDI=APPEND/PD=APPEND $  
$ PERFORM INITIAL ERROR CHECKS ON NSEGS AND KMAX.  
CEED  ERRGC,1,NSEGS $ IF USER HAS NOT SPECIFIED NSEGS.  
CEED  ERRGC,1,KMAX $ IF USER HAS NOT SPECIFIED KMAX.  
PARAM  //C,N,EQ /V,N,CYCL2ERR /V,Y,LIC2U=O /C,N,0 $  
CEED  ERRGC,1,CYCL2ERR $ IF USER HAS NOT SPECIFIED CYCL2.  
PARAM  //C,N,DIU /V,N,NSEG2 /V,Y,NSEGS /C,N,2 $ NSEG2 = NSEGS/2  
PARAM  //C,N,SUB /V,N,KMAKERR /V,N,NSEG2 /V,Y,KMAX $  
CEED  ERRGC,1,KMAKERR > IF KMAX GT. NSEGS/2  
$ SET DEFAULTS FOR PARAMETERS.  
PARAM  //C,N,NOP /V,Y,NCPEKT=A1 /V,Y,LGKAD=-1 $  
$ CALCULATE OMEGA, 2*OMEGA AND OMEGA2 FROM MPS. SET DEFAULT MPS.  
PARAM  //C,N,MPY /V,N,OMEGA /V,Y,RPS=0.0 /C,N,0.28318 $  
PARAM  //C,N,MPY /V,N,OMEGA2 /C,N,2.0 /V,N,OMEGA $  
PARAM  //C,N,MPY /V,N,OMEGASQ /V,N,OMEGA /V,N,OMEGA $  
$ GENERATE NUKPS FLAG IF MPS IS ZERO.  
PARAM  //C,N,NEW //C,N,RPS /C,N,0 //V,N,NORPS $  
$ MAKE SURE COUPLED PASS HAS NOT BEEN REQUESTED.  
PARAM  //C,N,NOT /V,N,NUJUMP /V,Y,CCUPMASS=-1 $  
CEED  ERRGC,2,NJUMP $  
ALTLN 21,21  ADD SLT TO OUTPUT FOR TRLG.  
GP3  GEMX3,EUXIN1,EUM2 / SLT,GPTT / V,N,NOGRAV $  
CEM3  SLT,GPTT $  
ALTLN 23  
$ SINCE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NOW SO THAT  
$ MERE ERROR CHECKS CAN BE MADE BEFORE ELEMENT GENERATION.  
$ ADD EN Needed FOR PSF RECOVERY IN RS2.  
PARAM  //C,N,MPY /V,N,NSKIP /C,N,0 /C,N,0 $  
GP4  CASELC,GEMX3,EUXIN1,EPOT,BCDP1,CSM/CG,YS,USETASET/V,N,LSET/  
S,N,KEPLA/S,N,NSET1/S,N,NCL/S,N,DDA/C,Y,ASELUT/S,Y,ANTLSPC $  
PURGE  GM,CN,MPEL/1,G,CCD/CMTKNKPS,PSF,OPC/1,SINGLE $  
CEM3  GM,CSM,CG,CCD,PSF,OPC,USET,YS $  
$ SUPPORT BULK DATA IS NOT ALLOWED.  
PARAM  //C,N,NOT /V,N,REACTA $ V,N,REACT $  
CEED  ERRGC,1,REACTA $  
$ EXECUTE GP4 NOW SO CHECKS CAN BE MADE. ADD TRL TO OUTPUT DATA BLOCKS.  
DPL  DYNAMICS /GUTL,SUL,USET / GUDL,SUL,USET +TFPGDL,DTL,PSOL,FRL,  
TRL,PEUL /V,N,LUSE11/V,N,LUSE12 /V,N,NGF1L/S,N,NUDLT/  
S,N,HPS,/ Sin,S,N,UFRL/V,N,NGNFTT/S,N,NUTRL/V,N,NGCPL/C,N,/  
S,N,NOUE $  
$ MUST HAVE EITHER FREQ OR TSTEP BULK DATA.  
PARAM  //C,N,AND /V,N,FREQK /V,N,FREQL /V,N,NUTRL $  
CEED  ERRGC,5,FILK $ NO FREQ OR TSTEP BULK DATA.  
$ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL  
PARAM  //C,N,FREQL /C,N,FREQL /C,N,3D /V,N,TIMES $  
PARAM  //C,N,MPY /V,N,FREQL /V,N,FREQL /V,N,TIMES $  

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NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //CIN,NUZ /V,N,TERML /V,N,FREQTIME $
PARAM //CIN,LE /V,N,NPREWED /V,N,FREQUENCY /V,N,N0 $
PARAM //CIN,LE /V,N,NUITIME /V,N,TIOSET /CIN,N0 $
CEND ERRORCONTROL* BOTH FREQ AND TSTEP IN CASE CONTROL DECK.
$ EPOINT BULK DATA NOT ALLOWED
PARAM //CIN,NUZ /V,N,NEXTRAPTS /V,N,NOUE $
CEND ERRORCTRL*EXTRAPTS $
$ GENERATE DATA FOR CYCT2 MODULE.
GPUCY  GSON4,EUQYN,USETTY /CYCDU /V,N,CTYPE=971 /SCH,NGGU $
CEND ERRORCTRL,NOEC $
CHPNT CYCDU $
ALTER 32 $
$ PRE-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED
PARAM //CIN,UR /V,N,NODMI /V,N,NOMGG /V,N,NORKS $
PURGL 0,166,MIGG /NODMI $
PURGL 126,126 BASEXG /NOMGG $
ALTER 35 $
$ CLONE DATA BLOCKS FRX, BIGG, MIGG, M2GG AND BASEXG.
$ GENERATE PARAMETERS FMKMAK AND NBASEX.
LUXMOD1 CASELC,OPDTI,CMST,DIRT,FRX,REGG / /FRX,BIGG,MIGG, M2GG,RAVLAV,PDZRGG /V,N,NOMGG /V,Y,LICIC /V,Y,NSEG$Y:
V,Y,KMAX/S,N,PKMAX/V,Y,BXTID=-1/V,Y,BXTID=-1$Y:
V,Y,SYTID=-1/V,Y,SYTID=-1$Y:
V,Y,ZVID=-1/V,Y,ZVID=-1$Y:
V,Y,FVID=-1/V,Y,FVID=-1$Y:
V,Y,OMEGA $
PARAM  FRX //CIN,PRESENCE ///V,N,NOFRLX $
CEND LBLFRX,NOFRLX $
EQUIV FRX,FRX $
LABEL LBLFRX $
CHPNT FRX,BIGG,MIGG,M2GG,BASEXG $
ALTER 42 $
PARAM //CIN,ADDU /V,N,NODMM /V,N,NODMI /CIN,N0 $ RESET NUBUG.
ALTER 52 $
$ PREPURGE BIGG AND KGG.
CEND LBL114,NODMI $
PARAM //CIN,COMPLEX /V,N,OMEGA2 /CIN,N0 /V,N,COMPLX $
PARAM //CIN,SPU /V,N,MCHEGASQ /CIN,N0 /V,N,OMEGASQ $
PARAM //CIN,COMPLEX /V,N,OMEGA2 /CIN,N0 /V,N,OMEGASQ $
PLACE BGG,BIGG / BGGI /CIN,(1,0,0,0) /V,N,COMPLX $
EQUIV BGG,BIGG $
PLACE KGG,MIGG /KGGL /CIN,(1,0,0,0) /V,N,COMPLX $EQUV KGG,KGG $
CHPNT BGG,KGG $
LABEL LBL114 $
ALTER 53,55 $ G14 HAS BEEN MOVED-UP.
ALTER 83,68 $ BPD HAS BEEN MOVED-UP.
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LUKAD FOR FREW OR TRAN.
PARAM //CIN,ANDV/V,N,LUKEA/V,N,NOUE/V,N,NOK2PP $
CEND LUKAD1,LUKAD1 BRANCH IN NOT FREQESP.
ALTER 114 $ SEE ALTER 114 COMMENT.
JUMP LUKAD2 $
NASTRAN EXECUTIVE CONTROL DECK ECHO

LABEL  LGKAD1  $
EQUIV  H2PP,M2DD/NGA/K2PP,K2DD/NGA/K2PP,K2DD/NGA/MAA,MDD/HDEA/
        KAA,KDD/KDEKA  &
CHKPNT  K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDD,MDD  $
LABEL  LGKAD2  $
ALTER  117,117  &  ADD PARAMETERS GKAD, H3 AND H6 TO GKAD.
       GCD,K2DD,H2DD,B2DD/C,Y;GKAD=TRANKEEP/C,N,DIRECT/
       C,Y;G=0.0/C,Y;N3=0.0/C,Y;N4=0.0/V,N;NUK2PP/V,N;NUM2PP/
       V,N;NUB2PP/V,N;MPCF1/V,N;SINGLE/V,N;OHIT/V,N;NGUE/V,N;NUK4GG/
       V,N;NUK6GO/V,N;KDEK2/C,N,-1  $
ALTER  118  &  SEE ALTER 114 COMMENT.
ALTDU  LGKAD3,LGKAD  &  BRANCH IF NLT FREQESP.
ALTLK  119  &  SEE ALTER 114 COMMENT.
JUMP  LGKAD4  $
LABEL  LGKAD3  $
EQUIV  B2DD,BDU/NUGFO/T/K2DD,MDD/NOSIMP/K2DD,KDD/KDEK2  $
LABEL  LGKAD4  $
ALTLK  120,123  &  NEW SOLUTION LOGIC
        $  GENERATE TIME-DEPENDENT LOADS IF TSTEP WAS REQUESTED IN CASE CONTROL.
        CCNG  LEL1K1,NOTIME  $
        $  ALTDU  THRU ALL SUBCASES FOR TIME-DEPENDENT LOADS.
PARAM  //C,N,MPY /V,N,REPE2IT /C,N,1 /C,N,-1  $
JUMP  TRLGLOOP  $
LABEL  TRLGLOOP  $
CASE  CASLC;C/EASEY/Y/C,N,TRAN/S,N,REPRE2IT/S,N,NOUCLP1  $
CHKPNT  CASL2Y  $
PARAM  //C,N,MPY /V,N,NCOL /C,N,0 /C,N,1  $
TRLG  CASL2Y,USETC;ULT,SLT,UGPO/T,SIL,CTTM,TRL,DLT,GMJ,QUD,EST,MMG/
       ++PLT1,PDL1,TCL/V,N;NCGLT/S,N;POPEGU/V,N;NCGL  $
SUR1  TRL,PDT1,-------- / /P01/V,N;APPLG/C,N,DYNA2ICS  $
SUR1  TRL,P01,-------- / /PD /V,N;APPLG/C,N,DYNA2ICS  $
CCNG  TRLGUNN,REPEAT  $
KEPI  TRLGLOOP,10C  $
JUMP  LRRK3  $
LABEL  TRLGUNN  $
CHKPNT  PLT,PO,TUG  $
EQUIV  FC,POT,PLEPDD  $
CHKPNT  PGT  $
GMLMOD2  TCL,-------- / /FLZ,FLZ,REKDE1,REKDE2,-------- / /V,Y;NSEC5/V,Y,LC10/S,Y;LMAX=-1/V,N;FMAX/
       S,N;FLMAV/S,N;NTSTEPS/S,N;NGC1/S,N;NGC2  $
EQUIV  FRLZ,FLZ  // /PUL2,FCL  $
CHKPNT  FRL,FCL,REKDE1,REKDE2  $
JUMP  LRLFLR2  $
LABEL  LULTRL1  $
        $  GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC.

2.11
EQUIV PXFL2,PXFL $  
CHECK PXFL $  
JUMP LBLTRL3 $  
LABEL LBLTRL2 $  
$ CYCIC $61$  
MPYAD PPMKEORDER1 ,/PMPRZ2/CNN0 $  
CYCT1 PPMKZ2/PPMTZ2,GCYCF3/VN,NCTYPE/CNN,FORE/VNN,NTSTEPS/VY,LMAX/  
VY,NSEGS/SNN,NGGC $  
CGND ERRGPL,NGGC $  
CHECK PXFLZ2 $  
EQUIV PXMTZ2,PMKZ2/NUR02 $  
CGND LBLKZ2/NUR02 $  
MPYAD PMKZ2,KEORDER2 ,/PPMTZ2/CNN0 $  
LABEL LBLKZ2 $  
CYCT1 PPMKZ2/PPMTZ2,GCYCF4/VN,NCTYPE/CNN,FORE/VY,LMAX/  
VY,NSEGS/SNN,NGGC $  
CGND ERRGPL,NGGC $  
EQUIV PXMTZ2,PXFL $  
CHECK PXFL $  
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.  
CONV PXFL1,PXFL2 $ CONVERT REAL PXFL1 TO COMPLEX P'F.  
AFC PXFL1,PXFL2 /PXFL/CNN,(0.5,1.0) /CNN,(0.5,-1.0) $  
$ LIFINI NLLOA F GCYCF2.  
PARAM //C,N,AUD/VNN,VLLOAD/VNN,FLMAX/CN,0 $ NLCAU = FLMAX  
LABEL LBLPDONE $  
PARAM //C,N,AUD /VY,KINDEX /VY,KMIN=0/CN,0 $ INITIALIZE KINDEX.  
$ INITIALIZE UXVF IF KMIN IS NOT ZERO.  
$  
PARAM //C,N,AUD /VNN,KMINL /VY,KMINL /CNN,1 $  
CGND NUKMINNL,KMINL $  
PARAM //C,N,AUD /VNN,KMINV /CNN,0 /CNN,0 $  
JUMP KMINLUMP $  
LABEL KMINLUMP $  
CYCT2 CYCUL,...,PKF2,...,C,N,FORE/VN,NSEGS/  
VNN,KMINV/VNN,GCYCF3/VNN,FLMAX/SNN,NGGC $  
CGND ERRGPL,NGGC $  
AGC PKF2 ,/UXVF2 /COS,(0.00,0.0) $  
CYCT2 CYCUL,...,UVF2,...,UXVF,...,C,N,BACK/VY,NSEGS/  
VNN,KMINV/VNN,GCYCF3/VNN,FLMAX/SNN,NGGC $  
CGND ERRGPL,NGGC $  
PARAM //C,N,AUD /VNN,KMINV /CNN,0,KMINV /CNN,1 $  
REPT KMINLUPKMIN $  
LABEL NUKMINL $  
$  
JUMP TCPPCYC $  
LABEL TCPPCYC $ LOOP CN KINDEX
CCND  NDPR1,NDPR1 $  
PAXPAM //C.N,0 /C.N,KINDEX $  
LABEL  NDPR1 $  
CYCT2  CYCDD,KDD,MDU... /KKK,MKKF... /C.N,FORC/V,Y,NSEGS /V,N,KINDEX/V,N,CYCSEQ=-1/V,N,NLOAD/S,N,NOGCC $  
COND  ERRQRL1,NOGCC $  
CHMNT  KKK,MKKF $  
PXAM  //C.N,SYST //C.N,59 /C.N,2 $ METHOD 3T IN CYCT2 PRODUCES $ UNDERFLOWS FOR PXF. USE METHOD 2.  
CYCT2  CYCDD,BDU,...PXF.,.../KKK,MKKF... /C.N,FORC/V,Y,NSEGS/ V,N,KINDEX/V,N,CYCSEQ/V,N,NLOAD/S,N,NOGCC $  
PXAM  //C.N,SYST //C.N,59 /C.N,0 $ RESET MPPXAD METHOD CONTROL.  
CCND  ERRQRL1,NOGCC $  
CHMNT  BKKF,PKF $  
$ SOLUTION  
FRKU2  KKKF,BKKF,MKKF...PXF,FOL / UKF /C.N,0.0/C.N,0.0/C.N,-1.0 $  
CHMNT  UKF $  
CYCT2  CYCDD,...,KVF,... /...UKF,... /C.N,BACK/V,Y,NSEGS/V,N,KINDEX/ V,N,CYCSEQ/V,N,NLOAD/S,N,NOGCC $  
CCND  ERRQRL1,NOGCC $  
CHMNT  UKF $  
PXAM  //C.N,ADD /V,N,KINDEX/V,N,KINDEX/C,N,1 $ KINDEX = KINDEX & 1  
PXAM  //C.N,ADD /V,N,KINDEX/V,N,KINDEX/C,N,1 $ KINDEX = KINDEX & 1  
COND  LCY2,DONE $ IF KINDEX GT KMAX THEN EXIT  
REPT  TLPCY2,1CC $  
JUMP  ERRQ3 $  
LABEL  LCY2 $  
EQUIV  UKF,UDVF / CYCLO $  
CHMNT  UDFV $  
COND  LCY3,LCY3 $ IF CYCLO GE 0 THEN TRANSFORM TO PHYSICAL.  
CYCT1  UDFV / UDFV,LCY3 / V,N,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/ V,N,NLOAD $  
CHMNT  UDFV $  
LABEL  LCY3 $  
COND  LTR4,LNTIME $  
EQUIV  PXF,PXF2 / CYCIC $  
COND  LCY4,LCY4 $ IF CYCLO GE 0 THEN TRANSFORM TO PHYSICAL.  
CYCT1  PXF / PXF,PXF2,...,LCY3 / V,N,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/ V,N,NLOAD $  
LABEL  LCY4 $  
$ IF LOADS ARE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PXF.  
S312  USEU,PXF2,...,DUM / DUM,... /PPFZ... /C,N,1 /C,N,DYNAMICS $  
S322  USEU,JUS,...,SUS,...,PPFZ /...PCDFU,PSF2,PLDUM $  
EQUIV  PSFZ,PSF / PSFZ,PSF $  
CHMNT  PSFZ,PSF $  
LABEL  LTR4 $  
ALT 124,126 $ USE FOL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  
VOR  - CASEX,E=DYN,USEU,UDVF,FOL,XYCDD,... / OUDVC1 /C.N,FRESEQ/C,N,  
DRECT/S,N,AUXLR2/S,N,S,N,NGP/C,N,0 $  
ALT 164,140 $ USE FOL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.
NASTRAN EXECUTIVE CONTROL DECK ECHO

SUR2 CASEXX, CSTM, MPT, JIT, EDYNSLID, BGPDP, PLL, UPC, UPVC, EST, XCOB,
PPF/UPPCL, QCPC, OUPVC, VSLC, MFC, MFC, PUPVC/C, N, FREORSP/
S, N, NOSUR12 $.

ALTER 160 $ ADD LABEL FOR ERROR3 $.
LABEL ERROR3 $.
ALTER 103, 166 $ REMOVE ERROR1 AND ERROR2 $.
ALTER 168 $ FORCED VIBRATION ERRORS.
LABEL ERRORC1 $ CHECK NSCGS, KMAX AND OTHER CYCLIC DATA $.
PRTPAR//CN, -7 /CN, CYCSTATICS $.
LABEL ERRORC2 $ COUPLED MASS NOT ALLOWED $.
PRTPAR//CN, 0 /CN, COUPMASS $.
JUMP FINIS $.
LABEL ERRORC3 $ SUPORT BULK DATA NOT ALLOWED $.
PRTPAR//CN, 0 /CN, CYCSTATICS $.
LABEL ERRORC4 $ EPOINT BULK DATA NOT ALLOWED $.
PRTPAR//CN, 0 /CN, COUPME $.
JUMP FINIS $.
LABEL ERRORC5 $ NEITHER FREU OR TSTEP WERE IN BULK DATA DECK $.
PRTPAR//CN, 0 /CN, NOUTRL $.
PRTPAR//CN, 0 /CN, NOUTRL $.
JUMP FINIS $.
LABEL ERRORC6 $ BOTH FREU AND TSTEP WERE SELECTED IN CASE CONTROL $.
PRTPAR//CN, 0 /CN, NOFREU $.
PRTPAR//CN, 0 /CN, NOTIME $.
JUMP FINIS $.
LNLALTER

2.15
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 NOLIST NODECK NOREF NOOSCAR

1 BEGIN NO. B FORCED VIBRATIONS OF ROTATING CYCLIC STRUCTURES - SERIES R

2 PKLCHK ALL $

3 FILE KGXX=TAPE/KG=G=TAPE/GOOD=SAVE/GMD=SAVE/MDD=SAVE/BDU=SAVE $

4 FILE UXVF=APPEND/PDT=APPEND/PD=APPEND $

5 CUND ERRORC1,NSEGS $ IF USER HAS NOT SPECIFIED NSEGS.

6 CUND ERRORC1,KMAX $ IF USER HAS NOT SPECIFIED KMAX.

7 PARAM //C,N,E2 /V,N,CYCICERR /V,Y,CYCI0=0 /C,N,0 $

8 CUND ERRORC1,CYCI0ERR $ IF USER HAS NOT SPECIFIED CYCIO.

9 PARAM //C,N,DIV /V,N,NSEG2 /V,Y,NSEGS /C,N,2 $ NSEG2 = NSEGS/2

10 PARAM //C,N,SUB /V,N,CMERROR /V,N,NSEG2 /V,Y,KMAX $

11 CUND ERRORC1,CMERROR $ IF KMAX <T NSEGS/2

12 PARAM //C,N,NUP /V,Y,NOKPRT=41 /V,Y,LGDAD=-L $

13 PARAMR //C,N,MPY /V,N,CMega /V,Y,RPS=C.0 /C,N,6.283185 $

14 PARAMR //C,N,MPY /V,N,CMega2 /C,N,A,2.0 /V,N,CMega $

15 PARAMR //C,N,MPY /V,N,CMegaSUN /V,N,CMega /V,N,CMegaC $

16 PARAMR //C,N,EQ //V,Y,RPS /C,N,0.0 /////V,N,NURPS $ $

17 PARAM //C,N,NUT /V,N,NOLUMF /V,Y,COUPLM=1 $ $

18 CUND ERRORC2,NOLUM $ $

19 PARAM //MPY#/CARDNU/O/C $

20 GPL GEOM1,ECM2,/GTEQXIN,GPDT,ELSTP,BGPDT,SIL/S,N,LUSET/ S,N, NUGPDT $ $

21 PLTTRAN BGPDT,SIL/HUGPDP,SIP/LUSET/S,N,LUSEP $ $

22 PURGE USET,GM,GO,KAA,RAA,MAA,KAAA,KFS,PSF,QPC,EST,ECT,PLSETX,PLTPAR, GPSETS,ELSETS/NUGPDT $ $

2.16
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

23 COND LBL5,NOGPD $
24 GP2 GEOM2,EQEXIN/ECT $
25 PARAM PCOD///PRES///NOGPD $
26 PURGE PLTSETX,PLTPAR,GPSETS,ELSETS/NOGPD $
27 COND PI,NOGPD $
28 PLTSET PLUCB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/S,N,SIL/NSIL/S,N/JUMPPLOT=-1 $
29 PRTMSG PLTSETX// $
30 PARAM //MPY//PLTFLG/LI $
31 PARAM //MPY//PFILE/OO $
32 COND PI,JUMPPLOT $
33 PLJT PLTPAR,GPSETS,ELSETS,CASECC,NOGPD,EQEXIN,SIL,ECT,PLTWX/NSIL/LUSET/S,N,JUMPPLOT/S,N,PLTFLG/S,N,PFILE $
34 PRTMSG PLTWX//$
35 LABEL PI $
36 GP3 GEOM3,EQEXIN,GEOM2/SLT,GP1T/V,N,NOGRAV $
37 CHKPTI SLT,GP1T $
38 TA1 ECT,EP1T,NOGPD,SIL,GPIT,CSTM/EST,GEI,GPCT,LUSET/S,N,NGSIMP=-1/L/S,N,NOSGEN=-1/S,N,GENEL $
39 PURGE K4GG,GPST,GPGST,NOG,BGG,K4NN,K4FF,K4AA,INK,F,BN,BFF,BAA,KGX/NGSIMP/CGPST/GENEL $
40 PARAM //C,N,MPY/V,N,NSKIP/C,N,O/C,N,O $
42 PURGE GM,GO,MPCFL/GO,GO,COM/KFS,PSF,OPC/SINGLE $
43 CHKPTI GM,GO,RD,GO,COM,KEF,PSF,OPC,USET,YS $

2.17
LEVEL 2.0 NASTRAN DMAP COMPILED - SOURCE LISTING


67 CNO M LBLKGGX,NOKGX
68 EMA GPECT,KDICT,KELM/NGX,GPST
69 LABEL LBLKGGX
70 PARAM //C,N,OH /V,N,NOBMI /V,N,NOMGG /V,N,NOKPS
71 PURGE BIGG,M1GG /NOBM1
72 PURGE M2GG,M2BASEXG /NOMGG
73 CNO M LBLMGG,NOMGG
74 EMA GPECT,KDICT,KELM/MGG,-1/C,Y,NTMASS=1.0
75 LABEL LBLMGG
77 PARAM FRLX //C,N,PRESENCE ////V,N,NOFRLX
78 CNO M LBLFR1X,NOFRLX
79 EQUIV FRLX,FRL
80 LABEL LBLFR1X
81 CHKPT FRL,B1GG,M1GG,M2GG,BASEXG
82 CNO M LBL1GG,NOBGG
83 EMA GPECT,KDICT,BELM/RGG
84 LABEL LBL1GG
85 CNO M 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,NODM1 \//C,N,U $ \RES SET NOBGG.
90 PURGE BNN, OFF, BAA/NOBGG $
91 COND LBL1, GRDPNT $
92 COND ERR0R4, NOBGG $
93 GPWG BGP, DP, CSTH, EQEXIN, HGG/GRPWG/V,Y,GRDPNT=-1/C,Y,HTMASS $
94 DFP UGPWG, $ $/S,N,CARNO $
95 LABEL LBL1 $
96 EQUIV KGGX, KGG/NOGENL $
97 COND LBL1, NOGENL $
98 SMA3 GEO, KGGX/KGG/LUSET/NOGENL/NOSIMP $
99 LABEL LBL1 $
100 COND LBL1A, NORM1 $
101 PARAM \[/C,N,COMPLX \//V,N,OMEGA2 \//C,N,0.0 \//V,N,CMPLX1 $
102 PARAM \[/C,N,SUB \//V,N,OMEGA2 \//C,N,0.0 \//V,N,CMPLX2 $
103 PARAM \[/C,N,COMPLX \//V,N,OMEGA2 \//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 LBL1IA
110 COND LBL4, GENEL $
111 COND LBL4, NOSIMP $
112 PARAM \[/SEQR/GSPFLG/AUTOSPC/0 $
113 COND LBL4, GSPFLG $
LEVEL 2.0 NASTRAN DMA55 COMPILER - SOURCE LISTING

114 GPSP GPL,GPST,USE/6,GPSI/S,N,NGPSST$
115 COND LBL1,NGPSST$
116 OPE OGPST,1.../S,N,CARDAG$
117 LABEL LBL4$
118 EQIV KGG,KNN/MPCF1,HGG,NNN/MPCF1/BGG,HNN/MPCF1/K4GG,K4NN/MPCF1$
119 COND LBL2,MPCF1$
120 MCE1 USET,OG/CM$
121 MCE2 USET,OG,KGG,HGG,BGG,K4GG,KNN,MNN,BNN,K4NN$
122 LABEL LBL4$
123 EQIV KNN,KFF/SINGLE/MNN,4FF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE$
124 COND LBL3,SINGLE$
125 SCE1 USET,KN,4NN,BNN,K4NN/KFF,KFF,MFF,BFF,K4FF$
126 LABEL LBL3$
127 EQIV KFF,KA/A/OMIT$
128 EQIV MFF,MAA/OMIT$
129 EQIV BFF,BA/A/OMIT$
130 EQIV K4FF,K4AA/OMIT$
131 COND LBL5,OMIT$
132 SMP1 USET,KFF,GO,KA/KC,LCG,1...$
133 COND LBLM,NO/MGG$
134 SMP2 USET,GO,MFF/MAA$
135 LABEL LBLM$
136 COND LBLB,NO/BGG$
137 SMP2 USET,GO,BFF/BA$
138 LABEL LBLB
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

139 COND  LBL5,NOK4GG $  
140 SHP 2  USET,GO,K4FL/K4AA $  
141 LABEL  LBL5 $  
142 EQJ IV  GO,GOU/NOUE/GR,GM/NCL $  
143 PARAM  /*ADD*//NEVER/1/0 $  
144 PARAM  /*MPY*//REPEAT/-1/1 $  
145 B4G  MATPOLL,BGPDT,EQEXN,CSTM/BDPCCL/S,N,NCKHFL/S,N,NOAFL/ N, N, MFACT $  
146 PARAM  /*AND*//NOFL/NCABFL/NOKBF $  
147 PURGE  XBF FL/NOKBF/ ABFL/NCABFL $  
148 COND  LBF L3,NCFL $  
149 NTRXN  UFDOLL,EQDYN, /ABFL,KBF L,/LUSETD/S,N,NOAFL/S,N,NOKBF/0 $  
150 LABEL  LBLFL3 $  
151 JUMP  LBL13 $  
152 LABEL  LBL13 $  
153 PURGE  QUVGC1,ULGCL2,XYPLTF,UPPCI,UPVCI,CEC1,GEF11,UPPC - QPCC1,UPVPC2,OECS2,GEFC2,XYPLTF,PSDF,AUTG,XYPLTR, K2PP,MZPP, B2PP,K2JD,M2DD,B2DD/NEVER $  
154 CASE  CASECC,PSDL/CASEXX/FREQ*/S,N,REPEATF/S,N,NOLOOP $  
155 NTRXN  CASEXX,MATPOLL,EQDYN,TFPCOL/K2PP,MZPP,B2PP/LUSETD/S,N, NOK2FFP/S,N,NOZ2PP/S,N,NCB2PP $  
156 PARAM  /*AND*//N0M2PP/NCABFL/NCM2ZP $  
157 PARAM  /*AND*//NOK2PP/NOFL/NCK2PP $  
158 EQJ IV  M2BP,42PP/NOAFL $  
159 ADDS  ABFL,KBF L,K2DP, /K2PP/1-1.0,0.0) $  
160 COND  LBF L2,NCABFL $  
161 TKNSP  ABFL/AUFIT $  

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LEVEL 2.0 NASTRAN MAP COMPILER - SOURCE LISTING

162 ADD ABFLT,M2DP/N2PP/NFACT $
163 LABEL LBLFL2 $
164 PARAM //AND*/BDFA/NOUE/NGB2PP $
165 PARAM //AND*/KDEKA/NOSIMP $  
166 PARAM //AND*/NDEMA/NOUE/NCM2PP $
167 PURGE K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NGB2PP $
168 PARAM //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NCK2PP $
169 COV D LGKAD1,LGKA0 $ BRANCH IN NCT FREQRESP.
171 JUMP LGKAD2 $  
172 LABEL LGKAD1 $  
174 CHKPT K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,KDU,MDD $  
175 LABEL LGKAD2 $  
176 COVD LBL18,NOGPDT $  
178 LABEL LBL18 $  
179 COVD LGKAD3,LGKAJ $ BRANCH IF NOT FREQRESP.
180 EQJIV B2DD,BDD/NOBGG/M2DD,MDD/NOSIMP/K2DD,KDD/KDEK2 $  
181 JUMP LGKAD4 $  
182 LABEL LGKAD3 $  
183 EQJIV B2DD,BDD/NOGPDT/M2DD,MDD/NCSIMP/K2DD,KDD/KDEK2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

184 LABEL LCKAD4 $  
185 COND LBLTRL1,NOTIME $  
186 PARAM //C,N,MPY /V,N,REPEATT /C,N,1 /C,N,-1 $  
187 PARAM //C,N,AUD /V,N,APPFLG /C,N,1 /C,N,0 $ INITIALIZE FOR SDRL.  
188 JUMP TRLGLOOP $  
189 LABEL TRLGLOOP $  
190 CASE CASECC,/CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NCLLNOPI $  
191 CHKPTN CASEYY $  
192 PARAM //C,N,MPY /V,N,NCOL /C,N,0 /C,N,1 $  
193 TRLG CASEYY,USETO,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,EST,MGG/,PDT1,PD1,PD1,TOL/V,N,NGSET/S,N,PDEPDC/V,N,NCOL $  
194 SDRL TRL,PD1,PD1,PD1,PD1,PD1,PD1,PD1/ /PD1,PD1,PD1,PD1,PD1,PD1,PD1,PD1 $  
195 SDRL TRL,PD1,PD1,PD1,PD1,PD1,PD1,PD1/ /PD1,PD1,PD1,PD1,PD1,PD1,PD1,PD1 $  
197 COND TRLGDONE,REPEATT $  
198 REPT TRLGLORD,100 $  
199 JUMP ERROR3 $  
200 LABEL TRLGDONE $  
201 CHKPTN PD1,PD1,PD1,PD1 $  
202 LQIV PD1,PD1/PDEPDC $  
203 CHKPTN PDT $  
204 NUMM02 TDL,PD1,PD1,PD1,PD1,PD1,PD1,PD1/ /FRILZ,FGLZ,REORDER1,REORDER2, / V,Y,NSELG/S,Y,CYCLG/S,Y,LMAX=-1/V,N,FKMAX/ S,N,FLMAX/S,N,NTSPTS/S,N,NGRO1/S,N,NGRO2 $  
205 LQIV FRILZ,FRL // FOLZ,FCL $  
206 CHKPTN FRL,FRL,REORDER1,REORDER2 $  
207 JUMP LULFRL2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

208 LABEL    LBLTR1 $  
209 FRLG     CASEXX,USETU,ULT,FRL,GMD,GCD,DIT, /PPF,PSF,PDF,FOL,PHDUM /C,N,DIRECT/V,N,FREQ/C,N,FREQ $  
210 CND       LBLFRLX1,NOFRLX $  ZERO OUT LOAD COLUMNS IF FRLX HAS GENERATED.  
211 MPYAD     PPF,PDZERO, /PPFX /C,N,O $  
212 EQJIV     PPFX,PPF $  
213 LABEL    LBLFRLX1 $  
214 CND       LBLFRL1,NOBASEX $  
215 MPYAD     M2GS,BASEXG, /M2BASEXG /C,N,O $  
216 ADD       PPF,M2BASEXG /PPF1 /C,N,(1.0,0.0) /C,N,(-1.0,0.0) $  
217 EQJIV     PPF1,PPF $  
218 CND       LBLBASE1,NOSET $  
219 SSG2     USETU,GMD,YS,KFS,GCD,,PPF /,PODUM1,PSF1,PDF1 $  
220 EQJIV     PSF1,PSF //PDF1,PDF $  
221 LABEL    LBLBASE1 $  
222 LABEL    LBLFRL1 $  
223 EQJIV     PPF,PDF/NOSET $  
224 CHKPTNT  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,PDFX/CYCIC $  
228 CND       LBL?DUNE,CYCIO $  
229 PARAM    //C,N,DIV /V,N,NLOAD /V,N,PDFCGLS /V,Y,NSEG $ NLOAD = NF/NSEG  
230 CYCT1    PDF /PXF,GCYCF1 /V,N,CITYPE /C,N,FCRE /V,Y,NSEG=-1 /V,Y,FKMAX=-1 /V,N,HLLAD /S,N,NGG $  
231 CND       ERRORC1,NGG $  

2.25
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

232  CHKPNT  PXF $  
233  JUMP    LBLPDONE $  
234  LABEL   LBLFRL2 $  
235  PARAM   //C,N,KUT /V,N,NOTCYCIO /Y,Y,CYCIO $  
236  COND    LBLTRL2,NOTCYCIO $  
237  EQUIV   POT,PDTZ21/NCRO1 $  
238  COND    LBLRO1A,NORU1 $  
239  MPYAD   POT,REORDER1, / PDTZ21 / C,N,0 $  
240  LABEL   LBLRO1A $  
241  CYCT1   PDTZ21 / PXTRZ1,GCYCF2 /V,N,CTYPE/C,N,FORE/V,N,NTSTEPS/ 
                     V,Y,LMAX/V,N,FKMAX/S,N,NOGO $  
242  CYCT2   ERRURC1,NOGO $  
243  CHKPNT  PXTRZ1 $  
244  EQUIV   PXTRZ1,PXFZ1/NCRO2 $  
245  COND    LBLPO2A,NORL2 $  
246  MPYAD   PXTRZ1,REORDER2, / PXFZ1 /C,N,0 $  
247  LABEL   LBLRO2A $  
248  EQUIV   PXFZ1,PXF1 $  
249  CHKPNT  PXF1 $  
250  JUMP    LBLTRL3 $  
251  LABEL   LBLTRL2 $  
252  MPYAD   PDT,REORDER1, / PDTZ22 / C,N,0 $  
253  CYCT1   PDTZ22 /PXTP22,GCYCF3 /V,N,CTYPE/C,N,FCRE/V,N,NTSTEPS/V,Y,LMAX/ 
                     V,Y,NSEG5/S,N,NOGO $  
254  COND    ERRURC1,NOGO $  
255  CHKPNT  PXTRZ22 $  

2.26
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

256 EQUIV PXTR2,PXTR2/NORO2 $
257 COND LBLRO2B,NORO2 $
258 MPMAD PXTRZ2,REORDER2 / PXTR2 /C,N,0 $
259 LABEL LBLRO2B $
261 CONV ERRORC1,NOGO $
262 EQUIV PXFZ2,PXF1 $
263 CHKPTX PXF1 $
264 LABEL LBLTRL3 $
265 COPY PXF1 / PXF2 $ CONVERT REAL PXF1 TO 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,YMIN=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,, /,NKV2,, /,CYCSEL/V,N,KMINV/V,N,KMINL/V,N,KMAX/V,N,FLMAX/S,N,ACGC $
276 CONV ERRORC1,NOGO $
277 ADD PKFZ, / LKVF2 / C,N,(0.0,0.0) $
278 CYCT2 CYCUD,,LKV2,, /,UXVF,, /,C,N,BACK/V,Y,NSEGS/ V,N,KMINL/V,N,CYCESL/V,N,FLMAX/S,N,ACGC $
279 CONV ERRORC1,NOGO $

2.27
LEVEL 2.0 NASTRAN DHAP COMPILER - SOURCE LISTING

280 PARAM /C,N,ADD /V,N,KMINV /V,N,KMINV /C,N,1 $
281 REPT KMINLOOP,KMINL $
282 LABEL NOKMINL $
283 JMP TOPCYC $
284 LABEL TOPCYC $ LUOP ON KINDEX
285 COND NOKPRT,NOKPRT $
286 PRTPARM /C,N,0 /C,N,KINDEX $
287 LABEL NOKPRT $
288 CYCT2 CYCODD,KDD,MDD... /KKKF,MMKF... /C,N,FORE/V,Y,NSEGS / V,N,KINDEX/V,N,CYCSEQ=-1/V,N,NLOAD/S,N,NGC $
289 COND ERRRC1,NOGU $
290 CHKPT NK,MMKF $
291 PARAM /C,N,SYST /C,N,58 /C,N,2 $ METHOD 37 IN CYCT2 PRODUCES
292 CYCT2 CYCODD,DOM,DOM... /KKKF,MMKF... /C,N,FORE/V,Y,NSEGS/ V,N,KINDEX/V,N,CYCSEQ/V,N,NLOAD/S,N,NGO $
293 PARAM /C,N,SYST /C,N,58 /C,N,0 $ RESET MPYAD METHO CONTROL.
294 COND ERRRC1,NOGU $
295 CHKPT BKKF,PKF $
296 FRVD2 KKKF,BKKF,MMKF,PKF,FCL /UKVF /C,N,0,0/C,N,0,0/C,N,-1,0 $
297 CHKPT UKVF $
298 CYCT2 CYCODD,DOM,DOM... /UKVF... /C,N,BACK/V,Y,NSEGS/V,N,KINDEX/ V,N,CYCSEQ/V,N,MLCAD/S,N,NGC $
299 COND ERRRCIC,NOGU $
300 CHKPT 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,MMAX /V,N,KINDEX $
303 COND LCYC2,DONE $ IF KINDEX .GT. KMAX THEN EXIT
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

304 REPT  TOPCYC,100 $
305 JUMP  ERROR3 $
306 LABEL  LCYC2 $
307 EQUIV  UXVF,UDVF / CYCIO $
308 CHECK  UDVF $
309 COND  LCYC3,CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
310 CYC1  UXVF / UDVF,GCYCH1 / V,N,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/V,Y,N,LOAD $
311 CHECK  UDVF $
312 LABEL  LCYC3 $
313 COND  LBLTRL4,NOTIME $
314 EQUIV  PXF,PDF2 / CYCIO $
315 COND  LCWC4,CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
316 CYC1  PXF / PDF2,GCYCH2 / V,N,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/V,Y,N,LOAD $
317 LABEL  LCYC4 $
318 SAV1  USETO,PDX2,GMU,GMF,... / PPFZ1 / C,N,1 / C,N,DYNAMICS $
319 SAV2  USETO,GMU,GMF,GF2,GOJ,PPFZ / PCDUP,PSFZ,PLDUN $
320 EQUIV  PPFZ,PPF // PSFZ,PSF $
321 CHECK  PPF,PSF $
322 LABEL  LBLTRL4 $
323 VDR  CASEXX,EQDV1,USETO,UDVF,FTL,XYC0B,GUOVC1/C,N,FREQPSP/C,N, DIRECT/S,N,NOSORT2/S,N,NOD/S,N,NCP/C,N,0 $ $
324 COND  LBL15,NOD $ $
325 COND  LBL15A,NOSORT2 $ $
326 SDR 3  OUUVGC1,...,GUOVC2,..., $ $
327 OEP  OUUVGC2,...,/S,N,CARDNC $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

328 XYTRAN  XVCDB,OUVDVC2,*,/XYPLTF/A/FREQ/*DSET*/S,N,PFIL/S,N,CARDNO $ 
329 XYPLF T  XYP/LTF/A/* $ 
330 JUMP  LBL15 $ 
331 LABEL  LBL15A $ 
332 QFP  OUVDVC1,*,*,/S,N,CARDNC $ 
333 LABEL  LBL15 $ 
334 COND  LBL20,NUP $ 
335 EQUIV  UDFV,UPVC/NOA $ 
336 COND  LBL19,NUA $ 
337 SDR1  USETD,UDVF,*,GUD,GM,FIF,EF,S,UPVC,QPC/1/*DYNAMICS*/ $ 
338 LABEL  LBL19 $ 
339 SDR2  CASEXX,LMPT,OPT,EQOYN,SLD,*,BGPD,FUL,QPC,JPVC,EST,XVCDB, 
            PPF/QPC1,QPC1,QUPVC1,GESC1,CEF21,PUPVC1/C,N,FREDFRESP/ 
            S,N,NUORT2 $ 
340 CLVD  LBL17,NUORT2 $ 
341 SDR3  QPPC1,QPPC1,QUPVC1,GESC1,CEF21/QPPC2,QPPC2,QUPVC2,GESC2, 
            OEC2, $ 
342 QFP  QPPC2,QPPC2,QUPVC2,CEFC2,GESC2,*/S,N,CARDNC $ 
343 XYTRAN  XVCDB,UPPC2,COPC2,QUPVC2,GESC2,CEF22/XYPLTF*/FREQ*/PSFI*/ 
            S,N,PFIL/S,N,CARDNO $ 
344 XYPLF T  XYP/LTF/A/* $ 
345 COND  LBL16,NOPSOL $ 
346 FANDLM  XVCDB,DMT,PSOl,JUPVC2,QPPC2,COPC2,GESC2,CEFC2,CASEXX/PSDF,AUTU/ 
            S,N,NORD $ 
347 CLV  LBL16,NORD $ 
348 XYTRAN  XVCDB,PSFL,AUTO,*,/XYPLTR*/RAND*/PSFI*/S,N,PFIL/ 
            S,N, 
349 XYPLF T  XYP/LTR/A/* $ 

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LEVEL 2.0 NASTRAN DMAP CUMPILES - SOURCE LISTING

350. JUMP LBL16 $
351. LABEL LBL17 $
352. JFP UPVCI, OPPCI, OPPCAR, CEFC1, CESC1, /S, /A, CARDAC $
353. LABEL LBL16 $
354. CUDL LBL20, JUMPLOT $
355. PLOT PLTPAR, GSETS, ELSSETS, CASEXX, BOPDT, EQEIXN, SIP, PUPVCI, GPECTg, OESCf, PLOTX2/NSIL/LUSEP/JUMPLOT/PLTFLG/ S, N, PFILE $
356. PRTMSG PLOTX2/ $
357. LABEL LBL20 $
358. CUDL FINIS; REPEATF $
359. KEPT LBL13, 100 $
360. LABEL ERROR3 $
361. PRTPARM /*-3*/DIRFRRD* $
362. JUMP FINIS $
363. LABEL ERROR4 $
364. PRTPARM /*-4*/DIRFRRD* $
365. LABEL ERRORC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.
366. PRTPARM //C,N,-7 /C,N, CYCSTatics $
367. LABEL ERRJRC2 $ COUPLED MASS NOT ALLOWED.
368. PRTPARM //C,N,0 /C,Y, COUPPASS $
369. JUMP FINIS $
370. LABEL ERRORC3 $ SUPORT BULK DATA NOT ALLOWED.
371. PRTPARM //C,N,-6 /C,N, CYCSTatics $
372. LABEL ERRORC4 $ EPOINT BULK DATA NOT ALLOWED.
373. PRTPARM //C,N,0 /C,N, NOUE $
374. JUMP FINIS $
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 $ 

2.32
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 NSEG.S.
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 > NSEG.S/2.
18. Go to DMAP No. 367 if user has requested consistent mass.
20. GPl 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. PLLOT 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. TA1 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.

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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 \([K^X_{gg}]\) 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. DUMMODL generates modified Frequency Response List, FRLX, Coriolis acceleration coefficient matrix \([B_{1GG}_{gg}]\), centripetal coefficient matrix \([M_{1GG}_{gg}]\), Base acceleration coefficient matrix \([M_{2GG}_{gg}]\), Base acceleration matrix \([BASEXG_{gg}]\) and load modification matrix, \([PDZERO_{gg}]\), for base acceleration problems.
79. Equivalence FRLX to FRL if FRLX was generated by DUMMODL.
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 \([K^4_{gg}]\).
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. OFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.
96. Equivalence \([K^X_{gg}]\) to \([K^X_{gg}]\) if no general elements.
97. Go to DMAP No. 99 if no general elements.
98. SHA3 adds general elements to \([K^X_{gg}]\) 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
\[B_{GUL_{gg}} = [B_{gg}] + (4RPS) [B_{1GG}_{gg}]\]
105. Equivalence $[BGG]_{gg}$ to $[B_{gg}]$.

106. ADD assembles the centrifugal acceleration matrix into the stiffness matrix.

$[KGG]_{gg} = [K_{gg}] - (2\pi \cdot RPS)^2 [M16G]_{gg}$

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. OFP 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 $[K^4_{gg}]$ to $[K^4_{nn}]$ 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 $[R_g] = [K_m'] [R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m']^{-1} [R_n]$.

116. MCE2 partitions stiffness, mass and damping matrices

$[K_{gg}] = \begin{bmatrix} K_{nn} & K_{nn} \\ K_{mn} & K_{mm} \end{bmatrix}$, $[M_{gg}] = \begin{bmatrix} M_{nn} & M_{mn} \\ M_{mn} & M_{mm} \end{bmatrix}$

$[B_{gg}] = \begin{bmatrix} B_{nn} & B_{nn} \\ B_{mn} & B_{mm} \end{bmatrix}$, $[K^4_{gg}] = \begin{bmatrix} K^4_{nn} & K^4_{nn} \\ K^4_{mn} & K^4_{mm} \end{bmatrix}$

and performs matrix reductions

$[K_{nn}] = [R_{nn}] + [G_m^T][K_{nn}] + [K_{nn}'][G_m] + [G_m^T][K_{mm}'][G_m]$,

$[M_{nn}] = [R_{nn}] + [G_m^T][M_{nn}] + [M_{nn}'][G_m] + [G_m^T][M_{mm}'][G_m]$,

$[B_{nn}] = [B_{nn}] + [G_m^T][B_{nn}] + [B_{nn}'][G_m] + [G_m^T][B_{mm}'][G_m]$,

$[K^4_{nn}] = [K^4_{nn}] + [G_m^T][K^4_{nn}] + [K^4_{nn}'][G_m] + [G_m^T][K^4_{mm}'][G_m]$.

117. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no singlepoint constraints.

118. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no singlepoint constraints.
124. Go to DMAP No. 126 if no single-point constraints.

125. SCE1 partitions out single-point constraints

\[
\begin{bmatrix}
K_{ff} & K_{fs} \\
K_{sf} & K_{ss}
\end{bmatrix} = \begin{bmatrix}
H_{ff} & H_{fs} \\
M_{sf} & M_{ss}
\end{bmatrix}, \quad \begin{bmatrix}
B_{ff} & B_{fs} \\
B_{sf} & B_{ss}
\end{bmatrix} = \begin{bmatrix}
\bar{K}^f & \bar{K}^s \\
\bar{K}^s & \bar{K}^s
\end{bmatrix}, \quad \begin{bmatrix}
\bar{K}^f & \bar{K}^s \\
\bar{K}^s & \bar{K}^s
\end{bmatrix}
\]

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 \([K_{ff}^4]\) to \([K_{aa}^4]\) 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 \([m_{aa}^1] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]\).

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

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

and performs reduction

\[
[B_{aa}'] = [B_{aa}] + [B_{ao}][G_0] + [B_{ao}G_0]^T + [G_0^T][B_{oo}][G_0]
\]

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

140. SMP2 partitions constrained structural damping matrix

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

and performs matrix reduction

\[
k_{aa}' = [k_{aa}'] + [k_{ao}'][G_0] + [k_{ao}G_0]^T + [G_0^T][k_{oo}'][G_0]
\]

142. Equivalence \([G_o] \) to \([G_o']\) and \([G_m] \) to \([G_m']\) 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 \([A_{bf}, f_b]\) and \([K_{bf}, f_b]\) if a fluid

structure interface is defined. The matrix \([K_{bf}, f_b]\) 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 \([b_{pp}^{2d}]\).

158. Equivalence \([m_{pp}^{2d}] \) to \([m_{pp}']\) if no \([A_{bf}, f_b]\).

159. ADDS adds \([K_{bp}, f_b]\) and \([K_{pp}^{2d}]\) and subtracts \([A_{bf}, f_b]\) from them to form \([k_{pp}^{2d}]\).
160. Go to DMAP No. 163 if r == 0.

161. Transpose \([A_b, f_k] \) to obtain \([A_b, f_k]^T\).

162. ADD assembles input matrix \([M^2_{pp}] = MFACT [A_b, f_k]^T + [M^2_{dd}]\).

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

170. Equivalence \([H^2_{pp}] \to [M^2_{dd}, [B^2_{pp}] \to [B^2_{dd}] \text{ and } [K^2_{pp}] \to [K^2_{dd}] \text{ if no constraints applied, } [M^2_{aa}] \text{ to } [M^2_{dd}] \text{ if no direct input mass matrices and no extra points and } [B^2_{aa}] \text{ to } [B^2_{dd}] \text{ if no direct input damping matrices and no extra points.}

172. Go to DMAP No. 175.

173. Equivalence \([H^2_{pp}] \to [M^2_{dd}], [B^2_{pp}] \to [B^2_{dd}] \text{ and } [K^2_{pp}] \to [K^2_{dd}] \text{ if no constraints applied, } [M^2_{aa}] \text{ to } [M^2_{dd}] \text{ if no direct input mass matrices and no extra points, and } [K^2_{aa}] \text{ to } [K^2_{dd}] \text{ 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.

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

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

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

Direct input matrices may be complex.

or 

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

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

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

and \([B_{dd}] = [B^1_{dd}] + [B^2_{dd}] + \frac{g}{\omega_3} [k^1_{dd}] + \frac{1}{\omega_4} [K^4_{dd}],
\]

where 

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

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

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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 \([K_{dd}]\) if 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. \([P_l^t]\) is generated with one column per output time step, \([P_l]\) 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 \([P_l^t]\) to \([P_l]\).

195. SDR1 appends \([P_l^d]\) to \([P_l]\).

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 \([P_l^d]\) to \([P_l^t]\) 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 \(REAORDER1\) and \(REAORDER2\) 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 \( \{P^f_p\}, \{P^r_s\}, \{P^f_d\} \) 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 \( \{P^f_p\} \) in base acceleration problems.

212. Equivalence \( \{P^f_p\} \) to \( \{P^r_p\} \).

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

215. MPYAD forms the complete base acceleration matrix, \( \{M2BASEXG^f_g\} = [M2GG^g_g] \cdot \{BASEXG^f_g\} \).
216. ADD assembles the frequeny loads and the loads due to base acceleration.

\[
\{P_1^f\} = \{P_p^f\} - \{H2BASEXG\}
\]

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

217. Equivalence \(\{P_1^f\}\) 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 \(\{P_d^t\}\) and \(\{PDTRZ1\}\) if REORDER1 was not generated by DUMMOD2.

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

227. MYAD 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 \(\{PXTRZ1\}\) and \(\{PXFZ1\}\) if REORDER2 was not generated by DUMMOD2.

231. MYAD reorders columns of \(\{PXTRZ1\}\).

232. Equivalence \(\{PXFZ1\}\) to \(\{PXF1\}\).

233. Go to DMAP No. 264.

234. MYAD 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 \(\{PXTRZ2\}\) to \(\{PXTR2\}\) if REORDER2 was not generated.

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

239. MYAD reorders columns of \(\{PXTRZ2\}\).

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 \(\{PXFZ2\}\) to \(\{PXF1\}\).

243. COPY makes a physical copy of \(\{PXF1\}\) called \(\{PFX2\}\).
266. ADD makes loads complex, since SCR2 expects complex loads in a frequency response problem. Time-dependent loads are real.

\[(PFX) = (0.5, i0) \cdot (PFX1) \cdot (0.5, -1.0i) \cdot (PFX2)\]

271. Go to DMAP No. 282 if \(KMIN = 0\).

274. Beginning of loop to create \(KMIN\) null columns of \(UV^f\) 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 \(UV^f\) columns.

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

277. ADD generates a null vector \(UV^f_1 = \{PZ^f_1\} \cdot 0.0\).

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

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

280. PARAM increments the value of \(KMINV = KMINV + 1\).

281. Go to DMAP No. 274 if more null vectors are to be generated for \(UV^f\). If the initial \(UV^f\) 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:

\[
[K_{kk}] = [G_c^T][K_{aa}][G_c] + [G_s^T][K_{aa}][G_s]
\]

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

\[
[B_{kk}] = [G_c^T][B_{aa}][G_c] + [G_s^T][B_{aa}][G_s]
\]

\[
[P_k] = [G_c^T]\{P_c\} + [G_s^T]\{P_s\}
\]

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 \( \{U^r_x\} \) to \( \{U^r_d\} \) if parameter CYCIO = -1.

309. Go to DMAP No. 312 if parameter CYCIO = -1.

310. CYCT1 transforms displacements from symmetrical components to physical components.

313. Go to DMAP No. 322 if loads were frequency-dependent.

314. Equivalence \( \{P^r_f\} \) to \( \{P^r_p\} \) if parameter CYCIO = -1.

315. Go to DMAP No. 317 if parameter CYCIO = -1.

316. CYCT1 transforms loads from symmetrical components to physical components if loads were time-dependent.

318. SDR1 recovers dependent loads \( \{P^r_p\} \).

319. SSG2 applies constraints to \( \{P^r_p\} \) to form \( \{P^r_s\} \).

320. Equivalence \( \{P^r_p\} \) to \( \{P^r_s\} \) and \( \{P^r_s\} \) to \( \{P^r_s'\} \).

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. XYPL0T 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.
334. Go to DMAP No. 357 if no output requests for forces and stresses.

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

336. Go to DMAP No. 338 if no constraints applied.

337. SDR1 recovers independent components of displacements

\[
\{u_0\} = [G^d_{0d}]\{u_d\}, \quad \left\{\begin{array}{c} u_d \\ u_f + u_e \\ u_o \end{array}\right\} = \{u_f + u_e\}
\]

\[
\left\{\begin{array}{c} u_f + u_e \\ u_s \\ u_n + u_e \\ u_m \\ u_n \\ u_e \\ u_m \end{array}\right\} = \{u_i\}
\]

and recovers single-point forces of constraining \( \{q_s\} = -(P_s^T) + [K_s^T]u_f \).

339. SDR2 calculates element forces (\(\phi\text{EFC1}\)) and stresses (\(\phi\text{ESC1}\)) and prepares load vectors (\(\phi\text{PPC1}\)), displacement vectors (\(\phi\text{UPVC1}\)), and single-point forces of constraint (\(\phi\text{QPC1}\)) for output sorted by frequency.

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

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

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

343. XYTRAN prepares the input for requested X-Y plots.

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

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

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

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

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

349. XYPLT prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.

350. Go to DMAP No. 353 if no frequency response output requests sorted by frequency.
352. 6FP 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 plot are requested.

355. PLOT generates all requested deformed plots.

356. PRTMSG 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 CYC10 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. **CYC10** - 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. **CTYPE** - 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. **NLOAD** - fixed - The integer value of this parameter is the number of static loading conditions. The value of NLOAD 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 TABLEI 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 BUMOD1

3.1.1.1 FRLX (TABLE)

Description

Frequency Response List

The FRLX contains one log. 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

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

3.1.1.3 M1GG (MATRIX)

Description

\([\text{M1GG}_{gg}]\) = Centripetal acceleration coefficient matrix - g set.

3.1.1.4 M2GG (MATRIX)

Description

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

3.1
3.1.1.5 BASEXG (MATRIX)

Description

\([\text{BASEXG}_g^F]\) - Base acceleration matrix - g set.

3.1.1.6 PDZERO (MATRIX)

Description

\([\text{PDZERO}_g^F]\) - Load modification matrix in base acceleration problems - g set.

3.1.2 Data Blocks Output from Module DUMMOD2

3.1.2.1 FRL (TABLE)

Description

Frequency Response List

The FRL output by DUMMOD2 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></td>
<td>3</td>
<td>I</td>
<td>Set ID = 1</td>
</tr>
<tr>
<td>1</td>
<td>1-(w)</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 ((w = 2\pi F))</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>
3.1.2.3 REORDER1 (MATRIX)

Description


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


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 NOMMG=1.
2. B1GG and M1GG can be purged if NOMMG=-1 or if OMEGA=0.0.
3. FRLX and PDZERO can be purged if OMEGA=0.0.

4. FRLX, PDZERO, H2GG 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. H2GG 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 = 2π·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 CYCLO=-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 DUMM1OD1, 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 CSTN 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 DUMM1OD1. 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 \([\bar{M}_i]\). The average of the three diagonal terms of \([\bar{M}_i]\) is then used to form \([\bar{B}_i], [\bar{M}_i], \text{ and } [\bar{M}_i^2]\). These three submatrices are then transformed back to the global coordinate system, if necessary. The 3 x 3 matrices \([\bar{B}_i], [\bar{M}_i], \text{ and } [\bar{M}_i^2]\) are then packed into the B1GG, M1GG and M2GG matrices.

(a) 

\[
[MGG]_{g	imes g} = \begin{bmatrix}
[M_1] & [M_2] & 0 \\
0 & \ddots & 0 \\
0 & 0 & [M_n]
\end{bmatrix}
\]

where n = the total number of grid points.
where
\[
[H_i] = \begin{bmatrix} [H_i^1] & \cdots & [H_i^n] \end{bmatrix}
\]
for \(i = 1, n\)

and
\[
[H_i^1] = \begin{bmatrix} m_i^T & 0 & 0 \\ 0 & m_i^T & 0 \\ 0 & 0 & m_i^T \end{bmatrix}
\]

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

(c) Compute average of \([H_i]\)
\[
\bar{m}_i = \frac{3}{K} \sum_{k=1}^{K} \bar{m}_i^k
\]
where \(\bar{m}_i^k\) is the mass (in the basic coordinate system) at the \(i^{th}\) node point of the total of \(n\) nodes in the \(k^{th}\) direction.

(d) Form \(B1GG\)
\[
[B1GG] = \begin{bmatrix} [B1_1] & \cdots & [B1_n] \end{bmatrix}
\]
where
\[
[B1_i] = \begin{bmatrix} [B1_i^1] \\ \vdots \\ [0] \end{bmatrix}
\]
and
\[
[B1_i^1] = [T_i]^T \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -\bar{m}_i \\ 0 & \bar{m}_i & 0 \end{bmatrix} [T_i]
\]

(e) Form \(M1GG\)
\[
[M1GG] = \begin{bmatrix} [M1_1] & \cdots & [M1_n] \end{bmatrix}
\]

\[
[M1_i] = \begin{bmatrix} 0 \\ \vdots \\ [M1_i^2] \end{bmatrix}
\]
where
\[
[M_1]_{6x6} = \begin{bmatrix}
[H_1] & \vdots \\
\vdots & \ddots & \vdots \\
[0] & \cdots & [0]
\end{bmatrix}
\]

and
\[
[M_1]_{3x3} = [T_i]T \begin{bmatrix}
0 & 0 & 0 \\
0 & \bar{m}_i & 0 \\
0 & 0 & \bar{m}_i
\end{bmatrix} [T_i].
\]

(f) Form M2GG
\[
[M2GG]_{g \times g} = \begin{bmatrix}
[M2_1] & 0 & \cdots & 0 \\
\vdots & \ddots & \vdots & \vdots \\
0 & \cdots & [M2_g]
\end{bmatrix}
\]

where
\[
[M2_1]_{6x6} = \begin{bmatrix}
[H_2] & \vdots \\
\vdots & \ddots & \vdots \\
[0] & \cdots & [0]
\end{bmatrix}
\]

and
\[
[M2]_{3x3} = [T_i]T \begin{bmatrix}
\bar{m}_i & 0 & 0 \\
0 & \bar{m}_i & \bar{m}_i \\
0 & -\bar{m}_i & \bar{m}_i
\end{bmatrix} [T_i].
\]

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, \( |\omega_i - \text{OMEGA}| \), \( \omega_i \), 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 \( |\Omega| \) 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 FMAX times, thus creating FMAX 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 TABLED i 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).

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

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

\[
\begin{bmatrix}
\text{BASE} \\
3 \times \text{NF}
\end{bmatrix} = 
\begin{bmatrix}
\{\text{Base}(f_1)\} \\
\cdot \\
\cdot \\
\{\text{BASE}(f_{\text{NF}})\}
\end{bmatrix}
\begin{bmatrix}
3 \times 1 \\
3 \times 1
\end{bmatrix}
\]

3.9
where \( f_i = \omega_i / 2\pi \) for \( i = 1, 2, \ldots, NF \)
and
\[
\{\text{BASE}(f_i)\} = \left\{ \begin{array}{ccc}
\bar{x}_0(f_i) & e^{i\theta_x(f_i)} \\
\bar{y}_0(f_i) & e^{i\theta_y(f_i)} \\
\bar{z}_0(f_i) & e^{i\theta_z(f_i)} \\
\end{array} \right\}_{3x1}
\]

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

\[
[\text{BASE}]_{3xNF} = \begin{bmatrix}
[\text{BASE}(f_1)] & [\text{BASE}(f_2)] & \cdots & [\text{BASE}(f_{NF})]
\end{bmatrix}
\]

where \( f_i = \omega_i / 2\pi \) for \( i = 1, 2, \ldots, NF \)
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:

\[
[\text{BASE}(f_i)]_{3x2} = \begin{bmatrix}
A & 0 \\
0 & B \\
0 & C
\end{bmatrix}
\]

where
\[
SGN = 1.0 \text{ if parameter OMEGA} \geq 0.0, \text{ otherwise } SGN = -1.0 \text{ and}
A = \bar{x}_0(f_i) \cdot e^{i\theta_x(f_i)}
B = \bar{y}_0(f_i) \cdot \cos(\theta_y(f_i)) - i \cdot SGN \cdot \bar{z}_0(f_i) \cdot \cos(\theta_z(f_i))
C = \bar{z}_0(f_i) \cdot \cos(\theta_z(f_i)) + i \cdot SGN \cdot \bar{y}_0(f_i) \cdot \cos(\theta_y(f_i))
\]

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

\[
[\text{BASE}(f_i)]_{3x3} = \begin{bmatrix}
0 & A & 0 \\
B & 0 & C \\
D & 0 & E
\end{bmatrix}
\]

where
\[
SGNA = 1.0 \text{ if } (\omega_i - \text{OMEGA}) \geq 0.0, \text{ otherwise } SGNA = -1.0
SGNB = 1.0 \text{ if } (\omega_i + \text{OMEGA}) \geq 0.0, \text{ otherwise } SGNB = -1.0
\]
and
\[
A = \bar{x}_0(f_i) \cdot e^{i\theta_x(f_i)}
B = 0.5 \cdot \left[ \bar{y}_0(f_i) \cdot e^{i\theta_y(f_i)} \cdot \text{SGNA} \cdot \bar{y}_0(f_i) \cdot e^{i\theta_y(f_i)} - \text{SGNA} \cdot \bar{z}_0(f_i) \cdot e^{i\theta_z(f_i)} \cdot \text{SGNA} \cdot \bar{z}_0(f_i) \cdot e^{i\theta_z(f_i)} \right]
\]

3.10
(f) Define the complex base acceleration matrix BASEXG of order \( G \times (NF \times FMAX) \) as follows:

Let \( NF \) be the number of frequencies in the BASE matrix, i.e., let \( NF = NF \) if MODFRL was false or \( NF = NFX \) if MODFRL was true.

\[
[\text{BASEXG}]_{g \times (NF \times FMAX)} = [\text{BASEXG}^1]_{g \times NF} [\text{BASEXG}^2]_{g \times NF} [\text{BASEXG}^3]_{g \times NF} \ldots [\text{BASEXG}^FMAX]_{g \times NF}
\]

where

\[
[\text{BASEXG}^i]_{g \times NF} = \begin{bmatrix}
[\text{BASEX}^i]_{6 \times NF} \\
[\text{BASEX}^i]_{6 \times NF} \\
\vdots \\
[\text{BASEX}^i]_{6 \times NF}
\end{bmatrix}
\]

for \( i = 1, 2 \) and 3

and

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

NOTE: \([\text{BASEX}^i]_{g \times NF}\) 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.

\[
[\text{BASEX}^i]_{6 \times NF} = \begin{bmatrix}
\text{BASE}(1,1) & \text{BASE}(1,2) & \ldots & \text{BASE}(1,NF)
\end{bmatrix}
\]

3.11
3.2.1.8 Subroutines

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

3.2.1.8.1 Subroutine Name: DUMO1A

1. Entry Point: DUMODIA

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

3. Calling Sequence: Call DUMO1A (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, THOPI, RADEG, DEGRA, S4PISQ  
   COMMON/BLANK/DUM(5), BXID, BXPTID, BYID, BYPTID, BZID, 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, THOPI, RADEG, DEGRA, S4PISQ  
   COMMON/BLANK/DUM(5), BXID, BXPTID, BYID, BYPTID, BZID, 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, NF)  
   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
3.2.1.8.5 Subroutine Name: DUM01E

1. Entry Point: DUM01E

2. Purpose: To sort the list of expanded frequencies of data block FR1X 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) DUMOD1 resides in LINKNS07
d) Open core for five GINO buffers is needed.
e) The layout for open core is as follows:

Phase I

COMMON/DUM1XX/ Z

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

COMMON/DUMIXX/Z

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</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>3*NF</td>
</tr>
</tbody>
</table>

FREE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<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>Value</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) Complex</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>
</tbody>
</table>

FREE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IBUF1)</td>
<td>DIT/BASEXG</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>

3.2.1.10 Diagnosis Messages

The following fatal error messages may occur:

3091, 3002, 3003, 3008 and 3031.
3.2.2 Functional Module DUMM4MOD2

3.2.2.1 Entry Point: DUMM4MOD2

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 LMAS, NTSTEPS, FLMAX, NORD1, and NORD2 are also computed.

3.2.2.3 DMAP Calling Sequence

DUMM4MOD2 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,NORD1/V,
N,N,NORD2 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*FKMAX)/FKMAX
   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 radians, 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.

REORDER 1 and REORDER2 are used for reordering columns of a matrix by post-multiplying the matrix whose columns are to be reordered. Routine DUM02A is called twice, once to generate and output REORDER1 and once to generate and output REORDER2. See the subroutine description of DUM02A 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 NOR01 and NOR02.

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/
```

| Z(ITOL)  | TOL TIME DATA | NTIMES |
| Z(IFOL)  | FOL/FRL DATA  | FLMAX  |
|          | FREE          |        |

| Z(IBUF1) | TOL/FOL/FRL/REORDER | GINO BUFFER+1 |

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
null
X - Denotes new routines
+ - Denotes existing routines new to this link
MASTER existing routines: XSEM06
OPEN FOR - /ALOGER must be placed after the
largest link of output
link output 1 and output 2

LINKEDIT (CONTROL)
[CHANGE EXECUTABLE]
[INCLUDE LIBRARY(S)]
[CHANGE PLAIN RETURN], SYMBOL(RETURN), NUMBER(RETURN)
[INCLUDE LIBRARY(S)]
[CHANGE ROUT(RETURN), SYMBOL(RETURN)]
[INCLUDE LIBRARY(S)]
[CHANGE PLAIN RETURN], LINE(RETURN), AXIS(RETURN)
[INCLUDE LIBRARY(S)]

NASTRAN L17.1 (IBM)
L1HEN.506

Original Page is
Of Poor Quality
3.3.2 UNIVAC OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
NOTE - EQUI. LD17/RETN, LD20/REFMN
           LD49/ASMN, LD50/RETMN
           IN XRG07
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

Frequency Response of a 12-Bladed Disc
(Examples 1-5) 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:
   - Diameter at blade tip = 19.4 in.
   - Diameter at blade root = 14.2 in.
   - Shaft diameter = 4.0 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, RF6, 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:

   \[ P(f;n) = A(f) \cos \left( n - T \cdot \frac{2\pi}{12} \right) \]

   where
   \( n \) is the segment number,
   \( T \) represents \( k = 2 \),
   \( \frac{2\pi}{12} \) represents the total number of segments in the bladed disc.
   \( P \) is specified using RLOADi 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

<table>
<thead>
<tr>
<th>ID</th>
<th>NASA\textunderscore EXAMPLE1</th>
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</thead>
<tbody>
<tr>
<td>APP</td>
<td>DISP</td>
</tr>
<tr>
<td>SOL</td>
<td>0</td>
</tr>
<tr>
<td>TIME</td>
<td>15.  &amp; IBM 370/3031</td>
</tr>
<tr>
<td>DIAG</td>
<td>14.21</td>
</tr>
<tr>
<td>CEND</td>
<td></td>
</tr>
</tbody>
</table>
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

1 $ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

SUBTITLE = BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)

LABEL = INDEX 2C TYPE LOADS

$ SPC = 30

FREQ = 1

LOAD = 1

OUTPUT

SET 1 = 9, 2, 26, 80, 64, 70, 92, 126, 129, 140, 162.

16, 30, 44, 58, 73, 86, 100, 118, 126, 142, 156, 170.

18, 32, 48, 60, 74, 88, 102, 116, 130, 144, 150, 172

OLOAD = 1

DISP (SORT2, PHASE) = ALL

STRESS (SORT2, PHASE) = ALL

OUTPUT (XYPLOT)

PLOTTER NASTPLT, MODEL 0,0

XPAPER = 8.0

YPAPER = 10.5

XAXIS = YES

YAXIS = YES

XGRID LINES = YES

YGRID LINES = YES

CURVELINESYMBOL = 1

VLOG = YES

XTITLE = FREQUENCY (HERTZ)

YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)

XYPLOT, XPRINT DISP RESPONSE /14(T3RH), 18(T3RH), 95(T3RH)

XYPLOT, XPRINT STRESS RESPONSE /14(T3RH), 18(T3RH), 95(T3RH)

XCURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)

XYPLOT, XPRINT STRESS RESPONSE /11(3), 11(5), 11(7),

11(10), 11(12), 11(14)

XCURVE = 109(1), 109(5), 109(7), 109(10), 109(12), 109(14)

XYPLOT, XPRINT STRESS RESPONSE /109(1), 109(5), 109(7),

109(10), 109(12), 109(14)

BEGIN BULK

SER INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
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<th>4</th>
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This table represents the sorted bucket data echo code.
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:

   \[
   p^n(f) = A(f) \cos \left( n - \tau \cdot \frac{2\pi}{\Omega} \right),
   \]

   where
   - \( n \) is the segment number,
   - \( \tau \) represents \( k = 2 \),
   - \( \Omega \) 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.     9

BEGINNING OF RF ALTER 851 - RF 8 / SERIES R (LL17.71 / 1-20-82 / M.G. 9

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 9
2. RF ALTERS

CASE CONTROL DECK INPUT -

1. ALL SPG 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. OFREQUENCY 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 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 -

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**ORIGINAL PAGE OF POOR QUALITY.**

4.15
1. SUPPORT 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.
6. THE SKIP FACTOR FOR OUTPUT NO. ON 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. CYCLO - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE FORM OF THE INPUT AND OUTPUT DATA.
   A VALUE OF 0 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. CYTYP - FIXED - THE INTEGER VALUE OF THIS PARAMETER
   DEFINES THE TYPE OF CYCLIC SYMMETRY. THE VALUE
   OF THIS PARAMETER HAS BEEN SET TO -ROT- 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 LUMP. 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 0.0.

J. BXTID - OPTIONAL - THE POSITIVE INTEGER VALUES OF THESE
   PARAMETERS DEFINE THE SET IDENTIFICATION NUMBERS
   OF THE TABLED BULK DATA CARDS WHICH DEFINE THE
   BXPTID COMPONENTS OF THE BASE ACCELERATION VECTOR.
\textbf{NASTRAN EXECUTIVE CONTROL DECK ECHO}

\textbf{BYPTID} TABLES REFERED TO BY BYXTID, BYTID AND BZTID
\textbf{BZPTID} DEFINE MAGNITUDE (7.0) AND THE TABLES REFERED TO
\textbf{BYBPTID}, BYTID AND BZPTID DEFINE PHASE (DEGREE).
THE DEFAULT VALUES ARE -1 WHICH MEANS THAT THE
RESPECTIVE TERMS ARE IGNORED.

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

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

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

\textbf{N. COUPMASS} - FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.

\textbf{O. GKAD} - OPTIONAL - THE BCD VALUE OF THIS \textbf{PARAMETER IS
USED TO TELL THE GKAD MODULE THE DESIRED FORM OF
MATRICES RDO, BDO AND HDO. THE BCD VALUE CAN BE
FREKESP OR TRANRESP. THE DEFAULT IS TRANRESP.
SL: SECTION 9.3.3 (DIRECT DYNAMIC MATRIX
ASSEMBLY) PAGES 9.3-7 AND 9.3-8 OF THE
NASTRAN THEORETICAL MANUAL.}

\textbf{P. LGKAD} - OPTIONAL - THE INTEGER VALUE OF THIS \textbf{PARAMETER IS
USED IN CONJUNCTION WITH PARAMETER GKAD. IF
GKAD=FREKESP THEN SET LGKAD=1. IF GKAD=TRANRESP
THEN SET LGKAD=-1. THE DEFAULT VALUE IS -1.}

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

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

\textbf{S. W4} - OPTIONAL - THE REAL VALUE OF THIS \textbf{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. DEFAULT IS 0.0.}

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

\begin{align*}
4.17
\end{align*}
ALTER 3 $  
FILE UXVF=APPEND/PUT=APPEND/PD=APPEND  
$ PERFORM INITIAL ERROR CHECKS ON NSEGS AND KMAX.  
COND ERRORC1,NSEGS $ IF USER HAS NOT SPECIFIED NSEGS.  
COND ERRORC1,KMAX $ IF USER HAS NOT SPECIFIED KMAX.  
PARAM /C=N/EQ /V,N CYC1OERR /V,Y CYC1O=0 /C=N,O $  
COND ERRORC1,CYCLEERR $ IF USER HAS NOT SPECIFIED CYC1O.  
PARAM /C=N,DIV /V,N,NSEG2 /V,Y,NSEGS /C=N,2 $ NSEG2 = NSEGS/2  
PARAM /C=N,SUB /V,N,KMAXERR /V,Y,NSEG2 /V,Y,KMAX $  
COND ERRORC1,KMAXERR $ IF KMAX > GT. NSEGS/2  
$ SET DEFAULTS FOR PARAMETERS.  
PARAM /C=N,NUP /V,Y,NDKPKT=61 /V,Y,LDKAD=-1 $  
$ CALCULATE OMEGA, 2*OMEGA AND OMEGA**2 FROM RPS. SET DEFAULT RPS.  
PARAMR /C=N,HYP /V,N,OMEGA /V,Y,RPS=0.0 /C=N,O,283185 $  
PARAMR /C=N,HYP /V,N,GMEGA2 /C=N,2.0 /V,N,OMEGA $  
PARAMR /C=N,HYP /V,N,GMEASQR /V,N,OMEGA /V,N,OMEGA $  
$ GENERATE NTEGRIS FLAG IF KPS IS ZERO.  
PARAMR /C=N,EQ /V,Y,RPS /C,N,0.0 $ V,N,NORPS $  
$ MAKE SURF COUPLED MASSES HAVE NOT BEEN REQUESTED.  
PARAM /C=N,NUF /V,N,NOLUMP /V,Y,CLUMMASS=-1 $  
COND ERRORC2,NULLMP $  
ALTER 21,21 $ ADD SLT TO OUTPUT FOR TRLG.  
GP3 GEOM,ELLEX1,GEW2 / SLT,GPTT / V,N,NOGRAV $  
CNPST SLT,GPST $  
ALTER 23 $  
$ SINGLE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NOW SO THAT  
$ MAKE ERROR CHECKS CAN BE MADE BEFORE ELEMT GENERATION.  
$ ADD YS NEEDED FOR PSF RECOVERY IN SSG2.  
PARAM /C=N,HYP /V,N,ENSRIP /C=N,0 /C,N,O $  
GP4 CASECC,YLACK,ELLEX1,GPDT,BGPU,CMST/RG,YS,USET,ASET/V,N,LUSET/  
S,N,MPCF1/S,N,MPCF2/S,N,SINGLE/SPN,N,LREAlg/S,N,NSKIP/Y  
S,N,REPEAT/S,N,NUSET/S,N,NOUL/S,N,NOU/L/S,N,EA/ST/Y,ASL/UT/S,Y,OUTSIP  
RNUCE GM,MDT/MPCF1/GU,CMGT/FK,PSF,PSF,PSF /S,N,OGR,3 $  
CNPST GM,GM,GM,KS,GO,GD,KF,PSF,PSF,USET,Y $  
$ SUPERT BULK DATA IS NOT ALLOWED.  
PARAM /C=N NUT /V,N,REA DATA /V,N,REA CT $  
COND ERRORC3,REA CATA $  
$ EXECUTE DPD NOW SO CHECKS CAN BE MADE. ADD TRL TO OUTPUT DATA BLOCKS.  
DPD DYNAMICS,GPL,SIL,USET /GPL,SIL,USET,FPOOL,DLT,PSD,FRE,  
TRL,ELDYN /V,N,LUSET/S,N,DSETD/V,N,NUTFL/S,N,NULUT/  
S,N,NOFLSL/S,N,NOFLT/S,N,NOULFL/S,N,NOUL/PK/K,NEED/C,N/O  
$ MUST HAVE LTEERT FREE OR TSTEP BULK DATA.  
PARAM /C,N ANR /V,N,FTERR /V,N,NOFR /V,N,NOTRL $  
COND ERRORC5,FTERR $ NO FREE OR TSTEP BULK DATA.  
$ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL  
PARAML CASECC /C=N,UT /C,N,1 /C,N,14 /V,N,FREWSET $  
PARAML CASECC /C=N,UT /C,N,38 /V,N,TIMSE $  
PARAM /C=N,HYP /V,N,FREWTIME /V,N,FREWSET /V,N,TIMSET $
NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //C,N,NOT /V,N,FTEKI /V,N,FREUTINE $
PARAM //C,N,LE /V,N,NPRESS /V,N,FRESHET /C,N,0 $
PARAM //C,N,LE /V,N,NOTINE /V,N,TIMESET /C,N,0 $
COND ERRORS,FTEKI $ BOTH FREQ AND TIME IN CASE CONTROL DECK.
$ EPXINI $ ULK DATA NOT ALLOWED
PARAM //C,N,NCNT /V,N,EXTRAPTS /V,N,NOUE $
COND ERRORS,EXTRAPTS $
$ GENERATE DATA FOR CYC2Z MODULE.
CPVC GEOM4,EOBNL,USED /CYCDD /V,N,CTYPE=ROT /S,N,NGUG $
CCND ERRORS,NGUG $
CHPNT CYCDD $
ALTER 32 $
$ PRI-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED
PARAM //C,N,OK /V,N,NUBM1 /V,N,NGMGG /V,N,NGKPS $
PURGE V1GG,M1GG /AC01 $.
PURGE M2GG,M2BASEXG /NUMGG $
ALTER 35 $
$ GENERATE DATA BLOCKS FRRLX, BIGG, MLGG, M2GG AND BASEXG.
$ GENERATE PARAMETERS FKMAX AND NCBASEX.
CDUMO1 CASECC,DPOT,FCLM,T,BRFLX,MUG $ / FRLLX,BIGG,MLGG,
M2GG,BASEXG,P0ZERGS $ / V,N,NGMGG/V,Y,LICYC/V,Y,NGEGS/
V,Y,FKMAX/C,N,FKMAX/V,Y,BXU=1/V,Y,BXPTU=1/V,Y,BZTD=1/
V,Y,2PRTU=1/V,Y,NGBASEX/V,N,NGHEU/V,N,UMEGA $
PARAM FRLLX //C,N,PKESEND //V,N,NGFRLLX $
COND LBLFRLLX,NGFRLLX $
EQUIV FRLLX,FLK $.
LABEL LBLFRLLX $. 
CHPNT FRLL,BIGG,MLGG,M2GG,BASEXG $
ALTER 42 $
PARAM //C,N,ADD /V,N,NUBA $ /V,N,NUBM1 /C,N,0 $ RESET NGUG.
ALTER 52 $
$ REDEFINE BIGG AND KGG.
COND LBL11A,NGM1 $.
PARAM //C,N,COMPLEX // V,N,OMEGA2 / C,N,0,0 / V,N,CMPLX1 $
PARAM //C,N,SUB / V,N,OMEGASG / C,N,0,0 / V,N,OMEGASUR $
PARAM //C,N,COMPLEX // V,N,OMEGASG / C,N,0,0 / V,N,CMPLX2 $
AGE BIGG,BIGG / BIGG / C,N,(1,0,0,0) / V,N,CMPLX1 $
EQUIV BIGG,BIGG $
AGE KGG,MLGG / KGG1 / C,N,(1,0,0,0) / V,N,CMPLX2 $
EQUIV KGG1,KGG $
CHPNT BIGG,KGG $
LABEL LBL11A $
ALTER 53,55 $ GP4 HAS BEEN MOVED UP.
ALTER 57,68 $ LPU HAS BEEN MOVED UP.
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LGKAR FOR FREQ OR TRAN.
PARAM //C,N,AND /V,N,KULKA /V,N,NOUE /V,N,NGK2PP $
COND LGKAD1,LGKA2 & BRANCH IN GT FREQSP.
ALTER 115 $ SEE ALTER 114 COMMENT.
JUMP LGKAD2 $.

4.19
LABEL LGKA01 $
KAA,KDD/KDEKA $
CKPKNT K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDD,MDD $
LABEL LGKA02 $
ALTER 117 117 3 ADD PARAMETERS GKAU, n3 AND n1 TO GKAU
GKAU USFTD,GM,GO,KAA,CLMA,MAA,K4AA,K2PP,M2PP,B2PP/KDD+BUD,MDD,GMD
GUD*K2DD,M2DD,B2DD/C,Y,GKAD=TRANRESP/CN,DISP/CN,DIRECT/
C,Y,G=0.0/C,Y,n3=3.0/C,Y,n4=0.0/V,N,NOK2PP/V,N,NUMB2PP/
V,N,NGB2PP/V,N,MCPFL/V,N,SIMLE/V,N,HIT/V,N,NQUE/V,N,NOK4G6/
V,N,NOQGU/V,N,KDEK2/L,N,-1 $
ALTER 118 $ SEE ALTER 114 COMMENT
CNU LGKA03,LGKA0 $ BRANCH IF NOT FREGREP
ALTER 119 $ SEE ALTER 114 COMMENT
JUMP LGKA04 $
LABEL LGKA04 $
EOQUIV B2DD,GUD/NOGPNT/M2DD,MDD/NOSIMP/K2DD,KDD/KDEK2 $
LABEL LGKA04 $
ALTER 120 123 $
$ NEW SOLUTION LOGIC
$ GENERATE TIME-DEPENDENT LOADS IF TSTEP WAS REQUESTED IN CASE CONTROL
COND LBLTRL NOTIME $
$ LOOP THRU ALL SUBCASES FOR TIME-DEPENDENT LOADS
PARAM //C,N,MPY //V,N,REPEATT /C,N,1 /C,N,-1 $
PARAM //C,N,ADD /V,N,APPFLG /C,N,1 /C,N,0 $ INITIALIZE FOR SD01
JUMP TRLGLOOP $
LABEL TRLGLOOP $
CASE CASEYY/C,TRAN/S,N,REPEATT/S,N,NOLOOP1 $
CKPKNT CASEYY $
PARAM //C,N,MPY //V,N,NCOL /C,N,0 /C,N,1 $ 
TFLG CASEYY,USETD,UTL,SLT,BPUDT,SIL,STIM,TRL,UT,GM,HD,GUD,EST,HGG/
**PDT1,PD1,1CL//V,N,NSET/S,N,PDPEDO/V,N,NCOL $
SD01 TRLGPD1............ //PDT1 /V,N,APPFLG/C,N,DYNAMICS $
SD01 TRLGPD1............ //PD1 /V,N,APPFLG/C,N,DYNAMICS $
PARAM //C,N,ADD /V,N,APPFLG /V,N,APPFLG /C,N,1 $ APPFLG=APPFLG1
CNUO TRLGTONE,REPEATT $
KEEP TRLGLOOP,10G $
JUMP LKGRK3 $
LABEL TRLGONE $
CKPKNT PDT,PD,1CL $
EOQUIV PD,PD,PDPEDO $
LKPKNT PDT $
DUMNDZ TDL........ /FRKZ,FRZ,REGRER1,KERERZ........ / 
V,Y,NSEG/V,Y,TIGC/S,Y,LMAX=-1/V,N,FMAX/
S,N,FMAX/S,N,NSTEPS/S,N,NOHCL/S,N,NCRC2 $
EOQUIV FRKZ,FRZ /FOLZ,FCL $
CKPKNT FRKZ,FCL,KERER1,KERER2 $ 
JUMP LBLFRL2 $
LABEL LBLTRLI $
$ GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC.
FLG

CASEXX, USE, D1T, FRL, GU, C0, C1, / PPF, PSF, PDF, FUL, PHANO / 0, N, DIREC, V, N, FREQU, C0, N, FREQ

CONO
LFLRLX, NOFLR $ ZERO OUT LOAD COLUMNS IF FRL HAS BEEN GENERATED.

MPYAD
PPF, PDZERO, / PPF, IC, N, C

EQUIV
PPF, PDF $ 0,

LABEL
LFLRLX $ 0,

$ FORM NEW LOADS.

MPYAL
LFLRLX, NOBASEX $ 0,

ADL
PPF, M, BASEXG / PPF1 / C0, N, (1, 0, 0, 0) / C0, N, (-1, 0, 0, 0) $ 0,

EQUIV
PPF1, PDF $ 0,

CONO
LFLRLX, NUSET $ 0,

SSEG
USE0, G, Y, S, R, G0W, PDF / P, PDFUM, PDF1, PDF1 $ 0,

EQUIV
PS1, PDF / PDF1, PDF $ 0,

LABEL
LFLRLX $ 0,

LABEL
LFLRLX $ 0,

EQUIV
PPF, PDF, NUSET $ 0,

CHEPPN
PPF, PDF, PDF, FCL $ 0,

$ LOADS ARE FREQUENCY-DEPENDENT

$ PERFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIC=1.

PARAM
PDF / C0, N, Th, IM, LER / C0, N, / V, N, PDFCOLS $ 0,

$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=-1.

PARAM
/ C0, N, DIV / V, N, NLAD / V, N, PDFCOLS / V, N, FKMA $ NLAD = NF, FKMA

EQUIV
PDF, PDF / CYCIC $ 0,

CONO
LFLPABN, CYCIC $ 0,

$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=-1.

PARAM
/ C0, N, DIV / V, N, NLAD / V, N, PDFCOLS / V, N, NLAD $ NLAD = NF, NSEG

LUPI
PDF / PAF, GYCF1 / V, N, LTYPE / C0, N, FERE / V, N, NSEG = -1 / V, N, NLAD / S, N, NCIG $ 0,

CONO
ERRRCL, NCIG $ 0,

CPUKNT
PDF $ 0,

JUMP
LFLPABN $ 0,

LABEL
LFLRL2 $ 0,

$ LOADS ARE TIME-DEPENDENT

PARAM
/ C0, N, N0U1 / V, N, NOTCYCIC / V, Y, CYCIC $ 0,

$ BRANCH DEPENDING ON VALUE OF CYCIC

CONO
LULTRL2, NOTCYCIC $ 0,

$ CYCIC=-1

EQUIV
PDF, PDFZ1 / NOUNI $ 0,

CONO
LULRLN, NOUNI $ 0,

MPYAD
PDF, KEKDF, O1 / PDFZ1 / C0, N, J $ 0,

LABEL
LULRL1A $ 0,

LUPI
PDFZ1 / PXFR21 / CYCF2 / V, N, LTYPE / C0, N, FERE / V, N, NTSTEM $ 0,

CONO
ERRRCL, NCIG $ 0,

CPUKNT
PXFR21 $ 0,

EQUIV
PXFR21, PDFZX / NOUNI $ 0,

CONO
LULRUD, NOUNI $ 0,

MPYAD
PXFR21, KEKDFR2 / PDFZ1 / C0, N, O $ 0,

LABEL
LULRUD $ 0,

4.21
ORIGINAL PAGE IS OF POOR QUALITY

NASTRAN EXECUTIVE CONTROL DECK ECHO

EQUIV PXF1, PXF1 $  
CHKPNT PXF1 $  
JUMP LBLTRL3 $  
LABEL LBLTRL2 $  
$ CYC10 = 01  
MPYAD PDT, REORDER1, / PDTZ2 / C,N,0 $  
CYC11 PDTZ2 / PXTRZ2, GGYCF3 / V,N,CTYPE/C,N,FORE/V,Y,NSTEPS/V,Y,LMAX/  
V,Y,NSEGS/S,N,NOGC $  
COND ERRORC1, NOGO $  
CHKPNT PXTRZ2 $  
EQUIV PXTRZ2, PXTRZ2/NUR02 $  
COND LBLRO2B, NUR02 $  
MPYAD PXTRZ2, REORDER2, / PXTRZ2 / C,N,0 $  
LABEL LBLRO2B $  
CYC11 PXTR2 / PXFZ2, GGYCF4 / V,N,CTYPE/C,N,FORE/V,Y,NSEGS/V,Y,KMAX/  
V,Y,FLMAX/S,N,NOGC $  
COND ERRORKL1, NOGC $  
EQUIV PXFZ2, PXF1 $  
CHKPNT PXF1 $  
LABEL LBLTRL3 $  
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND  
$ TO FREQUENCY DEPENDENT LOADS. ALSC SOL2 EXPECTS LOADS TO BE COMPLEX  
$ IN FREQUENCY TYPE PROBLEMS.  
COPY PXF1 / PXFZ2 $ CONVERT REAL PXF1 TO COMPLEX PXF.  
ADL PXF1, PXF2 / PXF / C,N,0,5,1,0) / C,N,0,5,-1,0) $  
$ DEFINE LOAD FOR CYC12.  
PARAM // C,N,ADD / V,N,LLOAD / V,N,FLMAX / C,N,0 $ NLCAD = FLMAX  
LABEL LULPJCNE $  
PARAM // C,N,ADD / V,N,KINEQ / 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 $  
CYC12 CYCOO, , , PXF, , , PKF2, , , C,N,FRE / V,Y,NSEGS/  
V,N,KMINV/V,N,CYSEQ/V,N,NLCAD/S,N,NOGC $  
COND ERRORK1, NOGC $  
ADL PKF2, / UKVF2 / C,N,0,0,0 $  
CYC12 CYCOD, , , LKVFZ, , , UXVF, , / C,N, BACK / V,Y,NSEGS/  
V,N,KMINV/V,N,CYSEQ/V,N,NLOAD/S,N,NOGC $  
COND ERRORK1, NOGC $  
PARAM // C,N,ADD / V,N,KMINV / C,N,1 $  
REPT KMINLUP, KMINL $  
LABEL NOKMINL $  
$  
JUMP TUPCYC $  
LABEL TUPCYC $ LOOP ON KINDEX

4.22
CONU NOKPT,NOKPT $ 
PKTPAKM /C.N.O /C.N.KINDEX $ 
LABEL NOKPT $ 
CYCT2 CYCO@,KOU,MDD,... /KKKF,PKF,... /C,N,FORE/V,Y,NSEG $ 
V,N,KINDEX/V,V,N,CYSEQ=1/V,N,NLOAD/S,N,NOGD $ 
CONU ERRORCI,NOGU $ 
CHKPT KKF,PKF $ 
PARAM /C,N,SYST /C,N,59 /C,N,2 $ METHOD 3T IN CYCT2 PRODUCES $ UNDERFLOW FOR PKF, USE METHOD 2. 
CYCT2 CYCDU,BDD,PKF,... /KKKF,PKF,... /C,N,FORE/V,Y,NSEG $ 
V,N,KINDEX/V,N,CYSEQ/V,N,NLOAD/S,N,NOGD $ 
PARAM /C,N,SYST /C,N,59 /C,N,0 $ RESET HPGAU METHOD CONTOL. 
CONU ERRORCI,NOGU $ 
CHKPT KKF,PKF $ 
$ SOLUTION 
PRKD2 KKF,PKF,... /PKF,PKF,... /KUF /UKVF /C.N.O /C.N.O /C.N.-1.0 $ 
CHKPT UKVF $ 
CYCT2 CYCOU,...,UKVF,... /UKVF,... /C,N,BACK/V,Y,NSEG/V,N,KINDEX/ 
V,N,KINDEX/V,N,NLOAD/S,N,NOGD $ 
CONU ERRORCI,NOGU $ 
CHKPT UKVF $ 
PARAM /C,N,SAU /V,N,KINDEX/V,N,KINDEX /C,N,1 $ KINDEX = KINDEX & 1 
PARAM /C,N,SNB /V,N,DONE /V,Y,KMAX /V,N,KINDEX $ 
CONU LCYCI2,UCNE $ IF KINDEX .GT. KMAX THEN EXIT 
REPT TOLCY1,INC $ 
JUMP ERROR3 $ 
LABEL LCYCI2 $ 
EVUUV UKVF,UVF /LCYCI $ 
CHKPT UVF $ 
CONU LCYCI3,LCYCI $ IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL. 
CYTII UVF /UVF,LCYCL1/V,N,CYCL1 /V,N,CYCL2 /V,N,BAK/C,N,BACK/V,Y,NSEG/V,Y,KMAX/ 
V,N,NLOAD $ 
CHKPT UVF $ 
LABEL LCYCL $ 
CONU LBLC14,NOTML $ 
EVUUV PKF,PKF,... /LCYCI $ 
CCD LCYCI4,LCYCI $ IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL. 
CYTII PKF /PKF,LCYCL2 /V,N,CYCL2 /V,N,CYCL2 /V,N,BAK/C,N,BACK/V,Y,NSEG/V,Y,KMAX/ 
V,N,NLOAD $ 
LABEL LCYCL $ 
$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PKF. 
SDR1 USEUD,PF2,...,GOO,GMDO,... /PPF2,... /C,N,1 /C.N,DYNMICS $ 
SCC2 USEUD,GMDO,VS,KS,CGO,...,PPF2,... /PPCUM,PSF2,PLDUM $ 
LQPIV PPF2,PPF //PSF2,PSF $ 
CHKPT PPF,PSF $ 
LABEL LBLC14 $ 
ALTER 124,124 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST. 
VON CASEXX,LDV,USEUD,UVF,FCL,XYCOU /UVFYCL1/C.N,FREQLSP/C.N, 
DIREC/ C,N,KO1,GO12/S,N,NOGD /S,N,NUP /C,N,O $ 
ALTER 140,140 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST. 

4.23
SUN2 CASE XX.CSTM.MPT.DT,EUDYNSIL.

+BPDCP.FLL.UPVC.ESY,XYDDB.

PPF.UPPC1.UGPC1.UDPVC1.GESCL.CEFCL.PUPVC1/C,SN.FREQRES.

YES.NOSORT2 $.

ALTER 160 $ ADD LABEL FOR ERROR3.

LABEL ERROR3 $.

ALTER 163,166 $ REMOVE ERROR1 AND ERROR2.

ALTER 168 $ FORCED VIBRATION ERRORS.

LABEL ERR1RC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.

PERTAM //CN,-7 /CN,CYCSTATIC $.

LABEL ERR1RC2 $ COUPLED MASS NOT ALLOWED.

PERTAM //CN,0 /CN,CYCCOUPL $.

JUMP FINIS $.

LABEL ERR1RC3 $ SUPPORT BULK DATA NOT ALLOWED.

PERTAM //CN,-6 /CN,CYCSTATIC $.

LABEL ERR1RC4 $ EPCINT BULK DATA NOT ALLOWED.

PERTAM //CN,0 /CN,CYCE $.

JUMP FINIS $.

LABEL ERR1RC5 $ NEITHER FREW OR TSTEP WERE IN BULK DATA DECK.

PERTAM //CN,0 /CN,NCTRL $.

PERTAM //CN,0 /CN,NDTEN $.

JUMP FINIS $.

LABEL ERR1RC6 $ BOTH FREW AND TSTEP WERE SELECTED IN CASE CONTROL.

PERTAM //CN,0 /CN,NDELDR $.

PERTAM //CN,0 /CN,NOTIME $.

JUMP FINIS $.

END ALTER.

TIME 5 $ IBM 370/3031

DIAG 14.21

CEND
CASE CONTROL DECK ECHO

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

CARD
COUNT
51 YPAPER = 10.5
52 XAXIS = YES
53 YAXIS = YES
54 XGRID LINES = YES
55 YGRID LINES = YES
56 CURVELINESYMBOL = 1
57 YLOG = YES
58 XTITLE = FREQUENCY (HERTZ)
59 YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
60 TCURVE = 14(T3RH), 18(T3RH)
61 XYPLOT, XYPRINT DISP RESPONSE 1 / 14(T3RH), 18(T3RH)
62 TCURVE = 2(T3RH)
63 XYPLOT, XYPRINT DISP RESPONSE 8 / 2(T3RH)
64 XTITLE = ELEM ENENT STRESSES (MAGNITUDE, PSI)
65 TCURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
66 XYPLOT, XYPRINT STRESS RESPONSE 1 / 11(3), 14(5), 11(7),
67 11(10), 11(12), 11(14)
68 TCURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
69 XYPLOT, XYPRINT STRESS RESPONSE 10 / 11(3), 11(5), 11(7),
70 11(10), 11(12), 11(14)
71 BEGIN BULK

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TOPO ON POOR QUALITY.

4.29
EXAMPLE 3

A. Description

This example uses the forced vibration capability with cyclic symmetry. The 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,
   CYCIO = -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 TABLEI1 bulk data cards to specify
   BAPTID, BYPTID, 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) \P^0,2c = A(f) specified on RLOAD1 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:

\[
(1700 - 600) = 1100 \quad \text{to} \quad (1920 - 500) = 1320 \text{ Hz}, \quad \text{and} \\
(1700 + 600) = 2300 \quad \text{to} \quad (1920 + 600) = 2520 \text{ Hz}.
\]

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**

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2. SUBTITLE = BLADED DISC EXAMPLE 3 (CUT-RHOIEM,FREQUENCY ACCH LOAD,MASS 1/0)
3. SPC = 30
4. FREQ = 1

OUTPUT
5. SET 1 = 0,16,18
6. SET 2 = 11
7. OLOAD = 1
8. DISP(SORT2,PHASE) = 1
9. STRESS(SORT2,PHASE) = 2

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10. LABEL = KINDEK 9
11. OLOAD = 1
12. AXIAL BASE ACCH LOADS VIA PARAM BVID,BXPTID

SUBCASE 2
13. LABEL = KINDEK 1C
14. AXIAL BASE ACCH LOADS VIA PARAM BVID

SUBCASE 3
15. LABEL = KINDEK 1S
16. LATERAL BASE ACCH LOADS VIA PARAM BVID

SUBCASE 4
17. LABEL = KINDEK 2C
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53. YPAPER = 10.5
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55. YAXIS = YES
56. XGRID LINES = YES
57. YGRID LINES = YES
58. CURVELINESYMBOL = 1
59. XTITLE = FREQUENCY (HERTZ)
60. YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
61. YLOG = YES
62. TSCALE = BIT(3RH),10(3RH)
63. XYPLOT,XPRINT DISP RESPONSE 1 /8(T3RH),10(T3RH)
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72. YLOG = YES
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55 XYPLOTEXYPRINT STRESS RESPONSE 4/11(16),11(18)
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FORMAT MESSAGE 207. BULK DATA NOT SORTED XSORT WILL RE-ORDER DECKS

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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 (\( \& = 1 \)) -- the parameter LMAX accordingly has been set at 1 (\( \& = 0, 1c, 1s \)).

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
   LGKAD = +1 used.

2. Constraints:

   Same as general input constraints.

3. Loads:

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

   where
   
   \( n \) is the segment number,
   
   \( \theta \) represents \( k = 2 \),
   
   \( \Omega \) 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
$             ALTER PACKAGE AS IN EXAMPLE2
$             TIME          4 $ IBM 370/3031
DIAG         8,14,21
CEND
CASE CONTROL DECK ECHO

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

INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
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**Note:** The table appears to be sorted bulk data echo with various entries and context numbers.
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Sorted Bulk Data Echo

4.43
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,
   
   \[
   \begin{align*}
   \text{CYCIO} &= -1 \quad \text{harmonic cyclic input/output data} \\
   \text{KMIN} &= 2 \quad \text{minimum circumferential harmonic index} \\
   \text{KMAX} &= 2 \quad \text{maximum circumferential harmonic index} \\
   \text{LMAX} &= 1 \quad \text{maximum harmonic in the Fourier decomposition of periodic, time-dependent loads.} \\
   \text{NSEGS} &= 12 \quad \text{number of rotationally cyclic sectors} \\
   \text{RPS} &= 600.0 \quad \text{revolutions per second} \\
   \text{GKAO} &= \text{FREQRES} \quad \text{Specify the form in which the damping parameters} \\
   \text{LGKAD} &= +1 \quad \text{are used.}
   \end{align*}
   \]

2. **Constraints:**

   Same as general input constraints.

3. **Loads:**

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

   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

ID NASA,EXAMPLE5
APP DISP
SOL 8
$ ALTER PACKAGE AS IN EXAMPLE2
$ TIME 3 $ IBM 370/3031
DIAG 8,14,21
CEND
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 = 0,16,16
$ SET 2 = 11
$ OLOAD = 1
$ DISP (SCPT2, REAL) = 1
$ STRESS (SCRT2, REAL) = 2
$ SLCASE 1
$ LABEL = KINDEX 0
$ OLOAD = 99 & NULL LOAD
$ SLCASE 2
$ LABEL = KINDEX 1C
$ OLOAD = 99 & NULL LOAD
$ SLCASE 3
$ LABEL = KINDEX 1S
$ OLOAD = 95 & NULL LOAD
$ SLCASE 4
$ LABEL = KINDEX 2C
$ OLOAD = 1 & TIME DEPENDENT LOADS
$ SLCASE 5
$ LABEL = KINDEX 2S
$ OLOAD = 99 & NULL LOAD
$ BEGIN BULK

$ FINISH "KSCRT 207", BULK DATA NOT SCPTED, XSCRT WILL RE-ORDER DECK.
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**PARAMETERS**

- Cyclic: -1
- G: 0.02
- GKAD: 2
- KMAX: 2
- KWIN: 2
- LGKAD: 1
- LMAX: 1
- NSEGS: 12
- EPS: 600.0
- GRAD2: 2
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ENDATA

5.5131-41813.854-90.0

4.48
TABLE 1: PRINCIPAL FEATURES DEMONSTRATED BY EXAMPLE PROBLEMS

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<th>Time (periodic)</th>
<th>Base Acceleration</th>
<th>Rotational Speed</th>
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<td>2460 (4)</td>
</tr>
</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 Segment 1 (subcase 1)</th>
<th>Example 3 k = 2c (subcase 4)</th>
</tr>
</thead>
<tbody>
<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>

4.51
TABLE 4: COMPARISON OF RESPONSE AT 1814 Hz

<table>
<thead>
<tr>
<th>Grid Pt. Disp. or Elem. Stresses</th>
<th>Example 3</th>
<th>Example 4</th>
<th>Example 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$k = 2c$ (subcase 4)</td>
<td>Segment 1 (subcase 1)</td>
<td>$k = 2c$ (subcase 4)</td>
</tr>
<tr>
<td>Grid Pt. Disp. or Elem. Stresses</td>
<td>Mag.(in)/Phase(deg)</td>
<td>Mag.(in)/Phase(deg)</td>
<td>Mag.(in)/Phase(deg)</td>
</tr>
<tr>
<td>8 (T3RM), $u_z$</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), $\sigma_{xx,1}$*</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), $\sigma_{yy,1}$</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), $\tau_{xy,1}$</td>
<td>1.0774 E 2/64.7</td>
<td>1.0775 E 2/64.7</td>
<td>1.0775 E2/64.7</td>
</tr>
<tr>
<td>11 (10), $\sigma_{xx,2}$*</td>
<td>1.4677 E 3/263.3</td>
<td>1.4678 E3/263.3</td>
<td>1.4678 E3/263.3</td>
</tr>
<tr>
<td>11 (12), $\sigma_{yy,2}$</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), $\tau_{xy,2}$</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
Figure 4

141T3AM), 181T3AM, 951T3AM)
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES.
BLADED DISC EXAMPLE 1 (FULL MODEL,FREQ LOADS)
INDEX 2C TYPE LOADS

1E-5 1E-4 1E-3
1.68 1.72 1.76 1.80 1.84 1.88 1E-3
GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)

FREQUENCY (HERTZ)
Figure 6

FREQUENCY (HERTZ)
109(3), 109(5), 109(7), 109(9), 109(12), 109(14)
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE I (FULL MODEL, FREQUENCY LOADING)
MINIMUM LC TYPE LOADS

4.58
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FREED LOADS, PHYSICAL I/O)
SEGMENT 1
SUBCASE 1

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

Figure 8
Figure 9

Forced vibration analysis of rotating cyclic structures
Bladed disc example 2 (cyc model, FRF loads, physical 1/2)
Segment 1
Subcase 1
FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES
BLADED DISC EXAMPLE 2 (CYC MODEL, FIXED LOADS, PHYSICAL 1/3)
SEGMENT 10
SUBCASE 10

Figure 10
Figure 11: Base Acceleration Data in an Inertial Coordinate System
FREQUENCY Hertz

Figure 12
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 ICYC MODEL, FREQ=BASE ACCN LOAD, HARM 1/0, KINDEX 0, SUBCASE 1

Figure 13 4.65
Figure 14

Bladed Disc Example 3 (CYC Model, Freo: Base, Accn Load, MAM 1/0, KINDEX 1C)

Subcase 2
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQ+BASE ACCN LOAD, HARM 1/0
KINDEX 1C
SUBCASE 2

Figure 15
4.67
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 CYCLE MODEL, FREQ-BASE ACCN LOAD, HARM 1/0
KINDEX 1C
SUBCASE 2

Figure 16
Figure 17

Forced vibration analysis of rotating cyclic structures
Bladed disc example 3 (CYC model, free-base, mech load, harm 1/0, subcase 1)

KINDEX 15

BIT3AH, 18BIT3AH
Forced vibration analysis of rotating cyclic structures
Bladed disc example 3 (cyclic model, freq-base acc load, harm 1/0)
Kinex 15

Figure 18
Figure 19
End of Document