NASA CONTRACTOR REPORT

NASA CR-2504

NASA CR-2504

NASTRAN USER'S GUIDE

Level 15

Prepared by

UNIVERSAL ANALYTICS, INC.

Los Angeles, Calif. 90045

for Langley Research Center

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • APRIL 1975

1. Report No. NASA CR-2504	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle NASTRAN User's Guide - Level 15		5. Report Date APRIL 1975
		6. Performing Organization Code
7. Author(s) Anon.		8. Performing Organization Report No.
		10. Work Unit No. 502-32-01-02
9. Performing Organization Name and Address Universal Analytics, Inc. 7151 West Manchester Avenue Los Angeles, CA 90045		11. Contract or Grant No. NAS1-6024
		13. Type of Report and Period Covered Contractor Report
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Topical Report

16. Abstract

The NASTRAN structural analysis system is the most widely used structural analysis tool in the country. More capabilities are continually being added to the system, making it the most comprehensive as well. In order that many new users can determine how to use the program quickly, this user's guide was considered an essential addition to the original four NASTRAN manuals. Clear brief descriptions of capabilities with example input are included, with references to the location of more complete information if the user needs it. As new capability is added to the NASTRAN system (Level 15.1 is described in this first release) additional material will be published for incorporation into this user's guide.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
NASTRAN Finite Elements Static Structural Analysis Dynamic Structural Analysis User's Guide	Unclassified - Unlimited New Subject Category 39

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	231	$7.50

*For sale by the National Technical Information Service, Springfield, Virginia 22151

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FOREWORD

This NASTRAN User's Guide was prepared by Universal Analytics, Inc. (UAI) under Subcontract No. L.S.-2977-A3 with McDonnell Douglas Astronautics Company-West (MDAC) under their Contract NAS1-6024 with National Aeronautics and Space Administration, Langley Research Center, Hampton, Virginia. Dr. E. I. Field of UAI served as Program Manager with Messrs. D. Herting, S. E. Johnson, and K. E. Pauley contributing significantly to the program. This work was administered under the direction of MDAC with Mr. H. Adam as the contract monitor. Mr. H. Adelman of the NASTRAN Systems Management Office and Dr. E. Stanton of MDAC served as technical monitors.

The User's Guide is designed to assist the current and potential users of NASTRAN to make better use of the program's capabilities. The User's Guide is organized so as to present the many options available in the logical sequence in which the input data would be prepared. These options are briefly described and tabulated according to purpose to help the user select the alternative best suited to his needs. References are given for pointing to the location in the standard documentation where detail descriptions may be found. The User's Guide also contains many examples illustrating typical applications of NASTRAN modeling and control features which may be used as guides to input data preparation.

The User's Guide is not intended to represent the full detail of NASTRAN's capabilities. NASTRAN provides such a flexible array of analytical options, the user will find unending combinations of alternatives. As the user becomes familiar and comfortable with the use of NASTRAN, he will want to use the more sophisticated features of NASTRAN. The User's Guide will serve to help direct these users to effectively apply their imagination and analytical abilities. However, to keep the volume of this Guide within manageable proportions, the user is expected and encouraged to make full use of the references provided to the three standard NASTRAN manuals.

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1. INTRODUCTION

The User's Guide is designed to assist the current and potential users of NASTRAN (NASA STRuctural ANalysis) to make full use of the program's capabilities. NASTRAN is intended to serve the engineering community by bringing together the best features of the state of the art into a single program for the analysis of large and complex structures. Though it does not yet satisfy every requirement, it forms a comprehensive framework for the development of a common base for such work.

Three technical manuals serve to document the NASTRAN program. The Theoretical Manual presents a topic by topic discourse on the theory, assumptions and methods of analysis for those interested in the background of NASTRAN. The User's Manual is an excellent reference document devoted to describing those items related to the use of NASTRAN that are independent of the computing system being used. The third document is the Programmer's Manual which describes the details of the program, its organization, its file structure and its implementation on each of the three computer systems, IBM 360/370, UNIVAC 1100 Series and CDC 6000 Series for which NASA maintains NASTRAN.

Each of these three manuals provide a wealth of information useful to the understanding, use and development of NASTRAN. However, in that they were designed for reference purposes primarily, the organization of each does not readily lend itself to easy access except by experienced users and programmers. The User's Guide, on the other hand, is organized so as to present the many options available in the logical sequence in which the input data would be prepared. These options are briefly described and tabulated according to purpose to help the user select the alternative best suited to his needs. References are given for pointing to the location in the standard documentation where detail descriptions may be found. The User's Guide also contains many examples illustrating typical applications of NASTRAN modeling and control features which may be used as guides to input data preparation.

The user is expected to be familiar with the rudiments of finite element structural analysis and to be aware of basic modeling concepts. The Theoretical Manual, of course, can be referred to for a detail discussion of each of NASTRAN's analytical capabilities. The Guide will direct the user to the application of his knowledge and suggest extensions of it to new problem areas. The User's Manual defines all the input and control options, outlines the steps taken for each type of analysis, and summarizes the error messages which may then be issued by NASTRAN. For the sophisticated user, there is no substitute for the understanding of NASTRAN's organization, of its controlling functions and of its data handling techniques which are fully described in the Programmer's Manual.

The overall organization of the User's Guide begins with a review of NASTRAN design philosophy, specific instructions and suggestions on how to use the Guide, data descriptions for model and load definition and descriptions of the program control options. The description of these basic tools of NASTRAN is followed by examples and guidelines for the execution of each of the standard forms of analysis available in NASTRAN and a summary review of the computer and plotter output that can be obtained with NASTRAN. The Guide then discusses some of the utility functions available for user convenience, provides examples of machine-dependent card deck setup for execution of NASTRAN on the three major computer systems for which NASTRAN is maintained. This is followed by a reference table correlating the NASTRAN input options to the many examples included in the Guide for illustration and explanation of their use. Finally, the last chapter describes the communication devices set up by the NASTRAN Systems Management Office (NSMO) to help keep the user up to date with the current developments and to share the experiences of other NASTRAN users.

The User's Guide is not intended to represent the full detail of NASTRAN's capabilities. NASTRAN provides such a flexible array of analytical options, the user will find unending combinations of alternatives. As the user becomes familiar and comfortable with the use of NASTRAN, he will want to use the more sophisticated features of NASTRAN. The User's Guide will serve to help direct these users to effectively apply their imagination and analytical abilities. However, to keep the volume of this Guide within manageable proportions, the user is expected and encouraged to make full use of the references provided to the three standard NASTRAN manuals.

2. ORIENTATION TO NASTRAN

2.1 OVERVIEW

NASTRAN is a finite element computer program for structural analysis that is intended for general use. As such it must answer to a wide spectrum of requirements. It is structured to permit future modification and continued expansion to new problem areas. Its range of applications extend to almost every kind of structure and to almost every type of construction. Structural elements are provided for the specific representation of the more common types of construction, including rods, beams, solids, shear panels, plates, and shells of revolution. More general types of construction are treated by combinations of these elements and by the use of "general" elements.

NASTRAN provides input facilities to define static grid point force and displacement and element thermal, pressure and deformation loadings. Dynamic grid point force loadings are specified in functional form with a wide variety of options available. Grid point constraints and nonstandard interelement connectivities may be defined to satisfy nearly all possible complex modeling requirements. For sophisticated dynamic analyses, control systems, aerodynamic transfer functions, and other nonstructural features may also be incorporated into the analytical model.

NASTRAN has been specifically designed to treat large problems with many degrees of freedom. The only limitations on problem size are those imposed by practical considerations of running time and by the ultimate capacity of auxiliary storage devices. Computational procedures have been selected to provide resonable efficiency for large problems, and particular attention has been given to processing with sparse matrices. Though NASTRAN is decidedly not constrained to in-core processing only, the more core memory that can be made available, the more efficient that processing will be.

The needs of the structural analyst have been considered in all aspects of the design of the program. However, in view of the wide range of possible applications of the program now and in the future, not all these needs could be anticipated in advance. For this reason, a high degree of flexibility and generality has been incorporated into certain areas of the program. For example, in addition to the usual list of structural elements that refer to specific types of construction, the user is provided with more general elements that may be used to construct any type of special element, to represent part of a structure by deflection influence coefficients, or to represent part of a structure by its vibration modes. For the more conventional types of structural analysis, the user is presented with a large number of convenience features, including plotting routines, which are definite necessities for large problems.

A major difficulty that the user faces in the solution of large problems is the avoidance of errors in the preparation of input data. Card formats and card ordering are made as simple and flexible as possible in order to avoid errors caused by trivial violations of format rules. A number of aids such as extensive plotter capability, grid point singularity tests, and residual vector printout have been provided to help the user check the veracity of his model. A sophisticated checkpoint/restart capability is also provided to recover from data or system error conditions, to allow for examination of intermediate results, and to allow for retrieval of additional selective output following completion of the analysis.

The following sections summarize the functional organization of NASTRAN and provide brief descriptions for each of the problem-solving capabilities of NASTRAN. These capabilities are all exemplified in Chapter 7, along with detailed explanations of the input data cards used.

2.2 FUNCTIONAL ORGANIZATION

The many analytical capabilities of NASTRAN may be categorized as follows:

A. Standard NASTRAN Applications
   1. Linear Static Analysis
   2. Non-Linear Static Analysis
      a. Large Deflection and Stability
      b. Stress Dependent Material Properties
   3. Normal Modes Analysis
   4. Complex Eigenvalue Analysis
   5. Dynamic Response Analysis
      a. Frequency and Random Response
      b. Transient Response

B. Special NASTRAN Capabilities
   1. Heat Transfer Analysis
   2. Hydroelastic Analysis
   3. Acoustic Cavity Analysis
   4. Substructure Analysis

C. Direct Matrix Abstraction Programming

Each general problem class is further subdivided with regard to the type of information desired, the environmental factors considered, or the method of analysis. The mathematical computations required to solve problems are performed by subprogram units called functional modules. Each type of analysis requires a distinct sequence of functional module calls that is scheduled by NASTRAN's own Executive System. For the standard applications, the sequence of module calls and hence the general method of solution is established internally according to a Rigid Format stored in the Executive System. This relieves the user of a need to know and/or control each step of an analysis. Execution of a structural problem proceeds in one run to final solution, or, at the option of the user, to a desired intermediate point. Restart capabilities are provided for both scheduled and unscheduled interruptions in processing.

For the special NASTRAN capabilities, these same Rigid Formats can be used with little or no modification. Special input data features have been provided to facilitate the unusual modeling requirements imposed by the types of problems to be solved. In order to make these modifications, a flexible procedure has been provided in NASTRAN for these and other specialized user requirements.

All of the matrix operations (such as addition, multiplication, triangular decomposition, and eigenvalue extraction) used in the program can be directly controlled by the user through a system of macro or DMAP instructions. DMAP is the acronym for the Direct Matrix Abstraction Program which, on each execution of NASTRAN, compiles the user-supplied DMAP instructions and generates the data required for the NASTRAN Executive System to control the processing. These DMAP instructions allow the user to modify the existing Rigid Formats in order to change the processing sequence, to obtain printouts of selected data blocks, to provide for additional input which was generated by other programs, to output results to be used as input to other programs, and to construct entirely independent sequences of DMAP instructions to solve nearly any problem that can be formulated in matrix notation.

2.3 STANDARD NASTRAN APPLICATIONS

NASTRAN currently offers twelve Rigid Formats which can be used to control the processing of standardized structural analyses. Though each of these twelve sequences of DMAP instructions may be altered by the user, the normal problem can be solved from beginning to end with no modification. Each Rigid Format treats a particular class of problems and has its own particular set of control parameters, output options and types of input data. Because of the inevitable problem of selecting an appropriate Rigid Format, the following sections offer guidelines to help the user select the approach or method of analysis best suited to his particular problem. Examples of the input data required for each type of analysis are presented in Chapter 7.

2.3.1 Linear Static Analysis (Rigid Formats 1 and 2)

The Linear Static Analyses provided by Rigid Formats 1 and 2 use most of the features available for model definition in NASTRAN. These include specification of coordinate systems, grid point locations, element connectivities, material properties, constraints, and temperature distributions as well as direct grid point and element loadings. The results available for output consist of weight and balance information, displacements, grid point loadings, element forces and stresses and support reactions. The user may also request plots of the undeformed as well as the deformed structural model.

Rigid Format 2, which provides all the features of Rigid Format 1, also treats structural models which are not fully constrained. It computes the inertia effects of unconstrained rigid body accelerations. These effects are added to the user-specified loadings; the rigid body motions are constrained; and then a normal static analysis is performed.

2.3.2 Nonlinear Static Analysis (Rigid Formats 4, 5 and 6)

NASTRAN provides for two types of static nonlinearities, differential stiffness and material plasticity. The differential stiffness effects treated by Rigid Formats 4 and 5 provide the user with a second order approximation to the nonlinear effects of large deflections. The applied loads are assumed to move with their points of application and they remain fixed in magnitude and direction. The "differential stiffness" matrix is computed as a correction to the original stiffness matrix from the work done by each element in response to a user-specified preload. Rigid Format 4 adds this matrix to the original stiffness matrix in proportion to a user-specified increment of the preload. This new matrix is used in an independent static solution for the deflections due to the preload plus incremental load which is the total load applied to the model.

Rigid Format 5 takes the "differential stiffness" matrix and, together with the original stiffness matrix, solves an eigenvalue problem to obtain the critical load factor that would produce buckling. This critical load factor, or the eigenvalue, multiplied into the preload vector gives the critical loading at which the structure would go unstable. The eigenvector obtained is the mode shape in which the structure would buckle.

Rigid Format 6, on the other hand, is used for problems involving non-linear materials. That is, the material properties are assumed to be stress dependent. The loading is applied in "piecewise linear" increments. After each increment, a new stiffness matrix is generated based on the current state of stress in each element. This new matrix is used to solve for a corresponding increment of displacement and stress. These increments are accumulated to produce the final nonlinear results. Since each increment in load requires a new solution, the user is faced with the compromise between accuracy, which requires small increments, and efficiency, which suggests using the largest possible increments. All static load options are allowed except for those due to temperature and enforced element displacements.

2.3.3 Normal Modes Analysis (Rigid Format 3)

Rigid Format 3 provides for a normal modes analysis of undamped systems with symmetric matrices. Note that Rigid Formats 7 and 10 are also available for extracting complex eigenvalues and vectors of damped systems with unsymmetric matrices. Rigid Format 3 generates both the mass and stiffness matrices and offers a choice of three methods for eigenvalue extraction. The Inverse Power and the Determinant methods are intended to be used if only a limited number of mode shapes are required within a user specified range of frequencies. The Givens method of tridiagonalization is also available and is recommended if all or a large proportion of the natural frequencies and mode shapes are desired. A Guyan reduction, which is available in all Rigid Formats for eliminating specified degrees of freedom, is recommended for reducing the size of the matrices to be used by the Givens method. The available output includes the resulting eigenvalues and natural frequencies, mode shape deflections, modal forces and stresses for selected elements, modal reaction forces, modal mass and plots of the structural model for each mode shape.

2.3.4 Complex Eigenvalue Analysis (Rigid Formats 7 and 10)

Rigid Formats 7 and 10 offer the user the capability to compute the complex eigenvalue and vectors of non-conservative systems. These formats provide for a very general overview to the response of a system which includes user-specified input of real or complex mass, damping and stiffness matrices. The assembled matrices may be real or complex, symmetric or nonsymmetric, singular or nonsingular.

Two formulations are provided. The direct formulation of Rigid Format 7 and the modal formulation of Rigid Format 10. The direct formulation provides for the most general description of a model which includes also program generated viscous and structural damping. The unknowns are the degrees of freedom related to grid points, scalar points and the special "extra" points which are used to specify special conditions as may be encountered in control systems and aerodynamics or hydrodynamics.

The modal approach, in contrast, employs the free vibration modes of the undamped model as independent degrees of freedom to be assembled with the user-specified direct input matrices and "extra" point control parameters. Proportional viscous damping on the modal coordinates is included.

The selection of approach depends on the particular problem to be solved and the number of roots to be extracted. The direct approach offers the greatest flexibility if only a few roots are desired. If many roots are to be extracted, the modal approach may be more economical. A summary of features is presented in the next section in Table 2-1 to help the user select the Rigid Format most suited to his needs.

The available output includes frequencies and mode shape displacements, element forces and stresses and support reactions. These may be printed in either SØRT1 or SØRT2 in either real/imaginary or magnitude/phase angle format. SØRT1 prints all the requested output for each frequency. SØRT2 prints each component of output for all frequencies.

2.3.5 Dynamic Response Analysis (Rigid Formats 8, 9, 11 and 12)

The NASTRAN dynamic analysis Rigid Formats provide a maximum amount of flexibility and capability at the possible expense of program efficiency. Rigid Formats 8 and 11 offer Frequency and Random Response capability and Rigid Formats 9 and 12 offer Transient Analysis capability. Rigid Formats 8 and 9 use a direct approach; the other two use a modal approach. Table 2-1 summarizes the various options available to help the user select the Rigid Format best suited to his particular problem.

These capabilities can be used to solve problems with thousands of degrees of freedom, with many time steps or frequencies and mode shapes. Much effort has been expended to allow for many types of special modeling problems. The user, however, must beware that each time step, etc., could cost the equivalent of one static analysis solution. Every effort should be made to reduce the size of the problem either by careful design of the original model or by using the Guyan method to reduce the total degrees of freedom. The user

TABLE 2-1. SUMMARY OF ANALYSIS OPTIONS FOR DYNAMIC RIGID FORMATS

OPTIONS	RIGID FORMAT NUMBER, DYNAMICS					
	DIRECT			MODAL		
	Complex Eigenvalue 7	Frequency Response 8	Transient 9	Complex Eigenvalue 10	Frequency Response 11	Transient 12
Proportional Structural Damping	1	1				
Proportional Viscous Damping			1	2	2	2
Damping Elements	1	1	1			
Real Direct Input Matrices or Transfer Functions	3	3	3	3	3	3
Complex Direct Input Matrices	3	3		3	3	
Non-linear Functions			3			4
Initial Conditions			3			4
Loads		3	3		3	3

Optional input constraints:

(1) Applied to structure only
(2) Applied to modal coordinates only
(3) Applied to structure or extra points
(4) Applied to extra points only

should pay special attention to the selection of the most economical method for solving his particular problem.

The modal approach for dynamic analyses differs from the direct approach in that it uses the undamped mode shapes as independent degrees of freedom replacing the original model. In either approach, special "extra" points may be added for special modeling purposes. The input loads for the modal approach are transformed to the modal coordinater, and the resulting modal displacements are transformed back to the physical displacements for output purposes.

The choice of direct or modal approach is dependent on the specific problem. The direct approach solves a more general problem and does not require the extra steps of extracting the free vibration modes and of performing the transformations to form modal coordinates. If for transient analysis, however, many time steps are required, the direct formulation may be too costly. The modal formulation, on the other hand, has a limited range of response frequencies due to the limitations on the number of mode shapes used.

Also available with the modal approach (Rigid Formats 11 and 12) is a mode acceleration method of improving the solution accuracy. This procedure replaces the unconstrained rigid body accelerations with equivalent inertial and damping forces. The augmented loading is then solved statically to obtain improved element forces and stresses. The user is cautioned, however, that this method is costly and should be used selectively.

The Frequency and Random Response analysis (Rigid Formats 8 and 11) can be used to analyze the steady state response of systems due to sinusoidally varying loads at specified frequencies. The model may include direct user input matrices and transfer functions. The assembled matrices may be nonsymmetric, real or complex and singular or nonsingular. Loads must be input on specific degrees of freedom and may have phase angles, time lags and frequency dependent magnitudes. The output may be sorted by frequency (SØRT1) or by component for all frequencies (SØRT2) and printed in either a real/imaginary or a magnitude/phase angle format. Curve plotting of these results is also available for each output component or a function of frequency.

The Random Response analysis is treated as a data reduction procedure that is applied to the results of a Frequency Response analysis. The user inputs a power spectral density function, which is assumed to be stationary with respect to time, and the program computes the power spectral density, mean deviation and auto correlation function for the response of the selected output components. The output from the Random Analysis must be selected one component at a time, <u>not</u> via the Case Control options, but via the control cards of the X-Y plot package. The random output will be real numbers automatically printed and may be plotted versus frequency if so requested.

The Transient Analysis (Rigid Formats 9 and 12) perform a step by step integration of the structural response in a time domain. The user provides the initial conditions, time step requirements, and a time varying load. The available output for specified integration time intervals includes displacements, velocities, accelerations, forces and stresses for selected elements and support reactions.

Some special features available to Transient Analysis include the capacity to incorporate user-specified direct input matrices, nonsymmetric control function equations, and a limited nonlinear analysis capability. The non-linear capability is available through displacement and velocity dependent load components applied to specific degrees of freedom. For purposes of economy, the user may change the integration time step. However, for each time step change, the coefficient matrices must be reassembled.

2.4 SPECIAL NASTRAN CAPABILITIES

Each of the preceding Rigid Formats may also be used to solve specialized problems. The more recent versions of NASTRAN include the facilities for modeling hydroelastic, acoustic cavity, and heat transfer problems. The procedures are also available for performing substructuring analyses. Each of these capabilities will be summarized below. Examples of simple, but typical problems are included in Chapter 7, along with listings of the input data required. Also described in Chapter 7 are simple examples of how the DMAP instructions may be used either to modify existing Rigid Formats or to independently control a user-specified sequence of matrix operations.

2.4.1 Heat Transfer Analysis

The heat transfer problem is analogous to the structural problem with temperatures replacing deflections as the problem unknowns. Currently, only Rigid Format 1 is available for determination of steady-state temperatures. The same modeling features for specifying grid point geometry, element connectivity and material properties are provided. In addition, special features are available for specification of fixed temperature, convection and heat flux boundary conditions. The output available consists of resultant grid point temperatures throughout the model.

2.4.2 Hydroelastic Analysis

The hydroelastic capability is designed primarily to solve problems with combined structure and fluid effects. The options include both rigid and flexible container boundaries, free surface effects and compressibility. The fluid is described with axisymmetric finite elements. The structure, however, can only be described with non-axisymmetric elements even though the boundaries with the fluid must conform. The analysis assumes small perturbations about static equilibrium, and second-order velocity terms are ignored. Rigid Formats 7, 8 and 9 may be used to analyze combined fluid and structure models for eigenvalues, frequency response or transient response. Rigid Format 3 may be used to compute the normal modes of the fluid alone. The output available includes the pressure in the fluid, the displacements, velocities and accelerations, as well as the structural element forces and stresses.

2.4.3 Acoustic Cavity Analysis

An acoustic cavity analysis may be performed with Rigid Format 3 to obtain the stationary waves in the steady-state flow of a gas through an axisymmetric chamber with radial slots. The width and depth of the slots and the diameter of the center volume may vary along the axis of the chamber. The boundaries of the chamber are assumed to be rigid. The output available includes pressures at points in the gas and the velocities in the fluid elements.

2.4.4 Substructure Analysis

A substructure analysis capability is provided for both a Static (Rigid Format 1) and a Normal Modes (Rigid Format 3) analysis. Both require the uses of DMAP alters to direct the operations involved with the interfacing between the three phases of substructure analysis. The first phase is used to develop the component matrices for each of the substructures. The second phase combines the substructure matrices and obtains the solution desired. The third phase recovers the detail results for each substructure. The output available includes the standard detail results for each substructure and the solution displacements or mode shapes for the combined structure.

It should be noted, however, that though standard DMAP alters have not been described, the user may design his own alter packets to perform substructure analyses with any of the other Rigid Formats.

2.5 DIRECT MATRIX ABSTRACTION PROGRAM (DMAP)

NASTRAN provides the user with not only the Rigid Format sequences of matrix operations discussed earlier, but the facility also to alter these sequences or build entirely independent sequences. The DMAP facilities include the instructions required to perform matrix operations and data manipulation to exercise executive control, to perform structural computations, to exercise user-designed functions programmed by the user, and to output the desired results. Utility DMAP instructions may be used to output data to tape for input to programs external to NASTRAN and to read input data generated outside of NASTRAN. When difficult modeling problems arise, these DMAP instructions may be used to retrieve internal NASTRAN data blocks, to perform special operations to verify the accuracy of a solution, or to extract intermediate results. All these options can be used to help detect the source of errors, to avoid problems, or to improve the results.

This extensive capability allows the user to go beyond the scope of the existing Rigid Formats, and it allows the user to solve a broad range of non-structural matrix problems, all within the framework of NASTRAN.

3. HOW TO USE THE GUIDE

3.1 OVERVIEW

This User's Guide is designed to facilitate the understanding and use of NASTRAN. Examples are presented throughout the Guide which should be carefully examined by the user to help him set up his own problem for execution with NASTRAN. The content of each chapter provides a simplified view of the subject matter to help orient the user to the capabilities of NASTRAN and to direct him by reference to the standard documentation for the necessary detail. The sequence of chapters follows a natural development from problem definition through to actual execution. The first-time user is therefore encouraged not to worry about information in the later chapters until the time comes when it is actually required.

The first chapter simply introduces the user to the concepts of NASTRAN and to the fundamental purposes of the User's Guide. Chapter 2 summarizes all the current analytical capabilities of NASTRAN. Chapter 3 suggests how a user may go about preparing a problem for analysis, where to go to get more information, and how the Guide can help. The following three chapters present, in brief summary form, all the available input options for describing the problem to be solved, controlling its execution, and selection the printed output. Chapter 7 gives examples of actual problems with explanations of the input cards. Chapter 8 illustrates the typical output available from NASTRAN and suggests how to use the plotting capability. Chapter 9 indicates how to interface NASTRAN with other programs. Chapter 10 illustrates how to set up the job control language for each of the UNIVAC, IBM, and CDC computer systems. Chapter 11 provides a quick cross reference relating each input option to many examples in this User's Guide. Finally, Chapter 12 summarizes the available sources for information relating to user experiences, errors encountered, and current developments of NASTRAN.

3.2 STANDARD NASTRAN DOCUMENTATION

Throughout the remainder of the Guide, references are given to the location in the standard NASTRAN documentation where additional information is available. Each parenthetical reference includes the initials of the document and the section number where the information can be found, e.g., (UM 3.2) refers to the User's Manual, Section 3.2, where Rigid Format 1 for Static Analysis is described. The contents of the three reference manuals and the demonstration problem reports provided with NASTRAN are summarized below.

3.2.1 Theoretical Manual (TM)

The Theoretical Manual presents the design concepts and the mathematical basis for NASTRAN. The user will find an overall view of the basic philosoply of NASTRAN, a summary definition of how the program is organized, and a mathematical description of the operations it performs. The available finite element modeling tools are defined, such as grid points and coordinate systems, element connectivity and direct matrix input, multipoint constraints and modal coordinates, transfer functions, etc. Each available analytical capability is mathematically defined. The assumptions and approximations are identified. Suggestions are made on how to use these capabilities. Sections are included on special topics such as heat transfer analysis, plotter graphics, special modeling techniques, error analysis, and interaction between structures and fluids.

3.2.2 User's Manual (UM)

The User's Manual presents the more practical subjects, how to input data to NASTRAN and how to control its processing. This manual begins with a general discussion of structural modeling with a description, in physical terms, of each modeling tool available. Of special interest to the user are the descriptions of the many elements in NASTRAN. Each type of element is discussed in terms of how it can be used, the input that is required, and the results that can be obtained. The reader is shown how to use the constraints and partitioning features of NASTRAN. The many types of static and dynamic load capabilities are summarized. Both the direct and modal formulations of the dynamic equations of motion are presented. And, examples are given for the more esoteric modeling capabilities of NASTRAN, including substructuring, fluid/structure interaction, and acoustic cavity analysis.

The specific detail of format and card content for each option of the Executive Control, Case Control, and Bulk Data Decks is presented in separate sections of Chapter 2. In each section, the card mnemonics are listed alphabetically for easy reference. Also, since large problems may require sizable input decks, this chapter concludes with a description of how to use the User's Master File feature for storing the data on tape. The extensive plotting capability and its control options are discussed separately in Chapter 4.

Chapter 3 presents a general description on how to use the current Rigid Formats, what steps NASTRAN takes to prepare the input data for processing, how to use the checkpoint/restart feature, and how to alter the Rigid Format for special purposes. A section of the chapter is devoted to each available Rigid Format. Each section contains a detail description of the processing steps, a summary of the Case Control requirements, a list of the output options, and a list of the special parameters provided for execution control and special output requests.

Chapter 5 contains all the detail instructions, with examples, for using the Direct Matrix Abstraction Program (DMAP) commands. These DMAP commands can be used to alter the Rigid Formats or to create entirely new sequences for matrix processing with NASTRAN.

Chapter 6 lists and explains all of the error and diagnostic messages issued by NASTRAN. Chapter 7 contains a very useful dictionary of the common terms and mnemonics used throughout the NASTRAN documentation.

3.2.3 Programmer's Manual (PM)

The Programmer's Manual contains the detailed description of the modules and subroutines of NASTRAN and the data blocks on which they operate. The user who will be using NASTRAN extensively would do well to read the first chapter which contains a lot of information on how NASTRAN processes data and how it controls that processing. Though this understanding is not required, it will help to visualize what happens and may help the user to efficiently organize his processing requests. Also, NASTRAN offers such a plethora of options, not all combinations can be adequately described. Hence, an understanding of how they are used will also help in the interpretation of the documentation.

Chapter 2 is also of value to an experienced user. Here he will find a detail description of the many pools of data generated and maintained in NASTRAN. Occasionally the user will encounter the need for some of this data to help him locate an error in his model. NASTRAN provides the facility for retrieving this data and printing it out with special DMAP utilities. An alphabetical index of the dataset names is provided to help locate the pertinent data descriptions.

The remaining chapters are devoted to describing the utility subroutines, the functional modules, the matrix processing modules, the routines that generate the element matrices, and the interfaces of NASTRAN with the resident computer operating systems. Also, instructions are given for adding new program capabilities and new input cards to NASTRAN. Finally, attention is given to describing the utility programs available to support and maintain NASTRAN.

3.2.4 Demonstration Problem Manual (DP)

The Demonstration Problem Manual contains a discussion of each of the demonstration problems supplied with the NASTRAN program. Each section describes the problem to be solved, the model selected, and its loads. Also included is a discussion of the NASTRAN results with a comparison to the theoretical solution, where possible. Each Rigid Format analysis is demonstrated at least once, and practically all of the NASTRAN input options are exercised. No listings of the actual input cards are provided in the manual; however, the data decks are supplied with the NASTRAN system package and can be run by the user if he so desires.

3.3 DATA PREPARATION

The first task before data preparation can begin is to define the problem to be solved. This involves an evaluation of the available information concerning the problem, such as identification of the types of excitation and special modeling problems, determination of what results are required and selection of an appropriate method of analysis, setting the budget limitations, and evaluation of the suitability of the computer facilities available.

The data preparation also requires planning. First a general outline of the model must be defined. Can symmetry properties be exploited? Can the structure be subdivided into segments to be analyzed separately and independently? How are the loads to be specified? What type and distribution of elements is required to adequately represent the anticipated response and to provide the required results? Are there special considerations that must be given to unusual material properties? Given a basic arrangement of grid points, how should they be numbered for maximum processing efficiency? Have the special modeling problems been solved? Can special coordinate systems be used to advantage for simplifying the preparation of coordinate data for providing unusual boundary constraint and loading conditions or for aiding in the interpretation of results?

To answer many of these questions, and to be certain that all the required data has been specified, the user should refer to the list of Bulk Data options presented in Chapter 4. Here he will find the available options catagorized according to data type. He will also find a list of options he can use to control the analysis. To use these options effectively, he must have some understanding of how the structure will respond to the applied loads and an approximate idea of the magnitude of the results. This understanding is also required to adequately validate the model and to verify the accuracy of the input data.

The user's next task is to set up his Case Control. These options are summarized in Chapter 5. Here he will find how to have titles printed on his output listings, how to select data sets from Bulk Data for each condition to be analyzed, how to control the sequence of the processing, and how to selectively call for his desired output. If plotted output is desired for checking the model and/or for helping in the visualization of the results obtained, the user should turn to Chapter 8 for a description of these special output options.

Next comes the setting up of the Executive Control Deck which is described in Chapter 6. These options include the specification of the actual processing that is to take place. They provide the information for restart and limit the time of execution, and specify the diagnostic output requests.

Now that all the three decks are ready, they should be ordered in the sequence shown in Figure 3-1 for submission to the computer for processing. The user should now turn to Chapter 10 for help in setting up the job control cards appropriate to the particular computer system he is using. These cards are required to initiate the NASTRAN system, assign the appropriate disk, drum, and/or tape files, and provide the computer system with the necessary accounting information. Chapter 10 also illustrates the control cards required when using some of the special input/output features of NASTRAN described in Chapter 9.

3.4 PROCESSING

The first step of the processing should always be to check the data and the model it represents. NASTRAN provides a careful check of each input card against the type of data it expects to find. It also performs many other checks as processing continues for certain types of modeling or data consistency errors. The user should exploit the plotting features which are perhaps the most useful debugging tools available. Plotting of the model in segments, to be viewed from many angles and perhaps in stereo, will quickly identify most of the obvious modeling errors.

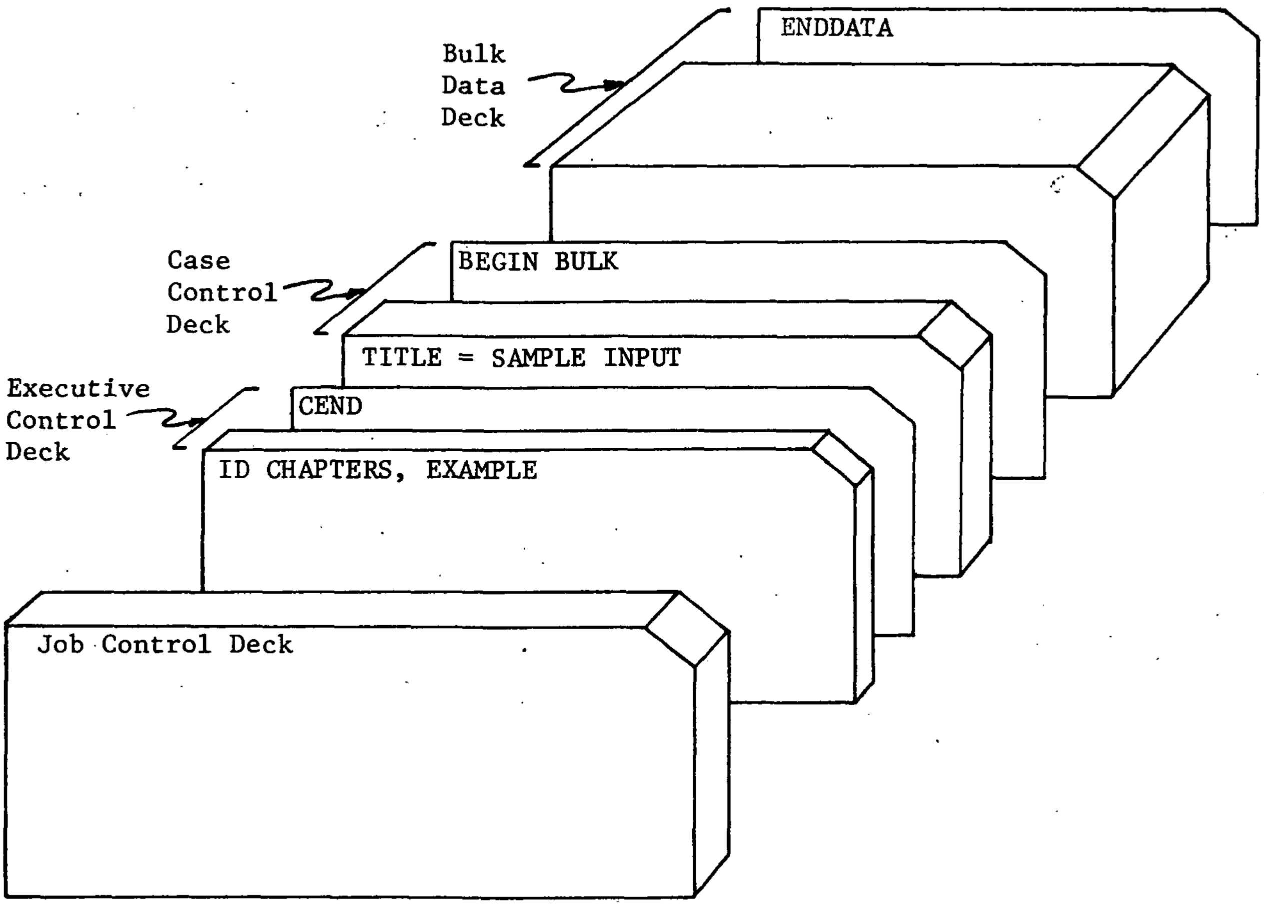


FIGURE 3-1. DECK SETUP FOR PROCESSING

A simple static analysis of segments of the model will help detect less obvious mistakes such as in material properties, element connectivities, multipoint constraints, and boundary conditions. Again, plots of the deformed structure are easier to use than flipping through pages of output. The relative deformations that are shown in these plots are a quick check on localized behavior that may point out loading as well as modeling errors.

When the full model is as well checked out as possible, then solve only a portion of the problem and take a checkpoint. Again, plot the response of the full model or selected segments of it, if it is complex. If the more complex and costly analyses are to be performed, checkpoint at intermediate steps to be certain such results as the natural frequencies are within the expected range. When many mode shapes are required, perhaps, the Inverse Power Method could be used to extract only the fundamental frequency prior to using the more costly Givens Method. If theoretical or approximate results are known for certain cases, use these as a check prior to solving for the other load cases.

NASTRAN provides several measures of accuracy at various stages of processing. Examine these to verify if the conditioning of the matrices is within an acceptable range. Request the residual vectors be computed whenever there is a question as to the accuracy of a decomposition. An overall weight and balance computation can be requested to check for distribution of the mass in the model. If a modal dynamic analysis is being performed, alter the DMAP sequence and request a printout of the PHIA matrix of mode shape for the analysis set of displacement coordinates.

These are but some of the suggestions that can be made to use the extensive features of NASTRAN in helping the user to qualify his model and the results obtained from it. Hopefully, however, these will encourage the user to use his own imagination and explore other alternatives. The capability is in NASTRAN, as in no other structural program, to fully assist the user in the overall objectives of obtaining qualified answers to his problems.

4. BULK DATA DESCRIPTION

4.1 GENERAL DESCRIPTION

The primary NASTRAN input medium for definition of the data required for a structural analysis is the Bulk Data Card. These cards are used to define the structural model and the various other sets of data used to specify the environment to which the model is subjected for analysis. Also, the Bulk Data Cards are used to specify the parameters and limits required to control the analysis. A brief summary of the available options are presented later in Table 4-1.

In general, all the data submitted describing the physical properties of the model are used directly by NASTRAN. Those data used to specify conditions of the environment such as constraints, temperatures, and loadings must be selected via Case Control options (UG 5) if they are to be applied to the model. Methods of analysis, including the associated parameters and limits, must also be selected from Bulk Data via the Case Control options. Because these last two categories of information are fully under the control of the user, the Bulk Data Deck may include several sets of these data at once. The "subcase" structure of the Case Control deck provides the user with the facility to define each unique combination of these parameters as separate subcases to be analyzed, and for most types of analysis, more than one such subcase may be solved in a single run with NASTRAN.

For large problems, the Bulk Data Deck may consist of several thousand cards, In order to minimize the handling of large numbers of cards, provision has been made in NASTRAN to alphabetically sort and store the Bulk Data on a checkpoint tape and/or on a User's Master File tape (UM 2.5 and UG 6.2.1 and 10). These data can then be added to or selectively deleted on subsequent runs.

For cold starts, the first run of NASTRAN for a new model, the entire Bulk Data Deck must be submitted. With this run, the user may create either a User's Master File or a standard checkpoint tape called the New Problem Tape (UM 2.5) on which will be stored the Bulk Data Deck in sorted order. Any subsequent run can then be made with either tape as a source for that data deck. If this run is a restart from a checkpoint, the old checkpoint tape (now called the Old Problem Tape) must be provided. Any Bulk Data cards submitted with this restart run will be added to the old Bulk Data Deck for access during processing. If a checkpoint for this run is requested, another New Problem Tape will be written on which will be stored the new augmented Bulk Data Deck.

Not only can a user thereby add Bulk Data cards with each subsequent run, he can also delete cards by inserting Bulk Data cards with a / in column one, followed by one or two of the sequence numbers assigned to each card of the sorted Bulk Data Deck from the previous run. All cards in the range of these sequence numbers will be deleted. If only one number is input, only that Bulk Data card is removed. These features are also available for editing and updating the User's Master File.

The Bulk Data Deck may be submitted with the cards in any order as a sort is performed prior to the execution of an analysis. It should be noted that the machine time to perform this sort is minimized for a deck that is already sorted. The sort time for a badly sorted deck will become significant for large decks. The user may obtain a printed copy of the unsorted and/or the sorted bulk data by selection in the Case Control Deck (UM 2.3, ECHØ). A sorted listing is necessary in order to make modifications during a subsequent execution. This listing is automatically provided as an echo of the Bulk Data Deck unless specifically suppressed by the user.

4.2 PROBLEM DEFINITION

NASTRAN embodies a lumped element approach, wherein the distributed physical properties of a structure are represented by a model consisting of a finite number of idealized substructures or elements that are interconnected at a finite number of grid points, to which loads are applied. All input and output data pertain to this idealized structural model.

The grid point definition forms the basic framework for the structural model. All other parts of the structural model are referenced either directly or indirectly to the grid points.

Three general types of grid points are used in defining the structural model. They are:

1. Geometric grid point - A point in three-dimensional space at which three components of translation and three components of rotation are defined. The coordinates of each grid point are specified by the user.
2. Scalar point - A point in vector space to which one degree of freedom is assigned. Scalar points can be coupled to geometric grid points by means of scalar elements and by constraint relationships.
3. For axisymmetric analyses, the geometric grid point becomes a ring -- a point in space rotated about the structural axis of symmetry.

The structural element is a convenient means for specifying many of the properties of the structure, including material properties, mass distribution and some types of applied loads. In static analysis by the displacement method, stiffness properties are input exclusively by means of structural elements. Mass properties (used in the generation of gravity and inertia loads) are input either as properties of structural elements or as properties of grid points. In dynamic analysis, mass, damping, and stiffness properties may be input either as the properties of structural elements or as the properties of grid points (direct input matrices).

Structural elements are defined on connection cards by referencing grid points. In a few cases, all of the information required to generate the structural matrices for the element is given on the connection card. In most cases the connection card refers to a property card, on which the cross-sectional properties of the element are given. The property card in turn refers to a material card which gives the material properties. If some of the material properties are stress-dependent or temperature-dependent, a further reference is made to tables for this information.

Various kinds of constraints can be applied to the grid points. Single-point constraints are used to specify boundary conditions, including enforced displacements of grid points. Multipoint constraints are used to specify a linear relationship among selected degrees of freedom, including the definition of infinitely rigid elements. Omitted points are used as a tool in matrix partitioning and for reducing the number of degrees of freedom used in the analysis. Free-body supports are used to remove stress-free motions in static analysis and to evaluate the free-body inertia properties of the structural model.

Static loads may be applied to the structural model by concentrated loads at grid points, pressure loads on surfaces, or indirectly, by means of the mass and thermal expansion properties of structural elements and enforced deformations of one-dimensional structural elements. Due to the great variety of possible sources for dynamic loading, only general functional and tabular forms of loads are provided to the user in dynamic analysis.

General procedures for defining structural models are described in the User's Manual, Chapter 1. The user is encouraged to become familiar with the many suggestions and guidelines presented in that chapter, such as how to use the special coordinate systems, how to number grid points to avoid inefficient processing, what elements can be used for which purpose, how to load and support a structure, and how to exploit the unusual modeling features of NASTRAN. Additional technical detail, of course, can be found throughout the Theoretical Manual.

4.3 OPTIONS AND FORMAT

There are nearly two hundred Bulk Data options currently available in NASTRAN. Detail descriptions of each option are presented in alphabetical order in the User's Manual, Section 2.4. Because there are so many and varied alternatives, these options are summarized in the following Table 4-1, where they are organized according to data types for easy reference by the user. A scan of these options will provide the user with an overview of his alternatives for model specification, for load definition and for control of the execution. Each option is listed in alphabetical sort of the Bulk Data Card mnemonic in the User's Manual, Section 2.4.2. Here, the user will find the full description of the input card format, the applicable restrictions and the references to other Bulk Data Cards required to complete the input. Here also, the user will find which Case Control option must be used, if any, to selectively apply these data to the problem at hand.

Each category of data found in Table 4-1 includes references to the standard NASTRAN manuals for the related theory and application of the input shown. The order of the categories was selected to follow a natural sequence for model development. As such, a user may use these tables as a checklist to be assured that he has considered every aspect of his input.

It should be noted that some options appear in more than one category. This is done to help avoid overlooking an option that may serve several purposes.

Specific procedures and the formats for Bulk Data input are clearly spelled out in the User's Manual, Section 2.4.1. Examples of many of the Bulk Data options can be found in Chapter 7 of this User's Guide where actual problems for each of the standard and special analysis capabilities of NASTRAN are illustrated and explained. An index to these examples is included in Chapter 11.

To summarize, each Bulk Data Card is divided into ten fields, normally eight columns wide. The first field contains either the card mnemonic or the continuation code from the preceding card if more than one card is required for definition of the data. These continuation codes must be unique in order to facilitate the sorting of the Bulk Data Deck. The last seven columns (74-80) of field 10 on each card are used only for specification of that unique continuation code. The card mnemonic always starts in card column 1. The continuation code from the preceding card starts in card column 2 with a + in card column 1. Each of the remaining data entries to be supplied, may be placed without imbedded blanks anywhere within the appropriate field. These entries may be integer, real, or alphanumeric data.

However, occasionally more than eight-card columns are required for the user to specify his data with sufficient accuracy. In these situations, each Bulk Data Card may be expanded to cover two separate cards with 16-column fields for the data entries (fields 2-9). When this arrangement is used, an * must appear following the card mnemonic and/or in card column 1 of the continuation card.

The type of data to be expected in each field is checked by NASTRAN on input, and a message is issued in the event of an error. To help detect possible modeling errors, NASTRAN also performs many other checks as the input data is used by the program.

A. SPATIAL GEOMETRY

Axisymmetric Approach (UM 1.3.7, 1.7.1, TM 4.1, 5.9)

AXIC	Req'd to define existence of conical shell problem.
AXIF	Req'd to define existence of fluid coordinate system, includes default parameters.
AXSLØT	Req'd to define existence of acoustic slot analysis, includes default parameters.
PØINTAX	Location on shell ring (conical shell) at which loads can be applied and displacements are requested.
RINGAX	Ring for conical shell.
SECTAX	Sector of a conical shell.

Coordinate Systems (UM 1.2.2, TM 3.4.1)

BARØR	Simple beam orientation and property default for CBAR.
CØRD1C	Cylindrical coordinate system by reference to (i=1, three grid points, and i=2, coordinates of three points).
CØRD1R	Rectangular coordinate system by reference to (i=1, three grid points, and i=2, coordinates of three points).
CØRD1S	Spherical coordinate system by reference to (i=1, three grid points, and i=2, coordinates of three points).

Fluid Points (UM 1.7.1, TM 16.1.1)

FREEPT	Fluid surface points for recovery of displacements.
FSLIST	Declares fluid points (RINGFL) which lie on free surface boundary.
GRIDB	Grid location on RINGFL for fluid boundary.
GRIDF	Scalar degree of freedom for acoustic analysis of a fluid.
GRIDS	Scalar degree of freedom on acoustic slot boundaries.
PRESPT	Pressure points for data recovery in fluid analyses.
RINGFL	Circle (fluid point) in fluid model.
SLBDY	List of slot points (GRIDS) on interface between fluid and radial slots.

A. SPATIAL GEOMETRY (cont'd)

Grid Points (UM 1.1, 1.2, TM 3.1)

GRID	Grid point location, direction of displacement and constraints.
GRIDB	Grid location on RINGFL for fluid boundary.
GRDSET	Default options for all GRID cards.
SEQGP	Grid and scalar point number resequencing.

Scalar Points (UM 1.1, TM 3.1, 14.2)

EPOINT	Extra points defined for dynamics.
SEQEP	Extra point number resequencing
GRIDF	Scalar degree of freedom for acoustic fluid analysis.
GRIDS	Scalar degree of freedom on acoustic slot boundary.
SPØINT	Scalar points defined.
SEQGP	Grid and scalar point number resequencing.

TABLE 4-1. BULK DATA OPTIONS (A. SPATIAL GEOMETRY)

B. ELEMENT AND PROPERTIES

Axisymmetric (UM 1.3.7, 1.7.1, TM 4.1, 5.9)

AXIC	Req'd to define existence of conical shell problems.
CCØNEAX	Conical shell element connection.
PCØNEAX	Conical shell property.
CTØRDRG	Toroidal ring element connection.
PTØRDRG	Toroidal ring property.
CTRAPRG	Trapezoidal ring element connection and property.
CTRIARG	Triangular ring element connection and property.
DMIAX	Direct matrix input for axisymmetric problems.

Dummy (UM 1.3.1, TM 5.1)

ADUMi	Attributes for CDUMi and PDUMi dummy elements (for user-defined element types i = 1 thru 9).
CDUMi	Dummy element connection.
PDUMi	Dummy element property.
PLØTEL	Dummy element definition (for plotting only)

Fluid (UM 1.7.1, TM 16.1.4)

AXIF	Req'd to define existence of fluid analysis and default parameters.
AXSLØT	Req'd to define existence of axisymmetric slot analysis and default parameters.
CASIFi	Fluid element connection i = 2, 3 or 4 fluid points in an acoustic slot analysis.
CFLUIDi	Fluid element connection for axisymmetric fluid (for user-defined fluid points i = 2, 3, or 4).
CSLØTi	Slot element connecting i = 3 or i = 4 GRIDS points for evenly spaced radial slots.

General (UM 1.3.1, TM 5.7)

GENEL	General element in terms of its transformation matrices.

B. ELEMENT AND PROPERTIES (cont'd)

Line (UM 1.3.2, TM 5.2)

CBAR	Simple beam element connection.
PBAR	Simple beam property.
BARØR	Simple beam orientation default for CBAR.
CØNRØD	Rod element property and connection.
CRØD	Rod tension-compression-torsion element connection.
PRØD	Rod element property.
CTUBE	Tube tension-compression-torsion element connection.
PTUBE	Tube element property.

Plate (UM 1.3.5, TM 5.8)

CQDMEM	Quadrilateral membrane element connection.
PQDMEM	Quadrilateral membrane element property.
CQDPLT	Quadrilateral bending element connection.
PQDPLT	Quadrilateral bending element property.
CQUADi	Quadrilateral membrane and bending element connection (i=1 for general and i=2 for homogeneous behavior).
PQUADi	Quadrilateral membrane and bending element property (i=1 for general and i=2 for homogeneous properties).
CSHEAR	Shear panel element connection.
PSHEAR	Shear panel property.
CTRBSC	Basic triangular bending element connection.
PTRBSC	Basic triangular bending element property.
CTRIAi	Triangular membrane and bending element connection (i=1 for general and i=2 for homogeneous behavior).

TABLE 4-1. BULK DATA OPTIONS (B. ELEMENTS AND PROPERTIES)

B. ELEMENT AND PROPERTIES (cont'd)

Plate (cont'd)

PTRIAi	Triangular membrane and bending element property (i=1 for general and i=2 for homogeneous properties).
CTRMEM	Triangular membrane element connection.
PTRMEM	Triangular membrane element property.
CTRPLT	Triangular bending element (TRPLT) connection.
PTRPLT	Triangular bending element (TRPLT) property.
CTWIST	Twist panel element connection.
PTWIST	Twist panel property.

Rigid Connectors (UM 1.4.2, TM 3.5.1)

MPC	Equations of constraint which may be used to simulate a rigid element.
MPCADD	Union of multipoint constraint sets defined by MPC cards.

Scalar (UM 1.3.8, TM 5.6)

CDAMPi	Scalar viscous damper connection (i = 2 or 4 without reference to property).
PDAMP	Scalar viscous damper property.
CELASi	Scalar spring connection (i = 2 or 4 without reference to property).
PELAS	Scalar spring property.
CMASSi	Scalar mass connection (i = 2 or 4 without reference to property).
PMASS	Scalar mass property.
CØNMi	Concentrated mass element connection (i=1 for mass matrix, or i=2 for offset mass inertia properties).
CVISC	Viscous damping connection, extensional and rotational.
PVISC	Viscous damper property, extensional and rotational.

B. ELEMENT AND PROPERTIES (cont'd)

Solid (UM 1.3.9, TM 5.12)

CHEXAi	Hexahedron constant strain element connection (i=1 uses 5 tetrahedra, i=2 uses 10 overlapping tetrahedra).
CTETRA	Tetrahecron constant strain element connection.
CWEDGE	Wedge constant strain element connection.

Surface Heat (UM 1.8.3, TM 8.3)

CHBDY	Heat convection boundary for steady-state heat condition.

TABLE 4-1. BULK DATA OPTIONS (B. ELEMENTS AND PROPERTIES CON'T)

C. MATERIALS

Anistropic (UM 1.3.1, TM 4.2)

MAT2	Anisotropic material properties.
MATT2	Temperature-dependent table references for MAT2 properties.
MAT3	Orthotropic material properties.
MATT3	Temperature-dependent table references for MAT3 properties.
MAT5	Anisotropic thermal material properties.
MATT5	Temperature-dependent table references for thermal conductivity matrix (MAT5).

Fluid (UM 1.7, TM 16.1.1)

AXIF	Defines default parameters and existence of fluid analysis.
AXSLOT	Default parameters and the existence of axisymmetric slot analysis.
BDYLIST	Fluid mass density at fluid boundary.
CFLUIDi	Fluid mass density and bulk modulus.
CSLOTi	Slot fluid element mass density and bulk modulus.
FSLIST	Fluid mass density at free surface.
SLBDY	Fluid mass density at boundary between axisymmetric fluid and evenly spaced radial slots.

Isotropic (UM 1.3.1, TM 4.2)

MAT1	Isotropic material properties.
MATT1	Temperature-dependent table references for MAT1 properties.
MAT4	Isotropic thermal material properties.
MATT4	Temperature-dependent table reference for thermal conductivity or convective film coefficient (MAT4).

C. MATERIALS (cont'd)

Stress Dependent (UM 1.3.1, TM 3.8.1)

MATS1	Stress-dependent table references for MAT1 properties.
TABLES1	Tabular stress-strain function referenced by MATS1.

Temperature Dependent (UM 1.8.3)

MATTi	Table references for MATi type material and thermal properties (i = 1, 4 for isotropic, i = 2, 3, 5 for anisotropic).
TABLEMi	Tabular function for generating material properties and parameter data (i = 1 thru 4 for specific algorithm).
TEMP	Grid point temperature field.
TEMPD	Grid point temperature field default.
TEMPAX	Temperature sets for conical shell problem.
TEMPPi	Plate element temperature field (i=1 includes gradient, i=2 includes thermal moments, and i=3 includes tabular description over cross section).
TEMPRB	Temperature field for line elements.

TABLE 4-1. BULK DATA OPTIONS (C. MATERIALS)

D. CONSTRAINTS AND PARTITIONING

Fluid Boundary (UM 1.7.2, TM 16.1.3)

BDYLIST	Defines boundary (RINGFL points) between fluid and structure.
FLSYM	Axisymmetric symmetry control.
FSLIST	Required to define fluid points which lie on free surface.
SLBDY	List of slot points (GRIDS) between fluid and radial slots.

Heat Boundary (UM 1.8.3, TM-8.3)

CHBDY	Heat convection boundary element for steady-state heat condition.

Multipoint Constraints (UM 1.4.2, TM 3.5.1)

MPC	Defines linearly dependent constraint relations between displacements.
MPCADD	Union of multipoint constraint sets defined by MPC cards.
MPCAX	Required to define MPC-type relations for conical shell coordinates.

Partitioning (UM 1.4.4, TM 3.5.3)

ASET	Defines independent degrees of freedom to be placed in analysis set.
ASET1	Defines independent degrees of freedom to be placed in analyses set.
ØMIT	Defines degrees of freedom omitted from analysis set (reduces independent degrees of freedom).
ØMIT1	Defines degrees of freedom omitted from analysis set (reduces independent degrees of freedom).
ØMITAX	Omitted conical shell degrees of freedom.

Rigid Body Motion Constraints (UM 1.4.3, TM 3.5.5)

SUPAX	Conical shell fictitious supports for determinate reactions for free body analysis.
SUPØRT	Fictitious supports for determinate reactions applied to free body analysis.

D. CONSTRAINTS AND PARTITIONING (cont'd)

Single-Point Constraints (UM 1.4.1, TM 3.5.2)

GRID	Grid point location, direction of displacement and constraints.
GRIDB	Grid location on RINGFL for fluid boundary and constraints.
GRDSET	Default options for all GRID cards.
SPC	Defines single-point constraints and enforced displacements.
SPC1	Defines sets of single-point constraints.
SPCADD	Union of singular point constraint sets defined by SPC and SPC1 cards.
SPCAX	Defines single-point constraints for conical shell coordinates.

TABLE 4-1. BULK DATA OPTIONS (D. CONSTRAINTS AND PARTITIONING).

E. LOADS

Combinations (UM 1.5.1, TM 11.1)

DLØAD	Linear combination of dynamic load sets.
LØAD	Linear combination of static load sets (except temperature and displacement loads).

Dynamic (UM 1.52, 1.53, TM 11.1, 12.1)

DAREA	Dynamic load scale factor and grid point location.
DELAY	Dynamic load function time delay and grid point location.
DLØAD	Linear combination of dynamic load sets.
DPHASE	Dynamic load function phase lead term θ (theta).
NONLINi	Nonlinear displacement dependent transient forcing functions (i = 1 thru 4 defines function type).
PRESPT	Fluid pressure point locations for output and control devices.
RANDPS	Frequency dependent self and cross-power spectral density factors of load sets.
RANDT1	Autocorrelation function time lag for random analysis.
TABRND1	Tabular function of power spectral density versus frequency for random analysis.
RLØADi	Frequency dependent dynamic loads for frequency response (i = 1, 2 defines function type).
TABLEDi	Tabular function for generating frequency or time-dependent loads (i = 1 thru 4 for specific algorithm).
TLØADi	Time-dependent dynamic load for transient response (i = 1, 2 for function type).
TSTEP	Time step intervals for solution and output in transient analysis.

E. LOADS (cont'd)

Heat Transfer (UM 1.5.1, TM 8.0)

QHBDY	Thermal load at boundary for steady-state heat conduction.
TEMP	Grid point temperature field.
TEMPD	Grid point temperature field default.
TEMPAX	Temperature sets for conical shell problem.
TEMPPi	Plate element temperature field (only average temperature used for heat transfer analysis).
TEMPRB	Temperature field for line elements (only average grid point temperature used for heat transfer analysis).

Static (UM 1.5.1, TM 3.6)

DEFØRM	Enforced axial deformation for line elements.
DSFACT	Defines scale factors for loads and stiffness matrices in differential stiffness analysis.
FØRCE	Force load apecified at grid point by vector.
FØRCEi	Force load specified at grid point (i=1, two grid points, or i=2, four grid points).
FØRCEAX	Force loading of a conical shell coordinate.
GRAV	Gravity load vector defined (uses mass matrix).
LØAD	Linear combination of static load sets (not including thermal or deformation loadings).
MØMAX	Moment loading of a conical shell coordinate.
MØMENT	Moment specified at grid point by vector.
MØMENTi	Moment specified at grid point (i=1, two grid points, or i=2, four grid points).
PLFACT	Defines scale factors for load increments in piecewise linear analysis.
PLØAD	Defines a static pressure load on an area.
PLØAD2	Defines a pressure load applied to two-dimensional (plate) elements.

TABLE 4-1. BULK DATA OPTIONS (E. LOADS)

E. LOADS (cont'd)

Static (cont'd)

PØINTAX	Defines location on axisymmetric conical shell ring (RINGAX) at which loads may be applied.
PRESAX	Defines pressure loading of conical shell element.
RFØRCE	Static loading condition due to centrifugal force field.
SLØAD	Defines static loads on scalar points.
TEMP	Grid point temperature field.
TEMPD	Grid point temperature field default.
TEMPAX	Temperature sets for conical shell problems.
TEMPPi	Plate element temperature field (i=1 includes gradient, i=2 includes thermal moment, and i=3 includes tabular description of temperature over cross section).
TEMPRB	Temperature field for line elements including gradient.

TABLE 4-1. BULK DATA OPTIONS (E. LOADS CON'T)

F. METHODS

Buckling (TM 10.3, 10.4)

EIGB	Required data for eigenvalue extraction for buckling analysis.

Control Systems (TM 1.4.2)

TF	Dynamic transfer function as equation or direct matrix input.

Differential Stiffness (TM 7.1)

DSFACT	Define scale factors for applied loads and stiffness matrices in differential stiffness approach.

Eigenvalue (TM 10.0)

EIGC	Data required to perform complex eigenvalue analysis.
EIGP	Defines poles used in complex eigenvalue analysis.
EIGR	Data required to perform real eigenvalue analysis.
TABDMP1	Tabular function of structural damping versus frequency for modal formulations only.

Frequency Response (TM 12.1)

FREQ	Set of frequencies used in frequency response analysis.
FREQ1	Set of frequencies specified by starting frequency, increment, and number of increments desired.
FREQ2	Set of frequencies specified by starting frequency, final frequency, and number of logarithmic increments desired.
TABDMP1	Tabular function of structural damping versus frequency for modal formulations only.

Hydroelastic (UM 1.7, TM 16.1, 16.2)

FREEPT	Location of fluid free surface points for displacement recovery.
AXSLØT	Required to define existence of axisymmetric slot analysis and default parameters.

F. METHODS (cont'd)

Piecewise Linear (TM 3.8)

PLFACT	Required to define scale factors for load increments in piecewise linear analysis.

Random Response (TM 12.2)

RANDPS	Frequency dependent self and cross-power spectral density factors of load sets.
RANDT1	Autocorrelation function time lag for random analysis.
TABRND1	Tabular function of power spectral density versus frequency for random analysis.

Transient Response (UM 1.6, TM 11.0)

TABDMP1	Tabular function of power spectral density versus frequency for modal formulations only.
TIC	Initial conditions for both displacement and velocity for direct formulations only.
TSTEP	Time step intervals used in transient analysis solution.

TABLE 4-1. BULK DATA OPTIONS (F. METHODS)

G. MISCELLANEOUS

Comment (UM 2.4.2)

$	For inserting commentary material into unsorted ^^ho deck.

Delete (UM 2.4.2)

/	For removing cards from either Old Problem Tape on restart or the User's Master File.

Direct Matrix Input

CØNMi	Concentrated mass element connection (i=1 for mass matrix, i=2 for offset mass inertia properties).
DMI	User-defined direct matrix input, real or complex (general)
DMIG	User-defined direct structural matrix input, real or complex at grid points.
DMIAX	Axisymmetric related user-defined direct matrix input (fluid or structural).
TF	Direct matrix input for dynamic transfer function.

Output Control

FREEPT	Location of free surface fluid points for displacement recovery.
PLØTEL	Dummy element definition for plotting purposes only.
PØINTAX	Defines location on axisymmetric conical shell ring (RINGAX) for recovery of displacements.
PRESPT	Pressure point on RINGFL for pressure data recovery in fluid.
TSTEP	Time step intervals for which solutions and output quantities to transient analysis are desired.

Parameters (UM 3.1.5)

PARAM	Specifies parameter values used in DMAP sequences (including rigid formats).

G. MISCELLANEOUS (cont'd)

Resequencing (UM 1.2.2)

SEQEP	Resequences extra point numbering to optimize bandwidth.
SEQGP	Resequences grid and scalar point numbering to optimize bandwidth.

Tabular Input (UM 1.8.3)

DTI	Input table data blocks directly.
TABDMP1	Tabular functionoof structural damping versus frequency.
TABLEDi	Tabular function for generating frequency or time-dependent loads (user prescribes i = 1 thru 4 for specific algorithm).
TABLEMi	Tabular function for temperature-dependent material properties and parametric data (user prescribes i = 1 thru 4 for specific algorithm).
TABLES1	Tabular stress-strain function referenced by MATS1 card.
TABRND1	Tabular function of power spectral density versus frequency.

TABLE 4-1. BULK DATA OPTIONS (G. MISCELLANEOUS)

5. CASE CONTROL DESCRIPTION

5.1 GENERAL DESCRIPTION

The Case Control Deck is used to provide titling information, to select sets of data from the Bulk Data Deck, to generate the subcase structure, and to make output requests for printing, punching and/or plotting.

The Case Control data is placed in a separate file which is read by each NASTRAN functional module. This information is used by that module to control its processing and to select the specific data on which it is to operate. The sequence in which these functional modules themselves are called is controlled by user input to the NASTRAN Executive Control Deck (UG 6.0). The current Case Control options (UM 2.3) are listed in Table 5-1. Typical examples of their use are given in Section 5.4. Additional examples related to actual problems can be found in Chapter 7.

5.2 INPUT SEQUENCE AND FORMAT

The Case Control Deck is input immediately following the last card (CEND) of the Executive Control Deck (UG 6.0). It terminates with the BEGIN BULK card which initiates the input of the Bulk Data Deck. This card and the ENDDATA card which signals the end of Bulk Data, must always be used, even if there are no Bulk Data cards.

The Case Control card is free format. Only the ENDDATA card is required to begin in either card column 1 or 2. Blanks are used to separate the control words. The equal sign (=) is used as an assignment statement. A comma (,) at the end of a physical card signals that a continuation card will be used. Comment cards, signalled by a dollar sign ($) in card column one, can be inserted anywhere in the Case Control Deck and thus may contain any alphanumeric characters the user desires. Only the first four characters of each control word need be used so long as that option is uniquely identified.

5.3 CASE CONTROL OPTIONS (UM 2.3)

The currently available Case Control options are listed in Table 5-1. These options are divided into functional groups for Bulk Data Selection, Output Selection and Subcase Specification as described below. A brief summary of the subcase specification options is presented in Table 5-2. Examples, with explanations, are presented in Section 5.4. Additional examples as they apply to specific problems can be found in Chapter 7. Refer to the discussion of each available Rigid Format (UM 3.2-3.13) for a detailed description of the applicable Case Control options.

5.3.1 Bulk Data Selection (UG 4.0)

In general, element connectivities, element properties, gridpoint coordinates and related geometry data used to describe a structural model are not

BULK DATA SELECTION

Loads:	Constraints:	Direct Input Matrices:	Dynamic Analyses Conditions:	Thermal Fields:
DEFØRM	AXISYMMETRIC	B2PP	CMETHØD	TEMPERATURE
DLØAD	MPC	K2PP	FREQUENCY	TEMPERATURE(LØAD)
DSCØEFFICIENT	SPC	M2PP	IC	TEMPERATURE(MATERIAL)
LØAD		TFL	METHØD	
NØNLINEAR			RANDØM	
PLCØEFFICIENT			SDAMPING	
			TSTEP	

OUTPUT SELECTION

Output Control:	Specific Output Amounts:	SØLUTIØN Set Response:	Stress, Force, Degree-of-Freedom Response:
ECHØ	HARMØNICS	NLLØAD	ACCELERATIØN
LABEL	MØDES	SACCELERATIØN	DISPLACEMENT
LINE	ØFREQUENCY	SDISPLACEMENT	ELFØRCE
MAXLINES	SET	SVECTØR	ELSTRESS
ØUTPUT	TSTEP	SVELØCITY	FØRCE
ØUTPUT(PLØT)			ØLØAD
ØUTPUT(XYØUT)			PRESSURE
ØUTPUT(XYPLØT)			SPCFØRCES
PLØTID			STRESS
SUBTITLE			THERMAL
TITLE			VECTØR
			VELØCITY

SUBCASE SPECIFICATION

General Case:	Symmetric Case:	Combination Coefficients — General:	Combination Coefficients — Symmetric:
SUBCASE	SYM	SUBSEQ	SYMSEQ
REPCASE	SYMCØM		
SUBCØM			

TABLE 5-1 CASE CONTROL OPTIONS

TABLE 5-2 CASE CONTROL - SUBCASE SPECIFICATION

SUBCASE	Defines the beginning of a subcase that is terminated by the next subcase delimiters encountered.
SUBCØM	Defines a combination of two or more immediately preceding subcases in static or inertia relief problems only. Output requests above the subcase level are used.
SUBSEQ	Must appear in a subcase defined by SUBCØM to give the coefficients for making the linear combination of the preceding subcases. The first coefficient applies to the first subcase, the second to the next subcase, etc., for all subcases except combination subcases.
SYM	Defines a subcase in static or inertia relief problems only for which only output requests within the subcase will be honored. Primarily for use with symmetry problems where the individual parts of the solution may not be of interest.
SYMCØM	Defines a combination of two or more immediately preceding SYM subcases in static or inertia relief problems only. Output requests above the subcase level are used.
SYMSEQ	May appear in a subcase defined by SYMCØM to give the coefficient, one for each subcase, for making the linear combination of the preceding SYM subcases. A default value of 1.0 is used if no SYMSEQ card appears, otherwise, a coefficient must be specified for all subcases except combination subcases.
REPCASE	Defines a subcase in static or inertia relief problems only that is used to make additional output requests for the previous real subcase. This card is required because multiple output requests for the same item are not permitted in the same subcase.

selected from Bulk Data by Case Control. All of these data that are found in the Bulk Data Deck are used in defining the model. However, Case Control is used to select from Bulk Data by specification of the appropriate set identifiers, those load sets, constrains sets, temperature data, direct input matrix data and method of analysis to be used in solving a particular problem. The concept of Case Control allows the user to analyze one model under many different loading and constraint conditions all in one run. Each unique combination of conditions is identified in Case Control as a separate subcase within that one run.

Additional control, it should be noted, is provided directly in Bulk Data via the PARAM card (UM 3.1.5). Each Rigid Format (UM 3.2-3.13) allows for selected parameters to be specified on this card. These parameters may be used in directing NASTRAN to perform additional processing and to provide for additional output.

5.3.2 Output Selection (UM 2.3.2)

The Case Control options for control of NASTRAN output allow the user to be selective of the results he wishes to have printed, punched or plotted. General structural analyses as can be performed by NASTRAN can produce such overwhelming volumes of computer printout that this selective feature is one of the most important functions of the Case Control Deck. A full description of the specialized output available is presented at the conclusion of the discussion of each Rigid Format (UM 3.2-3.13).

Certain categories of NASTRAN output are automatically provided (UM 3.1.4). The automatic output includes the NASTRAN title page, echo of the Executive Control, Case Control and sorted Bulk Data Decks, DMAP sequence listing on restarts and the Checkpoint Dictionary when a check point has been requested. Additional output can be requested for diagnostic purposes, e.g., see Executive Control DIAG card (UG 6.3.1) and DMAP alters (UG 7.10).

The specific output which may be requested through Case Control can be divided into categories as follows:

1. Output Control - provide for titles, organization, pagination and mode of output.

2. Output Amounts - provide for definition of sets and intervals to limit volume of output.

3. Output Categories - provide for selection of data types to be output.

These requests may be applied for all subcases or selectively to individual subcases to further limit the volume of desired output. Within a subcase, the user also has the option to suppress output which had been requested above the subcase level. The output requests for specific types of data provide the parameters (UM 2.3.4) with which the user may select special sorting of the output, e.g., printed or punched. The user should make reference to the explanations of the Case Control examples in Section 5.4 where certain idiosyncrasies in the use of the output options are described.

Special note should be made of how to get the output available from a Random Response Analysis, Rigid Formats 8 and 11. Unlike the results from other available analyses, the printout of the power spectral density and autocorrelation functions is available only through the plotting control options provided for ØUTPUT (XYØUT) (UM 4.3.3, UG 7.1.5.4 and 8.4).

Plotting requests; which always appear after the last subcase, are sufficiently specialized that separate sections (UG 8.3 - 8.5) with examples (UG 7) are devoted primarily to a discussion of the three forms of plotting available in NASTRAN. These forms may be summarized as follows:

1. Structural - includes picturing the actual model in an undeformed and/or in a deformed state (UM 4.2).
2. X-Y Plot - includes curve plotting for selected response data in functional form (UM 4.3).
3. Matrix Plot - which offers a topological display of matrix coefficients in graphical form (UM 5.3.2 "SEEMAT").

5.3.3 Subcase Specification (UM 2.3.3)

In general, separate subcases are used to define unique combinations of loadings and constraint sets. Subcases also are used to control output requests, to identify the method of analysis, to change integration time intervals and/or to specify unique sets of direct input matrices. Furthermore, separate subcases are used to control symmetry and anti-symmetry conditions including superposition of the corresponding solutions. Guidelines for subcase requirements according to each of the available Rigid Formats can be found in the "Case Control Deck and Parameters" subsection of the User's Manual Sections 3.2 to 3.13. The following summarizes these requirements as they apply to the different classes of analyses:

1. Static Analyses, Rigid Formats 1 and 2 (UM 3.2.4 and 3.3.4)
   - Separate subcases for each unique combination of loadings and constraint sets.
   - Loading conditions, selected from Bulk Data with LØAD, DEFØRM or TEMPERATURE (LØAD) cards, which are associated with the same sets of constraints should be called for in contiguous subcases to avoid unnecessary computations. The SPC constraint sets may include gridpoint displacements as a loading condition which will be superimposed on any other loading selected in that subcase.
2. Static Analysis with Differential Stiffness, Rigid Format 4 (UM 3.5.5)
   - Case Control must contain at least two subcases. The loading and constraint sets must be specified above the subcase level. The

first subcase is used to specify the output requests that apply only to the linear solution. The second subcase contains the DSCØEFFICIENT card selecting the preload scale factors.

- All subsequent subcases are used only to specify output requests for the non-linear solution.

3. Buckling Analysis, Rigid Format 5 (UM 3.6.5)

   - Same as #2 above except that the second subcase contains the METHØD card selecting the EIGB card from Bulk Data which defines the method of eigenvalue extraction.

4. Piecewise Linear Analysis, Rigid Format 6 (UM 3.7.4)

   - Case Control must contain one and only one subcase.
   - The PLCØEF card which must be used to select the sequence of loading factors to be applied.

5. Normal Modes Analysis, Rigid Format 3 (UM 3.4.5)

   - Multiple subcases are used only to control output requests.
   - The METHØD card must be used to select the EIGR card from Bulk Data.

6. Direct Complex Eigenvalue Analysis, Rigid Format 7 (UM 3.8.5)

   - At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP).
   - The CMETHØD card must be used to select the EIGC card from Bulk Data for each set of direct input matrices.
   - Multiple subcases for each set of direct input matrices are used only for output control.

7. Direct Frequency and Random Response, Rigid Format 8 (UM 3.9.4)

   - At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies and only one FREQUENCY card and one ØFREQUENCY card can be used for each such set.
   - Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading conditions - one subcase for each dynamic loading condition selected from Bulk Data by the DLØAD card.
   - Constraints must be specified directly in Bulk Data (GRID or GRIDSET) or selected above the subcase level. Grid point displacements specified with these constraint sets will be ignored.
   - Output from a Random Response Analysis may be selected only with the XYØUT options (UG 8.4)

8. Direct Transient Response, Rigid Format 9 (UM 3.10.4)

- One subcase must be defined for each dynamic loading condition selected from Bulk Data by the DLØAD card.
- Constraints must be specified directly in Bulk Data (GRID or GRIDSET) or specified above the subcase level. Grid point displacements specified with these constraint sets will be ignored.

9. Modal Complex Eigenvalue, Frequency and Random Response, and Transient Response Analyses, Rigid Formats 10, 11 and 12 (UM 3.11.5, 3.12.5, 3.13.5)

- METHØD must appear above the subcase level to select the method of eigenvalue extraction.
- Constraints must be specified directly in Bulk Data (GRID or GRIDSET) or specified above the subcase level. Grid point displacements specified with these constraint sets will be ignored.
- Output from a Random Response Analysis may be selected only with the XYØUT options (UG 8.4).

5.4 EXAMPLES OF CASE CONTROL DECKS

The following are examples of commonly encountered Case Control Deck arrangements. Additional examples can be found in Chapter 7, as they apply to specific problems. The notes that are provided are intended to highlight the particular intent of the current example.

Details already explained in preceding examples are not repeated.

5.4.1 Example 1 - Multiple Static Loadings

Card No.

```
1    CEND
2    TITLE = STATIC ANALYSIS OF DØØR FRAME
3    SUBTITLE = CLØSED PØSITIØN
4        ØUTPUT
5            DISPLACEMENTS = ALL
6        MPC = 3
```

```
 7        SPC = 15
 8        SET 1 = 256 THRU 289
 9        SET 5 = 15 THRU 20, 23, 25, 101 THRU 123
10    SUBCASE 1
11        LABEL = DECØMPRESSIØN
12        LØAD = 561
13        ØLØAD = 1
14    SUBCASE 2
15        LABEL = REENTRY THERMAL
16        TEMPERATURE (LØAD) = 761
17        STRESS = ALL
18    SUBCASE 3
19        LABEL = IMPACT
20        SPC = 25
21        LØAD = 1061
22        STRESS = 5
23    BEGIN BULK
```

Notes:

1. Last card of Executive Control Deck
2-3. Identifies basic problem and special conditions
4-5. Overall output request for all gridpoint displacements
6. Selects multipoint constraint set from Bulk Data Deck
7. Selects single point constraint set from Bulk Data Deck
8-9. Defines sets of grid points and elements for selective output to be specified later
10-13. First load subcase, label information, loading selected from Bulk Data and special output request for applied loads on grid point set #1
14-17. Second load subcase, label information, thermal load set selection and special output request for stresses for all elements
18-22. Third load subcase, label information, change in single point constraint set, load selection and limited stress output for elements defined by set #5.
23. Signals beginning of Bulk Data Deck to follow

5.4.2 Example 2 - Linear Combination of Subcases

Card No.

```
 1   CEND
 2   TITLE = BUILDING ASG637-111-PG
 3   $ SET 1  GRØUND FLØØR AND FIRST FLØØR BEAMS
 4       SET = 1 THRU 25, 51 THRU 75,
 5           101 THRU 125, 151 THRU 175
 6   $ SET 2  SUPPØRT GRID PØINTS
 7       SET 2 = 1 THRU 26
 8       DISPLACEMENTS = ALL
 9       ELFØRCE = 1
10       ØLØAD = ALL
11       SPCFØRCE = 2
12   SUBCASE 10
13       ELFØRCE = NØNE
14       DEFØRM = 10
15       SPC = 10
16   SUBCASE 20
17       ELFØRCE = NØNE
18       SPC = 20
19   SUBCØM 31
20       LABEL = PRETENSIØN PLUS TWICE SUPPORT SETTLEMENT
21       SUBSEQ = 1.0, 2.0
22   SUBCØM 32
23       LABEL = PRETENSIØN MINUS TWICE SUPPORT SETTLEMENT
24       SUBSEQ = 1.0, -2.0
25   BEGIN BULK
```

Notes:

3,6. Comment card to facilitate interpretation of set definition.

11. Output request for support reactions on single point constraints and printout of gridpoint loading vector.

12-15. First subcase, element deformation loading, suppression of element force output request above subcase level, and selection of single point constraint set.

16-18. Second subcase, enforced displacements at support specified by single point constraint set and suppression of element force output. A null load vector will be output due to absense of direct applied gridpoint loads.

19-21. Combination subcase adding two previous subcases, label information and coefficients for combination with output for displacements, element forces, reactions and applied loads.

22-24. Combination subcase taking subcase 10 and subtracting twice subcase 20. Same output with new label.

Special note should be made of the fact that NASTRAN applies the combination coefficients to the element stress and force results before they are corrected for the DEFØRM or TEMP(LØAD) loading effects. These corrective effects are not multiplied by the combination coefficient when they are added to the combination loading results.

5.4.3 Example 3 - Statics Problem with Symmetry

Card No.

```
 1   CEND
 2   TITLE = GRØUND LEVEL STØRAGE TANK
 3   SUBTITLE = NØN-SYMMETRIC LØADS
 4       SET 1 = 1, 11, 21, 31, 51
 5       SET 2 = 1 THRU 10, 101 THRU 110
 6       DISPLACEMENTS = ALL
 7       ELSTRESS = 2
 8       ØLØADS = 1
 9   SYM 1
10       SPC = 11
11       LØAD = 21
12   SYM 2
13       SPC = 12
14       LØAD = 22
15   SYMCØM 3
16   SYMCØM 4
17       SYMSEQ 1.0, -1.0
18   BEGIN BULK
```

Notes: 9-14. Definition of symmetric and anti-symmetric loads and support conditions.

15. Symmetric summation of subcases 1 and 2.

16-17. Anti-symmetric combination of subcases 1 and 2. The output selected will be printed for all four subcases.

5.4.4 Example 4 - Use of REPCASE in Static Analysis

Card No.

```
 1   CEND
 2   TITLE = FRAMING FØR BLDG 673-7A
 3   SUBTITLE = HEAVY EQUIPMENT LØADING
 4       SET 1 = 1 THRU 10, 101 THRU 110, 201 THRU 210
 5       SET 2 = 21 THRU 30, 121 THRU 130, 221 THRU 230
 6       SET 3 = 41 THRU 100 EXCEPT 55, 57, 59, 61, 65, 72, 78, 95
 7   SUBCASE 1
 8       LØAD = 10
 9       SPC = 11
10       DISP = ALL
11       ELFØRCE = 1
12   REPCASE 2
13       ELFØRCE = 2
14   REPCASE 3
15       ELFØRCE = 3
16   BEGIN BULK
```

Notes: 8-11. Specifies load and support conditions to be analyzed and requests output for displacements at all grid points and element forces for the elements in set #1.

12-15. Specifies two subcases for output control for printing element forces for sets #2 and #3.

5.4.5 Example 5 - Use of MØDES and PUNCH Output Options

Card No.

```
 1   CEND
 2   TITLE = ØXTANK SUPPØRT SYSTEM WITH CØNSTRAINED MØDES
 3   LINE = 40
```

```
 4       METHØD = 2
 5       SPC = 10
 6    SUBCASE 1
 7       DISP(PUNCH) = ALL
 8       STRESS = ALL
 9       MØDES = 2
10    SUBCASE 3
11       DISP = ALL
12    BEGIN BULK
```

Notes: 3. Specifies 40 lines maximum per page of printout.

4. Selects EIGR card from Bulk Data for specification of method for eigenvalue extraction.

6-9. Specifies displacements be punched and element stresses be printed for the first two modes.

10-11. Specifies displacements be printed for all remaining modes.

5.4.6 Example 6 - Use of SØRT2 Output Option

Card No.

```
 1    CEND
 2    TITLE = TRANSIENT ANALYSIS ØF AXLE
 3    SUBTITLE = TRAVELLING WAVE
 4       TSTEP = 9
 5       IC = 9
 6    SET 1 = 2, 4, 6, 8, 10, 12, 14, 16, 18, 20
 7    ØUTPUT
 8       DISP(SØRT2) = 1
 9       VELØ(SØRT2) = 1
10    BEGIN BULK
```

Notes: 4. Selects timestep definition from Bulk Data.

5. Selects initial conditions from Bulk Data.

7-9. Specifies output requests for displacements and velocities for all output time steps (SØRT2) at each grid point selected by set #1. The excitation is produced by initial conditions only.

Special note should be taken that there is only one subcase here and, therefore, it need not be explicitely defined.

5.4.7 Example 7 - Use of XYØUT with Frequency and Random Response

Card No.

```
 1   CEND
 2   TITLE = DIRECT RANDØM RESPØNSE TØ PSD102-A
 3   SUBTITLE = CABINET 5A
 4       SPC = 11
 5       DLØAD = 102
 6       FREQ = 101
 7       RANDØM = 2
 8   ØUTPUT
 9       SET 1 = 1 THRU 10, 101 THRU 110, 120, 130, 150
10       SET 2 = 0.1, 0.3, 0.6, 1.2, 1.8, 2.4, 3.0
11       ØFREQ = 2
12       ACCEL(SØRT2,PHASE) = 1
13   SUBCASE 15
14       LABEL = DAMPING SØURCE TØP
15       B2PP = TIEDAMP
16   ØUTPUT(XYØUT)
17       TCURVE = PSD FØR TØP DAMPING
18       XYPRINT ACCE PSDF,15/1(T1)/1(T2)/101(R3)
19   BEGIN BULK
```

Notes: 4-7. Specifies environment for the analysis including support conditions, frequency dependent dynamic load, the set of frequencies for solution and the power spectral density function.

11. Specifies frequency set #2 for outputting results.

12. Requests the acceleration for all output frequencies for each grid point of set #1 in magnitude/phase angle format.

15. Specifies the direct input damping matrix.

18. Requests output from the Random Response analysis consisting of the power spectral density function for the first subcase (#15) at gridpoint 1 (X-acceleration), gridpoint 1 (Y-acceleration) and gridpoint 101 (Z-angular acceleration).

6. EXECUTIVE CONTROL DESCRIPTION

6.1 GENERAL DESCRIPTION

The Executive Control Deck serves to identify the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed.

If the job is to be executed with one of NASTRAN's standard Rigid Formats, the number of that Rigid Format is declared. Any alterations to the Rigid Format that may be desired would also be part of the Executive Control Deck. These alterations would be specified as a set of DMAP instructions to be inserted into the Rigid Format sequence (UM 5).

If Direct Matrix Abstraction (UG 7.3) is used, the complete DMAP sequence must appear in the Executive Control Deck. These DMAP instructions allow the user to specify his own sequence of matrix operations independent of the standard sequences provided by the Rigid Formats.

The organization of the NASTRAN input deck is described along with the card format in Section 6.2. The Executive Control options are described in Section 6.3 and summarized in Table 6-1. Examples are also provided in Section 6.4.

6.2 INPUT SEQUENCE AND FORMAT

The sequence of input cards for execution of a NASTRAN run begins with the required resident operating system control cards. The type and number of these cards varies with the conventions used at each computer installation. See the programming staff at that installation for instruction in the preparation of these control cards. Typical examples of the operating system control cards used by NASTRAN are illustrated in Chapter 10 for all three main computer systems on which NASTRAN is maintained (PM 5).

These operating system control cards are followed by the NASTRAN Data Deck, Figure 6-1, which consists of three sections:

1. Executive Control Deck (described here)
2. Case Control Deck (Chapter 5)
3. Bulk Data Deck (Chapter 4)

The Executive Control Cards are summarized later in Table 6-1 and illustrated with examples in Section 6.4. They may occur in any sequence with only the following exceptions:

NASTRAN keyword$_1$ = value, keyword$_2$ = value .....

If this card is used, it must occur first preceding the Executive Control Deck. This card is used to modify standard default values of the NASTRAN Executive System parameters.

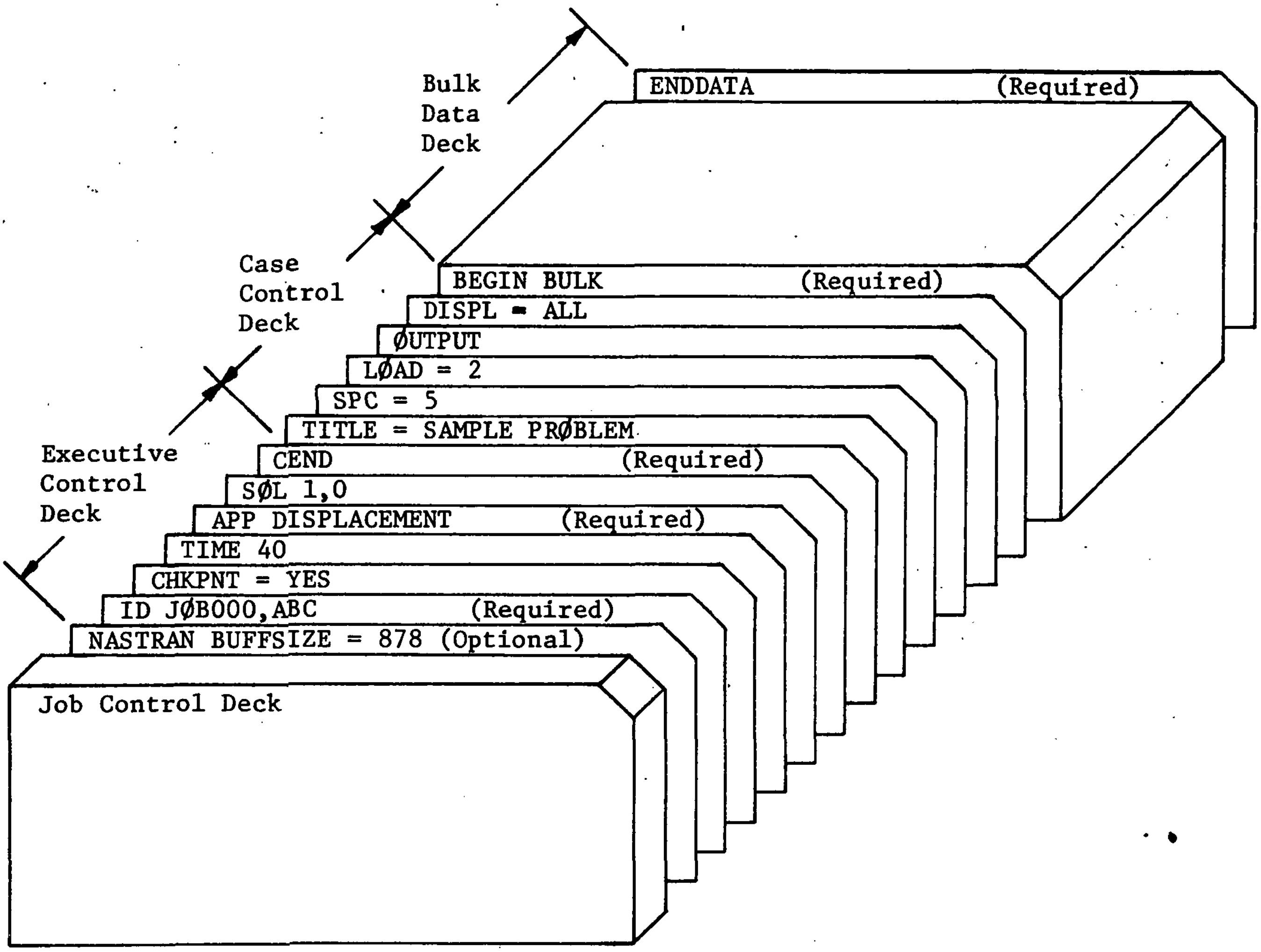


FIGURE 6-1. SAMPLE NASTRAN INPUT DATA DECK

ID A1,A2

This is the first card of the Executive Control Deck. It may be preceded only by the NASTRAN card, if used, and the operating system control cards.

CEND

This card is the last card of the Executive Control Deck and is followed by the Case Control Deck.

The Executive Control Card format is free field. The name of the operation (e.g., CHKPNT, TIME, CEND, etc.) may begin in any card column and is followed by the operand. The operand must be separated from the name by one or more blanks. The fields of the operand are separated by commas and may be integers (Ki) or alphanumeric (Ai) as indicated in the control card descriptions of Table 6-1. The first character of an alphanumeric field must be alphabetic, followed by up to 7 additional alphanumeric characters. If desired, blanks may be placed adjacent to separating commas for legibility. If a card ends with a comma, a continuation card will be expected. Comment cards ($ in column 1) may be inserted anywhere in the deck following the ID card. The individual options are described next.

6.3 EXECUTIVE CONTROL OPTIONS

The Executive Control options are summarized in Table 6-1. Note that the DMAP options, which are included as part of the Executive Control Deck on input to NASTRAN, are not summarized here. See instead UG 7.3 for examples and UM 5 for full detail on the individual DMAP instructions. The full explanation for each of the Executive Control options and the operands Ai and Ki is found in UM 2.2.1, with examples in UM 2.2.2. Also, helpful references for individual options are included in Table 6-1.

6.3.1 Use of Executive Control Cards

As already noted in the preceding section (6.2), the NASTRAN card, when used, is always the first card in the input stream following the operating system control cards. Otherwise, the ID card is the first card and CEND is the last card of the Executive Control Deck.

If a restart run is being made, the restart dictionary punched from the preceding run must be included. The RESTART card is the first card of the dictionary which contains the user problem identifiers provided for the run being checkpointed. The last card contains the comment $ END OF CHECKPØINT DICTIØNARY. The information on the RESTART card is used by NASTRAN to check that the correct restart tape (Old Problem Tape) has been provided. If a new Rigid Format execution is to be made with the same model from a previous run, a restart with Rigid Format switch could save processing time by not requiring the regeneration of matrices saved from the earlier run. If desired, the restart dictionary also may be modified to alter the reentry point used for the current problem (see UM 3.1.3 for detail).

EXECUTIVE CONTROL DECK - Directs NASTRAN Operations (UM 2.2, TM 1.3)
Ai - alphanumeric, Ki - muneric

NASTRAN A1=K1,...	Optional, changes default values of the NASTRAN Executive system parameters (UM 2.1, PM 6.3.1).
ID A1,A2	Required, user problem identification.
RESTART A1,A2,K1/K2/K3	Required if restart after checkpointing. Use restart dictionary punched at time of checkpoint (UM 2.2.1).
DIAG K	Optional, requests diagnostic output (UM 2.2.1, PM 3.3.11).
UMF K1,K2	Required if using User's Master File. May not be used if using Old Problem Tape (ØPTP) (UM 2.5).
CHKPNT A1 or A1,A2	Optional, requests checkpointing as specified in DMAP instructions.
APP A1	Required, defines approach - DISPlacement for standard Rigid Format or DMAP for user-specified instructions.
SØL K1,K2	Required if using Rigid Format (UM 3.1 for options).
ALTER K or K1,K2	Optional, to alter a set of rigid format instructions. Insert here user-specified DMAP instructions (UM 5).
ENDALTER	Required if using ALTER ends instruction set.
TIME K	Required, limits execution time (minutes).
UMFEDIT	Required if using User's Master File Editor (UM 2.5).
BEGIN$	Required if using DMAP approach to begin DMAP sequence.
END$	Required if using DMAP approach to terminate DMAP sequence.
CEND	Required, signals end of Executive Control Deck.

Rigid Format Summary (SOL K1,K2) See UM 3.1 for K2 Options.

K1 = 1	Static Analysis (UM 3.2, TM 3.2)
K1 = 2	Static Analysis with Inertia Relief (UM 3.3, TM 3.2)
K1 = 3	Normal Mode Analysis (UM 3.4, TM 9.1)
K1 = 4	Static Analysis with Differential Stiffness (UM 3.5, TM 3.2)
K1 = 5	Buckling Analysis (UM 3.6, TM 3.2)
K1 = 6	Piecewise Linear Analysis (UM 3.7, TM 3.2)
K1 = 7	Direct Complex Eigenvalue Analysis (UM 3.8, TM 9.1)
K1 = 8	Direct Frequency and Random Response (UM 3.9, TM 9.1)
K1 = 9	Direct Transient Response (UM 3.10, TM 9.1)
K1 = 10	Modal Complex Eigenvalue Analysis (UM 3.11, TM 9.1)
K1 = 11	Modal Frequency and Random Response (UM 3.12, TM 9.1)
K1 = 12	Modal Transient Response (UM 3.13, TM 9.1)

TABLE 6-1 EXECUTIVE CONTROL OPTIONS

If DIAGnostics are desired, the "sense switches" K must be specified. See the list of alternatives in UM 2.2.1. If long runs are being made with the user monitoring the operator's console, a status report can be requested by inputting DIAG 5,6 to get BEGIN and END times for each functional module printed on the operator's console. Most of the options, however, are designed for use in programming development and debugging of NASTRAN. Use of DMAP print utilities (UG 7.3) and NASTRAN's plot capabilities (UG 8) are suggested for obtaining detailed information which would be helpful in finding an error in a structural model.

If a CHKPNT is requested (A1 = YES), be certain a New Problem Tape is provided (UG 10). If a direct access disk is to be used in place of tape (A2 = DISK), instruct the resident operating system to permanently catalog the checkpoint file or use a private disk that may be stored off-line.

To modify a Rigid Format sequence, use the ALTER card to add the desired DMAP instructions. The sequence numbering of the resident Rigid Formats are provided in UM 3. More than one alter package may be used; however, each package must terminate with ENDALTER. See UG 7.3 for examples of typical packages.

To be assured that a checkpoint is taken before the operating system terminates a job for too little time, be certain to set the TIME operand K to less than the time limit specified on the operating system run, job, or job step control card. That way NASTRAN will provide a normal exit, and the punching of the checkpoint dictionary can be completed.

If the UMFEDIT editing feature is to be used, be certain to mount the appropriate input (UMF) and output (NUMF) tapes (UM 2.5 and UG 10).

If the approach being used is APP DMAP, the desired DMAP instructions must be initiated with BEGIN$ and terminated with END$. Note that any alphanumeric commentary (except $) may be inserted between BEGIN and the dollar sign ($).

6.4 EXAMPLES OF EXECUTIVE CONTROL DECKS

The following are examples of commonly encountered Executive Control Deck arrangements. Additional examples can be found throughout Chapter 7.

6.4.1 Example 1 - Cold Start, No Checkpoint

Card No.		
1	ID	MYNAME,BRIDGE23
2	APP	DISP
3	SØL	2,0
4	TIME	5
5	DIAG	1,2
6	CEND	

Notes: 2. Execute a displacement approach.

3. Use the unmodified (K2=0), Rigid Format 2 - Static analysis with inertia relief.

5. Request core memory dump if a nonpreface fatal message is generated, and print File Allocation Table (FIAT) (PM 2.4.1.2) following each call to the File Allocator.

6.4.2 Example 2 - Cold Start, Checkpoint, Modified System Parameters

Card No.

```
1   NASTRAN   BUFFSIZE=878,SYSTEM(4)=4
2   ID        PERSØNZZ,SPACECFT
3   CHKPNT    YES
4   APP       DISP
5   SØL       1,3
6   TIME      15
7   CEND
```

Notes: 1. Requests a change in GINØ buffer size for NASTRAN's own read/write routine, and requests that Unit 4 be used for reading the input data cards.

3. Requests a checkpoint tape be written (New Problem Tape).

5. Remove instructions for loop control which process additional sets of constraints (K2=3), Rigid Format 1 - Static Analysis.

6.4.3 Example 3 - Restart, Checkpoint, Rigid Format Switch

Card No.

```
1   NASTRAN   BUFFSIZE=878,SYSTEM(4)=4
2   ID        PERSØNZZ,
3   RESTART   PERSØNZZ,SPACECFT,2/21/72,  3353,
4       1,   XVPS,   FLAG=0,   REEL=1,   FILE=6
5       2,   REENTER AT DMAP SEQUENCE NUMBER 7
6       3,   GPL,    FLAG=0,   REEL=1,   FILE=7
                      .
                      .
                      .
7   $ END ØF CHECKPØINT DICTIØNARY
8   APP      DISP
9   SØL      3,3
```

10	TIME	.10
11	CHKPNT	YES
12	CEND	

Notes:

1. The same NASTRAN card is used to retain system parameters of the original cold start run.
2. New ID parameters specified to help identify the restart dictionary to be punched by this run.
3. The first card of the restart dictionary punched by the previous run in which the CHKPNT option was selected. Data and time of execution is added to the checkpointed run ID to prevent inadvertent restart from the wrong tape. (See UM 2.2.1 for explanation of cards to follow.)

4-7. The restart dictionary identifying the data stored on the restart tape (Old Problem Tape) which was created as the New Problem Tape on the previous run.

9. Requests a switch to a normal modes analysis (Rigid Format 3), and removes the looping instructions for processing additional sets of constraints (K2=3).

11. Requests a new checkpoint tape be written, a New Problem Tape for this run.

6.4.4 Example 4 - Restart, No Checkpoint, Altered Rigid Format

Card No.

1	ID	PERSØNYY,PRØJECTY
2	RESTART	PERSØNZZ,SPACECRAFT, 3/1/73, 5351,
3	1,	XVPS, FLAGS=0, REEL=1, FILE=6
4	2,	REENTER AT DMAP SEQUENCE NUMBER 7
5	3,	GPL, FLAGS=0, REEL=1, FILE=7
		⋮
6	$ END ØF CHECKPØINT DICTIØNARY	
7	CHKPNT	NØ
8	APP	DISP
9	SØL	3,3
10	TIME	15
11	ALTER	20
12	MATPRN	KGGX,,,,// $
13	TABPT	GPST,,,,// $
14	ENDALTER	
15	CEND	

Notes:

7. CHKPNT card is optional here since <u>NØ</u> is the default.

11. Begin of ALTER package for inserting DMAP instructions after Rigid Format 3 sequence number 20.

12. Request printout of stiffness matrix KGGX (UM 5.3.2, PM 2.2.1 and 2.3.9.1).

13. Request printout of Grid Point Singulatity Table GPST (UM 5.3.2, PM 2.2.1 and 2.3.9.3).

14. ENDALTER concludes the alter package.

7. EXAMPLE INPUT

This chapter of the Users Guide is devoted to exemplifying the input data for solving actual problems. These examples are divided into groups, one for the standard application of the NASTRAN Rigid Formats and one for the specialized applications discussed earlier in Chapter 2. A third group is devoted to examples of how to use the Direct Matrix Abstraction Program (DMAP) commands (UMS), either by themselves, or in conjunction with the standard Rigid Formats. The standard application examples are extracted from the actual input data used for the problems discussed in the NASTRAN Demonstration Problem Manual. The user should refer to this manual for additional detail concerning the model and a discussion of the results. The specialized applications and the examples of how to use the DMAP commands, however, are not available as demonstration problems and the user is encouraged to actually execute these problems himself.

7.1 STANDARD APPLICATIONS OF NASTRAN

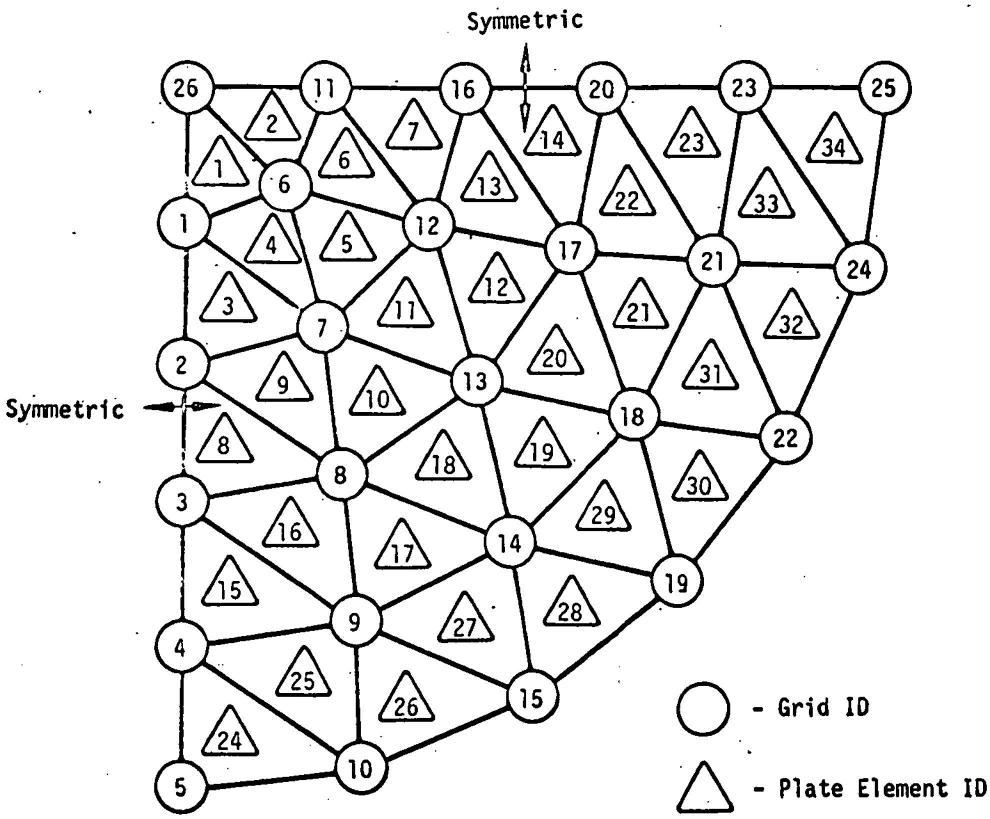
The current version of NASTRAN includes twelve Rigid Formats which are exemplified in Section 7.1.1 through 7.1.5, respectively, for Linear Static, Non Linear Static, Normal Mode, Complex Eigenvalue and Dynamic analysis capability. Each of these capabilities is summarized in Section 2.2.1, and therefore, only the actual problem input will be discussed. The discussion of that input will highlight the points of particular interest to the user who may look at these input examples as a model for his own data preparation.

7.1.1 Linear Static Analysis (Rigid Formats 1 and 2)

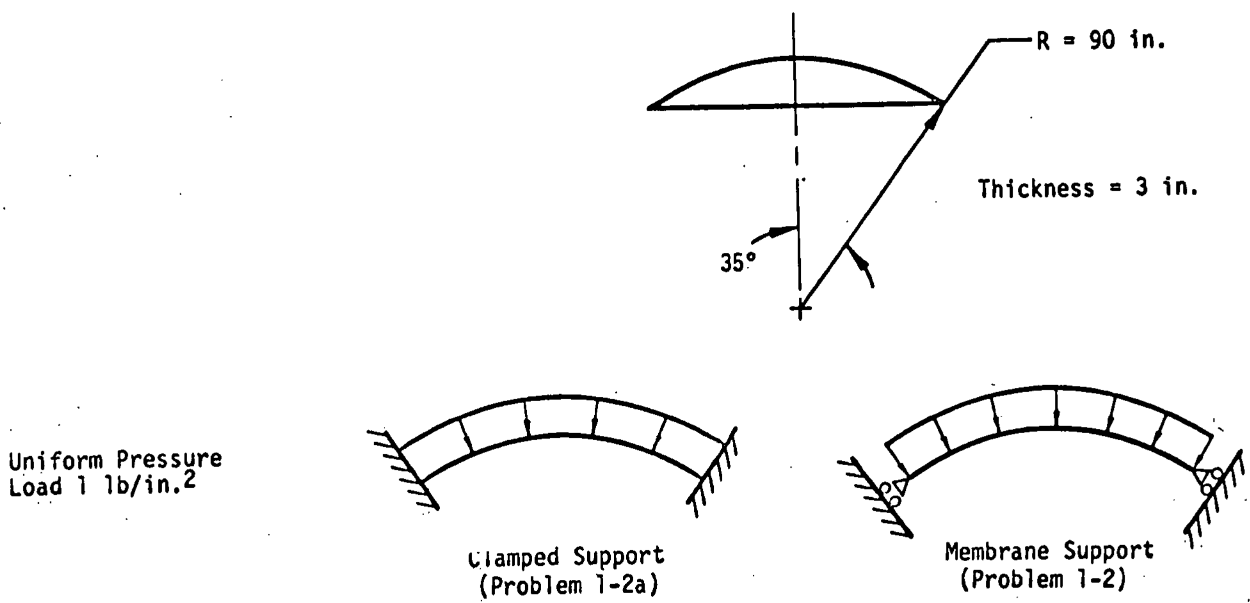
Linear static analysis (TM 3.1) of a fully constrained structure can be analyzed with Rigid Format 1. However, if the structure is not fully constrained, as could be the case for aircraft, missile and ship analyses, Rigid Format 2 can be used to compute the rigid body accelerations due to the imbalance in the applied loads. These rigid body accelerations are represented by compensating inertial force systems (TM 3.6.3) which are added to the originally applied loads and the structure is then analyzed as a fully constrained model. These extra steps provided by Rigid Format 2 are required in order to obtain accurate element forces and stresses. The following examples illustrate the important options available with these two rigid formats including an axisymmetric structural analysis (TM 4.1).

7.1.1.1 Rigid Format 1 - Shell with Symmetry Boundary Conditions

This problem demonstrates the finite-element approach to the modeling of a uniform spherical shell. A spherical coordinate system is chosen to describe the location and displacement degrees of freedom at the grid points. Triangular plate elements are used to provide a nearly uniform pattern. Two symmetric boundaries are used to analyze the structure with a symmetric pressure load. Further modeling detail is given in the Demonstration Problem Manual 1.2-1. The model and its loads are pictured below.



Symmetric
Symmetric
- Grid ID
- Plate Element ID



R = 90 in.
Thickness = 3 in.
35°
Uniform Pressure
Load 1 lb/in.²
Clamped Support
(Problem 1-2a)
Membrane Support
(Problem 1-2)

The analysis is carried out in two parts. First with the roller supports which produces primarily a membrane behavior. The second solution is a restart which solves the same problem but with a clamped edge support which induces bending moments at the boundary.

7.1.1.2 Input Cards - Unclamped Boundary and Symmetry Plots

<u>Card No.</u>

```
 1    ID DEM102, NASTRAN
 2    UMF 21904 120102
 3    CHKPNT YES
 4    TIME 5
 5    APP DISPLACEMENT
 6    SØL 1,1
 7    CEND
 8    TITLE = SPHERICAL SHELL WITH PRESSURE LØADING, NØ MØMENTS ØN
      BØUNDARY
 9    SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 1-2
10        LØAD = 1
11        SPC = 2
12    ØUTPUT
13    DISP = ALL
14    SPCF = ALL
15    STRESS = ALL
16    PLØT ID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 1-2
17    ØUTPUT (PLØT)
18        PLØTTER SC
19        MAXIMUM DEFØRMATIØN 6.0
20    SET 1 INCLUDE ELEMENTS TRIA2
21    $ PLØTEL - EDGES AND CENTERLINE
22    SET 2 INCLUDE, PLØTEL
23        FIND SCALE  ØRIGIN 1
24    PLØT LABELS  SYMBØLS 6
25        PLØT STATIC DEFØRMATIØN 0,1, SET 1, ØRIGIN 1, SHAPE, LABELS
26        PERSPECTIVE PRØJECTIØN
27        FIND SCALE,ØRIGIN 1000, SET  1,VANT PØINT, REGIØN 0.3,
          0.35,0.1, 0.9, 0.8
```

```
28        PLØT SET 2, ØRIGIN 1000, LABELS
29        PLØT  SET 1, ØRIGIN 1000, SYMBØLS 9, SHAPE,
30              SET 1, ØRIGIN 1000 SYMBØLS 9 SHAPE  SYMMETRY X,
31              SET 1, ØRIGIN 1000 SYMBØLS 9 SHAPE  SYMMETRY Y,
32              SET 1, ØRIGIN 1000 SYMBØLS 9 SHAPE  SYMMETRY XY
33        PLØT STATIC DEFØRMATIØN 0,1,
34              SET 2, ØRIGIN 1000, SHAPE,
35              SET 2, ØRIGIN 1000, SHAPE, SYMMETRY X,
36              SET 2, ØRIGIN 1000, SHAPE, SYMMETRY Y,
37              SET 2, ØRIGIN 1000, SHAPE, SYMMETRY XY
38        BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
39	CØRD2S	2		.0	.0	.0	.0	.8	1.	+CØR1
40	+CØR1	1.	0.0	0.0						
41	CTRIA2	1	31	1	6	26	.0			
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮			
74	CTRIA2	34	31	24	25	23	.0			
75	GRDSET		2							
76	GRID	1		90.	7.	.0				
⋮	⋮	⋮	⋮	⋮	⋮	⋮				
101	GRID	26	0	.0	.0	90.0	0			
102	MAT1	1	3.+6		.1666					
103	PLØAD2	1	-1.0	1	2	3	4	5	6	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
108	PLØAD2	1	-1.0	31	32	33	34			
109	PLØTEL	50	26	1		51	1	2		
	⋮	⋮	⋮	⋮		⋮	⋮	⋮		
118	PLØTEL	68	13	17		69	17	20		
119	PTRIA2	31	1	3.						
120	SPC	1	26	12456	0.0					
121	SPC1	1	346	1	2	3	4	11	16	+SPC1-2

CARD NO.	1	2	3	4	5	6	7	8	9	10
122	+SPC1-2	20	23							
123	SPC1	1	123456	5	10	15	19	22	24	+SPC1-1
124	+SPC1-1	25								
125	SPC1	2	2	10	15	19	22	24		
126	SPC1	2	345	1	2	3	4	11	16	+SPC2-1
127	+SPC2-1	20	23							
128	SPC1	2	2345	5	25					
129	SPC1	2	12456	26						
130	ENDDATA									

Notes:

1. NASTRAN run identifier.
2. User Master File with tape number and problem identification number.
3. Checkpoint is requested for restart with clamped boundary conditions.
4. Limits execution time to 5 minutes. Local installation job card should provide a max time of more than 5 minutes to allow NASTRAN to exit normally and punch the check point dictionary.
5. The displacement approach is selected (the only current alternative is DMAP).
6. Rigid Format 1 is to be executed without looping which allows NASTRAN to purge files when they are no longer required.
7. End of NASTRAN Executive Control Deck.

10. Load condition 1 is the only loading. Note, since this implies only one subcase, no subcase delimiter is required.

11. Selects single point constraint set #2 from Bulk Data for symmetry boundary conditions and unclamped supports.

12-15. Specifies output for all gridpoint displacements, support reactions and element stresses.

16-18. Identifies plot label and Stromberg-Carlson plotter.

19. Specifies the maximum displacement to be plotted to a scale of 6 inches relative to the 90-inch radius of the sphere.

20-23. Specifies element sets scaling factors and origin for plotting.

24. Plot first set of elements (set #1), undeformed and orthographic projection.

25. Plot elements of set #1, deformed shape.

26-27. Calls for perspective plots and definition of plot parameters.

28. Perspective plot with PLØTEL only, undeformed.

29-32. Perspective plot of all triangular plate elements fully developed for symmetry, undeformed (UM 4.2.2.3).

33-37. Perspective plot of all PLØTEL fully developed for symmetry, deformed.

39-40. Defines orientation of spherical coordinate system.

41-74. Triangular element connectivities.

75. Sets default values 2 for the spherical coordinate system for output displacements at all grid points.

76-101. Grid point data in spherical coordinate system.

102. Material properties data.

103-108. Pressure load data.

109-118. Fictitious line elements for plot purposes.

119. Triangular element properties.

120-124. Single point constraint set #1 including both clamped edge supports and symmetry boundary conditions. (Not selected in this run.)

125-129. Single point constraint set #2 including unclamped edge supports and symmetry boundary conditions.

130. Signals the end of Bulk Data

Special note that the degrees of freedom constrained by the single point constraint cards #120-129 are relative to a spherical coordinate system and not in the Basic X, Y, Z System.

7.1.1.3 Input Cards - Restart with Clamped Boundary

<u>Card No.</u>

1	ID	DEM102A, RESTART	
2	TIME	5	
3	APP	DISPLACEMENT	
4	SØL	1,1	
5	RESTART	DEM102, NASTRAN	
6		1, XVPS	, FLAGS = 0, REEL = 1, FILE = 5

```
  7              2,  REENTER AT DMAP SEQUENCE NUMBER 7
  .              .      .     .  .        .       .   .
  .              .      .     .  .        .       .   .
105             98,  REENTER AT DMAP SEQUENCE NUMBER 116
106             99,  QG    ,  FLAGS = 0,  REEL = 1,  FILE = 54
107            100, XVPS   ,  FLAGS = 0,  REEL = 1,  FILE = 55
108     $ END ØF CHECKPØINT DICTIØNARY
109     CEND
110     TITLE = SPHERICAL SHELL  RESTART WITH CLAMPED BØUNDARY
111     SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 1-2A
112             ECHØ = BØTH
113             LØAD = 1
114             SPC = 1
115     ØUTPUT
116             DISPLACEMENT = ALL
117             SPCFØRCE = ALL
118             ELFØRCE = ALL
119             STRESSES = ALL
120     BEGIN BULK
121     ENDDATA
```

Notes: 5-108. Restart dictionary from previous run with unclamped boundary conditions.

112. Requests printout of both the current Bulk Data Deck as input (only one card in this case, ENDDATA) and the sorted printout of the full Bulk Data Deck kept from the previous checkpoint as modified by the current input.

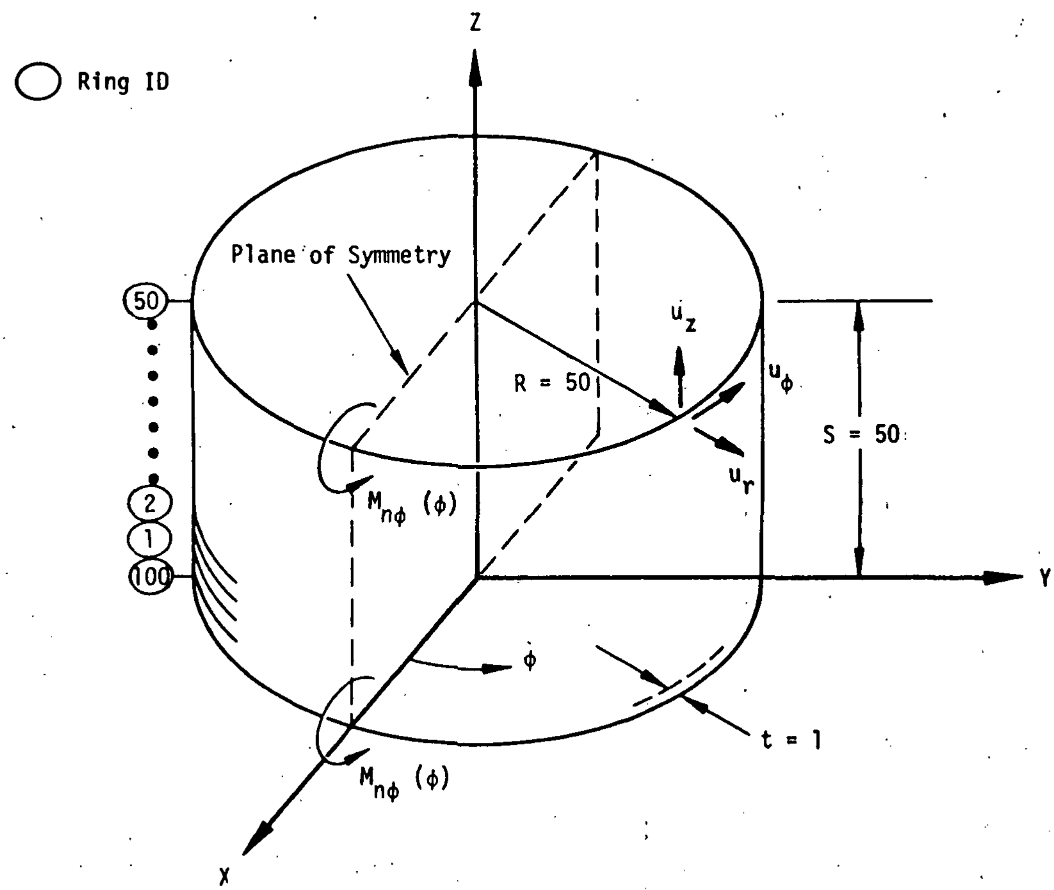
113. Specifies the one pressure load condition.

114. Selects single point constraint set #1 from Bulk Data for symmetry boundary conditions and clamped supports.

7.1.1.4 Rigid Format 1 - Nonsymmetric Bending of a Cylinder

This problem illustrates the application of the conical shell element and its related special data. This element uses the Fourier components of displacement around an axisymmetric structure as the solution coordinates. The geometry of the structure is defined by rings instead of grid points. Its constraints must be defined by the particular Fourier harmonics, and the loads must be defined either with special data or in a harmonic form. This element is used only for statics and inertia relief analysis and may not be used in conjunction with any of the other structural elements.

The structure to be solved is a short, wide cylinder with a moderate thickness ratio. The applied loads and the output stresses are pure uncoupled harmonics. The basic purpose of this problem is to check the harmonic deflections, element stresses, and forces. Further modeling and loading detail is given in the Demonstration Problem Manual 1.5-1. The model and its applied edge moment loading is pictured below.



7.1.1.5 Input Cards - Axisymmetric Model

Card No.	
1	ID DEM105, NASTRAN
2	UMF 21904 130105
3	TIME 24
4	APP DISP
5	SØL 1,1
6	CEND
7	TITLE = NØNSYMMETRIC BENDING ØF A CYLINDER ØF REVØLUTIØN
8	SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 1-5
9	LØAD = 15
10	AXISYM = CØSINE
11	ØUTPUT
12	SET 1 = 5,10,15,20,25,30,35,40,45,50,100
13	SET 2 = 1,6,11,16,21,26,31,36,41,46,50
14	DISP = 1
15	FØRCE = 2
16	HARMONICS = ALL
17	BEGIN BULK

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
18	AXIC	20								
19	CCØNEAX	1	15	100	1					
⋮	⋮	⋮	⋮	⋮	⋮					
68	CCØNEAX	50	15	49	50					
69	MAT1	15	91.0		.3	.5				
70	MØMAX	15	50	0	157.0796		2.0			
	⋮	⋮	⋮	⋮	⋮		⋮			
111	MØMAX	15	100	20	157.0796		-1.0			
112	PCØNEAX	15	15	1.0	15	.083333315		1.0	.5	+PC

CARD NO.	1	2	3	4	5	6	7	8	9	10
113	+PC	0.0	0.5	0.	90.	180.				
114	PØINTAX	200	100							
115	RINGAX	1		50.0	1.0			4		
⋮	⋮	⋮		⋮	⋮			⋮		
165	RINGAX	100		50.0	.0			1234		
166	ENDDATA									

Notes: 10. Constrains the motions to be symmetric with respect to the X-Y plane.

14. Selects displacement output for rings specified in set #1, each harmonic will be output separately.

15. Selects element forces for all conical shell elements in set #2.

16. Output is to be printed for all harmonics of the applied load.

18. Required to define existence of an axisymmetric conical shell problem and specifies 20 harmonics to be used.

19-68. Conical shell element connectivities.

69. Specifies material properties.

70-111. Specifies edge moment loading for each harmonic.

112-113. Conical shell properties.

114. Defines the ID and location of a point on a RINGAX at which the moment can be applied.

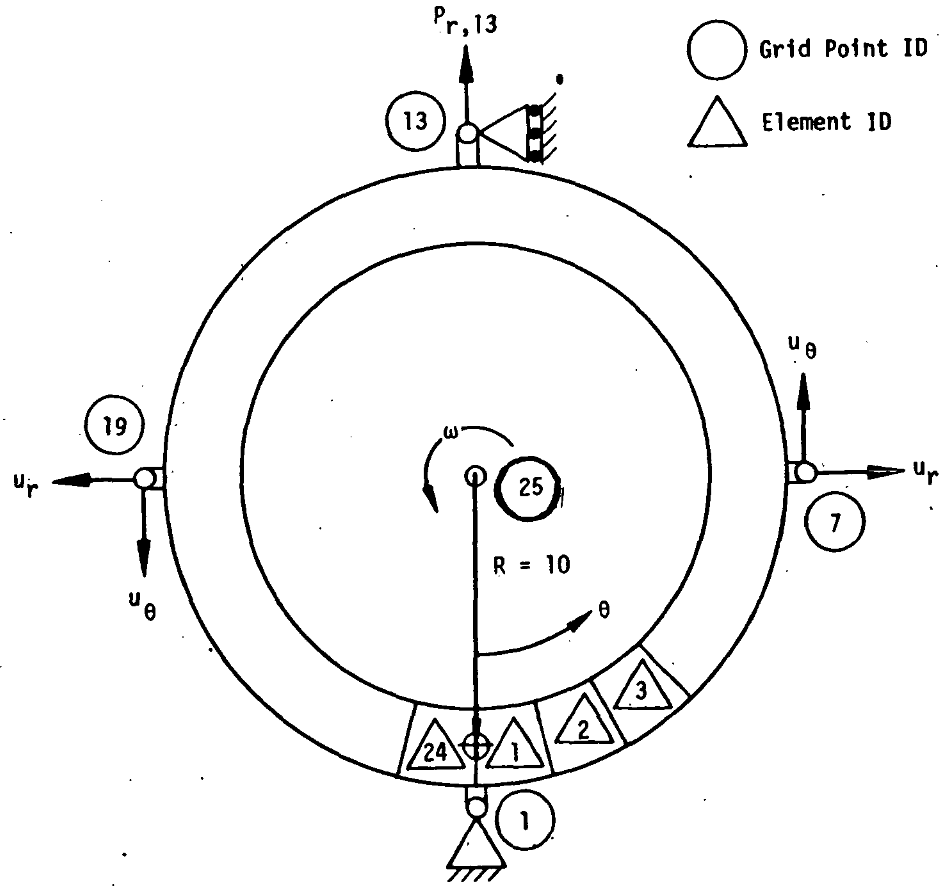
115-165. Specifies location of axisymmetric rings.

Special note that if the user had referenced point 200 in SET 1 he would be referencing the PØINTAX location and would obtain the sum of all displacement harmonics. This same PØINTAX could be used to input a concentrated moment at point 200 and NASTRAN would evaluate the appropriate harmonic coefficients.

7.1.1.6 Rigid Format 2 - Free Body Ring

This problem illustrates the use of inertia relief analysis to solve a free-body problem. In inertia relief the structure is under constant acceleration due to the applied loads; the reactions to the applied load are due to the masses of the structure. Ficticious, nonredundant, support points must be provided to define a reference system attached to the body. The displacements of the body are measured relative to the supported coordinates.

The basic problem is illustrated below. The structure consists of a spinning ring with a constant radial load applied to one point. The rotational velocity creates centrifugal loads and the point load causes inertial reactions. The actual dynamic motion of the whole structure is a cyclic motion of the center point coinciding with the rotation of the ring. The displacements measured by the inertia relief analysis, however, will be the static motion relative to the support point displacements. The displacements are defined in a cylindrical coordinate system ($u_1 = u_r$, $u_2 = u_\phi$, $u_3 = u_z$). See the Demonstration Problem Manual 2.1-1 for further modeling details and a discussion of the theoretical solution.



7.1.1.7 Input Cards - Inertial Relief

```
Card No.

 1        ID  DEM201, NASTRAN
 2        UMF  21904  160201
 3        TIME  5
 4        APP  DISPLACEMENT
 5        SØL  2,1
 6        CEND
 7        TITLE = INERTIA RELIEF ANALYSIS ØF A CIRCULAR RING
 8        LABEL = CØNCENTRATED AND CENTRIFUGAL LØADS
 9        SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 2-1
10        LØAD = 3
11            ØUTPUT
12            DISP = ALL
13            ØLØAD = ALL
14            SPCFØRCE = ALL
15            STRESSES = ALL
16            SET 1 = 1,6,7,12,13,18,19,24
17            ELFØRCE = 1
18        BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
19	BARØR		5			1.0	0.0	0.0	1	
20	CBAR	1		1	2				1	+B1
21	+B1			-1.0	0.0	0.0	-1.0	0.0	0.0	
⋮	⋮			⋮	⋮	⋮		⋮	⋮	
66	CBAR	24		24	1				1	+B24
67	+B24			-1.0	0.0	0.0	-1.0	0.0	0.0	
68	CØRD2C	2	0	0.0	10.0	0.0	0.0	10.0	1.0	+CØRD
69	+CØRD	0.	9.0	0.0						

CARD NO.	1	2	3	4	5	6	7	8	9	10
70	FØRCE	1	13	2	100.0	1.0	.0	.0		
71	GRDSET		2				2	345		
72	GRID	1		11.0	0.0	0.0				
	⋮	⋮		⋮	⋮	⋮				
96	GRID	25	2	0.0	0.0	0.0		123456		
97	LØAD	3	1.0	1.0	1	1.0	2			
98	MAT1	1	1000.0	400.0		.5				+MAT1
99	+MAT1	100	200.	300.						
100	PARAM	GRDPNT	19							
101	PBAR	5	1	1000.0	10.	10.				+P5
102	+P5	1.0	1.0	-1.0	-1.0					
103	RFØRCE	2	25	2	.159155	0.0	0.0	1.0		
104	SUPØRT	1	2	1	1	13	2			
105	ENDDATA									

Notes:

5. Selects Rigid Format 2 without looping instructions to allow removal of files not required.

10. Load set selection required for Rigid Format 2.

13. Requests for all grid points, the output of non-zero components of load.

16-17. Requests element forces for all elements selected in set #1.

19. Specifies beam properties and orientation default. The orientation is defined in terms of the displacement coordinate system of the BAR origin grid points, which in this case are cylindrical systems.

20-67. BAR element connectivities and offset vectors.

68-69. Definition of cylindrical coordinate system.

70. Specifies a force applied at grid point 13 in coordinate system 2 for loading number 1.

71. Provides gridpoint default input and displacement coordinate system and single point constraints.

72-96. Gridpoint definition.

97. Static load combination of load sets 1 and 2.

100. Sets a parameter to generate weight and balance information referenced to grid point 19.

101. BAR element properties.

103. Defines a centrifugal force field for load set 2.

104. Specifies fictitious supports for determinate reactions to be applied to constrain the free body motion.

7.1.2 Non-Linear Static Analysis (Rigid Formats 4, 5 and 6)

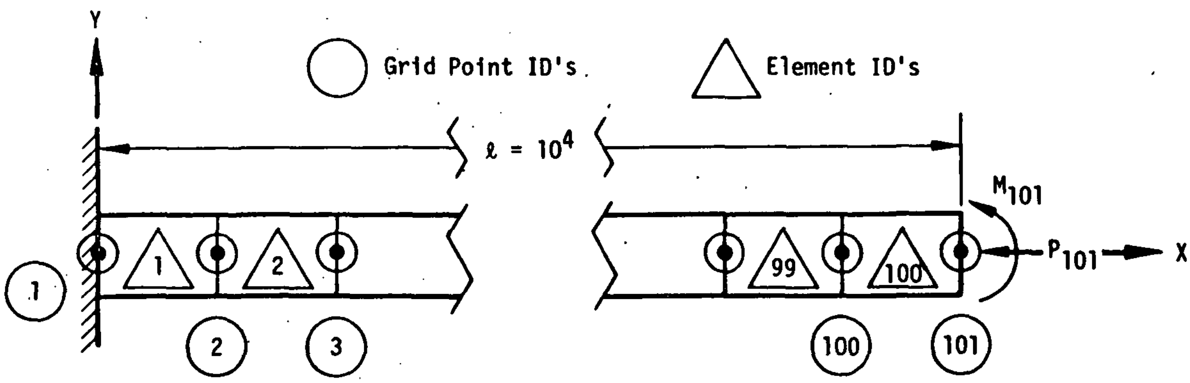
NASTRAN offers three Rigid Formats for non-linear static analysis:

R.F.4 - Differential Stiffness (TM 7.1)
R.F.5 - Buckling (TM 7.1)
R.F.6 - Piecewise Linear (TM 3.8)

A brief summary of each analysis has already been presented in Section 2.2.1.2 of this User's Guide. An example follows for each of these Rigid Formats. The first two examples deal with obtaining the second order non-linear effects due to large deflections. The third treats the non-linear effects of stress dependent material properties representative of plastic behavior without hysteresis.

7.1.2.1 Rigid Format 4 - Differential Stiffness of a Beam

This case illustrates the use of differential stiffness to solve for the non-linear effects of a 100-cell beam under axial compression. The internal loads in the beam create a differential stiffness for the bending deflections which ultimately will result in buckling of the beam. The structural model, illustrated below, is a uniform cantilever beam with an offset load on the free end simulated by a force and a moment. See the Demonstration Problem Manual 4.1-1 for model and loading detail.



7.1.2.2 Input Cards - Large Deflection Analysis

Card No.	
1	ID DEM401, NASTRAN
2	UMF 21904 230401
3	APP DISPLACEMENT
4	SØL 4,0

```
5     TIME 6
6     CEND
7     TITLE = DIFFERENTIAL STIFFNESS ØF A 100 CELL BEAM
8     SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 4-1
9     LØAD = 2
10        SPC = 2
11    ØUTPUT
12        SET 101 = 6,11,16,21,26,34,36,41,46,51,56,61,66,
13                  71,76,81,86,91,96,101
14        SET 102 = 1,11,21,31,41,51,61,71,81,91,100
15        DISP = 101
16        ELFØRCE = 102
17        SUBCASE 1
18        ØUTPUT
19        LABEL = LINEAR CASE
20        SET 103 = 1, 50, 100
21        FØRCE = 103
22        ØLØAD = ALL
23        SUBCASE 2
24        DSCØEFFICIENT = 200
25        LABEL = LARGE DISPLACEMENT CASE
26    BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
27	BARØR					0.0	1.0	0.0	1	
28	CBAR	1	17	1	2					
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
127	CBAR	100	17	100	101					
128	DSFACT	200	9.0	16.0	24.0					
129	FØRCE1	3	101	9.8960	101	1				
130	GRDSET							345		

CARD NO.	1	2	3	4	5	6	7	8	9	10
131	GRID	1		.00	.00	.00				
⋮	⋮	⋮		⋮	⋮	⋮				
231	GRID	101		10000.0	.00	.00				
232	LØAD	2	1.00E02	1.0	3	1.0	1			
233	MAT1	3	1.0+8	4.0+7						
234	MØMENT	1	101		9.8960	.0	.0	1.0		
235	ØMIT1	621	2	4	6	8	10	12	14	+1
236	+1	16	18	20	22	24	26	28	30	+2
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
241	+6	96	98	100						
242	PARAM	GRDPT	1							
243	PARAM	IRES	1							
244	PBAR	17	3	1.0+2	1.0+4			1.00		+PBAR
245	+PBAR	5.0	0.0	0.0	5.0					
246	SPC	2	1	126						
247	ENDDATA									

Notes: 4. Selects Rigid Format 4 for a Differential Stiffness Analysis.

9. Selects the preload condition from which the "differential stiffness" matrix is to be computed.

17. Delimits the first subcase for the linear static analysis under load set 2.

20-22 Defines a new set of elements for printout of element forces overriding the request for element forces in set #102 that was specified above the subcase level. Output will also be provided for the displacements of all grid points in set #101 and for all the non-zero components for load set 2.

23. Delimits the second subcase required for performing the non-linear segment of the analysis.

24. Selects the DSFACT card from Bulk Data that specifies the load increments to be analyzed.

25. Provides the information for the labeling printout. All the output requested above the subcase level will be provided.

27-127. Defines the beam element orientation and connectivity data.

128. Defines three load factors to be applied to the preload for the purpose of computing the non-linear response including differential stiffness effects.

129. Specifies a force to be applied at grid point #101.

130-231. Defines gridpoint locations and default single point constraint data.

232. Defines load set 2 which is a combination of load sets 3 and 1.

233. Specifies the material properties.

234. Specifies a moment load applied to grid point #101.

235-241. Selects degree of freedom components 1, 2 and 6 to be reduced out of the matrix equations by a Guyan reduction (TM 3.5.4) for the specified set of grid points.

242-243. Sets two parameters to obtain weight and balance information (GRDPT) and the printing of the residual vector (IRES) after each execution of SSG3 which computes the solution displacement vector.

244-245. Specifies beam element properties.

246. Defines cantilever support single point constraints.

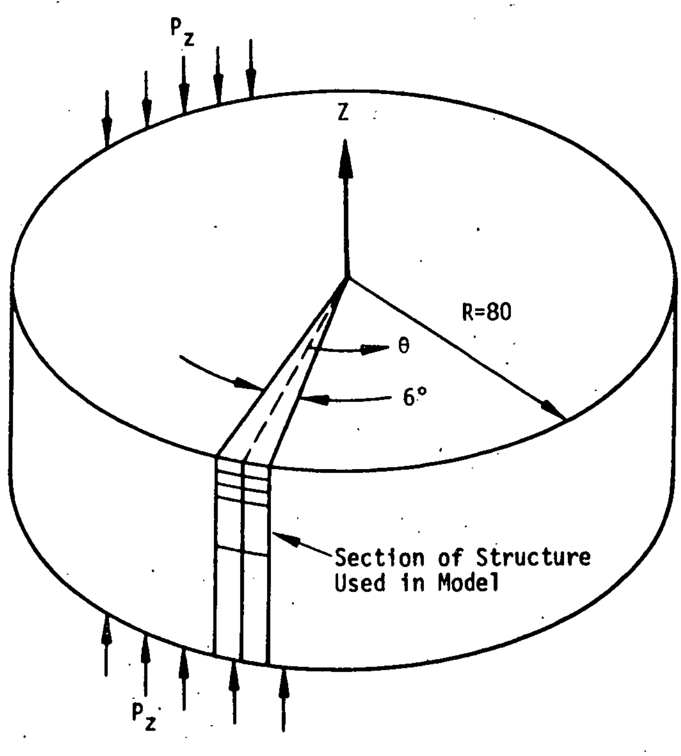
7.1.2.3 Rigid Format 5 - Symmetric Buckling of a Cylinder

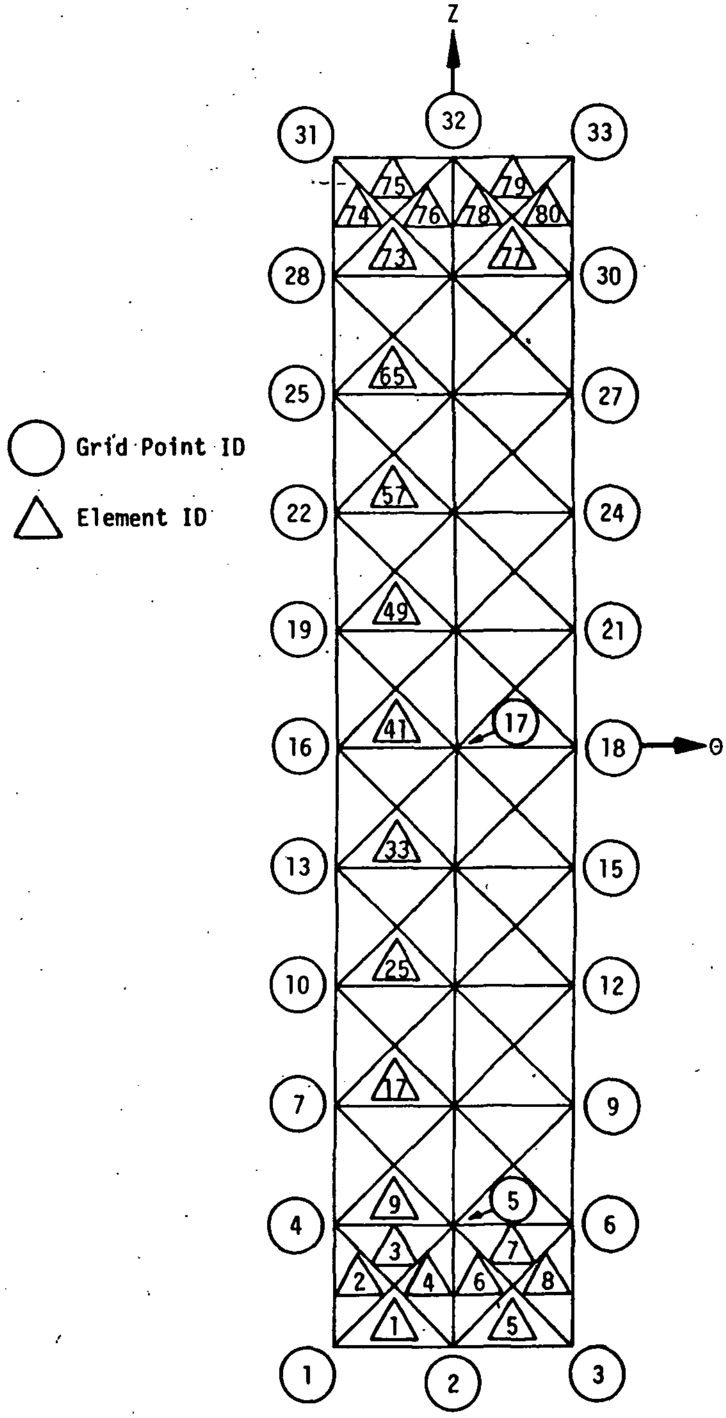
This problem demonstrates the use of buckling analysis to extract the critical loads and the resulting displacements of a cylinder under axial loads. The Buckling Analysis rigid format solves the statics problem to obtain the internal loads in the elements. The internal loads define the differential stiffness matrix $[K^d]$ which is proportional to the applied load. The load factors, λ_i, which causes buckling are defined by the equation:

$$(\lambda_i [K^d] + [K])\{u_i\} = 0$$

where [K] is the linear stiffness matrix. This equation is solved by the Real Eigenvalue Analysis methods for positive eigenvalues λ_i. λ_i is the multiplying factor, which when applied to the preload will produce buckling. More than one mode of buckling can be extracted if so desired.

The problem as illustrated below; consists of a short, large radius cylinder under a purely axial compression load. A section of arc of 6 degrees is used to model the axisymmetric motions of the whole cylinder. See the Demonstration Problem Manual 5.1-1 for the theoretical solution.




Z
Grid Point ID
Element ID
θ
31
32
33
75
79
74
76
78
80
73
77
28
30
65
25
27
57
22
24
49
19
21
41
17
16
18
33
13
15
25
10
12
17
7
9
9
5
4
6
3
7
2
4
6
8
1
5
1
2
3

7.1.2.4 Input Cards - With Structural Plotting

```
Card No.

 1      ID  DEM501, NASTRAN
 2      UMF  21904  170501
 3      APP  DISPLACEMENT
 4      SØL  5,1
 5      TIME   16
 6      CEND
 7      TITLE = SYMMETRIC BUCKLING ØF A CYLINDER
 8      SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 5-1
 9          SPC = 1
10      LØAD = 100
11      ØUTPUT
12          SET 1 = 1 THRU 33
13          SET 2 = 2,6,10,14,18,22,26,30,34,38,42,46,50,54,58,62,
14                  66,70,74,78
15          DISPLACEMENTS = 1
16              SPCFØRCE = ALL
17              ELFØRCE = 2
18              ELSTRESS = 2
19      SUBCASE 1
20      LABEL = STATICS SØLUTIØN
21          ØUTPUT
22          ØLØAD = ALL
23      SUBCASE 2
24      LABEL = BUCKLING SØLUTIØN
25          METHØD = 300
26      $
27      PLØTID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 5-1
28      ØUTPUT(PLØT)
29          PLØTTER SC
30          SET 1 INCLUDE TRIA1
31      $
32          PERSPECTIVE PRØJECTIØN
```

```
33          AXES Y, X, MZ
34          FIND SCALE,ØRIGIN 1, VANTAGE PØINT
35      PLØT LABELS,SYMBØLS 6,5
36      $
37          ØRTHØGRAPHIC PRØJECTIØN
38          MAXIMUM DEFØRMATIØN  3.0
39          FIND SCALE, ØRIGIN 2
40      PLØT STATIC DEFØRMATIØN 0,1, ØRIGIN 2, LABELS, SHAPE
41      PLØT MØDAL DEFØRMATIØN 2, RANGE 0.5, 3.0,
42          ØRIGIN 2, VECTØR R, SYMBØLS 5,6
43              VIEW 0.0, 0.0, 0.0
44          FIND SCALE, ØRIGIN 1
45      PLØT MØDAL DEFØRMATIØN 0.2, RANGE 0.0, 200.0, ØRIGIN 1, SHAPE
46      BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
47	CØRD2C	100	0	25.0	.0	80.0	50.0	.0	80.0	+CØRD100
48	+CØRD100	25.0	0.0	0.0						
49	CTRIA1	1	200	1	2	51	.0			
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮			
128	CTRIA1	80	200	33	30	79	.0			
129	EIGB	300	DET	.10	2.5	4	4	0	1.5E-05	+EIGB300
130	+EIGB300	MAX								
131	FØRCE	1	1	100	1.0+3	0.0	0.0	0.5		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
136	FØRCE	1	33	100	1.0+3	0.0	0.0	-0.5		
137	GRDSET							462		
138	GRID	1	100	80.0	-3.0	-25.0	100			
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮			
190	GRID	79	100	80.0	1.5	22.5	100			
191	LØAD	100	1.0	1.897	1					
192	MAT1	400	1.+4		.0					

CARD NO.	1	2	3	4	5	6	7	8	9	10
193	PARAM	IRES	1							
194	PTRIA1	200	400	2.5	400	1.302				+PTRIA1*
195	+PTRIA1*	1.510	0.0							
196	SEQGP	51	2.5	52	3.5	54	5.5	55	6.5	
:	:	:	:	:	:	:	:	:	:	
200	SEQGP	75	26.5	76	27.5	78	29.5	79	30.5	
201	SPC	50038	17	3	.0					
202	SPC1	50037	1	1	2	3	31	32	33	
203	SPCADD	1	50037	50038						
204	ENDDATA									

Notes: 4. Selects Rigid Format 5 for Buckling Analysis.

9-10. Selects single point constraint and preload sets from Bulk Data. Required to be specified above the subcase level.

19. Subcase delimiter for linear static analysis of preload condition.

23. Subcase delimiter for Buckling Analysis.

25. Selects method for Real Eigenvalue Extraction from Bulk Data. Output will be that selected above the subcase level.

27. Specifies labeling information to identify plots.

28-29. Selects structural plotter package and Stromberg Carleson plotter.

30. Defines set of all triangular elements (TRIA1) to be plotted.

32. Calls for perspective projection.

33. Defines orientation of model relative to view axes.

34. Sets plotting parameters.

35. Plots undeformed model with element set #1.

37. Calls for orthographic projection.

38. Specifies the maximum displacement to be plotted to a scale of 3 units relative to the 80-unit radius of the cylinder model.

39. Sets plotting parameters.

40. Calls for a deformed structural plot of the static preload deformations, Subcase 1.

41-42. Calls for plotting of all buckling mode shapes within the eigenvalue range of 0.5 to 3.0 without showing the undeformed model.

43-44. Defines the view angle and defines plotting parameters.

45. Calls for plotting of all buckling mode shapes within the range of 0.0 to 200.0 superimposed on a plot of the undeformed model.

47-48. Defines a cylindrical coordinate system.

49-128. Specifies the triangular element connectivities.

129-130. Provides the parameters for the Determinant method of real eigenvalue extraction.

131-136. Defines the forces to be applied.

137-140. Defines grid point locations and default single point constraints.

191. Scales the applied load set #1.

193. Calls for printing of residual vectors after static solution.

194-195. Triangular element properties.

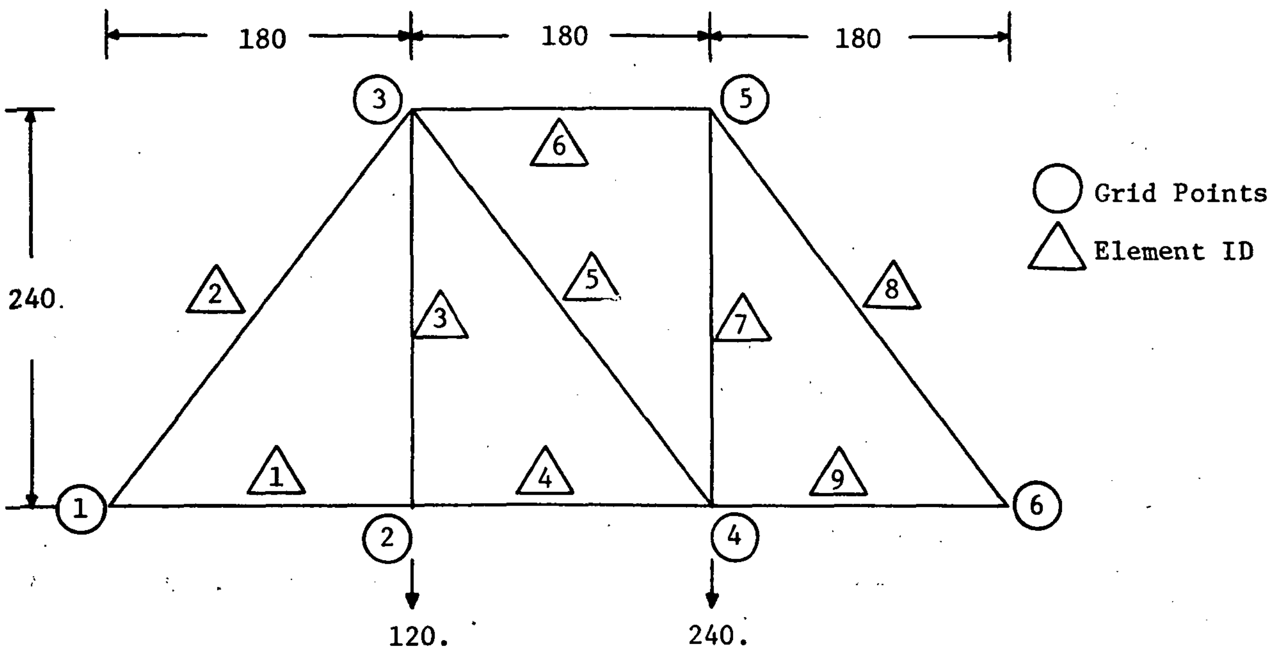
196-200. Gridpoint sequencing to improve banding of the stiffness and differential stiffness matrices.

201-202. Single point constraint set definitions.

203. Union of single point constraint sets.

7.1.2.5 Rigid Format 6 - Piecewise Linear Analysis with Beam Elements

This problem, as shown below, illustrates elastic-plastic deformation of a three-panel truss subjected to concentrated gridpoint loads. Piecewise Linear Analysis involves loading the truss in increments and recalculating the material properties for each element as a function of the element stresses for the last load increment. The new stiffness matrix is used to solve for the change in the deflection caused by a new increment in load. The sum of all these increments represent the final solution (TM 3.8). This problem, though a "standard" demonstration problem,is not described in the manual.



7.1.2.6 Input Cards - Stress Dependent Materials

Card No.	
1	ID DEM601, NASTRAN
2	UMF 21904 180601
3	APP DISPLACEMENT
4	SØL 6,0
5	TIME 5
6	CEND
7	TITLE = PIECEWISE LINEAR ANALYSIS ØF A THREE-PANEL TRUSS
8	LABEL = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 6-1
9	SPC = 1

```
10          LØAD = 1
11          PLCØEFFICIENT = 4
12      ØUTPUT
13      SET 1 = 1,2,3,4,5,6, THRU 10
14          DISPLACEMENT = 1
15              SPCFØRCE = ALL
16              ELFØRCE = 1
17              ELSTRESS = ALL
18              ØLØAD = 1
19      $
20      PLØTID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 6-1
21      ØUTPUT(PLØT)
22          PLØTTER SC
23          CAMERA 3
24          VIEW 0,0, 0.0, 0.0
25          AXES Z, X, Y
26          MAXIMUM DEFORMATION 60.0
27      SET 1 INCLUDE RØD
28          FIND SCALE, ØRIGIN 1, SET 1
29      PLØT LABELS
30      PLØT STATIC DEFØRMATIØN 0,1 THRU 4, MAXIMUM DEFØRMATIØN 1.3,
             SHAPE, LABELS
31      BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
32	CRØD	1	1	1	2					
33	CRØD	2	2	1	3					
34	CRØD	3	3	2	3					
35	CRØD	4	1	2	4					
36	CRØD	5	4	3	4					
37	CRØD	6	3	3	5					
38	CRØD	7	3	4	5					

CARD NO.	1	2	3	4	5	6	7	8	9	10
39	CRØD	8	2	5	6					
40	CRØD	9	1	4	6					
41	FØRCE	1	2	0	120.0		-1.0			
42	FØRCE	1	4	0	240.0		-1.0			
43	GRID	1	0	.0	.0	.0	0	3456		
44	GRID	2	0	180.0	.0	.0	0	3456		
45	GRID	3	0	180.0	240.0	.0	0	3456		
46	GRID	4	0	360.0	.0	.0	0	3456		
47	GRID	5	0	360.0	240.0	.0	0	3456		
48	GRID	6	0	540.0	.0	.0	0	3456		
49	MAT1	1	3.0+4		.3					*MAT1
50	*MAT1	16.99235344		11.814744801		1.E04				
51	MAT1	2	3.0+4		.3					*MAT-1
52	*MAT-1	18.82057716		100.0		200.0				
53	MATS1	2	1000							
54	PARAM	IRES	1							
55	PLFACT	4	1.0	2.0	2.5					
56	PRØD	1	1	7.97						
57	PRØD	2	1	21.16						
58	PRØD	3	1	11.77						
59	PRØD	4	2	7.97						
60	SPC	1	1	1	.0	1	2	.0		
61	SPC	1	6	2	.0					
62	TABLES1	1000								*1001
63	*1001	0.0		0.0		2.0911766-4		6.273525		*1002
64	*1002	4.1823532E-04		10.0		5.61167508E-4		11.0		*1003
65	*1003	1.0561495E-03		13.0					ENDT	
66	ENDDATA									

Notes: 4. Selects Rigid Format 6 for Piecewise Linear Analysis.

9-11. Only one subcase allowed (here it is implied by lack of subcase delimiter). Selects single point constraint and load set from Bulk Data. Also selects PLFACT for increments to be applied to the load for each step of the analysis.

12-18. Specifies the desired printout of results. The results for elements with stress dependent material properties will be printed out for each load increments, otherwise only the cumulation stresses will be printed. All other selected output will be printed for the cumulation results at each load increment.

23. Requests three blank frames be skipped before plotting the next request.

29. Requests plot of undeformed structure for element set #1 (default to first defined set).

30. Requests plot of deformed shape superimposed on undeformed plot for load increments 1 through 4 and defines the same deformation factor for all load increments. However, in this problem, only three increments are specified.

49-50. Specifies material properties which are <u>not</u> stress dependent. Uses a double precision continuation card format.

51-52. Specifies material properties which <u>are</u> stress dependent.

53. Specifies table reference for stress dependent material property factors.

55. Provides for three load increments.

56-59. Element properties.

62-65. Tabular definition of stress dependent properties using double precision continuation card format. The abscissa (X-entry) represents the strain (E) and the ordinate (Y-entry) represents the corresponding stress. At each load increment NASTRAN recomputes Young's Modulus (E) to be applied for the next load increment (TM 3.8.3). The algorithms used differ with element type (TM 3.8.4).

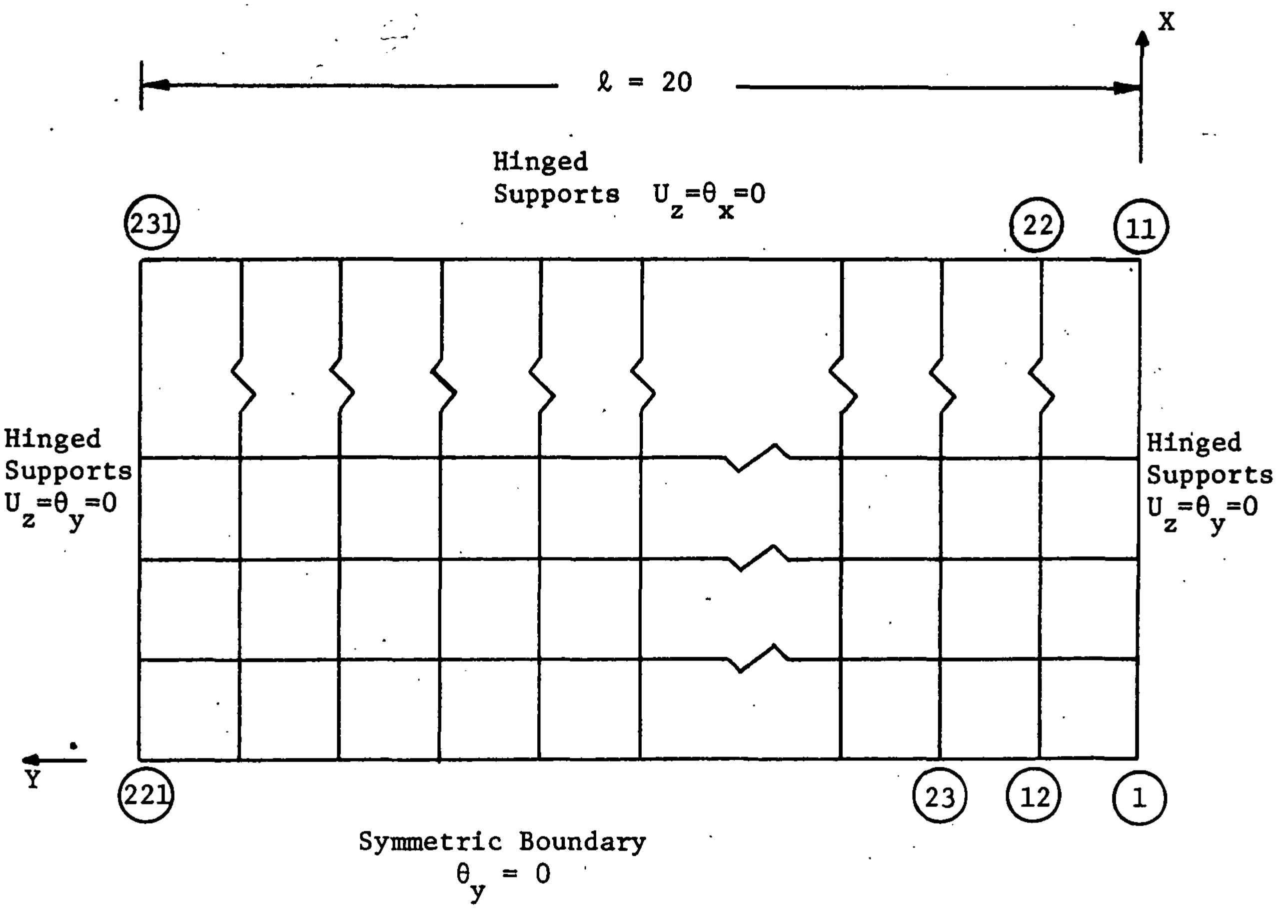
7.1.3 Normal Modes Analysis (Rigid Format 3)

The Normal Modes Analysis capability of NASTRAN (TM 9.2.1) is provided with Rigid Format 3. Section 2.2.1.3 of this Guide summarizes this capability which is, perhaps, the most commonly used tool for preliminary dynamic analyses. It provides an insight to the expected behavior of an undamped structural model in terms of its natural frequencies and modes of vibration. The following example illustrates the input required.

7.1.3.1 Rigid Format 3 - Normal Modes Analysis of a Plate

This problem demonstrates the solution for natural frequencies of a large-order problem. The structural problem consists of a square plate with hinged supports on all boundaries. The 10x20 model, shown below, uses one half of the structure and symmetric boundary constraints on the mid-line in order to reduce the order of the problem and the bandwidth by one-half. The results of this analysis can be found in the Demonstration Problem Manual 3.1.

Because only the bending modes are desired, the in-plane deflections and rotations normal to the plane are constrained. The inverse power method of eigenvalue extraction is selected and both structural mass density and non-structural mass-per-area are used to define the mass matrix.



7.1.3.2 Input Cards - With Structural Plotting

```
Card No.

 1        ID DM301x20, NASTRAN
 2        UMF  21904  290301
 3        APP  DISPLACEMENT
 4        SØL  3,1
 5        TIME  32
 6        CEND
 7        TITLE = VIBRATIØNS ØF A 10 BY 20 PLATE
 8        SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 3-1
 9        $
10        SPC = 37
11            METHØD = 3  $ INV - ENCLØSES 1 MØDE - FINDS 3 RØØTS
12        $
13        ØUTPUT
14        SET 1 = 1 THRU 11,34 THRU 44,56 THRU 66,78 THRU 88,111 THRU 121
15        SET 2 = 1 THRU 12,22,23,33,34,44,45,55,56,66,67,77,78,88,89,
16                99,100,110 THRU 121
17            DISPLACEMENTS = 1
18            SPCFØRCE = 2
19        $
20        PLØTID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 3-1
21        ØUTPUT(PLØT)
22            PLØTTER SC
23            SET 1 INCLUDE PLØTEL
24            SET 2 INCLUDE QUAD1
25            MAXIMUM DEFØRMATIØN  1.0
26            FIND SCALE, ØRIGIN 10
27        PLØT ØRIGIN 10, SET 2, LABELS
28            FIND SCALE, ØRIGIN 11
29        PLØT MØDAL DEFØRMATIØN 1, ØRIGIN 11, SHAPE
30        BEGIN BULK
```

CARD NO.	1	2	3	4	5	6	7	8	9	10
31	CQUAD1	1	23	1	2	13	12	.00		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
230	CQUAD1	219	23	219	220	231	232	.00		
231	EIGR	2	INV	.85	.89	1	1	0		CSIMPL-1
232	+SIMPL-1	MAX								
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
251	EIGR	12	DET	.89	29.0	20	20	0		+EIG1220
252	+EIG1220	MAX								
253	GRDSET							126		
254	GRID	1		.0000	.000	.000				
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
484	GRID	231		10.000	20.000	.000				
485	MAT1	2	3.0+7		.300	200.0				+MAT1
486	+MAT1	30000.	28000.							
487	PARAM	GRDPNT	111							
488	PLØTEL	301	1	11		302	11	231		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
536	PLØTEL	397	36	25		398	25	3		
537	PQUAD1	23	2	1.0	2	.083333			6.04303	+PQUAD1
538	+PQUAD1	0.5	0.0							
539	SPC1	37	5	1	12	23	34	45	56	+31001H
540	+31001H	67	78	89	100	111	122	133	144	+31002H
541	+31002H	155	166	177	188	199	210	221		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
547	SPC1	37	35	221	222	223	224	225	226	+21001H
548	+21001H	227	228	229	230	231				
549	ENDDATA									

Notes:
- 4. Selects Rigid Format 3 for a Normal Modes Analysis.
- 11. Selects method of real eigenvalue extraction from Bulk Data.
- 13-18. Requests printout of results.

20-27. Sets up for orthographic projection plotting of the original model, undeformed.

28-29. Sets up for orthographic projection plotting of the mode shapes using the first element set (PLØTEL) for each of the three mode shapes generated.

31-230. Quadrilateral plate element connectivities.

231-252. Specify methods for real eigenvalue extraction.

253-484. Grid point location and default single point constraints.

488-536. Defines line elements for plotting.

537-538. Quadrilateral plate element properties.

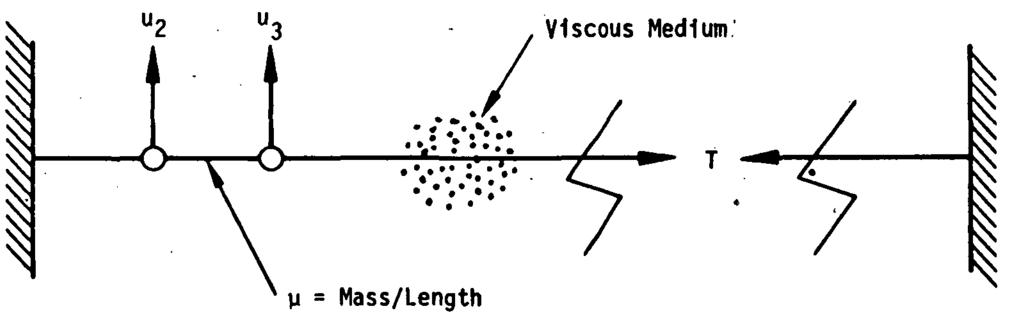
539-548. Single point constraints to define support conditions and symmetry boundary conditions.

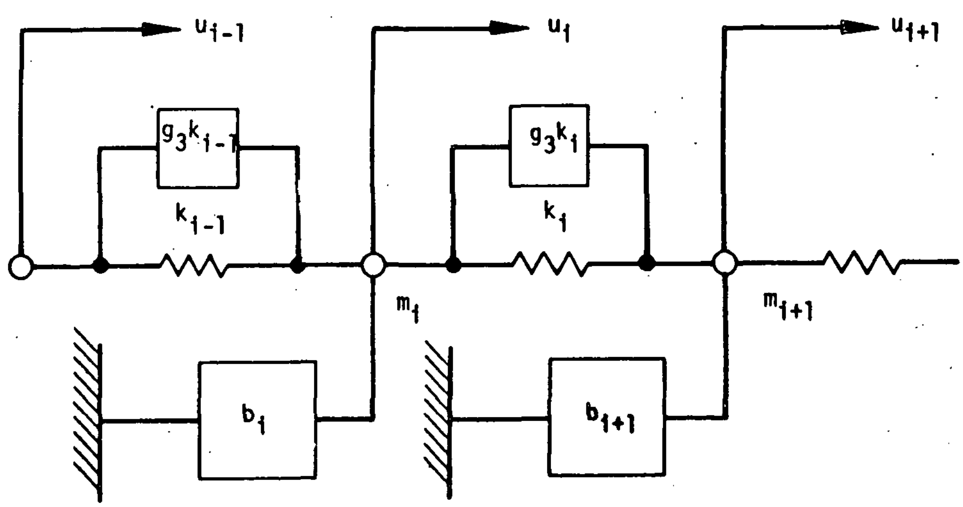
7.1.4 Complex Eigenvalue Analysis (Rigid Formats 7 and 10)

Both a direct (Rigid Format 7) and a modal (Rigid Format 10) approach are available for complex eigenvalue analysis in NASTRAN (TM 9.2.2). Section 2.2.1.4 of this Guide summarizes the features of these two approaches. The examples follow illustrate the input data for the corresponding problems described in the Demonstration Problem Manual. The first is a simple vibrating string problem. The second is a practical definition of a controls systems analysis.

7.1.4.1 Rigid Format 7 - Damped Vibration of a String

This problem demonstrates both the use of direct complex eigenvalue analysis and the various methods of supplying damping to the structure. The simulated model is a string under tension having uniform viscous and structural damping as shown below. The stiffness due to tension is modeled with scalar springs, the mass is represented by scalar masses, and the viscous damping is provided by scalar dampers connected on one end to the points and fixed on the other end. The structural damping is provided by the scalar springs and an overall damping factor, g_3. The user is encouraged to refer to the Demonstration Problem Manual 7.1 for a detailed discussion of the theory and background to this problem.





7.1.4.2 Input Cards - Scalar Elements

Card No.	
1	ID DEM701, NASTRAN
2	UMF 21904 260701
3	TIME 8
4	APP DISP
5	SØL 7,1
6	CEND
7	TITLE = CØMPLEX EIGENVALUES ØF A 500 CELL STRING
8	SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 7-1
9	CMETHØD = 7
10	ØUTPUT
11	SET 1 = 1,51,101,151,201,251,301,351,401,451,501
12	DISP = 1
13	BEGIN BULK

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
14	CDAMP3	60002	401	2	0					
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
263	CDAMP3	60499	401	499	0	60500	401	500	0	
264	CELAS3	1	101	0	2	2	101	2	3	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
513	CELAS3	499	101	499	500	500	101	500	0	
514	CMASS3	40002	301	2	0					
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
763	CMASS3	40499	301	499	0	40500	301	500	0	
764	EIGC	7	DET	MAX			1.0-5			+EIGC7
765	+EIGC7	-.5	5.0	-.9	16.0	10.0	2	2		
766	PARAM	G	.05							
767	PDAMP	481	6.283185							
768	PELAS	101	1.0+07	.05	10.0					
769	PMASS	301	10.0							
770	ENDDATA									

Notes:

5. Selects the Direct Complex Eigenvalue Analysis approach.

9. Selects the method of complex eigenvalue extraction from Bulk Data.

10-12. Requests printout of displacements for all grid points in set #1 which will be printed for each mode shape, real components only.

14-263. Scalar damper connectivities.

264-513. Scalar spring connectivities.

514-763. Scalar masses.

764-765. Specifies parameters and method for complex eigenvalue extraction.

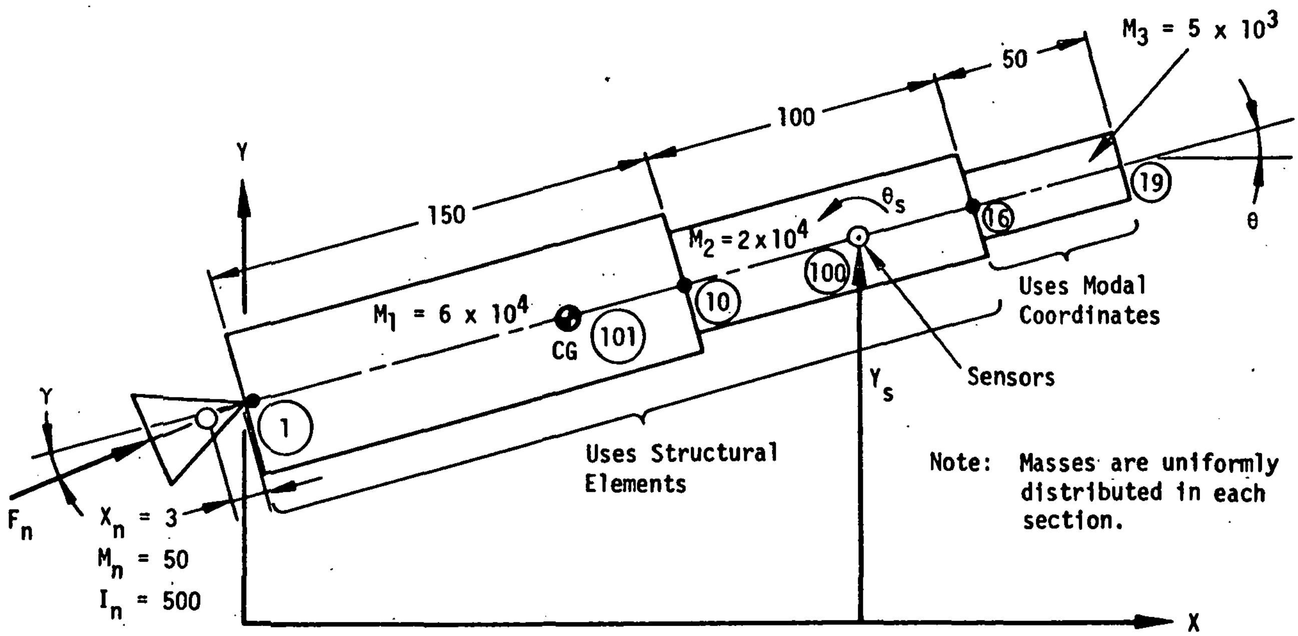
766. Defines a uniform structural damping coefficient.

767-769. Defines scalar element properties.

7.1.4.3 Rigid Format 10 - Rocket Guidance and Control

This problem although a simplified model, contains all of the elements used in a linear control system analysis. The flexible structure, shown below, consists of three sections: two sections are constructed of structural finite elements; the third section is formulated in terms of its modal coordinates. A sensor is located at an arbitrary point on the structure and connected to a structural point with multipoint constraints. The measured attitude and position of the sensor point is used to generate a control voltage for the gimbal angle of the thrust nozzle. The nozzle control is in itself a servomechanism consisting of an amplifier, a motor, and a position and velocity feedback control. The nozzle produces a force on the structure due to its mass and the angle of thrust. The motion of any point on the structure is dependent on the elastic motions, and the large angle effects due to free-body notations.

The user should refer to the Demonstration Problem Manual 10.1 for the discussion of the control system, the associated transfer function parameters and other modeling details.



7.1.4.4 Input Cards - DMAP Alter, Transfer Function and Resequencing

<u>Card No</u>

```
 1        ID  DEM1001, NASTRAN
 2        UMF  21904  211001
 3        TIME  5
 4        APP DISPLACEMENT
 5        SØL  10,1
 6        ALTER 99
 7        MATGPR  GPLD,USETD,SILD,PHIA//C,N,H/C,N,A  $
 8        ENDALTER
 9        CEND
10        TITLE = CØMPLEX EIGENVALUE ANALYSIS - RØCKET CØNTRØL SYSTEM
11        SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 10-1
12            LABEL = FLEXIBLE STRUCTURE CASE
13        MPC = 101
14            METHØD = 2
15                TFL = 20
16                CMETHØD = 11
17        ØUTPUT
18        SET 1 = 1,100,101,1010 THRU 1090
19                SVECTØR (SØRT1,PHASE) = ALL
20            DISPLACEMENT (SØRT1,PHASE) = 1
21        BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
22	BARØR					.0	10.0	.0	1	
23	CBAR	1	10	1	2					
⋮	⋮	⋮	⋮	⋮	⋮		⋮			
37	CBAR	15	20	15	16					
38	CELAS4	1001	2.026+7	1001		1002	32.42+7	1002		

CARD NO.	1	2	3	4	5	6	7	8	9	10
39	CELAS4	1003	164.1+7	1003		1004	518.7+7	1004		
40	CMASS4	2001	2.5+3	1001	2001	2002	2.5+3	1002	2002	
41	CMASS4	2003	2.5+3	1003	2003	2004	2.5+3	1004	2004	
42	CØNM2	101	1		3333.3					
⋮	⋮	⋮	⋮		⋮		⋮			
60	CØNM2	119	19		833.3					
61	EIGC	11	DET	MAX						+EC
62	+EC	-2.0	-1.0	-2.0	10.0	10.0	6	6		
⋮		⋮	⋮		⋮					
67	EIGP	11	0.0	0.0	2					
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
71	EIGR	2	INV	0.0	50.0	8	8	2		+E2
72	+E2	MASS								
73	EPØINT	1010	1011	1030	1040	1050	1060	1070	1080	
74	GRDSET							1345		
75	GRID	1		0.0	0.0	0.0				
⋮	⋮	⋮		⋮	⋮	⋮				
95	GRID	101		116.176	0.0	0.0				
96	MAT1	1	10.4+6	4.0+6						
97	MPC	3	16	6	-1	1001		.0628318		+161
⋮	⋮	⋮		⋮	⋮	⋮		⋮		
118	MPC	100	11	6	1.0	100	6	-1.0		
119	MPCADD	101	100	3						
120	PARAM	GRDPNT	101							
121	PARAM	LMODES	4							
122	PBAR	10	1	4.0+2	6.0+4	6.0+4				
123	PBAR	20	1	2.0+2	2.0+4	2.0+4				
124	SEQGP	100	10.5	101	7.5					
125	SPØINT	1001	1002	1003	1004	2001	2002	2003	2004	
126	SUPØRT	101	2	101	6					
127	TF	20	1	2	.0	.0	50.0			+T6
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮			⋮
155	TF	20	1080				8.5+4			+TX
156	+TX	100	6	-4.25+6						
157	ENDDATA									

Notes:

5. Selects the Modal Complex Eigenvalue Analysis approach.

6-8. DMAP alter package to print out the grid point list (GPLD), u-set degrees of freedom (USETD), scalar index list (SILD) and the normal modes matrix for the a-set displacements.

13. Selects a multipoint constraint set from Bulk Data.

14. Selects a method for real eigenvalue extraction from Bulk Data.

15. Selects the transfer function (TF) set from Bulk Data.

16. Selects the method for complex eigenvalue extraction from Bulk Data.

17-20. Request printout of SØLUTIØN set displacements and displacements for structural grid points of set #1 for each mode shape in magnitude/phase angle format.

22-37. Beam element connectivity.

38-41. Scalar element connectivity.

42-60. Concentrated mass data.

61-69. Parameters for methods of eigenvalue extraction card 67 defines poles in complex plane that are used with the associated EIGC parameters.

73. Definition of extra points used to define control system parameters.

74-95. Defines location of grid points and default single point constraints.

96-119. Multipoint constraint equations used to represent modal coordinates of model between grid points 16 and 19.

120. Requests weight and balance printout.

121. Defines number of lowest modes to be used in this modal formulation.

122-123. Beam element properties.

124. Specifies resequencing of gridpoints 100 and 101.

125. Scalar point definition (need not be defined on SPØINT card if number is used with scalar element definition, e.g., cards 38-41).

126. Defines degrees of freedom for use in computing determinate reactions for constraining rigid body motion.

127-156. Specification of transfer function parameters.

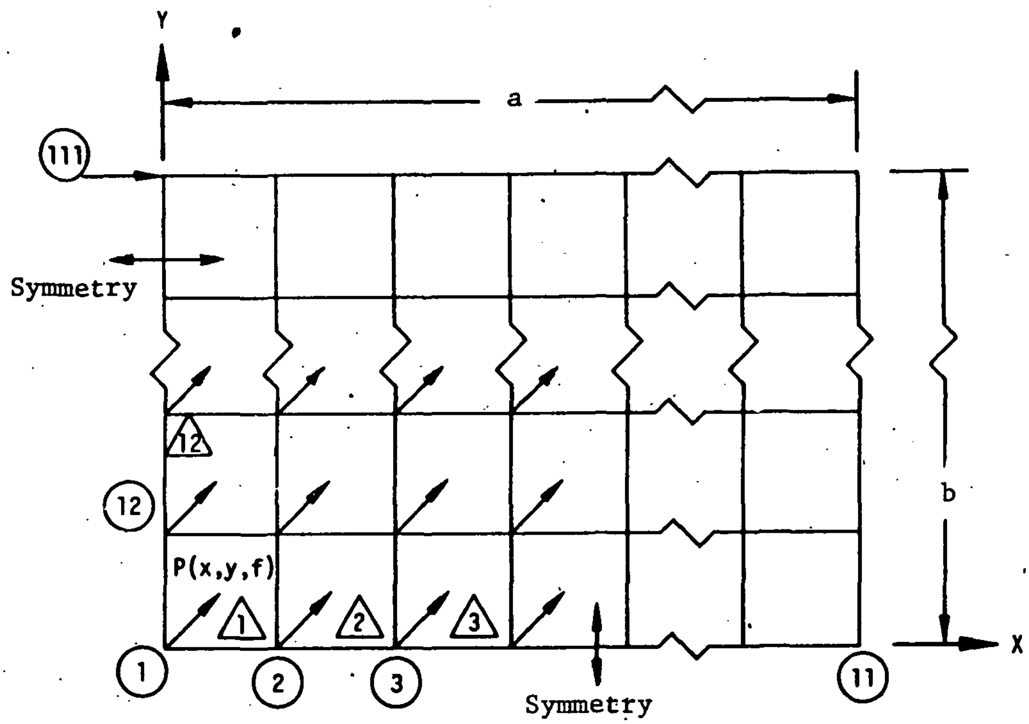
7.1.5 Dynamic Analyses (Rigid Formats 8, 9, 11 and 12)

NASTRAN currently offers four Rigid Formats for dynamic analyses. Both a direct and a modal approach are available for Frequency and Random Response with Rigid Formats 8 and 11 (TM 10.) and Transient Analysis with Rigid Formats 9 and 12 (TM 11.) respectively. A summary of these capabilities is presented in Section 2.2.1.5 of this Guide. The examples that follow illustrate the input data for the corresponding problems described in the Demonstration Problem Manual. The first two examples show the Frequency and Random Response input alternatives for a square plate and a simple beam. The second set of two examples show the Transient Analysis input alternatives for a model with nonsymmetric matrices and for a free-body beam.

7.1.5.1 Rigid Format 8 - Direct Frequency Response of a Plate

This problem illustrates the use of the direct method of determining structural response to steady-state sinusoidal loads. The steady-state response of the structure at each frequency is calculated in terms of complex numbers which reflect the magnitudes and phases of the results.

The particular model for this study is a square plate composed of quadrilateral plate elements as shown below. The exterior edges are supported on hinged supports and symmetric boundaries are used along x=0 and y=0. The applied load is sinusoidally distributed over the panel and increases with respect to frequency. For further details on the input and results, see the Demonstration Problem Manual 8.0.



7.1.5.2 Input Cards - Frequency Dependent Loading

Card No.	
1	ID DM801X10, NASTRAN
2	UMF 21904 190801
3	APP DISPLACEMENT
4	SØL 8,1
5	TIME 22
6	CEND
7	TITLE = FREQUENCY RESPØNSE ØF A SQUARE PLATE
8	SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 8-1
9	SPC = 37
10	DLØAD = 8
11	FREQUENCY = 8
12	ØUTPUT
13	SET 1 = 1,4,7,11,45,55,78,88,111,114,117,121
14	SET 100 = 0.7, .99, 1.21, 1.3, 1.5
15	ØFREQ = 100
16	DISPLACEMENT(PHASE) = 1
17	SPCFØRCE = 1
18	BEGIN BULK

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
19	CQUAD1	1	23	1	2	13	12	.00		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
118	CQUAD1	109	23	109	110	121	120	.00		
119	DAREA*	37		1		3		2.500000E-01		
⋮	⋮	⋮		⋮		⋮		⋮		
218	DAREA*	37		109		3		2.4471748E-02		
219	FREQ	8	9.0							
220	GRDSET							126		

CARD NO.	1	2	3	4	5	6	7	8	9	10
221	GRID	1		.0	.0	.0				
⋮	⋮	⋮		⋮	⋮	⋮				
341	GRID	121		10.0	10.0	.0				
342	MAT1	8	3.0+7		.300					
343	PQUAD1	23			8	.6666667			13.55715	
344	RLØAD1	8	37			1				
345	SPC1	37	4	1	2	3	4	5	6	+41001H
346	+41001H	7	8	9	10	11				
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
351	SPC1	37	35	111	112	113	114	115	116	+21001H
352	+21001H	117	118	119	120	121				
353	TABLED1	1								+T1
354	+T1	0.0	10.0	100.0	40.0	ENDT				
355	ENDDATA									

Notes:

4. Selects Direct Frequency and Random Response Analysis approach.

10. Selects the RLØAD1 frequency response dynamic loading condition from Bulk Data.

11. Required to select from Bulk Data the set of frequencies to be solved.

15. Selects the set of frequencies desired for output. The output will be provided for the solution frequencies closest to those given in set #100. (In this case, only one output frequency (9.0) is available)

16. Request the displacements for grid points of set #1 to be printed in magnitude/phase format.

17. Requests support forces to be printed at grid points of set #1 to be printed in real/imaginary format.

19-118. Quadrilateral element connectivities.

119-218. Specifies the dynamic load scale factor and point of application in double precision format.

219. Defines set of frequencies for solution (in this case, only one is requested).

220-341. Provides gridpoint locations and default single point constraints.

342-343. Defines material and element properties.

344. Defines frequency dependent dynamic load function.

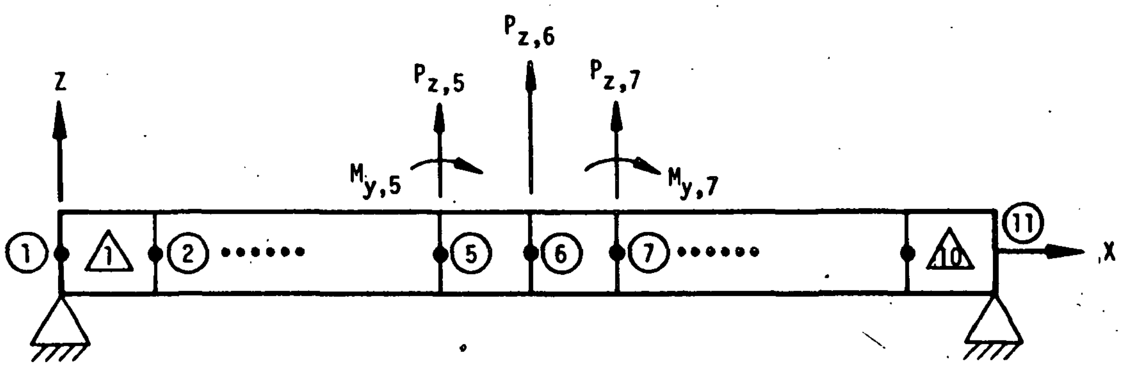
345-352. Specifies support and symmetric boundary single point constraints.

353-354. Defines table of frequency dependent coefficients referenced, in this case, by RLØAD1 (field 6).

7.1.5.3 Rigid Format 11 - Modal Frequency and Random Response of a Beam

This problem demonstrates the frequency response solution of a structure using an uncoupled modal formulation. The structural degrees of freedom are the uncoupled modal displacements. This problem also illustrates various methods of applying frequency response loads which may be input as complex numbers and added together for each subcase.

The structure to be solved consists of a beam with simple supports as shown below. Included in the structural model is a "general element" representing the first two cells of the ten-cell beam. The applied load for the three subcases are applied to the center three points on the beam. The random analysis data consists of a flat power spectral density function ("white noise") for the three loading subcases. The first subcase spectral density is correlated to the third subcase spectral density, simulating two interdependent probability functions. The XY-plotter capability is used for output. For further details and some theory, see the Demonstration Problem Manual 11.1.



7.1.5.4 Input Cards - "Complex" Loading and Random Response Output

Card No.	
1	ID DEM1101, NASTRAN
2	UMF 21904 221101
3	CHKPNT YES
4	APP DISPLACEMENT
5	SØL 11,3
6	TIME 6
7	ALTER 96
8	MATPRN PHIA,,,,// $
9	ENDALTER

```
CEND
MAXLINES = 50000
TITLE =  FREQUENCY AND RANDØM RESPØNSE ØF A 10 CELL BEAM
SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 11-1
    SPC = 11
    METHØD = 2
    FREQUENCY = 503
    RANDØM = 11
    SDAMPING = 11
ØUTPUT
    SET 2 = 5,10
    SET 6 = 6
    SET 10 = 6,11
    DISP(SØRT2,PHASE) = 10
    ACCELER(SØRT2,PHASE) = 10
    ØLOAD = 6
    ELFØRCE(SØRT2,PHASE) = 2
SUBCASE 1
    LABEL = THREE PØINTS LØADED WITH TWØ SETS
    DLØAD = 506
SUBCASE 2
    LABEL = ØNE PØINT LØADED WITH TWØ SETS AND TIME DELAYS
    DLØAD = 507
SUBCASE 3
    LABEL = ØNE PØINT LØADED WITH TWO TABULAR LØADS
    DLØAD = 510
$ * * * * * * * * * * * * * * * * * * * * * * * * * * * *
PLØTID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 11-1
ØUTPUT(XYØUT)
    PLØTTER SC
    CAMERA = 3
    SKIP BETWEEN FRAMES = 1
    XGRID LINE = YES
    YGRID LINE = YES
    XLØG = YES
```

```
45          YLØG = YES
46          XTITLE =     FREQUENCY (HERTZ)
47          YTITLE = S
48          TCURVE = PØWER SPECTRAL DENSITY ØF PØINT 6 DISPLACEMENT
49          XYPLØT,XYPRINT DISP PSDF /  6(T3)
50      $
51          TCURVE = PØWER SPECTRAL DENSITY ØF PØINT 6 ACCELERATIØN
52          XYPLØT ACCELERATIØN PSDF / 6(T3)
53      $
54          XLØG = NØ
55          YLØG = NØ
56          XTITLE =     TIME LAG (SECØNDS)
57          YTITLE = R
58          TCURVE = AUTØCØRRELATIØN FUNCTIØN FØR PØINT 6 DISPLACEMENT
59          XYPLØT,XYPRINT DISP AUTØ /  6(T3)
60      BEGIN BULK
```

BULK DATA FIELDS

CARD NO.	1	2	3	4	5	6	7	8	9	10
61	CBAR	3	1	3	4	20.	.0	1.	1	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
68	CBAR	10	1	10	11	20.	.0	1.	1	
69	CØNM2*	11		1				5.34604-3		*M1
70	*M1	0.0								
71	CØNM2*	12		2				1.069208-2		*M2
72	*M2	0.		0.						
73	CØNM2*	13		3				5.34604-3		*M3
74	*M3									
75	DAREA	2	5	5	-100.					
76	DAREA	2	6	3	50.	5	3	50.		
77	DAREA	2	7	3	50.	7	5	100.		
78	DAREA	3	6	3	100.					

CARD NO.	1	2	3	4	5	6	7	8	9	10
79	DAREA	510	6	3	1.0					
80	DELAY	1	6	3	.5555-2					
81	DLØAD	506	1.	1.	5	1.	6			
82	DLØAD	507	1.	1.	5	1.	7			
83	DLØAD	510	2.0	1.0	5101	1.0	5102			
84	DPHASE	1	6	3	30.					
85	DPHASE	5102	6	3	-30.0					
86	EIGR	2	INV	40.	1000.	3	3			+EG
87	+EG	MASS								
88	FREQ1	508	.0	5.0	40					
89	GENEL	1101		2	1	2	3	2	5	+1
90	+1	3	1	3	3	3	5			+2
91	+2	UD		1	1	1	3	1	5	*30
92	*30	2		.89044935-8		0.		0.		*31
93	*31	.89044935-8		0.		0.		3.08928-6		*40
94	*40	-2.31696-6		0.		7.7232005-6		-2.31696-6		*41
95	*41	2.31696-6		0.		-6.9508804-6		2.31696-6		*50
96	*50	1.7808987-8		0.		0.		24.714241-6		*51
97	*51	-9.26784-6		4.6339203-6						+60
98	+60	S	1.0	0.0	0.0	0.0	1.0	-2.0	0.0	+70
99	+70	0.0	1.0	1.0	0.0	0.0	0.0	1.0	-4.0	+80
100	+80	0.0	0.0	1.0						
101	GRDSET							246		
102	GRID	1		.0	.0	.0				
⋮	⋮	⋮		⋮	⋮	⋮				
112	GRID	11		20.	.0	.0				
113	MAT1	1	10.4+6	4.+6		.2523-3				
114	PARAM	GRDPNT	0							
115	PARAM	LMØDES	4							
116	PBAR	1	1	21.189	.083	.083				
117	RANDPS	11	1	1	.5		11			
118	RANDPS	11	1	3	.5		11			
119	RANDPS	11	2	2	1.0		11			

CARD NO.	1	2	3	4	5	6	7	8	9	10
120	RANDPS	11	3	3	.5		11			
121	RANDT1	11	100	.0	.1					
122	RLØAD1	101	510			5101				
123	RLØAD1	5102	510		5102		5102			
124	RLØAD2	5	2			1				
125	RLØAD2	6	3		1	1	2			
126	RLØAD2	7	3	1		1				
127	SPC	1	1	13		11	13			
128	SPC	11	1	13		11	3			
129	TABDMP1	11								+DAMP
130	+DAMP	0.0	0.0	50.0	0.02	ENDT				
131	TABLED1	1								+TAUU
132	+TAUU	0.0	1.	100.	1.	ENDT				
133	TABLED1	2								+TAD21
134	+TAD21	0.0	30.	100.	30.	ENDT				
135	TABLED1	5101								+TAD30
136	+TAD30	0.0	75.0	100.	75.0	ENDT				
137	TABLED1	5102								+TAD31
138	+TAD31	0.0	50.0	100.	50.0	ENDT				
139	TABRND1	11								+TR
140	+TR	-1.0	0.0	0.0	100.0	100.0	100.0	100.0	0.0	+TR2
141	+TR2	101.0	0.0	ENDT						
142	ENDDATA									

Notes:

3. Checkpoint is requested to be taken.

5. Selects modal approach for Frequency and Random Response analysis removing the looping and mode acceleration computations.

7-9. DMAP alter to obtain a printout of the mode shapes for the analysis set of displacements generated during the real eigenvalue analysis. (This output is not otherwise available with this Rigid Format.)

11. Specifies a user limit in NASTRAN for a maximum of 50,000 lines of output.

14. Selects a set of single point constraints from Bulk Data.

15. Selects the method to be used for real eigenvalue extraction required to get the appropriate modal coordinate data for this modal approach.

16. Selects the set of frequencies required for solution of the frequency response analysis.

17. Selects the power spectral density factors (RANDPS) and auto-correlation function time lag (RANDT1) from Bulk Data required for the random response analysis.

18. Defines the equivalent of structural damping as a function of frequency in modal formulation problems (TM 9.3.4).

19-26. Specifies output sets for displacements, accelerations, loads and element forces. Note that the loads will be output for all frequencies at each grid point (SØRT2) and in real/imaginary format. Because SØRT2 was specified for other output qualities, it overrides the SØRT1 default for loads. Also note that requests for output of the results of the Random Response analysis are part of the XY plot output package.

27-29. Defines the first dynamic load to be analyzed.

30-32. Defines the second dynamic load to be analyzed.

33-35. Defines the third dynamic load to be analyzed.

37-40. Sets up for XY plots using Stromberg Carlson requesting both film and paper inserting one blank frame between each plot.

42. Requests drawing of vertical grid lines at each tic mark.

43. Requests drawing of horizontal grid lines at each tic mark.

46-47. Provides axis labeling information.

48. Provides label to identify curve being plotted.

49. Requests both plotted and printed output of the z-displacement power spectral density function for grid point 6.

51. Provides label to identify next curve to be plotted.

52. Requests plotted output of the z-acceleration power spectral density function for grid point 6.

54-55. Requests scalar distribution of tic marks for both the X and Y axes.

56-58. Provides titling information for next curve to be plotted.

59. Requests both plotted and printed output of the autocorrelation function for the z-displacement at grid point 6.

61-68. Defines beam element connectivities.

69-74. Defines concentrated mass elements in double precision format.

75-79. Specifies dynamic load scale factor sets and the points of application.

80. Provides for the dynamic load time delay to be referenced by the RLØAD2 (SID = 7 in field 4) card number 126.

81-83. Specifies the dynamic load combinations to be applied.

84-85. Provides for the dynamic load phase lead to be referenced in field 5 of the RLØAD2 and RLØAD1 cards 125 and 123 respectively.

86-87. Specifies parameters for real eigenvalue extraction.

88. Specifies frequency range and intervals for use in frequency response analysis (f_i = 0.0,5.0,10.0...,200.0) or 40 increments.

89-100. Specifies general element matrix data (TM 5.7).

101-112. Defines grid point locations and default single point constraints.

113. Defines material properties.

114. Requests output for weight and balance as well.

115. Requests the four fundamental modes be used as modal coordinates.

116. Beam element properties.

117-120. Specification of input power spectral density function.

121-126. Frequency response dynamic load functions.

127-128. Single point constraint sets (set #11 was selected).

129-130. Frequency dependent damping coefficient table referenced by SDAMP in Case Control.

131-138. Tabular definition of frequency dependent load coefficients referenced by RLØAD1 and RLØAD2 cards.

139-141. Tabular function of power spectral density function referenced by RANDPS cards.

7.1.5.5 Rigid Format 9 - Direct Transient Analysis with Direct Matrix Input

This problem demonstrates the capability of NASTRAN to perform a transient analysis on a system having nonsymmetric stiffness, damping and mass matrices. The problem is formulated with direct matrix input without the use of elements. It illustrates the use of time step changes, selection of printout intervals, application of loads, initial conditions and a simple curve plot package. For details of the problem formulation and the results, see the Demonstration Problems Manual 9.1.

7.1.5.6 Input Cards - Direct Matrix Input and XYØUT Plotting

Card No.

```
 1      ID  DEM901,  NASTRAN
 2      UMF  21904  200901
 3      APP  DISPLACEMENT
 4      SØL  9,1
 5      TIME  5
 6      CEND
 7      TITLE = TRANSIENT ANALYSIS WITH DIRECT MATRIX INPUT
 8      SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBELM NØ. 9-1
 9      TSTEP = 32
10      IC = 32
11      DLØAD = 32
12      K2PP=KCØMP
13      M2PP=MCØMP
14      B2PP=BCØMP
15      ØUTPUT
16          SVELØ = ALL
17          DISP(SØRT2) = ALL
18          ØLØAD(SØRT2) = ALL
19      PLØTID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 9-1
20      ØUTPUT(XYØUT)
21          PLØTTER SC
22          CAMERA = 3
23          SKIP BETWEEN FRAMES = 1
24          TCURVE = * * * *  EPOINT  DISPLACEMENT(INCHES)  * * * *
25          XTITLE =       TIME (SECØNDS)
```

```
26    $
27        YVALUE PRINT SKIP = 1
28        XDIVISIØNS = 25
29        XVALUE PRINT SKIP = 1
30    $ * * * * * * * * * * * * * FULL FRAME PLØTS * * * * * *
31        YGRID LINES = YES
32        XGRID LINES = YES
33        YDIVISIØNS = 22
34    $
35        YTITLE = EPØINT 10     DISPLACEMENT *INCH*
36    XYPLØT DISP / 10(T1)
37    $
38        YDIVISIØNS = 20
39        YTITLE = EPØINT 11     DISPLACEMENT *INCH*
40    XYPLØT DISP / 11(T1)
41    $
42        YTITLE = EPØINT 12     DISPLACEMENT *INCH*
43    XYPLØT DISP / 12(T1)
44    $
45        YTITLE = EPØINT 13     DISPLACEMENT *INCH*
46        XYPLØT DISP / 13(T1)
47    BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
48	DAREA	1	10		-1.5	11		-1.0		
49	DAREA	1	12		-13.5	13		36.0		
50	DELAY	1	10		1.0	11		1.0		
51	DELAY	1	12		1.0	13		1.0		
52	DMIG	BCØMP	0	1	1	2				
53	DMIG	BCØMP	11	0		10	0	-15.0		+BC1
54	+BC1	11	0	30.0		12	0	-15.0		

CARD NO.	1	2	3	4	5	6	7	8	9	10
55	DMIG	BCØMP	12	0		11	0	-24.0		+BC2
56	+BC2	12	0	48.0		13	0	-24.0		
57	DMIG	BCØMP	13	0		12	0	-2.0		+BC3
58	+BC3	13	0	4.0						
59	DMIG	KCØMP	0	1	1	2				
60	DMIG	KCØMP	10	0		10	0	2000.		+KC1
61	+KC1	11	0	-1000.						
62	DMIG	KCØMP	12	0		11	0	-100.8		+KC2
63	+KC2	12	0	200.0		13	0	-100.0		
64	DMIG	KCØMP	13	0		12	0	-20.0		+KC3
65	+KC3	13	0	40.0						
66	DMIG	MCØMP	0	1	1	2				
67	DMIG	MCØMP	10	0		10	0	20.0		+MC1
68	+MC1	11	0	-10.0						
69	DMIG	MCØMP	11	0		18	0	-1.5		+MC2
70	+MC2	11	0	3.0		12	0	-1.5		
71	DMIG	MCØMP	12	0		11	0	-4.0		+MC4
72	+MC4	12	0	8.0		13	0	-4.0		
73	EPØINT	10	11	12	13					
74	TABLED1	1								+T1
75	+T1	-1.0	0.0	0.0	0.0	.00	1.0	100.0	1.0	+T2
76	+T2	ENDT								
77	TIC	32	10		0.0	10.				
78	TIC	32	11		.0	.5				
79	TIC	32	12		.0	.0				
80	TIC	32	13		-10.0	.0				
81	TLØAD1	32	1	1		1				
82	TSTEP	32	40	.025	2					+S1
83	+S1		100	.015	5					
84	ENDDATA									

Notes: 4. Selects the direct approach to Transient Analysis.

9. Selects the integration time steps from Bulk Data (TSTEP).

10. Selects the initial conditions from Bulk Data (TIC).

11. Selects the dynamic loading function from Bulk Data (TLØAD1).

12-14. Specifies the direct matrix input for stiffness, mass and damping respectively.

15-18. Specifies output requirements for all degrees of freedom in the model. Notice that because one output quantity specifies SØRT2, all time steps for each degree of freedom, the SVELØCITY request will default also to SØRT2.

19-23. Sets up for plotting with the XY-curve plotter.

24-25. Labeling information.

27. Plot the value for every other tic mark along the Y-axis.

28. Provide 25 divisions along the X-axis.

29. Plot the value for every other tic mark along the X-axis.

31-32. Plot grid lines for each tic mark in both directions.

33. Provide 22 divisions along the Y-axis.

35. Title for Y-axis.

36. Requests plot of displacement for extra point 10 versus time.

38-39. Provide 20 divisions and new title for Y-axis

40. Requests plot of displacement for extra point 11 versus time.

42. Use same 20 divisions and new title for Y-axis.

43. Requests plot of displacement for extra point 12 versus time.

45-46. Repeat 42 and 43 for plot of displacements for extra point 13.

48-49. Dynamic load factors applied to extra points.

50-51. Delay factors for each extra point loading.

52-58. Direct matrix input at extra points for damping.

59-65. Direct matrix input at extra points for stiffness.

66-72. Direct matrix input at extra points for mass.

73. Provides identification for extra points (single degree of freedom per point).

74-76. Table of dynamic load coefficients versus time referenced by TLØAD1 card (field 6).

77-80. Specifies initial conditions for each extra point.

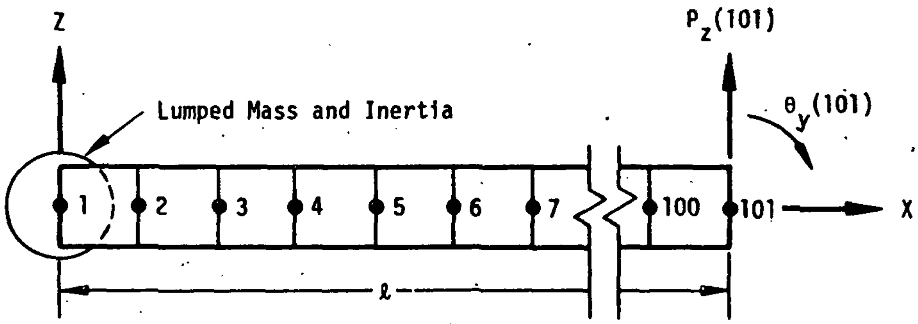
81. Specifies time dependent loading function.

82-83. Specifies two sets of time step intervals for integration of the transient response and user specifies output interval.

Special note, no structural elements were used in this problem. All degrees of freedom were identified with separate extra points.

7.1.5.7 Rigid Format 12 - Modal Transient Response of a Beam

This problem demonstrates the transient analysis of a free-body using the integration algorithm for uncoupled modal formulation. The hundred-cell beam model is shown below. Modal damping is included as a function of natural frequency. The omitted coordinate feature was used to reduce the number of degrees of freedom to an analysis set equivalent to eleven grid points. Both structural and curve plots are requested. For further details and the results, see the Demonstration Problem Manual 12.1.



7.1.5.8 Input Cards - Both Structural and XYØUT Plotting

<u>Card No.</u>

```
 1      ID  DEM1201,  NASTRAN
 2      UMF  21904  241201
 3      APP  DISPLACEMENT
 4      SØL  12,3
 5      TIME  10
 6      CEND
 7      TITLE = TRANSIENT ANALYSIS ØF A FREE ØNE HUNDRED CELL BEAM
 8      SUBTITLE = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 12-1
 9          DLØAD = 516
10          SDAMP = 15
11          TSTEP = 516
12          METHØD = 2
13      ØUTPUT
14          SET 1 = 1, 26, 51, 75, 100
15          SET 2 = 1, 26, 76
```

```
          DISPLACEMENT = 2
          STRESS = 1
      PLØTID = NASTRAN DEMØNSTRATIØN PRØBLEM NØ. 12-1
      ØUTPUT(PLØT)
          PLØTTER SC
          SET 1 INCLUDE BAR EXCLUDE GRID PØINTS 1 THRU 9,11 THRU 20
          22 THRU 30,32 THRU 40,42 THRU 50,52 THRU 60,62 THRU 70
          72 THRU 80 82 THRU 90, 92 THRU 100
          MAXIMUM DEFØRMATIØN 2.0
      STEREØ PRØJECTIØN
          FIND SCALE, ØRIGIN 100, VANTAGE PØINT, SET 1
          PLØT SET 1, ØRIGIN 100,SHAPE, LABELS
          PLØT MØDAL DEFØRMATIØN 1, RANGE 0.004, 0.013,
          MAXIMUM DEFØRMATIØN 0.76, SET 1, ØRIGIN 100, SHAPE
      ØRTHØGRAPHIC PRØJECTIØN
          FIND SCALE, ØRIGIN 1, REGIØN 0.0,0.0,1.0,0.5
          FIND SCALE, ØRIGIN 2, REGIØN 0.0,0.5,1.0,1.0
          PLØT MØDAL DEFØRMATIØN 1, RANGE 0.0, .019,
          MAXIMUM DEFØRMATIØN 1.0,
          SET 1, ØRIGIN 1, SHAPE ,
          SET 1, ØRIGIN 2, VECTØR Z, SYMBØLS 6, LABELS
      $
      ØUTPUT(XYØUT)
          PLØTTER SC
          CAMERA = 3
          SKIP BETWEEN FRAMES = 1
          YGRID LINES = YES
          XGRID LINES = YES
          YDIVISIØNS = 10
          XDIVISIØNS = 10
          XVALUE PRINT SKIP = 1
          YVALUE PRINT SKIP = 1
          XTITLE =                TIME (SECØNDS)
          YTITLE =       D I S P  * INCH *
          TCURVE = * * * * * * * G R I D  5 1 * * * * * * * * *
```

```
51      XYPLØT,XYPRINT,DISP RESP /  51(T3)
52          TCURVE = * * * * * * *  G R I D  1 0 1  * * * * * * * *
53      XYPLØT,XYPRINT,DISP RESP / 101(T3)
54          YTITLE = ACCELERATIØN
55          TCURVE = * * * * * * *  G R I D  5 1  * * * * * * * * *
56      XYPLØT,XYPRINT,ACCE RESP /  51(T3)
57          TCURVE = * * * * * * *  G R I D  1 0 1  * * * * * * * *
58      XYPLØT,XYPRINT,ACCE RESP / 101(T3)
59      BEGIN BULK
```

BULK DATA FIELD

CARD NO.	1	2	3	4	5	6	7	8	9	10
60	BARØR					10.0	.0	100.0	1	
61	CBAR	1	17	1	2					
⋮	⋮	⋮	⋮	⋮	⋮					
160	CBAR	100	17	100	101					
161	CØNM2	20	1		10.0					+M1
162	+M1			1666.7						
163	DAREA	1	101	3	100.					
164	EIGR	2	INV	.0	1000.	5	5			+EG
165	+EG	MASS								
166	GRDSET							1246		
167	GRID	1		.00	.00	.00				
⋮	⋮	⋮		⋮	⋮	⋮				
267	GRID	101		20.00	.00	.00				
268	MAT1	1	10.4+6	4.+6		.2523-3				+MAT1
269	+MAT1	111.11	11.111							
270	ØMIT1	53	2	3	4	5	6	7	8	+100
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
281	+201	98	99	100						
282	PARAM	GRDPNT	0							
283	PARAM	LMØDES	6							
284	PBAR	17	1	1.	.083	.083				+PBAR

CARD NO.	1	2	3	4	5	6	7	8	9	10
285	+PBAR	1.111	-1.111							
286	SUPØRT	1	3	1	5					
287	TABDMP1	15								+TDI1
288	+TDI1	10.0	.01	100.	.1	3000.	.1	ENDT		
289	TLØAD2	516	1			.0	.1	60.		
290	TSTEP	516	104	.00139	1					
291	ENDDATA									

Notes:

4. Selects the modal approach to Transient Analysis without looping and without modal acceleration computations.

9-11. Selects dynamic load function, frequency dependent equivalent coefficients for structural damping (TM 9.3.4) and integration time step intervals from Bulk Data.

12. Selects method for real eignevalue extraction.

13-17. Specifies desired output for displacements and element stresses.

18-20. Sets up for structural plotting.

21-23. Defines elements and grid points to be plotted.

24. Specifies the maximum deformation to be plotted on a scale of 2.0 relative to the length of the beam (I = 20.0). Note, must come before the FIND card.

25. Requests the following plots be in stereo.

26. Sets up plot parameters.

27. Plot element set #1 as undeformed structure.

28. Plot modal deformations in the eigenvalue range from 0.004 to 0.013 without the underlay of the undeformed model. Note that only one subcase is implied even though no subcase delimiter is present. Also, the maximum deformation will be plotted to 76% of originally defined scale for all mode shapes.

30. Sets up now for orthographic projection.

31. Sets parameters for a plot on the lower half page.

32. Sets parameters for a plot on the upper half page.

33-36. Requests two plots of the mode shapes within the eigenvalue range of 0.0 to 0.019 the deformed shape in the lower half of the plot page and the z-component vectors plotted in the upper half of the plot page.

38-41. Sets up for XY curve plotting.

42-43. Requests plots of grid lines both in X and Y directions.

44-45. Specifies ten intervals in both X and Y directions.

46-47. Requests values be plotted for every other tic mark.

48-50. Axes and curve labeling information.

51. Requests both plotted and printed output of the z-displacement response at grid point 51.

52-53. New curve title and same output request for grid point 101.

54-58. New axis and curve label information and a request for both plotted and printed output of the z-acceleration response at grid points 51 and 101.

60-160. Beam default parameters and element connectivities.

161-162. Concentrated mass inertial properties.

163. Dynamic load factor and point of application.

164-165. Specifies parameters for real eigenvalue extraction.

166-267. Gridpoint location and default single point constraints.

268-269. Material properties.

270-281. Specifies degrees of freedom to be omitted by Guyan reduction.

282-283. Requests weight and balance output and specifies first six fundamental modes be used as modal coordinates.

284-285. Beam properties.

286. Provides fictitious components for computing determinate reactions for constraining free body accelerations.

287-288. Defines frequency dependent coefficients for equivalent structural damping to be selected from Case Control (SDAMP).

289. Specifies transient response dynamic load.

290. Specifies integration time step intervals and the interval for which output is generated.

7.2 SPECIAL APPLICATIONS OF NASTRAN

The current version of NASTRAN includes modeling capabilities designed to treat specialized problems in heat transfer and structure/fluid interaction. NASTRAN is continuously being developed to extend its matrix abstraction and modeling capabilities into diverse engineering mechanics disciplines. The noted successes already achieved, as demonstrated below, show that generality in application programs is not only possible, by is distinctly advantageous. Development programs are now underway, not only to augment each of the current capabilities of NASTRAN, but to add new analytical tools for automated aeroelastic and substructuring analyses.

The following sections are devoted to exemplifying the specialized capabilities already available. These are summarized in Table 7-1 below.

TABLE 7-1 SPECIALIZED APPLICATIONS OF NASTRAN

Application	Section	Description
Heat Flow	7.2.1	Steady state heat transfer analysis
Hydroelastic	7.2.2	Combined fluid/structure interaction
Accoustic Cavity	7.2.3	Resonant frequencies in compressible fluid flow
Substructuring	7.2.4	Static and/or Normal Modes analysis of large structures using the sub-structuring technique

7.2.1 Heat Flow Problems (UM 1.8, TM 8.)

The heat flow problem is analogous to the structural problem, but with temperatures replacing deflections as the problem unknowns. The same grid points, coordinate systems, elements, constraints, and grid-point sequencing may be used for both problems. The temperature at each grid point requires just one degree of freedom, which is taken to be the first degree of freedom at each grid point. The heat conduction elements will resist temperature differences, which is analogous to the fact that structural elements resist deformation. As in structural analysis, the choice of an appropriate finite element model is left to the analyst. If the same finite elements can be used for both heat conduction and structural analysis, then the same connection cards may be used.

Remarks

- Currently restricted in NASTRAN Level 15.1 to the determination of steady-state temperatures Rigid Format 1. (UM 1.8.1)
- Invoked by using Rigid Format 1 with PARAM bulk data card ØPTIØN=HEAT. (UM 3.1.5 and 3.2.4)
- The structural elements listed in Table 7-2 may be used. (UM 1.8.2, TM 8.2)

TABLE 7-2 HEAT CONDUCTION ELEMENTS

Type	Elements
Linear	BAR*, RØD, CØNRØD, TUBE
Planar	TRMEM*, TRIA1*, TRIA2* QDMEM*, QUAD1*, QUAD2*
Solid of Revolution	TRIARG, TRAPRG*
Solid	TETRA, WEDGE, HEXA1, HEXA2
Scalar	ELAS1, ELAS2, ELAS3, ELAS4

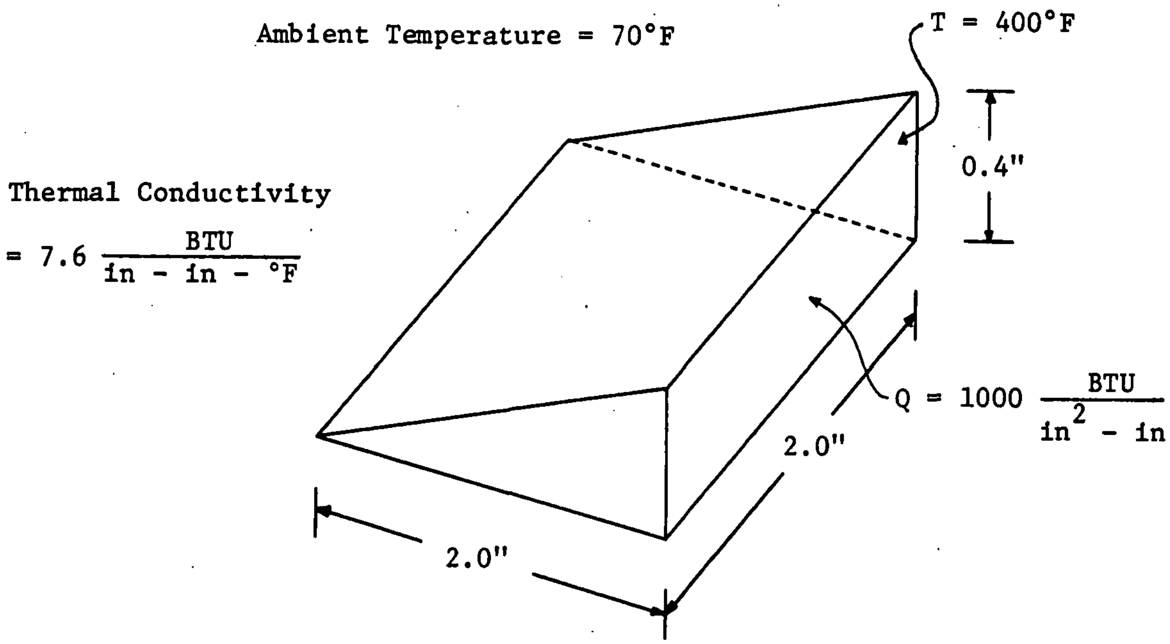
*Bending characteristics are ignored. For plates, the membrane thickness is used to determine heat conduction matrices. For BAR, there is no temperature drop across offsets. For TRAPRG, the top and bottom need not be perpendicular to the z-axis.

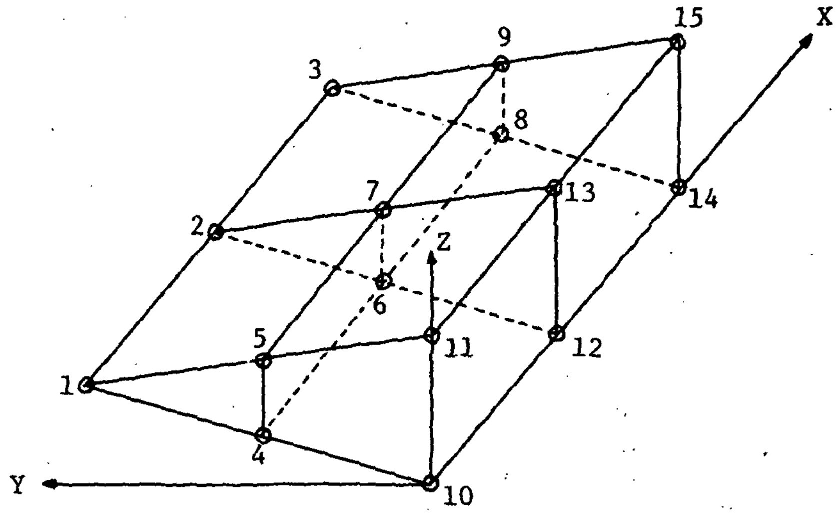
- Thermal material properties are defined on MAT4 and MAT5 bulk data cards. (UM 1.8.2, TM 8.2)

- Degrees of freedom 23456 of every grid point must be constrained to zero with single-point constraints. (SPC1 bulk data card recommended. However, GRDSET, GRID, or SPC may be used.) (UM 1.8.3, TM 8.1)
- Multipoint constraints may be used. (TM 8.1, TM 8.2)
- Temperature boundary conditions are specified with the SPC bulk data card. (UM 1.8.3, TM 8.1)
- Heat flux boundary conditions are specified with the QHBDY bulk data card. (UM 1.8.3, TM 8.3.1)
- Convection boundary conditions are specified with the thermal element CHBDY. Ambient temperatures for every grid point must be specified with TEMP and/or TEMPD bulk data cards when using this element. (UM 1.8.3, TM 8.3.2)
- To use volume heat generation, the thermal power must be computed and specified on a QHBDY bulk data card. (UM 1.8.3)
- Symmetry may be used. For symmetric temperatures, the boundary is free. For anti-symmetric temperatures, the boundary is fixed. (UM 1.8.3)
- Output requests for grid point temperatures are made with the DISPLACEMENT case control card.

7.2.1.1 Example - Heat Flow Problem

A metal fin of triangular cross-section attached to a plane surface (y = 0) to help carry off heat for the latter. The modeling details are pictured below.





Note: The cooling fin is assumed to be infinitely long.
For symmetry, the Y-Z surfaces are left unconstrained.

7.2.1.2 Input Cards - Example Heat Flow Problem

Card No.	
1	ID HEAT,FLØW
2	APP DISP
3	SØL 1,0
4	TIME 2
5	CEND
6	TITLE=HEAT FLØW EXAMPLE PRØBLEM
7	SUBTITLE=CØØLING FIN
8	LØAD=10
9	SPC=7
10	TEMP=11
11	ØUTPUT
12	DISP=ALL
13	BEGIN BULK

BULK DATA FIELD

Card No.	1	2	3	4	5	6	7	8	9	10
14	CHBDY	101	LINE	7.6	2.0	2	7			
15	CHBDY	102	LINE	7.6	2.0	7	13			
16	CHBDY	103	LINE	7.6	2.0	2	6			
17	CHBDY	104	LINE	7.6	2.0	6	12			
18	CHEXA2	201	1	4	5	11	10	6	7	+E201
19	+E201	13	12							
20	CHEXA2	202	1	6	7	13	12	8	9	+E202
21	+E202	15	14							
22	CWEDGE	301	1	1	5	4	2	7	6	
23	CWEDGE	302	1	2	7	6	3	9	8	
24	GRID	1	0.	2.	.2					
25	GRID	2	1.	2.	.2					
26	GRID	3	2.	2.	.2					
27	GRID	4	0.	1.	.1					
28	GRID	5	0.	1.	.3					
29	GRID	6	1.	1.	.1					
30	GRID	7	1.	1.	.3					
31	GRID	8	2.	1.	.1					
32	GRID	9	2.	1.	.3					
33	GRID	10	0.	0.	.0					
34	GRID	11	0.	0.	.4					
35	GRID	12	1.	0.	.0					
36	GRID	13	1.	0.	.4					
37	GRID	14	2.	0.	.0					
38	GRID	15	2.	0.	.4					
39	MAT4	1 .	7.6							
40	PARAM	ØPTIØN	HEAT							
41	QHBDY	10	LINE	1.+3	2.0	12	13			
42	SPC	7	10	1	400.	11	1	400.		
43	SPC	7	12	1	400.	13	1	400.		
44	SPC	7	14	1	400.	15	1	400.		
45	SPC1	7	23456	1	THRU	15				
46	TEMPD	11	70.							
47	ENDDATA									

Input Explanation

Notes:

3. The heat flow option is currently available for Rigid Format 1 only.

8. References heat flux boundary conditions.

9. References temperature boundary conditions.

10. References ambient temperatures.

12. Output request for grid point temperatures.

17. Heat convection elements for the surface.

40. Required for heat flow option.

41. Heat flux boundary conditions.

44. Temperature boundary conditions.

45. Only one defree of freedom per grid point allowed. All others must be constrained.

46. Ambient temperature.

7.2.2 Hydroelastic Analysis

Although the Hydroelastic capability may be applied to many problems with combined structure and fluid effects, it was designed primarily to analyze the case of a cylindrical tank, partially filled with fluid, in a gravitational field, e.g. the fluid sloshing problems of a liquid propellent rocket tank. The options include both rigid and flexible container boundaries, free surface effects, compressibility, and the options of gravity or variable fluid densities. The analysis assumes small perturbations about static equilibrium, and second order velocity terms are ignored.

Combined fluid and structure models may be analysed for eigenvalues, frequency and random response, or transient response, Rigid Formats 7, 8 and 9 respectively. Loads and initial conditions may be applied only to the structure and problems involving no structure may only be analysed for normal modes, Rigid Format 3.

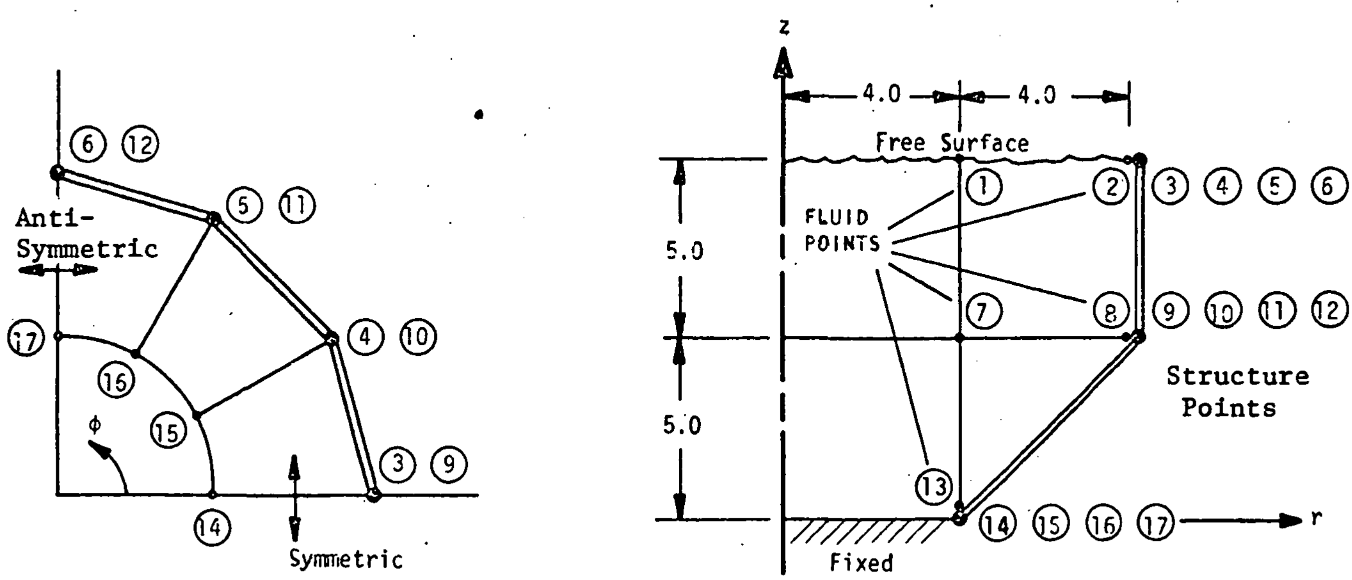
<u>Remarks</u>

- The fluid is defined by finite axisymmetric elements, CFLUID2, CFLUID3, and CFLUID4. Each element defines a volume of fluid generated by rotating a triangle or a qradrilateral about a central axis. The corners of the triangle or qradrilateral are defined by RINGFL points located on the plane $\phi=0$. An axisymmetric volume of fluid may be subdivided into these elements much like a flat plate is subdivided into triangles and quadrilaterals.
- The RINGFL points are treated like GRID points in the structural problem except that each point is related to a set of pressure coefficients rather than to a set of displacements. This approach is very similar to the axisymmetric shell analysis in which the unknown degrees of freedom represent the coefficients of a Fourier Series about the circumference.
- The boundary of the fluid may be defined in any one of three ways. If the boundary is a free surface, a list of RINGFL points are specified on the FSLIST data card. If the boundary is elastically supported, the RINGFL points to be connected to the elastic structure must be specified on the BDYLIST data card. If neither of these options is specified, the boundary is assumed to be rigid with no flow across it.
- If only the fluid and its free or rigid boundaries are defined, Rigid Format 3 is used to produce normal modes.
- If the fluid may be enclosed by a flexible structure defined with normal NASTRAN finite elements, Rigid Formats 7, 8, or 9 may be used to produce natural modes, frequency and random response, or transient results. Although the modes may be undamped the formulation produces unsymmetric matrices and the general complex eigenvalue analysis must be used. Loads and initial conditions may only be applied to the structural grid points.

- The FREEPT and PRESPT data cards may be used for additional output. The FREEPT data card defines a point on the free surface for output of the displacement normal to the surface. The PRESPT data card defines a point in the fluid for output of the pressure at that location. That point may be used as a pressure pick -off for a control system or to model fluid flow into or out of the system. The latter would require specification of a scalar spring to represent the pressure differential that would cause that flow.
- The accuracy of the solution is controlled by the number of terms in the Fourier Serier (harmonics) and, of course, the mesh size of the finite elements. The fluid elements are limited to a linear pressure distribution over each element in the plane, $\phi=0$. The circumferential distribution is determined by the harmonics chosen in the Fourier Series. If the fluid is bounded by rigid and/or free boundaries, the harmonics are not coupled and the normal modes may be determined with a separate run for each harmonic of the Fourier Series.
- Axisymmetric structural elements can not be used. Therefore, except for the location of the grid points at the fluid boundary, the structure need not be axisymmetric. All of the general finite element modeling features may be used except that GRIDB points are substituted for GRID points at the actual fluid/structure interface.

7.2.2.1 Example - Hydroelastic Problem

The problem to be illustrated is shown below and the input is given in Section 7.2.2.2. The model consists of one quarter section of a basket-shaped tank filled with water in a one-g gravitational field. With the boundary conditions shown, the lateral sloshing modes will be calculated with structural flexibility effects included. All of the modes could be extracted, however, by changing the constraints on the symmetric boundaries.



7.2.2.2 Input Cards - Example Hydroelastic Problem

Card No.

1 ID HYDRØ, USER
2 APP DISP
3 SØL 7,0
4 TIME 2
5 CEND
6 TITLE = SAMPLE HYDRØELASTIC PRØBLEM.
7 SUBTITLE = EIGENVALUE ANALYSIS WITH FLEXIBLE BØUNDARY.
8 AXISYM = FLUID
9 SPC = 3
10 CMETHØD = 1
11 ØUTPUT
12 DISP = ALL
13 HARMØNICS = ALL
14 ELFØRCE = ALL
15 BEGIN BULK

BULK DATA FIELD

Card No.	1	2	3	4	5	6	7	8	9	10
16	AXIF	2	386.0	.96-4		NØ				+AX
17	+AX	1	3							
18	CØRD2C	2		0.	0.	0.	0.	0.	1.0	+CØ
19	+CØ	1.0	0.	0.						
20	RINGFL	1	4.0		10.0	2	8.0		10.0	
21	RINGFL	7	4.0		5.0	8	8.0		5.0	
22	RINGFL	13	4.0		0.0					
23	CFLUID2	101	1	7						
24	CFLUID2	102	7	13						
25	CFLUID3	103	7	8	13					
26	CFLUID4	104	1	2	7	8				

(Continued)

BULK DATA FIELD (CON'T)

Card No.	1	2	3	4	5	6	7	8	9	10
27	FSLIST	.96-4	AXIS	1	2					
28	BDYLIST		-2	8	13					
29	GRIDB	3			0.0		2	4	2	
30	GRIDB	4			30.0		2	4	2	
31	GRIDB	5			60.0		2	4	2	
32	GRIDB	6			90.0		2	4	2	
33	GRIDB	9			0.0		2		8	
34	GRIDB	10			30.0		2		8	
35	GRIDB	11			60.0		2		8	
36	GRIDB	12			90.0		2		8	
37	GRIDB	14			0.0		2		13	
38	GRIDB	15			30.0		2		13	
39	GRIDB	16			60.0		2		13	
40	GRIDB	17			90.0		2		13	
41	CQUAD2	10	11	3	9	10	4			
42	CQUAD2	11	11	4	10	11	5			
43	CQUAD2	12	11	5	11	12	6			
44	CQUAD2	13	11	9	14	15	10			
45	CQUAD2	14	11	10	15	16	11			
46	CQUAD2	15	11	11	16	17	12			
47	PQUAD2	11	12	0.5						
48	MAT1	12	10.6+6		0.3	0.05				
49	SPC1	3	246	3	9	14				
50	SPC1	3	135	6	12	17				
51	SPC1	3	135	14	15	16				
52	FLSYM	4	S	A						
53	EIGC	1	INV	MAX						+EI
54	+EI	0.	0.	0.	5.	3.	2	2		
55	ENDDATA									

Input Explanation

Notes:

3. Rigid Format 7 is used to extract the eigenvalues of the system. Although the eigenvalues and eigenvectors may be real, the matrix formulation is unsymmetric and a general method must be used.

8. The AXISYM card is necessary to identify a fluid problem for output purposes.

10. Selects the EIGC card from bulk data.

12. Requests printout of all displacements and pressures.

13. Requests printout of the fluid pressure coefficients for ALL the harmonics.

16-17. The required AXIF data card is used to set the miscellaneous general data for the problems.

18-19. Specifies a cylindrical coordinate system to be used for defining both the fluid and the structure points.

20-22. The RINGFL points define the fluid pressure degrees of freedom. The numbering sequence of the RINGFL and the GRIDB points when combined, determine the matrix bandwidth.

23-26. Defines the fluid element connectivities. The densities and bulk moduli are left blank thereby causing the default values on the AXIF card to be used.

27. Defines the RINGFL points on the free surface. Since RINGFL points are not allowed at r = 0, the BCD word AXIS may be used.

28. Defines the RINGFL points on the fluid/structure interface. The default density is used by leaving field 2 blank.

29-40. Define the GRIDB points by their circumferential location on the RINGFL point to which they are connected. They serve the same purpose as GRID point cards.

41-51. Defines the structural elements, materials, and constraints in the normal manner.

52. Defines the symmetry conditions in order to couple the correct fluid motions to the structural boundary condition.

53-54. Specifies the search region for the root extraction to be from zero to five radians per second with two roots expected.

7.2.3 Acoustic Cavity Analysis

The acoustic cavity analysis capability was implemented primarily to obtain the resonant frequencies of a compressible fluid in a solid rocket motor cavity. The enclosed gas is modeled with finite elements. The surrounding propellant is assumed to be rigid and small motion theory is used, i.e. the steady state velocities are small with respect to the wave velocity. Rigid Format 3 is used to obtain these resonant frequencies.

The shape of the cavity may consist of a circular center volume surrounded by equally spaced narrow radial slots. The width and depth of the slots and the diameter of the center volume may vary along the axis of the cavity. The finite-element model is defined by a set of two-dimensional elements lying on the center plane of one slot and on the corresponding cross section of the center volume. The entire cavity is solved by assuming a Fourier Series of pressure and velocity around the circumference. With minor correction terms, the pressure coefficients in the slots couple directly with the Fourier coefficients of pressure in the center volume. The user may request a printout of the pressures at the points and/or the velocities in the elements.

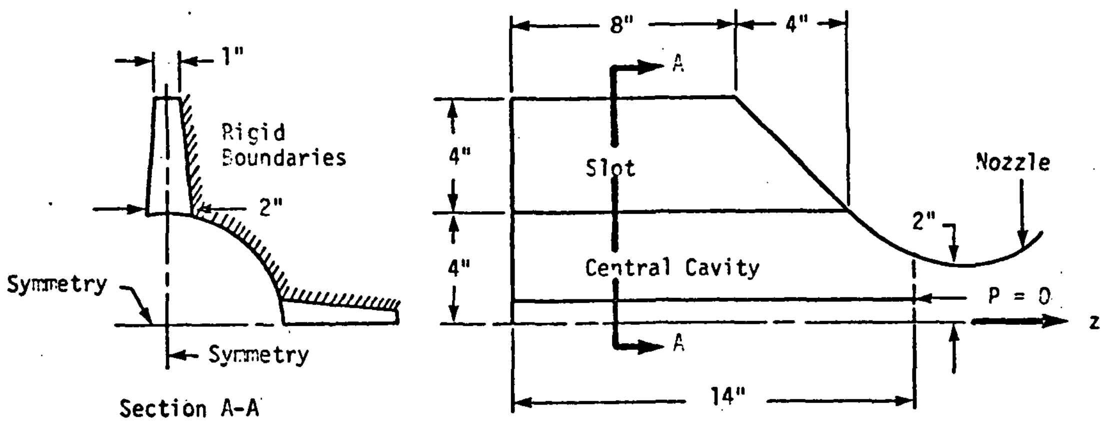
Remarks

- The fluid grid points are defined by GRIDF cards for the central volume and by GRIDS cards for the slot area. One degree of freedom is produced for each point in the model. The width and number of slots are defined on the GRIDS card. If the slot point lies on the opening to the central cavity, the location is specified on a GRIDS card on which is also given a unique GRIDF identifier. This eliminates the need for inputting a separate GRIDF card for the same point. The SLBDY card is used to define a list of GRIDS points which lie on the opening to the central cavity.
- The GRIDF points are connected by the CAXIF2, CAXIF3, and CAXIF4 elements. Each element defines a volume generated by revolving the cross section shape around the center axis. The CAXIF2 element defines a volume which contains the center axis.
- The GRIDS points are connected by the CSLØT3 and CSLØT4 elements. Each element may have a different fluid property.
- The default properties of the model are defined by the required AXSLØT card. The harmonic index N specifies the Fourier Series term to be analysed. N = 0 restricts the motion to axisymmetric radial and longitudinal motion. N = 1 defines the lateral motion where the velocity is normal to the center axis, etc. Repeated runs with N = 0, 1, ...M/2 may be necessary to extract all possible modes. M is the number of radial slots specified.

- The default on all boundaries is a fixed surface. If a free surface with zero pressure is desired, the SPC or SPC1 data cards may be used to constrain the pressure at selected points.
- The two dimensional wave equation problem may be solved by using only CSLØT elements and GRIDS points, by specifying only one slot (M = 1) and by setting the harmonic index, N, to zero.
- The finite element approximation assumes that the velocity is constant over the cross section of each element and that the pressure distribution does not vary across the width of the slot. In regions where the velocity may abruptly change direction, a finer finite element mark should be chosen.

7.2.3.1 Example - Acoustic Cavity Problem

The acoustic cavity shown below consists of a central cavity having a radius of four inches and four equally spaced slots. The cavity is open at the right end. The slot width varies linearly with radial position. The input data for the simple finite element model chosen is presented in Section Three CSLØT elements and six CAXIF elements are used. The harmonic index is one, which will result in lateral motion. That is, the gas will travel back and forth across the cavity from one slot to the slot on the opposite side.



7.2.3.2 Input Cards - Example Acoustic Cavity Problem

Card No.	
1	ID ACØUS
2	APP DISP
3	SØL 3,0
4	TIME 2
5	CEND

```
6       TITLE = ACØUSTIC CAVITY EXAMPLE PRØBLEM
7       SUBTITLE = FIRST HARMØNIC, LATERAL MØDES
8       METHØD
9           SPC = 1
10              PRES = ALL
11              STRESS = ALL
12      BEGIN BULK
```

BULK DATA FIELD

Card No.	1	2	3	4	5	6	7	8	9	10
13	AXSLØT	1.2-7	21.0	1		4				
14	GRIDS	2	4.0	0.0	0.2E 01	1				
15	GRIDS	3	8.0	0.0	1.0					
16	GRIDS	5	4.0	4.0	2.0	4				
17	GRIDS	6	8.0	4.0	1.0					
18	GRIDS	8	4.0	8.0	2.0	7				
19	GRIDS	9	8.0	8.0	1.0					
20	GRIDS	12	4.0	1.2+1	2.0	11				
21	GRIDF	10	2.0	12.0						
22	GRIDF	13	2.0	1.4E1						
23	CSLØT4	1	2	3	6	5				
24	CSLØT4	2	5	6	9	8				
25	CSLØT3	3	8	9	12					
26	CAXIF2	4	1	4						
27	CAXIF2	5	4	7						
28	CAXIF2	6	7	10						
29	CAXIF2	9	10	13						
30	CAXIF3	7	7	10	11					
31	CAXIF3	8	10	11	13					
32	EIGR	11	GIV				3			+AB
33	+AB	MAX								
34	SLBDY			12	8	5	2			
35	SPC	1	13							
36	ENDDATA									

Notes:

10-11. The PRESSURE control card requests output pressures at the GRIDF and GRIDS points. The STRESS control card requests the velocities in the finite elements.

13. Required for acoustic cavity analysis and defines the default density, compressibility, harmonic index, slot width, and number of slots for the overall problem. These values may be overridden by the individual cards below.

14-20. Defines the points on the slot. GRIDS 2, 5, 8, and 12 also define GRIDF points 1, 4, 7, and 11 at the same location. The slot w dth is varied on these data cards.

21-22. Defines remaining GRIDF points directly.

23-25. Specifies the CSLØT elements, which, in this case use the default fluid properties and number of slots specified on the AXSLØT card.

26-31. Specifies the CAXIF elements of the central axisymmetric volume. The default fluid properties will be used.

34. Identifies the GRIDS points at the interface between the slots and the central volume.

35. Sets the pressure at point 13 to zero.

7.2.4 Substructuring Analysis

The capability is provided in NASTRAN with Rigid Formats 1 and 3 for performing a static and/or a normal modes analysis of large structures using the substructuring technique. This technique consists of dividing up a structure into smaller component substructures, building the corresponding matrices for each component and reducing them to the boundary gridpoint degrees of freedom. These reduced matrices are combined and the solution is obtained for the complete structure. Finally the reduction process is reversed and the detail solution is recovered for each substructure. These three phases of processing are described below. Each required DMAP alters to the Rigid Formats used.

Several significant advantages are gained by processing with the smaller substructure matrices using several computer runs rather than solving the complete structure all in one run. Each run is usually of much shorter duration with less core memory required for efficiency. And perhaps even more important, model checkout is easier and only those operations affected by modeling or data errors need to be rerun. There are some disadvantages, however. The user will spend more effort in data preparation, in keeping track of numerous user tapes and, of course, in submitting multiple runs.

Remarks

- The present NASTRAN substructure analysis requires that the user modify the corresponding Rigid Formats with DMAP alters. This tool, however, is highly flexible and allows the user many options which are necessary to analyse a wide variety of of structural combinations and solution options. Although the DMAP alter examples given in this section and in the UM1.10 example will be adequate for many applications, it is recommended that the user become familiar with the basic rules and operations before attempting any large, expensive runs.
- A "Phase I" run must be made for each component substructure. In this run the structural matrices and load vectors are reduced (Guyan reduction) to only those degrees of freedom required to define the boundary connections and those retained to describe the dynamic effects. The results are written on tapes which must be set up by the user. The problem must also be checkpointed to allow for Phase III data recovery.
- The "Phase II" run is performed to combine the various component substructure matrices and load vectors, apply constraints to the combination and structure, perform the required analysis, and write the resulting solution vectors on user tapes. The primary user tasks are:

  1. To construct tables for preparation of the "partitioning vectors" which identify the degrees of freedom of each substructure relative to the entire set.

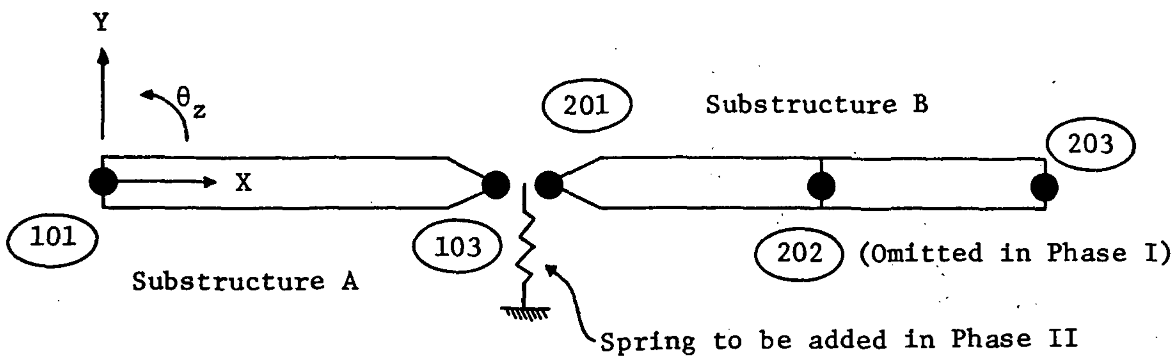
2. To supply the DMAP alter control cards to perform the necessary operations.

3. To input the Bulk Data necessary to analyse his particular problem.

- A series of "Phase III" runs are used to obtain detailed results for each component substructure. The solution vectors, generated in Phase II, are read from the user tapes in conjunction with the corresponding Phase I checkpoint tape for that substructure. The solutions are processed with all of the normal output options available. The user must supply the required DMAP alters and make all printing and plotting output requests.

7.2.4.1 Example - Substructure Problem

The problem as illustrated below consists of two substructures, represented by BAR elements, to be connected at one point. The x, y, and θ_z motions are retained for all grid points of both substructures. Only the x and y displacements are connected at the interface grid points.



The following table illustrates the "partitioning vectors" to be input on the DMI Bulk Data cards. One vector must be defined for each substructure.

Combination Scalar Point	Substructure A GRID	Comp	Vector "VA"	Substructure B GRID	Comp	Vector "VB"
1	101	1	1.0			0.
2	101	2	1.0			0.
3	101	6	1.0			0.
4	103	1	1.0	201	1	1.0
5	103	2	1.0	201	2	1.0
6	103	6	1.0			0.
7			0.	201	6	1.0
8			0.	203	1	1.0
9			0.	203	2	1.0
10			0.	203	6	1.0

The example presented here illustrates some of the alternatives to the sequence given in the UM1.10 including some of the more convenient methods of transfering data onto user tapes. Some specific differences are:

1. The use of "tape labels" in the NASTRAN system is redundant for most problems and may be conveniently dropped.

2. The partitioning vectors are input in the Phase II run where they are actually used.

3. The user may input structural elements to define a model in Phase II. However, if no elements are specified, the user must provide a direct input stiffness matrix which may contain all zeroes.

4. The sequence shown here allows the user to specify gridpoint loads in Phase II in addition to the loadings carried over from Phase I.

5. In many cases, the constraints will not be defined until the substructures are combined in Phase II. This example shows, therefore, how to recover the support reactions in Phase III.

7.2.4.2 Input Cards - Phase I

In addition to the NASTRAN input data shown below, the user must provide the necessary system control cards to set up the NPTP and INPT user tapes.

Substructure A
(Typical Phase I)

Card No.

```
 1    ID PHASE ØNE $ SUBSTRUCTURE A
 2    APP DISP
 3    SØL 1,0
 4    DIAG 21,22
 5    ALTER 84
 6    JUMP LBL7 $
 7    ALTER 102
 8    ØUTPUT1 KLL,PL, ,,//C,N,0/C,N,0 $
 9    EXIT $
10    ENDALTER
11    CHKPNT YES
12    TIME 1
13    CEND
14    TITLE = SUBSTRUCTURE A, PHASE ØNE
15    SUBCASE 1
16    LØAD = 1
17    SUBCASE 2
18    LØAD = 2
19    BEGIN BULK
        .
        .
        .
        .
20    ENDDATA
```

Substructure B

The data deck for Substructure B has virtually identical Executive and Case Control data cards. Of course, a different set of Bulk Data cards would be input to describe the model and loads for substructure B. The identical number of loadings must be selected in Care Control for both substructures, even if this requires specification of a null load on one of the substructures.

Input Explanation - Phase I

Notes: 4. Diagnostics numbers 21 and 22 print out complete lists of all degrees of freedom and the partitions of the displacement set to which they belong. This output helps in constructing the partitioning vectors to be input in Phase II.

5-6. This causes the system to skip the matrix decomposition. The Guyan reduction process has already eliminated the degrees of freedom specified in Bulk Data.

7-8. The reduced stiffness matrix and load vectors are written on the INPT tape. No label is written.

9. No solution is required for the substructure so the execution is manually terminated.

15-18. The sequence of substructure loadings is defined for input to Phase II.

7.2.4.3 Input Cards - Phase II

The Phase II requires tape mount requests for the INPT tapes created in Phase I. In this example, these tapes are named the INPT and INPT1 for substructures A and B respectively. The output will be written on tape INPT2, also to be defined in the Job Control deck by the user.

Card No.	
1	ID PHASE, TWØ $ CØMBINATIØN
2	APP DISP
3	SØL 1,0
4	TIME 4
5	ALTER 28,28
6	CØND LBL11A, NØELMT $
7	ALTER 49
8	PARAM //C,N,NØP/V,N,TRUE=-1 $
9	INPUTT1 /KA,PA,,,/C,N,0/C,N,0 $
10	MERGE ,,,KA,VA,/KGGA $
11	ADD KGG,KGGA/KGGC
12	EQUIV KGGC,KGG/TRUE $
13	MERGE ,PA,,,,VA/PGA/C,N,1 $
14	INPUTT1 /KB,PB,,,/C,N,0/C,N,1 $

```
MERGE ,,,KB,VB,/KGGB $
ADD KGG,KGGB/KGGD $
EQUIV KGGD,KGG/TRUE $
MERGE ,PB,,,,VB/PGB/C,N,1 $
ADD PGA,PGB/PGC $
ALTER 60,64
ALTER 95
ADD PGC,PG/PGT $
EQUIV PGT,PG/TRUE $
ALTER 118
PARTN UGV,,VA/,UGVA,,/C,N,1 $
PARTN QG,,VA/,QGA,,/C,N,1 $
PARTN UGV,,VB/,UGVB,,/C,N,1 $
PARTN QG,,VB/,QGB,,/C,N,1 $
ØUTPUT1 UGVA,QGA,UGVB,QEB/C,N,0/C,N,2 $
ENDALTER
CEND
TITLE = CØMBINATIØN STRUCTURE
SUBTITLE = STATIC LØADS
SPC = 2
ØUTPUT
DISP = ALL
SPCF = ALL
SUBCASE 1
LABEL = LØAD CASE 1
LØAD = 1
SUBCASE 2
LABEL = LØAD CASE 2
LØAD = 2
BEGIN BULK
```

Card No.	1	2	3	4	5	6	7	8	9	10
45	SPØINT	1	THRU	10						
46	CELAS3	101	5		1.5+3					
47	SLØAD	1	9	0.0						
48	SLØAD	2	10	0.0						
49	SPC1	2		1	2	3				
50	DMI	VA	0	2	1	1		10	1	
51	DMI	VA	1	1	1.0	1.0	1.0	1.0	1.0	+DMIA
52	+DMIA	1.0								
53	DMI	VB	0	2	1	1		10	1	
54	DMI	VB	1	4	1.0	1.0	1.0	0.0	1.0	+DMIB
55	+DMIB	1.0	1.0							
56	ENDDATA									

Input Explanation - Phase II

Notes:

5-6. Premature termination is averted in the event the user does not input structural elements in Bulk Data.

8. The parameter, TRUE, is set.

9. The matrix and loads from sutstructure A are read from the INPT tape.

10-11. The stiffness matrix from substructure A is expanded to the combination size, using the direct input vector VA, and added to the existing matrix.

12. The existing stiffness matrix is set to equal the sum from above.

13. The load vectors from substructure A are expanded to the combination size.

14-18. The same operations as in steps 9-13 are performed for substructure B.

19. The load matrices from the two substructures are added.

20. The grid point singularity output is skipped.

21-23. The load vectors defined in the Phase II run are added to those defined by the Phase I runs. The result is given the original name, PG.

24-28. The solution displacement and constraint force vectors are partitioned to correspond to each substructure.

29. The results for both substructures are written on tape INPT2. No label is written.

36-37. Outputs for the Phase II run will be identified by the scalar indices.

38-43. Loads processing references load identifiers provided in Phase II. The loads input from Phase I have already been added to and identified by the Phase II identifiers.

45. The combination structure has ten degrees of freedom. Using scalar points aids in identifying load and constraint points.

46-48. The DMAP alters given above require that a structural matrix and a loading data set be generated in Phase II. The user may input elements and loads in Phase II for this purpose, as is done here. (Note, the loads are in fact all zero.) The user may choose to provide a direct input matrix KGG in place of the structural elements. If desired, this matrix also may contain all zeroes.

49. Any constraints must be given in terms of the psuedo structure scalar points.

50-55. The partitioning vectors are best defined in Phase II. Usually the final numbering of all the degrees of freedom is not known until after the Phase I runs have been made.

7.2.4.4 Input Cards for Substructure Example - Phase III

In addition to the data cards given below, the user must provide the Job Control cards to set up the INPT3 tape and ØPTP checkpoint tape from the Phase I run to be read in Phase III.

Card No.	
1	ID PHASE,THREE $ RESULTS
2	APP DISP
3	SØL 1,0
4	TIME 1
5	ALTER 20,109
6	PARAM //C,N,NØP/V,N,TRUE=-1 $
7	INPUTT1 /ULV,QL,UDUM,QDUM/C,N,0/C,N,2 $
8	ALTER 111

```
9     VEC VSET/VLG/C,N,G/C,N,L/C,N,CØMP $
10    MERGE QL,,,,,VLG/QGC/C,N,2/C,N,2 $
11    ADD QGC,QG/QG2 $
12    EQUIV QG2,QG/TRUE $
13    ALTER 112,117
14    ALTER 127,138
15    ENDALTER
16    RESTART Dictionary
17    CEND
18    TITLE = SUBSTRUCTURE A, PHASE 3
19    SUBTITLE = STATIC LØADS
20    ØUTPUT
21    DISP = ALL
22    SPCF = ALL
23    STRESS = ALL
24    SUBCASE 1
25    LABEL = LØAD CASE 1
26    SUBCASE 2
27    LABEL = LØAD CASE 2
28    BEGIN BULK
29    ENDDATA
```

Input Explanation - Phase III Substructure

Notes:

5. The structural assembly and solution operations are deleted.

6. The parameter, TRUE, is set.

7. The solution vectors from Phase II are read from file INPT2. The data for this substructure were written on the first two files. For substructure B the second two files are used.

8-12. Since constraints were applied in Phase II and the forces of constraint are desired output, this DMAP alter will add the Phase II results to the Phase III results.

13-14. The operations not strictly involved with output processing are deleted.

16. The restart dictionary from Phase I is used to set the appropriate files.

18-27. The output is controlled with the normal case control logic.

7.3 DIRECT MATRIX ABSTRACTION PROGRAM (DMAP) (UM 5)

DMAP is the "programming language" of NASTRAN. DMAP instructions control the execution logic and sequence of the NASTRAN program operations. Each DMAP instruction causes a block (module) of NASTRAN code to be executed, and each Rigid Format is simply a sequence of DMAP instructions permanently stored in NASTRAN. The user may code and execute a DMAP sequence in place of a Rigid Format. He may also make changes to the Rigid Formats themselves. In either case, the DMAP instructions are always included in the Executive Control Deck (UG 6).

The format and detailed usage of all of the DMAP instructions are described in Chapter 5 of the User's Manual. Structurally oriented DMAP instructions and NASTRAN modules are described in Chapter 4 of the Programmer's Manual. The types of tasks which can be performed by NASTRAN using DMAP instructions include the following operations:

1. Executive, e.g., checkpoint and exit (UM 5.3.4)
2. Utility, e.g., read and write user tapes (UM 5.3.2)
3. Matrix, e.g., add and multiply (UM 5.3.1)
4. Structural, e.g., structural matrix assembler (PM 4)

In addition to these available options which are currently provided in NASTRAN, the user may program his own functions which he himself must program and implement into NASTRAN (UM 5.3.3). He may implement his code as a completely new module which would require adding a new DMAP instruction to access that new module (PM 6.7 and 6.12). Or, he may use a series of skeletal DMAP instructions and their associated dummy modules which already have been implemented into NASTRAN for the purpose of facilitating subsequent addition of user developed code (UM 5.3.3).

The following sections present a series of simple, but typical examples using DMAP instructions from each of the four categories mentioned above. A particularly good set of more complex examples is described in detail in Section 7.2.4 where DMAP alters have been used for Substructuring Analysis.

7.3.1 DMAP - Executive Operations

The Executive Operation instructions (UM 5.3.4) can be divided into general categories (UM 5.2.2) as follows:

1. Declarations (e.g., FILE, LABEL and BEGIN)
2. Operations (e.g., CHKPNT, EQUIV, PURGE, and SAVE)
3. Control (e.g., REPT, JUMP, CØND, EXIT and END)

These instructions are used by the DMAP compiler in NASTRAN to aid in file allocation, to interface between functional modules, and to control the order of execution both for cold starts and restarts after checkpointing.

The example that follows is most useful for those situations which call for controlling the partial execution of a Rigid Format. The subsequent sections present additional examples of execution operations.

7.3.1.1 Example 1 - Partial Execution of Rigid Format 1

Alter Rigid Format 1 (Static Analysis) in order to stop execution after plotting the undeformed structure.

Card No.		
1	ID	EXAMPLE1,MØDES
2	APP	DISP
3	SØL	1,0
4	TIME	2
5	ALTER	17
6	EXIT	$
7	ENDALTER	
8	CEND	
9	TITLE = DMAP EXAMPLE 1	
10	PLØTID = MODE1 DESIGN CHECK	
11	ØUTPUT (PLØT)	
12	SET 1 ALL	
13	FIND SET 1	
14	PLØT	
15	BEGIN BULK	

BULK DATA FIELD

Card No.	1	2	3	4	5	6	7	8	9	10
16	CØNRØD	1	1	2	1	1.0				
17	CØNRØD	2	2	3	1	1.0				
18	GRID	1		0.0	0.0	0.0		123456		
19	GRID	2		1.0	1.0	0.0		3456		
20	GRID	3		2.0	0.0	0.0		123456		
21	MAT1	1	3.+7							
22	ENDDATA									

Notes:
2. Use displacement approach.
3. Use Rigid Format 1.
5. Insert the immediately following DMAP instructions(s) after Line 17 of the Rigid Format identified by the SØL card (UM 2.3.1).
6. NASTRAN will execute the Rigid Format up to the point where it encounters "EXIT", where it will terminate.
7. End of Rigid Format alters.

7.3.2 DMAP - Utility Operations

The Utility Operation instructions (UM 5.3.2) can be divided into general categories as follows:

1. Read and write of user tapes (e.g., INPUT, INPUTTi, ØUTPUTi)
2. Matrix and table printout (e.g., MATGPR, MATPRN, MATPRT, TABPRT, TABPT)
3. Manipulate parameters (e.g., PARAM, PRTPARM, SETVAL)
4. Display matrix topology (e.g., SEEMAT)
5. Generate partitioning vectors (e.g., VEC)

These utilities are particularly helpful for debugging a structural model as well as for checking out new routines developed by a user. Also, when external programs are to be used for data preparation for input to NASTRAN, or for post processing the results obtained from NASTRAN, these utilities facilitate the transmission of these data (UG 9). Examples of these utilities are presented below and in subsequent sections.

7.3.2.1 Example 2 - Printout of Table Data

Alter Rigid Format 1 (Static Analysis) in order to print the grid point coordinates in the basic coordinate system.

Card No.		
1	ID	EXAMPLE2,BGPDT
2	APP	DISP
3	SØL	1,0
4	TIME	3
5	ALTER	5
6	TABPRT	BGPDT//C,N,BGPDT $
7	ENDALTER	
8	CEND	
9	TITLE = DMAP EXAMPLE 2	
10	BEGIN BULK	

BULK DATA FIELD

Card No.	1	2	3	4	5	6	7	8	9	10
11	CØNRØD	1	1	2	1	1.				
12	CØNRØD	2	2	3	1	1.				
13	GRID	1		.0	.0	.0		123456		
14	GRID	2		1.	1.	.0		3456		
15	GRID	3		2.	.0	.0		123456		
16	MAT1	1	3.E+7							
17	ENDDATA									

Notes: 2. Use displacement approach.

3. Use Rigid Format 1

5. Insert the immediately following DMAP instruction(s) after Line 5 of the Rigid Format identified by the SØL card.

6. Print the Basic Grid Point Data Table (PM 2.3.3.5).

7. End of Rigid Format alters.

7.3.2.2 Example 3 - Write User Tape and Printout Intermediate Matrix

The following illustrates the writing of a user tape via FØRTRAN for use in subsequent processing outside NASTRAN. The matrix data represents the mode shapes for the reduced set (u_a) of dynamic degrees of freedom (TM 9.3.1) computed with Rigid Format 3 (UM 3.4.1).

Card No.

```
 1      ID      EXAMPLE3,TEST2
 2      APP     DISP
 3      TIME    10
 4      SØL     3,1
 5      ALTER   91
 6      OUTPUT2  PHIA,,,,//V,N,-1/V,N,11/V,N,TEST2 $
 7      OUTPUT2,  ,,,,//V,N,-9/V,N,11 $
 8      MATGPR  GPL,USET,SIL,PHIA//C,N,FE/C,N,A $
 9      ENDALTER
10      CEND
11      TITLE = BØX3 FRAME
12          SPC = 12
13          METHØD = 3
14          DISP = ALL
15      PLØTID = MØDE SHAPES WITHØUT EQUIPMENT
16      ØUTPUT(PLØT)
17          SET 1 = ALL
18          VIEW  34., 30., 0.
19          MAXIMUM DEFØRMATIØN  12.0
20          FIND SCALE
21          PLØT MØDAL DEFØRMATIØNS 0, SET 1 SYMBØLS 2, SHAPE
22      BEGIN BULK
          .
          .
          .
23      ENDDATA
```

Notes:

4. Requests execution of Normal Modes Analysis.
5. Insert following alter package following DMAP instruction 91, Rigid Format 3.

6. Requests output via FØRTRAN of the mode shapes for displacement set u_a to user tape on FØRTRAN Unit 11 after rewinding and writing the NASTRAN label TEST2. (See UG 10 for FØRTRAN unit assignments.)

7. Writes final end of file (EØF) on the tape. Note that the first comma is required as a delimiter when the first field is blank.

8. Requests printout of the same mode shape matrix for all modes generated (Number of modes is FE, Degrees of Freedom Set is A).

9. Concludes the alter package.

10. Concludes the Executive Control Deck.

11-21. Case Control deck which specifies the constraint set, selects from Bulk Data the method of eigenvalue extraction, requests printing of the mode shapes for all grid points and directs the structural plotter package to plot all mode shapes underlayed by the undeformed plot of the model using all elements.

22-23. Contain the Bulk Data Deck for the model which would include either ØMIT or ASET data to reduce problem size via Guyan reduction to the desired displacement set u_a.

7.3.3 DMAP - Matrix Operations

The Matrix Operation instructions (UM 5.3.1) include the basic functions of adding, multiplying, partitioning, merging, transposing and solving matrix equations with single and double precision, real or complex data. These DMAP instructions may be used to process any matrix data generated by NASTRAN or input to NASTRAN from outside sources via the user tape facilities.

7.3.3.1 Example 4 - Processing with User Supplied Matrices

The following example illustrates a complete DMAP sequence for reading two matrices from user tape, adding them together and printing the results.

Card No.

```
 1     ID       EXAMPLE4,ADD
 2     APP      DMAP
 3     TIME     5
 4     BEGIN    $
 5     INPUTT2  /MTXA,MTXB,,,/V,N,-1/V,N,15/V,N,B9U $
 6     ADD      MTXA,MTXB/MTXSUM/ $
 7     MATPRN   MTXA,MTXB,MTXSUM,,// $
 8     END      $
 9     CEND
10     BEGIN BULK
          .
          .
          .
11     ENDDATA
```

Notes:

2. Defines DMAP approach.

4. Initiates input of user specified DMAP sequence.

5. Reads in two matrices (MTXA and MTXB) from user tape on FØRTRAN Unit 15 which were written via FØRTRAN by a program external to NASTRAN. (Note, this tape could also be written with NASTRAN using ØUTPUT2 (UG 7.3.2.2).) NASTRAN tape label B9U is used for positive identification.

6. Add the two matrices to form MTXSUM.

7. Printout all three matrices.

8. Terminates DMAP sequence.

9. Terminates Executive Control Deck.

10-11. Case Control Deck is empty except for initiation of the Bulk Data Deck which should contain at least one Bulk Data Card (e.g., DMI cards with null data) and the ENDDATA card required to terminate the NASTRAN input stream.

7.3.4 DMAP - Structural Operations

The Structural Operation instructions (PM 4) include all the basic functions specialized to solving structural problems. These include processing of basic input data, generation and assembly of element and user specified stiffness, mass, damping and load matrices, execution of static and dynamic analyses and data recovery. The modules called by these DMAP instructions may in turn call the utility matrix operation subroutines as required to process the data.

The best examples for use of the Structural Operation DMAP instructions, of course, are the Rigid Formats themselves. A simple application is illustrated below. For more complex applications, see the Substructuring sample input in this Guide, Section 7.2.4. Additional examples are given in the User's Manual, Section 5.4.

7.3.4.1 Example 5 - Replace Program Generated Data with User Data

This example illustrates an alter to Rigid Format 3 (Normal Mode Analysis) so that a mass matrix input on DMIG Bulk Data cards is used in place of the NASTRAN generated mass matri..

```
Card No.

  1    ID         EXAMPLE5,DMIG
  2    APP        DISP
  3    TIME       2
  4    SØL        3,0
  5    ALTER      28,28
  6    MTRXIN,  ,MATPØØL,EQEXIN,SIL,/MFRØMDMI/,,/
  7               V,N,LUSET/V,N,NØMGG/C,N,0/C,N,0 $
  8    ENDALTER
  9    ALTER      30
 10    SETVAL     //V,N,EQIV/C,N,-1 $
 11    SAVE       EQIV $
 12    EQUIV      MFRØMDMI,MGG/EQIV $
 13    ENDALTER
 14    CEND
 15    TITLE = DMAP ALTER, EXAMPLE5
 16    METHØD = 10
 17    DISP = ALL
 18    BEGIN BULK
```

BULK DATA FIELD

Card No.	1	2	3	4	5	6	7	8	9	10
19	CØNRØD	1	1	2	1	1.0				
20	CØNRØD	2	2	3	1	1.0				
21	DMIG	MFRØMDMI	0	6	1	2				
22	DMIG	MFRØMDMI	2	1		2	1	1.5+3		
23	DMIG	MFRØMDMI	2	2		2	2	1.5+3		
24	EIGR	10	GIV				2			+EIG10
25	+EIG10	MAX								
26	GRID	1		0.0	0.0	0.0		123456		
27	GRID	2		1.0	1.0	0.0		3456		
28	GRID	3		2.0	0.0	0.0		123456		
29	MAT1	1	3.+7							
30	ENDDATA									

Notes:

2. Use displacement approach.
3. Select Rigid Format.
5. Replace line 28 of Rigid Format 3 (UM 3.4.1) with the following DMAP alter.

6-7. Use the structural operation MTRXIN (PM 4.57) to replace SMA2 (PM) and create the matrix MFRØMDMI supplied by the user on DMIG Bulk Data cards. Sets flag NØMGG = 1 if that matrix is created, otherwise sets flag to -1.

8. Conclude current alter package.
9. Initiate another alter package to be inserted following line 30 of Rigid Format 3 (without replacing line 30).

10-11. Set flag EQIV = -1 and save for use in next instruction.

12. Equivalence user supplied matrix (MFRØMDMI) to the NASTRAN mass matrix (MGG). This user supplied matrix will now be used in all subsequent operations which reference MGG.
13. Concludes current DMAP alter package.
14. Concludes Executive Control Deck.

15-18. Case Control deck for extracting normal modes and specification of output requests.

21-23. Provides data for user supplied mass matrix referenced above by the name provided here (MFRØMDMI).

Special Notes: The data set MATPØØL used as input for MTRXIN (Card No. 6) is generated during the NASTRAN preface operation (PM 2.3.2) and is <u>not</u> an output from a previously specified DMAP instruction. Also, the two cards #10 and 11 can be replaced by the entirely equivalent utility operation (UM 5.3.2):

```
PARAM //C,N,NØP/V,N,EQUIV = -1 $
```

8. OUTPUT AND PLOTTING

8.1 OVERVIEW

The possible options for printing and/or plotting the results obtained with NASTRAN are many and varied. In most cases the labeling of this output is self-explanatory, or it is deductively obvious. In spite of the wide variety of possible output, certain uniformity has been provided to expedite its interpretation. This chapter, therefore, will discuss only the characteristic sets of output and will describe some of the perhaps less obvious interpretations where necessary.

8.2 PRINTED OUTPUT

The types of NASTRAN printed output may be subdivided into four general categories according to input echo, error messages, Case Control requests, and miscellaneous. The latter category itself may be segregated into special output requests, controlled other than from Case Control, and automatic output. The location of this output will vary with the sequence of operations performed by NASTRAN, and some will vary with the particular computer system being used. Each of these output categories will be discussed in the sections that follow.

8.2.1 Input Data Echo and Diagnosis

The input data to NASTRAN undergoes extensive checking, rearranging, and numerical processing in the initial phases of execution. The Executive Control Deck, the Case Control Deck, the Bulk Data Deck, and the DMAP sequence are processed in four phases, each phase having its own procedure for processing and diagnosis.

The Executive Control Deck is printed as shown in Figure 8-1a on every execution of NASTRAN exactly as it is input on cards, except when approach DMAP is used. In this case, the DMAP deck is echoed later. Diagnostic messages, if any, follow the printout of each data card.

The Case Control Deck printout is shown in Figure 8-1b. All input cards are printed with no modifications. The diagnostic messages deal primarily with proper data format. In certain levels of NASTRAN, a complete list of all legal Case Control requests are printed if the user misspells a request. The plot control cards, a subset of the Case Control Deck, are processed in a similar manner.

The Bulk Data Deck may be printed in two forms, depending on the ECHØ option selected. The unsorted Bulk Data echo option (Figure 8-2) is an unprocessed printout of the input Bulk Data Deck. On a restart from a previous run, only the new cards and deletion cards are printed along with a sorted echo of the modified Bulk Data Deck, including these new cards that were added.

The default printout is a sorted echo (Figure 8-3) of all the Bulk Data cards to be used in the computer run. They are arranged in alphabetical and numerical order. All entries in fields 2-9 are shifted and left-justified by NASTRAN for proper alignment to facilitate the sorting. The continuation cards are printed following the parent card. No comment cards are printed in the sorted echo. Each card is assigned a sequence number on the left-hand side to allow for modification of the Bulk Data Deck on restart from a checkpoint.

The diagnostics are printed with the sorted Bulk Data Echo. If errors occurred in the data format, the card containing the error is identified as shown in Figure 8-3. On some systems it is printed again, and the specific data field containing the error is underlined. The Bulk Data Deck is processed one card at a time, and errors occurring from a combination of different data cards may not be detected at this time.

Following the Bulk Data Deck, in most versions of NASTRAN, is the DMAP compilation listing (UM 3.2 to 3.13). In normal structural analyses, this is a listing of the Rigid Format selected in the Executive Control Deck, including the user-selected ALTER modifications, if any. Chapter 3 of the User's Manual describes the Rigid Formats, and Chapter 5 of the User's Manual describes the details of the DMAP language. Diagnostics should not occur unless the user has modified the Rigid Format.

A special procedure is used on a restart from a previous run. The DMAP operations to be executed on this run are identified with an asterisk (*). The types of data which are to be modified are marked with a dollar sign ($). Only those users who are interested in the detailed mathematical operations performed during a restart need to be concerned with these details.

8.2.2 Error and Warning Messages

The NASTRAN system will print out messages to the user for several reasons: user information messages, user warning and fatal messages, and system error messages. Most of these messages are listed with a brief description in Chapter 6 of the User's Manual. Each message is given a number and may refer to a specific data item, mathematical operation, or internal operation. Fatal messages will cause the program to exit. Examples are given in Figure 8-4.

Of specific user interest are the user information messages which provide data regarding the performance of a particular job. User information messages 3023 through 3028 provide data on the matrix decomposition. These include such data as the semi-bandwidth (B), the active columns (C), the number of columns held in core (R), and the estimated CPU running time in seconds. Message number 3035 prints out the error ratio for a solution. Message number 2073 prints the method selected for a matrix multiply operation. These messages aid the user in detecting problems with running time and accuracy.

Another type of message is the warning of gridpoint singularities (Figure 8-4) which provides useful information. This printout lists the grid points which have a possible singularity in the stiffness matrix. The number of singularities and the specific unconstrained degrees of freedom (gridpoint displacements or rotations) are listed in the order that they are detected. This is only a warning message and may not be significant in certain special cases.

8.2.3 Printout Requested by Case Control

The output data processing for presentation of results is performed by NASTRAN with a single, general purpose routine which prints titles, labels, column headings, and the numerical results. It is therefore obvious that many types of data will share similar formats and have the same general appearance.

The Case Control input contains specifications for the type and contents of printout (UG 5.3). Each output request defines a physical type of variable and specifies a set of points (Figures 8-5, 6 and 7) or elements (Figures 8-8, 9 and 10) to which the request applies. Options are available to print out the results of a dynamic analysis in either of two types of sort. The default option, SØRT1, will print the results for all points or elements for each time step or frequency. SØRT2 will print the results (Figures 8-6 and 10) for each point or element for all time steps or frequencies.

In certain dynamic problems (Figures 8-7 and 10 for Complex Eigenvalues or Frequency Response), the output consists of complex numbers. The user has the option of specifying the output to be printed in a real/imaginary format or in a magnitude/phase angle format. Each pair of numbers is written with the real value or magnitude directly above the imaginary value or phase angle. (Note: The phase angles are in degrees.)

The most common format of printed output relates to the grid, scalar, or extra points (Figures 8-5, 6 and 7). The following quantities are printed in this format:

DISPLACEMENT	ACCELERATIØN
ØLØAD	VECTØR
SPCFØRCE	PRESSURE
VELØCITY	THERMAL

In dynamic analysis, the following types of output are available as SØLUTIØN set output (Figure 8-7):

SDISPLACEMENT	SACCELERATIØN
SVELØCITY	NLLØAD

This output provides the results only for the degrees of freedom used in the solution of the dynamic problem. If a direct formulation is used, the quantities printed relate to the motion of the grid, scalar, or extra points remaining after the constraints and matrix reductions have been applied. If a modal formulation is used, the output describes the motion of the modal coordinates and any user-supplied extra points. The NLLØAD output request provides the nonlinear, displacement-dependent loads generated only for the transient analysis.

Note that grid, scalar, and extra points as well as modal coordinates may be intermingled in the output. The points with only one degree of freedom are printed in a special format. The "ID" = N number is printed only for the first point in a sequential set of up to six such points. The results for the second and succeeding points are printed on the same line with the first. If more than six points occur in a numerical sequence, the seventh "ID" will be printed so as to identify the second line of printout, and so on for every succeeding set of six such points.

In the general gridpoint output, the values given for T1, T2, and T3 correspond to the three translations, and R1, R2, and R3 correspond to the three rotations of that grid point. The orientation of these displacement components is defined by the output displacement coordinate system, which is either the NASTRAN "basic" rectangular system or a special coordinate system that is specified by the user for that grid point. If a rectangular system is used, the T1, T2, T3 and R1, R2, R3 directions correspond to the X,Y,Z axes of that system. If a cylindrical system is used, the directions are T1 = u_r (radial), T2 = u_θ (circumferential), and T3 = u_z (axial). The rotations R1, R2, and R3 are given in units of radians and are defined as vectors with the same directions as the translations.

The formats of the element forces and stresses (Figures 8-8, 9 and 10) are not as uniform as the output formats for gridpoint data. Each element type has a particular set of output quantities which is printed in a self-explanatory format. These formats may vary with the type of analysis. Element force output, in general, is the self-equilibrating internal load system for that element in units of force (moment), or force (moment) per length. Element stress output, in general, consists of direct stresses at a particular point in the element. Both these sets of element output quantities are defined in the local element coordinate system. Chapter 2 of the User's Manual lists the output quantities available for each element. Examples of these printouts are given in Figures 8-8 and 9. The first example is a typical element stress output; the second is a more elaborate printout of the moments and shear forces occurring in the harmonic analysis of an axisymmetric conical shell element. As with the gridpoint data printout for dynamic analyses, these values may be real or complex, and may be requested in either SØRT1 or SØRT2 format (Figure 8-10).

8.2.4 Miscellaneous Printout

Along with the standard output options, certain results are printed automatically or may be selectively requested independent of the Case Control options. Those quantities which are selected by the user are described below, followed by a description of the results which are output automatically.

8.2.4.1 Parameter-Controlled Output

Specialized output may be requested via the PARAM Bulk Data Card (UM 3.1.5). These options include:

GRDPNT - requests the weight and balance results (Figure 8-11)

The output quantities for the user-specified grid points are:

1. Reference points.
2. Rigid body mass matrix [MO] relative to the reference point in the basic coordinate system.
3. Transformation matrix [S] from basic coordinate system to principal mass axes.
4. Principal masses and associated centers of gravity.
5. Inertia matrix I(S) about the center of gravity relative to the principal mass axes.
6. Inertia matrix I(Q) about the center of gravity relative to the principal inertia axes.
7. Transformation matrix [Q] such that $[I(Q)] = [Q]^T [I(S)] [Q]$.

The generality of this output is necessary due to the potential problems of the user inputting directional masses and general inertia terms. The effects of scalar points are ignored, but all other mass effects are included.

IRES - requests the printout of the static analysis residual load vector (Figure 8-12)

This will produce a printout of the error occurring at each solution degree of freedom for each static load vector. The form of the data is in general matrix output format printed by the DMAP module MATGPR (UM 5.3.2).

8.2.4.2 DMAP-Controlled Output

The Utility Output Module (UM 5.3.2) printout is controlled by including DMAP modules MATPRN, MATGPR, and/or TABPT in the DMAP alters to a Rigid Format or in the user-specified DMAP program. The MATGPR module which prints results with gridpoint references, and MATPRN module which prints results using the internal numbering sequence, are highly recommended for finding difficult errors in a matrix formulation, but the size of printout precludes their use in routine debugging of large problems. Examples of the printout format are given in Figures 8-12 and 13. The TABPT module prints the internal NASTRAN table data specified in the DMAP instructions. The use of these modules requires some knowledge of the DMAP language (UM 5), and requires an understanding of the NASTRAN data block contents (PM 2).

8.2.4.3 Automatic Printout

Diagnostic printout which may be augmented with the Executive Control DIAG card (UG 6.2, UM 2.2) is a convenient tool for the experienced NASTRAN user to analyze the execution of a problem. A description of all possible outputs is beyond the scope of this Guide. Also, an understanding of some of the available printout requires a knowledge of the NASTRAN program.

Some of this diagnostic output is automatic in most versions of the NASTRAN system. This printout occurs in different locations, depending on the particular computer system being used. The standard output consists of the begin and end times (DIAG 5,6) for every functional module and some of the major subroutines.

When a user requests a checkpoint be taken, the restart data is automatically printed. This data is written as it is created and is a duplicate of the checkpoint dictionary cards punched at the end of each run. If the restart deck is lost, the cards may be punched manually from this printout.

Every time an eigenvalue extraction routine is executed, the Eigenvalue Summary Tables are automatically printed. This occurs in normal modes, buckling, and complex eigenvalue analyses. The output shown in Figure 8-14 includes the eigenvalue routine diagnostics and the eigenvalues, frequencies, generalized (modal) mass, and generalized (modal) stiffness for each solution root. Refer to the Rigid Format descriptions (UM 3) for a definition of the contents printed for each Rigid Format.

Each time a plot output request is made, a Plot Summary Table is automatically printed for both the structure (Figure 8-15) or XYPLØT plot (Figures 8-16 and 17) operations. Each plot produces a page of output containing data in the scale factors, origins, sets, labels, and/or curve maximums and minimums.

8.3 STRUCTURAL PLOTTING

The structure plot control options as summarized in Table 8-1 are described in detail in Chapter 4 of the User's Manual. Illustrative examples of their use are explained in Chapter 7 of this Guide. The following describes the actual results and contains recommendations for general usage.

1. The undeformed plots are generated near the beginning of the NASTRAN execution. These plots are excellent tools to be used for checking the geometry and element connectivities of a model. For large complex problems, it is recommended that several plots be made using different sets of elements, view angles, and labeling options in various combinations. The user may then select the best views of his structure for plotting the results of subsequent runs.

2. Use of the FIND option is recommended to automatically calculate the origin and scaling factors used for plotting each section of a structure. Figure 8-15 illustrates the plot data summary printed out for each plot requested. If the user specifies his own data, it is possible that some points will not be included in the plot. This also occurs frequently when a different set of structure elements are plotted with the origin and scale of a previously plotted structure. The FIND card should be used before each PLØT command, unless the structure and view data are unchanged. This problem also

TABLE 8-1. SUMMARY FOR STRUCTURAL PLOTTING OPTIONS

STRUCTURAL PLOTTING OPTIONS	
PLØTID	Opt'l to give plot identification, must precede ØUTPUT (PLØT)
SET i	Req'd and specifies sets of elements for plotting (UM 4.2.2.1 for options)
PLØTTER	Opt'l to specify plotter name and MØDEL names (UM 4.1) if other than SC 4020 (UM 4.2.2.2 for options)
PRØJECTIØN	Opt'l to specify type if other than ØRTHØGRAPHIC (TM 13.)
AXES } VIEW }	Opt'l to define observer's coordinate system and to position the figure (UM 4.2.2.2)
MAXIMUM DEFØRMATIØN	Req'd to specify scale for plotting deformed structure and must precede FIND card (UM 4.2.2.2)
SCALE	Req'd to specify scale of plotted object, may be replaced by FIND card (UM 4.2.2.2)
ØRIGIN	Req'd to define origin of plotted object relative to lower left-hand corner of paper, may be replaced by FIND card (UM 4.2.2.2)
VANTAGE PØINT	Req'd to specify location of observer with respect to structural model for either prespéctive or stereoscopic projections only, may be replaced by FIND card (UM 4.2.2.2, TM 13.)
PRØJECTIØN PLANE SEPARATIØN	Req'd to specify R-direction separation of the observer and the projection plane for perspective or stereoscopic projections only, may be replaced by FIND card (UM 4.2.2.2, TM 13.)
ØCULAR SEPARATIØN	Opt'l to specify S-coordinate separation of the two vantage points of other than 2.756 inches in the stereoscopic projections only (UM 4.2.2.2)
CAMERA	Opt'l to specify type of film and/or paper and number of blank frames on microfilm plotters only (UM 4.2.2.2)

occurs when a deformed structure is plotted and the MAXIMUM DEFØRMATIØN card is missing. Without it, the scale is chosen to place the extreme limits of the structure at the edge of the plot. Large deformations at these points, therefore, might not get plotted.

3. The use of the symmetry options, perspective and stereo projections, and user-defined scales and origins is not recommended for the inexperienced user. See the sample input data decks of Section 7.1.1.2 for examples and explanations. These options are best approached in an experimental mode with the anticipation of encountering some problems. These options are precisely defined in the User's Manual, Chapter 4, but there are many possibilities for user errors.

4. Quite frequently some of the plotter choices available in NASTRAN are not compatible with a certain installation hardware or may be inefficient for some plotters. Plot tape conversion programs are commonly available to remedy these situations. They require only an additional tape set-up and an extra job step in the job control deck.

8.4 XYØUT/XYPLØT*

The XYØUT options (UM 4.3) are used for a variety of purposes in dynamic analysis. The prime use is to produce curve plots of selected variables versus time or frequency. The options are also available to print out selected components of the results versus time or frequency, or to print out the peak values only. Also, the printer itself may be used as a plotter when quick qualitative results are desired. The printed characters are placed in locations on the printout to represent one or more curves at a time.

The XYØUT options provide the <u>only</u> means for requesting printed output from a Random Response analysis. Examples of the printed output provided are shown in Figures 8-16 and 17. Note that this output includes maximums and minimums for each curve being plotted.

The command cards to produce XYØUT printout or plots are illustrated in examples given in Chapter 7 of this Guide, and details are described in Section 4.3 of the User's Manual. The following discussion is concerned with aiding the user in interpreting his output and avoiding problems.

1. Quite frequently the user cannot anticipate the critical points and elements for which plots are desired. The use of a shotgun approach to plot a large number of points and elements may be inefficient and confusing. A common procedure is to checkpoint the solution run and print out

---

*XYØUT and XYPLØT options are synonymous.

much of the data. From these data, the critical points and elements and the plot scales may be selected, and a restart can be made for plotting only.

2. The automatic selection of scales in the XYPLØT option was designed for the general case and may be undesirable for a specific user problem. For instance, quantities which are to be compared should be plotted with the same scale with perhaps more than one curve plotted per page. But, the plotter automatically sizes each plot to reach the upper and lower limits of the plot region specified. The procedure suggested in #1 above should help avoid this problem.

3. The automatic labeling of the plots includes the point or element identification number and plot sequence number. This sequence number corresponds to the order in which the plots were created. A separate and unique TCURVE title for each frame should be input for every plot. Later this title will be very useful when the user attempts to recall what he had intended to have shown in each plot.

4. The number of options available in the XYØUT control package is usually overshelming to the beginner. It is suggested that, at first, single plots be placed on single frames and that most of the defaults be used. If a checkpoint has been taken, the options could be selectively and economically experimented with, using the restart feature of NASTRAN.

8.5 MATRIX TOPOLOGY

NASTRAN provides a special capability to print or plot the topology of any matrix. This capability requires the user to insert a DMAP alter packet (UG 7.3) with the SEEMAT instruction (UM 5.3.2) which identifies the matrix data set and selects the output options. Whether printed or plotted, the SEEMAT output will show the nonzero matrix elements positioned pictorially by row and column within the outlines of the matrix. Currently, SEEMAT identifies each degree of freedom which, for large matrices, will produce a large volume of output.

```
N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K          MAY   3, 1969

ID        DEMI01,NASTRAN
UMF       21904   110101
CHKPNT    YES
APP       DISPLACEMENT
SOL       1,1
TIME      5
CEND

DELTA WING WITH BICONVEX CROSS SECTION                               MAY   3, 1969
NASTRAN DEMONSTRATION PROBLEM NO. 1-1

LOAD ON TRAILING EDGE

                        C A S E   C O N T R O L   D E C K   E C H O
CARD
COUNT
  1      TITLE = DELTA WING WITH BICONVEX CROSS SECTION
  2      SUBTITLE = NASTRAN DEMONSTRATION PROBLEM NO. 1-1
  3      LABEL =      LOAD ON TRAILING EDGE
  4         SPC = 1
  5          LOAD = 1
  6      OUTPUT
  7      $    SET 1  HAS GRIDS ON THE UPPER SURFACE  * * * * * * * * * * * * * * *
  8      $     SET 2  HAS TOP SURFACE ELEMENTS, SHEAR(TRAILING AND LEADING EDGE),
  9      $      SHEAR(CENTERLINE - BOTH DIRECTIONS), SHEAR(TIP)    * * * * * * * *
 10      $
 11               SET 1 = 11 THRU 18,31 THRU 36,51 THRU 55,71 THRU 74,91 THRU 93
 12               SET 2 = 1 THRU 22,28 THRU 31, 35, 36, 41 THRU 44, 50
 13      $
 14               DISPLACEMENTS = 1
 15               SPCFORCE = ALL
 16           ELSTRESS = 2
 17      BEGIN BULK
```

FIGURE 8-1 EXECUTIVE AND CASE CONTROL DECK ECHO

```
SIMPLY SUPPORTED RECTANGULAR PLATE REINFORCED BY TEE SECTIONS          JULY 30, 1973   NASTRAN  2/ 1/73    PAGE
EFFECT OF NEUTRAL AXIS OFFSET OF BAR FROM PLATE IS IGNORED


                              I N P U T   B U L K   D A T A   D E C K   E C H O

                    .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                    GRID    1                0.0     0.0     0.0
                    GRID    2               10.0     0.0     0.0
                    GRID    3               20.0     0.0     0.0
                    GRID    4                0.0    15.0     0.0
                    GRID    5               10.0    15.0     0.0
                    GRID    6               20.0    15.0     0.0
                    GRID    7                0.0    30.0     0.0
                    GRID    8               10.0    30.0     0.0
                    GRID    9       20.0    30.0     0.0
                    SPC1    10      6       1       3       7       9
                    SPC1    10      3       1       2       3       4       6       7       +SP
                    +SP     8       9
                    SPC1    10      2       1       3
                    SPC1    10      1       2
                    MAT1    50      1.0E+7          .32
                    FORCE1  22      8       20000.0 2       8
                    FORCE   11      5               -1200.0 0.0     0.0     1.0
                    CQUAD1  11      70      1       2       5       4
                    CQUAD1  12      70      2       3       6       5
                    CQUAD1  13      70      4       5       8       7
                    CQUAD1  14      70      5       6       9       8
                    PQUAD1  70      50      .1      50      8.3333-5 50     .1              +PQ
                    +PQ     .05     -.05
                    CBAR    101     60      2       5       4                       2
                    CBAR    102     60      4       5       8                       2
                    CBAR    103     60      6       5       2                       2
                    CBAR    104     60      8       5       6                       2
                    $
                    PBAR    60      50      1.61    .75     .94     .09                     +BAR
                    +BAR    -1.5    .68     1.5     .68     .15625  -1.52   -.15625 -1.82
                    $
                    $ TEE SECTION---FLANGE=3  STEM=2.5  THICKNESS=5/16
                    $
                    ENDDATA

              TOTAL COUNT=   34


*** USER INFORMATION MESSAGE 207, BULK DATA NOT SORTED,XSORT WILL RE-ORDER DECK.
```

FIGURE 8-2 UNSORTED BULK DATA DECK ECHO

S O R T E D B U L K D A T A E C H O

CARD COUNT	. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
1-	CBAR	101	60	2	5	4			2	
2-	CBAR	102	60	4	5	8			2	
3-	CBAR	103	60	6	5	2			2	
4-	CBAR	104	60	8	5	6			2	
5-	CQUAD1	11	70	1	2	5	4			
6-	CQUAD1	12	70	2	3	6	5			
7-	CQUAD1	13	70	4	5	8	7			
8-	CQUAD1	14	70	5	6	9	8			
9-	FORCE	11	5		-1200.0	.0	.0	1.0		
10-	FORCE1	22	8	20000.0	2	8				
11-	GRID	1		.0	.0	.0				
12-	GRID	2		10.0	.0	.0				
13-	GRID	3		20.0	.0	.0				
14-	GRID	4		.0	15.0	.0				
15-	GRID	5		10.0	15.0	.0				
16-	GRID	6		20.0	15.0	.0				
17-	GRID	7		.0	30.0	.0				
18-	GRID	8		10.0	30.0	.0				
19-	GRID	9	20.0	30.0	.0					
20-	MAT1	50	1.0E+7		.32					
21-	PBAR	60	50	1.81	.75	.94	.09			+BAR
22-	+BAR	-1.5	.68	1.5	.68	.15625	-1.52	-.15625	-1.82	
23-	PQUAD1	70	50	.1	50	8.3333-550		.1		+PQ
24-	+PQ	.05	-.05							
25-	SPC1	10	1	2						
26-	SPC1	10	2	1	3					
27-	SPC1	10	3	1	2	3	4	6	7	+SP
28-	+SP	8	9							
29-	SPC1	10	6	1	3	7	9			
	ENDDATA									

*** USER FATAL MESSAGE 307, ILLEGAL NAME FOR BULK DATA CARD CQUADI

*** USER FATAL MESSAGE 315, FORMAT ERROR ON BULK DATA CARD GRID 9 SORTED CARD COUNT = 19

JOB TERMINATED DUE TO ABOVE ERRORS

FIGURE 8-3 SORTED BULK DATA DECK ECHO AND DIAGNOSTICS

```
*** USER INFORMATION MESSAGE 2073, MPYAD METHOD          1,NO. PASSES =          1

***USER INFORMATION MESSAGE 3035

FOR LOAD     1 EPSILON SUB E =  -3.5597472-15


***USER INFORMATION MESSAGE 3023

B =      27 C =       1 R =      26

***USER INFORMATION MESSAGE 3027

DECOMPOSITION TIME ESTIMATE IS        6


*** USER WARNING MESSAGE 2015, NO ELEMENTS CONNECT INTERNAL GRID POINT          8

*** USER WARNING MESSAGE 2015, NO ELEMENTS CONNECT INTERNAL GRID POINT         12


COMPLEX EIGENVALUE ANALYSIS OF A ROCKET CONTROL SYSTEM          MAY   3, 1969      PAGE    17
NASTRAN DEMONSTRATION PROBLEM NO. 10-1

FLEXIBLE STRUCTURE CASE
```

G R I D   P O I N T   S I N G U L A R I T Y   T A B L E

POINT ID.	TYPE	SINGULARITY ORDER	LIST OF COORDINATE COMBINATIONS THAT WILL REMOVE SINGULARITY — STRONGEST COMBINATION	WEAKER COMBINATION	WEAKEST COMBINATION
101	G	1	2		
101	G	1	6		
100	G	1	2		
100	G	1	6		

FIGURE 8-4 SAMPLES OF NASTRAN MESSAGES

SPHERICAL SHELL WITH PRESSURE LOADING, NO MOMENTS ON BOUNDARY MAY 3, 1969 PAGE 24
NASTRAN DEMONSTRATION PROBLEM NO. 1-2

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

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-3.696471-04	-4.165500-07	.0	.0	.0	-4.662165-08
2	G	-3.717106-04	-6.684192-07	.0	.0	.0	3.332521-07
3	G	-3.724426-04	-6.529852-08	.0	.0	.0	-4.098735-07
4	G	-3.403430-04	8.604606-07	.0	.0	.0	-2.526694-06
5	G	-3.257666-04	.0	.0	.0	.0	-4.607509-06
6	G	-3.666220-04	-2.433428-07	-2.668172-13	-7.031274-13	-4.269667-13	-5.214647-07

(a) GENERAL THREE DIMENSIONAL DISPLACEMENTS

NONSYMMETRIC BENDING OF A CYLINDER OF REVOLUTION MAY 3, 1969 PAGE 15
NASTRAN DEMONSTRATION PROBLEM NO. 1-5

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

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
5	0	-5.596043-01	.0	7.232452-03	.0	2.147646-02	.0
10	0	-2.662636-01	.0	1.458527-02	.0	6.399009-02	.0
15	0	-2.968834-02	.0	1.307471-02	.0	2.880915-02	.0
20	0	4.575958-02	.0	7.061837-03	.0	5.657684-03	.0
25	0	5.523072-02	.0	1.927594-14	.0	-3.257319-15	.0
30	0	4.575958-02	.0	-7.061837-03	.0	-5.657684-03	.0
35	0	-2.968834-02	.0	-1.307471-02	.0	-2.880915-02	.0
40	0	-2.662636-01	.0	-1.458527-02	.0	-6.399009-02	.0
45	0	-5.596043-01	.0	-7.232452-03	.0	-2.147646-02	.0
50	0	.0	.0	.0	.0	3.313595-01	.0
100	0	.0	.0	.0	.0	-3.313595-01	.0
5	1	-5.755621-01	2.169677-02	7.638954-03	.0	1.842680-02	-1.091299-02
10	1	-2.946750-01	3.102718-02	1.486085-02	.0	6.220968-02	-5.297229-03
15	1	-6.336755-02	3.308212-02	1.320076-02	.0	2.835333-02	-6.429863-04
20	1	1.148996-02	3.310501-02	7.110834-03	.0	5.719255-03	8.769679-04
25	1	2.125947-02	3.300953-02	4.095466-14	.0	-6.715231-15	1.082555-03
30	1	1.148996-02	3.310501-02	-7.110834-03	.0	-5.719255-03	8.769679-04
35	1	-6.336756-02	3.308212-02	-1.320076-02	.0	-2.835333-02	-6.429863-04
40	1	-2.946750-01	3.102718-02	-1.486085-02	.0	-6.220968-02	-5.297229-03
45	1	-5.755621-01	2.169677-02	-7.638954-03	.0	-1.842680-02	-1.091299-02

(b) AXISYMMETRIC DISPLACEMENT COMPONENTS

FIGURE 8-5 STATIC ANALYSIS "DISP=" OUTPUT

TRANSIENT ANALYSIS OF A 1000 CELL STRING
NASTRAN DEMONSTRATION PROBLEM NO. 9-2

MAY 3, 1969 PAGE 98

TRAVELING WAVE PROBLEM
POINT-ID = 26

V E L O C I T Y   V E C T O R

TIME	TYPE	T1	T2	T3	R1	R2	R3
.0	S	2.753619-05					
5.000000-04	S	4.575292-04					
1.000000-03	S	3.923509-03					
1.500000-03	S	2.297032-02					
2.000000-03	S	1.026892-01					
2.500000-03	S	3.721990-01					
3.000000-03	S	1.139675+00					
3.500000-03	S	2.943666+00					
4.000000-03	S	6.881613+00					
4.500000-03	S	1.409852+01					
5.000000-03	S	2.588700+01					
5.500000-03	S	4.298514+01					
6.000000-03	S	6.436431+01					
6.500000-03	S	8.776041+01					
7.000000-03	S	1.088619+02					
7.500000-03	S	1.229428+02					
8.000000-03	S	1.266049+02					
8.500000-03	S	1.195725+02					
9.000000-03	S	1.059307+02					
9.500000-03	S	9.060924+01					
9.999999-03	S	8.172266+01					
1.050000-02	S	8.249929+01					
1.100000-02	S	9.176345+01					
1.150000-02	S	1.038826+02					
1.200000-02	S	1.115775+02					
1.250000-02	S	1.097126+02					
1.300000-02	S	9.792263+01					
1.350000-02	S	8.046339+01					
1.400000-02	S	6.327809+01					
1.450000-02	S	4.997641+01					
1.500000-02	S	3.936643+01					
1.550000-02	S	2.586167+01					
1.600000-02	S	3.225580+00					
1.650000-02	S	-3.109005+01					
1.700000-02	S	-7.339650+01					
1.750000-02	S	-1.146411+02					
1.800000-02	S	-1.449975+02					
1.850000-02	S	-1.576959+02					
1.900000-02	S	-1.529755+02					
1.950000-02	S	-1.362941+02					
2.000000-02	S	-1.159276+02					

FIGURE 8-6 TRANSIENT ANALYSIS "VELØ(SØRT2)=" OUTPUT

FLEXIBLE STRUCTURE CASE
COMPLEX EIGENVALUE = -1.505789+00, 9.731801-27

COMPLEX EIGENVECTOR NO. 1 (SOLUTION SET)
(MAGNITUDE/PHASE)

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	M	3.999034-01	2.656004-01	1.076607-02	1.558504-03		
		.0000	180.0000	180.0000	.0000		
1010	E	3.375449-04	1.693200-03				
		.0000	.0000				
1020	E	1.349396-23	1.412120-21				
		-.0000	-.0000				
1030	E	1.280088-03					
		180.0000					
1040	E	2.000000-03					
		.0000					
1050	E	2.000000-03					
		.0000					
1060	E	1.000000+00					
		.0					
1070	E	4.167406-05					
		180.0000					
1080	E	3.733793-04					
		.0000					

FIGURE 8-7 COMPLEX EIGENVECTOR "SVECTØR(SØRT1,PHASE)=" OUTPUT

PIECEWISE LINEAR ANALYSIS OF A THREE-PANEL TRUSS MAY 3, 1969 PAGE 37

NASTRAN DEMONSTRATION PROBLEM NO. 6 - 1

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN	ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN
1	3.011292+01	-7.7-01	.0	1.0+00	2	-1.890359+01	-6.0-01	.0	1.0+00
3	2.039082+01	-2.0-01	.0	1.0+00	4	3.011292+01	-7.7-01	.0	1.0+00
6	-2.548853+01	-1.2+00	.0	1.0+00	7	3.398471+01	-1.0+00	.0	1.0+00
8	-2.362949+01	-1.0+00	.0	1.0+00	9	3.764115+01	-1.2+00	.0	1.0+00

(a) RØD ELEMENT STRESSES

SPHERICAL SHELL WITH PRESSURE LOADING, NO MOMENTS ON BOUNDARY MAY 3, 1969 PAGE 27
NASTRAN DEMONSTRATION PROBLEM NO. 1-2

S T R E S S E S   I N   G E N E R A L   T R I A N G U L A R   E L E M E N T S   (C T R I A 2)

ELEMENT ID.	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM NORMAL-X	NORMAL-Y	SHEAR-XY	PRINCIPAL STRESSES (ZERO SHEAR) ANGLE	MAJOR	MINOR	MAX SHEAR
16	1.500000+00	-1.536602+01	-1.491124+01	-1.209651-01	-61.3049	-1.484502+01	-1.513223+01	1.436026-01
	-1.500000+00	-1.509194+01	-1.473920+01	6.150864-01	53.0003	-1.427571+01	-1.555546+01	6.398759-01
17	1.500000+00	-1.519199+01	-1.470562+01	-1.016779-01	-78.6549	-1.468522+01	-1.521239+01	2.635667-01
	-1.500000+00	-1.476342+01	-1.516263+01	6.008628-01	35.8119	-1.432988+01	-1.559617+01	6.331492-01
18	1.500000+00	-1.461260+01	-1.468054+01	3.397823-02	22.5040	-1.459852+01	-1.469462+01	4.804581-02
	-1.500000+00	-1.505332+01	-1.564760+01	2.963749-01	22.4629	-1.493078+01	-1.577014+01	4.196811-01
19	1.500000+00	-1.489862+01	-1.457938+01	-1.527104-06	-89.9997	-1.457938+01	-1.489862+01	1.596195-01
	-1.500000+00	-1.507481+01	-1.544139+01	2.149257-06	.0003	-1.507481+01	-1.544139+01	1.832914-01
20	1.500000+00	-1.461260+01	-1.468059+01	-3.397929-02	-22.5043	-1.459852+01	-1.469462+01	4.804677-02
	-1.500000+00	-1.505332+01	-1.564760+01	-2.963742-01	-22.4629	-1.493078+01	-1.577014+01	4.196803-01
21	1.500000+00	-1.519198+01	-1.470562+01	1.016759-01	78.6550	-1.468522+01	-1.521238+01	2.635840-01
	-1.500000+00	-1.476343+01	-1.516263+01	-6.008611-01	-35.8119	-1.432968+01	-1.559618+01	6.331472-01

(b) TRIA2 ELEMENT STRESSES

FIGURE 8-8 STATIC ANALYSIS "STRESS=" OUTPUT

F O R C E S   I N   A X I S - S Y M M E T R I C   C O N I C A L   S H E L L   E L E M E N T S   (CCONEAX)

ELEMENT ID.	HARMONIC NUMBER	POINT ANGLE	BEND-MOMENT U	BEND-MOMENT V	TWIST-MOMENT	SHEAR U	SHEAR V
1	0		9.071877-01	2.721563-01	.0	2.030700-01	.0
1	1		9.085724-01	2.731370-01	2.233313-02	2.025647-01	-2.745126-02
1	2		9.126810-01	2.761456-01	4.630967-02	2.010809-01	-5.757006-02
1	3		9.192043-01	2.813055-01	7.324657-02	1.987694-01	-9.240669-02
1	4		9.268586-01	2.884646-01	1.033259-01	1.961126-01	-1.323476-01
1	5		9.323465-01	2.965417-01	1.339463-01	1.942670-01	-1.728126-01
1	6		9.316562-01	3.035463-01	1.595286-01	1.949096-01	-2.040241-01
1	7		9.246103-01	3.084189-01	1.764158-01	1.990153-01	-2.218667-01
1	8		9.145965-01	3.117896-01	1.859429-01	2.063346-01	-2.269165-01
1	9		9.040801-01	3.144535-01	1.908449-01	2.162097-01	-2.244102-01
1	10		8.937379-01	3.166925-01	1.928555-01	2.280256-01	-2.172824-01
1	11		8.835814-01	3.185520-01	1.929356-01	2.412296-01	-2.071626-01
1	12		8.735509-01	3.200529-01	1.917135-01	2.553445-01	-1.951109-01
1	13		8.636278-01	3.212330-01	1.896369-01	2.699943-01	-1.818762-01
1	14		8.538194-01	3.221362-01	1.870202-01	2.849045-01	-1.679809-01
1	15		8.441393-01	3.228024-01	1.840767-01	2.998614-01	-1.537768-01
1	16		8.345971-01	3.232638-01	1.809477-01	3.147925-01	-1.394963-01
1	17		8.252059-01	3.235455-01	1.777262-01	3.295459-01	-1.252914-01
1	18		8.159635-01	3.236665-01	1.744732-01	3.440771-01	-1.112618-01
1	19		8.068731-01	3.236422-01	1.712292-01	3.583413-01	-9.747308-02
1	20		7.979344-01	3.234846-01	1.680209-01	3.723067-01	-8.390856-02
1		.0000	1.847483+01	6.465031+00	.0	5.310777+00	.0
1		90.0000	8.468690-01	2.970249-01	-8.341649-02	2.949634-01	4.090912-02
1		180.0000	8.503440-01	2.977676-01	6.146151-08	2.911400-01	-1.154176-07
6	0		2.178815-01	6.536445-02	.0	1.033475-01	.0
6	1		2.197678-01	6.754273-02	-3.961314-03	1.030625-01	4.665272-03
6	2		2.252800-01	7.465420-02	-5.911344-03	1.023028-01	9.832371-03
6	3		2.337939-01	8.821573-02	-3.980253-03	1.010830-01	1.594912-02
6	4		2.434647-01	1.076345-01	2.539389-03	9.957194-02	2.352673-02
6	5		2.500850-01	1.373927-01	1.131351-02	9.780431-02	3.265910-02
6	6		2.482696-01	1.646357-01	1.644711-02	9.539557-02	4.245351-02
6	7		2.365386-01	1.841555-01	1.414298-02	9.198642-02	5.140474-02
6	8		2.181493-01	1.948659-01	6.490268-03	8.792591-02	5.861671-02
6	9		1.966463-01	1.990757-01	-2.934985-03	8.379769-02	6.393418-02
6	10		1.741971-01	1.987451-01	-1.213212-02	7.985938-02	6.797517-02
6	11		1.521130-01	1.961231-01	-2.032736-02	7.608950-02	6.945035-02
6	12		1.312295-01	1.891413-01	-2.726539-02	7.238293-02	7.011791-02
6	13		1.120336-01	1.815553-01	-3.290123-02	6.865913-02	6.974180-02
6	14		9.474764-02	1.729594-01	-3.729152-02	6.488734-02	6.656062-02

FIGURE 8-9 STATIC ANALYSIS "ELFØRCE=" OUTPUT (AXISYMMETRIC)

ONE POINT LOADED WITH TWO SETS AND TIME DELAYS SUBCASE 2
ELEMENT-ID = 5

C O M P L E X F O R C E S I N B A R E L E M E N T S (C B A R)
(MAGNITUDE/PHASE)

FREQUENCY	BEND-MOMENT-END-A PLANE 1	PLANE 2	BEND-MOMENT-END-B PLANE 1	PLANE 2	SHEAR PLANE 1	PLANE 2	FORCE	TORQUE
.0	1.071971+03	.0	1.179365+03	.0	5.394678+01	.0	.0	.0
	180.0000	.0	180.0000	.0	.0	.0	.0	.0
5.000000+00	1.077610+03	.0	1.185641+03	.0	5.401601+01	.0	.0	.0
	175.9938	.0	176.0108	.0	356.1799	.0	.0	.0
1.000000+01	1.096864+03	.0	1.205357+03	.0	5.424707+01	.0	.0	.0
	171.9954	.0	172.0290	.0	352.3686	.0	.0	.0
1.500000+01	1.132031+03	.0	1.241451+03	.0	5.471235+01	.0	.0	.0
	168.0118	.0	168.0613	.0	348.5735	.0	.0	.0
2.000000+01	1.188673+03	.0	1.299996+03	.0	5.556604+01	.0	.0	.0
	164.0478	.0	164.1121	.0	344.7997	.0	.0	.0
2.500000+01	1.278665+03	.0	1.392848+03	.0	5.709877+01	.0	.0	.0
	160.1023	.0	160.1794	.0	341.0432	.0	.0	.0
3.000000+01	1.424743+03	.0	1.544568+03	.0	5.992305+01	.0	.0	.0
	156.1584	.0	156.2456	.0	337.2630	.0	.0	.0
3.500000+01	1.682412+03	.0	1.813306+03	.0	6.546242+01	.0	.0	.0
	152.1506	.0	152.2437	.0	333.4415	.0	.0	.0
4.000000+01	2.219030+03	.0	2.375034+03	.0	7.802432+01	.0	.0	.0
	147.8287	.0	147.9216	.0	329.2431	.0	.0	.0
4.500000+01	3.878051+03	.0	4.116480+03	.0	1.192497+02	.0	.0	.0
	141.7748	.0	141.8580	.0	323.2104	.0	.0	.0
5.000000+01	3.219718+04	.0	3.384457+04	.0	8.238732+02	.0	.0	.0
	43.0830	.0	43.1425	.0	224.3046	.0	.0	.0
5.500000+01	2.699943+03	.0	2.605529+03	.0	5.279389+01	.0	.0	.0
	327.9482	.0	327.9627	.0	148.3330	.0	.0	.0

FIGURE 8-10 COMPLETE ANALYSIS "ELFØRCE(SØRT2,PHASE)=" OUTPUT

FLEXIBLE STRUCTURE CASE

```
                    O U T P U T   F R O M   G R I D   P O I N T   W E I G H T   G E N E R A T O R

                                           REFERENCE POINT =        101

                                                    M O
      *                                                                                                *
      *  8.499999+04   0.000000      0.000000      0.000000      0.000000      0.000000      *
      *  0.000000      8.499999+04   0.000000      0.000000      0.000000      3.969336+01   *
      *  0.000000      0.000000      8.499999+04   0.000000     -3.969336+01   0.000000      *
      *  0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      *
      *  0.000000      0.000000     -3.969336+01   0.000000      5.025258+08   0.000000      *
      *  0.000000      3.969334+01   0.000000      0.000000      0.000000      5.025258+08   *
      *                                                                                                *

                                                    S
                  *                                              *
                  *  1.000000+00   0.000000      0.000000      *
                  *  0.000000      1.000000+00   0.000000      *
                  *  0.000000      0.000000      1.000000+00   *
                  *                                              *

          DIRECTION
     MASS AXIS SYSTEM (S)       MASS            X-C.G.        Y-C.G.        Z-C.G.
               X             8.499999+04     0.000000      0.000000      0.000000
               Y             8.499999+04     4.669807-04   0.000000      0.000000
               Z             8.499999+04     4.669807+04   0.000000      0.000000

                                                    I(S)
                  *                                              *
                  *  0.000000      0.000000      0.000000      *
                  *  0.000000      5.025258+08   0.000000      *
                  *  0.000000      0.000000      5.025258+08   *
                  *                                              *

                                                    I(G)
                  *                                              *
                  *  0.000000                                    *
                  *                5.025258+08                   *
                  *                              5.025258+08   *
                  *                                              *

                                                    Q
                  *                                              *
                  *  1.000000+00   0.000000      0.000000      *
                  *  0.000000      1.000000+00   0.000000      *
                  *  0.000000      0.000000      1.000000+00   *
                  *                                              *
```

FIGURE 8-11 INERTIA AND CENTER OF GRAVITY ("PARAM=GRDPNT") OUTPUT

5X40 LONG, NARROW, ORTHOTROPIC PLATE   MAY 3, 1969   PAGE 31
NASTRAN DEMONSTRATION PROBLEM No. 1-4

SEQUENCED FOR WIDE BAND

RULV

COLUMN 1 (1-T3).

POINT	VALUE	POINT	VALUE	POINT	VALUE	POINT	VALUE	POINT	VALUE
1 T3	-1.68615-15	7 T3	-6.47052-15	7 R1	3.63598-15	13 T3	-2.27596-15	13 R1	1.42247-15
19 T3	-5.55458-15	19 R1	6.31439-16	25 T3	-2.79117-15	25 R1	-5.62867-16	31 T3	-1.91167-15
31 R1	2.15106-16	37 T3	-2.79290-15	37 R1	1.81452-15	43 T3	-3.42434-15	43 R1	1.11369-15
49 T3	-1.73819-15	49 R1	3.78170-16	55 T3	-2.79030-15	55 R1	4.64906-16	61 T3	-7.61493-16
61 R1	5.01335-16	67 T3	-5.85469-16	67 R1	6.31439-16	73 T3	-1.01742-15	73 R1	5.53377-16
79 T3	-9.65807-16	79 R1	2.08167-16	85 T3	-9.06393-16	85 R1	-2.82760-15	91 T3	-1.05384-16
91 R1	1.50054-16	97 T3	-5.16514-16	97 R1	3.81639-16	103 T3	-8.59555-16	103 R1	2.26381-16
109 T3	1.64799-17	109 R1	1.52656-16	115 T3	-5.84385-16	115 R1	8.93383-17	121 T3	-2.62109-16
121 R1	-4.16334-17	127 T3	-6.42932-17	127 R1	5.81112-17	133 T3	-2.71051-16	133 R1	1.19913-16
139 T3	-1.75966-16	139 R1	8.47846-17	145 T3	-1.75207-16	145 R1	-3.17250-17	151 T3	-3.58329-17
151 R1	2.34188-17	157 T3	-1.66659-16	157 R1	5.51859-17	163 T3	-1.00614-16	163 R1	5.42101-17
169 T3	-2.28767-17	169 R1	7.22079-17	175 T3	-9.69819-17	175 R1	5.65954-17	181 T3	-4.85994-17
181 R1	3.75134-17	187 T3	-5.97666-17	187 R1	3.44776-17	193 T3	-4.31241-17	193 R1	3.01950-17
199 T3	-5.29091-17	199 R1	1.42030-17	205 T3	-3.48707-17	205 R1	4.39102-18	211 T3	-3.14961-17
211 R1	-1.14654-17	217 T3	-1.42979-17	217 R1	-1.10860-17	223 T3	-1.67645-17	229 T3	-1.46232-17
229 R1	2.03288-18	235 T3	-7.16929-18	235 R1	7.45389-19	241 T3	-1.26852-17	241 R1	7.66047-18
247 T3	-9.37935-18	247 R1	-4.70128-19	253 T3	-8.52793-18	253 R1	1.15196-16	259 T3	1.80249-18
259 R1	1.00249-18	265 T3	-2.05998-18	265 R1	3.80148-18	271 T3	-7.49455-18	271 R1	2.98833-18
277 T3	-3.50672-19	277 R1	1.61953-18	283 T3	-4.08270-18	283 R1	2.12097-18	289 T3	-7.77576-19
289 R1	5.96311-19	295 T3	-2.36830-18	295 R1	1.40946-18	301 T3	-1.18415-18	301 R1	1.20617-18
307 T3	-9.11407-19	307 R1	1.52127-18	313 T3	-2.04558-18	313 R1	3.74389-19	319 T3	-6.26804-19
319 R1	8.97855-19	325 T3	-1.53421-18	325 R1	1.41763-18	331 T3	-1.11806-18	331 R1	7.86047-19
337 T3	-4.92124-19	337 R1	1.84160-19	343 T3	-1.11512-18	343 R1	3.30343-19	349 T3	-1.88465-19
349 R1	6.60684-20	355 T3	-4.04982-19	355 R1	5.25160-19	361 T3	-5.31937-19	361 R1	2.11756-19
2 T3	-3.28624-14	2 R2	-3.38618-15	8 T3	-8.57439-14	8 R1	3.63027-15	8 R2	-9.27036-15
14 T3	-7.70078-14	14 R1	-1.19349-15	14 R2	-4.20997-15	20 T3	-7.51552-14	20 R1	-5.14866-15
20 R2	-9.02262-15	26 T3	-7.21437-14	26 R1	-5.56112-17	26 R2	-2.10942-15	32 T3	-6.92571-14
32 R1	-1.01308-15	32 R2	-3.81986-15	38 T3	-5.30742-14	38 R1	-1.97065-15	38 R2	-5.25621-15
44 T3	-5.03035-14	44 R1	5.89806-16	44 R2	-5.27703-15	50 T3	-5.22863-14	50 R1	-9.71445-17
50 R2	-2.07126-15	56 T3	-3.80763-14	56 R1	5.34295-16	56 R2	-3.29597-15	62 T3	-4.05036-14
62 R1	8.22259-16	62 R2	-3.70363-15	68 T3	-3.28002-14	68 R1	4.05925-16	68 R2	-3.05658-15
74 T3	-3.20039-14	74 R1	-1.60289-15	74 R2	-1.00614-15	80 T3	-2.64519-14	80 R1	-5.23806-16
80 R2	-1.44329-15	86 T3	-2.48421-14	86 R1	8.79505-16	86 R2	-2.19789-15	92 T3	-2.14108-14
92 R1	7.54605-16	92 R2	-2.11550-15	98 T3	-1.84262-14	98 R1	9.00321-16	98 R2	-1.53870-15
104 T3	-1.34744-14	104 R1	1.94289-16	104 R2	-1.10719-15	110 T3	-1.43358-14	110 R1	-3.08781-16
110 R2	-8.65193-16	116 T3	-1.10949-14	116 R1	-4.01568-16	116 R2	-7.06900-16	122 T3	-8.06815-15
122 R1	6.76542-17	122 R2	-5.21718-16	128 T3	-8.34489-15	128 R1	-9.02056-17	128 R2	-4.56232-16
134 T3	-6.33261-15	134 R1	-1.22732-16	134 R2	-6.30896-16	140 T3	-5.46156-15	140 R1	1.38778-17
140 R2	-4.61220-16	146 T3	-4.02040-15	146 R1	2.46764-16	146 R2	-3.50414-16	152 T3	-3.95799-15

FIGURE 8-12 RESIDUAL LOAD VECTOR ("PARAM=IRES") OUTPUT

FLEXIBLE STRUCTURE CASE

PHIA

POINT	VALUE	POINT	VALUE	POINT	VALUE	POINT	VALUE	POINT	VALUE
COLUMN 1 (	0-).								
1 T2	-5.12943-03	1 R3	4.33476-05	2 T2	-4.40697-03	2 R3	4.33476-05	3 T2	-3.68451-03
3 R3	4.33476-05	4 T2	-2.96205-03	4 R3	4.33476-05	5 T2	-2.23960-03	5 R3	4.33476-05
6 T2	-1.51714-03	6 R3	4.33476-05	7 T2	-7.94676-04	7 R3	4.33476-05	101 T2	-9.34980-05
101 R3	4.33476-05	9 T2	6.50243-04	9 R3	4.33476-05	10 T2	1.37270-03	10 R3	4.33476-05
100 T2	2.07388-03	100 R3	4.33476-05	12 T2	2.81762-03	12 R3	4.33476-05	13 T2	3.54008-03
13 R3	4.33476-05	14 T2	4.26254-03	14 R3	4.33476-05	15 T2	4.98500-03	15 R3	4.33476-05
16 T2	5.70746-03	19 T2	7.87484-03	1001 S	2.54510-20	1002 S	1.71063-20	1003 S	-3.36416-22
1004 S	2.13826-21								
COLUMN 2 (	0-).								
1 T2	3.40661-03	1 R3	6.18261-19	2 T2	3.40661-03	2 R3	6.11482-19	3 T2	3.40661-03
3 R3	5.88433-19	4 T2	3.40661-03	4 R3	5.40976-19	5 T2	3.40661-03	5 R3	4.62340-19
6 T2	3.40661-03	6 R3	3.49806-19	7 T2	3.40661-03	7 R3	1.96596-19	101 T2	3.40661-03
9 T2	3.40661-03	9 R3	-7.22498-20	10 T2	3.40661-03	10 R3	-1.01757-19	100 T2	3.40661-03
100 R3	-2.09876-19	12 T2	3.40661-03	12 R3	-2.60138-19	13 T2	3.40661-03	13 R3	-2.00850-19
14 T2	3.40661-03	14 R3	-2.86918-19	15 T2	3.40661-03	15 R3	-2.87170-19	16 T2	3.40661-03
19 T2	3.40661-03	1001 S	2.55375-20	1002 S	1.08383-20	1003 S	-2.90742-22	1004 S	1.35477-21
COLUMN 3 (	0-).								
1 T2	4.99348-03	1 R3	-7.95627-05	2 T2	3.64907-03	2 R3	-7.92674-05	3 T2	2.35692-03
3 R3	-7.79473-05	4 T2	1.08048-03	4 R3	-7.48898-05	5 T2	-1.27490-04	5 R3	-6.96881-05
6 T2	-1.22992-03	6 R3	-6.22295-05	7 T2	-2.19016-03	7 R3	-5.26746-05	101 T2	-2.95600-03
101 R3	-4.14279-05	9 T2	-3.56509-03	9 R3	-2.91037-05	10 T2	-3.94406-03	10 R3	-1.64667-05
100 T2	-3.92132-03	100 R3	2.00908-05	12 T2	-3.29407-03	12 R3	5.34094-05	13 T2	-2.15570-03
13 R3	8.23611-05	14 T2	-5.78608-04	14 R3	1.05929-04	15 T2	1.34264-03	15 R3	1.23627-04
16 T2	3.51043-03	19 T2	1.16033-02	1001 S	-2.64666-04	1002 S	-4.62012-05	1003 S	-1.26237-05
1004 S	-5.67326-06								
COLUMN 4 (	0-).								
1 T2	-5.13947-03	1 R3	1.29009-04	2 T2	-2.99258-03	2 R3	1.26803-04	3 T2	-9.42524-04
3 R3	1.17610-04	4 T2	6.70156-04	4 R3	9.80477-05	5 T2	2.26777-03	5 R3	6.00522-05
6 T2	3.09559-03	6 R3	3.03227-05	7 T2	3.26119-03	7 R3	-1.05281-05	101 T2	2.76176-03
101 R3	-4.90331-05	9 T2	1.46855-03	9 R3	-8.00156-05	10 T2	1.53440-04	10 R3	-9.96674-05
100 T2	-1.67256-03	100 R3	-1.20042-04	12 T2	-3.64932-03	12 R3	-1.03762-04	13 T2	-5.02512-03
13 R3	-5.77644-05	14 T2	-5.46684-03	14 R3	6.74573-06	15 T2	-4.77163-03	15 R3	7.62933-05
16 T2	-2.96935-03	19 T2	1.24642-02	1001 S	-1.79087-03	1002 S	-2.85124-04	1003 S	-7.58858-05
1004 S	-3.34314-05								

FIGURE 8-13. DMAP "MATPRN" OUTPUT OF "PHIA" MODE SHAPES

COMPLEX EIGENVALUE ANALYSIS OF A ROCKET CONTROL SYSTEM   MAY 3, 1969   PAGE 20
NASTRAN DEMONSTRATION PROBLEM NO. 10-1

FLEXIBLE STRUCTURE CASE

E I G E N V A L U E   A N A L Y S I S   S U M M A R Y   (INVERSE POWER)

NUMBER OF EIGENVALUES EXTRACTED 11

NUMBER OF STARTING POINTS USED 1

NUMBER OF STARTING POINT MOVES 0

NUMBER OF TRIANGULAR DECOMPOSITIONS 10

TOTAL NUMBER OF VECTOR ITERATIONS 87

REASON FOR TERMINATION 6

LARGEST OFF-DIAGONAL MODAL MASS TERM 0

. . . 0
MODE PAIR . . . .
. . . 0

NUMBER OF OFF-DIAGONAL MODAL MASS
TERMS FAILING CRITERION 0

R E A L   E I G E N V A L U E S

MODE NO.	EXTRACTION ORDER	EIGENVALUE	RADIANS	CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	2	.0	.0	.0	1.000000+00	.0
2	1	.0	.0	.0	1.000000+00	.0
3	8	7.971889+01	8.928543+00	1.421022+00	1.000000+00	7.971889+01
4	9	5.795971+02	2.407462+01	3.831627+00	1.000000+00	5.795971+02
5	7	1.739272+03	4.170459+01	6.637491+00	1.000000+00	1.739272+03
6	6	4.828727+03	6.948904+01	1.105953+01	1.000000+00	4.828727+03
7	4	1.085697+04	1.041968+02	1.658343+01	1.000000+00	1.085697+04
8	3	2.282007+04	1.510631+02	2.404245+01	1.000000+00	2.282007+04
9	5	3.911660+04	1.977792+02	3.147753+01	1.000000+00	3.911660+04
10	10	6.128440+04	2.475569+02	3.939990+01	1.000000+00	6.128440+04
11	11	9.360659+04	3.059519+02	4.869377+01	1.000000+00	9.360659+04

FIGURE 8-14 EIGENVALUE ANALYSIS SUMMARY OUTPUT

```
SPHERICAL SHELL WITH PRESSURE LOADING, NO MOMENTS ON BOUNDARY                    MAY  3, 1969      PAGE   19
NASTRAN DEMONSTRATION PROBLEM NO. 1-2

                                   MESSAGES FROM THE PLOT MODULE

                                     P L O T T E R   D A T A

                              THIS PLOT TAPE IS FOR A S-C 4020 ELECT.  PLOTTER
                             THE TAPE IS WRITTEN AT  800 BPI IN THE GAPLESS FORMAT
                                  CAMERA 2 WILL PRODUCE PLOTS ON PAPER
                                THERE WILL BE 1 FRAMES SKIPPED BETWEEN PLOTS

                                 E N G I N E E R I N G   D A T A

                                   PROJECTION  -  PERSPECTIVE
SCALE                 =        9.631373+00 COUNTS/INCH
ROTATIONS (DEG)       -  GAMMA =    34.270,  BETA  =        .000,  ALPHA =       .000, AXES = +X,+Y,+Z, SYMMETRIC
VANTAGE POINT (IN)    - RO =  1.863494+02, SO =  2.573929+01, TO =  1.716385+02
PROJ.PLANE SEP.(IN)   - DO =  1.346650+02

                  ORIGIN    1000 (IN)   -  XO =  -2.619895-01, YO =   3.199666-01
```

FIGURE 8-15 STRUCTURAL PLOTTER SUMMARY OUTPUT

```
                         X Y - O U T P U T   S U M M A R Y

MEAN RESPONSE =     .7516484+02
AUTOCORRELATION
DISPLACEMENT     CURVE           6( 5)

ALL XY-PAIRS FOR THIS CURVE WILL BE PRINTED
XY-PAIRS WITHIN FRAME LIMITS WILL BE PLOTTED
PLOTTER SPECIFIED IS SC 4020
CAMERA 3 USED. (PAPER AND 35MM FILM)
DENSITY =  1

THIS IS CURVE   1 OF WHOLE FRAME    3

CURVE  TITLE = AUTOCORRELATION FUNCTION FOR POINT 6  DISPLACEMENT
X-AXIS TITLE =                     TIME LAG (SECONDS)
Y-AXIS TITLE = R
Y-AXIS TITLE = R
Y-AXIS TITLE = R

THE FOLLOWING INFORMATION IS FOR THE ABOVE DEFINED CURVE ONLY.

WITHIN THE FRAME X-LIMITS       ( X =    .0000000    TO X =    .1000000+00 )

                        THE SMALLEST Y-VALUE =   -.5545848+04 AT X =    .1000000-01

                        THE LARGEST  Y-VALUE =    .5649753+04 AT X =    .0000000

WITHIN THE X-LIMITS OF ALL DATA ( X =    .0000000    TO X =    .1000000+00 )

                        THE SMALLEST Y-VALUE =   -.5545848+04 AT X =    .1000000-01

                        THE LARGEST  Y-VALUE =    .5649753+04 AT X =    .0000000

                              E N D   O F   S U M M A R Y

                P R I N T E D   D A T A   F O R   T H I S   C U R V E   F O L L O W S
```

FIGURE 8-16 XY-OUTPUT PLOTTER SUMMARY

DISPLACEMENT CURVE ID = 6 COMPONENT = 5 WHOLE FRAME

PRINT NUMBER	X-VALUE	Y-VALUE	CARD NUMBER
1	0.000000	5.649753+03	
2	1.000000-03	5.373922+03	
3	2.000000-03	4.573741+03	
4	3.000000-03	3.328385+03	
5	4.000000-03	1.761069+03	
6	5.000000-03	2.648880+01	
7	6.000000-03	-1.704464+03	
8	7.000000-03	-3.261840+03	
9	8.000000-03	-4.493432+03	
10	9.000000-03	-5.279785+03	
11	1.000000-02	-5.545848+03	
12	1.100000-02	-5.268156+03	
13	1.200000-02	-4.476870+03	
14	1.300000-02	-3.252483+03	
15	1.400000-02	-1.717596+03	
16	1.500000-02	-2.458383+01	
17	1.600000-02	1.659605+03	
18	1.700000-02	3.169978+03	
19	1.800000-02	4.359745+03	
20	1.900000-02	5.114660+03	
21	2.000000-02	5.364060+03	
22	2.100000-02	5.087512+03	
23	2.200000-02	4.316453+03	
24	2.300000-02	3.130670+03	
25	2.400000-02	1.650030+03	
26	2.500000-02	2.230234+01	
27	2.600000-02	-1.591680+03	
28	2.700000-02	-3.034001+03	
29	2.800000-02	-4.165213+03	
30	2.900000-02	-4.877877+03	
31	3.000000-02	-5.106819+03	
32	3.100000-02	-4.835074+03	
33	3.200000-02	-4.095011+03	
34	3.300000-02	-2.964574+03	
35	3.400000-02	-1.559075+03	
36	3.500000-02	-1.938864+01	
37	3.600000-02	1.502213+03	
38	3.700000-02	2.857192+03	
39	3.800000-02	3.915305+03	
40	3.900000-02	4.577182+03	
41	4.000000-02	4.763684+03	
42	4.100000-02	4.521176+03	

FIGURE 8-17 XY-OUTPUT RANDOM RESPONSE "AUTØ" OPTION

9. DATA TRANSMISSION

NASTRAN allows the user to conveniently and easily read and write data blocks on user tapes. Access to this capability is provided through the five DMAP-callable modules summarized in Table 9-1. The user must code a DMAP sequence or use Rigid Format alters to make use of these utilities. Each option and its use is explained in the sections that follow.

TABLE 9-1 DATA TRANSMISSION UTILITY MODULES

Module	Data Format	Operation
INPUTT1	GINØ	Read
INPUTT2	FØRTRAN	Read
ØUTPUT1	GINØ	Write
ØUTPUT2	FØRTRAN	Write
ØUTPUT3	"DMI" CARD	Punch

9.1 TRANSMISSION OF NASTRAN GINØ FILES ON TAPE

If the user wishes to place any of the standard NASTRAN files on tape for direct input to subsequent NASTRAN runs, he may call the DMAP utility modules INPUTT1 (PM 4.98) and ØUTPUT1 (PM 4.100) for this purpose. These modules will use the NASTRAN read/write utility GINØ (General Input/Output) routines. Use of GINØ will provide the most efficient processing of all the utilities listed in Table 9-1. Examples of how INPUTT1 and ØUTPUT1 can be used can be found in this Guide, Section 7.2.4 on Substructuring Analysis and in Section 7.3 on DMAP instructions. Many examples with explanations are presented in the UM 5.3.2.

9.2 TRANSMISSION OF FØRTRAN FILES ON TAPE

A more general capability, whereby the user may interface NASTRAN with external computer programs, is provided by the DMAP utility modules INPUTT2 (PM 4.99) and ØUTPUT2 (PM 4.101). These two utilities read (or write) data blocks (tables or matrices) from tape using standard unformated FØRTRAN I/Ø calls. Examples of how to use INPUTT2 and ØUTPUT2 can be found in this Guide, Section 7.3. The same examples given in UM 5.3.2 for INPUTT1 and ØUTPUT1 apply here and should be referenced by the user along with the data format explanations given in PM 4.99. See UG 10 for details of which FØRTRAN units are available for reference. These will vary from one computer system to another. If the user intends to communicate these tables and/or matrices only between NASTRAN runs, he should use the more efficient DMAP utilities described above in Section 9.1.

9.3 TRANSMISSION OF MATRICES VIA CARDS

Occasionally a user may wish to store a particular matrix on cards rather than on tape. This may be to facilitate preparation of Bulk Data cards, for permanent storage and/or shipment or to allow for selective modification of the matrix data. For these purposes, NASTRAN provides the DMAP utility module ØUTPUT3 (PM 4.103) which will punch a specified matrix on cards using the DMI Bulk Data card format. Note that to use these data from the Bulk Data Deck, the user must include an appropriate DMAP alter package to define the data block for NASTRAN to use the data in subsequent processing. An example of a similar application using the DMIG input cards is included in Section 7.3.4.1 of this Guide.

9.4 GENERAL USAGE AND EXECUTIVE DECK SET-UP

Section 5.3.2 of the User's Manual contains complete descriptions of the usage of the above modules. Comprehensive annotated examples may also be found in that section.

Detailed descriptions of the contents and format of all NASTRAN data blocks may be found in Chapter 2 of the Programmer's Manual. The details of the processing relative to each of these modules, including formats for the FØRTRAN data blocks, can be found in PM 4.98 through 4.103.

The particular user tapes for INPUTT1 and ØUTPUT1 (INPT,INP1,...,INP9) and for INPUTT2 and ØUTPUT2 (UT1,...,UT5) which are to be read from or written to, are selected in the DMAP calling sequence (UM 5.3.2). The parameters in the DMAP calling sequence allow the user to position the tape, to read or write, to mark an end of file and to place a NASTRAN label on the tape if so desired. If the resident computer system allows him to do so, the user may, if so desired, assign space on a disk rather than use a physical tape for storage of these sequential files.

The execution deck set-ups for user tapes are described in Chapter 10 of this Guide, complete with annotated examples. The user should make reference to this chapter in order to augment the information on the tape assignment conventions contained in the User's and Programmer's Manuals. Also, it should be noted, these conventions may vary with the particular computer installation being used.

10. CONTROL CARD DECK SET-UP

This chapter is designed to orient a new user of NASTRAN to the basic requirements for operating NASTRAN on any of the standard computer systems listed in Table 10-1.

TABLE 10-1. STANDARD COMPUTER SYSTEMS FOR NASTRAN

Section	Computer System
10.1	UNIVAC 1108 (Exec 8) (PM 5.4)
10.2	IBM 360/370 (ØS) (PM 5.3)
10.3	CDC 6400/6600 (SCØPE 3) (PM 5.5)

NASTRAN is maintained by NASA on each of these three basic systems. Though a vast majority of the NASTRAN subroutines are written in a subset of FØRTRAN which is compilable on all three systems, certain utilities have been written in assembly language to facilitate interfacing the NASTRAN Executive System with the resident operating system software.

NASTRAN itself consists of approximately 90 boxes of source code and is currently subdivided into 14 functional links (PM 5). When the NASTRAN program is actually installed at the user's location, the local usage conventions must be considered in order to determine the most advantageous means of making NASTRAN accessible to the user. At certain installations, where NASTRAN is heavily used, it may be made available as a system resident program. Alternatively, the program may be stored off-line, but in load module form so that it can be readily loaded into the system when required. It should be noted that NASTRAN is designed to dynamically allocate core so that at execution time, all the core memory that can be made available will be used. Whenever practicable, the maximum core available should be used to achieve minimum run times. In any case, the minimum core requirements for NASTRAN are approximately 42,000 words on the UNIVAC 1108, 168,000 bytes on the IBM 360/370, and $138{,}000_8$ words on the CDC 6400/6600. These minimums may be adjusted for certain types of problems. In this event, the user should consult the local systems personnel to determine how to best solve the problem.

Each of the following sections will summarize the rudiments of the system control cards required to operate NASTRAN on each of the three standard computer systems. Examples are provided for many of the typical situations encountered, including usage of checkpoint tapes, user tapes, and plot tapes. Not all conditions can be covered in this Guide. However, sufficient examples are given to indicate what questions to ask of the resident systems personnel in the event more complex arrangements are desired.

10.1 NASTRAN ON THE UNIVAC 1108 (EXEC 8)

This section describes how the NASTRAN input deck (including control cards) must be set up.for operation on the UNIVAC hardware (PM 5.4). The overall organization of the deck is shown in the table below. Each item in the table is described in Section 10.1.1 in the following text. Section 10.1.2 explains the procedure to catalogue NASTRAN. Many examples of common deck set-ups are presented in Section 10.1.3.

TABLE 10-2. ORGANIZATION OF THE INPUT DECK

1	RUN card
2	QUAL card
3	Control cards for tapes
4	ASGCRDS card
5	NASTRAN data deck
6	CONTRL card
7	FIN card

Throughout this section the NASTRAN program is assumed to be catalogued on FASTRAND.[1] If NASTRAN is instead stored on tape, it will be necessary to catalogue it. Section 10.1.2 explains this procedure.

Many control cards are exemplified in this section. In all cases, they begin with the symbol "@". This symbol (a 7/8 multi-punch) must be punched in column one of the control card. An alphanumeric string of characters always immediately follows this symbol, beginning in card column two.

10.1.1 Descriptions of the Input Deck

10.1.1.1 RUN Card

The RUN card identifies the run and furnishes parameters necessary for scheduling and accounting purposes. It is installation-dependent; therefore, check with cognizant personnel at your installation for the proper usage.

10.1.1.2 QUAL card

The QUAL card is used to qualify for NASTRAN the file names which are referenced downstream in the input deck. The format is:

@QUAL qualifier

Replace "qualifier" with the proper alphanumeric string in use at your installation. This string should be preceded by at least one blank space.

10.1.1.3 Control Cards for Tapes

No tapes are required to run NASTRAN. However, if the user wishes to checkpoint, restart, plot or have access to user tapes, etc., tapes are needed. The tape units which may be used have been assigned by the system utility routine NTAB$ (PM 5.4.2) as follows:

FØRTRAN Unit No.(s)	External Name
1-7	Standard units assigned for operations
8	ØPTP - Old Problem Tape used for restart
9	NPTP - New Problem Tape used for checkpointing
10	UMF - User Master File used for input
11	NUMF - New User Master File used for output
12	PLT1 - Plot tape for EAI or Benson Lehner Plots
13	PLT2 - Plot tape for SC4020, Calcomp, or DD80 Plots
14	INPT - User tapes for input and/or output
15-23	INPi (i = 1 - 9) - Available for user tapes (UG 9.4)
24-39	24-39 - Available as UT1-UT5 user tapes (UG 9.4)

These units will be dynamically assigned by NASTRAN for internal use unless they have been previously assigned by user-supplied assign cards. The user-supplied tape control cards must reference the external name as shown in the following examples:

```
@ASG,T  PLT2,T,tapeno   or   @ASG,T  25,T,tapeno
```

Note that "tapeno" must be replaced with the reel number of the tape to be used; and one or more blank spaces must follow "@ASG,T".

When executing on the UNIVAC 1108, the enternal names INPT and INPi can be assigned as user tapes (UG 9) and referenced via the companion DMAP utilities (UM 5.3.2) INPUTT1 and ØUTPUT1. These same FØRTRAN unit numbers (14-23) plus units 24-39 may be referenced directly as user tapes (UG 9) via the companion DMAP utilities (UM 5.3.2) INPUTT2 and ØUTPUT2. The user must, however, take care that the FØRTRAN unit number referenced INPUTT1 and/or ØUTPUT1 not also be referenced by INPUTT2 and/or ØUTPUT2 in the same NASTRAN run.

10.1.1.4 ASGCRDS Card

The ASGCRDS card adds control cards to the run stream from a NASTRAN program file. These cards cause the system heading to be turned off and then initiate execution. The format is:

```
@ADD  *ASGCRDS.
```

One or more blank spaces must follow "@ADD".

10.1.1.5 The NASTRAN Data Deck

This is the standard NASTRAN data input consisting of the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. See Sections 4, 5, and 6 of this guide for details.

10.1.1.6 The CØNTRL Card

The CØNTRL card adds about 1400 control cards to the run stream from a NASTRAN program file. These cards are required during the execution of NASTRAN. The format is:

```
@ADD  *CØNTRL.
```

One or more blank spaces must follow "@ADD".

10.1.1.7 The FIN Card

The FIN card indicates the end of the input deck. The format is:

```
@FIN
```

10.1.2 Cataloguing the NASTRAN Program

If NASTRAN is stored on tape at your installation, it will be necessary to copy it to FASTRAND before it can be executed. To perform this task, the following cards should replace the QUAL card (item 2) in the input deck:

```
@DELETE,C  NASTRAN.
@DELETE,C  ASGCRDS.
@DELETE,C  CØNTRL.
@ASG,UPR   NASTRAN,F//PØS/20
@ASG,UPR   ASGCRDS,F///10
@ASG,UPR   CØNTRL,F///10
@ASG,T     ABSTAP,T,tapeno*
@CØPY,G    ABSTAP.,NASTRAN.
@CØPY,F    ABSTAP.,ASGCRDS.
@MØVE      ABSTAP.,1
@CØPY,F    ABSTAP.,CØNTRL.
@FREE      ABSTAP.
```

*Replace "tapeno" with the serial number of the tape.

10.1.3 Examples

This section presents a large number of examples which illustrate the deck of control cards needed to successfully execute NASTRAN for a variety of problems. These examples are annotated. However, because of the volume of the text, notations made for a given example are not repeated on subsequent examples. Therefore, if a card in some example is not understood, it will be necessary to refer to an earlier example where the card is annotated. The examples are organized as shown in Table 10-3. Table 10-4 identifies the key features of each example.

TABLE 10-3. ORGANIZATION OF THE EXAMPLES

Example	Description
1-4	Non-restart runs
5-8	Restart runs
9-14	Runs using the User's Master File
15-17	Runs performing data transmission to/from other programs

TABLE 10-4. NASTRAN KEY FEATURES IN CONTROL CARD EXAMPLES

Feature	Example Number																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Restart					X	X	X	X									
Checkpoint			X	X			X	X					X	X			
Plot		X		X		X		X				X		X			
User's Master File									X	X	X	X	X	X			
Data Transmission															X	X	X
User Tapes															X	X	X
NPTP			X	X			X	X					X	X			
NUMF									X	X							
ØPTP					X	X	X	X									
PLT1																	
PLT2		X		X		X		X				X		X			
UMF										X	X	X	X	X			

10.1.3.1 Example 1 - Options = none

1	@RUN	- - -
2	@QUAL	qualifier
3	@ADD	*ASGCRDS.
4	(NASTRAN Data Deck)	
5	@ADD	*CØNTRL.
6	@FIN	

Notes:
1. Installation-dependent RUN card.
2. Replace "qualifier" with the proper alphanumeric string in use at your installation.
3. Add control cards to initiate execution.
4. NASTRAN data deck.
5. Add control cards needed for NASTRAN execution.
6. Terminates input.

10.1.3.2 Example 2 - Options = plot

1	@RUN	- - -
2	@QUAL	qualifier
3	@ASG,T	PLT2,T,tapeno
4	@ADD	*ASGCRDS.
5	(NASTRAN Data Deck)	
6	@ADD	*CØNTRL.
7	@FIN	

Notes: 3. This card defines the plot tape. Replace "tapeno" with the reel number of the tape. Either "PLT1" or "PLT2" may be used depending on the type of plotter:

Plotter Name	Plot Tape
Benson Lehner	PLT1
Calcomp	PLT2
Data Display	PLT2
Electronic Associates, Inc.	PLT1
NASTRAN General Purpose Plotter	PLT2
Stromberg Carlson	PLT2

10.1.3.3 Example 3 - Options = checkpoint

```
1    @RUN       - - -
2    @QUAL      qualifier
3    @ASG,T     NPTP,T,tapeno
4    @ADD       *ASGCRDS.
5    (NASTRAN Data Deck)
6    @ADD       *CØNTRL.
7    @FIN
```

Notes: 3. This card defines the New Problem Tape (or checkpoint tape). Replace "tapeno" with the reel number of the tape.

10.1.3.4 Example 4 - Options = checkpoint, plot

```
1    @RUN       - - -
2    @QUAL      qualifier
3    @ASG,T     NPTP,T,tapeno
4    @ASG,T     PLT2,T,tapeno
5    @ADD       *ASGCRDS.
6    (NASTRAN Data Deck)
7    @ADD       *CØNTRL.
8    @FIN
```

10.1.3.5 Example 5 - Options = restart

```
1    @RUN       - - -
2    @QUAL      qualifier
3    @ASG,T     ØPTP,T,tapeno
4    @ADD       *ASGCRDS.
5    (NASTRAN Data Deck)
6    @ADD       *CØNTRL.
7    @FIN
```

Notes: 3. This card defines the Old Problem Tape (or restart tape). Replace "tapeno" with the reel number of the tape.

10.1.3.6 Example 6 - Options = restart, plot

```
@RUN          - - -
@QUAL         qualifier
@ASG,T        ØPTP,T,tapeno
@ASG,T        PLT2,T,tapeno
@ADD          *ASGCRDS.
(NASTRAN Data Deck)
@ADD          *CØNTRL.
@FIN
```

10.1.3.7 Example 7 - Options = restart, checkpoint

```
@RUN          - - -
@QUAL         qualifier
@ASG,T        NPTP,T,tapeno
@ASG,T        ØPTP,T,tapeno
@ADD          *ASGCRDS.
(NASTRAN Data Deck)
@ADD          *CØNTRL.
@FIN
```

10.1.3.8 Example 8 - Options = restart, checkpoint, plot

```
@RUN          - - -
@QUAL         qualifier
@ASG,T        NPTP,T,tapeno
@ASG,T        ØPTP,T,tapeno
@ASG,T        PLT2,T,tapeno
@ADD          *ASGCRDS.
(NASTRAN Data Deck)
@ADD          *CØNTRL.
@FIN
```

10.1.3.9 Example 9 - Options = create a UMF

```
1    @RUN        - - -
2    @QUAL       qualifier
3    @ASG,T      NUMF,T,tapeno
4    @ADD        *ASGCRDS.
5    (NASTRAN Data Deck)
6    @ADD        *CØNTRL.
7    @FIN
```

Notes: 3. This card identifies the tape for the New User's Master File. Replace "tapeno" with the serial number of the tape.

10.1.3.10 Example 10 - Options = edit the UMF

```
1    @RUN        - - -
2    @QUAL       qualifier
3    @ASG,T      NUMF,T,tapeno
4    @ASG,T      UMF,T,tapeno
5    @ADD        *ASGCRDS.
6    (NASTRAN Data Deck)
7    @ADD        *CØNTRL.
8    @FIN
```

Notes: 4. This card identifies the tape for the User's Master File. Replace "tapeno" with the serial number of the tape.

10.1.3.11 Example 11 - Options = UMF

```
1    @RUN        - - -
2    @QUAL       qualifier
3    @ASG,T      UMF,T,tapeno
4    @ADD        *ASGCRDS.
5    (NASTRAN Data Deck)
6    @ADD        *CØNTRL.
7    @FIN
```

10.1.3.12 Example 12 - Options - UMF, plot

```
@RUN            - - -
@QUAL           qualifier
@ASG,T          PLT2,T,tapeno
@ASG,T          UMF,T,tapeno
@ADD            *ASGCRDS.
(NASTRAN Data Deck)
@ADD            *CØNTRL.
@FIN
```

10.1.3.13 Example 13 - Options = UMF, checkpoint

```
@RUN            - - -
@QUAL           qualifier
@ASG,T          NPTP,T,tapeno
@ASG,T          UMF,T,tapeno
@ADD            *ASGCRDS.
(NASTRAN Data Deck)
@ADD            *CØNTRL.
@FIN
```

10.1.3.14 Example 14 - Options = UMF, checkpoint, plot

```
@RUN            - - -
@QUAL           qualifier
@ASG,T          NPTP,T,tapeno
@ASG,T          PLT2,T,tapeno
@ASG,T          UMF,T,tapeno
@ADD            *ASGCRDS.
(NASTRAN Data Deck)
@ADD            *¢ONTRL.
@FIN
```

10.1.3.15 Example 15 - Options = user tape input

```
1   @RUN       - - -
2   @QUAL      qualifier
3   @ASG,T     INPT,T,tapeno
4   @ADD       *ASGCRDS.
5   (NASTRAN Data Deck)
6   @ADD       *CØNTRL.
7   @FIN
```

Notes: 3. This card identifies the user's input tape. Replace "tapeno" with the serial number of the tape. More than one user input tape may be used in a given job. Additional tape names are INPi, i=1,9.

10.1.3.16 Example 16 - Options = user tape output

```
1   @RUN       - - -
2   @QUAL      qualifier
3   @ASG,T     INPT,T,tapeno
4   @ADD       *ASGCRDS.
5   (NASTRAN Data Deck)
6   @ADD       *CØNTRL.
7   @FIN
```

Notes: 3. This card identifies the user's output t pe. Replace "tapeno" with the serial number of the tape. More than one user output tape may be used in a given job. Additional tape names are INPi, i=1,9.

10.1.3.17 Example 17 - Options = user tape input and output

```
1   @RUN       - - -
2   @QUAL      qualifier
3   @ASG,T     INP3,T,tapeno
4   @ASG,T     INP7,T,tapeno
5   @ADD       *ASGCRDS.
6   (NASTRAN Data Deck)
7   @ADD       *CØNTRL.
8   @FIN
```

Notes: 3,4. Either of these cards can be used for input or output, as desired by the user.

10.2 NASTRAN ON THE IBM SYSTEM 360/370 (ØS)

This section describes how the NASTRAN input deck (including control cards) must be set up for operation on the IBM 360/370 hardware (PM 5.3). The overall organization of the deck is shown in the table below. Each item in the table is described in Section 10.2.1 in the following text. Many examples of common deck set-ups are presented in Section 10.2.2.

TABLE 10-5. ORGANIZATION OF THE INPUT DECK

1	JØB card
2	NASTRAN instream procedure
3	EXEC card
4	Control cards for tapes
5	NASTRAN data deck
6	/*

Many examples of control cards are shown in this section. In all cases they have two slashes (//) punched in columns 1 and 2.

10.2.1 Descriptions of the Input Deck

10.2.1.1 JØB Card

The JØB card identifies the job and furnishes parameters necessary for scheduling and accounting purposes. It is installation-dependent; therefore, check with cognizant personnel at your installation for the proper usage.

10.2.1.2 NASTRAN Instream Procedure

The NASTRAN instream procedure is a deck of about 100 control cards which are required to execute NASTRAN. These cards must be included in every run. However, some installations may have these cards permanently stored in the system (catalogued). In this case, the instream procedure deck may be left out of the input deck.

A detailed description and listing of the NASTRAN instream procedure deck may be found in Section 5.3.5 of the NASTRAN Programmer's Manual.

10.2.1.3 EXEC Card

The EXEC card actually causes NASTRAN to execute. The format is:

    //name EXEC NASTRAN

where "name" is an alphanumeric name of up to 8 characters, the first of which must be alphabetic. "Name" is optional. If used, it should begin in column 3.

There must be at least one blank space preceding the word EXEC, and at least one blank space between EXEC and NASTRAN.

> Note: For some unusual problems, it may be necessary to specify parameters on this card. These parameters are described in Section 5.3.5 in the NASTRAN Programmer's Manual.

10.2.1.4 Control Cards for Tapes

No types are required to run NASTRAN. However, if the user wishes to checkpoint, restart, plot or have access to user tapes, etc., tapes and/or their disk file equivalences are required. The user should refer to PM 5.3.2 and 5.3.5 as well as his local systems personnel for additional detail concerning the procedures for assigning tapes for use by NASTRAN. Those tapes which are to be used must be declared by the user in his Job Control Language (JCL) as exemplified later in Section 10.2.2. The file names used by NASTRAN (PM 5.35) are as follows:

File Name	Purpose
INPi (i=T,1,2,...,9)	User tapes referenced by DMAP utility modules INPUTT1 and ØUTPUT1 (UG 9, UM 5.3.2)
NPTP	New Problem Tape for checkpointing
NUMF	New User Master File
ØPTP	Old Problem Tape for restarting
PLT1	Plot tape for EAI or Benson Lehner plots (assigned FØRTRAN unit number 13)
PLT2	Plot tape for SC4020, Calcomp, or DD80 plots (assigned FØRTRAN unit number 14)
UMF	User Master File

Note that these file names are in alphabetical order as they appear in the standard NASTRAN PRØC deck. If this deck is catalogued in the local system library, the user-provided control cards must be submitted in the same alphabetical order to successfully override the PRØC library specifications. If the user wishes to apply the DMAP utilities INPUTT2 and/or ØUTPUT2 (UG 9), he must specify a DD card to declare each of the appropriate FØRTRAN unit numbers referenced by these utilities (UM 5.3.2, DMAP parameter P2). For this purpose, he may use any unit number available <u>except</u> units 1, 4, 5, 6, 7, 13 and 14, which are reserved for use by NASTRAN. Examples 16 and 17 of Section 10.2.2 illustrate the required JCL.

Generally, sequential data sets, except for plot tapes PLT1 and PLT2, may be located on user-assigned diskpacks instead of on tape. If the user wishes to store his checkpoint files on disk, he must specify CHKPNT=DISK in the NASTRAN Executive Control Deck (UG 6).

10.2.1.5 NASTRAN Data Deck

The NASTRAN data deck must be preceded by the following card:

```
//NS.SYSIN DD *
```

There must be at least one blank space on either side of "DD". The data deck must be followed by one delimiter card with "/*" punched in columns 1 and 2:

```
/*
```

10.2.2 <u>Examples</u>

This section presents a large number of examples which illustrate the deck of control cards needed to successfully execute NASTRAN for a variety of problems. These examples are annotated. However, because of the volume of the text, notations made for a given example are not repeated on subsequent examples. Therefore, if a card in some example is not understood, it will be necessary to refer to an earlier example where the card is annotated. The examples are organized as shown in Table 10-6. Table 10-7 identifies the key features of each example.

10.2.2.1 Example 1 - No Options

```
1    //    (JØB Card)
2    (Procedure Deck)
3    //NSGØ       EXEC  NASTRAN
4    //NS.SYSIN   DD    *
5    (NASTRAN Data Deck)
6    /*
```

Notes:
1. Installation-dependent JØB card.
2. NASTRAN procedure deck. (May be left out if the procedure is catalogued at your installation. See Section 10.2.1.2.)
3. The EXEC card causes NASTRAN to execute.

TABLE 10-6. ORGANIZATION OF THE EXAMPLES

Example	Description
1-4	Non-restart runs
5-8	Restart runs
9-14	Runs using the User's Master File
15-17	Runs performing data transmission to/from other programs

TABLE 10-7. NASTRAN KEY FEATURES IN CONTROL CARD EXAMPLES

Feature	Example Number																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Restart					X	X	X	X									
Checkpoint			X	X			X	X					X	X			
Plot		X		X		X		X				X		X			
User's Master File									X	X	X	X	X	X			
Data Transmission															X	X	X
INPi (i=T,1,...,9)															X		X
NPTP			X	X			X	X					X	X			
NUMF									X	X							
ØPTP					X	X	X	X									
PLT1																	
PLT2		X		X		X		X				X		X			
UMF										X	X	X	X	X			
FTxxF001																X	X

4. Identifies the following cards as NASTRAN input data.

5. NASTRAN data deck.

6. Indicates end of NASTRAN data.

10.2.2.2 Example 2 - Options = Plot

```
1    //   (JØB Card)
2    (Procedure Deck)
3    //NSGØ        EXEC  NASTRAN
4    //NS.PLT2     DD    DSN=PLØT360,UNIT=2400,
5    //                  VØL=SER=serno,DISP=(NEW,KEEP)
6    //NS.SYSIN    DD    *
7    (NASTRAN Data Deck)
8    /*
```

Notes: 4,5. These cards define the plot tape. Replace "serno" with the volume serial number of the tape. Either "PLT1" or "PLT2" may be used, depending on the type of plotter:

Plotter Name	Plot Tape
Benson Lehner	PLT1
Calcomp	PLT2
Data Display	PLT2
Electronic Associates, Inc.	PLT1
NASTRAN General Purpose Plotter	PLT2
Stromberg Carlson	PLT2

10.2.2.3 Example 3 - Options = Checkpoint

```
1    //   (JØB Card)
2    (Procedure Deck)
3    //NSGØ        EXEC  NASTRAN
4    //NS.NPTP     DD    DSN=NPTP360,UNIT=2400-3,
5    //                  VØL=SER=serno,DISP=(NEW,KEEP),
6    //                  LABEL=(,NL)
7    //NS.SYSIN    DD    *
8    (NASTRAN Data Deck)
9    /*
```

Notes: 4,5,6. These cards define the New Problem Tape (or checkpoint tape). Replace "serno" with the volume serial number of the tape.

10.2.2.4 Example 4 - Options = Checkpoint, Plot

```
1    //     (JØB Card)
2    (Procedure Deck)
3    //NSGØ         EXEC  NASTRAN
4    //NS.NPTP      DD    DSN=NPTP360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=(NEW,KEEP),
6    //                   LABEL=(,NL)
7    //NS.PLT2      DD    DSN=PLØT360,UNIT=2400,
8    //                   VØL=SER=serno,DISP=(NEW,KEEP)
9    //NS.SYSIN     DD    *
10   (NASTRAN Data Deck)
11   /*
```

10.2.2.5 Example 5 - Options = Restart

```
1    //     (JØB Card)
2    (Procedure Deck)
3    //NSGØ         EXEC  NASTRAN
4    //NS.ØPTP      DD    DSN=ØPTP360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=ØLD
6    //NS.SYSIN     DD    *
7    (NASTRAN Data Deck)
8    /*
```

Notes: 4,5. These cards define the Old Problem Tape (or restart tape). Replace "serno" with the volume serial number of the tape.

10.2.2.6 Example 6 - Options = Restart, Plot

```
1    //     (JØB Card)
2    (Procedure Deck)
3    //NSGØ         EXEC  NASTRAN
4    //NS.ØPTP      DD    DSN=ØPTP360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=ØLD
```

```
//NS.PLT2     DD     DSN=PLØT360,UNIT=2400,
//                   VØL=SER=serno,DISP=(NEW,KEEP)
//NS.SYSIN    DD     *
(NASTRAN Data Deck)
/*
```

10.2.2.7 Example 7 - Options = Restart, Checkpoint

```
//    (JØB Card)
(Procedure Deck)
//NSGØ        EXEC   NASTRAN
//NS.NPTP     DD     DSN=NPTP360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=(NEW,KEEP),
//                   LABEL=(,NL)
//NS.ØPTP     DD     DSN=ØPTP360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=ØLD
//NS.SYSIN    DD     *
(NASTRAN Data Deck)
/*
```

10.2.2.8 Example 8 - Options = Restart, Checkpoint, Plot

```
//    (JØB Card)
(Procedure Deck)
//NSGØ        EXEC   NASTRAN
//NS.NPTP     DD     DSN=NPTP360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=(NEW,KEEP),
//                   LABEL=(,NL)
//NS.ØPTP     DD     DSN=ØPTP360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=ØLD
//NS.PLT2     DD     DSN=PLØT360,UNIT=2400,
//                   VØL=SER=serno,DISP=(NEW,KEEP)
//NS.SYSIN    DD     *
(NASTRAN Data Deck)
/*
```

10.2.2.9 Example 9 - Options = Create a UMF

```
1    //     (JØB Card)
2    (Procedure Deck)
3    //NSGØ        EXEC   NASTRAN
4    //NS.NUMF     DD     DSN=NUMF360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=(NEW,KEEP)
6    //NS.SYSIN    DD     *
7    (NASTRAN Data Deck)
8    /*
```

10.2.2.10 Example 10 - Options = Edit the UMF

```
1    //     (JØB Card)
2    (Procedure Deck)
3    //NSGØ        EXEC   NASTRAN
4    //NS.NUMF     DD     DSN=NUMF360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=(NEW,KEEP)
6    //NS.UMF      DD     DSN=UMF360,UNIT=2400-3,
7    //                   VØL=SER=serno,DISP=ØLD
8    //NS.SYSIN    DD     *
9    (NASTRAN Data Deck)
10   /*
```

Notes: 6,7. These cards identify the User's Master File which is to be edited. Replace "serno" with the volume serial number of the tape.

10.2.2.11 Example 11 - Options = UMF

```
1    //     (JØB Card)
2    (Procedure Deck)
3    //NSGØ        EXEC   NASTRAN
4    //NS.UMF      DD     DSN=UMF360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=ØLD
6    //NS.SYSIN    DD     *
7    (NASTRAN Data Deck)
8    /*
```

10.2.2.12 Example 12 - Options = UMF, Plot

```
//       (JØB Card)
(Procedure Deck)
//NSGØ         EXEC  NASTRAN
//NS.PLT2      DD    DSN=PLØT360,UNIT=2400,
//                   VØL=SER=serno,DISP=(NEW,KEEP)
//NS.UMF       DD    DSN=UMF360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=ØLD
//NS.SYSIN     DD    *
(NASTRAN Data Deck)
/*
```

10.2.2.13 Example 13 - Options = UMF, Checkpoint

```
//       (JØB Card)
(Procedure Deck)
//NSGØ         EXEC  NASTRAN
//NS.NPTP      DD    DSN=NPTP360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=(NEW,KEEP),
//                   LABEL=(,NL)
//NS.UMF       DD    DSN=UMF360,UNIT=2400-3,
//                   VØL=SER=serno,DISP=ØLD
//NS.SYSIN     DD    *
(NASTRAN Data Deck)
/*
```

10.2.2.14 Example 14 - Options = UMF, Checkpoint on Disk, Plot

```
//       (JØB Card)
(Procedure Deck)
//NSGØ         EXEC  NASTRAN
//NS.NPTP      DD    DSN=NPTP360,UNIT=2314,
//                   VØL=SER=serno,DISP=(NEW,KEEP),
//                   SPACE=($SUNITS,($S1,$S2),RLSE)
//NS.PLT2      DD    DSN=PLØT360,UNIT=2400,
//                   VØL=SER=serno,DISP=(NEW,KEEP)
```

```
9    //NS.UMF       DD    DSN=UMF360,UNIT=2400-3,
10   //                   VØL=SER=serno,DISP=ØLD
11   //NS.SYSIN     DD    *
12   (NASTRAN Data Deck)
13   /*
```

Notes: 4-6. Defines a new disk to be used for checkpointing and hence requires specification of space parameters. The parameters used are those specified in PRØC deck. They may require changes, depending on the size of the problem to be solved. When this disk is then used for a subsequent restart, the DISP parameter must be changed to ØLD.

10.2.2.15 Example 15 - Options = User Tape Input

```
1    //      (JØB Card)
2    (Procedure Deck)
3    //NSGØ         EXEC  NASTRAN
4    //NS.INPT      DD    DSN=INPT360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=ØLD
6    //NS.SYSIN     DD    *
7    (NASTRAN Data Deck)
8    /*
```

Notes: 4,5. These cards identify the user's input tape referenced by the DMAP utility INPUTT1 (or ØUTPUT1) (UM 5.3.2, P2=0). Replace "serno" with the volume serial number of the tape. More than one user-input tape may be used in a given job. Additional tape names are INPi, i=1,9. The tapes must be ordered as shown in Section 10.3.1.4.

10.2.2.16 Example 16 - Options = User Tape Output

```
1    //      (JØB Card)
2    (Procedure Deck)
3    //NSGØ         EXEC  NASTRAN
4    //NS.FT15F001  DD    DSN=USER360,UNIT=2400-3,
5    //                   VØL=SER=serno,DISP=(NEW,KEEP),
6    //                   LABEL=(,NL),DCB=(RECFM=VS,
7    //                   LRECL=X,BLKSIZE=8190)
```

```
8      //NS.SYSIN    DD    *
9      (NASTRAN Data Deck)
10     /*
```

Notes: 4-7. These cards identify the user's output tape, in this case on FØRTRAN Unit 15. Replace "serno" with the volume serial number of the tape. This file can be referenced by the ØUTPUT2 (or INPUTT2) utility DMAP module (UM 5.3.2, P2=15).

10.2.2.17 Example 17 - Options = User Tape Input and Output

```
1      //     (JØB Card)
2      (Procedure Deck)
3      //NSGØ          EXEC   NASTRAN
4      //NS.INP6       DD     DSN=INP6360,UNIT=2400-3,
5      //                     VØL=SER=serno,DISP=(OLD,KEEP)
6      //NS.FT19F001   DD     DSN=USER360,UNIT=2400-3,
7      //                     VØL=SER=serno,DISP=(NEW,KEEP),
8      //                     LABEL=(,NL),DCB=(RECFM=VS,
9      //                     LRECL=X,BLKSIZE=8190)
10     //NS.SYSIN    DD    *
11     (NASTRAN Data Deck)
12     /*
```

Notes: 4-5. Specifies user tape to be referenced by DMAP utilities INPUTT1 and/or ØUTPUT1 (UM 5.3.2, P2=6).

6-9. Specifies user tape to be referenced by DMAP utilities INPUTT2 and/or ØUTPUT2 (UM 5.3.2, P2=19).

10.3 NASTRAN ON THE CONTROL DATA 6400/6600 (SCØPE 3)

This section describes how the NASTRAN input deck (including control cards) must be set up. The overall organization of the deck is shown in the table below:

TABLE 10-8. ORGANIZATION OF THE INPUT DECK

1	Job description cards
2	Control cards to load NASTRAN
3	Tape set-up cards
4	NASTRAN execution command
5	NASTRAN data deck
6	EØR/EØF

Each item in the table is described in Section 10.3.1 in the following text. Many examples of common deck set-ups are presented in Section 10.3.2. Throughout this section, the NASTRAN program is assumed to be loaded on a random access file. If NASTRAN is instead stored on tape, it will be necessary to read it in. There is, however, considerable variation among CDC installations.

10.3.1 Descriptions of the Input Deck

10.3.1.1 Job Description

These cards vary according to installation and whether or not a terminal is being used. The contents are exactly the same as any other program running on the system. A key card is the JØB card. It contains limits on core size, CPU time, IØ time, tapes, and priorities. NASTRAN requires a minimum of approximately 138000_8 words of core.

10.3.1.2 Setting Up NASTRAN File

The NASTRAN executable file may be stored on tape, on the system permanent file, on the system CØMMØN file, or on private disc packs. These options vary considerably from site to site.

If NASTRAN exists on a CØMMØN file, the CØMMØN(NASTRAN) card is used. If NASTRAN exists on the system permanent files, the ATTACH card is used. If NASTRAN is stored on tape, the tape should be read onto a random access device. Various methods are used to accomplish the latter, depending on the operating system and hardware configuration. Consult the system programmer or NASTRAN representative for assistance in this case.

10.3.1.3 Control Cards for Tapes

No tapes are required to run NASTRAN. However, if the user wishes to checkpoint, restart, plot or have access to user tapes, etc., tapes are required. The user should refer to PM 5.5.2 and 5.5.4 as well as his local systems personnel for additional detail concerning the procedures for assigning tapes for use by NASTRAN. The tapes which are available to the user are as follows:

File Name	Purpose
INPi (i=T,1,2,...,9)	User tapes referenced by DMAP utility modules INPUTT1 and ØUTPUT1 (UG 9, UM 5.3.2)
UTi (i=1,...,5)	User tapes referenced by DMAP utility modules INPUTT2 and OUTPUT2 (UG 9, UM 5.3.2)
NPTP	New Problem Tape for checkpointing
ØPTP	Old Problem Tape for restarting
NUMF	New User Master File
UMF	User Master File
PLT1	Plot tape for EAI or Benson Lehner plots
PLT2	Plot tape for SC4020, Calcomp, or DD80 plots

The user must reference these file names in his job control deck if they are to be used on a NASTRAN run. The user tapes INPi and UTi are accessed via the DMAP parameter P2 (UM 5.3.2) corresponding to the specified file name. Example 6 of Section 10.3.2 illustrates the control cards for accessing user tapes. Typical formats of the tape control cards are:

```
REQUEST,ØPTP,HI.4363,RØL
REQUEST,PLT2,HI.(SAVE,RING,NL)
```

These requests also vary with the local operating system.

10.3.1.4 NASTRAN.ATTACH Card

This card transfers control to the NASTRAN linkage editor which, in turn, sets up the execution.

10.3.1.5 The NASTRAN Data Deck

This is the standard NASTRAN data input consisting of the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. See Chapters 4, 5, and 6 of this guide for details.

10.3.1.6 EØR and EØF Cards ($^{7}8_{9}$ and $^{6}7_{8_{9}}$)

If one NASTRAN job is to be executed, an EØF card is sufficient to define the end of data. If two or more NASTRAN problems are to be executed, the NASTRAN.ATTACH card is repeated, and the data decks are separated by EØR cards.

10.3.2 Examples

The following examples illustrate the control statements necessary to execute the NASTRAN program once the generation procedure is complete. Where explanation is needed, notes are provided with reference to the card number in question. Table 10-9 identifies the key features of each example.

TABLE 10-9. KEY FEATURES OF EXAMPLES

Feature	Example Number					
	1	2	3	4	5	6
Restart				X	X	
Checkpoint		X	X		X	
Plot		X			X	
User's Master File	X		X			
Data Transmission						X

10.3.2.1 Example 1 - Options = Execute from Tape, Read Data from UMF

```
1     JØB.
2     MAP(ØFF)
3     REQUEST NSTRN,HI. reel#,RØL
4     REQUEST UMF,HI. reel#,RØL
5     NSTRN.CREATE(NASTRAN)
6     RETURN(NSTRN)
7     RETURN(UMF)
8     7/8/9
9     (NASTRAN Data Deck)
10    6/7/8/9
```

Notes: 1. The installation-dependent JØB card should specify sufficient resources to run the job.

5. In addition to executing the NASTRAN program, this control statement will cause the NASTRAN file to be declared a common file.

10.3.2.2 Example 2 - Options = Run from CØMMØN File, Checkpoint

1 JØB.

2 MAP(ØFF)

3 REQUEST NPTP,HI. SAVTP,RIL

4 REQUEST PLT2,HI. SAVTP,RIL

5 CØMMØN(NASTRAN)

6 NASTRAN.ATTACH

7 RETURN(NPTP)

8 RETURN(PLT2)

9 $^{7}8_{9}$

10 (NASTRAN Data Deck)

11 $^{6}7_{8_{9}}$

Note: 5. This control statement attaches the common file to the job. If NASTRAN is executed as a common file, running time will be approximately 5-8 minutes faster in elapsed time and 20 seconds faster in CPU time.

10.3.2.3 Example 3 - Options = Run from CØMMØN File, Read Data from UMF and Checkpoint

1 JØB.

2 MAP(ØFF)

3 REQUEST UMF,HI. reel#,RØL

4 REQUEST NPTP,HI. SAVTP,RIL

5 CØMMØN(NASTRAN)

6 NASTRAN.ATTACH

7 RETURN(UMF)

8 RETURN(NPTP)

9 $^{7}8_{9}$

10 (NASTRAN Data Deck)

11 $^{6}7_{8_{9}}$

10.3.2.4 Example 4 - Options = Run from Tape, Restart from Old Problem Tape

1 JØB.

2 MAP(ØFF)

3 REQUEST ØPTP,HI. reel#,RØL

4 REQUEST NASTRAN,HI. reel#,RØL

5 NASTRAN.CATALØG(NASTDA)

6 RETURN(NASTRAN)

7 NASTDA.ATTACH

8 RETURN(ØPTP)

9 NASTDA.ATTACH

10 $^{7}8_{9}$

11 (NASTRAN Data Deck, including RESTART packet in the Executive Control Deck)

12 $^{7}8_{9}$

13 (2nd NASTRAN Data Deck)

14 $^{6}7_{8_{9}}$

Notes: 5. This control statement copies the sequential file NASTRAN to the direct access file NASTDA which can then be executed repeatedly.

7. This card attaches NASTRAN for execution with first data deck.

9. This card attaches NASTRAN for execution with second data deck.

10.3.2.5 Example 5 - Options = Execute from Tape, Checkpoint, Restart, Plot

1 JØB.

2 MAP(ØFF)

3 REQUEST NASTRAN,HI. reel#,RØL

4 REQUEST NPTP,HI. SAVTP,RIL

5 REQUEST ØPTP,HI. reel#,RØL

```
6    REQUEST PLT2,HI. SAVTP,RIL
7    NASTRAN(,,X)
8    RETURN(NASTRAN)
9    RETURN(NPTP)
10   RETURN(ØPTP)
11   RETURN(PLT2)
12   789
13   (NASTRAN Data Deck, including RESTART packet in the
     Executive Control Deck)
14   6789
```

Note: 7. Any of the NASTRAN program files (INPUT, ØUTPUT, PUNCH) may be substituted for X, i.e., X replaces PUNCH in this example.

10.3.2.6 Example 6 - Options = Execute from Tape, User Tapes

```
1    JØB.
2    MAP(ØFF)
3    REQUEST NASTRAN,HI. reel#,RØL
4    REQUEST INP2,HI. reel#,RØL
5    REQUEST UT5,HI. SAVTP,RIL
6    NASTRAN(,,X)
7    RETURN(NASTRAN)
8    RETURN(INP2)
9    RETURN(UT5)
10   789
11   (NASTRAN Data Deck)
12   789
```

Notes: 4. Requests user tape for read only by DMAP utility INPUTT1 (UM 5.3.2, P2=2)

5. Requests user tape for read or write by DMAP utility INPUTT2 or ØUTPUT2 (UM 5.3.2, P2=15).

11. USER OPTION INDEX

This chapter is devoted to the sole purpose of providing the user with a reference to the NASTRAN input options used in the many examples provided in this Guide. These options are listed alphabetically in three tables as follows:

Table 11-1: Executive Control Options and DMAP

Table 11-2: Case Control Options and Plot Commands

Table 11-3: Bulk Data Deck Options

The headings for each table point to the section and page number of the example illustrating the use of each input option referenced. Though all the available options are not included, examples of every type of option can be found in this Guide. The first table contains all the Executive Control options as summarized in Table 6-1 and several of the more commonly used utility DMAP instructions discussed in Chapters 8 and 9. The second table contains nearly all the Case Control options presented in Table 5-1 as well as references to the major plot control commands. The third table contains references to over half of the more than 180 available Bulk Data Deck options that are summarized in Table 4-1. The options that are exemplified in this Guide have been carefully selected so that each of the Bulk Data input categories of Table 4-1 is represented.

If the user is interested in locating additional examples, an index to the input cards for the NASTRAN Demonstration Problem Manual can be found on pages 502 to 512 of the Second Colloquium Proceedings on NASTRAN: USER'S EXPERIENCE (NASA TM X-2637) held at Langley Research Center September 11 - 12, 1973.

TABLE 11-1. EXECUTIVE CONTROL OPTIONS AND DMAP

Executive Control Deck Options — Page	6-5	6-6	6-6	6-7	7-3	7-6	7-9	7-12	7-14	7-20	7-24	7-29	7-33	7-36	7-40	7-42	7-49	7-53	7-61	7-66	7-70	7-75	7-77	7-80	7-84	7-85	7-87	7-89	7-90
Section	6.4.1	6.4.2	6.4.3	6.4.4	7.1.1.2	7.1.1.3	7.1.1.5	7.1.1.7	7.1.2.2	7.1.2.4	7.1.2.6	7.1.3.2	7.1.4.2	7.1.4.4	7.1.5.2	7.1.5.4	7.1.5.6	7.1.5.8	7.2.1.2	7.2.2.2	7.2.3.2	7.2.4.2	7.2.4.3	7.2.4.4	7.3.1.1	7.3.2.1	7.3.2.2	7.3.3.1	7.3.4.1
ALTER				X										X		X						X	X	X	X	X	X		X
APP	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BEGIN$																												X	
CEND	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHKPNT		X	X	X	X											X						X							
DIAG	X																					X							
END$																												X	
ENDALTER				X										X		X						X	X	X	X	X	X		X
ID	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NASTRAN		X	X																										
RESTART			X	X		X																		X					
SØL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
TIME	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
UMF					X		X	X	X	X	X	X	X	X	X	X	X	X											
DMAP:																													
ADD																							X	X				X	
CØND																							X						
EQUIV																							X	X					X
EXIT																						X			X				
INPUTT1																							X	X					
INPUTT2																												X	
JUMP																						X							
MATGPR														X													X		
MATPRN				X												X												X	
MERGE																							X	X					
MTRXIN																													X
ØUTPUT1																						X	X						
ØUTPUT2																											X		
PARAM																							X	X					
PARTN																							X						
SAVE																													X
SETVAL																													X
TABPT				X																						X			
VEC																								X					

TABLE 11-2. CASE CONTROL OPTIONS AND PLOT COMMANDS

Case Control Deck Options — Page	5-7	5-9	5-10	5-11	5-11	5-12	5-13	7-3	7-6	7-9	7-12	7-14	7-20	7-24	7-29	7-33	7-36	7-40	7-42	7-49	7-53	7-61	7-66	7-70	7-75	7-77	7-80	7-84	7-85	7-87	7-89	7-90
Section	5.4.1	5.4.2	5.4.3	5.4.4	5.4.5	5.4.6	5.4.7	7.1.1.2	7.1.1.3	7.1.1.5	7.1.1.7	7.1.2.2	7.1.2.4	7.1.2.6	7.1.3.2	7.1.4.2	7.1.4.4	7.1.5.2	7.1.5.4	7.1.5.6	7.1.5.8	7.2.1.2	7.2.2.2	7.2.3.2	7.2.4.2	7.2.4.3	7.2.4.4	7.3.1.1	7.3.2.1	7.3.2.2	7.3.3.1	7.3.4.1
ACCELERATION							X												X													
AXISYMMETRIC										X													X									
B2PP							X													X												
CMETHØD																X	X						X									
DEFØRM		X																														
DISPLACEMENT	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X			X		X
DLØAD							X											X	X	X	X											
DSCØEFFICIENT												X																				
ECHØ									X																							
ELFØRCE		X		X					X		X	X	X	X					X				X									
ELSTRESS			X										X	X																		
FØRCE										X		X																				
FREQUENCY							X											X	X													
HARMØNICS										X													X									
IC						X														X												
K2PP																				X												
LABEL	X	X					X				X	X	X	X			X		X							X	X					
LINE					X																											
LØAD	X		X	X				X	X	X	X	X	X	X								X			X	X						
M2PP																				X												
MAXLINES																			X													
METHØD					X								X		X		X		X		X			X						X		X
MØDES					X																											
MPC	X																X															
ØFREQUENCY							X											X														
ØLØAD	X	X	X								X	X	X	X					X	X												
ØUTPUT	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X		X		
PLCØEFFICIENT														X																		
PLØTID								X					X	X	X				X	X	X							X		X		
PRESSURE																								X								
RANDØM							X												X													
REPCASE				X																												
SDAMPING																			X		X											
SET	X	X	X	X		X	X			X	X	X	X	X	X	X	X	X	X		X							X		X		
SPC	X	X	X	X	X		X	X	X			X	X	X	X			X	X			X	X	X		X				X		
SPCFØRCES		X						X	X		X		X	X	X			X								X	X					
STRESS	X				X			X	X		X										X			X			X					
SUBCASE	X	X		X	X		X					X	X						X						X	X	X					
SUBCØM		X																														

TABLE 11-2. CASE CONTROL OPTIONS AND PLOT COMMANDS (cont'd)

Case Control Deck Options — Page	5-7	5-9	5-10	5-11	5-11	5-12	5-13	7-3	7-6	7-9	7-12	7-14	7-20	7-24	7-29	7-33	7-36	7-40	7-42	7-49	7-53	7-61	7-66	7-70	7-75	7-77	7-80	7-84	7-85	7-87	7-89	7-90
Section	5.4.1	5.4.2	5.4.3	5.4.4	5.4.5	5.4.6	5.4.7	7.1.1.2	7.1.1.3	7.1.1.5	7.1.1.7	7.1.2.2	7.1.2.4	7.1.2.6	7.1.3.2	7.1.4.2	7.1.4.4	7.1.5.2	7.1.5.4	7.1.5.6	7.1.5.8	7.2.1.2	7.2.2.2	7.2.3.2	7.2.4.2	7.2.4.3	7.2.4.4	7.3.1.1	7.3.2.1	7.3.2.2	7.3.3.1	7.3.4.1
SUBSEQ		X																														
SUBTITLE	X		X	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X					
SVECTØR																	X															
SVELØCITY																				X												
SYM			X																													
SYMCØM			X																													
SYMSEQ			X																													
TEMPERATURE	X																					X										
TFL																	X															
TITLE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
TSTEP						X														X	X											
VELØCITY						X																										
<u>Plot Control</u>																																
ØRTHØGRAPHIC													X								X											
PERSPECTIVE								X					X																			
PLØT								X					X	X	X						X							X		X		
STEREØ																					X											
SYMMETRY								X																								
XYPLØT																			X	X	X											
XYPRINT							X																									

TABLE 11-3. BULK DATA DECK OPTIONS

Bulk Data Deck Options — Page	7-3	7-9	7-12	7-14	7-20	7-24	7-29	7-33	7-36	7-40	7-42	7-49	7-53	7-61	7-66	7-70	7-77	7-84	7-85	7-90
Section	7.1.1.2	7.1.1.5	7.1.1.7	7.1.2.2	7.1.2.4	7.1.2.6	7.1.3.2	7.1.4.2	7.1.4.4	7.1.5.2	7.1.5.4	7.1.5.6	7.1.5.8	7.2.1.2	7.2.2.2	7.2.3.2	7.2.4.3	7.3.1.1	7.3.2.1	7.3.4.1
AXIC		X																		
AXIF															X					
AXSLØT																X				
BARØR			X	X					X				X							
BDYLIST															X					
CAXIFi																X				
CBAR			X	X					X		X		X							
CCØNEAX		X																		
CDAMP3								X												
CELAS3								X									X			
CELAS4									X											
CFLUIDi															X					
CHBDY														X						
CHEXAi														X						
CMASS3								X												
CMASS4									X											
CØNM2									X		X		X							
CØNRØD																		X	X	X
CØRD1C																				
CØRD2C			X		X										X					
CØRD2S	X																			
CQUAD1							X			X										
CQUAD2															X					
CRØD						X														
CSLØTi																X				
CTRIA1					X															
CTRIA2	X																			
CWEDGE														X						
DAREA										X	X	X	X							
DELAY											X	X								
DLØAD											X									
DMI																	X			
DMIG												X								X
DPHASE											X									
DSFACT				X																
EIGB					X															
EIGC								X	X						X					
EIGP									X											

TABLE 11-3. BULK DATA DECK OPTIONS (cont'd)

Bulk Data Deck Options — Section	7.1.1.2	7.1.1.5	7.1.1.7	7.1.2.2	7.1.2.4	7.1.2.6	7.1.3.2	7.1.4.2	7.1.4.4	7.1.5.2	7.1.5.4	7.1.5.6	7.1.5.8	7.2.1.2	7.2.2.2	7.2.3.2	7.2.4.3	7.3.1.1	7.3.2.1	7.3.4.1
Page	7-3	7-9	7-12	7-14	7-20	7-24	7-29	7-33	7-36	7-40	7-42	7-49	7-53	7-61	7-66	7-70	7-77	7-84	7-85	7-90
EIGR							X		X		X		X			X				X
EPOINT									X			X								
FLSYM															X					
FØRCE			X		X	X														
FØRCE1				X																
FREQ										X										
FREQ1											X									
FSLIST															X					
GENEL											X									
GRDSET	X		X	X	X		X		X	X	X		X							
GRID	X		X	X	X	X	X		X	X	X		X	X				X	X	X
GRIDB															X					
GRIDF																X				
GRIDS																X				
LØAD			X	X	X															
MAT1	X	X	X	X	X	X	X		X	X	X		X		X			X	X	X
MAT4														X						
MATS1						X														
MØMAX		X																		
MØMENT				X																
MPC									X											
MPCADD									X											
ØMIT1				X									X							
PARAM			X	X	X	X	X	X	X		X		X	X						
PBAR			X	X					X		X		X							
PCØNEAX		X																		
PELAS								X												
PLFACT						X														
PLØAD2	X																			
PLØTEL	X						X													
PMASS								X												
PØINTAX		X																		
PQUAD1							X			X										
PQUAD2															X					
PRØD						X														
PTRIA1					X															
PTRIA2	X																			
QHBDY														X						

TABLE 11-3. BULK DATA DECK OPTIONS (cont'd)

Bulk Data Deck Options — Page	7-3	7-9	7-12	7-14	7-20	7-24	7-29	7-33	7-36	7-40	7-42	7-49	7-53	7-61	7-66	7-70	7-77	7-84	7-85	7-90
Section	7.1.1.2	7.1.1.5	7.1.1.7	7.1.2.2	7.1.2.4	7.1.2.6	7.1.3.2	7.1.4.2	7.1.4.4	7.1.5.2	7.1.5.4	7.1.5.6	7.1.5.8	7.2.1.2	7.2.2.2	7.2.3.2	7.2.4.3	7.3.1.1	7.3.2.1	7.3.4.1
RANDPS											X									
RANDT1											X									
RFØRCE			X																	
RINGAX		X																		
RINGFL															X					
RLØAD1										X	X									
RLØAD2											X									
SEQGP					X				X											
SLBDY																X				
SLØAD																	X			
SPC	X			X	X	X					X			X		X				
SPC1	X				X		X			X				X	X		X			
SPCADD					X															
SPØINT									X								X			
SUPØRT			X						X				X							
TABDMP1											X		X							
TABLED1										X	X	X								
TABLES1						X														
TABRND1											X									
TEMPD														X						
TF									X											
TIC												X								
TLØAD1												X								
TLØAD2													X							
TSTEP												X	X							

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12. NASTRAN INFORMATION SOURCES

12.1 NASTRAN NEWSLETTER

The NASTRAN Systems Management Office (NSMO) periodically publishes the NASTRAN Newsletter to provide NASTRAN users with timely information on the development of new capability, Software Problem Reports (SPR), Documentation Error Reports (DER) and user's experiences. This Newsletter may be subscribed to by writing:

NASTRAN Systems Management Office
Mail Stop 253B
NASA - Langley Research Center
Hampton, Virginia 23365

The application form to be used is provided at the conclusion of this chapter. The information provided on this form is used by NSMO to help them provide better service to all NASTRAN users.

12.2 SOFTWARE PROBLEM REPORT (SPR) LOG

Another service called the Software Problem Report (SPR) Log is also provided by NSMO as part of their NASTRAN maintenance service. This Log is available to all interested users by writing to COSMIC. The address and phone number are:

COSMIC
Barrow Hall
University of Georgia
Athens, Georgia 30601

Telephone: (404) 542-3265

The SPR Log is essentially a working document whose primary value lies in its currency. For this reason, it is continuously updated and published at frequent intervals. The user is encouraged to submit SPRs to NSMO as a service to all other users of NASTRAN. The recommended procedures for doing so are presented in Section 12.4.

12.3 NASTRAN USER'S COLLOQUIUM

More formal reports on application and development of NASTRAN have been published by NASA following each NASTRAN User's Colloquium held at the Langley Research Center. Three sets of the Colloquium proceedings are now available, entitled:

"NASTRAN: USER'S EXPERIENCES"

1. NASA TM X-2378, September 13 - 15, 1971
2. NASA TM X-2637, September 11 - 12, 1972
3. NASA TM X-2893, September 11 - 12, 1973

These proceedings may be obtained at modest cost from:

National Technical Information Service
Springfield, Virginia 22151

12.4 SPR SUBMITTAL

It is a goal of NASTRAN that every run terminate with either correct results or a user-oriented message describing the difficulties encountered. Progress towards this goal is made by means of user-submitted materials describing Software Problems. At the end of this chapter is a sample copy of the standard SPR submittal form. It is requested that all new SPRs be submitted using this new form and that all old forms be destroyed.

The following guidelines are recommended so that each Software Problem Report (SPR) can be efficiently handled.

1. If you suspect an error, first try to determine if the error is already known. An SPR log is available through COSMIC which lists known errors (UG 12.2). This log is indexed by module and often contains a suggested user avoidance procedure. Please do not submit runs covered by a previous SPR to NSMO unless you feel that the additional information will prove useful. In this case, please identify the SPR.

2. If the malfunction involves a computer-dependent termination, such system abends on the IBM 360, or error modes on the CDC computers, consult first with your own programming/operations staff for possible job set-up or machine errors.

3. Having decided that the problem is caused by an unknown malfunction in NASTRAN and if you have programmers available, attempt to determine the cause by consulting them and the listings. The best error submittal is one which contains a run which exemplifies a stated error and contains a suggested program correction along with the statement, "We tried this fix and it worked," or even "We tried this and it didn't work."

4. Having exhausted your own resources, consider sending the run to NSMO for further investigation. <u>If</u> you consider this approach, be sure that the run has as much diagnostic data as possible. In particular, be sure that DIAG's 1, 2, 3, 8, 13, 15, 16 (for Inverse Power problems) and 19 were on and that a dump was taken. Be sure to include an echo of <u>all</u> the input data and the Run Log (the day

file (CDC), Log (UNIVAC), or FT04 (IBM)). If this data is not available, please rerun the job to obtain it. You should also take the time to describe the circumstances surrounding the run, i.e., "I changed this one card from when it ran before," etc. A complete NASTRAN data deck in card form should also be submitted, because later testing and other reruns may need to be made. If plots have been made send copies of them. If User Tapes are involved, dump them and send the dump. Be sure to give your name, address, phone number and as precise description of the difficulty as you can.

If you take the time to follow these guidelines, NSMO will be able to respond to SPRs more quickly and more economically. The processing of SPRs can be delayed for extended periods when insufficient information is submitted to permit prompt identification and correction of the reported error.

12.5 DER SUBMITTAL

It is also a goal of NSMO to supply the user with complete and accurate documentation to facilitate the application and development of NASTRAN. Even though NSMO carefully edits all documentation, errors of commission and errors of omission do occur. NSMO recognizes, however, that it is the user who ultimately puts the documentation to its most severe test. Therefore, NSMO welcomes all user reports of documentation errors. Valid errors will be reported to other users via the NASTRAN Newsletter.

A sample DER form is included at the end of this chapter. The user is encouraged to submit this form to NSMO along with a copy of the documentation page with annotations to indicate the error. If appropriate, also provide the specific text which would serve to correct that error. Some types of documentation errors may indicate the presence of software problems as well. If this is known, the user should consider submitting a supporting SPR following the procedures suggested in Section 12.4.

APPLICATION TO RECEIVE NASTRAN NEWSLETTER

If this application is not returned within 45 days, your name must be removed from Newsletter Mailing list.

1. Please supply the following mailing list information, including ZIP code.

Last Name: RANEY

Address:
NSMΦ
MAIL STΦP 253B - NASA
LANGLEY RESEARCH CENTER
HAMPTΦN VA 23365

Prefix: (Mr., Miss, Dr., etc.) DR

Initials: JP

You can help us provide better service to NASTRAN users by supplying the following information:

2. On what computer(s) do you run NASTRAN:

☑ CDC 6400	☐ IBM 360/50	☐ IBM 360/91	☐ IBM 370/145	☐ Univac 1106
☐ CDC 6500	☐ IBM 360/65	☐ IBM 360/95	☐ IBM 370/155	☐ Univac 1108
☑ CDC 6600	☐ IBM 360/75	☐ IBM 360/195	☐ IBM 370/165	☐ Univac ____
☐ CDC 6700	☐ IBM 360/85	☐ IBM 360/___	☐ IBM 370/___	
☐ CDC ____				

Others: ________________________

3. What is the maximum amount of main memory a user can obtain on any machine on which you run NASTRAN?

Machine: CDC 6600

Max. Main Memory: (in bytes or words) 330000

4. Which of the NASTRAN plotter(s) do you use?

☐ None	☑ DD 80,B
☐ NASTPLT Model: ______	☑ CALCØMP Model: ______
☐ SC 4020	☐ Benson-Lehner Model: ______
☐ EAI 3500 Model: ______	☐ Other: ______

5. What level(s) of NASTRAN do you use? L15.1.0, L__._._, L__._._

6. How many NASTRAN users are there in your company or organization? 5

7. Please indicate your use of the various NASTRAN rigid formats and Direct Matrix Abstraction capability by circling the appropriate entries below.

No Need	1	2	3	4	5	6	(7)	8	9	10	11	12	DMAP
Not Tried	1	(2)	3	4	5	6	7	(8)	9	(10)	(11)	12	DMAP
Rare Usage	1	2	3	4	5	(6)	7	8	9	10	11	12	(DMAP)
Occasional Usage	1	2	3	(4)	(5)	6	7	8	(9)	10	11	(12)	DMAP
Regular Usage	(1)	2	(3)	4	5	6	7	8	9	10	11	12	DMAP

8. We would appreciate your comments on the single most important improvement that could be made to NASTRAN at this time. AERΦELASTIC CAPABILITY.

9. Do you wish card image and compilation listings on tape ___ or microfilm ✓?

10. Additional Comments:

NASTRAN SOFTWARE PROBLEM REPORT (SPR)

Date: 10/15/72

NSMO Use	
SPR No. :	
Priority :	
Date Rec'd. :	
Date Assigned:	

Originator: DØE, EDWARD GEØRGE

Organization: XYZ AERØSPACE, INC.

Address: 1234 W. ZULU AVE.
PASADENA, CALIFORNIA
54321

Phone No.: (213) 123-4567

Materials Submitted:

- (X) Output: 2 Runs
- (X) Deck
- ( ) Plots
- (X) Letter
- (X) Dump
- (X) Traceback
- ( ) Fix: ________
- ( ) Program Listing
- ( ) Link Map Listing
- ( ) Other: ________

Level: 15.1.0

Computer: IBM 360/65

Rigid Format (or DMAP): 3.0 ☐ Alters?

Error Message: 3002

Module: READ - GIV

Subroutine(s): READ4

Avoidance (if known): MAKE EIGR CARD ND-VALUE THE SAME AS THE ØRDER ØF THE KAA MATRIX

Estimate correction effort (if known): ________

SAMPLE - DO NOT USE. A COPY OF THIS FORM IS ENCLOSED WITH THIS NEWSLETTER

Description: FAILURE IN EIGENVALUE EXTRACTIØN BY THE GIVENS METHØD. PRØBLEM RUNS CØRRECTLY WHEN ALL ØF THE EIGENVECTØRS ARE REQUESTED.

NSMO Use	
Level Fixed :	
Test Problem :	
Verified by NSMO :	

DER No. ________________

SPR No. ________________

NASTRAN DOCUMENTATION ERROR REPORT (DER)

Originator: DØE, EDWARD G. Date: 10/15/72

Organization: XYZ AERØSPACE Phone No.: (213) 123-4567

Manual
- [ ] Theoretical ________________
- [x] User's 10.9-4 (6/1/72)
- [ ] Programmer's ________________
- [ ] Demonstration ________________

} Page Numbers

Description of the Error and Corrections
(A copy of the page(s) in error with marked corrections should be attached.)

SPELLING ERROR SHOWN ØN ENCLØSED XERØX CØPY ØF PAGE.

Comments

Editor Approva	MPSL Entry	NSMO Approval	Change Made	Editor Verif.	MPSL Entry
Date	Date	Date	Date	Date	Date

APPLICATION TO RECEIVE NASTRAN NEWSLETTER

If this application is not returned within 45 days, your name must be removed from Newsletter Mailing list.

1. Please supply the following mailing list information, including ZIP code.

Last Name:

Address:

Prefix: (Mr., Miss, Dr., etc.)

Initials:

You can help us provide better service to NASTRAN users by supplying the following information:

2. On what computer(s) do you run NASTRAN:

- ☐ CDC 6400
- ☐ CDC 6500
- ☐ CDC 6600
- ☐ CDC 6700
- ☐ CDC ____
- ☐ IBM 360/50
- ☐ IBM 360/65
- ☐ IBM 360/75
- ☐ IBM 360/85
- ☐ IBM 360/91
- ☐ IBM 360/95
- ☐ IBM 360/195
- ☐ IBM 360/___
- ☐ IBM 370/145
- ☐ IBM 370/155
- ☐ IBM 370/165
- ☐ IBM 370/___
- ☐ Univac 1106
- ☐ Univac 1108
- ☐ Univac ____

Others: ______________________

3. What is the maximum amount of main memory a user can obtain on any machine on which you run NASTRAN?

Machine: ______________ Max. Main Memory: ______________ (in bytes or words)

4. Which of the NASTRAN plotter(s) do you use?

- ☐ None
- ☐ NASTPLT Model: ______
- ☐ SC 4020
- ☐ EAI 3500 Model: ______
- ☐ DD 80,B
- ☐ CALCØMP Model: ______
- ☐ Benson-Lehner Model: ______
- ☐ Other: ______

5. What level(s) of NASTRAN do you use? L_ _._._ , L_ _._._ , L_ _._._

6. How many NASTRAN users are there in your company or organization?

7. Please indicate your use of the various NASTRAN rigid formats and Direct Matrix Abstraction capability by circling the appropriate entries below.

No Need	1	2	3	4	5	6	7	8	9	10	11	12	DMAP
Not Tried	1	2	3	4	5	6	7	8	9	10	11	12	DMAP
Rare Usage	1	2	3	4	5	6	7	8	9	10	11	12	DMAP
Occasional Usage	1	2	3	4	5	6	7	8	9	10	11	12	DMAP
Regular Usage	1	2	3	4	5	6	7	8	9	10	11	12	DMAP

8. We would appreciate your comments on the single most important improvement that could be made to NASTRAN at this time.

9. Do you wish card image and compilation listings on tape ___ or microfilm ___ ?

10. Additional Comments:

Fold, Staple and Mail

NASTRAN Systems Management Office
Mail Stop 253B
NASA-Langley Research Center
Hampton, Virginia 23365

Fold, Staple and Mail

NASTRAN SOFTWARE PROBLEM REPORT (SPR)

Date: ____________

Originator: ____________

Organization: ____________

Address: ____________

____

____

Phone No.: ____________

NSMO Use

SPR No. : ____________

Priority : ____________

Date Rec'd. : ____________

Date Assigned: ____________

Materials Submitted:

( ) Output: _____ Runs

( ) Deck

( ) Plots

( ) Letter

( ) Dump

( ) Traceback

( ) Fix: ____________

( ) Program Listing

( ) Link Map Listing

( ) Other: ____________

Level: ____________

Computer: ____________

Rigid Format: _____, _____ ☐ Alters?
(or DMAP)

Error Message: ____________

Module: ____________

Subroutine(s): ____________

____

____

____

____

Avoidance (if known): ____________

____

____

Estimate correction effort (if known): ______

____

____

Description: ____________

____

____

____

____

____

____

____

NSMO Use

Level Fixed : ____________

Test Problem : ____________

Verified by NSMO : ____________

DER No. ____________

SPR No. ____________

NASTRAN DOCUMENTATION ERROR REPORT (DER)

Originator: ____________________ Date: ____________

Organization: ____________________ Phone No.: ____________

Manual ☐ Theoretical ____________

☐ User's ____________

☐ Programmer's ____________

☐ Demonstration ____________

} Page Numbers

Description of the Error and Corrections

(A copy of the page(s) in error with marked corrections should be attached.)

____

____

____

____

____

Comments

____

____

____

____

Editor Approval	MPSL Entry	NSMO Approval	Change Made	Editor Verif.	MPSL Entry
______	______	______	______	______	______
Date	Date	Date	Date	Date	Date
______	______	______	______	______	______

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WASHINGTON, D.C. 20546

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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