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Forced Vibration Analysis of Rotating Cyclic Structures in NASTRAN

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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 NAS3-22333 from NASA Lewis Research Center, Cleveland, Ohio, with Mr. Richard E. Morris as the Technical Monitor.
FORCED VIBRATION ANALYSIS
OF ROTATING CYCLIC STRUCTURES
IN NASTRAN

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ABSTRACT

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

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

\[ M^n u^n + B^n u^n + K^n u^n = P^n - M^n_2 \hat{R}, \quad n = 1, 2, ..., N. \quad (1) \]

For the \( n^{th} \) cyclic sector, \( u^n \) represents the vibratory degrees of freedom; \( M^n, B^n \) and \( K^n \) represent its mass, damping and stiffness matrices respectively; \( P^n \) represents the directly applied loads on \( u^n \), and \( -M^n_2 \hat{R} \) represents the inertial loads on \( u^n \) due to base acceleration \( \hat{R} \). The damping matrix \( B^n \) consists of the viscous and structural damping, and the contribution due to the Coriolis acceleration, i.e.,

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

(2)

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

\[ K^n = K^n_{\text{elastic}} + K^n_{\text{differential}} - \Omega^2 M^n_{\text{centripetal}}. \quad (3) \]

The derivation of the coefficient matrices \( B^n_{\text{Coriolis}}, M^n_{\text{centripetal}} \) 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),

\[ u^n_{\text{side 1}} = u^n_{\text{side 2}}, \quad n = 1, 2, ..., N. \quad (4) \]

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

1.2.2 Method of Solution

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

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

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

3) Solution of frequency-dependent circumferential harmonic components of displacements.

1.2
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

\[
p^n = p^n + \sum_{\ell=1}^{\infty} \left[ p^n \cos(m-1) + p^n \sin(m-1) \right] + (-1)^{M-1} p^n , \quad (5)
\]

where \( b = 2\pi/M \), \( \ell_L = (M-1)/2 \) 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 \( p'^{\ell_L} \) ("\( \ell_L \) = 0; \( \ell_L \) = 1, 2, ..., \( M/2 \)) in equation (5) are independent of time, and are defined by the relations

\[
p^n = \sum_{m=1}^{M} p^n_m \quad \ell = 0 \quad (6)
\]
Each of the coefficient vectors $p^n$ on the left hand sides of equations (6) can further be expanded in a circumferential (truncated) Fourier series

$$p^n = p^0 + \sum_{k=1}^{k_L} \left[ p^{kC} \cos(n-ka) + p^{kS} \sin(n-ka) \right] + (-1)^{n-1} p^{n/2} \quad (7)$$

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

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

$$p^0 = \frac{1}{N} \sum_{n=1}^{N} p^n \quad (k = 0) \quad (9)$$

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

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

$$p^{n/2} = \frac{1}{N} \sum_{n=1}^{N} (-1)^{n-1} p^n \quad (N \text{ even only}) \quad (k = N/2).$$

1.4
The terms $p^{\text{h}}_k$ ($k = 0; k_c, k_s, k = 1, 2, \ldots, k_L; N/2$ and $k = 0; k_c, k_s, k = 1, 2, \ldots, k_L; N/2$) 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

$$p^m_n = p^m_0 + \sum_{k=1}^{k_L} \left[ p^{\text{h}}_k \cos(m\theta_k) + p^{\text{h}}_k \sin(m\theta_k) \right] + (-1)^{m-1}p^m_0^{N/2}, \quad (10)$$

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

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

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

This type of loads can be represented as

$$p^m_n = p^m_0 + \sum_{k=1}^{k_L} \left[ p^{\text{h}}_k \cos(n\theta_k) + p^{\text{h}}_k \sin(n\theta_k) \right] + (-1)^{n-1}p^{N/2}_0, \quad (11)$$

where $\theta_k$ ($= 1, 2, \ldots, F$) now represents the frequencies at which excitation is specified. The transformed frequency-dependent circumferential harmonic components $p^{\text{h}}_k$ ($"k" = 0; k_c, k_s, k = 1, 2, \ldots, k_L; N/2$) are obtained using equations (9) with $"\theta"$ as defined above.

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

These loads are the transformed frequency-dependent circumferential harmonic components $p^{\text{h}}_k$ ("k" = 0; k_c, k_s, k = 1, 2, \ldots, k_L; N/2) with "k" (=1, 2, \ldots, F) representing the various frequencies at which the directly applied loads are specified.

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

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

2. Lateral components contribute to $F^{*k}$ where "k" = 1c and 1s, and "z" represents the effective excitation frequencies which are shifted from the specified frequencies by $\omega$, the rotational frequency.

The user specifies the components of the base acceleration vector $\ddot{R}$ as functions of frequency. The program computes the inertial loads $-M_2^{*k}\ddot{R}$ 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:

\[
\begin{align*}
\bar{u}^{0}_{2} &= \bar{u}^{0}_{1} \\
\bar{u}^{kc}_{2} &= \bar{u}^{kc}_{1} \cos(ka) + \bar{u}^{ks}_{1} \sin(ka) \\
\bar{u}^{ks}_{2} &= -\bar{u}^{kc}_{1} \sin(ka) + \bar{u}^{ks}_{1} \cos(ka) \\
\text{and } \bar{u}^{N/2}_{2} &= -\bar{u}^{N/2}_{1} \\
\end{align*}
\]

\(k = 0, 1, 2, \ldots, k_L\) \(k = N/2\) \(k = k_L/2\)

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

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

$\bar{u}^{kc}$ and $\bar{u}^{ks}$ 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 \( \bar{u}^k \) in the equations of motion, (1), results in the transformed equations of motion (Reference 3)

\[
\bar{M}^k \bar{u}^k + \bar{B}^k \bar{u}^k + \bar{K}^k \bar{u}^k = \bar{p}^k
\]  \hspace{1cm} (14)

where

\[
\bar{M}^k = \bar{G}_{ck}^T M^n G_{ck} + G_{sk}^T M^n G_{sk},
\]

\[
\bar{B}^k = \bar{G}_{ck}^T \bar{B}^n G_{ck} + G_{sk}^T \bar{B}^n G_{sk},
\]

\[
\bar{K}^k = \bar{G}_{ck}^T \bar{K}^n G_{ck} + G_{sk}^T \bar{K}^n G_{sk}, \text{ and}
\]

\[
\bar{p}^k = \bar{G}_{ck}^T \bar{p}_{kc} + G_{sk}^T \bar{p}_{ks}.
\]  \hspace{1cm} (15)

As discussed in subsection 1 of Section 1.2.2, \( \bar{p}_{kc} \) and \( \bar{p}_{ks} \) are the transformed frequency-dependent circumferential harmonic components of the directly applied and base acceleration loads.

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

\[
\bar{p}^k = \bar{p}_{ke} \omega^\ast t \quad \text{and accordingly,}
\]

\[
\bar{u}^k = \bar{u}_{ke} \omega^\ast t,
\]  \hspace{1cm} (16)

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

\[
[-\omega^2 \bar{M}^k + i\omega \bar{B}^k + \bar{K}^k] \bar{u}^k = \bar{p}^k.
\]  \hspace{1cm} (17)

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

\[
\omega^\ast = \omega \text{ for all directly applied and axial true acceleration loads, and}
\]

\[
= \omega \Omega \text{ for lateral base acceleration loads.}
\]  \hspace{1cm} (18)

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

4. Recovery of Frequency-Dependent Displacements in Various Segments

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

For loads specified as functions of frequency, equation (11) is used to obtain the displacements $u^{i}_{k}$ in various segments with $\omega_{i}^{*}$ 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


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.

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

Yes

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

Recovery of dependent displacements

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

Exit

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

2.1 Introduction

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

2.2 NASTRAN Model

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

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

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

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

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

The following notes apply when using TLOAD bulk data cards:

1. Time delay t must be set to zero.
2. In conjunction with the TSTEP bulk data card, TLOAD information is used to discretely define \( P(t) \) at \( M \) time instances as \( p^m \) or \( p^m \), \( (m = 1, 2, ..., M) \), as discussed in Section 1.2.2 of the Theoretical
3. $P(t)$ is defined in the interval $[T_1, T_2]$ with $(T_2 - T_1)$ 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 $\text{PARAMs BXTID, BXPTID, BYTID, BYPTID, BZTID and BZPTID}$.

The user is provided with two options to include damping by specifying the form of the matrices $K_{dd}$, $B_{dd}$ and $M_{dd}$ in the Functional module $\text{GKAD}$ as per equations 16 through 21, pages 9.3-7 and 9.3-3, Section 9.3.3 of the NASTRAN Level 17.7 Theoretical Manual. The $\text{PARAMeters GKAD and LGKAD}$ 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, ≤NSEG/2 for even NSEG, ≤(NSEG-1)/2 for odd NSEG) determine the number, order, and meaning of subcases as follows:

**CYCIO=+1**

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

- SUBCASE 1 (SEGMENT NO. 1)
- SUBCASE 2 (SEGMENT NO. 2)
- ...
- SUBCASE NSEG (SEGMENT NO. NSEG)

**CYCIO=-1**

The number of subcases is equal to KMAX, where

- KMAX = 1, if KMAX = 0,
- = 1 + 2 ⋅ KMAX, if 0 < KMAX ≤ (NSEG-1)/2, NSEG odd,
- = 1 + 2 ⋅ KMAX, if 0 < KMAX ≤ (NSEG-2)/2 NSEG even, and
- = NSEG, if KMAX = NSEG/2, NSEG even.

- SUBCASE 1 ('k' = 0)
- SUBCASE 2 ('k' = 1c)
- SUBCASE 3 ('k' = 1s)
- SUBCASE 4 ('k' = 2c)
- SUBCASE 5 ('k' = 2s)
- ...
- SUBCASE KMAX ('k' = KMAX)

In the event that NSEG is even and KMAX = NSEG/2, Subcase KMAX 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 RLOAD bulk data cards, null loads need not be specified by the user. With TLOAD bulk data cards, the user is required to provide information to generate null loads where applicable.
Base acceleration is included only when CYCIO=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

BEGINNING OF RF ALTER 241 - RF 8 / SERIES R (L17-7) / 1-28-82 / M.G.

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

EXECUTIVE DECK INPUT -

1. SOL 8
2. 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 FREQ, FREQ1 OR FREQ 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-STEMPS TO BE USED FOR LOCAL DEFINITION AND MUST BE DEFINED ABOVE THE SUBCASE LEVEL.
5. DIRECT INPUT MATRICES ARE NOT ALLOWED.
6. OFREQUENCY MUST NOT BE USED.
7. A SEPARATE GROUP OF SUBCASES MUST BE DEPLETED FOR EACH SYMMETRIC SEGMENT.
8. ACLOAD MUST BE USED TO DEFINE A FREQUENCY OR TIME-DEPENDENT LOADING CONDITION FOR EACH SUBCASE.
9. FOR FREQUENCY-DEPENDENT LOADS, SUBCASES WITHOUT LOADS NEED NOT REFER TO A LOADING CARD.
10. FOR TIME-DEPENDENT LOADS, SUBCASES WITHOUT LOADS MUST REFER TO A LOADING CARD THAT GENERATES A NULL LOAD.
11. AN ALTERNATE LOADING METHOD IS TO DEFINE A SEPARATE GROUP OF SUBCASES FOR EACH HARMONIC INDEX, K. THE PARALLEL CYCLIC 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. 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, OR THE TSTEP CARD MUST BE 1.
7. 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. CYCSEQ - 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 BC0 VALUE OF THIS PARAMETER
   DEFINES THE TYPE OF CYLIC SYMMETRY. THE VALUE
   OF THIS PARAMETER HAS BEEN SET TO -NOT- FOR
   ROTATIONAL SYMMETRY.
E. KMAX - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE MAXIMUM VALUE OF THE HARMONIC
   INDEX. THERE IS NO DEFAULT FOR THIS PARAMETER.
   THE MAXIMUM VALUE THAT CAN BE SPECIFIED IS NSEGS/2
F. KMIN - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER
   SPECIFIES THE MINIMUM VALUE OF THE HARMONIC
   INDEX TO BE USED IN THE SOLUTION LOOP. KMIN CAN
   BE A Voice. 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 3.0.
J. bxtid - OPTIONAL - THE POSITIVE INTEGER VALUES OF THESE
   BYTID PARAMETERS DEFINE THE SET IDENTIFICATION NUMBERS
   BZTID OF THE TABLED BULK DATA CARDS WHICH DEFINE THE
   COMPONENTS OF THE BASE ACCELERATION VECTOR. THE
BYPTIO  TABLES REFERRED TO BY BYTIO, BYT10 AND BYT10

BYTIO  DEFINE MAGNITUDE (LT-2) AND THE TABLES REFERRED TO

BY BYTIO, BYT10 AND BYT1E DEFINE PHASE (DEGREE).

BYT10  THE DEFAULT VALUES ARE -1 WHICH MEANS THAT THE

K. NOKPRT  RESPECTIVE TERMS ARE IGNORED.

L. GROPT  OPTIONAL - AN INTEGER VALUE OF 61 FOR THIS

PARA'AMETER WILL CAUSE THE CURRENT HARMONIC INDEX, KINDA, TO BE PRINTED AT THE TOP OF THE HARMONIC

LOOP. THE DEFAULT VALUE IS 61.

M. HCMAS  OPTIONAL - A POSITIVE INTEGER VALUE OF THIS

PARAMETER WILL CAUSE THE GRID PRINT WEIGHT GENERATOR TO BE EXECUTED AND THE RESULTING WEIGHT

BALANCE INFORMATION TO BE PRINTED. DEFAULT IS -1.

A. MCMPAS  THE TERMS OF THE STRUCTURAL MASS

MATRICES ARE MULTIPLIED BY THE REAL VALUE OF THIS

PARAMETER WHEN THEY ARE GENERATED IN EN, THE

DEFAULT IS 1.0.

G. GRAD  FIXED - ONLY LUMPED MASS MATRICES MUST BE USED.

G. KMASS  OPTIONAL - THE ODO VALUE OF THIS PARAMETER IS

USED TO TELL THE GRAD MODULE THE DESIRED FORM OF

MATRICES K20, BB2, AND K20. THE B0D VALUE CAN BE

FREQUENCY OR TRANSFORM. THE DEFAULT IS TRANSFORM.


SEE SECTION 9.3.3 (DIRECT DYNAMIC MATRIX

ASSEMBLY) PAGES 9.3-7 AND 9.3-8 OF THE

NASTRAN THEORETICAL HANDBOOK.

P. LKAD  OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER

IS USED IN CONJUNCTION WITH PARAMETER GRAD. IF

GRAD=FREQUENCY THEN SET LKAD=1. IF GRAD=TRANSFORM

THEN SET LKAD=-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=TRANSFORM. 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=TRANSFORM. 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,

   KINDA = KMIN TO KMAX.
FILE UXVF=APPEND/PDI=APPEND/PD=APPEND
$ PERFORM INITIAL ERROR CHECKS ON NSEG5 AND KMAX.
CUND ERRCR1,NSEG5 $ IF USER HAS NOT SPECIFIED NSEG5.
CUND ERRCR1,MAX $ IF USER HAS NOT SPECIFIED KMAX.
PARAM //CN,N0, CYCLOERR //V,Y, CYCLO=0 /C,N,NO $ CUND ERRCR1, CYCLOERR $ IF USER HAS NOT SPECIFIED CYCLO.
PARAM //CN,Div //V,N, NSEGS //V,Y, NSEG5/2 $ NSEGS = NSEG5/2
PARAM //CN,SN, SUB //V,Y, KNMAX //V,N, NSEGS //V,Y, KNMAX $ CUND ERRCR1,KNMAX $ IF KNMAX GT NSEG5/2
$ SET DEFAULTS FOR PARAMETERS.
PARAM //CN,NOP //V,Y, NCKPT=61 //V,Y, LGKAD=-1 $ $ CALUCULATE OMEGA, 2*OMEGA AND OMEGA*2 FROM RPS. SET DEFAULT RPS.
PARAM //CN,MPY //V,N, OMEGA //V,Y, RPS=0.0 /C,N,NO.283185 $ PARAM //CN,MPY //V,N, OMEGA2 //C,N,2.0 /V,N, OMEGA $ PARAM //CN,MPY //V,N,OMEGASQR //V,N,MEGA //V,N,MEGA $ $ GENERATE NUKPS FLAG IF RPS IS ZERO.
PARAM //CN,New //V,Y, KPS //C,N,CO ///V,N, NUKPS $ $ MAKE SURE COUPLED PASSS HAVE NOT BEEN REQUESTED.
PARAM //CN,NOT //V,N, NLUUMP //V,Y, CCUPMASS=-1 $ CUND ERRR2,NOLUMP $ ALTRK 2121 $ ADD SLT TO OUTPUT FOR TRLG.
GP3 GEM3, EVEL3, EVEL2 / SLT, GPTT / V,N, NOGRAV $ CHKPTT SLT, GPTT $ ALTRK 23 $ $ SINCE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NOW SO THAT $ MORE ERROR CHECKS CAN BE MADE BEFORE ELEMENT GENERATION.
$ ADD YS NEEDED FOR PSF RECOVERY IN SS2.
PARAM //CN,NOT //V,N, NULLDATA /V,N, REACT $ CUND ERRR3, NULLDATA $ $ EXECUTE LDP NOW SO CHECKS CAN BE MADE. ADD TRL TO OUTPUT DATA BLOCKS.
PARAM //CN,ANG //V,N, FRELK //V,N, NFOFL /V,N, NDLT $ CUND ERRR4, FRELK $ NO FREL OR TSTEP BULK DATA.
$ ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL.
PARAM //C,N,NUT /V,N,N,TERML /V,N,FREQTIME $
PARAM //C,N,LE /V,N,N,OFREE /V,N,FREQUIT /V,N,0 $
PARAM //C,N,LE /V,N,N,UNITIME /V,N,TIMESET /V,N,0 $
COND ERRORCO +,TERML BOTH FREQUE AND TSTEP IN CASE CONTROL DECK.
$ EPPOINT BULK DATA NOT ALLOWED
PARAM //C,N,NUT /V,N,NEVRAPS /V,N,NOUE $
COND ERRORC4E,NEVRAPS $
$ GENERATE DATA FOR CYC72 MODULE.
GPECYC GEOM4,EUQNY,USETO CYC72 /V,N,CTYPE=RG1 /S,N,NGG $
CLUD ERRORC1E,NOEG $
CHKPNT CYC72 $
ALTER 32 $
$ PRE-PURGE DATA BLOCKS THAT WILL NOT BE GENERATED.
PARAM //C,N,UR /V,N,NUDDM /V,N,NOMG /V,N,NORKPS $
PURGL B1GG,M1GG /NUDDM $
PURGL M2GG,M2BASEXG /NOEG $
ALTER 35 $
$ CLEAN UP DATA BLOCKS FRLX, B1GG, M1GG, M2GG AND BASEXG.
$ GENERATE PARAMETERS CKMAX AND NCBASEX.
DUMPDLU CASLCC,DCDPIT,CSMB,DIR,FRLX,NGG / / FRLX,B1GG,M1GG,
M2GG,CSLAV,POSEGUN, /V,N,NOMG/V,Y,LYCIC/V,Y,NSEG$
V,Y,CKMAX/S,V,Y,CKMAX/V,Y,RXTID=-1/V,Y,RTTID=-1/
V,Y,NTID=-1/V,Y,INTID=-1/V,Y,BXTID=-1/
V,Y,OPTID=-1/S,N,NCBASEX/V,N,NUFREQ/V,N,OMEGA $
PARAM  FRLX //C,N,PRESNLE // //V,N,NOFRLX $
CLUD L1FLX,NOFRLX $
EQUIV FRLX,FRL $
LABEL L1FLXFLX $
CHKPNT FRLX,B1GG,M1GG,M2GG,BASEXG $
ALTER 42 $
PARAM //C,N,ADD /V,N,NOBGG /V,N,NUDDM /C,N,0 $ RESET NOBGG.
ALTER 52 $
$ HLEELIN B1GG AND KGG.
CLUD L1F1L1A,NUDDM $
PARAM //C,N,COMPLEX /V,N,OMEGA2 /C,N,0,0 /V,N,COMPLX1 $
PARAM //C,N,SCU /V,N,CMHEQASO /C,N,0,0 /V,N,OMEGASOR $
PARAM //C,N,COMPLEX /V,N,OMEGAASO /C,N,0,0 /V,N,COMPLX2 $
ALL B1GG,B1GG / B1GI / C,N,(1.0,0,0) /V,N,COMPLX1 $
EQUIV B1GG,B1GG $
ALL KGG,M1GG / K1GG / C,N,(1.0,0,0) /V,N,COMPLX2 $
EQUIV K1GG,KGG $
CHKPNT B1GG,KGG $
LABEL L1L1A $
ALTER 53,55 $ G14 HAS BEEN MOVEUP.
ALTER 89,08 $ LDP HAS BEEN MOVEUP.
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LUKAD FOR FREQ OR TRAN.
PARAM //C,N,ADD /V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $
CLUD LUKADILUKAD $ BRANCH IN NOT FREQSP.
ALTER 119 $ SEE ALTER 114 COMMENT.
JUMP LUKAD2 $
LABEL  LOKAD1 $
EQUV  K2PP,M2DD/N0A/02PP,K2DD/N0A/K2PP,K2DD/N0A/MAA,HD0,MDA/
       KAA,KDD/KDEK &
CHRPNT  K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDD,MOD $
LABEL  LOKAD2 $
ALTER  117,117 & ADD PARAMETERS $KAD, H3 AND W6 TO $KAD
       $KAD  USE1D,UN,AA,AAA,MAA,KA4A,K2PP,M2PP,B2PP,K2DD,BDD,MOD,HD0,
       GDD,K2DD,H2DD,B2DD/C, YGKAD=TRANKEEP/C, DIP/C, DIRECT/
       C, Y, G=0.0/C, Y, N=0.0/C, Y, W=0.0/ V, N: NOK2PP/V, N: NOM2PP/
       V, N: NOB6G/V, N: KEOK2/C, N=-1 $
ALTER  116 & SEE ALTER 114 COMMENT.
ALTL  LOKAD3, LOKAD & BRANCH IF NOT FREQESP.
ALTL  119 & SEE ALTER 114 COMMENT.
JUMP  LOKAD4 $
LABEL  LOKAD3 $
EQUV  B2DC,BDD/N0GFT/K2DD,HD0/NOSIMP/K2DD,KDD/KDEK2 $
LABEL  LOKAD4 $
ALTL  120,123 & NEW SOLUTION LOGIC
$ GENERATE TIME-DEPENDENT LOADS IF TSTEP HAS REQUESTED IN CASE CONTROL.
CNC  LEL1KL1,NOTIME $
$ EQUV  THRU ALL SUBCASES FOR TIME-DEPENDENT LOADS.
PARAM  //C, N, NPY/V, N, REPEAT /C, N, 1/C, N, -1 $
PARAM  //C, N, ADD/V, N, APPFLG /C, N, 1/C, N, 0 & INITIALIZE FOR SUNL.
JUMP  TRLGLOOP $
LABEL  TRLGLOOP $
CASE  CASLG/CASEY/Y/C, N, TRAN/S, N, REPEAT/S, N, NOLECP1 $
CHRPNT  CASL $Y $
PARAM  //C, N, NPY/V, N, NCOL /C, N, 0 /C, N, 1 $
TRLG  CASLGY/USEU/LT/LT, U, GFT/S, LT, CSTM, TRL, U, GM, GDD, EST, MGG/
       *PLT*3LPA1,TCL/V, N, NSLM/T, S, N, PDEPGU/V, N, NCOL $
SUREL  TRL, P01,00000000/0, PDL/V, N, APPFLG/C, N, DYNAMICS $
SUREL  TRL, P01,00000000/0, PDL/V, N, APPFLG/C, N, DYNAMICS $
PARAM  //C, N, ADU/V, N, APPFLG /V, N, APPFLG /C, N, 1 & APPFLG=APPFLG1L.
CNC  TRLGLO/CASEY/Y/C, N, TRAN/S, N, REPEAT/S, N, NOLECP1 $
RECI  TRLGLO/CASEY/Y/C, N, TRAN/S, N, REPEAT/S, N, NOLECP1 $
JUMP  LRRCK3 $
LABEL  TRLGUNL1 $
CHRPNT  TL0, 40, TOL $
EQUIV  FCL, FOT/PLEPDU $
CHRPNT  TOL $
GTNFC2  TL0,00000000 / FRLZ,FGLZ,KEKEK1,RKLRUER/Z
S, N, FLMAX/S, N, NTESTP/S, N, NTRC1/S, N, NTRC2 $
EQUIV  FRLZ,FRLZ/ FULZ,FCL $
CHRPNT  FRLZ,FCL,KEKEK1,RKLRUER/Z
JUMP  LRFLRLZ $
LABEL  LRFLRL $
NASTRAN EXECUTIVE CONTROL DECK ECHO

FRLG CASEXX, USETLU, DL7, FR1, GRO, GCD, OIT, / PPF, PSF, PDF, FOL, PFREDM /  
C, N, DIREC1 / V, N, FREQU, C, N, FREEQ $  
LCALD LBLFRXL1, NOFRXL $ ZEROUZ LOAD COLUMNS IF FRLX WAS GENERATED  
MPLYAD PPF, PDZEKO, / PPFX / C, N, O $  
LQLIV PPF, PPF $  
LABEL LBLFRXL1 $  
$ FOR NEW LOADS  
MPLYAD M2G0, BASEXG / M2BASEXG / C, N, O $  
ACE PPF, M2BASEXG / PPF1 / C, N, (1.0, 0.0) / C, N, (-1.0, 0.0) $  
EQUIL PPF1, PPF $  
LND LBLBASE1, NOSET $  
SSEG USED, GMO, YS, KFS, GOD, / PPF / POFUMI, PSF1, PFP $  
EQUIL PSFI, PFI / PDF1, PDF $  
LABEL LBLBASE1 $  
LABEL LBLFRXL1 $  
EQLIV PPF, PPF/NOSI $  
CNPNT PPF, PPF/PDF, FOL $  
$ LOADS ARE FREQUENCY-DEPENDENT  
$ PLRFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIC=61  
PARAM PDF / C, N, TAILER / C, N,1 / V, N, PDFCOLS $  
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1  
PARAM // C, N, OLIV / V, N, NLOAD / V, N, PDFCOLS / V, N, NMAX $ NLOAD = NF/FKMAX  
EQLIV PDF, PPF/CYCLIC $  
LND LBLPODNE, CYCLIC $  
$ CALCULATE THE NUMBER OF LOADS FOR CYCIC=1  
PARAM // C, N, OLIV / V, N, NLOAD / V, N, PDFCOLS / V, Y, NSEG $ NLOAD = NF/NSEG  
CYC11 PDF / PPF, GLYCF1 / V, N, CMPE / C, N, FORE / V, Y, NSEG $ V, Y, KMAX $ V, N, NLOAD / S, N, NSEG $  
CNDN ERRORC1, NUGO $  
CNPNT PPF $  
JUMP LBLPODNE $  
LABEL LBLFRXL2 $  
$ LOADS ARE TIME-DEPENDENT  
PARAM // C, N, NUTC / V, N, NUTCYCLIC / V, Y, CYCLIC $  
$ CYCIC DEPENDING ON VALUE OF CYCLIC  
CNDN LBLTRCL2, NUTCYCLIC $  
$ CYCIC=1  
EQLIV PDT, PDTZI1/NKU1 $  
CNDN LBLA1A, NURCI $  
MPLYAD PDT, REORJERI, / PDTZ1 / C, N, O $  
LABEL LBLA1A $  
CYC1I PDTZ1 / PXZ1, GLYCF2 / V, N, CMPE / C, N, FORE / V, Y, NSTEPS /  
V, Y, LMAX / V, N, KMAX / S, N, NCEG $  
CNDN ERRORC1, NUGO $  
CNPNT PXZ1 $  
JUMP PXZI1, PXZ1/NKU2 $  
CNDN LBLR02A, NOKC2 $  
MPLYAD PXZI1, KLORDEK2 / PXFZ1 / C, N, O $  
LABEL LBLR02A $  

2.12
NASTRAN EXECUTIVE CONTROL DECK ECHO

EQUIV  PXF2, PXF1 $
CHKPT  PXF1 $
JUMP  LBLTRL3 $
LABEL  LBLTRL2 $
$ CYCLIC = 61
MPXAD  PUT, KORDER1, / PSTRZ2 / C,N,0 $
CYCT1  PSTRZ2 / PXKZ2, GCYCF3 / V,N,CTYPE/C,N,FORE/V,Y,NTSTEPS/V,Y,LMAX/
V,Y,NSEGS/S,N,NGGC $
CGND  ERRGC1, NGGC $
CHKPT  PXKZ2 $
EQUIV  PXKZ2, PSTRZ2/NUR2 $
CGND  LBLRZ2B, NUR2 $
MPXAD  PSTRZ2, KORDER2, / PSTRZ2 / C,N,0 $
LABEL  LBLRZ2B $'
CYCT1  PSTRZ2 / PXKZ2, GCYCF4 / V,N,CTYPE/C,N,FORE/V,Y,NSEGS/V,Y,KMAX/
V,Y,FLMAX/S,N,NGGC $
CGND  ERRGC1, NGGC $
EQUIV  PXKZ2, PXF1 $'
CHAPNT  PXF1 $
LABEL  LBLTRL3 $

$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND
$ TO FREQUENCY DEPENDENT LOADS. ALSO SUR2 EXPECTS LOADS TO BE COMPLEX
$ IN FREQUENCY TYPE PROBLEMS.$
COPY  PXF1 / PXF2 / CCXFR IT REAL PXF1 TO COMPLEX P'F$.
AUX  PXF1, PXF2 $ PXF / C,N,(0.5,1.0) / C,N,(0.5,-1.0) $
$ LDEFIN $ LOAD FCG CYL2.$
PARAM  //C,N,AUD / V,N,NLOAD / V,N,FLMAX / C,H,0 $ NLCAD = FLMAX
LABEL  LBLPDONE $'
PARAM  //C,N,AUD / V,Y,KINDEX / V,Y,KMIN=0 / C,N,0 $ INITIALIZE KINDEX$.$

$ INITIALIZE UXVF IF KMIN IS NOT ZERO.$
$ PARAM  //C,N,AUD / V,N,KMINL / V,Y,KMIN / C,N,-1 $
CGND  NUKMINL, KMINL $'
PARAM  //C,N,AUD / V,N,KMINV / C,N,0 / C,N,0 $'
JUMP  KMINLUP $'
LABEL  KMINLUP $'
CYCT2  CYCU,*,PFX, / ***PKF2, / C,N,FORE/V,Y,NSEGS/
V,N,KMINV/V,N, CYCSEQ/V,N,NLCAU/S,N,NGGC $'
CGND  ERRGC1, NGGC $'
AGC  PKF2, / UKVFZ / C,(0.0,0.0,0) $'
CYCT2  CYCU,*,SKVFZ, / ***UXVF, / C,N,BACK/V,Y,NSEGS/
V,N,KMINV/V,N, CYCSEQ/V,N,NLCAU/S,N,NGGC $'
CGND  ERRGC1, NGGC $'
PARAM  //C,N,AUD / V,N,KMINV / V,N,KMINV / C,N,1 $'
KEEP  KMINLUP, KMINL $'
LABEL  NUKMINL $'$
JUMP  TCPYC $'
LABEL  TCPYC $ LOOP UN KINDEX

2.13
NASTRAN EXECUTIVE CONTROL DECK ECHO

CCND  NDRPR!,NDRPR! $  
PRTPARM  //CN,90/CN,9INDEX $  
LABEL  NDRPR! $  
CYCT2  LECUUD,MDU,... /KKK,FNKKF,... /CN,FORCE/VY,NSEGS/  
       VY,N,INDEX/VY,CYCSEQ=-1/VY,N,NLOAD/SN,NOGC $  
COND  ERRCDL1,NOGC $  
CHMPNT  KKK,FNKKF $  
PARAM  //CN,SYST //CN,5B/CN,2 $ METHOD 3T IN CYCT2 PRODUCES  
       UNDERFLOW F/CNF, USE METHOD 2.  
CYCT2  LECUUD,BUD,...PXF,... /KKK,FNKKF,... /CN,FORCE/VY,NSEGS/  
       VY,N,INDEX/VY,CYCSEQ/VY,N,NLOAD/SN,NOGC $  
PARAM  //CN,SYST //CN,5B/CN,2 $ METHOD 3T IN CYCT2 PRODUCES  
       UNDERFLOW F/CNF, USE METHOD 2.  
COND  ERRCDL1,NOGC $  
CHMPNT  KKK,FNKKF $  
$ SOLUTION  
FRKU2  KKK,FNKKF,FMKK,...PXF,.../UKV/UKV/CN,0.0/CN,0.0/CN,-1.0 $  
CHMPNT  UKV $  
CYCT2  LECUUD,BUD,...PXF,... /KKK,FNKKF,... /CN,FORCE/VY,NSEGS/  
       VY,N,INDEX/VY,CYCSEQ/VY,N,NLOAD/SN,NOGC $  
COND  LRRRDL1,NOGC $  
CHMPNT  UKV $  
PARAM  //CN,ADD /CN,INDEX/VY,N,INDEX/CN,1 $ INDEX = INDEX + 1  
PARAM  //CN,ADD /CN,INDEX/VY,N,INDEX/CN,1 $ INDEX = INDEX + 1  
COND  LCEU2,DONE $ IF INDEX > KMAX THEN EXIT  
KEPT  TLPCYL,1CC $  
JUMP  ERRCD 3 $  
LABEL  LCEU2 $  
EQUIV  UXVF,UVDF / CYCTI $  
CHMPNT  UVDF $  
COND  LCRYC3,LCYCU $ IF CYCL > GE.0 THEN TRANSFORM TO PHYSICAL  
CYCTI  UXVF / UVDF / LCYCU / VY,N,LTYPE/CN,BACK/VY,N,NSEGS/VY,N,KMAX/  
       VY,N,NLOAD $  
CHMPNT  UVDF $  
LABEL  LCRYC3 $  
COND  LCRYC4,NOTIME $  
EQUIV  PXF,PXF2 / CYCT2 $  
COND  LCRYC4,LCYCU $ IF CYCL > GE.0 THEN TRANSFORM TO PHYSICAL  
CYCTI  PXF / PXF2 / LCYCU / VY,N,LTYPE/CN,BACK/VY,N,NSEGS/VY,N,KMAX/  
       VY,N,NLOAD $  
LABEL  LCRYC4 $  
$ IF LOADS W/A TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PXF.  
SDR1  USEUL,...SUZ,...SUZ,...SUZ,... / PPFZ,... /CN,1 /CN,DYNAMICS $  
SSC1  USEUL,...SUZ,...SUZ,...SUZ,... / PPFZ,... /PCBUMP,PSFZ,PLBUMP $  
EQUIV  PPFZ,PPF2 / PSFZ,PSF $  
CHMPNT  PPF,PSF $  
LABEL  LCRYC4 $  
ALTER 124,120 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  
VOR  CASEA-XE-DYN/USEUL,...SUZ,...SUZ,...SUZ,... / PPFZ,... /CN,1 /CN,DYNAMICS $  
       USEUT3,...SUZ,...SUZ,... / PPFZ,... /PCBUMP,PSFZ,PLBUMP $  
ALTER 140,140 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.  

2.14
SUR2 CASEXX, CSTH, MPT, JIT, EQDYN, SLD, EGPDP, FLL, UPC, UPVC, EST, XYG, PPF, UPPL, OPC, OUP, OPCL, DESC, OPC, UPVC, CN, FREQ, NGP, S, N, NOSURT2 $.
ALTER 160 $ ADD LABEL FOR ERROR3 $.
LABEL $ ERROR3 $.
ALTER 103, 166 $ REMOVE ERROR1 AND ERROR2 $.
ALTER 168 $ FORCED VIBRATION ERRORS.
LABEL $ ERROR1 $ CHECK NSCGS, KMAX AND OTHER CYCLIC DATA $.
PKTPARM $ /CN, -1 /CN, CYCSTATICS $.
LABEL $ ERROR2 $ COUPLED MASS NOT ALLOWED $.
PKTPARM $ /CN, 0 /CN, COUPMASS $.
JUMP FINIS $.
LABEL $ ERROR3 $ SUPORT BULK DATA NOT ALLOWED $.
PKTPARM $ /CN, -1 /CN, CYCSTATICS $.
LABEL $ ERROR4 $ EPOINT BULK DATA NOT ALLOWED $.
PKTPARM $ /CN, 0 /CN, NGUE $.
JUMP FINIS $.
LABEL $ ERROR5 $ NEITHER FREU OR TSTEP WERE IN BULK DATA DECK $.
PKTPARM $ /CN, 0 /CN, NUFRL $.
PKTPARM $ /CN, 0 /CN, NUTRL $.
JUMP FINIS $.
LABEL $ ERROR6 $ BOTH FREU AND TSTEP WERE SELECTED IN CASE CONTROL $.
PKTPARM $ /CN, 0 /CN, NDEFREU $.
PKTPARM $ /CN, 0 /CN, NDFTIME $.
JUMP FINIS $.
LNALTER

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.8 FORCED VIBRATIONS OF ROTATING CYCLIC STRUCTURES - SERIES R
2 PKLCHK ALL $
3 FILE KGGX=TAPE/KGG=TAPE/GOU=SAVE/GMD=SAVE/HDD=SAVE/BDU=SAVE $
4 FILE UXVF=APPEND/PDT=APPEND/PD=APPEND $
5 CUND ERR*LRC1,NSEGS $ IF USER HAS NOT SPECIFIED NSEGS. $
6 CUND ERR*RKC1,KMAX $ IF USER HAS NOT SPECIFIED KMAX. $
7 PARAM //C,N,E2 /V,N,CYCIERR /V,Y,CYCI=0 /C,N,0 $ $
8 CUND ERR*RKC1,CYCIERR $ IF USER HAS NOT SPECIFIED CYCI. $
9 PARAM //C,N,DIV /V,N,NSEG2 /V,Y,NSEGS /C,N,2 $ NSEG2 = NSEGS/2 $
10 PARAM //C,N,SUB /V,N,KMAXERR /V,N,NSEG2 /V,Y,KMAX $ $
11 CUND ERR*RKC1,KMAXERR $ IF KMAX.GT. NSEGS/2 $
12 PARAM //C,N,NUM /V,Y,NOKPKT=61 /V,Y,LGKAD=-L $ $
13 PARAM /C,N,MPY /V,N,OMEGA /V,Y,RPS=0.0 /C,N,6.283185 $ $
14 PARAM /C,N,MPY /V,N,OMEGA2 /C,N,2.0 /V,N,OMEGA $ $
15 PARAM /C,N,MPY /V,N,OMEGASUP /V,N,OMEGA /V,N,CMEGA $ $
16 PARAM /C,N,EQ //V,Y,RPS /C,N,0,0 //C,N,NURPS. $ $
17 PARAM //C,N,NUT /V,N,NOLUMP /V,Y,COUPMASS=-1 $ $
18 CUND ERR*RKC2,NOLUMP $ $
19 PARAM //MPY*/CARANO/0/C $ $
20 GPL GEOM1,GEOM2,GPL,EXEXIN,GPOT,STEP,BGPOT,SIL/S,N,LUSET/S,N,NUGPOT $ $
21 PLTTRAN BGPOT,SIL/HUGPOT,SIL/LUSET/S,N,LUSEP $ $
22 PURGE USET,GM,GO,KAA,RAA,MAA,KAAA,KS,F,PSF,QPC,EST,ECT,PLTSETX,PLTPAR, GPSETS,ELSETS/NUGPOT $ $

2.16
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

44 PARAM /C,N,NOT /V,N,REAO DATA /V,N,REACT $ 
45 COND ERRORC3,REALDATA $ 
46 UPE DYNAMICS,GPL,SIL,USEST /GPLD,SILD,USEST;/T,FPOGL,OLT,PSDLP,FRL/L, 
TRL;EQQDYN /V,N,LUSET/S,N,LUSETU/V,N,NOFLFL/S,N,NOOLT/ 
S,N,NOPSDL/S,N,NOFDRL/V,N,NONLET/S,N,NOTRL/V,N,NOED/C,N/ 
S,N,NOUE $ 
47 PARAM /C,N,ANG/V,N,FTERR /V,N,NOFDRL /V,N,NOTRL $ 
48 COND ERRORC9,FTERR $ NC FREQ OR TSTEP BULK DATA. 
49 PARAM CASECC /C,N,DTI /C,N,1 /C,N,14 /V,N,FREQSET $ 
50 PARAM CASECC /C,N,DTI /C,N,1 /C,N,38 /V,N,TIMESET $ 
51 PARAM /C,N,MPY /V,N,FREQTIME /V,N,FREQSET /V,N,TIMESET $ 
52 PARAM /C,N,NOT /V,N,FTERRL /V,N,FRECTIME $ 
53 PARAM /C,N,LE /V,N,NOFREQ /V,N,FREQSET /C,N,0 $ 
54 PARAM /C,N,LE /V,N,NOFREQ /V,N,FREQSET /C,N,0 $ 
55 COND ERRORC6,FTERRL $ BOTH FREQ AND TSTEP IN CASI CONTROL DECK. 
56 PARAM /C,N,NOT /V,N,EXTRAPTS /V,N,NGUE $ 
57 COND ERRORC4,EXTRAPTS $ 
58 GPCY C GEOM4,EQQDYN,USEST /CYCDO /V,N,CTYPE=ROT /S,N,NOGG $ 
59 COND ERRORC1,NOGG $ 
60 CHKPT CYCDO $ 
61 COND LBL1,NOUSIMP $ 
62 PARAM //ADD*/NUKGX/1/O $ 
63 PARAM //ADD*/NUKGG/1/O $ 
64 PARAM //ADD*/NUBGG=-1/1/O $ 
65 PARAM //ADD*/NUKG/1/0. $ 
66 EMG EST,CSTM,MPT,DIT,GEOM2,/KELM,KUICT,MELM,MDICT,BELM,MDICT/ 
S,N,NOKGX/S,N,NOGG/S,N,NOBGG/S,N,NOBGG/S,N,NOBGG/ //C,Y,COUPMASS/C,Y, 
CPBAR/C,Y,CRUDD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIAI/C,Y, 
2.18
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


67 COND  LBLKGGX,NOKGGX $
68 EMA    GPECT,KDICT,KELM/KGGX,GPS $
69 LABEL  LBLKGGX $
70 PARAM  //C,Y,OR /V,N,NOKBL /V,N,NOMGG /V,N,NOKPS $
71 PURGE  M2GG,M2BASEXG /NOMGG $
72 COND   LBLMGG,NOMGG $
73 EMA    GPECT,KDICT,KELM/MGG,/-1/C,Y,N,TMASS=1.0 $
74 LABEL  LBLMGG $
77 PARAM  FRLX //C,Y,PRESENCE ////V,N,NDFRLX $
78 COND   LBLFRLX,NDFRLX $
79 EQUIV  FRLX,FRL $
80 LABEL  LBLFRLX $
81 CKPNT  FRL,B1GG,M1GG,M2GG,BASEXG $
82 COND   LBLBGG,N0BGG $
83 EMA    GPECT,KDICT,BELM/RGG, $
84 LABEL  LBLBGG $
85 COND   LBLK4GG,NOK4GG $
86 EMA    GPECT,KDICT,KELM/K4GG,NOK4GG $
87 LABEL  LBLK4GG $
88 PURGE  MNN,MFF,MAA/NOMGG $
LEVEL 2.0 NASTRAN DMAP COMPI lER - SOURCE LISTING

99 PARAM //C,N,ADD /V,N,NOBGG /V,N,NODM1 /C,N,0 $ REM EXT NOBGG.
90 PURGE RNN,OFF,BA/NODM $ +
91 COND LBL1,GRDPNT $
92 COND EDR4,NOBGG $ +
93 GPG BGP,DP,CSL,EQEXIN,NOBGG/GRDPNT=0/CGP,DP/V,Y,GRDPNT=0/C,Y,NTMASS $ +
94 ODP CGP,DP,...,0//S,N,CARDNO $ +
95 LABEL LBL1 $ +
96 EQUIV KGGX,KGG/NOGENL $ +
97 COND LBL11,NOGENL $ +
98 SNA3 GEI,KGGX/KGG/LUSET/NOGENL/NOSIMP $ +
99 LABEL LBL11 $ +
100 COND LBL1IA,NORMI $ +
101 PARAM //C,N,COMPLXX //V,N,OMEGA2 /C,N,0.0 / V,N,CMPLX1 $ +
102 PARAM //C,N,COMPXX //V,N,OMEGA2 /C,N,0.0 / V,N,CMPLX1 $ +
103 PARAM //C,N,COMPLXX //V,N,OMEGA2 /C,N,0.0 / V,N,CMPLX2 $ +
104 ADD BGG,BLGG / 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 //EQS/GPSPLG/UNITPC/0 $ +
113 COND LBL4,GPSPFLG $ +

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LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

114 GPSP GPL,GPST,USE T,GIL/UGPS1/S,N,HGPPST $
115 COND LBL4,NGPPST $
116 DFP OGPST,,,,/S,N,CARDAG $
117 LABEL LBL4 $
118 EQJIV KGG,KNH/MPCF1/HGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
119 COND LBL2,MPCEF1 $
120 MCE1 USET,RG/GM $
121 MCE2 USET,GM,KGG,HGG,BGG,K4GG/K4NN,MNN,BNN,K4NN $
122 LABEL LBL2 $
123 EQJIV KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
124 COND LBL3,SINGLE $
125 SCE1 USET,KNN,MNN,BNN,K4NN/KFF,K4FF,SINGLE/MFF,BFF,K4FF $
126 LABEL LBL3 $
127 EQUIV KFF,KAA/OMIT $
128 EQUIV MFF,MAA/OMIT $
129 EQUIV BFF,BAA/OMIT $
130 EQUIV K4FF,K4AA/OMIT $
131 COND LBL5,OMIT $
132 MP1 USET,KFF,,,,/GO,KAA,KCC,LCG,,,,, $
133 COND LBLM,NUMGG $
134 MP2 USET,GO,MFF/MAA $
135 LABEL LBLM $
136 COND LBLB,NOBGG $
137 MP2 USET,GO,BFF/BAA $
138 LABEL LBLB $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

139 COND LBL5,NOK4GG $
140 SYP2 USET,GO,K4FL/K4AA $
141 LABEL LBL5 $
142 EQJIV GO,GOU/NOUE/GM,GMF/NCLE $
143 PARAM //ADD*/NEVER/1/0 $
144 PARAM //MPY*/REPEATF/-1/1 $
145 BfG MAPIPOOL,BSPOOT,EQEXIN,CSMF/BDPCCL/S,N,NCKHFL/S,N,NOABFL/ S,N, MFAT $ 
146 PARAM //AND*/NOFL/NOABFL/HOKBFL $
147 PURGE XBFL/NOKBFL/ ABFL/NCABFL $ 
148 COND LBLFL3/NCFL $ 
149 WTXIN, HUPPOOL,EQUYN, /ABFL,KBFL, /LUSETO/S,N,NOABFL/S,N,OKBFL/0 $ 
150 LABEL LBLFL3 $ 
151 JUMP LBL13 $ 
152 LABEL LBL13 $ 
153 PURGE OUVC1,ULVC2,XYPLTFA,UPPC1,GQPC1,GUPVC1,CESC1,GEFC1,UPPC2, 
DQPC2,GUPVC2,DESC2,GEFC2,XYPLTF,PSDF,AUTG,XYPLTR, K2PP,M2PP, 
B2PP,K2J2,M2J2,B2D0/NEVER $ 
154 CASE CASECC,PSDL/CASEXX/FREQ*/S,N,REPEATF/S,N,NOLODDP $ 
155 WTXIN CASEXX,MATPOOL,EQUYN, TFPSTL/K2PP,M2PP,B2PP/LUSETO/S,N, 
NOK2DPP/S,N,NO2DPP/S,N,NCB2PP $ 
156 PARAM //AND*/NO2DPP/NOABFL/NCM2DPP $ 
157 PARAM //AND*/NOK2PP/NOFL /NCM2DPP $ 
158 EQJIV M2DPP,M2PP/NOABFL $ 
159 ADDS ABFL,KBFL,K2DPP, /K2PP/(-1.0,0.0) $ 
160 COND LBLFL2,NCABFL $ 
161 TRNSP ABFL/AUFLT $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

162 ADD ABFLT, M2DD/N2PP/IMPACT $
163$ LABEL LBLFL2 $
164$ PARAM //Ander/BDEBA/NQUE/NGB2PP $
165$ PARAM //Ander/KDEK2/NOSIMP $
166$ PARAM //Ander/MDMA/NQUE/NCH2PP $
167$ PURGE K2DD/NOK2PP/M2DD/NOM2PP/02DD/NGB2PP $
168$ PARAM //C,N,AND/V,N,KDEKA/V,N,AQUE/V,N,NCK2PP $
169$ COVD LGKA01, LGKA0 $BRANCH \ IN \ NOT \ FREQRESP.$
170 EQJIV M2PP, M2DD/NOA/B2PP, B2DD/NOA/K2PP, K2DD/NOA/MAA, MDD/MDMA/BAA,
171 JUMP BOD/BDEBA $\$
172$ LABEL LGKA02 $
174$ CHKPT K2PP, M2PP, B2PP, K2DD, M2DD, B2DD, KDD, MDD $\$
175$ LABEL LGKA02 $
176$ COVD LBL18, NOGPD $\$
177$ GKA0 USETD, CM4G0, KAA, BAA, HAA, K4AA, K2PP, M2PP, 02PP/KDD, BOD, MDD, GMD, $\$
178$ LABEL LBL18 $\$
179$ COVD LGKA03, LGKA0 $BRANCH \ IF \ NOT \ FREQRESP.$
180$ EQUIV B2DD, BOD/NOBGG/ M2DD, MDD/NOSIMP/ K2DD, KDD/KDEK2 $\$
181$ JUMP LGKA04 $\$
182$ LABEL LGKA03 $\$
183$ EQUIV B2DD, BOD/NOGPD/M2DD, MDD/NCSIMP/K2DD, KDD/KDEK2 $\$

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LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

184 LABEL LOKAD4 $
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,0 /C,N,0 $ INITIALIZE FOR SDRL.
188 JUMP TRLGLOOP $
189 LABEL TRLGLOOP $.
190 CASE CASECC,/CASEYY/C,N,TRAN/S,N,REPEATT/S,N,NCLLOP1 $.
191 CHKPTNT CASEYY $.
193 TRLG CASEYY,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMMS,GOV,EST,MMG/

194 SDR1 TRL,PD1,......, /PD1/ /V,N,APPFLG/C,N,DYNAMICS $.

195 SDR1 TRL,PD1,......, /PD /V,N,APPFLG/C,N,DYNAMICS $.
197 COND TRLGDONE,REPEATT $.
198 REPT TRLGLGLOP,100 $.
199 JUMP ERROR3 $.
200 LABEL TRLGDONE $.
201 CHKPTNT PD1,PD,TOL $.
202 EQU IV PD,PDT/PDEPDC $.
203 CHKPTNT PDT $.
204 DUMMOD2 TUL,......, /FLZ,FGLZ,RECRDER1,RECRDER2,......,

205 EQU IV FRLZ,FRL, /FOLZ,FCL $.
206 CHKPTNT FRL,FOL,RECRDER1,RECRDER2 $.
207 JUMP LULFRL2 $.
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

208  LABEL  LBLTRL1 $
209  FRLG  CASEXX,USETO,ULT,FRL,GMD,GCD,DIT, / PPF,PSF,PDF,FOL,FHDUM / C,N,DIRECT/V,N,FREQ/C,N,FREQ $
210  COVD  LBLFRLX1,NOFRLX $ ZERO OLT LOAD COLUMNS IF FRLX WAS GENERATED.
211  MPYAD  PPF,PDZERO, / PPFX /C,N,0 $
212  EQIV  PPFX,PPF $
213  LABEL  LBLFRLX1 $ 
214  COVD  LBLFRL1,NOBASEX $ 
215  MPYAD  M2GG.BASESG, / M2BASEXG /C,N,0 $ 
216  ADD  PPF,M2BASEXG / PPF1 /C,N,(1.0,0.0) /C,N,(-1.0,0.0) $ 
217  EQIV  PPF1,PPF $ 
218  COVD  LBLBASE1,NOSET $ 
219  SSG2  USETO,GMD,YS,KFS,GCD,,PPF /,PODUM1,PSFL,PDF1 $ 
220  EQIV  PSFL,PSF / PDF,PDF $ 
221  LABEL  LBLBASE1 $ 
222  LABEL  LBLFRL1 $ 
223  EQIV  PPF,PDF/NOSET $ 
224  CHKPT  PPF,PSF,PDF,FOL $ 
225  PARAML  PDF /C,N,TRAILFR /C,N,1 /V,N,PDFCGLS $ 
226  PARAM  /C,N,DIV /V,N,NLOAD /V,N,PDFCGLS /V,N,FKMAX $ NLOAD = NF/FKMAX 
227  EQUIV  PDF,PDF/FCYCLE $ 
228  COVD  LBLDUN,FCYCLE $ 
229  PARAM  /C,N,DIV /V,N,NLOAD /V,N,PDFCGLS /V,Y,NSEGNS $ NLOAD = NF/NGS 
230  CYC1  PDF / PXF,FCYCLE /V,N,CTYPE /C,N,FCRE /V,Y,NSEGNS=-1 / V,Y,KMAX=-1 / V,N,HLLAD /S,N,NGG $ 
231  COVD  ERRORC1,NGG $ 

2.25
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

232 CHKPNT PXF $  
233 JUMP LBLPDONE $  
234 LABEL LBLFRL2 $  
235 PARAM /C,N,KUT /V,N,NOTCYCIO /V,Y,CYCIO $  
236 COND LBLFRL2,NOTCYCIO $  
237 EQUIV POT,PDTRZ1/NCRO1 $  
238 COND LBLRO1A,NOR01 $  
239 MPYAD POT,REORDER1, / PDTRZ1 / C,N,0 $  
240 LABEL LBLRO1A $  
241 CYCT1 PDTRZ1 / PXTRZ1,GCYCF2 /V,N,CTYPE/C,N,FORE/V,N,NTSTEPS/ V,Y,LMAX/V,N,FKMAX/$,N,NOGO $  
242 CYCT1 ERRURC1,NOGO $  
243 CHKPNT PXTRZ1 $  
244 EQUIV PXTRZ1,PFZ2/NCRO2 $  
245 COND LBLPD02A,NOR0L2 $  
246 MPYAD PXTRZ1,REORDER2, / PXFZ1 /C,N,0 $  
247 LABEL LBLRO2A $  
248 EQUIV PXFZ1,PFZ1 $  
249 CHKPNT PFZ1 $  
250 JUMP LBLTRL3 $  
251 LABEL LBLTRL2 $  
252 MPYAD POT,REORDER1, / PDTRZ2 / C,N,0 $  
253 CYCT1 PDTRZ2 / PXTPZ2,GCYCF3 /V,N,CTYPE/C,N,FCRE/V,N,NTSTEPS/V,Y,LMAX/ V,Y,NSEGS$/N,NOGO $  
254 COND ERRURC1,NOGO $  
255 CHKPNT PXTRZ2 $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

256  EQUIV  PXTRZ2,PXTR2/NORO2 $
257  COND  LBLRO28,NORO2 $
258  MPYAD  PXTRZ2,REORDER2; / PXTR2 /C,N,O $
259  LABEL  LBLRO29 $
260  CYCT2  PXTR2 / PXFZ2,GCYCF4 / V,N,CTYPE/C,N,FORE/V,Y,NSEGS/V,Y,KMAX/$
261  COND  ERRORC1,NOGO $
262  EQUIV  PXFZ2,PXF1 $
263  CHKPT  PXF1 $
264  LABEL  LBLTRL3 $
265  CUPY  PXF1 / PXF2 $ CONVERT REAL PXF1 TC COMPLEX PXF.
266  ADD  PXF1,PXF2 / PXF / C,N,(0.5,1.0) / C,N,(0.5,-1.0) $
267  PARAM  //C,N,ADD /V,N,NLOAD /V,N,FLMAX /C,N,O $ NLOAD = FLMAX
268  LABEL  LBLPDONE $
269  PARAM  //C,N,ADD /V,N,KINDEX /V,Y,KMIN=0 /C,N,O $ INITIALIZE KINDEX.
270  PARAM  //C,N,ADD /V,N,KMINL /V,Y,KMIN /C,N,-1 $
271  COND  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,; / ,PFZ,; / C,N,FORE/V,Y,NSEGS/$
276  COND  ERRORC1,NOGO $
277  ADD  PKFZ, / LKVFI / C,N,(0.0,0.0) $
278  CYCT2  CYCUD,;LKVFI,; / ,UXVF,; / C,N,BACK/V,Y,NSEGS/$
279  COND  ERRORC1,NOGO $
LEVEL 2.0 NASTRAN DHAP COMPILER - SOURCE LISTING

280 PARAM //C,N,ADD /V,N,MINV /V,N,MINV /C,N,1 $
281 REPT KMINLOOP,KMINL $
282 LABEL NOKMINL $
283 JMP TOPCYC $
284 LABEL TOPCYC $ LUOPT ON KINDEX
285 COND NOKPRT,NOKPRT $
286 PRTPARM //C,N,0 /C,N,KINDEX $
287 LABEL NOKPRT $
289 COND ERRORC1,NOGO $
290 CHKPTN KKKF,HHKFP $
291 PARAM //C,N,SYST //C,N,58 /C,N,2 $ METHOD 3T IN CYCT2 PRODUCES
292 CYCT2 CYCODD,ADD,,PXF,, /KKF,HHKFP,, /C,N,FORE/V,Y,NSEGS/V,N,KINDEX/V,N,CYCSEQ/V,N,NLOAD/S,N,NCGC $
293 PARAM //C,N,SYST //C,N,58 /C,N,0 $ RESET MPYAD METHO CONTROL
294 COND ERRORC1,NOGO $
295 CHKPTN KKKF,PKF $
296 FRD2 KKKF,HHKFP,PKF,,FCL / UKVF /C,N,0,0/C,N,0,0/C,N,-1,0 $
297 CHKPTN UKVF $
298 CYCT2 CYCODD,,LKVF,, /UXVF,, /C,N,BACK/V,Y,NSEGS/V,N,KINDEX/V,N,CYCSEQ/V,N,NLCAC/S,N,NCGC $
299 COND ERRORC1,NOGO $
300 CHKPTN UXVF $
301 PARAM //C,N,ADD //V,N,KINDEX/V,N,KINDEX/C,N,1 $ KINDEX = KINDEX & 1
302 PARAM //C,N,ADD /V,N,DONE /V,Y,KFAX /V,N,KINDEX $
303 COND LCYC2,DONE $ IF KINDEX .GT. KMAX THEN EXIT

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LEVEL 2.0 NASTRAN DHAP COMPILER - SOURCE LISTING

304 REPT TOPCYC, 100 $
305 JUMP ERROR3 $
306 LABEL LCYC2 $
307 EQUIV UXVF, UDVF / CYCIO $
308 CHKPN T UDVF $
309 CUND LCYC3, CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
310 CYCT1 UXVF / UDVF, GCYCL1 / V,N,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/ V,N,NLOAD $
311 CHKPN T UDVF $
312 LABEL LCYC3 $
313 CUND LBLTRL4, NOTIME $
314 EQUIV PXF, PDF2 / CYCIO $
315 CUND LCYC4, CYCIO $ IF CYCIO .GE. 0 THEN TRANSFORM TO PHYSICAL.
316 CYCT1 PXF / PDF2, GCYCL2 / V,N,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/ V,N,NLOAD $
317 LABEL LCYC4 $
318 SUK1 USETO, PDF2, GUD, GMD, ... / PPFZ, / C,N,1 / C,N,DYNAMICS $
319 SSG2 USEGD, GMD, YS, KFS, GOU, PPZL / , PCDOH, PSFZ, PLDOM $
320 EQUIV PPZL, PPF / PSFZ, PSF $
321 CHKPN T PPF, PSF $
322 LABEL LBLTRL4 $
323 VDR CASEXX, EQUY1, USETO, LDVF, PCL, XYCOB, / GUOVC1, / C,N,FREQSP/C,N, DIRECT/S,N,NOSORT2/S,N,NOD/S,N,NCP/C,N,0 $
324 CUND LBL15, NOD $
325 CUND LBL15A, NOSORT2 $
326 SDR 3 OUOVC1, ..... / OUOVC2, .... $
327 OEP OUOVC2, ..... / S,N,CARDNC $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

328 XYTRAN XVCUB,OUVVC2,.../XYPLTFA/*FREQ*/DSET*/S,N,PFILE/S,N,CARUNO $
329 XYPLLOT XYPLTFA/ $
330 JUMP LBL15 $
331 LABEL LBL15A $
332 QFP OUDVC1,...,/S,N,CARUNC $
333 LABEL LBL15 $
334 COND LBL20,NUP $
335 EQUIV UDFV,UPVC/NOA $
336 COND LBL19,NUa $
337 SDR1 USETD,UDVF,...,GUO,GOO,PSF,KFS,.../UPVC,...,QPC/1/*DYNAMICS*/ $
338 LABEL LBL19 $
339 SDR2 CASEXX,CSTM,MPT,DIT,EQDY,SLD,...,BG,IPF,FUL,QPC,EP,XYCB,PPF/OUPC1,OUPC1,OUPVC1,EGSL1,CEFC1,PUPVC1/C,N,FRE,FRSP/ S,N,NUSSRT2 $
340 CIVD LBL17,NUSSRT2 $
341 SDR3 OUPC1,OUPC1,CUPVC1,EGSL1,CEFC1,0UPPC2,0UPPC2,0UPVC2,0ESC2,0EFC 2, $
342 QFP 0UPPC2,0UPPC2,0UPVC2,0ESC2,0ESC2,//S,N,CARUNC $
343 XYTRAN XVCUB,0UPPC2,0UPPC2,0UPVC2,0ESC2,0ESC2/XYPLTFA/*FREQ*/PSET*/ S,N,PFILE/S,N,CARUNO $
344 XYPLLOT XYPLTFA/ $
345 COND LBL16,NOPSOL $
346 FANDLM XVCUB,DIT,PSOL,0UPVC2,0UPPC2,0UPPC2,0ESC2,0ESC2,CASEXX/PSDF,AUTU/ S,N,NORD $
347 CIVD LBL16,NORD $
348 XYTRAN XVCUB,PSDF,AUTO,...,XYPLTR/*RAND*/PSET*/S,N,PFILE/S,N,CARUNO $
349 XYPLLOT XYPLTR/ $
LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

350 JUMP LBL16 $
351 LABEL LBL17 $
352 JUP UPPVC1,OPPC1,OQPC1,CEFC1,DESC1, //S,1,CARDAC $
353 LABEL LBL16 $
354 CDVD LBL20,JUMPPLCT $
355 PLOT PLTPAR,GPSETS,ELSETS,CASEXX,BUPDT,EQEXIN,SIP,UPUPVC1, GPEC1, DESC1/PLTOX2/NSIL/LUSEP/JLMPPLCT/PLTFLG/ S,N,PFILE $
356 PRTMSG PLOTX2// $
357 LABEL LBL20 $
358 CDVD FINIS:REPEATF $
359 KEPT LBL13,100 $
360 LABEL ERROR3 $
361 PRTPARM //--3/#DIFFRND# $
362 JUMP FINIS $
363 LABEL ERROR4 $
364 PRTPARM //--4/#DIFFRND# $
365 LABEL ERRREC1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.
366 PRTPARM //C,N,-7 /C,Y,CYCSTAC S $
367 LABEL ERRJRC2 $ COUPLED MASS NCT ALLOWED.
368 PRTPARM //C,N,0 /C,Y,CYMPASS $
369 JUMP FINIS $
370 LABEL ERRREC3 $ SUPORT BULK DATA NCT ALLOWED.
371 PRTPARM //C,N,-6 /C,N,CYCSTAC S $
372 LABEL ERRREC4 $ EPPOINT BULK DATA NUT 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,NODRL $
377 PRTPARM //C,N,0 /C,N,NCTRL $
378 JUMP FINIS $
379 LABEL ERRORC6 $ BOTH FREQ AND TSTEP WERE SELECTED IN CASE CONTROL.
380 PRTPARM //C,N,0 /C,N,NOFREQ $
381 PRTPARM //C,N,0 /C,N,NOTIME $
382 JUMP FINIS $
383 LABEL FINIS $
384 END $
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES

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

5. Go to DMAP No. 365 if user has not specified parameter NSEGS.
6. Go to DMAP No. 365 if user has not specified parameter KMAX.
8. Go to DMAP No. 365 if user has not specified parameter CYCIO.
11. Go to DMAP No. 365 if KMAX > NSEGS/2.
18. Go to DMAP No. 367 if user has requested consistent mass.
20. GPI generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.
23. Go to DMAP No. 141 if only Direct Matrix Input.
24. GP2 generates Element Connection Table with internal indices.
27. Go to DMAP No. 35 if no plot output is requested.
28. PLTSET transforms user input into a form used to drive structure plotter.
29. PRTMSG prints error messages associated with structure plotter.
32. Go to DMAP No. 35 if no undeformed structure plots are requested.
33. PLT generates all requested undeformed structure plots.
34. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
36. GP3 generates Grid Point Temperature Table.
38. TAI generates element tables for use in matrix assembly and stress recovery.
41. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations \([R_g] \{u_g\} = 0\).
45. Go to DMAP No. 370 and print error message if free-body supports are present.
46. DPD generates flags defining members of various displacement sets used in dynamic analysis (USSETD), 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.

2.33
57. Go to DMAP No. 372 and print parameter NOUE if extra points are present.

58. GPCYC prepares segment boundary table (CYCDD).

59. Go to DMAP No. 365 and print error message if CYJOIN data is inconsistent.

61. Go to DMAP No. 95 if there are no structural elements.

66. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.

67. Go to DMAP No. 69 if no stiffness matrix is to be assembled.

68. EMA assembles stiffness matrix $[K_{gg}^X]$ and Grid Point Singularity Table.

73. Go to DMAP No. 75 if no mass matrix is to be assembled.

74. EMA assembles mass matrix $[M_{gg}]$.

76. DUMMOD1 generates modified Frequency Response List, FRLX, Coriolis acceleration coefficient matrix $[B1GG_{gg}]$, centripetal coefficient matrix $[M1GG_{gg}]$, Base acceleration coefficient matrix $[M2GG_{gg}]$, Base acceleration matrix $[BASEXG_{gg}]$ and load modification matrix, $[PDZERO^F_g]$, for base acceleration problems.

79. Equivalence FRLX to FRL if FRLX was generated by DUMMOD1.

82. Go to DMAP No. 84 if no viscous damping matrix is to be assembled.

83. EMA assembles viscous damping matrix $[B_{gg}]$.

85. Go to DMAP No. 87 if no structural damping matrix is to be assembled.

86. EMA assembles structural damping matrix $[K_{gg}^A]$.

91. Go to DMAP No. 95 if no weight and balance is requested.

92. Go to DMAP No. 363 and print error message if no mass matrix exists.

93. GPWG generates weight and balance information.

94. OEP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

96. Equivalence $[K_{gg}^X]$ to $[K_{gg}]$ if no general elements.

97. Go to DMAP No. 99 if no general elements.

98. SMWA3 adds general elements to $[K_{gg}^X]$ to obtain stiffness matrix $[K_{gg}]$.

100. Go to DMAP No. 109 if parameter RPS = 0.0 or if no mass matrix is present.

104. ADD assembles the Coriolis acceleration matrix into the viscous damping matrix

$$[BG_{gg}] = [B_{gg}] + (4 \cdot RPS) [B1GG_{gg}]$$
105. Equivalence $[BGG]_{gg}$ to $[B_{gg}]$.

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

$$[K_{GG}]_{gg} = [K_{gg}] - (2 \pi \cdot \text{RPS})^2 [M_{GG}]_{gg}$$

107. Equivalence $[K_{GG}]_{gg}$ to $[K_{gg}]^T$.

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

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

110. GPSP determines if possible grid point singularities remain.

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

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

113. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

114. Go to DMAP No. 117 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

115. MCE1 partitions multipoint constraint equations $[R_y] = [K_{m}]^T R_n$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-T} [R_n]$.

116. MCE2 partitions stiffness, mass and damping matrices

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

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

and performs matrix reductions

$$[K_{nn}] = [R_{nn}] + [G_m^T][K_{nn}] + [K^T_{mn}][G_m] + [G_m^T][K^4_{nn}][G_m],$$

$$[M_{nn}] = [R_{nn}] + [G_m^T][M_{nn}] + [M^T_{mn}][G_m] + [G_m^T][M^4_{nn}][G_m],$$

$$[B_{nn}] = [R_{nn}] + [G_m^T][B_{nn}] + [B^T_{mn}][G_m] + [G_m^T][B^4_{nn}][G_m],$$

$$[K^4_{nn}] = [R_{nn}] + [G_m^T][K^4_{nn}] + [K^4_{mn}][G_m] + [G_m^T][K^4_{mm}][G_m].$$

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.
124. Go to DMAP No. 126 if no single-point constraints.

125. SCE1 partitions out single-point constraints

\[ [K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix} \]

\[ [B_{nn}] = \begin{bmatrix} B_{ff} & B_{fs} \\ B_{sf} & B_{ss} \end{bmatrix} \quad \text{and} \quad [K^4_{nn}] = \begin{bmatrix} K^4_{ff} & K^4_{fs} \\ K^4_{sf} & K^4_{ss} \end{bmatrix} \]

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 \([K^4_{ff}] \) to \([K^4_{aa}] \) 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 \([G_o]\) = \([-K_{do}]^{-1}[K_{oa}]\)

and performs matrix reduction \([K^T_{aa}] = [K_{aa}] + [K_{ao}][G_o]\).

133. Go to DMAP No. 135 if \(\rho\) 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

\[ [M^T_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o] \]

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

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

and performs reduction

\[
[B_{aa}^1] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}][G_o]^T + [G_o][B_{oo}][G_o]
\]

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

\[
[K_{aa}^1] = [K_{aa}] + [K_{ao}][G_o] + [K_{ao}][G_o]^T + [G_o][K_{oo}][G_o]
\]

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

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

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

14: MTRXIN generates fluid boundary matrices \([A_{b,f}], [K_{b,f}]\) if a fluid structure interface is defined. The matrix \([K_{b,f}]\) 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, \([K_{pp}^2], [M_{pp}^2]\) and \([B_{pp}^2]\).

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

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

2.37
160. Go to DMAP No. 163 if 

161. Transpose $[A_{b,fp}]$ to obtain $[A_{b,fp}]^T$. 

162. ADD assembles input matrix $[M_{pp}^2] = \text{MFACT} [A_{b,fp}]^T + [M_{pp}^2]$. 

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

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

172. Go to DMAP No. 175. 

173. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[K_{aa}]$ to $[K_{dd}]$ 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 $\text{GKAD} = \text{FREQRESP}$:

$$[K_{dd}] = (1 + ig)[K_{dd}] + [K_{dd}^2] + i[K_{dd}^4],$$
$$[M_{dd}] = [M_{dd}] + [M_{dd}^2]$$ and
$$[B_{dd}] = [B_{dd}] + [B_{dd}^2].$$

Direct input matrices may be complex.

or

GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response if parameter $\text{GKAD} = \text{TRANRESP}$:

$$[K_{dd}] = [K_{dd}] + [K_{dd}^2],$$
$$[M_{dd}] = [M_{dd}] + [M_{dd}^2],$$
and $$[B_{dd}] = [B_{dd}] + [B_{dd}^2] + \frac{g}{\omega^3} [K_{dd}] + \frac{1}{\omega^4} [K_{dd}^4],$$

where

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

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

2.38
All matrices are real.

179. Go to DMAP No. 102 if transient type GKAD matrices were generated.

180. Equivalence $[K_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

181. Go to DMAP No. 184.

183. Equivalence $[B_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input, $[M_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[K_{dd}]$ 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. $\{P_{d}^{t}\}$ is generated with one column per output time step. $\{P_{d}\}$ is generated with one column per solution time step, and the Transient Output List (TOL) is a list of output time steps.

194. SDR1 appends $\{P_{d}^{t}\}$ to $\{P_{d}\}$.

195. SDR1 appends $\{P_{d}^{t}\}$ to $\{P_{d}\}$.

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

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

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

202. Equivalence $\{P_{d}\}$ to $\{P_{d}^{t}\}$ if the output times are the same as the solution times.

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

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

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

210. Go to DMAP No. 213 if FRLX was not generated by DUMM0D1.

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

212. Equivalence $\{P_X^f\}$ to $\{P_p^f\}$.

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

215. MPYAD forms the complete base acceleration matrix, $\{M2BASEXG_g\} = \{M2GG_g\} \cdot \{BASEXG_g\}$.
216. ADD assembles the frequency response loads and the loads due to base acceleration.

\[ \{P_f^p\} = \{P_p^f\} - \{N2BASEXG^g\} \]

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

217. Equivalence \(\{P_f^p\}\) 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 \(\{P_f^t\}\) and \(\{PDTRZ1\}\) if REORDER1 was not generated by DUMMOD2.

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

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

228. CYCT1 transforms loads on analyses 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. MPYAD reorders columns of \(\{PXTRZ1\}\).

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

233. Go to DMAP No. 264.

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

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

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

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

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

239. MPYAD 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.

\[ (PFX) = (0.5, i.0) \cdot (PFX1) \cdot (0.5, -1.0i) \cdot (PFX2) \]

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

274. Beginning of loop to create KMIN null columns of \( \{UV_x^f\} \) 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 \( \{UV_x^f\} \) columns.

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

277. ADD generates a null vector \( \{UV_z^f\} = \{P_z^f\} \cdot 0.0 \).

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

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 \( \{UV_x^f\} \). If the initial \( \{UV_x^f\} \) for KINDEX values 0 to (KMIN-1) has been completed then go to DMAP No. 282.

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

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

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

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

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

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

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

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

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

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

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

289. Go to DMAP No. 282 if KMIN = 0.
301. PARAM increments the value of KINDEX = KINDEX + 1.

303. Go to DMAP No. 306 if all cyclic index values are complete.

304. Go to DMAP No. 284 if additional index values are needed.

305. Go to DMAP No. 360 and print error message if more than 100 loops on KINDEX.

307. Equivalence \( \{U_x^f \} \) to \( \{U_d^f \} \) if parameter CYCIO = -1.

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

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

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

314. Equivalence \( \{P_x^f \} \) to \( \{P_d^f \} \) if parameter CYCIO = -1.

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

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

318. SDR1 recovers dependent loads \( \{P_{Zp}^f \} \).

319. SSG2 applies constraints to \( \{P_{Zp}^f \} \) to form \( \{P_{Zs}^f \} \).

320. Equivalence \( \{P_{Zp}^f \} \) to \( \{P_{p}^f \} \) and \( \{P_{Zs}^f \} \) to \( \{P_{s}^f \} \).

323. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.

324. Go to DMAP No. 333 if no output request for the independent degrees of freedom.

325. Go to DMAP No. 331 if no output request for independent displacements sorted by point number.

326. SDR3 sorts the independent displacements by point number.

327. OFP formats the requested independent displacements, sorted by point number, prepared by SDR3 and places them on the system output file for printing.

328. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.

329. 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 sorted by point number involving dependent degrees of freedom 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

\[
\begin{align*}
\{u_0\} &= [G^d_0]\{u_d\}, \\
\{u_f + u_e\} &= \{u_n + u_e\}, \\
\{u_m\} &= \{G^d_{m}\}\{u_f + u_e\}.
\end{align*}
\]

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

339. SDR2 calculates element forces (\(\varnothing\)EFC1) and stresses (\(\varnothing\)ESC1) and prepares load vectors (\(\varnothing\)PPC1), displacement vectors (\(\varnothing\)UPVC1), and single-point forces of constraint (\(\varnothing\)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. \&FP 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. XYPL\&T 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. XYPL\&T 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.

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352. *EFP* formats frequency response output requests prepared by SDR2, sorted by frequency, and places them on the system output file for printing.

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

355. PLOT generates all requested deformed plots.

356. 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 ERRORS.

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
ROTTING 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 CYCLO 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 RANDT1 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. WITMASS - 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, N3 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) **ROT** - 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 TABLE1 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 BUMODD

3.1.1.1 FRLX (TABLE)

Description

Frequency Response List

The FRLX contains one log. rec. 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>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>BCD</td>
<td>Data block name</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>Set ID₁</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+n</td>
<td>I</td>
<td>Set IDₙ</td>
</tr>
<tr>
<td>1</td>
<td>R</td>
<td>Radian frequencies belonging to set ID₁</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(w = 2πF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>R</td>
<td>Radian frequencies belonging to set IDₙ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(w = 2πF)</td>
</tr>
</tbody>
</table>

Table Trailer

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

3.1.1.2 BIGG (MATRIX)

Description

[BIGGₙ] = Coriolis acceleration coefficient matrix - g set.

3.1.1.3 M1GG (MATRIX)

Description

[M1GGₙ] = Centripetal acceleration coefficient matrix - g set.

3.1.1.4 M2GG (MATRIX)

Description

[M2GGₙ] = Base acceleration coefficient matrix - g set.
3.1.5 BASEXG (MATRIX)

Description

\([BASEXG_g^F]\) - Base acceleration matrix - \(g\) set.

3.1.6 PDZERO (MATRIX)

Description

\([PDZERO_g^F]\) - Load modification matrix in base acceleration problems - \(g\) set.

3.1.2 Data Blocks Output from Module DUMMO2

3.1.2.1 FRL (TABLE)

Description

Frequency Response List

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

Table Format

<table>
<thead>
<tr>
<th>Record</th>
<th>Word</th>
<th>Type</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></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-m</td>
<td>R</td>
<td>Radian frequencies (\omega = 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></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 (\nu = 2\pi F)</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>End-of-file</td>
</tr>
</tbody>
</table>
Table Trailer

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

3.1.2.3 REORDER1 (MATRIX)

Description


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 NOMGG=1.
2. B1GG and M1GG can be purged if NOMGG=1 or if OMEGA=0.0.
3. FRLX and PDZERO can be purged if OMEGA=0.0.
4. FRLX, PDZERO, 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 TABLEd Bulk Data cards which define
   the components of the base acceleration vector. The tables referred
   to by BXTID, BYTID and BZTID define magnitude (LT-2) and 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 DUMMOD1, otherwise computations proceed in three phases. In the first phase B1GG and M1GG are generated unless parameter OMEGA=0.0. M2GG is generated if parameter NOBASEX=+1. The second and third phases generate data blocks associated with base acceleration problems and are only executed if NOBASEX=+1. In the second phase FRLX and PDZERO are generated unless parameter OMEGA=0.0. Data block BASEXG is generated and output in phase three.

3.2.1.7.1 Phase 1 - Generation of B1GG, M1GG and M2GG

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

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

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

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

and
\[ [H_{i}] = \begin{bmatrix} m_{i} & 0 & 0 \\ 0 & m_{i}T_{2} & 0 \\ 0 & 0 & m_{i}T_{3} \end{bmatrix} \]

(b) Transform \([M_{i}]\) from global to basic coordinate system
\[ [\bar{M}_{i}] = [T_{i}] [M_{i}] [T_{i}]^{T} \]

(c) Compute average of \([\bar{M}_{i}]\)
\[ \bar{m}_{i}^{K} = \frac{1}{3} \sum_{k=1}^{3} \bar{m}_{i}^{K} \]
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 \(B_{1GG}\)
\[ [B_{1GG}] = \begin{bmatrix} [B_{11}] & \cdots & [B_{1g}] \\ 0 & \cdots & [B_{1n}] \end{bmatrix} \]
where
\[ [B_{1i}] = \begin{bmatrix} [B_{1i}^1] & \cdots & [B_{1i}^n] \end{bmatrix} \]
and
\[ [B_{1i}] = [T_{i}]^{T} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -\bar{m}_{i} \\ 0 & \bar{m}_{i} & 0 \end{bmatrix} [T_{i}] \]

(e) Form \(M_{1GG}\)
\[ [M_{1GG}] = \begin{bmatrix} [M_{11}] & \cdots & [M_{1g}] \\ 0 & \cdots & [M_{1n}] \end{bmatrix} \]

3.7
where
\[ [M_1]_{6 \times 6} = \begin{bmatrix} \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \end{bmatrix} \]

and
\[ [M_1]_{3 \times 3} = [T_i]^{\top} \begin{bmatrix} 0 & 0 & 0 \\ 0 & \bar{m}_i & 0 \\ 0 & 0 & \bar{m}_i \end{bmatrix} [T_i] \]

(f) Form M2GG
\[ [M2GG]_{g \times g} = \begin{bmatrix} [M2_1] & 0 \\ 0 & \ddots & \ddots \\ 0 & 0 & [M2_n] \end{bmatrix} \]

where
\[ [M2_i]_{6 \times 6} = \begin{bmatrix} \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \end{bmatrix} \]

and
\[ [M2_i]_{3 \times 3} = [T_i]^{\top} \begin{bmatrix} \bar{m}_i & 0 & 0 \\ 0 & \bar{m}_i & \bar{m}_i \\ 0 & -\bar{m}_i & \bar{m}_i \end{bmatrix} [T_i] \]

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 \( \omega = 0.0 \), 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 DUUMI1E to sort it in ascending order. DUUMI1E 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 F/MAX times, thus creating F/MAX 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, BTID, 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 DUUM1A, DUM1B, DUM1C and DUM1D are used to generate data block BASEXG. Routine DUUM1A 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 DUM1B is called to generate the BASE table if the original FRL frequency list was not expanded, see phase two, otherwise routine DUM1C is called. Routine DUM1D 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 \( \tilde{x}(f_i), \tilde{y}(f_i), \tilde{z}(f_i), \tilde{x}(f_i), \tilde{y}(f_i) \) be input via frequency dependent tables TABLEDi where the table IDs are defined by parameters BXTID, BXPTID, BTID, BYPTID, BZTID and BZPTID respectively. \( \tilde{x}, \tilde{y}, \tilde{z} \) are magnitudes in \( \text{LT-2} \) units while \( \tilde{x}, \tilde{y}, \tilde{z} \) 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).

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

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

\[
[BASE]_{3xNF} = [(BASE(f_1))_{3x1} \cdots (BASE(f_{NF}))_{3x1}] 
\]
where \( f_i = \omega_i / 2\pi \) for \( i = 1, 2, \ldots, \text{NF} \) and

\[
\{\text{BASE}(f_i)\}_{3x1} = \begin{cases} \ddot{x}_0(f_i) - e^{i\Omega_x(f_i)} \\ \ddot{y}_0(f_i) - e^{i\Omega_y(f_i)} \\ \ddot{z}_0(f_i) - e^{i\Omega_z(f_i)} \end{cases}
\]

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

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

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

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 \( \{\text{BASE}(f_i)\}_{3x2} \) is defined as follows:

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

where

\[
\text{SGN} = 1.0 \quad \text{if \ parameter \ OMEGA} \geq 0.0, \quad \text{otherwise} \quad \text{SGN} = -1.0
\]

\[
A = \ddot{x}_0(f_i) \cdot e^{i\Omega_x(f_i)}
\]

\[
B = \ddot{y}_0(f_i) \cdot \cos(\Omega_y(f_i)) - i \cdot \text{SGN} \cdot \ddot{z}_0(f_i) \cdot \cos(\Omega_z(f_i))
\]

\[
C = \ddot{z}_0(f_i) \cdot \cos(\Omega_z(f_i)) + i \cdot \text{SGN} \cdot \ddot{y}_0(f_i) \cdot \cos(\Omega_y(f_i))
\]

(e.2) If \( \omega_i \neq 0.0 \), then \( \{\text{BASE}(f_i)\}_{3x3} \) is defined as follows:

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

where

\[
\text{SGNA} = 1.0 \quad \text{if} \quad (\omega_i - \text{OMEGA}) \geq 0.0, \quad \text{otherwise} \quad \text{SGNA} = -1.0
\]

\[
\text{SGNB} = 1.0 \quad \text{if} \quad (\omega_i + \text{OMEGA}) \geq 0.0, \quad \text{otherwise} \quad \text{SGNB} = -1.0
\]

and

\[
A = \ddot{x}_0(f_i) \cdot e^{i\Omega_x(f_i)}
\]

\[
B = 0.5 \cdot \begin{bmatrix} \ddot{y}_0(f_i) \cdot e^{i\text{SGNA} \cdot \Omega_y(f_i)} - \text{SGNA} \cdot \ddot{z}_0(f_i) \cdot e^{i\text{SGNA} \cdot \Omega_z(f_i)} \end{bmatrix}
\]

\[
3.10
\]
(f) Define the complex base acceleration matrix BASEXG of order G x (NF•FKMAX) as follows:

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

\[
[BASEXG]_{g x (NF•FKMAX)} = [BASEXG^1]_{6xNF} [BASEXG^2]_{g x NF} [BASEXG^3]_{g x NF} \ldots [BASEXG^{FKMAX}]_{g x NF}
\]

where

\[
[BASEXG^i]_{g x NF} = \begin{bmatrix}
[BASEX^i]^1_{6xNF} \\
[BASEX^i]^2_{6xNF} \\
\vdots \\
[BASEX^i]^3_{6xNF}
\end{bmatrix}
\]

and

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

NOTE: \([BASEX^i]^1\) 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.

\[
[BASEX^1]_{6xNF} = \begin{bmatrix}
BASE(1,1) & BASE(1,2) & \ldots & BASE(1,NF) \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & 0
\end{bmatrix}
\]


3.2.1.8 Subroutines

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

3.2.1.8.1 Subroutine Name: DUMOIA

1. Entry Point: DUMOIA

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

3. Calling Sequence: Call DUMOIA (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, TWOPI, 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
NFX - Number of columns of matrix BASE and length of INDEX - integer - input.

3.2.1.8.5 Subroutine Name: DUMO1E

1. Entry Point: DUMO1E

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

3. Calling Sequence: CALL DUMO1E(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 /DUMIxx/
   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/DUMIxx/ Z

<table>
<thead>
<tr>
<th>Z(1)</th>
<th>Column of MGG</th>
<th>NTYPE*G-set</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z(ICST1)</td>
<td>CSTM_DATA</td>
<td>LCST1</td>
</tr>
<tr>
<td>Z(IBUF5)</td>
<td>M2GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF4)</td>
<td>M1GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF3)</td>
<td>B1GG</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF2)</td>
<td>BGPDT</td>
<td>GINO BUFFER</td>
</tr>
<tr>
<td>Z(IBUF1)</td>
<td>CSTM/MGG</td>
<td>GINO BUFFER+1</td>
</tr>
</tbody>
</table>
The following fatal error messages may occur:

<table>
<thead>
<tr>
<th>Phase III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL) FRL DATA</td>
</tr>
<tr>
<td>Z(IBUF3) BASEXG FREE</td>
</tr>
<tr>
<td>Z(IFRL) PRETAG TABLE DATA</td>
</tr>
<tr>
<td>Z(IFRL) BASE MATRIX</td>
</tr>
<tr>
<td>Z(IFRL) SORT INDEX</td>
</tr>
<tr>
<td>Z(IFRL) INDEX</td>
</tr>
<tr>
<td>Z(IFRL) COMNON/COMMON/Z</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL) FRL DATA</td>
</tr>
<tr>
<td>Z(IBUF1) CASEL/FRLX</td>
</tr>
<tr>
<td>Z(IFRL) FRLX DATA</td>
</tr>
<tr>
<td>Z(IFRL) FRLX INDEX</td>
</tr>
<tr>
<td>Z(IFRL) INDEX</td>
</tr>
<tr>
<td>Z(IFRL) COMNON/COMMON/Z</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(IFRL) FRL DATA</td>
</tr>
<tr>
<td>Z(IBUF1) CASEL/FRLX</td>
</tr>
<tr>
<td>Z(IFRL) FRLX DATA</td>
</tr>
<tr>
<td>Z(IFRL) FRLX INDEX</td>
</tr>
<tr>
<td>Z(IFRL) INDEX</td>
</tr>
<tr>
<td>Z(IFRL) COMNON/COMMON/Z</td>
</tr>
</tbody>
</table>

3.15
3.2.2 Functional Module DUMMOD2

3.2.2.1 Entry Point: DUMMOD2

3.2.2.2 Purpose

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

3.2.2.3 DMAP Calling Sequence

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

3.2.2.4 Input Data Blocks

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

3.2.2.5 Output Data Blocks

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

3.2.2.6 Parameters

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

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

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

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

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

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

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

3.2.2.7.1 Computation of Parameters NTSTEPS, LMAX and FLMAX

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

a) Parameter NTSTEPS
   If CYCIO=-1, then NTSTEPS=(NTIMES*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 NORO1 and NORO2.

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

FILE - GINO file number of REORDER1 or REORDER2 - integer - input.

KK1 - Reordering row index - integer - input.

KK2 - Reordering column index - integer - input.

NORO - NORO=+1 if reordering matrix was generated, -1 otherwise - integer - output.

BUFFER - GINO buffer - real - input

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

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

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

3.2.2.9 Design Requirements

a) Open core is defined at /DUM2XX/

b) DUMOD2 resides in LINKNS07

c) No scratch files are used

d) Open core for one BUFFER+1 is required.
The layout of open core is as follows:

```plaintext
COMMON/DUM2XX/

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

### 3.2.2.10 Diagnostic Messages

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

3.3.1 IBM OVERLAY CHARTS
FOR NASTRAN LINKS
1, 6, 7, 9, 10, 11
X - Denotes new Routines
+ - Denotes existing Routines Now To This Link

Must be placed after the
Largest link of all previous
Level output and output

LINKEDIT Controls

- Change INST (RETURN)
- Execute LINE (RETURN)

- Change PLOT (RETURN), SYMBOL (RETURN), NUMBER (RETURN)
- Include LIB (RETURN)

- Change AUT (RETURN), SYMBOL (RETURN)
- Include LIB (SUB-32)

- Change PLOT (RETURN), LINE (RETURN), AXIS (RETURN)
- Include LIB (SUB-32)

FILE

FILE

FILE

FILE

FILE

FILE

FILE

FILE

FILE

FILE

FILE

FILE

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

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

A. General Description

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

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

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

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

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

B. General Input

1. Parameters:
   
   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 \text{ lbf/in}^2.
Poisson's ratio = 0.3
Material density = 7.4 \times 10^{-4} \text{ lbs-sec}^2/\text{in}^4
Uniform structural damping (\nu) = 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_2 at remaining grid points are constrained to zero.
EXAMPLE 1

A. Description

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

B. Input

1. Parameters:
   Same as general input parameters.

2. Constraints:
   Same as general input constraints.

3. Loads:

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

   where
   - \( n \) is the segment number,
   - \( k = 2 \) represents \( k = 2 \),
   - \( \frac{2\pi}{k} \) represents the total number of segments in the bladed disc.
   - \( P \) is specified using RLOAD1 bulk data cards.

C. Results

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

**NASTRAN EXECUTIVE CONTROL DECK ECHO**

<table>
<thead>
<tr>
<th>ID</th>
<th>NASA, EXAMPLE1</th>
</tr>
</thead>
<tbody>
<tr>
<td>APP</td>
<td>DISP</td>
</tr>
<tr>
<td>SOL</td>
<td>0</td>
</tr>
<tr>
<td>TIME</td>
<td>15</td>
</tr>
<tr>
<td>DIAG</td>
<td>IBM 370/3031</td>
</tr>
<tr>
<td>CEND</td>
<td>14.21</td>
</tr>
</tbody>
</table>
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADE DISC EXAMPLE 1  (FULL MODEL,FREQ LOADS)

INDEX 2C TYPE LOADS

CASE CONTROL DECK ECHO

CARD COUNT
1 $ 
2 TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
3 SUBTITLE = BLADE DISC EXAMPLE 1  (FULL MODEL,FREQ LOADS)
4 LABEL = INDEX 2C TYPE LOADS
5 $
6 SPC = 30
7 FREQ = 1
8 DLOAD = 1
9 OUTPUT
10 SET 1 = 0.22, 26, 50, 66, 78, 92, 106, 120, 134, 148, 162.
11 16, 30, 44, 58, 72, 86, 100, 114, 128, 142, 156, 170.
12 18, 32, 46, 60, 74, 88, 102, 116, 130, 144, 158, 172.
13 DLOAD = 1
14 DISP(SORT2,PHASE) = ALL
15 STRESS(SORT2,PHASE) = ALL
16 OUTPUT(XYPLT)
17 PLOTTER NASPLT  MODEL 0,0
18 XPAPER = 8.0
19 YPAPER = 10.5
20 XAXIS = YES
21 YAXIS = YES
22 XGRID LINES = YES
23 YGRID LINES = YES
24 CURVELINE SYMBOL = 1
25 VLOG = YES
26 XTITLE = FREQUENCY (HERTZ)
27 YTITLE = GRID POINT DISPLACEMENTS ( MAGNITUDE, INCH )
28 TCURVE = 14(T3RM), 10(T3RM), 95(T3RM)
29 XYPLT, XPRINT DISP RESPONSE /14(T3RM), 18(T3RM), 95(T3RM)
30 YTITLE = ELEMENT STRESSES ( MAGNITUDE, PSI )
31 TYURVE = 11(3), 11(5), 11(7), 11(10), 11(12), 11(14)
32 XYPLT, XPRINT STRESS RESPONSE /11(3), 11(5), 11(7),
33 11(10), 11(12), 11(14)
34 TCURVE = 109(3), 109(5), 109(7), 109(10), 109(12), 109(14)
35 XYPLT, XPRINT STRESS RESPONSE /109(3), 109(5), 109(7),
36 109(10), 109(12), 109(14)
37 BEGIN BULK

SER INFORMATION MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL RE-ORDER DECK.
<table>
<thead>
<tr>
<th>CORD2</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
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<td>0.0</td>
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<tr>
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<td>2</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CQAU2</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>12</td>
<td>11</td>
<td></td>
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<tr>
<td>CQAU2</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>8</td>
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<tr>
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<td>2</td>
<td>7</td>
<td>8</td>
<td>13</td>
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</tr>
<tr>
<td>CQAU2</td>
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<td>4</td>
<td>5</td>
<td>9</td>
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</tr>
<tr>
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<td>14</td>
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<td></td>
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</tr>
<tr>
<td>CQAU2</td>
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<td>3</td>
<td>9</td>
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<td>16</td>
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</tr>
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<td>3</td>
<td>16</td>
<td>17</td>
<td>19</td>
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<td></td>
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<td></td>
</tr>
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EXAMPLE 2

A. Description

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

B. Input

1. Parameters:

   In addition to general input parameters,

   \[ \text{CYCIO} = +1 \text{ physical cyclic input/output data} \]
   \[ \text{KMIN} = 2 \text{ minimum circumferential harmonic index} \]
   \[ \text{KMAX} = 2 \text{ maximum circumferential harmonic index} \]
   \[ \text{NSEG} = 12 \text{ number of rotationally cyclic segments} \]
   \[ \text{RPS} = 0.0 \text{ rotational speed} \]
   \[ \text{GKDAD} = \text{FREQRESP} \] Specify the form in which the damping parameters
   \[ \text{LGKDAD} = +1 \] are used.

2. Constraints:

   Same as general input constraints.

3. Loads:

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

   where \( n \) is the segment number,
   \( %d \) represents \( k = 2 \),
   \( \%d \) 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**

1. **ID**: NASA_EXAMPLE2
2. **APP**: DISP
3. **SOL**: 8

---

**EXECUTIVE DECK INPUT**

1. SOL 8
2. **R.F. ALTERS**

**CASE CONTROL DECK INPUT**

1. ALL SPC AND MPC CONSTRAINTS MUST BE ABOVE THE SUBCASE LEVEL.
2. EITHER FREQUENCY OR TSTEP MUST BE SELECTED AND MUST BE ABOVE
   THE SUBCASE LEVEL.
3. IF SELECTED, FREQUENCY MUST BE USED TO SELECT ONE AND ONLY
   ONE 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-STEMPS 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
   SECTOR.
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**

---

**ORIGINAL PAGE IS OF POOR QUALITY.**

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

A. NSEGS - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   IS THE NUMBER OF IDENTICAL SEGMENTS IN THE
   STRUCTURAL MODEL.
B. CYCLO - REQUIRED - THE INTEGER VALUE OF THIS PARAMETER
   SPELISHES 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. CYSEQ - FIXED - THE INTEGER VALUE OF THIS PARAMETER
   SPELISHES 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 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 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 0.0.
J. BAXID - 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

4.16
S. NUKPRT - OPTIONAL - AN INTEGER VALUE OF 61 FOR THIS PARAMETER WILL CAUSE THE CURRENT HARMONIC INDEX, KINDEX, TO BE PRINTED AT THE TOP OF THE HARMONIC LOOP. THE DEFAULT VALUE IS 61.

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

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

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

O. GKA - OPTIONAL - THE BCD VALUE OF THIS PARAMETER IS USED TO TELL THE GKAD MODULE THE DESIRED FORM OF MATRICES KUG, BDD, AND H00. 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.

P. LGKAD - OPTIONAL - THE INTEGER VALUE OF THIS PARAMETER IS USED IN CONJUNCTION WITH PARAMETER GKA. IF GKA=FREKESP THEN SET LGKAD=1. IF GKA=TRANRESP THEN SET LGKAD=-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 GKA=TRANRESP. IN THIS CASE W3 IS REQUIRED IF UNIFORMED STRUCTUAL 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 GKA=TRANRESP. IN THIS CASE W4 IS REQUIRED IF STRUCTUAL DAMPING IS DESIRED FOR ANY OF THE STRUCTURAL ELEMENTS. DEFAULT IS 0.0.

REMARKS -

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

4.17
$\text{NASTRAN EXECUTIVE CONTROL DECK ECHO}$

\text{ALTER 3}$
\text{FILE UXVF=APPEND/PUT=APPEND/PO=APPEND $}
\text{PERFLM INITIAL ERROR CHECKS ON NSEGS AND KMAX.}
\text{COND ERRORC1\#NSEGS $ IF USER HAS NOT SPECIFIED NSEGS.}
\text{COND ERRORC1\#KMAX $ IF USER HAS NOT SPECIFIED KMAX.}
\text{PARAM //\text{C},\text{N},\text{E}U \text{V_/\text{C}},\text{N},\text{CYC10ERR /V_/\text{Y},\text{CYC10}=0 /\text{C},\text{N},\text{O} $}
\text{COND ERRORC1\#CYC10ERR $ IF USER HAS NOT SPECIFIED CYC10.}
\text{PARAM //\text{C},\text{N},\text{DIV/V_/\text{C}},\text{N},\text{NSE}G2 /V_/\text{Y},\text{NSE}G /\text{C},\text{N},\text{2 $ NSEG2 = NSEGS/2}
\text{PARAM //\text{C},\text{N},\text{SUB/V_/\text{C}},\text{N},\text{KMAXERR /V_/\text{Y},\text{NSEG}2 /V_/\text{Y},\text{KMAX} $}
\text{COND ERRORC1\#KMAXERR $ IF KMAX = GT NSEGS/2}
\text{SET DEFAULTS FOR PARAMETERS.}
\text{PARAM //\text{C},\text{N},\text{N}UP/V_/\text{Y},\text{NDKPRET}=1 /V_/\text{Y},\text{LKGAD}=1 $}
\text{CALCULATE OMEGA. 2*OMEGA AND OMEGA**2 FROM RPS. SET DEFAULT KPS.}
\text{PARAMR //\text{C},\text{N},\text{H}P /V_/\text{N},\text{OMEGA /V_/\text{Y},\text{RPS}=0.0 /\text{C},\text{N},\text{O} 293185 $}
\text{PARAMR //\text{C},\text{N},\text{MPY/V_/\text{N},\text{OMEGA}2 /\text{C},\text{N},\text{2}=0 /V_/\text{Y},\text{OMEGA} $}
\text{PARAMR //\text{C},\text{N},\text{H}P /V_/\text{N},\text{OMEGASQ} /V_/\text{N},\text{OMEGA} /V_/\text{N},\text{OMEGA} $}
\text{GENERATE NURPS FLAG IF KPS IS ZERO.}
\text{PARAMR //\text{C},\text{N},\text{EU/V_/\text{Y},\text{RPS} /\text{C},\text{N},\text{O} $ /V_/\text{Y},\text{NORPS} $}
\text{MAKES SURF COUPLED MASSES HAVE NOT BEEN REQUESTED.}
\text{PARAM //\text{C},\text{N},\text{NU}T/V_/\text{Y},\text{NOLUMP /V_/\text{Y},\text{CLUMPHASS}=-1 $}
\text{COND ERRORC2\#NULMP $}
\text{ALTER 21 21 $ ADD SLT TO OUTPUT FOR TRLG.}
\text{GP3 GEQM3,ELEXH,GEWM2 / SLT,GPTT / V_/\text{N},\text{NUGRAV} $}
\text{LP\text{KPN} SLT,GPTT $}
\text{ALTER 23 $}
\text{SINGLE MULTIPLE CONSTRAINTS ARE NOT ALLOWED EXECUTE GP4 NOW SO THAT}
\text{SOME ERROR CHECKS CAN BE MADE BEFORE ELEMENT GENERATION.}
\text{ADC YS NEEDED FOR PSF RECOVERY IN SSG2.}
\text{PARAM //\text{C},\text{N},\text{MPY/V_/\text{N},\text{NSKIP} /\text{C},\text{N},\text{O} /\text{C},\text{N},\text{O} $}
\text{GP4 CASECC \#UOMQ,ELEXH\#GPDT\#BPDT\#BSTM/RH\#YS\#USET\#ASET/V_/\text{N},\text{LUSET/}
\text{S_/\text{N},\text{MPCF}2/S_/\text{N},\text{MPCF}2/S_/\text{N},\text{SIMPLE}/S_/\text{N},\text{QUIT}/S_/\text{N},\text{REAL}/S_/\text{N},\text{NSKIP/}
\text{S_/\text{N},\text{REPEAT}/S_/\text{N},\text{NUSET}/S_/\text{N},\text{HOLD}/S_/\text{N},\text{NUA/C_/\text{Y},\text{ASETUT}/S_/\text{Y},\text{AUTOSPC $}
\text{PUSHGE GM,GM\#MPCF2/GU,GM\#CMIT/FK\#PSF,PSF/PSF/SINGLE $}
\text{LP\text{KPN} GM,GM\#K\#GU/DS,FPS,PSF/PSF,USET/YS $}
\text{SU\#PT BULK DATA IS NOT ALLOWED.}
\text{PARAM //\text{C},\text{N},\text{KE}U/V_/\text{N},\text{KREACDATA /V_/\text{N},\text{KREAC} $}
\text{COND ERRORC3\#REACDATA $}
\text{EXECUTE BPD NOW SO CHECKS CAN BE MADE. ADD TRL TO OUTPUT DATA BLOCKS.}
\text{BPD DYNAMICS\#GP\#SIL\#USET / GP\#SIL\#USETD/FP\#PSD\#D\#FRL\#}
\text{T\#U\#D\#V_/\text{N},\text{LUSET}/S_/\text{N},\text{LUSETD/V_/\text{N},\text{NOTFL}/S_/\text{N},\text{NOLT/}
\text{S_/\text{N},\text{NOFLSD}/S_/\text{N},\text{NOFL}/V_/\text{N},\text{NOFL/}/V_/\text{N},\text{NOFL/}/V_/\text{N},\text{NOFL/}
\text{S_/\text{N},\text{NOUE $}
\text{MUST HAVE LITTLE FRE OR TSTEP BULK DATA.}
\text{PARAM //\text{C},\text{N},\text{AND/V_/\text{N},\text{FERT} /V_/\text{N},\text{NOFRL /V_/\text{N},\text{NOTRL} $}
\text{COND ERRORC5\#FERT $ NO FRE OR TSTEP BULK DATA.}
\text{ONLY FREQUENCY OR TSTEP IS ALLOWED IN THE CASE CONTROL}
\text{PARAML CASECC //\text{C},\text{N},\text{UTI/\text{C},\text{N},\text{1/\text{C},\text{N},\text{14 //V_/\text{N},\text{FREQSET $}
\text{PARAML CASECC //\text{C},\text{N},\text{UTI/\text{C},\text{N},\text{38 //V_/\text{N},\text{TIMSET $}
\text{PARAM //\text{C},\text{N},\text{HPY/V_/\text{N},\text{FRDLTIME /V_/\text{N},\text{FREQSET /V_/\text{N},\text{TIMSET $}

4.18
NASTRAN EXECUTIVE CONTROL DECK ECHO

PARAM //C,N,NOT /V,N,FTEK1 /V,N,FREUITE $
PARAM //C,N,LE /V,N,NPREL /V,N,FREUITE /C,N,0 $
PARAM //C,N,LE /V,N,NORL /V,N,FREUITE /C,N,0 $
COND ERRORCO,FTEK1 $ BOTH FREQ AND STEP IN CASE CONTROL DECK.
$ ERRORCI,EXTRAPTS $ 
$ GENERATE DATA FOR CYC72 MODULE. $ 
CPYC GEOM4,EUYN,USETO /CYCOD /V,N,CTYPE=RUT /S,N,NOGU $ 
CCND ERRORCI,NUGU $ 
CHKPT CYCOD $ 
ALTER 32 $ 
$ PRI-PURG DATA BLOCKS THAT WILL NOT BE GENERATED $ 
PARAM //C,N,OK /V,N,NUD1 /V,N,NGMCG /V,N,NUKPS $ 
PURGE U1GG,M1GG /NUD1 $ 
PURGE M2GG,M2GG,BASEXG /NUMGG $ 
ALTER 32 $ 
$ GENERATE DATA BLOCKS FRLX, B1GG, M1GG, M2GG AND BASEXG. $ 
$ GENERATE PARAMETERS FKMAX AND NCBASEX. $ 
DUMMO1 CASCC,DPUT,STH,DIT,FRLX,NUDG, / FRLX,81GG,M1GG, 
M2GG,BASEXG,POZERG, / V,N,NGMCG/V,Y,LXIC/V,Y,NSEGGS/ 
V,Y,KMAY/S,N,FKMAX/V,Y,BXTID=-1/V,Y,BOPTID-1/ 
V,Y,BXTID=-1/V,Y,BOPTID=1/V,Y,BXTID=-1/ 
V,Y,BXTID=-1/S,N,NCBASEX/V,N,NOFREU/V,N,LXICA $ 
PARAMFL FRLX //C,N,NPRES $ 
COND LBLFRLX,NUDFRLX $ 
EQUIV FRLX,FKL $ 
LABEL LBLFRLX $ 
CHKPNT FRLX,B1GG,M1GG,M2GG,BASEXG $ 
ALTER 42 $ 
PARAM //C,N,ADD /V,N,NUDG /V,N,NUD1 /C,N,0 $ RESET NUGG. 
ALTER 52 $ 
$ REDEFINE B1GG AND M1GG. $ 
COND LBLLIA,NUDB1 $ 
PARAM //C,N,COMPLEX // V,N,OMEGA2 / C,N,0.0 / V,N,CMPLX1 $ 
PARAM //C,N,COMPLEX // V,N,OMEGA2 / C,N,0.0 / V,N,CMPLX1 $ 
PARAM //C,N,CMPLEX // V,N,OMEGA2 / C,N,0.0 / V,N,CMPLX2 $ 
AGC B1GG,B1GG / B1GG1 / C,N,(1,0,0,0) / V,N,CMPLX1 $ 
EQUIV B1GG,B1GG $ 
AGC M1GG,M1GG / M1GG1 / C,N,(1,0,0,0) / V,N,CMPLX2 $ 
EQUIV M1GG,M1GG $ 
CHKPNT B1GG,M1GG $ 
LABEL LBLLIA $ 
ALTER 53,55 $ GP4 HAS BEEN MOVED-UP. 
ALTER 5,68 $ LPU HAS BEEN MOVED-UP. 
ALTER 114 $ PARAM AND EQUIV LOGIC DEPENDING ON LGKAD FOR FREQ ORTRAN. 
PARAM //C,N,ADD /V,N,KULKA/V,N,NOUE/V,N,NGK2PP $ 
COND LGKAD,LGKAD $ BRANCH IN FREQRESP. 
ALTER 115 $ SEE ALTE 114 COMMENT. 
JUMP LGKAD2 $
LABEL LGKAD1 $
EQUIV M2PP,M2DD,NGA/B2PP,B2DD/K2PP/K2DD/NGA/HAAM/DD/MDMAS
      KAA,KDD/KDEKA 
CHKPNT K2PP,M2PP,B2PP,K2DD,H2DD,B2DD,KDD,MDD 
LABEL LGKAD2 $ 
ALTER 117/117 $ ADD PARAMETERS GKAU, n3 ANU m TO GKAU.
GKAU USFTD,GM,GO,KAA,DA,M2,M2,KAA,K4A,K2PP,M2PP,B2PP/K2DD,B2DD,MDD,GDD
      GDD,K2DD,M2DD,B2DD/C,Y,GRA=TRANRSP/CN,DISP/CN,DIRECT/
      C,Y,G=0.0/C,Y,n3=0.0/C,Y,n4=0.0/V,N,K2PP/V,N,LUM2PP/
      V,N,LUM2PP/V,N,MFCF/ V,N,SLTRLE/V,N,UMIT/V,N,NOVE/V,N,K446/
      V,N,K446/V,N,KDEK2/L,N,-1 $ 
ALTER 118 $ SEE ALTER 114 COMMENT.
CUND LGKAD3, LGKAD5 $ BRANCH IF NOT FREGRESP.
ALTER 119 $ SEE ALTRK 114 COMMENT.
JUMP LGKAD4 $ 
LABEL LGKAD4 $ 
EQUIV B2DD,GDD/NUGKPNT/M2DD,MDD/NOIMP/K2DD,KDD/KDEK2 $ 
LABEL LGKAD4 $ 
ALTER 120/123 $ 
$ NEW SOLUTION LOGIC
$ GENERATE TIME-DEPENDENT LOADS IF TSTEP WAS REQUESTED IN CASE CONTROL.
COND LBLTRGL4, NOTIME $ 
$ LOOP THRU ALL SUHCASES FOR TIME-DEPENDENT LOADS.
PARAM //C,N,MPY/V,N,REPEAT/C,N,1/C,N,-1 $ 
PARAM //C,N,ADD/V,N,APPFLG/C,N,1/C,N,0 $ INITIALIZE FOR SORL.
JUMP TRLGLOOP $ 
LABEL TRLGLOOP $ 
CASE CASECC, /CASEYY/C,N,TRAN/S,N,REPEAT/S,N,NOLOOP1 $ 
CHKPNT CASEYY $ 
PARAM //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $ 
TRLG CASEYY,USETD,ULT,SLT,BGDPRT,SIL,CSIM,TRLGJ,UT,GM,DGU,EST,MGG/
      *PD1,PD1,1CL/V,N,NSETP/S,N,PEPDDO/V,N,NCOL $ 
SORL TRLGPD1,********/ *PD1/V,N,APPFLG/C,N,DYNAMICS $ 
SORL TRLGPD1,********/ *PD/V,N,APPFLG/C,N,DYNAMICS $ 
CUND TRLGUNIT,REPEAT $ 
KEPT TRLGUNIT,10G $ 
JUMP LKAGR3 $ 
LABEL TRLGUNIT $ 
CHKPNT PDT,PDL,TDL $ 
EQUIV PD,PDT/PEPDDO $ 
LKPPNT PDT $ 
DUNNOD2 TDL,********/ FRLZ,FRLZ,REORDER1,REORDER2,******/ 
      V,N,SEGS/V,Y,CYCIG/S,Y,LMAX=-1/V,N,FRMAB/
      S,N,FLMAX/S,N,NSTEPS/S,N,NGC1/S,N,NGC2 $ 
EQUIV FRLZ,FRLZ,FRLZ,FCG $ 
CHKPNT FRLA,FCL,9,ECORDER1,REORDER2 $ 
JUMP LBLFRL2 $ 
LABEL LBLTRL1 $ 
$ GENERATE FREQUENCY-DEPENDENT LOADS IF FREQUENCY WAS SELECTED IN CC.
NAISTAN EXECUTIVE CONTROL DECK ECH

FRLG
CASEXX, USETO, DLT, FRX, GH, CD, DI, / PPF, PSF, PDF, FUL, PHDFUM / C:N, DIRECT/V:N, FREQ/C:N, FREQ $
COND.
LBLFRXL1, NOFRXL1 $ ZERO OUT LOAD COLUMNS IF FRXL HAS BEEN GENERATED.
MPYAD
PPF, PZERO, / PCI, / C:N, O $
EQUIV
PPFX, PPF $
LABEL
LBLFRXL1 $ FORM NEW LOADS.

COND.
LBLFRXL1, NOBASE $ MPYAD
M2G, YASLEK, / M2BASEXG / C:N, O $ ADF
PPF, M2BASEXG / PPF1 / C:N, {1.0, 2.0, 0.0} / C:N, {0.0, -1.0, 0, 0} $
EQUIV
PPF1, PPF $ C:N, DLO1 / V:N, NLCAO / V:N, PF, FCOLS $ NLOAD = NF/FKMAX

EQUIV
PPF, PPFN/NUSET $ C:N, DLO1 / V:N, NLCAO / V:N, PF, FCOLS $ NLOAD = NF/NSEGS

EQUIV
PPF, PPFN/NUSET $ CKPNT
PPF, PSF, PDF, FCL $ $ LOADS ARE FREQUENCY-DEPENDENT
$ PERFORM CYCLIC TRANSFORMATION ON LOADS IF CYCIG=1.
PARAM

PARAM
/ C:N, DLO1 / V:N, NLCAO / V:N, PF, FCOLS $ NLOAD = NF/NSEGS
EQUIV
PPF1, PPF1 / CYCIG $ $ CALCULATE THE NUMBER OF LOADS FOR CYCIG=1.

EQUIV
PPF, PPFN/NUSET $ C:N, DLO1 / V:N, NLCAO / V:N, PF, FCOLS $ NLOAD = NF/NSEGS

LDXCT1
$ BRANCH DEPENDING ON VALUE OF CYCIG
PARAM
/ C:N, NO1 / V:N, NUCYCL1 / V:N, CYCIG $ C:N, DLO1 / NOCYCL1 $ $ CYCIG=1

EQUIV
PDT, PTZ1 / NURU1 $ C:N, DLO1 / NURU1 $ MPYAD
PDT, NURU1, / PTZ1 / C:N, O $ LABEL
LBLRU1A $ CYCIG1
PTZ1, PTZ1, GLYCF2 / V:N, LTYPE / C:N, FURE / V:N, NTSTEPS/ V:N, NLCAO / V:N, FKMAX / S:N, NCGG $ $ ERRRC1, NUGG $ C:N, DLO1 / NURU1 $ CKPNT
PTZ1 $ EQUIV
PTZ1, PTZ1 / NURU1 $ C:N, DLO1 / NURU1 $ MPYAD
PTZ1, NURU1, / PXZ1 / C:N, O $ LABEL
LBLRU2A $ 4.21
EQUIV PXFL2, PXF1 $
CHKPNT PXFL2 $
JUMP LBLTML3 $
LABEL LBLTML2 $
$ CYC10 = 11
MPYAD PDI, REORDER1, / P0TRZ2 / C,N,0 $
CYC11 P0TRZ2 / PXTRZ2, GCYCF3 / V,N,CTYPE/C,N,FORE/V,Y,NSTEPS/V,Y,LMAX/
V,Y,NSEG/S/N,NOGC $
COND ERRORCL1, NOGC $
CHKPNT PXTRZ2 $
EQUIV PXTRZ2, PXTRZ2/NOR02 $
COND LBLR02, NOR02 $
MPYAD PXTRZ2, REORDER2, / PXTRZ2 / C,R,0 $
LABEL LBLR02 $
V,Y,FLMAX/S,N,NOGC $
COND ERRORCL1, NOGC $
EQUIV PXFL2, PXF1 $
CHKPNT PXFL2 $
LABEL LBLTML3 $
$ TIME-DEPENDENT LOADS ARE REAL. MAKE LOADS COMPLEX TO CORRESPOND
$ TO FREQUENCY DEPENDENT LOADS. ALSO SOR2 EXPECTS LOADS TO BE COMPLEX
$ IN FREQUENCY DEPENDENT PROBLEMS.
COPY PXF1 / PXF2 $ CONVERT REAL PXF1 TO COMPLEX PXF.
ADD PXF1, PXF2 / PXF / C,N,(0.5,0.0) / C,N,(0.5,-1.0) $
$ DEFINE NLOAD FOR CYC12:
PARAM //C,N,ADD /V,N,NLOAD /V,N,FLMAX /C,N,0 $
LABEL LULPQJNE $
PARAM //C,N,ADD /V,N,KINDEX /V,Y,KMIN=0 /C,N,0 $
$ INITIALIZE KINDEX.
$ INITIALIZE UXVF IF KMIN IS NOT ZERO.
$ PARAM //C,N,ADD /V,N,KMINL /V,Y,KMIN /C,N,-1 $
COND NOKMINL, KMINL $
PARAM //C,N,ADD /V,N,KMINV /C,N,0 /C,N,0 $
JUMP KMINLUP $
LABEL KMINLUP $
CYC12 CYCDD,*,*,PF,*,*,PKE2,*,*,C,N,FRE/V,Y,NSEG/S/V,N,KMINV/V,N,LCY/SEQ/V,N,NLCAU/S/N,NOGC $
COND ERRORCL1, NOGC $
ADD PFKE2, / UXVFZ / C,N,(0.0,0.0) $
CYC12 CYCDD,*,*,LKF/2,*,*,UXVF,*,*,C,N,BACK/V,Y,NSEG/S/V,N,KMINV/V,N,LCY/SEQ/V,Y,NLOAD/S,N,NOGC $
COND ERRORCL1, NOGC $
PARAM //C,N,ADD /V,N,KMINV /C,N,1 $
REPT KMINLUP, KMINL $
LABEL NOKMINL $
$ JUMP TUPCYC $
LABEL TUPCYC $ Loop on KINDEX
NASMTRAN EXECUTIVE CONTROL DECK ECHO

CONU NOKPRT, NOKPRT
PKIPAKM \\
LABEL  NOKPRT
CYCT2 CYCDU,KDD, MDD, /KKKF, HKKF /C.N,FORE/V.Y.NSEG / V.Y.KINDEX/V.Y.CYSEQ=-1/V.Y.N,LOAD/S,N,NOGG
CONU ERRORC1,NOGG
CHKPNT HKKF, HKKF
PARAM \\
CYCT2 CYCDU, BDD, PXF, /BKKF, PKF /C.N,FORE/V.Y.NSEG /
PARAM \\
CONU ERRORC1, NOGG
CHKPNT HKKF, HKKF
$ SOLUTION
FRKD2 HKKF, BKKF, HKKF, PKF, FCL / UKVF / C.N,0,0/C.N,0,0/C.N,-1,0
CHKPNT UKVF
CYCT2 CYCDU, UKVF /UXVF /C.N, BACK/V.Y.NSEG/V.Y.KINDEX/
CONU ERRORC1, NOGG
CHKPNT UXVF
PARAM \\
PARAM \\
CONU LCVCI, UCN1 /V.Y.KINDEX/V.Y.KINDEX/C.N,1 /KINDEX = KINDEX + 1
PARAM \\
REPT TUPC-Y,1CC
JUMP ERROR3
LABEL LCVCI $ UCVF
EVULX UXVF, UCVF / LCVCI
CHKPNT UCVF
CONU LCVCI, LCVCI / IF CYC1O .GE. 0 THEN TRANSFORM TO PHYSICAL.
CYLTI UXVF / UKVF / LCVCI / V.Y.CTYPE/C.N, BACK/V.Y.NSEG/V.Y.KMAX/
CHKPNT LCVCI $ UXVF
LABEL LCVCI $ UXVF
CONU LBLTG4, NOTIML $ EQU LFX, PPF2 / LCVCI
CCON UCYCI, LCVCI $ IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL.
CCON UCYCI, LCVCI $ IF CYC10 .GE. 0 THEN TRANSFORM TO PHYSICAL.
CHKPNT PPF, PPF
LABEL LCVCI $ UXVF

$ IF LOADS WERE TIME-DEPENDENT THEN RECOVER PPF AND PSF FROM PFX.
SDR1 USET0, PDF2, UNDF, GMD, / PPF2 / C.N,1 / C.N,DYNAMICS
SSC2 USET0, GMD, YS, KFS, UNDF, PPF2 / PPDFM, PSF, PLDFM
LQULX PDF2, PDF / PSF, PDF
CHKPNT PDF, PSF
LABEL LBLTG4 $ ALTER 124,124 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.
VON CASEXX, LQDYN, USETU, UXDF, FCL, XYCOU / UXDFCI / C.N,FREKRSP/C.N
DIRECT / C.N, LOAD2/S, NOG/D, J, N,W/P/C.N,0
ALTER 140, 140 $ USE FUL INSTEAD OF PPF TO GET OUTPUT FREQUENCY LIST.
NASTRAN EXECUTIVE CONTROL DECK ECHO

SDR2 CASEXX,CSTM,MPD,UT,EDYN,SILD,BGGP,FLL,QPC,UPVC,EST,XYCDB,
PPF/UPPC1,QPC1,UPVC1,ESC1,CEPC1,UPVCI/C.N,FREQRS/ F
SN,NOSORT2 S
ALTER 160 $ ADD LABEL FOR ERROR3.$
LABEL ERROR3 $
ALTER 163,166 $ REMOVE ERROR1 AND ERROR2.$
ALTER 168 $ FORCED VIBRATION ERRORS
LABEL ERROR1 $ CHECK NSEGS, KMAX AND OTHER CYCLIC DATA.
PRTПАМ //C.N=7/C.NCYCSTATIC S
LABEL ERROR2 $ COUPLED MASS NOT ALLOWED.$
PRTПАМ //C.N=0/C.YCOUPMASS $
JUMP FINIS S
LABEL ERRORC $ SUPPORT BULK DATA NOT ALLOCAED.$
PRTПАМ //C.N=-6/C.NCYCSTATIC S
LABEL ERROR4 $ EPCINT BULK DATA NOT ALLOWED.$
PRTПАМ //C.N=0/C.NCGUE S
JUMP FINIS $
LABEL ERRORK $ NEITHER FREW OR TSTEP WERE IN BULK DATA DECK.$
PRTПАМ //C.N=0/C.NNOTFRE $ PRTПАМ //C.N=0/C.NNOTRL $ JUMP FINIS $
LABEL ERRORK $ BOTH FREW AND TSTEP WERE SELECTED IN CASE CONTROL.$
PRTПАМ //C.N=0/C.NNDTSTEP $ PRTПАМ //C.N=0/C.NNOTIME $ JUMP FINIS $ UNALTER TIME 5 $ IBM 370/3031
DIAG 14,21 GCEND
CASE CONTROL DECK ECHO

CARD COUNT
1

$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
2 SUBTITLE = BLADED DISC EXAMPLE 2 (CYC MODEL, FREQ LOADS, PHYSICAL I/O)
3$
4 SPC = 30
5 FREQ = 1
6
7 OUTPUT
8 SET 1 = 8, 16, 18
9 OLOAD = 1
10 DISP (SORT2, PHASE) = ALL
11 STRESS (SORT2, PHASE) = ALL
12 SUBCASE 1
13 LABEL = SEGMENT 1
14 OLOAD = 1 $ FREQ DEPENDENT LOADS
15 SUBCASE 2
16 LABEL = SEGMENT 2
17 OLOAD = 2 $ FREQ DEPENDENT LOADS
18 SUBCASE 3
19 LABEL = SEGMENT 3
20 OLOAD = 3 $ FREQ DEPENDENT LOADS
21 SUBCASE 4
22 LABEL = SEGMENT 4
23 OLOAD = 4 $ FREQ DEPENDENT LOADS
24 SUBCASE 5
25 LABEL = SEGMENT 5
26 OLOAD = 5 $ FREQ DEPENDENT LOADS
27 SUBCASE 6
28 LABEL = SEGMENT 6
29 OLOAD = 6 $ FREQ DEPENDENT LOADS
30 SUBCASE 7
31 LABEL = SEGMENT 7
32 OLOAD = 7 $ FREQ DEPENDENT LOADS
33 SUBCASE 8
34 LABEL = SEGMENT 8
35 OLOAD = 8 $ FREQ DEPENDENT LOADS
36 SUBCASE 9
37 LABEL = SEGMENT 9
38 OLOAD = 9 $ FREQ DEPENDENT LOADS
39 SUBCASE 10
40 LABEL = SEGMENT 10
41 OLOAD = 10 $ FREQ DEPENDENT LOADS
42 SUBCASE 11
43 LABEL = SEGMENT 11
44 OLOAD = 11 $ FREQ DEPENDENT LOADS
45 SUBCASE 12
46 LABEL = SEGMENT 12
47 OLOAD = 12 $ FREQ DEPENDENT LOADS
48 OUTPUT (XYPLOT)
49 PLOTTER NASTPLT, MODEL 0, 0
50 XPAPER = 8.0
51
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  ICURVE = 14(T3RN), 18(T3RN)
61  XYPLOT, XYPRINT DISP RESPONSE 1 /14(T3RN), 18(T3RN)
62  ICURVE = 2(T3RN)
63  XYPLOT, XYPRINT DISP RESPONSE 8 /2(T3RN)
64  YTITLE = ELEMENT STRESSES (MAGNITUDE, PSI)
65  ICURVE = 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  ICURVE = 1(3), 1(5), 1(7), 1(10), 1(12), 1(14)
69  XYPLOT, XYPRINT STRESS RESPONSE 10 /1(3), 1(5), 1(7),
70               1(10), 1(12), 1(14)

BEGIN BULK

Figuring Message 207. Bulk data not sorted, XSORT will re-order deck.
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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,
   CYCLO = -1 harmonic cyclic input/output data
   KM0IN = 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 TABLEDi 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 RLOADi bulk data cards.
   b) Base acceleration as shown in Figure 11.

C. Results

Results are shown in Figures 12 through 20.

Figures 12 and 13 present k = 0 results (subcase 1). The excitation consists of axial base acceleration and directly applied loads. The selected frequency band of excitation, 1700-1920 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.

4.30
Figures 14 through 18 present $k = 1$ results (subcases 2 ($k = 1c$) and 3 ($k = 1s$)). The excitation is due to lateral base acceleration only. Although the frequency band of input base acceleration is 1700-1920 Hz, the rotation of the bladed disc at 600 Hz (parameter RPS) splits the input bandwidth into two effective bandwidths:

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

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

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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4.32
CASE COOT-0-0-E-0-0-0-0-0-B-

CARD COUNT

$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING DISC CASES STRESSES
SUBTITLE = BLADED DISC EXAMPLE 3 (CTC KINEM.PREPBASE ACCN LOAD.KARN 1/0)
$ SPC = 30
FREQ = 1

OUTPUT
SET 1 = 0,14,18
SET 2 = 11
DLOAD = 1
DISP(SORT1,PHASE) = 1
STRES(SORT1,PHASE) = 2

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

SUBCASE 2
LABEL = KINDEX 1C
$ 6 LATERAL BASE ACCN LOADS VIA PARAM OYTD

SUBCASE 3
LABEL = KINDEX 1S
$ 9 LATERAL BASE ACCN LOADS VIA PARAM OYTD

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

SUBCASE 5
LABEL = KINDEX 2S

OUTPUT(XYPLT)
PLOTTER NASTPLT, MODEL D,0
XPAPER = 8.0
YPAPER = 10.5
XAXIS = YES
YAXIS = YES
XGRID LINES = YES
YGRID LINES = YES
CURVELINESYMBOL = 1
XTITLE = FREQUENCY (HERTZ)
YTITLE = GRID POINT DISPLACEMENTS (MAGNITUDE, INCH)
YLOG = YES
TCURVE = 8(T3RH),18(T3RH)
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XYPLT.XYPRTI NT DISP RESPONSE 2 /8(T3RH),18(T3RH)
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CASE CONTROL DECK E040

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53  11(10)*11(12)*11(14)
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55  11(10)*11(12)*11(14)
56  XYPLOT,XYPRENT STRESS RESPONSE 3 7/11(3)*11(5)*11(7) 4
57  11(10)*11(12)*11(14)
58  XYPLOT,XYPRENT STRESS RESPONSE 4 7/11(3)*11(5)*11(7) 8
59  11(10)*11(12)*11(14)
60  BEGIN BULK

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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 (\( \lambda = 1 \))-- the parameter \( \text{LMAX} \) accordingly has been set at 1 (\( \lambda = 0, 1, 1_s \)).

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
- \( \text{LMAX} = 1 \) maximum harmonic in the Fourier decomposition of periodic, time-dependent loads,
- \( \text{NSEGS} = 12 \) number of rotationally cyclic sectors
- \( \text{RPS} = 600.0 \) revolutions per second
- \( \text{GKAD} = \text{FREQRESP} \) Specify the form in which the damping parameters are used.
- \( \text{LGKAD} = +1 \)

2. Constraints:

Same as general input constraints.

3. Loads:

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

where

- \( n \) is the segment number,
- \( \tilde{k} \) represents \( k = 2 \),
- \( \tilde{\ell} \) 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

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</tbody>
</table>

4.42
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,

   \[ \begin{align*}
   \text{CYCIO} &= -1 \quad \text{harmonic cyclic input/output data} \\
   \text{KNIN} &= 2 \quad \text{minimum circumferential harmonic index} \\
   \text{KMAX} &= 2 \quad \text{maximum circumferential harmonic index} \\
   \text{LMAX} &= 1 \quad \text{maximum harmonic in the Fourier decomposition of periodic, time-dependent loads.} \\
   \text{NSEGS} &= 12 \quad \text{number of rotationally cyclic sectors} \\
   \text{RPS} &= 600.0 \quad \text{revolutions per second} \\
   \text{GKA0} &= \text{FREQRESP} \quad \text{Specify the form in which the damping parameters} \\
   \text{LGKAD} &= +1 \quad \text{are used.}
   \end{align*} \]

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

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

4.45
CASE CONTROL DECK. ECHO

CARD
COUNT
$ TITLE = FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
3 SUBTITLE = BLADED DISC EXAMPLE 5 (CYC MODEL, TIME DEP. LOAD, PARM I/O)
$ 5 SPC = 30
6 ISTEP = 1
7 OUTPUT
8 SET 1 = 0,16,18
9 SET 2 = 11
10 DLOAD = 1
11 DISP(SCT2,REAL) = 1
12 STRESS(SCT2,REAL) = 2
13 SBCASE 1
14 LABEL = KINDEX 0
15 DLOAD = 99 $ NULL LOAD
16 SBCASE 2
17 LABEL = KINDEX 1C
18 DLOAD = 99 $ NULL LOAD
19 SBCASE 3
20 LABEL = KINDEX 1S
21 DLOAD = 99 $ NULL LOAD
22 SBCASE 4
23 LABEL = KINDEX 2C
24 DLOAD = 1 $ TIME DEPENDENT LOADS
25 SBCASE 5
26 LABEL = KINDEX 2S
27 DLOAD = 99 $ NULL LOAD
28 BEGIN BULK

"CAUTION. 'BSCASE 207, BULK DATA NOT SCOTED, XSCRT WILL RE-ORDER DECK."
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**PARAMETERS**

- CYCIC: -1
- G: 0.02
- G0: 0.02
- KGAD: 0.02
- KMAX: 2
- KWIN: 2
- LGKAD: 1
- LMAX: 1
- NSEG: 12
- EPS: 600.0
- CLAD: 2.0

**RESULTS**

- 4.47
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4.48
TABLE 1: PRINCIPAL FEATURES DEMONSTRATED BY EXAMPLE PROBLEMS

<table>
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<th>Example No.</th>
<th>Finite Element Model of</th>
<th>Applied loads specified as functions of</th>
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<th>Base Acceleration</th>
<th>Rotational Speed</th>
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<td>Frequency (sinusoidal)</td>
<td>Time (periodic)</td>
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<td>Circum. Harmonic Components</td>
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<td>Circum. Harmonic Components</td>
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# Frequency (Mode No.), Hz.

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<th>k = 0</th>
<th>k = 1</th>
<th>k = 2</th>
<th>Mode Description</th>
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<tbody>
<tr>
<td>214 (1)</td>
<td>208 (1)</td>
<td>242 (1)</td>
<td><img src="image1" alt="Diagram 1" /></td>
</tr>
<tr>
<td>591 (2)</td>
<td>594 (2)</td>
<td>622 (2)</td>
<td><img src="image2" alt="Diagram 2" /></td>
</tr>
<tr>
<td>1577 (3)</td>
<td>1633 (3)</td>
<td>1814 (3)</td>
<td><img src="image3" alt="Diagram 3" /></td>
</tr>
<tr>
<td>2468 (5)**</td>
<td>2460 (4)</td>
<td>2433 (4)</td>
<td><img src="image4" alt="Diagram 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.

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<th>Frequency</th>
<th>Example 2</th>
<th>Example 3</th>
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<tbody>
<tr>
<td>Hz</td>
<td>Seg. 1 (subcase 1)</td>
<td>k = 2c (subcase 4)</td>
</tr>
<tr>
<td></td>
<td>Mag. (in)/Phase (deg)</td>
<td>Mag. (in)/Phase (deg)</td>
</tr>
<tr>
<td>1700</td>
<td>7.2655E-5/349.4</td>
<td>7.6132E-5/354.3</td>
</tr>
<tr>
<td>1750</td>
<td>1.3071E-4/343.1</td>
<td>1.3844E-4/347.3</td>
</tr>
<tr>
<td>1778</td>
<td>2.1580E-4/332.7</td>
<td>2.3252E-4/335.8</td>
</tr>
<tr>
<td>1796</td>
<td>3.4139E-4/314.6</td>
<td>3.7252E-4/315.2</td>
</tr>
<tr>
<td>1814</td>
<td>4.8374E-4/269.9</td>
<td>4.9177E-4/266.8</td>
</tr>
<tr>
<td>1832</td>
<td>3.4146E-4/224.9</td>
<td>3.2655E-4/225.5</td>
</tr>
<tr>
<td>1850</td>
<td>2.1451E-4/206.6</td>
<td>2.0742E-4/209.3</td>
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<td>1880</td>
<td>1.2433E-4/195.6</td>
<td>1.2214E-4/199.2</td>
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<tr>
<td>1920</td>
<td>7.6125E-5/190.4</td>
<td>7.5397E-5/194.3</td>
</tr>
<tr>
<td>Grid Pt. Disp. or Elem. Stresses</td>
<td>Example 3: ( k = 2c ) (subcase 4)</td>
<td>Example 4: Segment 1 (subcase 1)</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>--------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>8 (T3RM), ( u_z )</td>
<td>5.4297 E-4/226.6</td>
<td>5.4299 E-4/226.6</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>
</tr>
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<td>1.4841 E 3/284.7</td>
<td>1.4842 E 3/284.7</td>
</tr>
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<td>2.0891 E 2/283.4</td>
<td>2.0892 E 2/283.4</td>
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<td>1.0774 E 2/264.7</td>
<td>1.0775 E 2/264.7</td>
</tr>
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<td>1.4677 E 3/2263.3</td>
<td>1.4678 E 3/2263.3</td>
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<td>2.2489 E 2/2260.3</td>
<td>2.2491 E 2/2260.4</td>
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<td>11 (14), ( \tau_{xy,2} )</td>
<td>1.8510 E 2/2253.0</td>
<td>1.8511 E 2/2253.0</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
Mode 1
242 Hz

Mode 2
622 Hz

Mode 3
1814 Hz

Mode 4
2433 Hz

Figure 3: k = 2 Modes of Bladed Disc
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES.
BLADED DISC EXAMPLE 1 (FULL MODEL, FREQ LOADS)
INDEX 2C TYPE LOADS

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

Figure 5
FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES

Figures 6-30: Example (Full Model, Freq Loads)
KINDEY A/E TYPE LOADS

Figure 6

4.58
FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL SHELLS

BLADED DISC EXAMPLE 2: 1ST MODE FREQUENCY RESPONSE

Figure 7
Figure 10
Figure 11: Base Acceleration Data in an Inertial Coordinate System
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQ-LOAD ACCS LOAD, HARM 1/6, SUBCASE 1)

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
OF POOR QUALITY

GRID POINT DISPLACEMENTS INCH

FREQUENCY (HERTZ)

1E-7 1E-6 1E-5 1E-4 1E-3 1E-2 1E-1 1E 0 1E 1 1E 2 1E 3

0.9 1.2 1.5 1.8 2.1 2.4 Hz

Figure 14

FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 ICTC MODEL, FREQ = BASE ACCN LOAD, MANH 1/0
KINDEX 10
SUBCASE 2

4.66
Figure 16
FORCED VIBRATION ANALYSIS OF ROTATING CYLINDRICAL STRUCTURES

BLADED DISC EXAMPLE 3 IETC MODEL, FREQ-ASE CCU LOAD, HARM 1/0
KINDEX 15

SUBCASE 1

Figure 17
FORCED VIBRATION ANALYSIS OF ROTATING CYCLIC STRUCTURES
BLADED DISC EXAMPLE 3 (CYC MODEL, FREQUENCY BASE ACCN LOAD, HARM 1/0)
INDEX 15
SUBCASE 3

Figure 18: 4.70
Forced vibration analysis of rotating cyclic structures
Bladed disc example 3 (CTC model, Fred-Base Accn load, Harm 1°)
Kinex 2C

Figure 19

4.71
End of Document