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STEP AND STEPSPL - COMPUTER PROGRAMS FOR AERODYNAMIC MODEL STRUCTURE DETERMINATION AND PARAMETER ESTIMATION

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INTRODUCTION

The successful parametric modeling of the aerodynamics for an airplane operating at high angles of attack or sideslip is performed in two phases. First, the aerodynamic model structure must be determined and second the associated aerodynamic parameters (stability and control derivatives) must be estimated for that model. Though the aerodynamic model structure is known to be linear at low angles of attack, the appearance of nonlinearities at higher angles of attack has been a prominent feature in several recent reports of flight test results (refs. 1, 2, 3). Since a large number of possible nonlinear terms could contribute to the aerodynamic function, some method must be developed that examines only the influential terms while ignoring those that are superfluous. One possibility is to look at all combinations of linear and nonlinear terms. However, as pointed out in reference 4, the number of models to be considered grows too fast with the number of possible terms for such a technique to be practical. The use of stepwise regression was suggested in reference 5. Stepwise regression examines each term as to its usefulness in improving the model (by reducing residual variance). Candidate model terms are added one at a time and/or deleted one or more at a time until no more candidate terms can pass a given test of statistical significance. This provides a least squares equation error estimate of the model structure and associated parameters at each step of the model building.

The stepwise regression technique has been used (refs. 1, 2, 3) for analyzing flight data from high angle-of-attack and large amplitude maneuvers. The purpose of this paper is to document two versions of a stepwise regression computer program which were developed for the determination of airplane aerodynamic model structure and to provide two examples of their use. It is assumed that the reader is familiar with the airplane equations of motion. One should read references 1 and 2 for applications of the technique to actual flight data.

The two computer programs that are the subject of this report, STEP and STEPSPL, are written in FORTRAN IV (ANSI 1966) compatible with a CDC FTN4 compiler. Both programs are adaptations of a standard forward stepwise regression algorithm (ref. 6). The purpose of the adaptation is to facilitate the selection of an adequate mathematical model of the aerodynamic force and moment coefficients of an airplane from flight test data. The major difference between STEP and STEPSPL is in the basis for the model (found in SUBROUTINE DATASET). The basis for models in STEP is the standard polynomial Taylor's series expansion of the aerodynamic function about some steady-state trim condition (see refs. 1 and 3). Program STEPSPL utilizes a set of spline basis functions (refs. 3 and 7).

The paper is organized as follows. After this introduction is a section describing the approach and rationale of the program. The main program and subroutines are each described as to their respective purposes and dimensioning information. Next, a section addresses the interpretation of output based on two examples. There are seven appendices. Appendix A is the listing for STEP. Appendix B is a listing of the NAMELIST/INPUT/for the first example. Appendix C consists of the output for the first example (which demonstrates STEP). Appendix D is a sample job control deck for running the example in a batch mode at the Langley Research Center computer center. Appendix E is the STEPSPL listing. Appendix F contains the output of example 2, (which demonstrates STEPSPL). Finally, appendix G contains a sampling of options for the spline model basis used in conjunction with STEPSPL. The interested reader can start by running the given test case and then modifying the program to fit his specific use.

STEPWISE REGRESSION

This section describes the basic principles and features of the stepwise regression which is used to determine aerodynamic model structure from flight data. It is assumed that the general structural form of the mathematical model for the aerodynamic force and moment coefficients can be written as

$$y(t) = \theta_0 + \theta_1 x_1(t) + \theta_2 x_2(t) + \dots \theta_n x_n(t) \qquad (1)$$

where

$y(t)$ aerodynamic force or moment coefficient $(C_X, C_Y, C_Z, C_m, C_\ell, C_n)$ at time t

$x_j(t)$ airplane state plus control variables $(\alpha, q, \beta, p, r, \delta_e, \delta_a, \delta_r)$ and their combinations at time t $(j = 1, 2, \dots, n)$

θ_j airplane stability and control coefficients $(j = 1, 2, \dots, n)$

θ_0 constant reflecting and initial steady-state condition.

The forward stepwise regression described in this paper begins with the assumption that there are no variables in the postulated regression equation other than the bias term θ_0. An effort is then made to find an optimal subset of variables by inserting independent variables into the model one at a time. The first independent variable selected for entry into the equation is the one that has the largest correlation with the dependent variable y. Suppose that this variable is x_1. This is also the variable that produces the largest value of the F-statistic for testing the significance of regression. The variable is then entered if the partial F-statistic of its associated parameter, $\hat{\theta}_1$, exceeds a preselected critical F-value.

$$F_p = \frac{\hat{\theta}_1^2}{s^2(\hat{\theta}_1)} > F_{crit}$$

where $\hat{\theta}_1$ is the estimated parameter associated with x_1 and $s^2(\hat{\theta}_1)$ is the variance estimate of θ_1.

The second variable chosen for entry is the one that now has the largest correlation with y after adjusting for the effect on y of x_1. These correlations are referred to as partial correlations. In general, at each step, the independent variable having the highest partial correlation with y is added to the model if the partial F-statistic of its associated parameter exceeds the preselected F_{crit}. At each step of the procedure, all variables entered into the model previously are reassessed by examining their corresponding partial F-statistics. A variable added at an earlier step may be redundant because the relationship between it and the remaining variables now in the equation has reduced its value of F_p to less than F_{crit}. If this happens, the insignificant variable is deleted from the regression model. The procedure terminates when all significant terms have been included in the model.

Five Associated Information Criteria

At each stage of the stepwise regression, as a new variable enters the model, five useful quantities are calculated. All these quantities should be examined for the final model selection. First, the user can consider the total F-value for a given model of Q variables calculated as the ratio of the mean square due to the regression to the mean square of the residual. This ratio is given as

$$F = \frac{\sum_{i=1}^{N} \left(\hat{y}(i) - \bar{y}\right)^2}{\sum_{i=1}^{N} \left(y(i) - \hat{y}(i)\right)^2} \; \frac{N - Q}{Q - 1}$$

where

$$\bar{y} = \frac{1}{N} \sum_{i=1}^{N} y(i)$$

This number usually increases to some maximum value as new variables enter the regression, but then decreases slightly as the new terms are less effective in reducing the residuals. Heuristically, the maximum F-value represents a model which best fits the data with a minimum number of parameters. Second, the squared multiple correlation coefficient R^2 is calculated. This number, expressed as a percentage, is a measure of the usefulness of the terms, other than θ_0, in the model. The value of R^2 would be 100 percent for a model that perfectly fit the data. Third, at each stage, the partial F-values F_p for each parameter are printed. The user should look for consistency in the value of F_p. For example, if one value of F_p is only slightly greater than F_{crit} and all other values of F_p are much greater, the user may not want to include the variable with the small value of F_p in the model. The fourth aid in model selection is the estimated normalized autocorrelation function for the residuals. The estimate of the autocorrelation function at lag h is given by

$$\hat{W}(h) = \frac{1}{N - h} \sum_{i=1}^{N-h} \nu(i)\, \nu(i + h) \qquad (h\ 0,\ 1,\ \ldots,\ M)$$

where h is the lag number and M is the maximum lag number, which is usually 10 percent of N. For data sampled each Δt second, the time separation associated with lag h is $h \cdot \Delta t$. The normalized autocorrelation function is calculated as

$\hat{W}(h)/\hat{W}(0)$. This function should approach that for white noise with a value of 1 at zero lag and values of 0 at lags of 1 to M. In applications, when the value of F_p for a parameter makes the utility of an independent variable questionable, the contribution of that variable to the actual model structure can be assessed by observing the effect of the variable on the autocorrelation function of residuals. The fifth number that is useful is the standard error in the residuals, $\hat{\sigma}$, which is printed at each stage of the regression.

One learns from experience that not all of the five criteria listed above are "optimally" satisfied for any single model. However, the stepwise regression and its associated information criteria do significantly reduce the number of possible models from which the user must choose. Moreover, as the model structure is determined, so are the parameter estimates. Finally, ambiguity in the model selection can also be resolved by requiring that the estimated parameters make sense physically and that the selected model have good prediction capability.

Selection of Candidate Model Variables

The selection of a set of candidate model variables from which the stepwise regression can build a model should rely on the user's a priori knowledge of the physical system that is to be modeled. For the airplane, assumptions as to the most influential variables and symmetry considerations have led to the following logic for selection of candidate model variables for a spline analysis of the longitudinal maneuver. The range of the independent variable which is most important in the determination of the dependent variable is partitioned into several subsets, each having support on less of the range than the previous subset. For example, the force coefficient C_Z is mainly dependent on α. Hence if $\alpha = \{z | a \leqslant z \leqslant b\}$, then the α range, $[a,b]$, is divided according to the spline basis functions as follows:

$$(\alpha - \alpha_i)_+^m \equiv \begin{cases} (\alpha - \alpha_i)^m & (\alpha \geqslant \alpha_i) \\ 0 & (\alpha < \alpha_i) \end{cases}$$

The values of α_i are called knots. An example of the "+" function is given in figure 1. The four knots in this figure are at $\alpha = 2°$, $4°$, $6°$, and $8°$. Hence,

$$(\alpha - \alpha_1)_+^0 = 1 \quad \text{for} \quad \alpha \geqslant \alpha_1 = 2°, \text{ and } \quad (\alpha - \alpha_1)_+^0 = 0$$

for $\alpha < \alpha_1$. Similarly,

$$(\alpha - \alpha_2)_+^0 = 1 \quad \text{for} \quad \alpha \geqslant 4°, \text{ and } \quad (\alpha - \alpha_2)_+^0 = 0 \quad \text{for} \quad \alpha < 4°,$$

and so forth, for the rest of the "+" functions. If the order of the "+" function, denoted by the superscript m is other than zero, say 2, then

$$(\alpha - \alpha_1)_+^2 = (\alpha - \alpha_1)_+^2 \quad \text{for} \quad \alpha \geqslant \alpha_1 \quad \text{and}$$

$$(\alpha - \alpha_1)_+^2 = 0 \quad \text{for} \quad \alpha < \alpha_1.$$

Hence, the vertical force coefficient C_Z can be represented as:

$$C_Z = C_{Z,o} + C_{Z_\alpha}\alpha + \sum_{i=1}^{K} C_{Z_{\alpha_i}} (\alpha - \alpha_i)_+ + C_{Z_q} \frac{q\bar{c}}{2V} + \sum_{i=1}^{K} C_{Z_{q_i}} (\alpha - \alpha_i)_+^0 \frac{q\bar{c}}{2V}$$

$$+ C_{Z_{\delta_e}} \delta_e + \left(C_{Z_{\delta_e}}\right)_7 \delta_e (\alpha - \alpha_7)_+^0 + \left(C_{Z_{\delta_e}}\right)_{13} \delta_e (\alpha - \alpha_{13})_+^0$$

Though it appears lengthy and awkward, the following formulation of the FORTRAN code allows for simple deletion, addition, and/or change in candidate model variables.

```
      DO 910 I=1,NPTS
      X(1,I)=ALPH(I)
      X(2,I)=C/(2*VEL(I))*Q(I)
      X(3,I)=DELE(I)
      DO 911 III=4,39
911   X(III,I)=0.
      IF (ALPH(I).GE.XKNOT(1)) X(4,I)=ALPH(I)-XKNOT(1)
      IF (ALPH(I).GE.XKNOT(1)) X(5,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(2)) X(6,I)=ALPH(I)-XKNOT(2)
      IF (ALPH(I).GE.XKNOT(2)) X(7,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(3)) X(8,I)=ALPH(I)-XKNOT(3)
      IF (ALPH(I).GE.XKNOT(3)) X(9,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(4)) X(10,I)=ALPH(I)-XKNOT(4)
      IF (ALPH(I).GE.XKNOT(4)) X(11,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(5)) X(12,I)=ALPH(I)-XKNOT(5)
      IF (ALPH(I).GE.XKNOT(5)) X(13,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(6)) X(14,I)=ALPH(I)-XKNOT(6)
      IF (ALPH(I).GE.XKNOT(6)) X(15,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(7)) X(16,I)=ALPH(I)-XKNOT(7)
      IF (ALPH(I).GE.XKNOT(7)) X(17,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(8)) X(18,I)=ALPH(I)-XKNOT(8)
      IF (ALPH(I).GE.XKNOT(8)) X(19,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(9)) X(20,I)=ALPH(I)-XKNOT(9)
      IF (ALPH(I).GE.XKNOT(9)) X(21,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(10)) X(22,I)=ALPH(I)-XKNOT(10)
      IF (ALPH(I).GE.XKNOT(10)) X(23,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(11)) X(24,I)=ALPH(I)-XKNOT(11)
      IF (ALPH(I).GE.XKNOT(11)) X(25,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(12)) X(26,I)=ALPH(I)-XKNOT(12)
      IF (ALPH(I).GE.XKNOT(12)) X(27,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(13)) X(28,I)=ALPH(I)-XKNOT(13)
      IF (ALPH(I).GE.XKNOT(13)) X(29,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(14)) X(30,I)=ALPH(I)-XKNOT(14)
      IF (ALPH(I).GE.XKNOT(14)) X(31,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(15)) X(32,I)=ALPH(I)-XKNOT(15)
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      IF (ALPH(I).GE.XKNOT(15)) X(33,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(16)) X(34,I)=ALPH(I)-XKNOT(16)
      IF (ALPH(I).GE.XKNOT(16)) X(35,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(17)) X(36,I)=ALPH(I)-XKNOT(17)
      IF (ALPH(I).GE.XKNOT(17)) X(37,I)=X(2,I)
      IF (ALPH(I).GE.XKNOT(7)) X(38,I)=X(3,I)
      IF (ALPH(I).GE.XKNOT(13)) X(39,I)=X(3,I)
910 CONTINUE
```

In the preceding printout, VEL(I) = airspeed V at t_i, Q = pitch rate q, NPTS = number of data points N, C = wing mean aerodynamic chord $\bar{c}$, and X(J,I) = value of jth model variable at t_i. The symbols XKNOT( ) indicate knots for specific values of α. The code above actually gives the logic for creating the $(39 \times N)$ matrix containing the time histories of each of the 39 candidate independent variables. The 17 knots in angle of attack can be set at any value the user deems adequate for the data by setting XKNOT(I) in the program with I = 1,17. Changing the candidate model variables can easily be accomplished by substituting the new variable for any of the 39 candidate variables listed. The number of candidate variables is limited only by the size of the computer memory.

DESCRIPTION OF PROGRAM STEP

Main Program

The main program for STEP is dimensioned to accept measurements of flight data at 500 time points. For example, at a data rate of 20 points per second, this dimensioning allows 25.0 seconds of data to be used. The main program includes all logic for the actual regression procedure as well as most of the printing logic. The namelist INPUT is read in the main program. This namelist contains data for airplane mass, geometry and inertia characteristics, initial conditions, option switches and starting time. The namelist will be discussed in detail below. The main program also does all calculations involving the correlation matrix and analysis of variance. It provides for the printing of the partial F-values for variables in the regression, the estimates of their coefficients and standard errors of those coefficients. The total F-value for the model, the percent variation from the mean explained by the regression model, and the variance of the residual sequence are also printed from the main program.

Dimensions - As mentioned, most data arrays are dimensioned 500 to accommodate a maximum of 25 seconds of data at a rate of 20 points per second. However, this and other dimensions may be adjusted by the user to conform to individual computer capability. This section is written to aid the user in such changes. Let MAXNPTS be the maximum number of data points to be analyzed and N-1 be the maximum number of independent variables to be considered for the regression. For example N-1 is 24 in STEP since the lateral equations have 24 candidate model variables as seen from the X array in lines 79 through 102 of subroutine DATASET (appendix A). The dimensions for arrays in STEP are as follows:

T, Y, YHAT, XNU, AX, AY, AZ, PDOT, QDOT, RDOT, VEL, P, Q, R, and QQ are each dimensioned MAXNPTS

X is the two-dimensional data array and should be dimensioned N × MAXNPTS

S and XXSUM are two-dimensional work arrays and are dimensioned N × N

ICNT, IORD, B, V, STDER, FPART, TN, PPLT, FPLT, XSUM, XBAR, SIGMA, PPRT are each dimensioned N

W and XLAG are arrays for the autocorrelation function and its lag number. They should be dimensioned at least MAXNPTS/10.

APR is used in the calculation of the PRESS (Prediction Error Sum of Squares) criterion. It is a two-dimensional array with dimensions N × (MAXNPTS + N).

RR, A, AP are two-dimensional arrays containing variance and covariance information and are dimensioned (2N-1) × (2N-1).

Namelist Input - A namelist called INPUT communicates airplane geometry, mass and inertia characteristics as well as initial conditions and logic switches for program options. The elements of INPUT and their definitions are listed alphabetically as follows:

ALPHT - angle of attack trim value (radians)

BETT - angle of sideslip trim value (radians)

BSPAN - wing span (meters)

CBAR - wing mean aerodynamic chord (meters)

DELAT - aileron displacement at trim (radians)

DELET - elevator deflection at trim (radians)

DELRT - rudder displacement at trim (radians)

FCRT - critical F-value for entry or elimination of a term in the model

A nominal value between 5 and 10 for FCRT has proven effective from experience with high angle-of-attack airplane data.

G - acceleration due to gravity (m/sec^2)

IACELOP - option switch to read angular accelerations from data
0 - read from data
1 - calculate by cubic spline subroutine

IEQN - indicates which equations are to be fit:
If LATOP = 0 then IEQN = 1 for C_x
2 for C_z
3 for C_m
If LATOP = 1 then IEQN = 1 for C_y
2 for C_ℓ
3 for C_n

IFILOP - option switch to incorporate low pass filter on lateral acceleration measurements
IFILOP = 1 for filter active
IFILOP = 0 for filter inactive

IFLAG - option switch to have first LINMAX terms considered before any other terms. LINMAX is set in the main program.
IFLAG = 1 activates the option
IFLAG = 0 all terms are searched from the first pass on

LINMAX is set to 3 in line 38 of Program STEP (appendix A) for the longitudinal option (LATOP = 0) and 5 in line 40 for the lateral option (LATOP = 1). These values allow for consideration of the first three candidate model variables α, q, and δe for the longitudinal equations and the first five candidate model variables β, p, r, δa, and δr for the lateral equations. To consider any J terms first, in general, Linmax should be set to J and those J terms should be the first J terms entered into the two-dimensional X array in SUBROUTINE DATASET.

IPLOT - option to activate plotting
IPLOT = 1 activates plotting
IPLOT = 0 for no plotting

IPRESOP - option to invoke PRESS calculation
IPRESOP = 1 activates option
IPRESOP = 0 for no PRESS calculation

IPSKP - For IPRESOP = 1, IPSKP selects every (IPSKP)-th point for calculation of PRESS

ITRIMOP - option switch to read trim values from first data point to be analyzed. If ITRIMOP = 1, the namelist supplied values (or default values of 0) for ALPHT, BETT, DELAT, DELET, DELRT are used. IF ITRIMOP = 0, the values of angle of attack, angle of sideslip, aileron deflection, elevator deflection and rudder deflection at time TS are used for ALPHT, BETT, DELAT, DELET, DELRT, respectively.

IX - moment of inertia about longitudinal body axis (kg m^2)

IXZ - product of inertias (kg m^2)

IY - moment of inertia about lateral body axis (kg m^2)

IZ - moment of inertia about vertical body axis (kg m^2)

LATOP - option switch for lateral equations
LATOP = 1 for fitting lateral equations
LATOP = 0 for fitting longitudinal equations

M - airplane mass (kg)

NEQ - the number of equations to be fit (as opposed to IEQN which indicates which NEQ equations are to be fit). NEQ can be 1, 2, or 3.

NPTS - number of data points to be fit

PT - roll rate trim value (rad/sec)

QT - pitch rate trim value (rad/sec)

RHO - atmospheric density (kg/m^3)

RT - yaw rate trim value (rad/sec)

SAREA - wing area (m^2)

TS - starting time for data to be fit

Subroutines

SUBROUTINE DATASET - The purpose of SUBROUTINE DATASET is to read flight data from a file (TAPE 1) into the program and to set up the data array of time histories of the candidate independent model variables. The candidate variables for both the longitudinal and lateral options are given in Table 1. The user can easily change any of the candidate model variables in the table to meet his own needs. The candidate model variables presented here have proven to be useful in the work reported in reference 1.

The number of candidate model variables is limited only by the size of computer memory. Any changes in the number of candidate model variables in the X array of SUBROUTINE DATASET should be reflected in the value of N in the main program and possibly the dimensions which depend on N throughout the program.

SUBROUTINE DATASET also calls a cubic spline differentiation subroutine (SUBROUTINE SECDER AND FUNCTION DERSP) for the calculation of angular accelerations from the measured angular rates. These calls can be eliminated as can the SUBROUTINE SECDER and FUNCTION DERSP if the user has measured angular accelerations available.

SUBROUTINE AUTO - The normalized autocorrelation function for the residual sequence is calculated. XLAG and W must be dimensioned at least MAXNPTS/10.

SUBROUTINE FIL - This subroutine is a low pass filter for the smoothing of data in the time domain. The algorithm is taken from reference 8. When this filter routine is active (IFILOP = 1) the user must choose FC and FT (which define the frequency range in Hz for band pass roll off) in this subroutine so that H(I), I = 1, NPTS/2 is always defined.

Subroutines for PRESS calculation - STEP and STEPSPL programs use six subroutines for PRESS calculations. The main program calls upon three primary routines: PRESS, UPDATE, and PSET. These in turn call on three secondary routines: REDEF, INTRCHG, and RANDOM. Subroutines PRESS and UPDATE are called during each pass as model variables are added or deleted. The PRESS routine simply computes the value of PRESS associated with each candidate variable. This is done without any effect on the regular stepwise regression calculations. Subroutine UPDATE is used to modify the normal equations to reflect the change in model variables during each pass. A separate set of normal equations is used by PRESS so that the stepwise regression and PRESS calculations can proceed independently.

Subroutine PSET is called once at the start of a run to establish the dataset to be used in the PRESS computations. As described in reference 1, for a large number of data points PRESS approaches the residual sum of squares (RSS). Therefore it may be necessary when handling large datasets (number of points greater than 100) to use a reduced number of data points. The IPSKP variable controls the number of data points to be used by PRESS. The selection of 30 to 40 points has proven to be best. IRAN = 1 is the flag which indicates the reduced dataset is to be randomly selected.

The secondary routines RANDOM, REDEF, and INTRCHG provide a few simple operations. RANDOM returns a uniformly distributed random variable which is used to randomly select data when required by PSET. Subroutine INTRCHG is used by UPDATE to interchange rows and columns in the normal equation matrices. Subroutine REDEF is an initializing routine used to prepare the appropriate matrices for PRESS computations.

DESCRIPTION OF PROGRAM STEPSPL

STEPSPL differs from STEP mainly in the dimensions of arrays and in the SUBROUTINE DATASET. Program STEPSPL is dimensioned to accept data lengths of 900 points (45 seconds of data at 20 points per second). There is provision for 39 independent variables which will be spline "+" functions and for 23 spline knots. The "+" function is defined as $(\Delta\alpha)_+^m \equiv (\alpha - \alpha_k)_+^m \stackrel{\Delta}{=} (\alpha - \alpha_k)_+^m$ if $\alpha \geqslant \alpha_k$, $(\Delta\alpha)_+^m \stackrel{\Delta}{=} 0$, if $\alpha < \alpha_k$, where α_k is the value of the kth knot in angle of attack in radians.

Example 2 demonstrates the use of STEPSPL. Appendix E contains the STEPSPL listing.

Dimensions - Let MAXNPTS be the maximum number of points to be analyzed and let N - 1 be the maximum number of independent variables to be considered. The dimensions of arrays are as follows: T, Y, YHAT, XNU, AX, AY, AZ, PDOT, QDOT, RDOT, VEL, P, Q, R are each dimensioned MAXNPTS.

X is the two-dimensional data array and is dimensioned N × MAXNPTS.

S and XXSUM are two-dimensional work arrays and are dimensioned N × N.

ICNT, B, V, STDER, FPART, XSUM, XBAR, and SIGMA are each dimensioned N.

W and XLAG are arrays for the autocorrelation function and its lag number. They should each be dimensioned at least MAXNPTS/10.

RR, A, and AP are two-dimensional arrays containing variance and covariance information and are dimensioned (2N - 1) × (2N - 1).

Namelist Input - The namelist for STEPSPL is the same as that for STEP with the exception of the variables IPRESOP, and IPSKP which apply to PRESS subroutines not found in STEPSPL.

USING STEP AND STEPSPL

Aids in the Selection of an Adequate Model

Since there is no cost function which ensures that the best model has been found, STEP and STEPSPL provide a subset of all possible models. From this subset, one must make the selection of an adequate model for the data at hand. To assist in the selection of an adequate model, the programs provide several statistical and informational parameters at each step of the fitting process. These parameters are as follows:

1. The partial F-values for the coefficients of all variables that are currently in the model.

2. The total F-value associated with the current model.

3. The square of the correlation coefficient in percent corresponding to the percent variation from the mean of the data that is explained by the current model.

4. The Prediction Sum of Squares (PRESS) criterion - The scalar PRESS, corresponding to the ℓth subset of model variables, is defined as

$$\text{PRESS} = \sum_{i=1}^{N} \{y(i) - \hat{y}[i/x(1),\ \ldots,\ x(i-1),\ x(i+1),\ \ldots,\ x(N)]_{\ell}\}^2$$

where $y(i)$ is the ith response of the system and $\hat{y}(i/\ldots)_{\ell}$ is the least squares estimate of $E\{y(i)\}$ for the ℓth subset. Note the ith observation, $x(i)$, is not used in forming the estimate $\hat{y}(i/\ldots)_{\ell}$. The model corresponding to the smallest value of PRESS is the best predictor model. It is also a parsimonious model since PRESS reflects the added cost of redundant model variables.

5. The standard deviation of the residual. This should approach that calibrated for the instrument used to measure the dependent variable.

Also at each point in the selection process the user is provided with a synopsis of variables currently in the model as well as the estimates of the coefficients of those variables and the standard error of those estimates.

Example 1

In this example STEP is run on a simulated data set. The program listing is found in appendix A. The simulated data set to which the program STEP is applied is a subset of the time history for the mathematical model given in figure 2. The subset consists of the 43 points corresponding to an angle of attack in the range $14° < \alpha < 16°$. The true values for the parameters in this range are

$$C_{X_\alpha} = 0.700 \qquad C_{Z_\alpha} = -3.00 \qquad C_{m_\alpha} = -1.00$$

$$C_{X_q} = 0.0 \qquad C_{Z_q} = -20.0 \qquad C_{m_q} = +15.0$$

$$C_{X_{\delta e}} = 0.05 \qquad C_{Z_{\delta e}} = -1.10 \qquad C_{m_{\delta e}} = -1.00$$

The namelist/INPUT/for this example is found in appendix B and the output listing is in appendix C. In examining the namelist/INPUT/it is seen that:

1. IPRESOP = 0 - No PRESS calculation will be made; with PRESS inactive, processing time is cut by about a factor of 2.

2. TS = 0.0 - The first data point to be considered for fitting is that corresponding to time 0.0 sec on the data tape.

3. NEQ = 3 - All 3 equations corresponding to the choice of LATOP will be fit.

4. IEQN = 1, 2, 3 - The NEQ equations to be fit are 1, 2, and 3.

5. NPTS = 43 - 43 datapoints after TS are to be fit.

6. IPLOT = 1 - The program will plot the measured and computed time histories, residual sequence, and autocorrelation sequence at each step of the regression. If PRESS is active, IPLOT = 1 will also allow for the plotting of a synopsis of F-values and PRESS values after the last significant variable has been added to the model.

7. IFLAG = 1 - Selects the option whereby the first LINMAX terms are considered before any others. These terms correspond to a linear model.

8. SAREA = 13.74 - The wing area for the airplane is 13.74 m^2.

9. BSPAN = 9.98 - The airplane wingspan is 9.98 m.

10. CBAR = 1.40 - The airplane wing mean aerodynamic chord is 1.40 m.

11. M = 1055 - The airplane has a mass of 1055 kg.

12. RHO = 1.0272 - The mean atmospheric density during the maneuver was 1.0272 kg/m^3.

13. G = 9.81 m/sec^2 - is the gravitational acceleration constant.

14. IX = 2357 - The moment of inertia about the longitudinal body axis is 2357 kg m^2.

15. IY = 3051 - The moment of inertia about the lateral body axis is 3051 kg m^2.

16. IZ = 4833 - The moment of inertia about the vertical body axis is 4833 kg m^2.

17. IXZ = 177. - The product of inertia is 177 kg m^2.

18. DELET = -0.08318 - The elevator displacement at trim initial conditions is -0.08318 rad.

19. ALPHT = 0.2095 - The trim angle of attack is 0.2095 rad.

20. BETT = 0 - The trim angle of sideslip is 0. rad.

21. DELAT = 0 - The aileron displacement to trim is 0. rad.

22. DELRT = 0 - The rudder displacement to trim is 0. rad.

23. QT = 0 - Trim pitch rate is 0. rad/sec.

24. PT = 0 - Trim roll rate is 0. rad/sec.

25. RT = 0 - Trim yaw rate is 0. rad/sec.

26. FCRT = 5 - The critical partial F-value for entry into the regression is 5.

27. ITRIMOP = 1 - The trim values provided in this namelist will be used as opposed to the values of the associated variables at time TS.

28. IPSKP = 10. - Indicates the the PRESS option, if activated by IPRESOP = 1, should select every 10th point for the evaluation of the PRESS.

29. LATOP = 0 - Indicates that the longitudinal equations are to be considered for the fitting.

30. IACELOP = 0 - Indicates that angular accelerations will be read directly from the data string.

31. IFILOP = 0 - Indicates that the low pass filter will be inactive.

After the namelist, the trim values for angle of attack, angle of sideslip, aileron, elevator, and rudder are printed. The output is continued in appendix C with a line of header information and a run identifier from the data tape, the value of IEQN and the number of points to be fit printed. It is seen that for RUN 1, equation (1) (C_X since the longitudinal option is active), is to be fit for 43 data points (NPTS = 43). If an even number of points is specified for NPTS in the namelist, that number will be decreased by 1 by the program so that NPTS is always odd.

Next is a listing of the relevant data for the points being fit. Here, for the longitudinal option, time, velocity, angle of attack, pitch rate, and elevator deflection are listed. If the lateral option had been chosen (LATOP = 1), then time, velocity, angle of sideslip, roll rate, yaw rate, aileron deflection, and rudder deflection would have been printed.

The next line indicates that the highest correlation between the measured dependent variable (a_X here since LATOP = 0 and IEQN = 1) and an independent variable is for the first model variable, which is angle of attack. The partial F-value for this variable is 878, and its entry accounts for 95 percent of the variation. The standard deviation of the residual sequence ($a_{X_{measured}} - a_{X_{computed\ from\ model}}$) is 0.00139. The total F-value for this model is 857.

The next line gives the least squares estimates for parameters currently in the model. The order of the estimates is the same as the entry of data into the X array in SUBROUTINE DATASET. Below the parameter estimates is found the estimated standard error for that estimate. Here, $C_{X_\alpha} = 0.651$ with $\hat{\sigma}_{C_{X_\alpha}} = 0.022$ and the model for C_X is at this stage:

$$C_X = C_{X_o} + C_{X_\alpha}(\alpha - \alpha_o)$$

$$= 0.000229 + 0.651\ (\alpha - \alpha_o)$$

An optional visual aid is provided in the form of a plot. An example of the plot and its interpretation is given for the STEPSPL program in example 2.

The next variable chosen for the regression is variable 3, δ_e, with a partial F-value of 5.59×10^8. Since the entry of this term explains essentially 100 percent of the variation, it enhances the partial F-value of variable 1 also. The standard deviation of the residual sequence is now 0.38×10^{-6} and the F-value for the model is 5.98×10^9.

The new parameter estimates are $C_{X_\alpha} = 0.700$ and $C_{X_{\delta e}} = 0.050$. The respective standard errors are $\hat{\sigma}_{C_{X_\alpha}} = 0.61 \times 10^{-5}$ and $\hat{\sigma}_{C_{X_{\delta e}}} = 0.20 \times 10^{-5}$ and the model is

$$C_X = C_{X_o} + C_{X_\alpha}(\alpha - \alpha_o) + C_{X_{\delta e}}(\delta e - \delta e,o)$$

$$= 0.000063 + 0.700\ (\alpha - \alpha_o) + 0.05\ (\delta e - \delta e,o)$$

This completes the fitting of the C_X equation.

Next, RUN 1, equation (2) is to be fit. Equation (2) (for LATOP = 0) corresponds to the C_Z force coefficient. Again 43 points are to be fit. The most significant of the first three variables (since IFLAG = 1, the first LINMAX = 3 are considered) is variable 2, q. With 58.76 percent of the variation explained, the model at this point is

$$C_Z = C_{Z_0} + C_{Z_q} \frac{q\bar{c}}{2V}$$

$$= -1.31 - 15.0 \frac{q\bar{c}}{2V}$$

Next variable 3, δe, is added as being most highly correlated to the residual sequence of the previous model. With entry of the δe term, 72.64 percent of the variation is explained and the model is now

$$C_Z = C_{Z_o} + C_{Z_q} \frac{q\bar{c}}{2V} + C_{Z_{\delta e}}\ (\delta e - \delta e,o)$$

$$= -1.34 - 17.8 \frac{q\bar{c}}{2V} - 0.705\ (\delta e - \delta e,o)$$

With the entry of the variable 1, α, 100 percent of the variation is explained and the final model is simply the complete linear model.

$$C_Z = C_{Z_o} + C_{Z_\alpha} (\alpha - \alpha_o) + C_{Z_q} \frac{q\bar{c}}{2V} + C_{Z_{\delta e}} (\delta e - \delta e,o)$$

$$= -1.21 - 3.00 (\alpha - \alpha_o) - 20.0 \frac{q\bar{c}}{2V} - 1.10 (\delta e - \delta e,o)$$

The third and final equation to be fit in example 1 is the pitching moment equation. The process goes as in the equations (1) and (2) with the first three terms incorporated into the model. With the linear model completed, the model equation is

$$C_m = -0.731 - 1.05\alpha + 15.3 \frac{q\bar{c}}{2V} - 0.996 (\delta e - \delta e,o)$$

and explains 99.9 percent of the variation. However, the program adds, in the next step, variable 7. Note that the partial F-value of 29 for this variable is much less than and totally out of line with the first three terms (with partial F-values of 2960., 5530., and 20,300.). Hence, the user might consider this last term to be superfluous and retain the linear model from the previous step. The unexplained 0.06 percent has been contributed by the spline differentiation of q to obtain $\dot{q}$. When data for accelerations were read directly from the simulation program, 100 percent of the variation was accounted for.

Example 2

This example demonstrates the use of STEPSPL. STEPSPL is the basic STEP program with some dimension changes to allow for longer data lengths and the spline basis functions incorporated into SUBROUTINE DATASET. The simulated data for this example was generated by numerically integrating a model given by:

$$C_X = -0.180 + 0.700\alpha + 0.050 (\delta e - \delta e,o)$$

$$C_Z = 0.112 - 5.00\alpha + 2.00 (\alpha - 0.2269)_+ + 1.50 (\alpha - 0.3142)_+$$

$$- 10.0 \frac{q\bar{c}}{2V} - 10.0 (\alpha - 0.2269)^o_+ \frac{q\bar{c}}{2V} - 10.0 (\alpha - 0.3142)^o_+ \frac{q\bar{c}}{2V}$$

$$- 0.800 (\delta e - \delta e,o)$$

$$C_m = 0.105 - 0.400\alpha - 0.600\ (\alpha - 0.2269)_+ - 1.00\ (\alpha - 0.3142)_+$$

$$- 15.0\ \frac{q\bar{c}}{2V} + 10.0\ (\alpha - 0.1745)^o_+ \frac{q\bar{c}}{2V} + 10.0\ (\alpha - 0.2269)^o_+ \frac{q\bar{c}}{2V}$$

$$- 10.0\ (\alpha - 0.3142)^o_+ \frac{q\bar{c}}{2V}$$

$$- 2.00\ (\delta e - \delta e,o)$$

This longitudinal model is integrated using an elevator doublet input string. Random noise (with Gaussian distribution, zero mean, and $\sigma = 0.003$) was added to pitch rate q. This σ corresponds to ground calibration measurement error for the pitch rate gyro in previous flight testing. This σ should yield a σ of 0.08 for $\dot{q}$ and 0.023 for C_m.

Appendix E gives the results of applying STEPSPL to the noisy data sequence. The first information written is the namelist so that the user may quickly confirm that all elements on the list are correct. In this example, it is seen that only one equation (NEQ = 1) is to be fit. That is the third equation (IEQN = 3) which is the pitching moment equation since LATOP = 0. With IACELOP = 1, the spline subroutines are called to numerically differentiate the angular rate in order to derive angular accelerations. Since there is no PRESS option with STEPSPL, the PRESS associated options of example 1 are absent. Otherwise all INPUT options are the same as in example 1.

After the namelist, there is a listing of the angles of attack corresponding to cardinal knot positions. Following the knot values is a listing of trim conditions that the program will be using. Next is a line of header information giving a run identification number, the equation to be fit and the number of points to be fit. Here, it is seen that RUN 1, Equation 3 (C_m) is to be fit and 239 points will be used. Next the relevant data is printed. Since the longitudinal option has been selected, these data are time, airspeed, angle of attack, pitch rate and elevator deflection.

Following the data listing is the actual fitting information. The overall listing of information is the same as described in example 1 for STEP. The major difference is in the number of candidate model variables (which is now 39 plus a bias term). The maximum partial F-value (349.) is associated with the variable number 3, elevator deflection. The percent variation explained by the addition of this variable is 59.49 percent leaving a standard deviation of the residual sequence of 0.07. The parameter $C_{m_{\delta e}}$ is estimated as -2.31 with a standard error of 0.12. The bias term, C_{m_o}, is estimated to be -0.000723. The next term selected by STEPSPL is variable 1, angle of attack. The listing now shows that variables in positions 1 and 3 are in the regression (by the "1's" in those positions). The percent variation explained by this model is 89.65 percent leaving a standard deviation of the residual sequence of 0.036. The total F-value for this model is 1022. The parameter estimates are:

$C_{m_o} = 0.246$

$C_{m_\alpha} = -1.05\ (\pm 0.040)$

$C_{m_{\delta e}} = -2.09\ (\pm 0.063)$

The process continues until the entry of variable 13 corresponding to $q\,(\alpha - 0.1571)_+^0$ the knot at $\alpha = 9°$ $(9° = 0.1571 \text{ rad})$. The final estimated model is given in Table 2 and in figure 3, where it is compared with the true model used to generate the data. Though some of the values given in table 2 appear to be bad, it is seen from figure 3 that the overall model is very good. The program has approximated the one knot in C_{m_q} at 10° by two knots: one is at 9° and the other is at 11°. Thus, the table of values does not offer as good a feeling for the model as does the figure.

In addition to the printout that has been discussed for this example and example 1, a plotting option is available. The subroutines used in the listings provided for STEP and STEPSPL are local to the LaRC computer center, but the user may combine whatever software is at his disposal to plot the same information. Figure 4 contains the plot output for example 2. At each variable entry, three plots are generated. For example, figure 4(b) represents the entry of variable 3, δe. The bottom plot in figure 4(b) displays the measured C_m (+'s) and the C_m computed by the model (solid line) at this stage of the regression. Above that, is a plot of the residual time history and the top plot is the autocorrelation function of the residual sequence. It is seen in figure 4(b), that the one variable model leaves quite a bit of structure in the residual sequence. In figure 4(c), the model, residuals, and autocorrelation sequence for the model containing δe and α are plotted. The autocorrelation sequence and the residual sequence are improved dramatically over figure 4(b). By figure 4(f), the visual aid displays a good fit, and good autocorrelation for the residual sequence. Figure 4(f) corresponds to the model containing 5 variables plus a bias term. The remaining parts of figure 4 all indicate a good fit and acceptable autocorrelation function. In general the plots have several applications to the curve fitting problem. One application is through structure that is left in the residual sequence. The user can look for new candidate model variables that might remove that structure. Secondly, if the structure is too fine for the user's eye, the autocorrelation function may indicate that that structure is present. Third, of course, is simply a picture of how well the computed curve fits the measured data. This also demonstrates the noisiness of the data. For example, a large variance in the residual sequence may indicate some filtering is required on the measured data. The indication for filtering is especially strong when the model fits the overall trends in the measured data but the residual variance is still large.

CONCLUDING REMARKS

Two versions of a stepwise regression computer program which were developed for the determination of airplane model structure from flight data have been presented. The use of the program STEP with a Taylor's series expansion of the aerodynamic force and moment coefficients was demonstrated in example 1. It is recommended that this program be used in regions where the variations in angles of attack and sideslip are not large but nonlinearity or aerodynamic coupling is suspected. Secondly, an example employing program STEPSPL was given. This program uses spline basis functions for the aerodynamic force and moment coefficients. It is recommended that STEPSPL be used when maneuvers having large variations in angle of attack and/or angle of sideslip need to be analyzed. The appendices contain the program listings and output for the two examples.

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APPENDIX A

This appendix contains a listing of PROGRAM STEP.

```
      PROGRAM STEP(INPUT,OUTPUT,TAPE1,TAPE2,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL M,IY,IX,IZ,IXZ
      DIMENSION RR(49,49),A(49,49),AP(49,49)
      DIMENSION T(500),Y(500),YHAT(500),XNU(500)
      DIMENSION S(25,25),B(25),V(25)
      DIMENSION STDER(25),FPART(25)
      DIMENSION W(50),XLAG(50)
      DIMENSION IEQN(3)
      DIMENSION TN(25),PPLT(25),FPLT(25),TITLE(8)
      COMMON/START/ X(25,500),XXSUM(25,25),XSUM(25),XBAR(25),SIGMA(25)
      COMMON/ACDATA/ SAREA,BSPAN,CBAR,M,RHO,G,IX,IY,IZ,IXZ,DELET,ALPHT
     1,BETT,DELAT,DELRT,QT,PT,RT
      COMMON/AOP/ APR(25,525),QQ(500),PPRT(25),PRSMIN
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *              ,IPPTS,LATOP,ITRIMOP,ICALL,IACELOP,IFILOP
      COMMON/ORDER/ IEQ,N
      COMMON/ACCEL/ AX(500),AY(500),AZ(500),PDOT(500),QDOT(500),RDOT(500
     1),VEL(500),P(500),Q(500),R(500)
      EQUIVALENCE (A,RR)
      NAMELIST /INPUT/ IPRESOP,TS,NEQ,IEQN,
     *                 NPTS,IPLOT,IFLAG,
     *                 SAREA,BSPAN,CBAR,
     *                 M,RHO,G,
     *                 IX,IY,IZ,IXZ,
     *                 DELET,ALPHT,BETT,DELAT,DELRT,QT,PT,RT,
     *                 FCRT,ITRIMOP,IPSKP,LATOP,IACELOP,IFILOP
      ALPHT=BETT=DELET=DELAT=DELRT=QT=PT=RT=0.
      CALL PSEUDO
 2502 TOL=1.0E-08        $ICALL=0
      READ(5,INPUT)
      IF(EOF(5)) 2501,2503
 2503 WRITE(6,INPUT)
C
C     PRINT SUMMARY TITLES ON TAPE2
C
      WRITE(2,980)
  980 FORMAT(10X,*STEPWISE REGRESSION SUMMARY*)
      N=15  $LINMAX=3
      IF(LATOP.EQ.1) N=25
      IF(LATOP.EQ.1) LINMAX=5
C
      DO 1000 L=1,NEQ
```

```
              IEO=IEON(L)      $NGO=0
              ICALL=ICALL+1
              CALL DATASET(TS,T,Y,X)
              WRITE(2,985) IEO
          985 FORMAT(5X,*EQN #  *,I2)
              WRITE(2,981)
          981 FORMAT(2X,*TOT #*,2X,*PARAM #*,2X,*% VAR*,5X,*PRESS*,9X,*TOT F*)
      C
      C       SET UP DATA ARRAYS
      C
              IF(LATOP.EO.1) GO TO 800
              DO 804 I=1,NPTS
              IF(IEO-2) 801,802,803
          801 X(N,I)=Y(I)=2*M*G/(RHO*SAREA*VEL(I)*VEL(I))*AX(I)
              GO TO 804
          802 X(N,I)=Y(I)=2*M*G/(RHO*SAREA*VEL(I)*VEL(I))*AZ(I)
              GO TO 804
          803 X(N,I)=Y(I)=2*IY/(RHO*SAREA*CBAR*VEL(I)*VEL(I))*(QDOT(I)
             1-(IZ-IX)/IY*P(I)*R(I)-IXZ/IY*(R(I)*R(I)-P(I)*P(I)))
          804 CONTINUE
              GO TO 805
          800 DO 806 I=1,NPTS
              IF(IEO-2) 807,808,809
          807 X(N,I)=Y(I)=2*M*G/(RHO*SAREA*VEL(I)*VEL(I))*AY(I)
              GO TO 806
          808 X(N,I)=Y(I)=2*IX/(RHO*SAREA*BSPAN*VEL(I)*VEL(I))*(PDOT(I)-
             1(IY-IZ)/IX*Q(I)*R(I)-(IXZ/IX)*(P(I)*Q(I)+RDOT(I)))
              GO TO 806
          809 X(N,I)=Y(I)=2*IZ/(RHO*SAREA*BSPAN*VEL(I)*VEL(I))*(RDOT(I)-
             1(IX-IY)/IZ*P(I)*Q(I)-(IXZ/IZ)*(PDOT(I)-Q(I)*R(I)))
          806 CONTINUE
          805 CONTINUE
              IANOVA=0     $NM1=N-1   $N2M1=2*N-1  $IPASS=0
              N2=N2M1*N2M1        $MAXLAG=NPTS/10
              LINCNT=0       $LM1=NM1
              F1=F2=FCRT
              IF(IFLAG .EQ. 1) LINOP=1
              DO 206 I=1,MAXLAG
          206 XLAG(I)=I-1
              DO 51 I=1,2401
           51 A(I)=0.
              DO 52 I=1,NM1
```

```
     52 A(I,I+N)=1.
        DO 53 I=1,NM1
     53 A(I+N,I)=-1.
        DO 50 I=1,N
        XBAR(I)=XSUM(I)=ICNT(I)=0.
        DO 50 II=1,N
     50 XXSUM(II,I)=0.
        DO 100 II=1,N
        DO 100 I=1,N
        DO 100 J=1,NPTS
    100 XXSUM(I,II)=XXSUM(I,II)+X(I,J)*X(II,J)
        DO 101 II=1,N
        DO 101 J=1,NPTS
    101 XSUM(II)=XSUM(II)+X(II,J)
        DO 201 I=1,N
        DO 200 J=1,NPTS
    200 XBAR(I)=XBAR(I)+X(I,J)
    201 XBAR(I)=XBAR(I)/NPTS
        DO 202 I=1,N
        DO 202 J=1,N
        S(I,J)=XXSUM(I,J)-XSUM(I)*XSUM(J)/NPTS
    202 CONTINUE
        DO 203 I=1,N
    203 SIGMA(I)=SQRT(S(I,I))
        DO 204 I=1,NM1
        IP1=I+1
        DO 204 J=IP1,N
        RR(I,J)=S(I,J)/(SIGMA(I)*SIGMA(J))
    204 RR(J,I)=RR(I,J)
        DO 205 I=1,N
    205 RR(I,I)=1.
        DO 210 I=1,N
        SIGMA(I)=SIGMA(I)/SQRT(FLOAT(NPTS))
    210 CONTINUE
        PHI=NPTS-1
        DO 301 I=1,NM1
    301 B(I)=0.
        SY=SIGMA(N)*SQRT(RR(N,N)/PHI)
C
C       REDEFINE XXSUM,X WITH REDUCED # OF DATA PTS FOR USE BY PRESS
C
        IF(IPRESOP.EQ.0) GO TO 450
```

```
      IF(IPSKP .GT. 0) CALL PSET
      IF(IPSKP .EQ. 0) IPPTS=NPTS
C
C     START LARGE LOOP
C     VMAX CALCULATED
C
  450 I=1    $ VMAX=0.  $IPASS=IPASS+1
  320 IF(A(I,I).GT.TOL) 250,300
  250 IF(ICNT(I).EQ.1) GO TO 300
      V(I)=A(I,N)*A(N,I)/A(I,I)
      IF(V(I).GT.VMAX) 260,300
  260 VMAX=V(I) $NMAX=I
  300 IF(LINOP.EQ.1) LM1=LINMAX
      IF(I.EQ.LM1) 330,310
  310 I=I+1
      GO TO 320
  330 CONTINUE
      I=NMAX
*     CALCULATE  F
      IF(VMAX.LT.TOL) 2000,443
 2000 IF(LINOP.EQ.0) 1999,2111
  443 F=PHI*VMAX/(A(N,N)-VMAX)
      IF(F.GT.0.) GO TO 444
      A(N,N)=VMAX  $F=-F  $NGO=1  $PRINT 998
  444 PRINT 950,F,I
      IF(F.GT.F1.OR.LINOP.EQ.1) 400,1999
  400 IF(IPRESOP.EQ.0) GO TO 403
C
C     CALC PRESS
C
      CALL PRESS
  403 CONTINUE
*     UPDATE THE A MATRIX
      ICNT(I)=1  $PHI=PHI-1
      DO 401 II=1,N2M1
      DO 401 JJ=1,N2M1
      IF(II.NE.I) GO TO 402
      AP(II,JJ)=A(II,JJ)/A(II,II)
      GO TO 401
  402 AP(II,JJ)=A(II,JJ)-A(II,I)*A(I,JJ)/A(I,I)
  401 CONTINUE
      DO 411 I2=1,N2M1
```

```
          DO 411 J2=1,N2M1
      411 A(I2,J2)=AP(I2,J2)
*         PARTIAL F TESTS
      430 PRINT 951,(ICNT(II),II=1,NM1)
*
          IF(IPASS.EQ.1) GO TO 431
          IF(NGO.EQ.1) GO TO 431
          DO 419 II=1,NM1
          IF(ICNT(II).EQ.1) 410,419
      410 FPART(II)=PHI*A(II,N)*A(II,N)/(A(N,N)*A(II+N,II+N))
          PRINT 952,II,FPART(II)
      419 CONTINUE
      418 IF(IANOVA.EQ.1) GO TO 431
*         ELIMINATE VARIABLES WITH F<F2
          DO 429 I1=1,NM1
          IF(ICNT(I1).EQ.1) 420,429
      420 IF(FPART(I1).LT.F2.AND.LINOP.EQ.0) 421,429
      421 IMIN=I1  $ICNT(I1)=0  $PRINT 953,I1
          DO 428 II=1,N2M1
          DO 428 JJ=1,N2M1
          IF(II.NE.IMIN) GO TO 427
          AP(II,JJ)=A(II,JJ)/A(N+II,N+II)
          GO TO 428
      427 AP(II,JJ)=A(II,JJ)-A(II,N+IMIN)*A(IMIN,JJ)/A(N+IMIN,N+IMIN)
      428 CONTINUE
          DO 426 I2=1,N2M1
          DO 426 J2=1,N2M1
      426 A(I2,J2)=AP(I2,J2)
      429 CONTINUE
*         NEW ANOVA SUMMARY
          IANOVA=1
          GO TO 430
      431 CONTINUE
          IF(IPRESOP.EQ.0) GO TO 432
C
C         UPDATE A MATRIX (=APR) USED IN PRESS CALC'S
C
          CALL UPDATE
      432 IANOVA=0
          IV=0
          DO 439 II=1,N
      439 IV=IV+ICNT(II)
```

```
      SSDR=1.-A(N,N)  $XMSDR=SSDR/IV
      SSREG=A(N,N)  $XMSSREG=SSREG/PHI
      PVAR=100*SSDR
      PRINT 954,PVAR
      SDRES=SQRT(A(N,N)*S(N,N)/PHI)
      PRINT 955,SDRES
      FTOT=XMSDR/XMSSREG
      PRINT 957,FTOT
  957 FORMAT(1X,*TOTAL F VALUE IS*,E12.5)
C
C     PRINT SUMMAPY ON TAPE2
C
      WRITE(2,982) IV,NMAX,PVAR,PPRT(NMAX),FTOT
  982 FORMAT(1X,I5,2X,I5,3X,F6.2,3X,E12.5,3X,E12.5)
      TN(IV)=FLOAT(IV)
      PPLT(IV)=PPRT(NMAX)
      FPLT(IV)=FTOT
      DO 449 II=1,NM1
      IF(ICNT(II).NE.1) GO TO 448
      B(II)=A(II,N)*SQRT(S(N,N)/S(II,II))
      STDER(II)=SDRES*SQRT(A(II,II)/S(II,II))
      GO TO 449
  448 B(II)=0.  $STDEP(II)=0.
  449 CONTINUE
      SUM=0.
      DO 451 II=1,NM1
  451 SUM=SUM+B(II)*XBAR(II)
      B(N)=XBAR(N)-SUM
      PRINT958
      PRINT 956,(B(II),II=1,N)
      PRINT 956,(STDER(II),II=1,NM1)
      DO 460 II=1,NPTS
      YHAT(II)=B(N)
      DO 461 JJ=1,NM1
  461 YHAT(II)=YHAT(II)+B(JJ)*X(JJ,II)
  460 XNU(II)=Y(II)-YHAT(II)
      IF(IPLOT .EQ. 0) GO TO 470
      CALL AUTO(XNU,MAXLAG,NPTS,W,XXSUM(N,N),IV+1,YHAT,Y)
      CALL INFOPLT(0,NPTS,T,1,Y,1,0.,0.,0.,0.,1.,4,4HTIME,6,
     16HY,YHAT,22,5.,3.5,.75,.75)
      CALL INFOPLT(9,NPTS,T,1,YHAT,1,0.,0.,0.,0.,1.,4,4HTIME,6,
     16HY,YHAT,C,5.,3.5,.75,.75)
```

```
      CALL INFOPLT(9,NPTS,T,1,XNU,1,0.,0.,0.,0.,0.,4,4HTIME,6,
     16HY-YHAT,22,5.,3.5,0.0,4.75)
      CALL INFOPLT(1,MAXLAG,XLAG,1,W,1,0.,0.,0.,0.,0.,3,
     13HLAG,6,6HAUTO C,22,5.,3.5,0.C,4.75)
  470 CONTINUE
      IF(NGO.EQ.1) GO TO 1000
      GC TO 2112
 2111 LINOP=0  $LINCNT=LINMAX  $LM1=N-1
      GO TO 450
 2112 LINCNT=LINCNT+1
       IF(LINCNT.GE.LINMAX) LINOP=0
      LM1=N-1
      GO TO 450
  950 FORMAT(1X,///,10X,*MAXIMUM F VALUE IS *,E10.3,* FOR VARIABLE *,I3)
  951 FORMAT(1X,*VARIABLES IN REGRESSION*,24I4)
  952 FORMAT(1X,*PARTIAL F VALUE FOR VARIABLE *,I3,* IS *,E10.3)
  953 FORMAT(1X,*VARIABLE *,I3,* ELIMINATED*)
  954 FORMAT(1X,*PERCENT VARIATION EXPLAINED IS *,F6.2)
  955 FOPMAT(1X,*STD. DEVIATION OF RESIDUALS IS *,E10.3)
  958 FORMAT(1X,*NEW PARAMETER ESTIMATES AND STD. DEV. ARE*)
  956 FORMAT(1X,15E9.3,/,1X,10E9.3)
  998 FORMAT(1X,*NEGATIVE F VALUE CALCULATED*)
 1999 CONTINUE
      IF(IPRESOP.EQ.C) GO TO 1000
      CALL PLOT2(TN,PPLT,FPLT,IV,24HTOTAL NO. PARAM IN MODEL,24,
     *          5HPRESS,5,4HFTOT,4)
 1000 CONTINUE
      ENDFILE 2
      REWIND 2
      WRITE(6,3000)
 3000 FORMAT(1H1,2X,*  *)
      DO 1500 I=1,100
      READ(2,2001) TITLE
      IF(EOF(2)) 2500,1200
 1200 CONTINUE
      WRITE(6,2001) TITLE
 1500 CONTINUE
 2001 FORMAT(8A10)
 2500 CONTINUE
      GO TO 2502
 2501 CALL CALPLT(0.,0.,999)
      STOP
```

```
295          END
```

```
      SUBROUTINE DATASET(TS,T,Y,X)
      REAL M,IY,IX,IZ,IXZ
      DIMENSION T(500),Y(500),X(25,500)
      DIMENSION BETA(500),ALPH(500)
      DIMENSION DELA(500),DELR(500),DELE(500)
      DIMENSION NAMES(50),IUNITS(50),HDR(8),DATA(50)
      DIMENSION PDD(500),QDD(500),RDD(500),PTEM(500),QTEM(500),RTEM(500)
     1,WRK1(500),WRK2(500),WRK3(500),WRK4(500),WRK5(500),WRK6(500)
      COMMON/ACDATA/ S,B,C,M,RHO,G,IX,IY,IZ,IXZ,DELET,ALPHT
     1,BETT,DELAT,DELRT,QT,PT,RT
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *             ,IPPTS,LATOP,ITRIMOP,ICALL,IACELOP,IFILOP
      COMMON/ORDEP/ IEQ,N
      COMMON/ACCEL/ AX(500),AY(500),AZ(500),PDOT(500),QDOT(500),RDOT(500
     1),VEL(500),P(500),Q(500),R(500)
C
C
C
      IF(ICALL.GT.1) GO TO 46
      J2=NPTS/2
      JPTS=2*J2
      IF( (NPTS-JPTS) .EQ. 0) NPTS=JPTS-1
      JDIM=NPTS+N
      IDIM=N
      REWIND 1
      ID=1
      NCH=20
*     READ(1) ID,NCH,(NAMES(I),I=1,NCH),(IUNITS(I),I=1,NCH),HDR
*     IF(EOF(1)) 9994,502
  502 READ(1) (DATA(J),J=1,NCH)
      IF(EOF(1)) 9996,8001
 8001 IF((TS).GT.DATA(1)) 502,600
  600 CONTINUE
      IF(ITRIMOP.EQ.1) GO TO 602
      BETT=DATA(3) $DELAT=DATA(13) $DELRT=DATA(15)  $DELET=DATA(14)
      ALPHT=DATA(19)
  602 PRINT 1980,ALPHT,BETT,DELAT,DELET,DELRT
 1980 FORMAT(1X,///,10X,*TRIM VALUES*/,15X,
     **ALPHT        BETT          AILT          DELET         DELRT*/,
     *10X,5E12.5)
      DO 15 I=1,NPTS
      READ (1) (DATA(J),J=1,NCH)
```

```
      IF(EOF(1)) 9996,601
  601 CONTINUE
      T(I)= DATA(1)-TS
      VEL(I)= DATA(2)
      BETA(I)= DATA(18)-BETT
      ALPH(I)= DATA(19)-ALPHT
      P(I)= DATA(5)
      Q(I)= DATA(6)
      R(I)= DATA(7)
      AX(I)=DATA(10)
      AY(I)= DATA(11)
      AZ(I)= DATA(12)
      DELA(I)= DATA(13)-DELAT
      DELR(I)= DATA(15)-DELRT
      DELE(I)=DATA(14)-DELET
      PDOT(I)=DATA(16)  $QDOT(I)=DATA(20)  $RDOT(I)=DATA(17)
   15 CONTINUE
      IF(IACELOP.EQ.0)  GO TO 46
      CALL SECDER(3,3,T,P,PDD,PTEM,NPTS,P0,P3,.5,.5,WRK1,WRK2,WRK3,
     1WRK4,WRK5,WRK6)
      CALL SECDER(3,3,T,Q,QDD,QTEM,NPTS,P0,P3,.5,.5,WRK1,WRK2,WRK3,
     1WRK4,WRK5,WRK6)
      CALL SECDER(3,3,T,R,RDD,RTEM,NPTS,P0,P3,.5,.5,WRK1,WRK2,WRK3,
     1WRK4,WRK5,WRK6)
      DO 45 I=1,NPTS
      PDOT(I)=DERSP(T(I),T,P,NPTS,PDD,PTEM)
      QDOT(I)=DERSP(T(I),T,Q,NPTS,QDD,QTEM)
      RDOT(I)=DERSP(T(I),T,R,NPTS,RDD,RTEM)
   45 CONTINUE
   46 CONTINUE
      IF(IFILOP.EQ.0) GO TO 47
      CALL FIL(T,AY,NPTS)
   47 CONTINUE
C
      IF(LATOP.NE.1) GO TO 803
      DO 800 I=1,NPTS
      X(1,I)=BETA(I)
      X(2,I)=P(I)*B/(2.*VEL(I))
      X(3,I)=R(I)*B/(2.*VEL(I))
      X(4,I)=DELA(I)
      X(5,I)=DELR(I)
      X(6,I)=ALPH(I)*X(1,I)
```

```
      X(7,I)=ALPH(I)*X(2,I)
      X(8,I)=X(3,I)*ALPH(I)
      X(9,I)=DELA(I)*ALPH(I)
      X(10,I)=DELR(I)*ALPH(I)
      X(11,I)=ALPH(I)*ALPH(I)*X(1,I)
      X(12,I)=ALPH(I)*ALPH(I)*X(2,I)
      X(13,I)=ALPH(I)*ALPH(I)*X(3,I)
      X(14,I)=ALPH(I)*ALPH(I)*X(4,I)
      X(15,I)=ALPH(I)*ALPH(I)*X(5,I)
      X(16,I)=X(1,I)*X(1,I)
      X(17,I)=X(1,I)*X(16,I)
      X(18,I)=X(1,I)*X(17,I)
      X(19,I)=X(1,I)*X(18,I)
      X(20,I)=X(1,I)*X(11,I)
      X(21,I)=ALPH(I)*X(16,I)
      X(22,I)=ALPH(I)
      X(23,I)=ALPH(I)*ALPH(I)
      X(24,I)=ALPH(I)*X(23,I)
  800 CONTINUE
      GO TO 804
  803 CONTINUE
      DO 801 I=1,NPTS
      X(1,I)=ALPH(I)
      X(2,I)=C/(2*VEL(I))*Q(I)
      X(3,I)=DELE(I)
      X(4,I)=X(1,I)*X(1,I)
      X(5,I)=X(1,I)*X(2,I)
      X(6,I)=X(1,I)*X(3,I)
      X(7,I)=X(4,I)*X(2,I)
      X(8,I)=X(4,I)*X(3,I)
      X(9,I)=X(4,I)*X(1,I)
      X(10,I)=X(9,I)*X(1,I)
      X(11,I)=X(10,I)*X(1,I)
      X(12,I)=X(11,I)*X(1,I)
      X(13,I)=X(12,I)*X(1,I)
  801 X(14,I)=X(13,I)*X(1,I)
  804 CONTINUE
      PRINT 964,ID,IEQ,NPTS
      IF(ICALL.GT.1) GO TO 999
      IF(LATOP.EQ.0) GO TO 50
      PRINT 968
  968 FORMAT(1X,7X,*TIME*,11X,*V*,12X,*BETA*,11X,*P*,14X,*R*,11X,
```

```
     1*DELA*,11X,*DELR*)
 964 FORMAT(1H1,3X,*RUN*,I5,5X,*EQUATION *,I2,5X,*NPTS*,I5,///)
     PRINT 962,(T(I),VEL(I),BETA(I),P(I),R(I),DELA(I),DELR(I),I=1,NPTS)
 962 FORMAT(7(2X,E12.4))
     CALL INFOPLT(1,NPTS,T,1,DELA,1,0.,0.,0.,0.,0.,1,1HT,
    14,4HDELA,22,7.,5.,.75,.75)
     CALL INFOPLT(1,NPTS,T,1,DELR,1,0.,0.,0.,0.,0.,1,1HT,
    14,4HDELR,22,7.,5.,.75,.75)
     GO TO 999
  50 CONTINUE
     PRINT 998
 998 FORMAT(1X,7X,*TIME*,11X,*V*,11X,*ALPHA*,11X,*Q*,14X,*DELE*)
     PRINT 997,(T(I),VEL(I),ALPH(I),Q(I),DELE(I),I=1,NPTS)
 997 FORMAT(5(2X,E12.4))
     CALL INFOPLT(1,NPTS,T,1,DELE,1,0.,0.,0.,0.,0.,1,1HT,
    14,4HDELE,22,7.,5.,.75,.75)
     GO TO 999
9998 PRINT 9999
9999 FORMAT(1X,*EOF ON DUMMY READ*)
     GO TO 999
9996 PRINT 9997,J,I
9997 FORMAT(1X,*EOF ON DATA READ*,5X,*INDEX J,I= *,2I10)
     GO TO 999
9994 PRINT 9995
9995 FORMAT(1X,*EOF ON HDR READ*)
 999 CONTINUE
     RETURN
     END
```

```
      SUBROUTINE AUTO(X,MAXLAG,N,W,YSQ,IQ,YHAT,Y)
      DIMENSION X(1),W(1),YHAT(1),Y(1)
      MLAGM1=MAXLAG-1  $XN=FLOAT(N)
      XSUM=0.   $XXSUM=0. $YSUM=YHSUM=P=PL=0.
      DO 7 I=1,N
      YHSUM=YHSUM+YHAT(I)
      YSUM=YSUM+Y(I)
    7 XSUM=XSUM+X(I)
      YHBAR=YHSUM/N
      YBAR=YSUM/N
      XMEAN=XSUM/N
      DO 8 I=1,N
    8 X(I)=X(I)-XMEAN
      DO 12 I=1,N
   12 XXSUM=XXSUM+X(I)*X(I)
       YHATSQ=YSQ-XXSUM
      PRINT 900,XMEAN,XXSUM
  900 FORMAT(1X,*RESIDUAL MEAN IS*,E12.5,/,1X,*SIGMA SQ OF RESIDUAL IS *
     1,E12.5)
      DO 2 K=1,MAXLAG
      SUM=0.  $WO=0.
      NMK=N-K
      DO 1 I=1,NMK
    1 SUM=SUM+X(I)*X(I+K)
    2 W(K)=1./(N-K)*SUM
      DO 3 I=1,N
    3 WO=WO+X(I)*X(I)
      WO=WO/N
      DO 9 I=1,MAXLAG
    9 W(MAXLAG+2-I)=W(MAXLAG+1-I)
      W(1)=WO
      DO 10 I=1,N
   10 X(I)=X(I)+XMEAN
      DO 11 I=1,MAXLAG
   11 W(I)=W(I)/WO
      RETURN
      END
```

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```
      FUNCTION DERSP(XX,X,Y,N,P,H)                                    DSCF 230
C     FUNCTION DERSP                                                  DSCF  10
C                                                                     DSCF  20
C        DERSP IS USED TO OBTAIN THE FIRST DERIVATIVE OF SPLINE       DSCF  30
C        CURVE FITTED DATA                                            DSCF  40
C                                                                     DSCF  50
C        USAGE -                                                      DSCF  60
C        X = DERSP(XX,X,Y,N,P,H)                                      DSCF  70
C        NOTE -  IF XX LESS THAN X(1) THEN DERSP = DX(1)/DY           DSCF  80
C                IF XX GREATER THAN X(N) THEN DERSP = DX(N)/DY        DSCF  90
C                                                                     DSCF 100
C        WHERE -                                                      DSCF 110
C        XX          INDEPENDENT VARIABLE FOR WHICH INTERPOLATED SLOPE DSCF 120
C        IS DERSIRED                                                  DSCF 130
C        X           N-DIMENSIONED VECTOR OF INDEPENDENT POINTS       DSCF 140
C        Y           N-DIMENSIONED VECTOR OF DEPENDENT POINTS         DSCF 150
C        N           NUMBER OF DATA POINTS                            DSCF 160
C        P           N-DIMENSIONED VECTOR FROM UPDATE                 DSCF 170
C        H           (N-1)-DIMENSIONED VECTOR FROM UPDATE             DSCF 180
C                                                                     DSCF 190
C        SUBROUTINES CALLED -                                         DSCF 200
C        NONE                                                         DSCF 210
C                                                                     DSCF 220
      DIMENSION X(1),Y(1),P(1),H(1)                                   DSCF 240
      XP=XX                                                           DSCF 250
      IF(XX.LT.X(1)) GO TO 1                                          DSCF 260
      K=N-1                                                           DSCF 270
      DO 2 I=1,K                                                      DSCF 280
      IF(XX.LT.X(I+1)) GO TO 3                                        DSCF 290
    2 CONTINUE                                                        DSCF 300
      I=K                                                             DSCF 310
      XP=X(N)                                                         DSCF 320
      GO TO 3                                                         DSCF 330
    1 XP=X(1)                                                         DSCF 340
      I=1                                                             DSCF 350
    3 F1=(X(I+1)-XP)**2                                               DSCF 360
      F2=(XP-X(I))**2                                                 DSCF 370
      F3=H(I)/3.                                                      DSCF 380
      DERSP=((F3-F1/H(I))*P(I) + (F2/H(I)-F3)*P(I+1))/2.+(Y(I+1)-Y(I))/ DSCF 390
     1   H(I)                                                         DSCF 400
      RETURN                                                          DSCF 410
      END                                                             DSCF 420
```

```
      SUBROUTINE SECDER(L1,L2,X,Y,P,H,N,P0,P3,XK1,XK2,A,B,C,D,GAMMA,    UPD  480
     1   BETA)                                                          UPD  490
C     SUBROUTINE SECDER                                                 UPD   10
C                                                                       UPD   20
C        SECDER IS USED WITH FUNCTION SPLINE TO PREFORM A SPLINE        UPD   30
C        INTERPOLATION. IT IS USED TO GENERATE P AND H.                 UPD   40
C                                                                       UPD   50
C        USAGE -                                                        UPD   60
C        CALL SECDER(L1,L2,X,Y,P,H,N,P0,P3,XK1,XK2,A,B,C,D,GAMMA,BETA)  UPD   70
C                                                                       UPD   80
C        WHERE -                                                        UPD   90
C        L1,L2   DETERMINE THE END CONDITIONS AT X(1) AND X(N) TO BE    UPD  100
C        USED. (SEE BELOW)                                              UPD  110
C        X       N-DIMENSIONED VECTOR OF INDEPENT POINTS                UPD  120
C        Y       N-DIMENSIONED VECTOR OF DEPENDENT POINTS               UPD  130
C        P       N-DIMENSIONED VECTOR TO BE RETURNED                    UPD  140
C        H       (N-1)-DIMENSIONED VECTOR TO BE RETURNED                UPD  150
C        N       NUMBER OF DATA POINTS                                  UPD  160
C     SECOND DERIVATIVES ARE GIVEN AT THE END POINTS                    UPD  170
C        XK1     NOT USED                                               UPD  180
C        XK2     NOT USED                                               UPD  190
C        IF L1=1 THEN                                                   UPD  200
C        P0      SECOND DERIVATIVE AT X(1),Y(1)                         UPD  210
C        IF L2=1 THEN                                                   UPD  220
C        P3      SECOND DERIVATIVE AT X(N),Y(N)                         UPD  230
C     FIRST DERIVATIVES ARE GIVEN AT THE END POINT                      UPD  240
C        XK1     NOT USED                                               UPD  250
C        XK2     NOT USED                                               UPD  260
C        IF L1=2 THEN                                                   UPD  270
C        P0      FIRST DERIVATIVE AT X(1),Y(1)                          UPD  280
C       IF L2=2 THEN                                                    UPD  290
C        P3      FIRST DERIVATIVE AT X(N),Y(N)                          UPD  300
C     NO INFORMATION ABOUT THE CURVE IS KNOWN                           UPD  310
C        P0      NOT USED                                               UPD  320
C        P3      NOT USED                                               UPD  330
C        IF L1=3 THEN                                                   UPD  340
C        XK1     P''(3,0) = XK1*P''(3,1),  XK1 GREATER THAN 0           UPD  350
C        IF L2=3 THEN                                                   UPD  360
C        XK2     P''(3,N) = XK2*P''(3,N-1),  XK2 GREATER THAN 0         UPD  370
C        A       N-DIMENSIONED WORK VECTOR                              UPD  380
C        B       N-DIMENSIONED WORK VECTOR                              UPD  390
C        C       N-DIMENSIONED WORK VECTOR                              UPD  400
```

```
C         D        N-DIMENSIONED WORK VECTOR                         UPD  410
C         BETA     N-DIMENSIONED WORK VECTOR                         UPD  420
C         GAMMA    N-DIMENSIONED WORK VECTOR                         UPD  430
C                                                                    UPD  440
C         SUBROUTINES CALL -                                         UPD  450
C         NONE                                                       UPD  460
C                                                                    UPD  470
      DIMENSION X(N),Y(N),A(N),B(N),C(N),D(N),GAMMA(N),BETA(N),H(N),P(N)
      K=N-1                                                          UPD  510
      DO 1 J=1,K                                                     UPD  520
    1 H(J)=X(J+1)-X(J)                                               UPD  530
      DO 2 J=2,K                                                     UPD  540
      A(J) = H(J-1)/H(J)                                             UPD  550
      B(J) = 2.*(H(J)+H(J-1))/H(J)                                   UPD  560
      C(J) = 1.                                                      UPD  570
    2 D(J) = 6./H(J)*((Y(J+1)-Y(J))/H(J)-(Y(J)-Y(J-1))/H(J-1))       UPD  580
      IF(L1.EQ.2) GO TO 20                                           UPD  590
      IF(L1.EQ.3) GO TO 10                                           UPD  600
      B(1)=1.                                                        UPD  610
      C(1)=0.                                                        UPD  620
      D(1)=P0                                                        UPD  630
      GO TO 30                                                       UPD  640
   10 B(1)=1.                                                        UPD  650
      C(1)=-XK1                                                      UPD  660
      D(1)=0.                                                        UPD  670
      GO TO 30                                                       UPD  680
   20 B(1)=H(1)/3.                                                   UPD  690
      C(1)=H(1)/6.                                                   UPD  700
      D(1)=(Y(2)-Y(1))/H(1)-P0                                       UPD  710
   30 IF(L2.EQ.2) GO TO 21                                           UPD  720
      IF(L2.EQ.3) GOTO 11                                            UPD  730
      A(N)=0.                                                        UPD  740
      B(N)=1.                                                        UPD  750
      D(N)=P3                                                        UPD  760
      GO TO 40                                                       UPD  770
   11 A(N)=-XK2                                                      UPD  780
      B(N)=1.                                                        UPD  790
      D(N)=0.                                                        UPD  800
      GO TO 40                                                       UPD  810
   21 A(N)=H(K)/6.                                                   UPD  820
      B(N)=H(K)/3.                                                   UPD  830
      D(N)=P3-(Y(N)-Y(K))/H(K)                                       UPD  840
```

```
   40 BETA(1)=B(1)                                        UPD  850
      GAMMA(1)=D(1)/BETA(1)                               UPD  860
      DO 6 J=2,N                                          UPD  870
      BETA(J)=B(J)-A(J)*C(J-1)/BETA(J-1)                  UPD  880
    6 GAMMA(J)=(D(J)-A(J)*GAMMA(J-1))/BETA(J)             UPD  890
      P(N) = GAMMA(N)                                     UPD  900
      DO 7 J=1,K                                          UPD  910
      M=N-J                                               UPD  920
    7 P(M)=GAMMA(M)-C(M)*P(M+1)/BETA(M)                   UPD  930
      RETURN                                              UPD  940
      END                                                 UPD  950
```

```
      SUBROUTINE FIL(T,P,NPTS)
      DIMENSION PF(500),H(500),P(500),T(500)
      PI=3.14159  $FC=2.5 $FT=2.51 $WC=2*PI*FC $WT=2*PI*FT
      NMID=NPTS/2    $DT=.05
      W2=(WT-WC)*(WT-WC)
      DO 3 I=1,NMID
      K=I
    3 H(I)=PI/(2*K*DT)*(SIN(WT*K*DT)+SIN(WC*K*DT))/(PI*PI-W2*K*DT
     1*K*DT)
      HO=FC+FT
      NPM1=NPTS-1
      HNORM=HO
      DO 1 I=1,NMID
    1 HNORM=HNORM+H(I)*2.
      DO 2 I=1,NMID
    2 H(I)=H(I)/HNORM
      HO=HO/HNORM
      DO 5 I=2,NMID
      IM1=I-1
      PF(I)=HO*P(I)
      DO 51 J=1,IM1
   51 PF(I)=PF(I)+H(J)*(P(I+J)+P(I-J))
      DO 52 J=I,NMID
   52 PF(I)=PF(I)+2*H(J)*P(I+J)
    5 CONTINUE
      NP2=NMID+2
      DO 4 I=NP2,NPM1
      NPMI=NPTS-I
      PF(I)=HO*P(I)
      DO 41 J=1,NPMI
   41 PF(I)=PF(I)+H(J)*(P(I-J)+P(I+J))
      NPMIP1=NPMI+1
      DO 42 J=NPMIP1,NMID
   42 PF(I)=PF(I)+2*H(J)*P(I-J)
    4 CONTINUE
      PF(1)=HO*P(1)  $PF(NPTS)=HO*P(NPTS) $PF(NMID+1)=HO*P(NMID+1)
      DO 10 J=1,NMID
      PF(1)=PF(1)+2*H(J)*P(1+J)
      PF(NMID+1)=PF(NMID+1)+H(J)*(P(NMID+1+J)+P(NMID+1-J))
   10 PF(NPTS)=PF(NPTS)+2*H(J)*P(NPTS-J)
      DO 6 I=1,NPTS
    6 P(I)=PF(I)
```

```
      RETURN
      END
```

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```
      SUBROUTINE PLOT2(T,X,Y,N,LABT,LT,LABX,LX,LABY,LY)
      DIMENSION T(1),X(1),Y(1)
      N1=N+1
      N2=N+2
          CALL ASCALE(T,4.,N,1,10.)
          CALL ASCALE(X,2.,N,1,10.)
          CALL ASCALE(Y,2.,N,1,10.)
      CALL CALPLT(1.,1.,-3)
      CALL AXES(0.,0.,0.,4.,T(N1),T(N2),1.,5.,LABT,.15,-LT,2)
      CALL CALPLT(0.,1.,-3)
      CALL AXES(0.,0.,90.,2.,X(N1),X(N2),1.,5.,LABX,.15,LX,2)
      CALL LINPLT(T,X,N,1,0,0,1)
      CALL CALPLT(0.,2.5,-3)
      CALL AXES(0.,0.,90.,2.,Y(N1),Y(N2),1.,5.,LABY,.15,LY,2)
      CALL LINPLT(T,Y,N,1,0,0,1)
      CALL NFRAME
      RETURN
      END
```

```
  103 XXSUM(II,I)=0.
      DO 103 II=1,N
      DO 103 I=1,N
      DO 103 J=1,NPTS
  103 XXSUM(I,II)=XXSUM(I,II)+X(I,J)*X(II,J)
      DO 101 II=1,N
      DO 101 J=1,NPTS
  101 XSUM(II)=XSUM(II)+X(II,J)
      DO 201 I=1,N
      DO 200 J=1,NPTS
  200 XBAR(I)=XBAR(I)+X(I,J)
  201 XBAR(I)=XBAR(I)/NPTS
      DO 202 I=1,N
      DO 202 J=1,N
      S(I,J)=XXSUM(I,J)-XSUM(I)*XSUM(J)/NPTS
  202 CONTINUE
      DO 203 I=1,N
  203 SIGMA(I)=SQRT(S(I,I))
      DO 204 I=1,NM1
      IP1=I+1
      DO 204 J=IP1,N
      RR(I,J)=S(I,J)/(SIGMA(I)*SIGMA(J))
  204 RR(J,I)=RR(I,J)
      DO 205 I=1,N
  205 RR(I,I)=1.
      DO 210 I=1,N
      SIGMA(I)=SIGMA(I)/SQRT(FLOAT(NPTS))
  210 CONTINUE
      PHI=NPTS-1
      DO 301 I=1,NM1
  301 B(I)=0.
      SY=SIGMA(N)*SQRT(RR(N,N)/PHI)
C
C     START LARGE LOOP
C     VMAX CALCULATED
C
  450 I=1     $ VMAX=0.   $IPASS=IPASS+1
  320 IF(A(I,I).GT.TOL) 250,300
  250 IF(ICNT(I).EQ.1) GO TO 300
      V(I)=A(I,N)*A(N,I)/A(I,I)
      IF(V(I).GT.VMAX) 260,300
  260 VMAX=V(I) $NMAX=I
```

```
      CALL DATASET(TS,T,Y,X)
C
C     SET UP DATA ARRAYS
C
      IF(LATOP.EQ.1) GO TO 60
      DO 804 I=1,NPTS
      IF(IEQ-2) 801,802,803
  801 X(N,I)=Y(I)=2*M*G/(RHO*SAREA*VEL(I)*VEL(I))*AX(I)
      GO TO 804
  802 X(N,I)=Y(I)=2*M*G/(RHO*SAREA*VEL(I)*VEL(I))*AZ(I)
      GO TO 804
  803 X(N,I)=Y(I)=2*IY/(RHO*SAREA*CBAR*VEL(I)*VEL(I))*(QDOT(I)
     1-P(I)*R(I)*(IZ-IX)/IY-(R(I)*R(I)-P(I)*P(I))*IXZ/IY)
  804 CONTINUE
      GO TO 805
  800 DO 806 I=1,NPTS
      IF(IEQ-2) 807,808,809
  807 X(N,I)=Y(I)=2*M*G/(RHO*SAREA*VEL(I)*VEL(I))*AY(I)
      GO TO 806
  808 X(N,I)=Y(I)=2*IX/(RHO*SAREA*BSPAN*VEL(I)*VEL(I))*(PDOT(I)-
     1(IY-IZ)/IX*Q(I)*R(I)-(IXZ/IX)*(P(I)*Q(I)+RDOT(I)))
      GO TO 806
  809 X(N,I)=Y(I)=2*IZ/(RHO*SAREA*BSPAN*VEL(I)*VEL(I))*(RDOT(I)-
     1(IX-IY)/IZ*P(I)*Q(I)-(IXZ/IZ)*(PDOT(I)-Q(I)*R(I)))
  806 CONTINUE
  805 CONTINUE
      IANOVA=0      $NM1=N-1   $N2M1=2*N-1  $IPASS=0
      N2=N2M1*N2M1        $MAXLAG=NPTS/10
      LINCNT=0       SEND1=NM1
      F1=F2=FCRT
      IF(IFLAG .EQ. 1) LINOP=1
      DO 205 I=1,MAXLAG
  205 XLAG(I)=I-1
      DO 91 I=1,6241
   91 A(I)=0.
      DO 92 I=1,NM1
   92 A(I,I+N)=1.
      DO 93 I=1,NM1
   93 A(I+N,I)=-1.
      DO 95 I=1,N
      XBAR(I)=XSUM(I)=ICNT(I)=0.
      DO 96 II=1,N
```

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```
      PROGRAM STEPSPL(INPUT,OUTPUT,TAPE1,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL IX,IY,IZ,IXZ
      DIMENSION FF(79,79),A(79,79),AP(79,79)
      DIMENSION T(900),Y(900),YHAT(900),XNU(900)
      DIMENSION S(40,40),U(40),V(40)
      DIMENSION STDER(40),FPART(40)
      DIMENSION W(90),XLAG(90)
      DIMENSION IEQN(3),KNT(23)
      COMMON/START/ X(40,900),XXSUM(40,40),XSUM(40),XBAR(40),SIGMA(40)
      COMMON/CDATA/ SAREA,BSPAN,CBAR,M,RHO,G,IX,IY,IZ,IXZ,DELET,ALPHT
     1,BETT,DELAT,DELRT,QT,PT,RT
      COMMON/FLAGS/ NPTS,ICNT(40),LATOP,ITRIMOP,ICALL,IACELOP,IFILOP
      COMMON/ORDER/ IEQ,N
      COMMON/ACCEL/ AX(900),AY(900),AZ(900),PDOT(900),QDOT(900),RDOT(900
     1),VEL(900),P(900),Q(900),R(900)
      COMMON/KNOT/XNOT(23)
      EQUIVALENCE (A,FF)
      NAMELIST /INPUT/ TS,NEQ,IEQN,
     *                 NPTS,IPLOT,IFLAG,
     *                 SAREA,BSPAN,CBAR,
     *                 M,RHO,G,
     *                 IX,IY,IZ,IXZ,
     *                 DELET,ALPHT,BETT,DELAT,DELRT,QT,PT,RT,
     *                 FCKT,ITRIMOP,LATOP,IACELOP,IFILOP
      ALPHT=BETT=DELET=DELAT=DELRT=QT=PT=RT=0.
      CALL PSEUDO
 2502 TOL=1.0E-08          $ICALL=0
      DO 49 II=1,23
   49 XNOT(II)=.087265+(II-1)*.017453
      READ(5,INPUT)
      IF(EOF(5)) 2501,2503
 2503 WRITE(6,INPUT)
      DO 30 I=1,23
   30 KNT(I)=IFIX(XNOT(I)*57.3)
      PRINT 959,(I,I=1,17),(KNT(I),I=1,17)
      N=40    $LINMAX=3
      IF(LATOP.EQ.1) N=25
      IF(LATOP.EQ.1) LINMAX=5
C
      DO 1000 L=1,NEQ
      IEQ=IEQN(L)        $NGO=0
      ICALL=ICALL+1
```

APPENDIX 5

This appendix contains the listing for PROGRAM STEPSPL (as used in example 2).

```
A2VIPJP. 82/10/28.NASA/LRC CY175-R   NOS 1.4 (R23)        NOS 1.4 531 R CPFS
07.41.20.STEPJ,T3000.
07.41.20.BATTERSON                              R2142 B
07.41.20.USER,043450N.
07.41.21.CHARGE,101218,LRC.
07.41.21.GET,STEP1.
07.41.22.FTN(I=STEP1,R=0,A,PL=15000)
07.41.32.     13.535 CP SECONDS COMPILATION TIME
07.41.32.GET,DUM.
07.41.33.GET,BINVDP.
07.41.34.SKIPR,BINVDP,7,,B.
07.41.34.COPYBR,BINVDP,TAPE1,1.
07.41.34. COPY COMPLETE.
07.41.34.REWIND,TAPE1.
07.41.34.ATTACH,FTNMLIB/UN=LIBRARY.
07.41.34.ATTACH,AKCLIB/UN=LIBRARY.
07.41.35.ATTACH,LRCGOSF/UN=LIBRARY.
07.41.35.GET,ISSILIB/UN=474750C.
07.41.36.LDSET(LIB=FTNMLIB/AKCLIB/LRCGOSF/ISSILIB,PRESETA=NGINF,MAP=SBEX)
07.41.36.LGO,DUM.
07.41.42.     STOP
07.41.42.     251100 MAXIMUM EXECUTION FL.
07.41.42.      8.700 CP SECONDS EXECUTION TIME.
07.41.42.PLOT.VARIAN(FRAMCNT=30,EDIT(1,30))
07.41.44.V001
07.41.53.    10 FRAMES /    2.31 METERS GENERATED.
07.41.53.PICTURE IMAGE FILE WILL BE SAVED ON DISK
07.41.56. *****  PLOT OUTPUT COMPLETED  *****
07.41.56.PLOT.VARIAN(FRAMCNT=30,EDIT(31,60))
07.41.58.V002
07.42.04.     NO PLOTTING ATTEMPTED
07.42.05.PLOT.VARIAN(FRAMCNT=30,EDIT(61,90))
07.42.07.V002
07.42.13.     NO PLOTTING ATTEMPTED
07.42.13.PLOT.VARIAN(FRAMCNT=30,EDIT(91,120))
07.42.15.V002
07.42.21.     NO PLOTTING ATTEMPTED
07.42.22.PLOT.VARIAN(FRAMCNT=30,EDIT(121,150))
07.42.24.V002
07.42.30.     NO PLOTTING ATTEMPTED
07.42.30.EXIT.
07.42.30.UEAD,       0.002KUNS.
07.42.30.UEPF,       1.426KUNS.
07.42.30.UEMS,      21.462KUNS.
07.42.30. 175 CPU SEC = UECP/5.0.
07.42.30.UECP,      43.379SECS.
07.42.30.AESR,     192.282UNTS.
07.42.30.APPROXIMATE JOB EXECUTION COST = $      3
```

APPENDIX 4

This appendix contains a sample procedure file (JCL deck) for running example 1 at the Langley Research Center computer complex.

STEPWISE REGRESSION SUMMARY

EQN # 1

TOT #	PARAM #	% VAR	PRESS		TOT F
1	1	95.43		-R	.85710E+03
2	3	100.00		-R	.59773E+10

EQN # 2

TOT #	PARAM #	% VAR	PRESS		TOT F
1	2	58.76		-R	.58427E+02
2	3	72.64		-R	.53111E+02
3	1	100.00		-R	.28453E+11

EQN # 3

TOT #	PARAM #	% VAR	PRESS		TOT F
1	2	80.54		-R	.16970E+03
2	3	97.22		-R	.69957E+03
3	1	99.94		-R	.20866E+05
4	7	99.97		-R	.27162E+05

```
PERCENT VARIATION EXPLAINED IS  99.94
STD. DEVIATION OF RESIDUALS IS   .148E-02
TOTAL F VALUE IS  .20866E+05
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.105E+01 .153E+02-.996E+000.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       -.731E-01

 .236E-01 .866E-01 .784E-020.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS -.52800E-14
SIGMA SQ OF RESIDUAL IS   .85285E-04


        MAXIMUM F VALUE IS   .305E+02 FOR VARIABLE   7
VARIABLES IN REGRESSION   1   1   1   0   0   0   1   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .296E+04
PARTIAL F VALUE FOR VARIABLE   2 IS   .553E+04
PARTIAL F VALUE FOR VARIABLE   3 IS   .203E+05
PARTIAL F VALUE FOR VARIABLE   7 IS   .297E+02
VARIABLES IN REGRESSION   1   1   1   0   0   0   1   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .296E+04
PARTIAL F VALUE FOR VARIABLE   2 IS   .553E+04
PARTIAL F VALUE FOR VARIABLE   3 IS   .203E+05
PARTIAL F VALUE FOR VARIABLE   7 IS   .297E+02
PERCENT VARIATION EXPLAINED IS  99.97
STD. DEVIATION OF RESIDUALS IS   .112E-02
TOTAL F VALUE IS  .27162E+05
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.107E+01 .143E+02-.991E+000.      0.       0.       .327E+030.       0.       0.       0.       0.       0.       0.       -.717E-01

 .179E-01 .657E-01 .595E-020.      0.       0.       .203E+020.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS -.55085E-14
SIGMA SQ OF RESIDUAL IS   .47891E-04


        MAXIMUM F VALUE IS   .424E+01 FOR VARIABLE  14
```

57

```
RUN   1      EQUATION  3      NPTS   43

          MAXIMUM F VALUE IS   .174E+03 FOR VARIABLE   2
VARIABLES IN REGRESSION   0   1   0   0   0   0   0   0   0   0   0   0   0   0
PERCENT VARIATION EXPLAINED IS  80.54
STD. DEVIATION OF RESIDUALS IS   .255E-01
TOTAL F VALUE IS  .16970E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
0.        .195E+020.      0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        -.828E-01

0.        .149E+010.      0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS -.48282E-14
SIGMA SQ OF RESIDUAL IS   .26654E-01


          MAXIMUM F VALUE IS   .246E+03 FOR VARIABLE   3
VARIABLES IN REGRESSION   0   1   1   0   0   0   0   0   0   0   0   0   0   0
 PARTIAL F VALUE FOR VARIABLE   2 IS   .686E+03
 PARTIAL F VALUE FOR VARIABLE   3 IS   .240E+03
VARIABLES IN REGRESSION   0   1   1   0   0   0   0   0   0   0   0   0   0   0
 PARTIAL F VALUE FOR VARIABLE   2 IS   .686E+03
 PARTIAL F VALUE FOR VARIABLE   3 IS   .240E+03
PERCENT VARIATION EXPLAINED IS  97.22
STD. DEVIATION OF RESIDUALS IS   .976E-02
TOTAL F VALUE IS  .69957E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
0.        .160E+02-.858E+000.        0.        0.        0.        0.        0.        0.        0.        0.        0.        -.118E+00

0.        .571E+00 .517E-010.        0.        0.        0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS -.73430E-14
SIGMA SQ OF RESIDUAL IS   .38071E-02


          MAXIMUM F VALUE IS   .175E+04 FOR VARIABLE   1
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .170E+04
PARTIAL F VALUE FOR VARIABLE   2 IS   .260E+05
PARTIAL F VALUE FOR VARIABLE   3 IS   .121E+05
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .170E+04
PARTIAL F VALUE FOR VARIABLE   2 IS   .260E+05
PARTIAL F VALUE FOR VARIABLE   3 IS   .121E+05
```

```
PERCENT VARIATION EXPLAINED IS 100.00
STD. DEVIATION OF RESIDUALS IS   .114E-05
TOTAL F VALUE IS  .28453E+11
NEW PARAMETER ESTIMATES AND STD. DEV. ARE                                                                                              -.121E+0:
-.300E+01-.200E+02-.110E+010.       0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
 .182E-04 .668E-04 .605E-050.       0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
RESIDUAL MEAN IS -.79647E-13
SIGMA SQ OF RESIDUAL IS   .46754E-10
```

```
RUN    1      EQUATION  2      NPTS   43

         MAXIMUM F VALUE IS    .599E+02 FOR VARIABLE    2
VARIABLES IN REGRESSION    0   1   0   0   0   0   0   0   0   0   0   0   0
PERCENT VARIATION EXPLAINED IS  58.76
STD. DEVIATION OF RESIDUALS IS    .334E-01
TOTAL F VALUE IS   .58427E+02
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
0.        -.150E+020.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       -.131E+01
0.         .196E+010.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS -.79977E-13
SIGMA SQ OF RESIDUAL IS    .45829E-01

         MAXIMUM F VALUE IS    .208E+02 FOR VARIABLE    3
VARIABLES IN REGRESSION    0   1   1   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE    2 IS    .105E+03
PARTIAL F VALUE FOR VARIABLE    3 IS    .203E+02
VARIABLES IN REGRESSION    0   1   1   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE    2 IS    .105E+03
PARTIAL F VALUE FOR VARIABLE    3 IS    .203E+02
PERCENT VARIATION EXPLAINED IS  72.64
STD. DEVIATION OF RESIDUALS IS    .276E-01
TOTAL F VALUE IS   .53111E+02
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
0.        -.178E+02-.705E+000.      0.       0.       0.       0.       0.       0.       0.       0.       0.       -.134E+01
0.         .161E+01 .146E+000.      0.       0.       0.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS -.85596E-13
SIGMA SQ OF RESIDUAL IS    .30403E-01

         MAXIMUM F VALUE IS    .239E+11 FOR VARIABLE    1
VARIABLES IN REGRESSION    1   1   1   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE    1 IS    .234E+11
PARTIAL F VALUE FOR VARIABLE    2 IS    .749E+11
PARTIAL F VALUE FOR VARIABLE    3 IS    .249E+11
VARIABLES IN REGRESSION    1   1   1   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE    1 IS    .234E+11
PARTIAL F VALUE FOR VARIABLE    2 IS    .749E+11
PARTIAL F VALUE FOR VARIABLE    3 IS    .249E+11
```

```
        MAXIMUM F VALUE IS   .878E+03 FOR VARIABLE   1
VARIABLES IN REGRESSION  1  0  0  0  0  0  0  0  0  0  0  0  0  0
PERCENT VARIATION EXPLAINED IS  95.43
STD. DEVIATION OF RESIDUALS IS   .139E-02
TOTAL F VALUE IS  .85710E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
 .651E+000.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       .229E-03
 .222E-010.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS  .61450E-15
SIGMA SQ OF RESIDUAL IS   .79732E-04

        MAXIMUM F VALUE IS   .559E+09 FOR VARIABLE   3
VARIABLES IN REGRESSION  1  0  1  0  0  0  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE   1 IS   .118E+11
PARTIAL F VALUE FOR VARIABLE   3 IS   .546E+09
VARIABLES IN REGRESSION  1  0  1  0  0  0  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE   1 IS   .118E+11
PARTIAL F VALUE FOR VARIABLE   3 IS   .546E+09
PERCENT VARIATION EXPLAINED IS 100.00
STD. DEVIATION OF RESIDUALS IS   .382E-06
TOTAL F VALUE IS  .59773E+10
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
 .700E+000.      .500E-010.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       .630E-04
 .610E-050.      .203E-050.      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS  .69970E-15
SIGMA SQ OF RESIDUAL IS   .58433E-11
```

RUN 1 EQUATION 1 NPTS 43

TIME	V	ALPHA	Q	DELE
.1900E+01	.3500E+02	.5374E-01	.2420E+00	-.1732E+00
.1950E+01	.3500E+02	.6537E-01	.2647E+00	-.1732E+00
.2900E+01	.3500E+02	.6850E-01	-.3173E+00	-.5175E-01
.2950E+01	.3500E+02	.5170E-01	-.3565E+00	-.3884E-01
.4650E+01	.3500E+02	.3553E-01	.1953E+00	-.3984E-01
.4700E+01	.3500E+02	.4322E-01	.1919E+00	-.3961E-01
.4750E+01	.3500E+02	.5047E-01	.1868E+00	-.3917E-01
.4800E+01	.3500E+02	.5722E-01	.1798E+00	-.3906E-01
.4850E+01	.3500E+02	.6341E-01	.1711E+00	-.3884E-01
.4900E+01	.3500E+02	.6897E-01	.1605E+00	-.3861E-01
.5450E+01	.3500E+02	.6481E-01	-.1021E+00	-.3614E-01
.5500E+01	.3500E+02	.5780E-01	-.1290E+00	-.3570E-01
.5550E+01	.3500E+02	.4981E-01	-.1561E+00	-.3536E-01
.5600E+01	.3500E+02	.4086E-01	-.1833E+00	-.3469E-01
.7100E+01	.3500E+02	.3530E-01	.1309E+00	-.3782E-01
.7150E+01	.3500E+02	.4007E-01	.1237E+00	-.3839E-01
.7200E+01	.3500E+02	.4435E-01	.1153E+00	-.3906E-01
.7250E+01	.3500E+02	.4810E-01	.1056E+00	-.3950E-01
.7300E+01	.3500E+02	.5127E-01	.9469E-01	-.3984E-01
.7350E+01	.3500E+02	.5384E-01	.8256E-01	-.4006E-01
.7400E+01	.3500E+02	.5577E-01	.6929E-01	-.4039E-01
.7450E+01	.3500E+02	.5702E-01	.5486E-01	-.4028E-01
.7500E+01	.3500E+02	.5757E-01	.3936E-01	-.4028E-01
.7550E+01	.3500E+02	.5739E-01	.2289E-01	-.4039E-01
.7600E+01	.3500E+02	.5646E-01	.5478E-02	-.4017E-01
.7650E+01	.3500E+02	.5476E-01	-.1275E-01	-.4006E-01
.7700E+01	.3500E+02	.5230E-01	-.3164E-01	-.4028E-01
.7750E+01	.3500E+02	.4906E-01	-.5114E-01	-.4006E-01
.7800E+01	.3500E+02	.4504E-01	-.7107E-01	-.4017E-01
.7850E+01	.3500E+02	.4026E-01	-.9135E-01	-.4006E-01
.9200E+01	.3500E+02	.3555E-01	.8793E-01	-.3434E-01
.9250E+01	.3500E+02	.3834E-01	.7742E-01	-.3445E-01
.9300E+01	.3500E+02	.4052E-01	.6554E-01	-.3334E-01
.9350E+01	.3500E+02	.4208E-01	.5247E-01	-.3300E-01
.9400E+01	.3500E+02	.4298E-01	.3833E-01	-.3289E-01
.9450E+01	.3500E+02	.4321E-01	.2328E-01	-.3322E-01
.9500E+01	.3500E+02	.4272E-01	.7163E-02	-.3243E-01
.9550E+01	.3500E+02	.4151E-01	-.9791E-02	-.3232E-01
.9600E+01	.3500E+02	.3958E-01	-.2739E-01	-.3266E-01
.9650E+01	.3500E+02	.3691E-01	-.4561E-01	-.3266E-01
.1100E+02	.3500E+02	.3640E-01	.5560E-01	-.3547E-01
.1105E+02	.3500E+02	.3772E-01	.4323E-01	-.3513E-01
.1110E+02	.3500E+02	.3843E-01	.2984E-01	-.34[illegible]E-01

APPENDIX 3

This appendix contains the output generated by PROGRAM STEP for example 1.

```
RT      = 0.0,
FCRT    = .5E+01,
ITRIMOP = 1,
IPSKP   = 10,
LATOP   = 0,
IACELOP = 0,
IFILOP  = 0,
$END

         TRIM VALUES
              ALPHT         BETT         AILT         DELET         DELRT
          .20950E+00 0.           0.            -.83180E-01 0.
```

```
$INPUT
IPRESOP = 0,
TS      = 0.0,
NEQ     = 3,
IEQN    = 1, 2, 3,
NPTS    = 43,
IPLOT   = 1,
IFLAG   = 1,
SAREA   = .1374E+02,
BSPAN   = .998E+01,
CBAR    = .14E+01,
M       = .1055E+04,
RHO     = .10272E+01,
G       = .981E+01,
IX      = .2357E+04,
IY      = .3051E+04,
IZ      = .4833E+04,
IXZ     = .177E+03,
DELET   = -.8318E-01,
ALPHT   = .2095E+00,
BETT    = 0.0,
DELAT   = 0.0,
DELRT   = 0.0,
QT      = 0.0,
PT      = 0.0,
```

APPENDIX 2

This appendix contains the NAMELIST/INPUT/ for example 1.

```
      FUNCTION RANDOM(J)
      DATA ISEED/32741/
      ISEED=ISEED*16345
      ISEED=ISEED.AND.177777B
      RANDOM=FLOAT(ISEED)/65536.
      PETURN
      END
```

```
      SUBROUTINE PSET
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *             ,IPPTS,ITRIMOP,ICALL
      COMMON/START/ X(25,500),XXSUM(25,25),XSUM(25),XBAR(25),SIGMA(25)
      COMMON /ORDER/ IEO,N
      DIMENSION ITEMP(500),XTEM(500)
      IRAN=0
C
C     SET INDEX FOR SELECTED DATA PTS
C
      IPPTS=0
      DO 5 J=1,NPTS,IPSKP
      IPPTS=IPPTS+1
      JP=J
      IF(IRAN .EQ. 1) JP=RANDOM(J)*NPTS
      IF(JP .EQ. 0) JP=1
      ITEMP(IPPTS)=JP
    5 CONTINUE
      DO 10 I=1,N
      DO 20 J=1,IPPTS
      XTEM(J)=X(I,ITEMP(J))
   20 CONTINUE
      DO 30 J=1,IPPTS
      X(I,J)=XTEM(J)
   30 CONTINUE
   10 CONTINUE
      DO 40 K=1,625
      XXSUM(K)=0.0
   40 CONTINUE
      DO 50 II=1,N
      DO 50  I=1,N
      DO 50  J=1,IPPTS
      XXSUM(I,II)=XXSUM(I,II)+X(I,J)*X(II,J)
   50 CONTINUE
C
C      REDEFINE JDIM FOR REDUCED # OF DATA PTS
C
      JDIM=25+IPPTS
      RETURN
      END
```

```
      SUBROUTINE REDEF
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *              ,IPPTS,ITRIMOP,ICALL
      COMMON/START/ X(25,500),XXSUM(25,25),XSUM(25),XBAR(25),SIGMA(25)
      COMMON/AOP/ A(25,525),O(500),PPRT(25),PRSMIN
      COMMON /ORDER/ IEQ,N
C
C     INITIALIZE A,O,IORD
C
      NP1=N+1
      DO 100 I=1,N
      DO 100 J=1,N
      A(I,J)=XXSUM(I,J)
  100 CONTINUE
      DO 110 I=1,N
      K=0
      DO 110 J=NP1,JDIM
      K=K+1
      A(I,J)=X(I,K)
  110 CONTINUE
      DO 120 I=1,IPPTS
      O(I)=0.0
  120 CONTINUE
  130 CONTINUE
      DO 140 I=1,N
      IORD(I)=I
  140 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INTRCHG(ICHG,JCHG)
      COMMON/AQP/ A(25,525),Q(500),PPRT(25),PRSMIN
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *              ,IPPTS,ITRIMOP,ICALL,IACELOP,IFILOP
      DIMENSION AROW(525),ACOL(25),BROW(525),BCOL(25)
C
C     INTERCHANGE ROWS AND COLUMNS OF MATRIX A
C
      DO 10 J=1,JDIM
      AROW(J)=A(ICHG,J)
      BROW(J)=A(JCHG,J)
      A(ICHG,J)=BROW(J)
      A(JCHG,J)=AROW(J)
   10 CONTINUE
      DO 20 I=1,IDIM
      ACOL(I)=A(I,ICHG)
      BCOL(I)=A(I,JCHG)
      A(I,ICHG)=BCOL(I)
      A(I,JCHG)=ACOL(I)
   20 CONTINUE
C
C     INTERCHANGE ROWS OF IORD
C
      IROW=IORD(ICHG)
      JROW=IORD(JCHG)
      IORD(JCHG)=IROW
      IORD(ICHG)=JROW
      RETURN
      END
```

```
      DO 350 I=1,N
      DO 350 J=NP1,JDIM
      A(I,J)=AP(I,J)
  350 CONTINUE
C
C     UPDATE Q
C
      DO 400 I=1,IPPTS
      Q(I)=Q(I)+A(IDEF,N+I)*A(IDEF,N+I)
  400 CONTINUE
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE UPDATE
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *              ,IPPTS,ITRIMOP,ICALL,IACELOP,IFILOP
      COMMON/AOP/ A(25,525),O(500),PPRT(25),PRSMIN
      COMMON /ORDER/ IEO,N
      DIMENSION AP(25,525)
C
C     UPDATE A MATRIX (=APR) USED IN PRESS CALC
C
      NM1=N-1  $NP1=N+1
      CALL REDEF
      KK=0
      DO 10 II=1,NM1
      IF(ICNT(II).EQ.0) GO TO 10
      KK=KK+1
      IDEF=KK
      DO 210 LL=1,NM1
      IF(IORD(LL).EQ.II) K=LL
  210 CONTINUE
      CALL INTRCHG(IDEF,K)
      K=IDEF
      DO 100 I=1,IDIM
      DO 100 J=1,JDIM
      AP(I,J)=A(I,J)
  100 CONTINUE
      DO 200 I=K,N
      DO 200 J=K,JDIM
      IF(I.EQ.K) GO TO 225
      AP(I,J)=A(I,J)-(A(K,I)*A(K,J))/A(K,K)
      GO TO 200
  225 CONTINUE
      IF(J.EQ.K) GO TO 250
      AP(I,J)=A(I,J)/SQRT(A(K,K))
      GO TO 200
  250 CONTINUE
      AP(I,J)=SQRT(A(K,K))
  200 CONTINUE
      DO 300 I=1,N
      DO 300 J=I,N
      A(I,J)=AP(I,J)
      A(J,I)=A(I,J)
  300 CONTINUE
```

```
      SUBROUTINE PRESS
      COMMON/FLAGS/ IPSKP,NPTS,IDIM,JDIM,NMAX,IMIN,ICNT(25),IORD(25)
     *             ,IPPTS,ITRIMOP,ICALL,IACELOP,IFILOP
      COMMON/START/ X(25,500),XXSUM(25,25),XSUM(25),XBAR(25),SIGMA(25)
      COMMON/AOP/ A(25,525),Q(500),PPRT(25),PRSMIN
      COMMON /ORDER/ IEQ,N
      NM1=N-1
      IDEF=0
      IMIN=0
      PRSMIN=1.E06
      DO 10 I=1,NM1
      IDEF=IDEF+ICNT(I)
   10 CONTINUE
C
C     INITIALIZE A,Q,IORD IF IDEF=0
C
      IF(IDEF .GT. 0) GO TO 130
      CALL REDEF
  130 CONTINUE
C
C     COMPUTE PRESS (=PRSMIN) FOR VARIABLES NOT YET IN MODEL
C
      DO 200 II=1,NM1
      IF(ICNT(II).EQ.1) GO TO 200
      DO 210 LL=1,NM1
      IF(IORD(LL).EQ.II) K=LL
  210 CONTINUE
      PRS=0.0
      DO 250 I=1,IPPTS
      PNUM=A(K,K)*A(N,I+N)-A(K,N)*A(K,N+I)
      PDNM=A(K,K)*(1.-Q(I))-(A(K,N+I)*A(K,N+I))
      PRS=PRS+(PNUM*PNUM)/(PDNM*PDNM)
  250 CONTINUE
      WRITE(6,800) PRS,II
  800 FORMAT(5X,*PRESS= *E12.5,5X,*FOR VARIABLE*,I5)
      PPRT(II)=PRS
      IF(PRSMIN .LT. PRS) GO TO 200
      PRSMIN=PRS
      IMIN=II
  200 CONTINUE
      RETURN
      END
```

```
  300 IF(LINDP.EQ.1) LNI=LINMAX
      IF(I.LE.LNI) 330,310
  310 I=I+1
      GO TO 32
  330 CONTINUE
      I=NMAX
*     CALCULATE  F
      IF(VMAX.LT.TOL) 2000,443
 2000 IF(LINDP.EQ.0) 1999,2111
  443 F=PHI*VMAX/(A(N,N)-VMAX)
      IF(F.GT.0.) GO TO 444
      A(N,N)=VMAX  $F=-F  $NGO=1  $PRINT 998
  444 PRINT 950,F,I
      IF(F.GT.F1.OR.LINDP.EQ.1) 400,1999
  400 CONTINUE
*     UPDATE THE A MATRIX
      ICNT(I)=1  $PHI=PHI-1
      DO 401 II=1,N2M1
      DO 401 JJ=1,N2M1
      IF(II.NE.I) GO TO 402
      AP(II,JJ)=A(I,JJ)/A(I,I)
      GO TO 401
  402 AP(II,JJ)=A(II,JJ)-A(II,I)*A(I,JJ)/A(I,I)
  401 CONTINUE
      DO 411 I2=1,N2M1
      DO 411 J2=1,N2M1
  411 A(I2,J2)=AP(I2,J2)
*     PARTIAL F TESTS
  430 PRINT 951,(ICNT(II),II=1,NM1)
*
      IF(IPASS.EQ.1) GO TO 431
      IF(NGO.EQ.1) GO TO 431
      DO 419 II=1,NM1
      IF(ICNT(II).EQ.1) 410,419
  410 FPART(II)=PHI*A(II,N)*A(II,N)/(A(N,N)*A(II+N,II+N))
      PRINT 952,II,FPART(II)
  419 CONTINUE
  418 IF(IANOVA.EQ.1) GO TO 431
*     ELIMINATE VARIABLES WITH F<F2
      DO 427 II=1,NM1
      IF(ICNT(II).EQ.1) 420,429
  420 IF(FPART(II).LT.F2.AND.LINDP.EQ.0) 421,429
```


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```
  421 IMIN=II   $ICNT(II)=0   $PRINT 902,II
      DO 428 II=1,N2M1
      DO 428 JJ=1,N2M1
      IF(II.NE.IMIN) GO TO 427
      AP(II,JJ)=A(II,JJ)/A(N+II,N+II)
      GO TO 428
  427 AP(II,JJ)=A(II,JJ)-A(II,N+IMIN)*A(IMIN,JJ)/A(N+IMIN,N+IMIN)
  428 CONTINUE
      DO 426 I2=1,N2M1
      DO 426 J2=1,N2M1
  426 A(I2,J2)=AP(I2,J2)
  429 CONTINUE
*     NEW ANOVA SUMMARY
      IANOVA=1
      GO TO 430
  431 CONTINUE
*
      IF(NGO.EQ.1) A(N,N)=1.
*
      IANOVA=0
      IV=0
      DO 439 II=1,N
  439 IV=IV+ICNT(II)
      SSER=1.-A(N,N)   $XMSDR=SSDR/IV
      SSREG=A(N,N)   $XMSSREG=SSREG/PHI
      PVAR=100*SSDR
      PRINT 954,PVAR
      SDRES=SQRT(A(N,N)*S(N,N)/PHI)
      PRINT 955,SDRES
      FTOT=XMSDR/XMSSREG
      PRINT 957,FTOT
  957 FORMAT(1X,*TOTAL F VALUE IS*,E12.5)
      DO 449 II=1,NM1
      IF(ICNT(II).NE.1) GO TO 448
      B(II)=A(II,N)*SQRT(S(N,N)/S(II,II))
      STDER(II)=SDRES*SQRT(A(II,II)/S(II,II))
      GO TO 449
  448 B(II)=0.   $STDER(II)=0.
  449 CONTINUE
      SUM=0.
      DO 451 II=1,NM1
  451 SUM=SUM+B(II)*XBAR(II)
```

```
      B(N)=XSUM(N)-SUM
      PRINT 95
      PRINT 905,(B(II),II=1,N)
      PRINT 906,(STDER(II),II=1,NM1)
      DO 460 II=1,NPTS
      YHAT(II)=B(N)
      DO 461 JJ=1,NM1
  461 YHAT(II)=YHAT(II)+B(JJ)*X(JJ,II)
  460 XRU(II)=Y(II)-YHAT(II)
      IF(IPLOT .EQ. 0) GO TO 470
      CALL AUTO(XRU,MAXLAG,NPTS,W,XXSUM(N,N),YHAT,Y)
      NPT2=NPTS/2
      CALL INFOPLT(0,NPT2,T,2,Y,2,0.,0.,0.,0.,1.,4,4HTIME,6,
     16HY,YHAT,22,5.,3.5,.75,.75)
      CALL INFOPLT(9,NPT2,T,2,YHAT,2,0.,0.,0.,0.,1.,4,4HTIME,6,
     16HY,YHAT,22,5.,3.5,.75,.75)
      CALL INFOPLT(9,NPT2,T,2,XRU,2,0.,0.,0.,0.,0.,4,4HTIME,6,
     16HY-YHAT,22,5.,3.5,0.0,4.75)
      CALL INFOPLT(1,MAXLAG,XLAG,1,W,1,0.,0.,0.,0.,0.,3,
     13HLAG,6,6HAUTO C,22,5.,3.5,0.0,4.75)
  470 CONTINUE
      IF(PG1.LT.0.1) GO TO 1010
      GO TO 2112
 2111 LINOP=0 $LINCNT=LINMAX $LM1=N-1
      GO TO 420
 2112 LINCNT=LINCNT+1
      IF(LINCNT.GE.LINMAX) LINOP=0
      LM1=N-1
      GO TO 420
  900 FORMAT(1X,///,10X,*MAXIMUM F VALUE IS *,E10.3,* FOR VARIABLE *,I3)
  901 FORMAT(1X,*VARIABLES IN REGRESSION*,24I4)
  902 FORMAT(1X,*PARTIAL F VALUE FOR VARIABLE *,I3,* IS *,E10.3)
  903 FORMAT(1X,*VARIABLE *,I3,* ELIMINATED*)
  904 FORMAT(1X,*PERCENT VARIATION EXPLAINED IS *,F5.2)
  905 FORMAT(1X,*STD. DEVIATION OF RESIDUALS IS *,E10.3)
  906 FORMAT(1X,*REG PARAM FOR ESTIMATES AND STD. DEV. ARE*)
  907 FORMAT(1X,///,10X,*KNOT NUMBER*,4X,17I4,/,
     110X,*KNOT VALUE(DEG)*,17I4)
  908 FORMAT(1X,1E10.3,/,1X,1E10.3)
  999 FORMAT(1X,*NEGATIVE F VALUE CALCULATED*)
 1000 CONTINUE
 1010 CONTINUE
```

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```
      2500 CONTINUE
      2501 FORMAT(5A10)
255   2550 CONTINUE
           GO TO 2502
      2501 CALL CALPLT(0.,0.,999)
           STOP
           END
```

SYMBOLIC REFERENCE MAP (R=3)

```
ENTRY POINTS        DEF LINE      REFERENCES
 6217   STEPSPL         1

VARIABLES        SN  TYPE            RELOCATION
10127   A             REAL       ARRAY              REFS        3      17     122    3*124     136    2*147   4*149
                                                             4*161   2*173  4*175    192      193     196     203     204
                                                            DEFINED    77      79     81      133     153     179     156
   13   ALPHT         REAL                 ACDATA   REFS       10      18   DEFINED    25
24270   AP            REAL       ARRAY              REFS        3     153     179   DEFINED   147     145     173
                                                              175
    0   AX            REAL       ARRAY     ACCEL    REFS       14      50
 1604   AY            REAL       ARRAY     ACCEL    REFS       14      60
 3410   AZ            REAL       ARRAY     ACCEL    REFS       14      52
52551   B             REAL       ARRAY              REFS        5     210     213     216     218
                                                            DEFINED   115     203     206     211
   14   BETT          REAL                 ACDATA   REFS       10      18   DEFINED    25
    1   BSPAN         REAL                 ACDATA   REFS       10      18      52      65
    2   CBAR          REAL                 ACDATA   REFS       10      18      54
   15   DELAT         REAL                 ACDATA   REFS       10      18   DEFINED    25
   12   DELET         REAL                 ACDATA   REFS       10      18   DEFINED    25
   16   DELRT         REAL                 ACDATA   REFS       10      18   DEFINED    25
10110   F             REAL                          REFS      137     131     139     140   DEFINED   136     138
10057   FCRT          REAL                          REFS       18      72
52741   FPART         REAL       ARRAY              REFS        6     162     163   DEFINED   161
10124   FIDT          REAL                          REFS      199   DEFINED   198
10076   F1            REAL                          REFS      140   DEFINED    72
10077   F2            REAL                          REFS      168   DEFINED    72
    5   G             REAL                 ACDATA   REFS       10      18      50      52      60
```

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VARIABLES SN		TYPE		RELOCATION								
10062	I	INTEGER			REFS	2*34	2*35	5*50	5*52	11*54	5*60	10*62
					10*65	2*71	77	2*79	2*81	3*83	85	3*89
					3*95	2*96	3*99	3*102	104	3*106	2*107	2*109
					2*111	115	2*122	123	5*124	125	2*126	128
					127	139	143	146	4*149	DEFINED	33	2*35
					45	51	74	76	78	80	82	87
					93	97	101	103	108	110	114	121
					127	132						
54	IACFLOP	INTEGER		FLAGS	REFS	12	18					
10066	IANOVA	INTEGER			REFS	164	DEFINED	59	182	188		
53	ICALL	INTEGER		FLAGS	REFS	12	42	DEFINED	27	42		
1	ICNT	INTEGER	ARRAY	FLAGS	REFS	12	123	155	160	167	191	202
					DEFINED	43	143	159				
0	IEG	INTEGER		ORDER	REFS	13	49	59	DEFINED	41		
53275	IEGN	INTEGER	ARRAY		REFS	6	16	41				
55	IFILOP	INTEGER		FLAGS	REFS	12	18					
10056	IFLAG	INTEGER			REFS	18	73					
10101	II	INTEGER			REFS	85	3*89	3*92	146	4*147	3*149	155
					155	5*161	2*162	172	4*173	3*175	191	202
					4*203	5*204	2*206	2*210	213	214	216	3*218
					3*219	DEFINED	84	86	90	144	155	159
					170	190	201	209	213	214	215	
10114	IIN	INTEGER			REFS	172	4*175	DEFINED	169			
10071	IPASS	INTEGER			REFS	121	157	DEFINED	59	121		
10055	IPLOT	INTEGER			REFS	18	226					
10103	IP1	INTEGER			REFS	105	DEFINED	104				
52	ITRIMOP	INTEGER		FLAGS	REFS	12	18					
10115	IV	INTEGER			REFS	191	192	DEFINED	189	191		
6	IX	REAL		ACDATA	REFS	2	10	18	54	3*62	65	
11	IXZ	REAL		ACDATA	REFS	2	10	18	54	62	65	
7	IY	REAL		ACDATA	REFS	2	10	18	3*54	62	65	
10	IZ	REAL		ACDATA	REFS	2	10	18	54	62	3*65	
10061	I1	INTEGER			REFS	2*29	167	158	3*169	DEFINED	28	166
10112	I2	INTEGER			REFS	2*153	2*179	DEFINED	151	177		
10102	J	INTEGER			REFS	2*89	92	95	3*99	3*106	2*107	
					DEFINED	88	91	94	98	105		
10111	JJ	INTEGER			REFS	2*147	3*147	2*173	3*175	2*218		
					DEFINED	145	171	217				
10113	J2	INTEGER			REFS	2*153	2*179	DEFINED	152	178		
53306	KNT	INTEGER	ARRAY		REFS	6	35	DEFINED	34			
10064	L	INTEGER			REFS	41	DEFINED	40				
51	LATOP	INTEGER		FLAGS	REFS	12	18	37	38	47		

```
VARIABLES     SN  TYPE           RELOCATION
10074  LINCNT     INTEGER                         REFS       236      237    DEFINED       71      234      236
10063  LINMAX     INTEGER                         REFS       127      234      237    DEFINED       36       38
10100  LINOP      INTEGER                         REFS       127      135      140      168    DEFINED       73      234
                                                   237
10075  LM1        INTEGER                         REFS       128  DEFINED       71      127      234      238
    3  M          REAL               ACDATA       REFS         2       10       18       50       52       60
10073  MAXLAG     INTEGER                         REFS        74      221      229  DEFINED       70
    1  N          INTEGER            ORDER        REFS        13       50       52       54       60       62       65
                                                  2*69        79       81       82       84       86       87       90
                                                    93        97       98      101      105      108      110    3*116
                                                 2*124     2*136    2*138    6*161    2*173    3*175    2*186      190
                                                 2*192     2*193    4*196    3*203    2*211      213      216    2*221
                                                   234       238  DEFINED       36       37
10054  NEQ        INTEGER                         REFS        18       40
10065  NGO        INTEGER                         REFS       158      186      232  DEFINED       41      138
10107  NMAX       INTEGER                         REFS       132  DEFINED      126
10067  NM1        INTEGER                         REFS        71       78       80      103      114      155      159
                                                   166       201      209      214      217  DEFINED       69
    0  NPTS       INTEGER            FLAGS        REFS        12       18       48       58       70       88       91
                                                    94        96       99      111      113      215      221      222
10126  NPT2       INTEGER                         REFS       223      225      227  DEFINED      222
10072  N2       * INTEGER                      DEFINED        70
10070  N2M1       INTEGER                         REFS      2*70      144      145      151      152      170      171
                                                   177       178  DEFINED       69
14234  P          REAL      ARRAY    ACCEL        REFS        14     3*54       62       65
 5214  PDOT       REAL      ARRAY    ACCEL        REFS        14       62       65
10104  PHI        REAL                            REFS       116      136      143      161      193      196
                                               DEFINED       113      143
   20  PT         REAL               ACDATA       REFS        10       18  DEFINED       25
10122  PVAR       REAL                            REFS       195  DEFINED      194
16040  Q          REAL      ARRAY    ACCEL        REFS        14     2*62     2*65
 7020  QDOT       REAL      ARRAY    ACCEL        REFS        14       54
   17  QT         REAL               ACDATA       REFS        10       18  DEFINED       25
17644  R          REAL      ARRAY    ACCEL        REFS        14     3*54       62       65
10624  RDOT       REAL      ARRAY    ACCEL        REFS        14       62       65
    4  RHO        REAL               ACDATA       REFS        10       18       50       52       54       60       62
                                                    65
10127  RR         REAL      ARRAY                 REFS         3       17      107      116  DEFINED      106      107
                                                   109
   21  RT         REAL               ACDATA       REFS        10       18  DEFINED       25
47451  S          REAL      ARRAY                 REFS         5      102      106      196    2*203      204
                                               DEFINED        99
```

```
 VARIABLES      SN  TYPE              RELOCATION
      0  SAREA      REAL                ACDATA      REFS       10      18      50      52      54      60      62
                                                      65
  10123  SDRES      REAL                            REFS      197     204  DEFINED    196
 111460  SIGMA      REAL      ARRAY     START       REFS        9   2*106     111     116  DEFINED    102     111
  10116  SSDR       REAL                            REFS      192     194  DEFINED    192
  10120  SSREG      REAL                            REFS      193 DEFINED     193
  52671  STDER      REAL      ARRAY                 REFS        6     214  DEFINED    204     206
  10125  SUM        REAL                            REFS      210     211  DEFINED    208     210
  10105  SY       * REAL                         DEFINED      116
  40431  T          REAL      ARRAY                 REFS        4      43     223     225     227
  10060  TOL        REAL                            REFS      122     134  DEFINED     27
  10053  TS         REAL                            REFS       18      43
  52621  V          REAL      ARRAY                 REFS        5     125     126 DEFINED     124
  12430  VEL        REAL      ARRAY     ACCEL       REFS       14    2*50    2*52    2*54    2*60    2*62    2*65
  10106  VMAX       REAL                            REFS      125     134   2*136     138  DEFINED    121     126
  53011  W          REAL      ARRAY                 REFS        7     221     229
      0  X          REAL      ARRAY     START       REFS        9      43    2*89      92      95     218
                                                 DEFINED       50      52      54      60      62      65
 111410  XBAR       REAL      ARRAY     START       REFS        9      95      96     210     211
                                                 DEFINED       83      95      96
  53143  XLAG       REAL      ARRAY                 REFS        7     229  DEFINED     75
  10117  XMSDR      REAL                            REFS      198 DEFINED     192
  10121  XMSSREG    REAL                            REFS      198 DEFINED     193
      0  XNOT       REAL      ARRAY     KNOT        REFS       16      34  DEFINED     29
  45645  XNU        REAL      ARRAY                 REFS        4     221     227 DEFINED     219
 111340  XSUM       REAL      ARRAY     START       REFS        9      92    2*99 DEFINED      83      92
 106240  XXSUM      REAL      ARRAY     START       REFS        9      89      99     221  DEFINED     85      89
  42235  Y          REAL      ARRAY                 REFS        4      43     219     221     223
                                                 DEFINED       50      52      54      60      62      65
  44041  YHAT       REAL      ARRAY                 REFS        4     218     219     221     225
                                                 DEFINED      216     218

 FILE NAMES         MODE
      0  INPUT
   2054  OUTPUT     FMT                   WRITES       35     138     139     155     162     169     195     197
                                             199      212     213     214
   4130  TAPE1
      0  TAPE5      NAME                  READS        30
   2054  TAPE6      NAME                  WRITES       32
```

```
EXTERNALS             TYPE     ARGS          REFERENCES
        AUTO                      7              221
        CALPLT                    3              257
        DATASET                   4               43
        EOF          REAL         1               31
        INFOPLT                  20              223        225        227        229
        PSEUDO                    0               26
        SQRT         REAL         1  LIBRARY     102        111        116        196        203        204

INLINE FUNCTIONS      TYPE     ARGS            DEF LINE   REFERENCES
        FLOAT        REAL         1   INTRIN                 111
        IFIX         INTEGER      1   INTRIN                  34

NAMELISTS            DEF LINE       REFERENCES
        INPUT            18            30         32

STATEMENT LABELS                      DEF LINE    REFERENCES
     0  30                               34           33
     0  49                               29           28
     0  50                               85           82         84
     0  51                               77           76
     0  52                               79           78
     0  53                               81           80
     0  100                              89           86         87         88
     0  101                              92           90         91
     0  200                              95           94
     0  201                              96           93
     0  202                             100           97         98
     0  203                             102          101
     0  204                             107          103        105
     0  205                             109          108
     0  206                              75           74
     0  210                             112          110
     0  250              INACTIVE       123          122
     0  260              INACTIVE       126          125
  6734  300                             127          122        123        125
     0  301                             115          114
     0  310              INACTIVE       129          128
  6717  320                             122          130
  6744  330                             131          128
     0  400              INACTIVE       141          140
  7017  401                             150          144        145        148
```

STATEMENT LABELS			DEF LINE	REFERENCES		
7014	402		149	146		
0	410	INACTIVE	161	160		
0	411		153	151	152	
0	418	INACTIVE	164			
7070	419		163	159	160	
0	420	INACTIVE	168	167		
0	421	INACTIVE	169	168		
0	426		179	177	178	
7132	427		175	172		
7135	428		176	170	171	174
7157	429		180	166	167	168
7041	430		155	183		
7163	431		184	157	158	164
0	439		191	190		
6751	443		136	134		
6762	444		139	137		
7246	448		206	202		
7250	449		207	201	205	
6714	450		121	235	239	
0	451		210	209		
0	460		219	215		
0	461		218	217		
7342	470		231	220		
6352	800		58	47		
0	801	INACTIVE	50	49		
6325	802		52	49		
6333	803		54	49		
6347	804		56	48	51	53
6427	805		68	57		
6424	806		67	58	61	64
0	807	INACTIVE	60	59		
6373	808		62	59		
6410	809		65	59		
7732	950	FMT	240	139		
7741	951	FMT	241	155		
7746	952	FMT	242	162		
7755	953	FMT	243	169		
7762	954	FMT	244	195		
7770	955	FMT	245	197		
10013	956	FMT	249	213	214	
7713	957	FMT	200	199		
7776	958	FMT	246	212		

STATEMENT	LABELS			DEF LINE	REFERENCES	
10004	959	FMT		247	35	
10016	998	FMT		250	138	
7361	1000			252	40	232
0	1500		INACTIVE	253		
7361	1999			251	135	140
0	2000		INACTIVE	135	134	
10023	2001	FMT	NO REFS	254		
7345	2111			234	135	
7352	2112			236	233	
0	2500		INACTIVE	255		
7364	2501			257	31	
6226	2502			27	256	
0	2503		INACTIVE	32	31	

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES		
6233	49	II	28 29	5B	INSTACK		
6251	30	I	33 34	4B	INSTACK		
6260		I	35 35	4B		EXT REFS	
6276	1000	L	40 252	1066B		EXT REFS	NOT INNER
6315	804	I	48 56	34B	OPT		
6363	806	I	58 67	43B	OPT		
6450	206	I	74 75	3B	INSTACK		
6456	51	I	76 77	2B	INSTACK		
6467	52	I	78 79	3B	INSTACK		
6500	53	I	80 81	3B	INSTACK		
6505	50	I	82 85	15B		NOT INNER	
6515	50	II	84 85	2B	INSTACK		
6523	100	II	86 89	23B		NOT INNER	
6524	100	I	87 89	20B		NOT INNER	
6535	100	J	88 89	3B	INSTACK		
6547	101	II	90 92	14B		NOT INNER	
6555	101	J	91 92	3B	INSTACK		
6564	201	I	93 96	16B		NOT INNER	
6572	200	J	94 95	3B	INSTACK		
6603	202	I	97 100	21B		NOT INNER	
6613	202	J	98 100	5B	INSTACK		
6625	203	I	101 102	7B		EXT REFS	
6635	204	I	103 107	23B		NOT INNER	
6650	204	J	105 107	5B	INSTACK		
6664	205	I	108 109	3B	INSTACK		
6671	210	I	110 112	6B		EXT REFS	
6703	301	I	114 115	2B	INSTACK		

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```
LOOPS  LABEL   INDEX   FROM-TO   LENGTH   PROPERTIES
 6774   401     II     144 150     30B                NOT INNER
 7010   401     JJ     145 150     11B        OPT
 7025   411     I2     151 153     14B                NOT INNER
 7032   411     J2     152 153      3B     INSTACK
 7052   419     II     159 163     21B                EXT REFS
 7075   429     I1     166 180     65B                EXT REFS  NOT INNER
 7110   428     II     170 176     32B                NOT INNER
 7126   428     JJ     171 176     11B        OPT
 7143   426     I2     177 179     14B                NOT INNER
 7150   426     J2     178 179      3B     INSTACK
 7174   439     II     190 191      3B     INSTACK
 7226   449     II     201 207     25B                EXT REFS
 7256   451     II     209 210      4B     INSTACK
 7302   460     II     215 219     22B                NOT INNER
 7313   461     JJ     217 218      3B     INSTACK

COMMON BLOCKS  LENGTH    MEMBERS - BIAS NAME(LENGTH)
       START    37720          0 X       (36000)       36000 XXSUM   (1600)      37600 XSUM    (40)
                           37640 XBAR    (40)          37680 SIGMA   (40)
       ACDATA      18          0 SAREA   (1)               1 BSPAN   (1)             2 CBAR    (1)
                               3 M       (1)               4 RHO     (1)             5 G       (1)
                               6 IX      (1)               7 IY      (1)             8 IZ      (1)
                               9 IXZ     (1)              10 DELET   (1)            11 ALPHT   (1)
                              12 BETT    (1)              13 DELAT   (1)            14 DELRT   (1)
                              15 QT      (1)              16 PT      (1)            17 RT      (1)
       FLAGS       46          0 NPTS    (1)               1 ICNT    (40)           41 LATOP   (1)
                              42 ITRIMOP (1)              43 ICALL   (1)            44 IACELOP (1)
                              45 IFILOP  (1)
       ORDER        2          0 IEQ     (1)               1 N       (1)
       ACCEL     9000          0 AX      (900)           900 AY      (900)        1800 AZ      (900)
                            2700 PDOT    (900)          3600 QDOT    (900)        4500 RDOT    (900)
                            5400 VEL     (900)          6300 P       (900)        7200 Q       (900)
                            8100 R       (900)
       KNOT        23          0 XNOT    (23)

EQUIV CLASSES  LENGTH    MEMBERS - BIAS NAME(LENGTH)
       A         6241          0 RR      (6241)

STATISTICS
  PROGRAM LENGTH                 45457B    19247
  BUFFER LENGTH                   5670B     3000
  CM LABELED COMMON LENGTH      133331B    46809
```

STATISTICS

52000B CM USED

```
      SUBROUTINE DATASET(TS,T,Y,X)
      REAL M,IY,IX,IZ,IXZ
      DIMENSION IR(2)
      DIMENSION T(900),Y(900),X(40,900)
      DIMENSION BETA(900),ALPH(900)
      DIMENSION DELA(900),DELR(900),DELE(900)
      DIMENSION NAMES(50),IUNITS(50),HDR(8),DATA(50)
      DIMENSION PDD(900),QDD(900),RDD(900),PTEM(900),QTEM(900),
     1RTEM(900),WRK1(900),WRK2(900),WRK3(900),WRK4(900),WRK5(900),
     2WRK6(900)
      COMMON/ACDATA/ S,B,C,M,RHO,G,IX,IY,IZ,IXZ,DELET,ALPHT
     1,BETT,DELAT,DELRT,QT,PT,RT
      COMMON/FLAGS/ NPTS,ICNT(40),LATOP,ITRIMOP,ICALL,IACELOP,IFILOP
      COMMON/ORDER/ IEQ,N
      COMMON/ACCEL/ AX(900),AY(900),AZ(900),PDOT(900),QDOT(900),RDOT(900
     1),VEL(900),P(900),Q(900),R(900)
      COMMON/KNOT/XNOT(23)
C
C
C
      IF(ICALL.GT.1) GO TO 46
      J2=NPTS/2
      JPTS=2*J2
      IF( (NPTS-JPTS) .EQ. 0) NPTS=JPTS-1
* 501 READ(1) ID,NCH,(NAMES(I),I=1,NCH),(IUNITS(I),I=1,NCH),HDR
*     IF(EOF(1)) 9994,502
  501 CONTINUE
      ID=1    $NCH=20    $HDR(1)=3HHDR   $IN=1 $IR(1)=51 $IR(2)=100
  502 READ(1) (DATA(J),J=1,NCH)
      IF(EOF(1)) 9996,8001
 8001 IF((TS).GT.DATA(1)) 502,600
  600 CONTINUE
      IF(ITRIMOP.EQ.1) GO TO 602
      BETT=DATA(3) $DELAT=DATA(13) $DELRT=DATA(15)   $DELET=DATA(14)
      ALPHT=DATA(19)
  602 PRINT 1980,ALPHT,BETT,DELAT,DELET,DELRT
 1980 FORMAT(1X,///,10X,*TRIM VALUES*/,15X,
     **ALPHT        BETT          AILT          DELET          DELRT*/,
     *10X,5E12.5)
      DO 15 I=1,NPTS
      READ (1) (DATA(J),J=1,NCH)
      IF(EOF(1)) 9996,601
```

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 601 CONTINUE
     CALL GETRAN(IR,IN,2,RN,Y1,Y2)
     IN=IN+1
     T(I)= DATA(1)-TS
     VEL(I)= DATA(2)
     BETA(I)= DATA(18)-BETT
     ALPH(I)= DATA(19)
     P(I)= DATA(5)
     Q(I)=DATA(6)+.003*RN
     R(I)= DATA(7)
     AX(I)=DATA(10)
     AY(I)= DATA(11)
     AZ(I)= DATA(12)
     DELA(I)= DATA(13)-DELAT
     DELR(I)= DATA(15)-DELRT
     DELE(I)=DATA(14)-DELET
     PDOT(I)=DATA(16)  $QDOT(I)=DATA(20)  $RDOT(I)=DATA(17)
  15 CONTINUE
     IF(IACELOP.EQ.0)  GO TO 46
     CALL SECDER(3,3,T,P,PDD,PTEM,NPTS,PO,P3,.5,.5,WRK1,WRK2,WRK3,
    1WRK4,WRK5,WRK6)
     CALL SECDER(3,3,T,Q,QDD,QTEM,NPTS,PO,P3,.5,.5,WRK1,WRK2,WRK3,
    1WRK4,WRK5,WRK6)
     CALL SECDER(3,3,T,R,RDD,RTEM,NPTS,PO,P3,.5,.5,WRK1,WRK2,WRK3,
    1WRK4,WRK5,WRK6)
     DO 45 I=1,NPTS
     PDOT(I)=DERSP(T(I),T,P,NPTS,PDD,PTEM)
     QDOT(I)=DERSP(T(I),T,Q,NPTS,QDD,QTEM)
     RDOT(I)=DERSP(T(I),T,R,NPTS,RDD,RTEM)
  45 CONTINUE
  46 CONTINUE
     IF(LATOP.NE.1) GO TO 803
     DO 800 I=1,NPTS
     X(1,I)=BETA(I)
     X(2,I)=P(I)*B/(2.*VEL(I))
     X(3,I)=R(I)*B/(2.*VEL(I))
     X(4,I)=DELA(I)
     X(5,I)=DELR(I)
     X(6,I)=ALPH(I)*X(1,I)
     X(7,I)=ALPH(I)*X(2,I)
     X(8,I)=X(3,I)*ALPH(I)
     X(9,I)=DELA(I)*ALPH(I)
```

```
      X(10,I)=DELR(I)*ALPH(I)
      X(11,I)=ALPH(I)*ALPH(I)*X(1,I)
      X(12,I)=ALPH(I)*ALPH(I)*X(2,I)
      X(13,I)=ALPH(I)*ALPH(I)*X(3,I)
      X(14,I)=ALPH(I)*ALPH(I)*X(4,I)
      X(15,I)=ALPH(I)*ALPH(I)*X(5,I)
      X(16,I)=X(1,I)*X(1,I)
      X(17,I)=X(1,I)*X(16,I)
      X(18,I)=X(1,I)*X(17,I)
      X(19,I)=X(1,I)*X(18,I)
      X(20,I)=X(1,I)*X(11,I)
      X(21,I)=ALPH(I)*X(16,I)
      X(22,I)=ALPH(I)
      X(23,I)=ALPH(I)*ALPH(I)
      X(24,I)=ALPH(I)*X(23,I)
  800 CONTINUE
      GO TO 804
  803 CONTINUE
      DO 801 I=1,NPTS
      X(1,I)=ALPH(I)
      X(2,I)=C/(2*VEL(I))*Q(I)
      X(3,I)=DELE(I)
      DO 805 III=4,39
  805 X(III,I)=0.
      IF(ALPH(I).GE.XNOT(1)) X(4,I)=ALPH(I)-XNOT(1)
      IF(ALPH(I).GE.XNOT(1)) X(5,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(2)) X(6,I)=ALPH(I)-XNOT(2)
      IF(ALPH(I).GE.XNOT(2)) X(7,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(3)) X(8,I)=ALPH(I)-XNOT(3)
      IF(ALPH(I).GE.XNOT(3)) X(9,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(4)) X(10,I)=ALPH(I)-XNOT(4)
      IF(ALPH(I).GE.XNOT(4)) X(11,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(5)) X(12,I)=ALPH(I)-XNOT(5)
      IF(ALPH(I).GE.XNOT(5)) X(13,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(6)) X(14,I)=ALPH(I)-XNOT(6)
      IF(ALPH(I).GE.XNOT(6)) X(15,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(7)) X(16,I)=ALPH(I)-XNOT(7)
      IF(ALPH(I).GE.XNOT(7)) X(17,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(8)) X(18,I)=ALPH(I)-XNOT(8)
      IF(ALPH(I).GE.XNOT(8)) X(19,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(9)) X(20,I)=ALPH(I)-XNOT(9)
      IF(ALPH(I).GE.XNOT(9)) X(21,I)=X(2,I)
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```
      IF(ALPH(I).GE.XNOT(10)) X(22,I)=ALPH(I)-XNOT(10)
      IF(ALPH(I).GE.XNOT(10)) X(23,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(11)) X(24,I)=ALPH(I)-XNOT(11)
      IF(ALPH(I).GE.XNOT(11)) X(25,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(12)) X(26,I)=ALPH(I)-XNOT(12)
      IF(ALPH(I).GE.XNOT(12)) X(27,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(13)) X(28,I)=ALPH(I)-XNOT(13)
      IF(ALPH(I).GE.XNOT(13)) X(29,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(14)) X(30,I)=ALPH(I)-XNOT(14)
      IF(ALPH(I).GE.XNOT(14)) X(31,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(15)) X(32,I)=ALPH(I)-XNOT(15)
      IF(ALPH(I).GE.XNOT(15)) X(33,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(16)) X(34,I)=ALPH(I)-XNOT(16)
      IF(ALPH(I).GE.XNOT(16)) X(35,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(17)) X(36,I)=ALPH(I)-XNOT(17)
      IF(ALPH(I).GE.XNOT(17)) X(37,I)=X(2,I)
      IF(ALPH(I).GE.XNOT(7))  X(38,I)=X(3,I)
  801 IF(ALPH(I).GE.XNOT(11)) X(39,I)=X(3,I)
  804 CONTINUE
      PRINT 964,ID,IEQ,NPTS
      IF(ICALL.GT.1) GO TO 999
      IF(LATOP.EQ.0) GO TO 50
      PRINT 968
  968 FORMAT(1X,7X,*TIME*,11X,*V*,12X,*BETA*,11X,*P*,14X,*R*,11X,
     1*DELA*,11X,*DELR*)
  964 FORMAT(1H1,3X,*RUN*,I5,5X,*EQUATION *,I2,5X,*NPTS*,I5,///)
      PRINT 962,(T(I),VEL(I),BETA(I),P(I),R(I),DELA(I),DELR(I),I=1,NPTS)
  962 FORMAT(7(2X,E12.4))
      CALL INFOPLT(1,NPTS,T,1,DELA,1,0.,0.,0.,0.,0.,1,1HT,
     14,4HDELA,22,7.,5.,.75,.75)
      CALL INFOPLT(1,NPTS,T,1,DELR,1,0.,0.,0.,0.,0.,1,1HT,
     14,4HDELR,22,7.,5.,.75,.75)
      GO TO 999
   50 CONTINUE
      PRINT 998
  998 FORMAT(1X,7X,*TIME*,11X,*V*,11X,*ALPHA*,11X,*Q*,14X,*DELE*)
      PRINT 997,(T(I),VEL(I),ALPH(I),Q(I),DELE(I),I=1,NPTS)
  997 FORMAT(5(2X,E12.4))
      CALL INFOPLT(1,NPTS,T,1,DELE,1,0.,0.,0.,0.,0.,1,1HT,
     14,4HDELE,22,7.,5.,.75,.75)
      GO TO 999
 9998 PRINT 9999
```

```
      9999 FORMAT(1X,*EOF ON DUMMY READ*)
           GO TO 999
      9996 PRINT 9997,J,I
      9997 FORMAT(1X,*EOF ON DATA READ*,5X,*INDEX J,I= *,2I10)
           GO TO 999
      9994 PRINT 9995
      9995 FORMAT(1X,*EOF ON HDR READ*)
       999 CONTINUE
           RETURN
           END
```

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   SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS     DEF LINE     REFERENCES
    3  DATASET        1          177

 VARIABLES     SN  TYPE              RELOCATION
  3101  ALPH        REAL       ARRAY               REFS       5      81     82     83     84     85    2*86
                                                          2*87    2*88   2*89   2*90     96     97   2*96     99
                                                           104   2*109    110  2*111    112  2*113    114  2*115
                                                           116   2*117    118  2*119    120  2*121    122  2*123
                                                           124   2*125    126  2*127    128  2*129    130  2*131
                                                           132   2*133    134  2*135    136  2*137    138  2*139
                                                           140   2*141    142    143    144    163
                                                       DEFINED      49
    13  ALPHT       REAL              ACDATA       REFS      11      36  DEFINED     35
     0  AX          REAL       ARRAY  ACCEL        REFS      15  DEFINED     53
  1604  AY          REAL       ARRAY  ACCEL        REFS      15  DEFINED     54
  3410  AZ          REAL       ARRAY  ACCEL        REFS      15  DEFINED     55
     1  B           REAL              ACDATA       REFS      11      77     78
  1275  BETA        REAL       ARRAY               REFS       5      76    153  DEFINED     48
    14  BETT        REAL              ACDATA       REFS      11      36     48  DEFINED     34
     2  C           REAL              ACDATA       REFS      11     105
 12275  DATA        REAL       ARRAY               REFS       7      31   4*34     35     46     47     48
                                                            49      50     51     52     53     54     55     56
                                                            57      58   3*59  DEFINED     29     41
  4705  DELA        REAL       ARRAY               REFS       6      79     84    153    155
                                                       DEFINED      56
```

```
VARIABLES       SN  TYPE              RELOCATION
     15  DELAT       REAL                  ACDATA      REFS       11      36      56  DEFINED      34
  10315  DELE        REAL        ARRAY                 REFS        6     106     163      165  DEFINED      58
     12  DELET       REAL                  ACDATA      REFS       11      36      58  DEFINED      34
   6511  DELR        REAL        ARRAY                 REFS        6      80      85      153      157
                                                    DEFINED       57
     16  DELRT       REAL                  ACDATA      REFS       11      36      57  DEFINED      34
      5  G           REAL                  ACDATA      REFS       11
  12265  HDR         REAL        ARRAY                 REFS        7  DEFINED     28
   1264  I           INTEGER                           REFS       46      47      48       49       50      51      52
                                                          53      54      55      56       57       58    3*59    2*69
                                                        2*70    2*71    2*76    3*77     3*78     2*79    2*80    3*81
                                                        3*82    3*83    3*84    3*85     4*86     4*87    4*88    4*89
                                                        4*90    3*91    3*92    3*93     3*94     3*95    3*96    2*97
                                                        3*98    3*99   2*104   3*105    2*106      108   3*109   3*110
                                                       3*111   3*112   3*113   3*114    3*115    3*116   3*117   3*118
                                                       3*119   3*120   3*121   3*122    3*123    3*124   3*125   3*126
                                                       3*127   3*128   3*129   3*130    3*131    3*132   3*133   3*134
                                                       3*135   3*136   3*137   3*138    3*139    3*140   3*141   3*142
                                                       3*143   3*144   7*153   5*163      171  DEFINED      40      68
                                                          75     103     153     163
     54  IACELOP     INTEGER               FLAGS       REFS       13      61
     53  ICALL       INTEGER               FLAGS       REFS       13      21     147
      1  ICNT        INTEGER     ARRAY     FLAGS       REFS       13
   1260  ID          INTEGER                           REFS      146  DEFINED     20
      0  IEQ         INTEGER               ORDER       REFS       14     146
     55  IFILOP      INTEGER               FLAGS       REFS       13
   1272  III         INTEGER                           REFS      108  DEFINED    107
   1262  IN          INTEGER                           REFS       44      45  DEFINED       28       45
   1273  IR          INTEGER     ARRAY                 REFS        3      44  DEFINED     2*28
     52  ITRIMOP     INTEGER               FLAGS       REFS       13      33
  12203  IUNITS      INTEGER     *UNDEF                REFS        7
      6  IX          REAL                  ACDATA      REFS        2      11
     11  IXZ         REAL                  ACDATA      REFS        2      11
      7  IY          REAL                  ACDATA      REFS        2      11
     10  IZ          REAL                  ACDATA      REFS        2      11
   1263  J           INTEGER                           REFS       29      41     171  DEFINED       29      41
   1257  JPTS        INTEGER                           REFS     2*24  DEFINED     23
   1256  J2          INTEGER                           REFS       23  DEFINED     22
     51  LATUP       INTEGER               FLAGS       REFS       13      74     148
      3  M           REAL                  ACDATA      REFS        2      11
      1  N           INTEGER               ORDER       REFS       14
  12121  NAMES       INTEGER     *UNDEF                REFS        7
```

```
VARIABLES        SN  TYPE            RELOCATION
  1261  NCH          INTEGER                        REFS        29     41   DEFINED     28
     0  NPTS         INTEGER               FLAGS    REFS        13     22     24        40      62      64      66
                                                      68        69     70     71        75     103     146     153
                                                     155       157    163    165   DEFINED      24
 14234  P            REAL        ARRAY     ACCEL    REFS        15     62     69        77     153
                                                 DEFINED        50
 12357  PDD          REAL        ARRAY              REFS         8     62     69
  5214  PDOT         REAL        ARRAY     ACCEL    REFS        15 DEFINED    59        69
    20  PT           REAL                  ACDATA   REFS        11
 17573  PTEM         REAL        ARRAY              REFS         8     62     69
  1270  PO           REAL                           REFS        62     64     66
  1271  P3           REAL                           REFS        62     64     66
 16040  Q            REAL        ARRAY     ACCEL    REFS        15     64     70       105     163
                                                 DEFINED        51
 14163  QDD          REAL        ARRAY              REFS         8     64     70
  7020  QDOT         REAL        ARRAY     ACCEL    REFS        15 DEFINED    59        70
    17  QT           REAL                  ACDATA   REFS        11
 21377  QTEM         REAL        ARRAY              REFS         8     64     70
 17644  R            REAL        ARRAY     ACCEL    REFS        15     66     71        78     153
                                                 DEFINED        52
 15767  RDD          REAL        ARRAY              REFS         8     66     71
 10624  RDOT         REAL        ARRAY     ACCEL    REFS        15 DEFINED    59        71
     4  RHO          REAL                  ACDATA   REFS        11
  1265  RN           REAL                           REFS        44     51
    21  RT           REAL                  ACDATA   REFS        11
 23203  RTEM         REAL        ARRAY              REFS         8     66     71
     0  S            REAL                  ACDATA   REFS        11
     0  T            REAL        ARRAY     F.P.     REFS         4     62     64        66    2*69    2*70    2*71
                                                     153       155    157    163       165 DEFINED       1      46
     0  TS           REAL                  F.P.     REFS        31     46 DEFINED         1
 12430  VEL          REAL        ARRAY     ACCEL    REFS        15     77     78       105     153     163
                                                 DEFINED        47
 25007  WRK1         REAL        ARRAY              REFS         8     62     64        66
 26613  WRK2         REAL        ARRAY              REFS         8     62     64        66
 30417  WRK3         REAL        ARRAY              REFS         8     62     64        66
 32223  WRK4         REAL        ARRAY              REFS         8     62     64        66
 34027  WRK5         REAL        ARRAY              REFS         8     62     64        66
 35633  WRK6         REAL        ARRAY              REFS         8     62     64        66
     0  X            REAL        ARRAY     F.P.     REFS         4     81     82        83      86      87      88
                                                      89        90   2*91   2*92      2*93    2*94    2*95      96
                                                      99       110    112    114       116     118     120     122
                                                     124       126    128    130       132     134     136     138
```

```
VARIABLES          SN  TYPE             RELOCATION
                                                    140       142       143       144     DEFINED       1         76        77
                                                     78        79        80        81        82        83         84        85
                                                     86        87        88        89        90        91         92        93
                                                     94        95        96        97        98        99        104       105
                                                    106       108       109       110       111       112        113       114
                                                    115       116       117       118       119       120        121       122
                                                    123       124       125       126       127       128        129       130
                                                    131       132       133       134       135       136        137       138
                                                    139       140       141       142       143       144
       0  XNOT         REAL          ARRAY    KNOT   REFS       17     2*109       110     2*111       112      2*113       114
                                                   2*115       116     2*117       118     2*119       120      2*121       122
                                                   2*123       124     2*125       126     2*127       128      2*129       130
                                                   2*131       132     2*133       134     2*135       136      2*137       138
                                                   2*139       140     2*141       142       143       144
       0  Y            REAL          ARRAY    F.P.   REFS        4   DEFINED         1
    1266  Y1         * REAL                          REFS       44
    1267  Y2         * REAL                          REFS       44

  FILE NAMES           MODE
          OUTPUT       FMT                  WRITES       36       146       149       153       161       163        168       171
                                               174
          TAPE1        UNFMT                 READS       29        41

  EXTERNALS             TYPE    ARGS       REFERENCES
          DERSP        REAL       6               69       70        71
          EOF          REAL       1               30       42
          GETRAN                  6               44
          INFOPLT                20              155      157       165
          SECDER                 17               62       64        66

  STATEMENT LABELS                   DEF LINE    REFERENCES
       0  15                             60          40
       0  45                             72          68
     160  46                             73          21        61
     573  50                            160         148
       0  501          INACTIVE          27
      23  502                            29          31
       0  600          INACTIVE          32          31
       0  601          INACTIVE          43          42
      45  602                            36          33
       0  800                           100          75
       0  801                           144         103
```

```
STATEMENT LABELS                DEF LINE   REFERENCES
   223  803                        102        74
   532  804                        145       101
     0  805                        108       107
  1156  962     FMT                154       153
  1133  964     FMT                152       146
  1122  968     FMT                150       149
  1205  997     FMT                164       163
  1164  998     FMT                162       161
   631  999                        176       147       159       167       170       173
  1072  1980    FMT                 37        36
     0  8001        INACTIVE        31        30
     0  9994        INACTIVE       174
  1235  9995    FMT                175       174
   624  9996                       171        30        42
  1224  9997    FMT                172       171
     0  9998        INACTIVE       168
  1213  9999    FMT                169       168

LOOPS  LABEL    INDEX     FROM-TO    LENGTH    PROPERTIES
   50  15       I          40 60       53B               EXT REFS     EXITS
  136  45       I          68 72       22B               EXT REFS
  171  800      I          75 100      31B        OPT
  224  801      I         103 144     306B               NOT INNER
  241  805      III       107 108       2B     INSTACK
  544           I         153 153      17B               EXT REFS
  600           I         163 163      14B               EXT REFS

COMMON BLOCKS    LENGTH     MEMBERS - BIAS NAME(LENGTH)
       ACDATA       18                 0 S        (1)            1 B      (1)           2 C       (1)
                                       3 M        (1)            4 RHO    (1)           5 G       (1)
                                       6 IX       (1)            7 IY     (1)           8 IZ      (1)
                                       9 IXZ      (1)           10 DELET  (1)          11 ALPHT   (1)
                                      12 BETT     (1)           13 DELAT  (1)          14 DELRT   (1)
                                      15 QT       (1)           16 PT     (1)          17 RT      (1)
       FLAGS        46                 0 NPTS     (1)            1 ICNT   (40)         41 LATOP   (1)
                                      42 ITRIMOP  (1)           43 ICALL  (1)          44 IACELOP (1)
                                      45 IFILUP   (1)
       ORDER         2                 0 IEQ      (1)            1 N      (1)
       ACCEL      9000                 0 AX       (900)        900 AY     (900)      1800 AZ      (900)
                                    2700 PDOT     (900)       3600 QDOT   (900)      4500 RDOT    (900)
                                    5400 VEL      (900)       6300 P      (900)      7200 Q       (900)
                                    8100 R        (900)
```

```
COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
     KNOT          23                 0 XNOT    (23)

STATISTICS
  PROGRAM LENGTH               37534B   16220
  CM LABELED COMMON LENGTH     21601B    9089
        52000B CM USED
```

```
      SUBROUTINE AUTO(X,MAXLAG,N,W,YSQ,YHAT,Y)
      DIMENSION X(1),W(1),YHAT(1),Y(1)
      MLAGM1=MAXLAG-1
      XSUM=0.    $XXSUM=0.
      DO 7 I=1,N
    7 XSUM=XSUM+X(I)
      XMEAN=XSUM/N
      DO 8 I=1,N
    8 X(I)=X(I)-XMEAN
      DO 12 I=1,N
   12 XXSUM=XXSUM+X(I)*X(I)
      PRINT 900,XMEAN,XXSUM
  900 FORMAT(1X,*RESIDUAL MEAN IS*,E12.5,/,1X,
     1*SIGMA SQ OF RESIDUALS IS*,E12.5)
      DO 2 K=1,MAXLAG
      SUM=0.  $WO=0.
      NMK=N-K
      DO 1 I=1,NMK
    1 SUM=SUM+X(I)*X(I+K)
    2 W(K)=1./(N-K)*SUM
      DO 3 I=1,N
    3 WO=WO+X(I)*X(I)
      WO=WO/N
      DO 9 I=1,MAXLAG
    9 W(MAXLAG+2-I)=W(MAXLAG+1-I)
      W(1)=WO
      DO 10 I=1,N
   10 X(I)=X(I)+XMEAN
      DO 11 I=1,MAXLAG
   11 W(I)=W(I)/WO
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS	DEF LINE	REFERENCES
3 AUTO	1	31

```
VARIABLES      SN  TYPE           RELOCATION
  153  I           INTEGER                        REFS        6        2*9      2*11      2*19      2*22      2*25      2*28
                                                  2*30   DEFINED        5         8        10        18        21        24
                                                   27       29
  155  K           INTEGER                        REFS       17        19      2*20   DEFINED        15
    0  MAXLAG      INTEGER               F.P.     REFS        3        15        24      2*25        29
                                               DEFINED        1
  150  MLAGM1    * INTEGER                     DEFINED        3
    0  N           INTEGER               F.P.     REFS        5         7         8        10        17        20        21
                                                   23       27   DEFINED         1
  160  NMK         INTEGER                        REFS       18   DEFINED        17
  156  SUM         REAL                           REFS       19        20   DEFINED        16        19
    0  W           REAL        ARRAY     F.P.     REFS        2        25        30   DEFINED         1        20        25
                                                   26       30
  157  WO          REAL                           REFS       22        23        26        30   DEFINED        16        22
                                                   23
    0  X           REAL        ARRAY     F.P.     REFS        2         6         9      2*11      2*19      2*22        28
                                               DEFINED        1         9        28
  154  XMEAN       REAL                           REFS        9        12        28   DEFINED         7
  151  XSUM        REAL                           REFS        6         7   DEFINED         4         6
  152  XXSUM       REAL                           REFS       11        12   DEFINED         4        11
    0  Y           REAL        ARRAY     F.P.     REFS        2   DEFINED         1
    0  YHAT        REAL        ARRAY     F.P.     REFS        2   DEFINED         1
    0  YSQ         REAL       *UNUSED    F.P.  DEFINED        1

FILE NAMES         MODE
       OUTPUT      FMT                  WRITES        12

STATEMENT LABELS                DEF LINE   REFERENCES
    0  1                           19          18
    0  2                           20          15
    0  3                           22          21
    0  7                            6           5
    0  8                            9           8
    0  9                           25          24
    0  10                          28          27
    0  11                          30          29
    0  12                          11          10
  137  900       FMT               13          12
```

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
15	7	I	5 6	3B	INSTACK
27	8	I	8 9	3B	INSTACK
36	12	I	10 11	3B	INSTACK
44	2	K	15 20	24B	NOT INNER
55	1	I	18 19	4B	INSTACK
73	3	I	21 22	3B	INSTACK
106	9	I	24 25	2B	INSTACK
116	10	I	27 28	3B	INSTACK
126	11	I	29 30	3B	INSTACK

STATISTICS
PROGRAM LENGTH 170B 120
52000B CM USED

```
      SUBROUTINE FIL(T,P,NPTS)
      DIMENSION PF(500),H(500),P(500),T(500),HOMEGA(500)
      PI=3.14159  $FC=2.5 $FT=2.51 $WC=2*PI*FC $WT=2*PI*FT
      NMID=NPTS/2    $DT=.05
      W2=(WT-WC)*(WT-WC)
      DO 3 I=1,NMID
      K=I
    3 H(I)=PI/(2*K*DT)*(SIN(WT*K*DT)+SIN(WC*K*DT))/(PI*PI-W2*K*DT
     1*K*DT)
      HO=FC+FT
      NPM1=NPTS-1
      HNORM=HO
      DO 1 I=1,NMID
    1 HNORM=HNORM+H(I)*2.
      DO 2 I=1,NMID
    2 H(I)=H(I)/HNORM
      HO=HO/HNORM
      DO 5 I=2,NMID
      IM1=I-1
      PF(I)=HO*P(I)
      DO 51 J=1,IM1
   51 PF(I)=PF(I)+H(J)*(P(I+J)+P(I-J))
      DO 52 J=I,NMID
   52 PF(I)=PF(I)+2*H(J)*P(I+J)
    5 CONTINUE
      NP2=NMID+2
      DO 4 I=NP2,NPM1
      NPMI=NPTS-I
      PF(I)=HO*P(I)
      DO 41 J=1,NPMI
   41 PF(I)=PF(I)+H(J)*(P(I-J)+P(I+J))
      NPMIP1=NPMI+1
      DO 42 J=NPMIP1,NMID
   42 PF(I)=PF(I)+2*H(J)*P(I-J)
    4 CONTINUE
      PF(1)=HO*P(1)  $PF(NPTS)=HO*P(NPTS) $PF(NMID+1)=HO*P(NMID+1)
      DO 10 J=1,NMID
      PF(1)=PF(1)+2*H(J)*P(1+J)
      PF(NMID+1)=PF(NMID+1)+H(J)*(P(NMID+1+J)+P(NMID+1-J))
   10 PF(NPTS)=PF(NPTS)+2*H(J)*P(NPTS-J)
      DO 6 I=1,NPTS
    6 P(I)=PF(I)
```

```
                          RETURN
                          END


         SYMBOLIC REFERENCE MAP (R=3)

     ENTRY POINTS       DEF LINE      REFERENCES
        3  FIL              1           43

     VARIABLES       SN  TYPE              RELOCATION
       237  DT            REAL                              REFS       5*8     DEFINED       4
       232  FC            REAL                              REFS        3        10     DEFINED       3
       233  FT            REAL                              REFS        3        10     DEFINED       3
      1237  H             REAL        ARRAY                 REFS        2        14        16         22        24        31        34
                                                               38       39        40     DEFINED       8        16
       245  HNORM         REAL                              REFS       14        16        17     DEFINED      12        14
      2223  HOMEGA        REAL       *UNDEF                 REFS        2
       243  HO            REAL                              REFS       12        17        20         29       3*36
                                                          DEFINED      10        17
       241  I             INTEGER                           REFS        7         8        14       2*16        19      2*20      4*22
                                                               23     3*24        28      2*29       4*31      3*34      2*42
                                                          DEFINED       6        13        15         18        27        41
       246  IM1           INTEGER                           REFS       21     DEFINED      19
       247  J             INTEGER                           REFS     3*22      2*24      3*31       2*34      2*38      3*39      2*40
                                                          DEFINED      21        23        30         33        37
       242  K             INTEGER                           REFS      5*8     DEFINED       7
       236  NMID          INTEGER                           REFS        6        13        15         18        23        26        33
                                                             2*36       37      4*39     DEFINED       4
       251  NPM1          INTEGER                           REFS       30        32     DEFINED       28
       252  NPM1P1        INTEGER                           REFS       33     DEFINED      32
       244  NPM1          INTEGER                           REFS       27     DEFINED      11
         0  NPTS          INTEGER                F.P.       REFS        4        11        28       2*36       3*40        41
                                                          DEFINED       1
       250  NP2           INTEGER                           REFS       27     DEFINED      26
         0  P             REAL        ARRAY      F.P.       REFS        2        20      2*22         24        29      2*31        34
                                                             3*36       38      2*39        40     DEFINED        1        42
       253  PF            REAL        ARRAY                 REFS        2        22        24         31        34        38        39
                                                               40       42     DEFINED      20         22        24        29        31
                                                               34     3*36        38        39         40
```

```
VARIABLES     SN   TYPE               RELOCATION
   231   PI        REAL                                  REFS        2*3       3*8   DEFINED        3
     0   T         REAL        ARRAY       F.P.          REFS        2      DEFINED        1
   234   WC        REAL                                  REFS        2*5        8    DEFINED        3
   235   WT        REAL                                  REFS        2*5        8    DEFINED        3
   240   W2        REAL                                  REFS        8      DEFINED        5

EXTERNALS              TYPE    ARGS         REFERENCES
          SIN          REAL      1 LIBRARY      2*8

STATEMENT LABELS                    DEF LINE   REFERENCES
      0  1                             14         13
      0  2                             16         15
      0  3                              8          6
      0  4                             35         27
      0  5                             25         18
      0  6                             42         41
      0  10                            40         37
      0  41                            31         30
      0  42                            34         33
      0  51                            22         21
      0  52                            24         23

LOOPS   LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
                                                                   EXT REFS
   22   3         I           6  8        22B
   53   1         I          13 14         3B        INSTACK
   62   2         I          15 16         3B        INSTACK
   70   5         I          18 25        33B                      NOT INNER
  101   51        J          21 22         4B        INSTACK
  114   52        J          23 24         4B        INSTACK
  126   4         I          27 35        35B                      NOT INNER
  140   41        J          30 31         4B        INSTACK
  154   42        J          33 34         4B        INSTACK
  201   10        J          37 40        11B          OPT
  217   6         I          41 42         2B        INSTACK

 STATISTICS
   PROGRAM LENGTH                   3222B      1682
              52000B CM USED
```

```
      FUNCTION DERSP(XX,X,Y,N,P,H)                                      DSCF 230
C     FUNCTION DERSP                                                    DSCF  10
C                                                                       DSCF  20
C        DERSP IS USED TO OBTAIN THE FIRST DERIVATIVE OF SPLINE         DSCF  30
C        CURVE FITTED DATA                                              DSCF  40
C                                                                       DSCF  50
C        USAGE -                                                        DSCF  60
C        X = DERSP(XX,X,Y,N,P,H)                                        DSCF  70
C        NOTE -  IF XX LESS THAN X(1) THEN DERSP = DX(1)/DY             DSCF  80
C                IF XX GREATER THAN X(N) THEN DERSP = DX(N)/DY          DSCF  90
C                                                                       DSCF 100
C        WHERE -                                                        DSCF 110
C        XX        INDEPENDENT VARIABLE FOR WHICH INTERPOLATED SLOPE    DSCF 120
C        IS DERSIRED                                                    DSCF 130
C        X         N-DIMENSIONED VECTOR OF INDEPENDENT POINTS           DSCF 140
C        Y         N-DIMENSIONED VECTOR OF DEPENDENT POINTS             DSCF 150
C        N         NUMBER OF DATA POINTS                                DSCF 160
C        P         N-DIMENSIONED VECTOR FROM UPDATE                     DSCF 170
C        H         (N-1)-DIMENSIONED VECTOR FROM UPDATE                 DSCF 180
C                                                                       DSCF 190
C        SUBROUTINES CALLED -                                           DSCF 200
C        NONE                                                           DSCF 210
C                                                                       DSCF 220
      DIMENSION X(1),Y(1),P(1),H(1)                                     DSCF 240
      XP=XX                                                             DSCF 250
      IF(XX.LT.X(1)) GO TO 1                                            DSCF 260
      K=N-1                                                             DSCF 270
      DO 2 I=1,K                                                        DSCF 280
      IF(XX.LT.X(I+1)) GO TO 3                                          DSCF 290
    2 CONTINUE                                                          DSCF 300
      I=K                                                               DSCF 310
      XP=X(N)                                                           DSCF 320
      GO TO 3                                                           DSCF 330
    1 XP=X(1)                                                           DSCF 340
      I=1                                                               DSCF 350
    3 F1=(X(I+1)-XP)**2                                                 DSCF 360
      F2=(XP-X(I))**2                                                   DSCF 370
      F3=H(I)/3.                                                        DSCF 380
      DERSP=((F3-F1/H(I))*P(I) + (F2/H(I)-F3)*P(I+1))/2.+(Y(I+1)-Y(I))/ DSCF 390
     1   H(I)                                                           DSCF 400
      RETURN                                                            DSCF 410
      END                                                               DSCF 420
```

```
SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE     REFERENCES
   4  DERSP          1            41

VARIABLES        SN  TYPE            RELOCATION
  56  DERSP          REAL                              DEFINED    39
  62  F1             REAL                                 REFS    39    DEFINED    36
  63  F2             REAL                                 REFS    39    DEFINED    37
  64  F3             REAL                                 REFS  2*39    DEFINED    38
   0  H              REAL        ARRAY     F.P.           REFS    24        38   3*39   DEFINED     1
  61  I              INTEGER                              REFS    29        36     37        38   7*39
                                                       DEFINED    28        31     35
  60  K              INTEGER                              REFS    28        31  DEFINED    27
   0  N              INTEGER               F.P.           REFS    27        32  DEFINED     1
   0  P              REAL        ARRAY     F.P.           REFS    24      2*39  DEFINED     1
   0  X              REAL        ARRAY     F.P.           REFS    24        26     29        32     34     36     37
                                                       DEFINED     1
  57  XP             REAL                                 REFS    36        37  DEFINED    25     32     34
   0  XX             REAL                  F.P.           REFS    25        26     29   DEFINED      1
   0  Y              REAL        ARRAY     F.P.           REFS    24      2*39  DEFINED     1

STATEMENT LABELS                  DEF LINE   REFERENCES
  27  1                              34         26
   0  2                              30         28
  32  3                              36         29         33

LOOPS  LABEL     INDEX      FROM-TO     LENGTH    PROPERTIES
  15   2         I          28 30         5B       INSTACK      EXITS

STATISTICS
  PROGRAM LENGTH                 70B        56
      52000B CM USED
```

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```
      SUBROUTINE SECDER(L1,L2,X,Y,P,H,N,P0,P3,XK1,XK2,A,B,C,D,GAMMA,     UPD  480
     1   BETA)                                                            UPD  490
C     SUBROUTINE SECDER                                                   UPD   10
C                                                                         UPD   20
C        SECDER IS USED WITH FUNCTION SPLINE TO PREFORM A SPLINE          UPD   30
C        INTERPOLATION. IT IS USED TO GENERATE P AND H.                   UPD   40
C                                                                         UPD   50
C        USAGE -                                                          UPD   60
C        CALL SECDER(L1,L2,X,Y,P,H,N,P0,P3,XK1,XK2,A,B,C,D,GAMMA,BETA)    UPD   70
C                                                                         UPD   80
C        WHERE -                                                          UPD   90
C        L1,L2    DETERMINE THE END CONDITIONS AT X(1) AND X(N) TO BE     UPD  100
C        USED. (SEE BELOW)                                                UPD  110
C        X        N-DIMENSIONED VECTOR OF INDEPENT POINTS                 UPD  120
C        Y        N-DIMENSIONED VECTOR OF DEPENDENT POINTS                UPD  130
C        P        N-DIMENSIONED VECTOR TO BE RETURNED                     UPD  140
C        H        (N-1)-DIMENSIONED VECTOR TO BE RETURNED                 UPD  150
C        N        NUMBER OF DATA POINTS                                   UPD  160
C     SECOND DERIVATIVES ARE GIVEN AT THE END POINTS                      UPD  170
C        XK1      NOT USED                                                UPD  180
C        XK2      NOT USED                                                UPD  190
C        IF L1=1 THEN                                                     UPD  200
C        P0       SECOND DERIVATIVE AT X(1),Y(1)                          UPD  210
C        IF L2=1 THEN                                                     UPD  220
C        P3       SECOND DERIVATIVE AT X(N),Y(N)                          UPD  230
C     FIRST DERIVATIVES ARE GIVEN AT THE END POINT                        UPD  240
C        XK1      NOT USED                                                UPD  250
C        XK2      NOT USED                                                UPD  260
C        IF L1=2 THEN                                                     UPD  270
C        P0       FIRST DERIVATIVE AT X(1),Y(1)                           UPD  280
C      IF L2=2 THEN                                                       UPD  290
C        P3       FIRST DERIVATIVE AT X(N),Y(N)                           UPD  300
C     NO INFORMATION ABOUT THE CURVE IS KNOWN                             UPD  310
C        P0       NOT USED                                                UPD  320
C        P3       NOT USED                                                UPD  330
C        IF L1=3 THEN                                                     UPD  340
C        XK1      P''(3,0) = XK1*P''(3,1),  XK1 GREATER THAN 0            UPD  350
C        IF L2=3 THEN                                                     UPD  360
C        XK2      P''(3,N) = XK2*P''(3,N-1),  XK2 GREATER THAN 0          UPD  370
C        A        N-DIMENSIONED WORK VECTOR                               UPD  380
C        B        N-DIMENSIONED WORK VECTOR                               UPD  390
C        C        N-DIMENSIONED WORK VECTOR                               UPD  400
```

```
C        D        N-DIMENSIONED WORK VECTOR                              UPD  410
C        BETA     N-DIMENSIONED WORK VECTOR                              UPD  420
C        GAMMA    N-DIMENSIONED WORK VECTOR                              UPD  430
C                                                                        UPD  440
C        SUBROUTINES CALL -                                              UPD  450
C        NONE                                                            UPD  460
C                                                                        UPD  470
      DIMENSION X(N),Y(N),A(N),B(N),C(N),D(N),GAMMA(N),BETA(N),H(N),P(N)
      K=N-1                                                              UPD  510
      DO 1 J=1,K                                                         UPD  520
    1 H(J)=X(J+1)-X(J)                                                   UPD  530
      DO 2 J=2,K                                                         UPD  540
      A(J) = H(J-1)/H(J)                                                 UPD  550
      B(J) = 2.*(H(J)+H(J-1))/H(J)                                       UPD  560
      C(J) = 1.                                                          UPD  570
    2 D(J) = 6./H(J)*((Y(J+1)-Y(J))/H(J)-(Y(J)-Y(J-1))/H(J-1))           UPD  580
      IF(L1.EQ.2) GO TO 20                                               UPD  590
      IF(L1.EQ.3) GO TO 10                                               UPD  600
      B(1)=1.                                                            UPD  610
      C(1)=0.                                                            UPD  620
      D(1)=PO                                                            UPD  630
      GO TO 30                                                           UPD  640
   10 B(1)=1.                                                            UPD  650
      C(1)=-XK1                                                          UPD  660
      D(1)=0.                                                            UPD  670
      GO TO 30                                                           UPD  680
   20 B(1)=H(1)/3.                                                       UPD  690
      C(1)=H(1)/6.                                                       UPD  700
      D(1)=(Y(2)-Y(1))/H(1)-PO                                           UPD  710
   30 IF(L2.EQ.2) GO TO 21                                               UPD  720
      IF(L2.EQ.3) GOTO 11                                                UPD  730
      A(N)=0.                                                            UPD  740
      B(N)=1.                                                            UPD  750
      D(N)=P3                                                            UPD  760
      GO TO 40                                                           UPD  770
   11 A(N)=-XK2                                                          UPD  780
      B(N)=1.                                                            UPD  790
      D(N)=0.                                                            UPD  800
      GO TO 40                                                           UPD  810
   21 A(N)=H(K)/6.                                                       UPD  820
      B(N)=H(K)/3.                                                       UPD  830
      D(N)=P3-(Y(N)-Y(K))/H(K)                                           UPD  840
```

```
       40 BETA(1)=B(1)                                                UPD  850
          GAMMA(1)=D(1)/BETA(1)                                       UPD  860
          DO 6 J=2,N                                                  UPD  870
          BETA(J)=B(J)-A(J)*C(J-1)/BETA(J-1)                          UPD  880
        6 GAMMA(J)=(D(J)-A(J)*GAMMA(J-1))/BETA(J)                     UPD  890
          P(N) = GAMMA(N)                                             UPD  900
          DO 7 J=1,K                                                  UPD  910
          M=N-J                                                       UPD  920
        7 P(M)=GAMMA(M)-C(M)*P(M+1)/BETA(M)                           UPD  930
          RETURN                                                      UPD  940
          END                                                         UPD  950
```


SYMBOLIC REFERENCE MAP (R=3)

```
ENTRY POINTS     DEF LINE      REFERENCES
   3  SECDER         1            94

VARIABLES      SN  TYPE        RELOCATION
   0  A            REAL       ARRAY   F.P.    REFS      50     88     89  DEFINED     1     55     74
                                                 78     82
   0  B            REAL       ARRAY   F.P.    REFS      50     85     88  DEFINED     1     56     61
                                                 65     69     75     79     83
   0  BETA         REAL       ARRAY   F.P.    REFS      50     86     88     89     93
                                           DEFINED       1     85     88
   0  C            REAL       ARRAY   F.P.    REFS      50     88     93  DEFINED     1     57     62
                                                 66     70
   0  D            REAL       ARRAY   F.P.    REFS      50     86     89  DEFINED     1     58     63
                                                 67     71     76     80     84
   0  GAMMA        REAL       ARRAY   F.P.    REFS      50     89     90     93  DEFINED     1     86
                                                 89
   0  H            REAL       ARRAY   F.P.    REFS      50   2*55   3*56   3*58     69     70     71
                                                 82     83     84  DEFINED     1     53
 201  J            INTEGER                    REFS    3*53   3*55   4*56     57   8*58   5*68   5*89
                                                 92  DEFINED     52     54     87     91
 200  K            INTEGER                    REFS      52     54     82     83   2*84     91
                                           DEFINED      51
   0  L1           INTEGER            F.P.    REFS      59     60  DEFINED     1
   0  L2           INTEGER            F.P.    REFS      72     73  DEFINED     1
```

```
VARIABLES      SN  TYPE            RELOCATION
  202  M            INTEGER                              REFS      5*93   DEFINED       92
    0  N            INTEGER                   F.P.       REFS     10*50        51       74       75       76       78       79
                                                            80       82        83     2*84       87     2*90       92
                                                       DEFINED        1
    0  P            REAL         ARRAY        F.P.       REFS        50        93  DEFINED        1       90       93
    0  PO           REAL                      F.P.       REFS        63        71  DEFINED        1
    0  P3           REAL                      F.P.       REFS        76        84  DEFINED        1
    0  X            REAL         ARRAY        F.P.       REFS        50      2*53  DEFINED        1
    0  XK1          REAL                      F.P.       REFS        66   DEFINED        1
    0  XK2          REAL                      F.P.       REFS        78   DEFINED        1
    0  Y            REAL         ARRAY        F.P.       REFS        50      4*58     2*71     2*84  DEFINED        1

STATEMENT LABELS                 DEF LINE   REFERENCES
    0  1                            53         52
    0  2                            58         54
    0  6                            89         87
    0  7                            93         91
   53  10                           65         60
  103  11                           78         73
   60  20                           69         59
  113  21                           82         72
   70  30                           72         64       68
  127  40                           85         77       81

LOOPS  LABEL    INDEX      FROM-TO     LENGTH    PROPERTIES
   15  1          J         52 53         3B      INSTACK
   30  2          J         54 58        12B        OPT
  142  6          J         87 89         6B      INSTACK
  165  7          J         91 93         5B      INSTACK

STATISTICS
  PROGRAM LENGTH                 212B      138
        52000B CM USED
```

APPENDIX 6

This appendix contains the output generated by PROGRAM STEPSPL for example 2.

```
$INPUT
TS       = 0.0,
NEQ      = 1,
IEQN     = 3, -576460752303354399, -576460752303354398,
NPTS     = 240,
IPLOT    = 1,
IFLAG    = 1,
SAREA    = .1374E+02,
BSPAN    = .998E+01,
CBAR     = .14E+01,
M        = .1055E+04,
RHO      = .10272E+01,
G        = .981E+01,
IX       = .2357E+04,
IY       = .3051E+04,
IZ       = .4833E+04,
IXZ      = .177E+03,
DELET    = 0.0,
ALPHT    = 0.0,
BETT     = 0.0,
DELAT    = 0.0,
DELRT    = 0.0,
QT       = 0.0,
PT       = 0.0,
RT       = 0.0,
```

```
FCRT    = .5E+01,
ITRIMOP = 0,
LATOP   = 0,
IACELOP = 1,
IFILOP  = 0,
$END
```

KNOT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KNOT VALUE(DEG)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

TRIM VALUES

ALPHT	BETT	AILT	DELET	DELRT
.26247E+00	0.	0.	0.	0.

RUN 1 EQUATION 3 NPTS 239

TIME	V	ALPHA	Q	DELE
.1000E+00	.3500E+02	.2629E+00	-.4934E-02	0.
.1500E+00	.3500E+02	.2632E+00	-.1711E-01	0.
.2000E+00	.3500E+02	.2632E+00	-.1775E-01	0.
.2500E+00	.3500E+02	.2639E+00	-.1881E-03	-.5000E-01
.3000E+00	.3500E+02	.2661E+00	.3127E-01	-.1000E+00
.3500E+00	.3500E+02	.2706E+00	.8009E-01	-.1400E+00
.4000E+00	.3500E+02	.2772E+00	.1338E+00	-.1400E+00
.4500E+00	.3500E+02	.2859E+00	.1873E+00	-.1400E+00
.5000E+00	.3500E+02	.2966E+00	.2309E+00	-.1400E+00
.5500E+00	.3500E+02	.3091E+00	.2842E+00	-.1400E+00
.6000E+00	.3500E+02	.3229E+00	.3255E+00	-.1400E+00
.6500E+00	.3500E+02	.3376E+00	.3476E+00	-.1400E+00
.7000E+00	.3500E+02	.3524E+00	.3550E+00	-.1000E+00
.7500E+00	.3500E+02	.3664E+00	.3353E+00	-.5000E-01
.8000E+00	.3500E+02	.3783E+00	.2925E+00	0.
.8500E+00	.3500E+02	.3872E+00	.2222E+00	.5000E-01
.9000E+00	.3500E+02	.3922E+00	.1382E+00	.1000E+00
.9500E+00	.3500E+02	.3927E+00	.3994E-01	.1400E+00
.1000E+01	.3500E+02	.3887E+00	-.7266E-01	.1400E+00
.1050E+01	.3500E+02	.3806E+00	-.1619E+00	.1400E+00
.1100E+01	.3500E+02	.3687E+00	-.2525E+00	.1400E+00
.1150E+01	.3500E+02	.3531E+00	-.3325E+00	.1400E+00
.1200E+01	.3500E+02	.3344E+00	-.4100E+00	.1400E+00
.1250E+01	.3500E+02	.3130E+00	-.4736E+00	.1400E+00
.1300E+01	.3500E+02	.2887E+00	-.5321E+00	.1000E+00
.1350E+01	.3500E+02	.2635E+00	-.5787E+00	.5000E-01
.1400E+01	.3500E+02	.2383E+00	-.5894E+00	0.
.1450E+01	.3500E+02	.2131E+00	-.5854E+00	0.
.1500E+01	.3500E+02	.1891E+00	-.5654E+00	0.
.1550E+01	.3500E+02	.1672E+00	-.5479E+00	0.
.1600E+01	.3500E+02	.1482E+00	-.5050E+00	0.
.1650E+01	.3500E+02	.1320E+00	-.4671E+00	0.
.1700E+01	.3500E+02	.1185E+00	-.4244E+00	0.
.1750E+01	.3500E+02	.1073E+00	-.3900E+00	0.
.1800E+01	.3500E+02	.9841E-01	-.3574E+00	0.
.1850E+01	.3500E+02	.9150E-01	-.3217E+00	0.
.1900E+01	.3500E+02	.8642E-01	-.2892E+00	0.
.1950E+01	.3500E+02	.8300E-01	-.2653E+00	0.
.2000E+01	.3500E+02	.8107E-01	-.2284E+00	0.
.2050E+01	.3500E+02	.8048E-01	-.2058E+00	0.
.2100E+01	.3500E+02	.8107E-01	-.1812E+00	0.
.2150E+01	.3500E+02	.8270E-01	-.1585E+00	0.
.2200E+01	.3500E+02	.8525E-01	-.1347E+00	0.
.2250E+01	.3500E+02	.8860E-01	-.1095E+00	0.

.2300E+01	.3500E+02	.9263E-01	-.9381E-01	0.
.2350E+01	.3500E+02	.9723E-01	-.7583E-01	0.
.2400E+01	.3500E+02	.1023E+00	-.5593E-01	0.
.2450E+01	.3500E+02	.1078E+00	-.3757E-01	0.
.2500E+01	.3500E+02	.1136E+00	-.2778E-01	0.
.2550E+01	.3500E+02	.1196E+00	-.1136E-01	0.
.2600E+01	.3500E+02	.1259E+00	-.9996E-04	0.
.2650E+01	.3500E+02	.1322E+00	.6836E-02	0.
.2700E+01	.3500E+02	.1386E+00	.1939E-01	0.
.2750E+01	.3500E+02	.1450E+00	.2393E-01	0.
.2800E+01	.3500E+02	.1514E+00	.3025E-01	0.
.2850E+01	.3500E+02	.1578E+00	.3542E-01	0.
.2900E+01	.3500E+02	.1640E+00	.4170E-01	0.
.2950E+01	.3500E+02	.1701E+00	.5218E-01	0.
.3000E+01	.3500E+02	.1761E+00	.5074E-01	0.
.3050E+01	.3500E+02	.1820E+00	.5636E-01	0.
.3100E+01	.3500E+02	.1878E+00	.6847E-01	0.
.3150E+01	.3500E+02	.1935E+00	.7366E-01	0.
.3200E+01	.3500E+02	.1991E+00	.7318E-01	0.
.3250E+01	.3500E+02	.2045E+00	.7445E-01	0.
.3300E+01	.3500E+02	.2098E+00	.8244E-01	0.
.3350E+01	.3500E+02	.2150E+00	.8232E-01	0.
.3400E+01	.3500E+02	.2199E+00	.8186E-01	0.
.3450E+01	.3500E+02	.2248E+00	.8550E-01	0.
.3500E+01	.3500E+02	.2293E+00	.8248E-01	0.
.3550E+01	.3500E+02	.2339E+00	.9095E-01	0.
.3600E+01	.3500E+02	.2384E+00	.8983E-01	0.
.3650E+01	.3500E+02	.2429E+00	.9937E-01	0.
.3700E+01	.3500E+02	.2474E+00	.9532E-01	0.
.3750E+01	.3500E+02	.2517E+00	.9461E-01	0.
.3800E+01	.3500E+02	.2559E+00	.9302E-01	0.
.3850E+01	.3500E+02	.2600E+00	.9058E-01	0.
.3900E+01	.3500E+02	.2639E+00	.8794E-01	0.
.3950E+01	.3500E+02	.2675E+00	.8191E-01	0.
.4000E+01	.3500E+02	.2709E+00	.8579E-01	0.
.4050E+01	.3500E+02	.2740E+00	.7619E-01	0.
.4100E+01	.3500E+02	.2768E+00	.7499E-01	0.
.4150E+01	.3500E+02	.2793E+00	.6357E-01	0.
.4200E+01	.3500E+02	.2814E+00	.5927E-01	0.
.4250E+01	.3500E+02	.2832E+00	.5458E-01	0.
.4300E+01	.3500E+02	.2846E+00	.4144E-01	0.
.4350E+01	.3500E+02	.2856E+00	.4290E-01	0.
.4400E+01	.3500E+02	.2863E+00	.3296E-01	0.
.4450E+01	.3500E+02	.2865E+00	.2299E-01	0.
.4500E+01	.3500E+02	.2864E+00	.1423E-01	0.
.4550E+01	.3500E+02	.2858E+00	-.2061E-03	0.
.4600E+01	.3500E+02	.2849E+00	.2479E-02	0.
.4650E+01	.3500E+02	.2836E+00	-.1426E-01	0.
.4700E+01	.3500E+02	.2820E+00	-.2013E-01	0.

.4750E+01	.3500E+02	.2800E+00	-.2407E-01	0.
.4800E+01	.3500E+02	.2777E+00	-.2981E-01	0.
.4850E+01	.3500E+02	.2751E+00	-.4994E-01	0.
.4900E+01	.3500E+02	.2722E+00	-.5214E-01	0.
.4950E+01	.3500E+02	.2691E+00	-.6066E-01	0.
.5000E+01	.3500E+02	.2657E+00	-.6375E-01	0.
.5050E+01	.3500E+02	.2622E+00	-.7531E-01	0.
.5100E+01	.3500E+02	.2585E+00	-.7541E-01	0.
.5150E+01	.3500E+02	.2546E+00	-.8217E-01	0.
.5200E+01	.3500E+02	.2507E+00	-.8685E-01	0.
.5250E+01	.3500E+02	.2466E+00	-.9317E-01	0.
.5300E+01	.3500E+02	.2426E+00	-.9941E-01	0.
.5350E+01	.3500E+02	.2385E+00	-.9451E-01	0.
.5400E+01	.3500E+02	.2345E+00	-.9816E-01	0.
.5450E+01	.3500E+02	.2306E+00	-.9195E-01	0.
.5500E+01	.3500E+02	.2268E+00	-.9546E-01	0.
.5550E+01	.3500E+02	.2230E+00	-.8529E-01	0.
.5600E+01	.3500E+02	.2196E+00	-.9100E-01	0.
.5650E+01	.3500E+02	.2167E+00	-.8144E-01	0.
.5700E+01	.3500E+02	.2140E+00	-.7906E-01	0.
.5750E+01	.3500E+02	.2118E+00	-.6757E-01	0.
.5800E+01	.3500E+02	.2098E+00	-.6279E-01	0.
.5850E+01	.3500E+02	.2082E+00	-.5825E-01	0.
.5900E+01	.3500E+02	.2069E+00	-.5324E-01	0.
.5950E+01	.3500E+02	.2059E+00	-.5007E-01	0.
.6000E+01	.3500E+02	.2052E+00	-.4390E-01	0.
.6050E+01	.3500E+02	.2048E+00	-.3115E-01	0.
.6100E+01	.3500E+02	.2046E+00	-.3270E-01	0.
.6150E+01	.3500E+02	.2046E+00	-.3020E-01	0.
.6200E+01	.3500E+02	.2049E+00	-.1904E-01	0.
.6250E+01	.3500E+02	.2054E+00	-.2132E-01	0.
.6300E+01	.3500E+02	.2061E+00	-.1146E-01	0.
.6350E+01	.3500E+02	.2070E+00	-.8414E-02	0.
.6400E+01	.3500E+02	.2080E+00	-.5343E-02	0.
.6450E+01	.3500E+02	.2092E+00	.1452E-02	0.
.6500E+01	.3500E+02	.2105E+00	.5945E-02	0.
.6550E+01	.3500E+02	.2119E+00	.4208E-02	0.
.6600E+01	.3500E+02	.2135E+00	.1151E-01	0.
.6650E+01	.3500E+02	.2151E+00	.1393E-01	0.
.6700E+01	.3500E+02	.2169E+00	.2098E-01	0.
.6750E+01	.3500E+02	.2187E+00	.2302E-01	0.
.6800E+01	.3500E+02	.2205E+00	.2094E-01	0.
.6850E+01	.3500E+02	.2225E+00	.2231E-01	0.
.6900E+01	.3500E+02	.2244E+00	.3161E-01	0.
.6950E+01	.3500E+02	.2264E+00	.3157E-01	0.
.7000E+01	.3500E+02	.2284E+00	.3870E-01	0.
.7050E+01	.3500E+02	.2305E+00	.3670E-01	0.
.7100E+01	.3500E+02	.2326E+00	.3658E-01	0.
.7150E+01	.3500E+02	.2348E+00	.4306E-01	0.

.7200E+01	.3500E+02	.2371E+00	.5063E-01	0.
.7250E+01	.3500E+02	.2394E+00	.4900E-01	0.
.7300E+01	.3500E+02	.2417E+00	.5066E-01	0.
.7350E+01	.3500E+02	.2439E+00	.4456E-01	0.
.7400E+01	.3500E+02	.2462E+00	.4336E-01	0.
.7450E+01	.3500E+02	.2484E+00	.4852E-01	0.
.7500E+01	.3500E+02	.2505E+00	.4354E-01	0.
.7550E+01	.3500E+02	.2525E+00	.4263E-01	0.
.7600E+01	.3500E+02	.2544E+00	.4184E-01	0.
.7650E+01	.3500E+02	.2562E+00	.4512E-01	0.
.7700E+01	.3500E+02	.2578E+00	.4072E-01	0.
.7750E+01	.3500E+02	.2593E+00	.3774E-01	0.
.7800E+01	.3500E+02	.2606E+00	.3791E-01	0.
.7850E+01	.3500E+02	.2618E+00	.2964E-01	0.
.7900E+01	.3500E+02	.2627E+00	.2572E-01	0.
.7950E+01	.3500E+02	.2635E+00	.1746E-01	0.
.8000E+01	.3500E+02	.2641E+00	.1568E-01	0.
.8050E+01	.3500E+02	.2645E+00	.2438E-01	0.
.8100E+01	.3500E+02	.2646E+00	.8031E-02	0.
.8150E+01	.3500E+02	.2646E+00	.6162E-02	0.
.8200E+01	.3500E+02	.2643E+00	.3082E-02	0.
.8250E+01	.3500E+02	.2638E+00	-.9692E-03	0.
.8300E+01	.3500E+02	.2632E+00	-.1275E-01	0.
.8350E+01	.3500E+02	.2623E+00	-.1454E-01	0.
.8400E+01	.3500E+02	.2613E+00	-.1714E-01	0.
.8450E+01	.3500E+02	.2600E+00	-.2094E-01	0.
.8500E+01	.3500E+02	.2587E+00	-.2915E-01	0.
.8550E+01	.3500E+02	.2571E+00	-.3490E-01	0.
.8600E+01	.3500E+02	.2554E+00	-.3315E-01	0.
.8650E+01	.3500E+02	.2536E+00	-.3291E-01	0.
.8700E+01	.3500E+02	.2517E+00	-.3785E-01	0.
.8750E+01	.3500E+02	.2497E+00	-.3979E-01	0.
.8800E+01	.3500E+02	.2476E+00	-.4808E-01	0.
.8850E+01	.3500E+02	.2454E+00	-.5018E-01	0.
.8900E+01	.3500E+02	.2432E+00	-.4747E-01	0.
.8950E+01	.3500E+02	.2410E+00	-.4659E-01	0.
.9000E+01	.3500E+02	.2388E+00	-.5029E-01	0.
.9050E+01	.3500E+02	.2366E+00	-.5204E-01	0.
.9100E+01	.3500E+02	.2344E+00	-.4532E-01	0.
.9150E+01	.3500E+02	.2323E+00	-.4815E-01	0.
.9200E+01	.3500E+02	.2303E+00	-.4862E-01	0.
.9250E+01	.3500E+02	.2284E+00	-.4763E-01	0.
.9300E+01	.3500E+02	.2265E+00	-.4677E-01	0.
.9350E+01	.3500E+02	.2248E+00	-.3728E-01	0.
.9400E+01	.3500E+02	.2234E+00	-.4370E-01	0.
.9450E+01	.3500E+02	.2222E+00	-.3741E-01	0.
.9500E+01	.3500E+02	.2211E+00	-.3352E-01	0.
.9550E+01	.3500E+02	.2204E+00	-.2693E-01	0.
.9600E+01	.3500E+02	.2198E+00	-.1753E-01	0.

.9650E+01	.3500E+02	.2194E+00	-.1332E-01	0.
.9700E+01	.3500E+02	.2192E+00	-.1259E-01	0.
.9750E+01	.3500E+02	.2192E+00	-.9658E-02	0.
.9800E+01	.3500E+02	.2193E+00	-.8545E-02	0.
.9850E+01	.3500E+02	.2196E+00	-.7939E-03	0.
.9900E+01	.3500E+02	.2201E+00	-.2986E-02	0.
.9950E+01	.3500E+02	.2206E+00	.3657E-02	0.
.1000E+02	.3500E+02	.2214E+00	.2176E-02	0.
.1005E+02	.3500E+02	.2222E+00	.7867E-02	0.
.1010E+02	.3500E+02	.2232E+00	.1566E-01	0.
.1015E+02	.3500E+02	.2242E+00	.1483E-01	0.
.1020E+02	.3500E+02	.2254E+00	.1691E-01	0.
.1025E+02	.3500E+02	.2266E+00	.1906E-01	0.
.1030E+02	.3500E+02	.2279E+00	.1646E-01	0.
.1035E+02	.3500E+02	.2293E+00	.3240E-01	0.
.1040E+02	.3500E+02	.2308E+00	.3030E-01	0.
.1045E+02	.3500E+02	.2323E+00	.2976E-01	0.
.1050E+02	.3500E+02	.2340E+00	.3124E-01	0.
.1055E+02	.3500E+02	.2357E+00	.3328E-01	0.
.1060E+02	.3500E+02	.2375E+00	.3682E-01	0.
.1065E+02	.3500E+02	.2393E+00	.3523E-01	0.
.1070E+02	.3500E+02	.2411E+00	.3839E-01	0.
.1075E+02	.3500E+02	.2429E+00	.4165E-01	0.
.1080E+02	.3500E+02	.2447E+00	.3969E-01	0.
.1085E+02	.3500E+02	.2464E+00	.3033E-01	0.
.1090E+02	.3500E+02	.2481E+00	.3435E-01	0.
.1095E+02	.3500E+02	.2497E+00	.3359E-01	0.
.1100E+02	.3500E+02	.2513E+00	.2790E-01	0.
.1105E+02	.3500E+02	.2528E+00	.3381E-01	0.
.1110E+02	.3500E+02	.2541E+00	.3078E-01	0.
.1115E+02	.3500E+02	.2554E+00	.3345E-01	0.
.1120E+02	.3500E+02	.2565E+00	.2878E-01	0.
.1125E+02	.3500E+02	.2575E+00	.2466E-01	0.
.1130E+02	.3500E+02	.2583E+00	.2593E-01	0.
.1135E+02	.3500E+02	.2590E+00	.2148E-01	0.
.1140E+02	.3500E+02	.2595E+00	.1938E-01	0.
.1145E+02	.3500E+02	.2598E+00	.1147E-01	0.
.1150E+02	.3500E+02	.2600E+00	.6646E-02	0.
.1155E+02	.3500E+02	.2600E+00	.1887E-02	0.
.1160E+02	.3500E+02	.2598E+00	.4867E-02	0.
.1165E+02	.3500E+02	.2595E+00	-.1069E-02	0.
.1170E+02	.3500E+02	.2590E+00	-.6463E-02	0.
.1175E+02	.3500E+02	.2583E+00	-.1552E-01	0.
.1180E+02	.3500E+02	.2575E+00	-.1205E-01	0.
.1185E+02	.3500E+02	.2565E+00	-.1383E-01	0.
.1190E+02	.3500E+02	.2554E+00	-.2619E-01	0.
.1195E+02	.3500E+02	.2542E+00	-.2713E-01	0.
.1200E+02	.3500E+02	.2528E+00	-.2881E-01	0.

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          MAXIMUM F VALUE IS   .349E+03 FOR VARIABLE   3
VARIABLES IN REGRESSION   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
PERCENT VARIATION EXPLAINED IS  59.49
STD. DEVIATION OF RESIDUALS IS   .706E-01
TOTAL F VALUE IS  .34801E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
0.        0.        -.231E+010.    0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        -.723E-0

0.        0.         .124E+000.    0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS -.46313E-15
SIGMA SQ OF RESIDUALS IS  .11819E+01


          MAXIMUM F VALUE IS   .691E+03 FOR VARIABLE   1
VARIABLES IN REGRESSION   1   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .688E+03
PARTIAL F VALUE FOR VARIABLE   3 IS   .109E+04
VARIABLES IN REGRESSION   1   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .688E+03
PARTIAL F VALUE FOR VARIABLE   3 IS   .109E+04
PERCENT VARIATION EXPLAINED IS  89.65
STD. DEVIATION OF RESIDUALS IS   .358E-01
TOTAL F VALUE IS  .10225E+04
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.105E+010.         -.209E+010.    0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.         .246E+00

 .398E-010.          .628E-010.    0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS  .79735E-13
SIGMA SQ OF RESIDUALS IS  .30185E+00


          MAXIMUM F VALUE IS   .575E+02 FOR VARIABLE   2
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
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ORIGINAL PAGE IS
OF POOR QUALITY

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PARTIAL F VALUE FOR VARIABLE   1 IS   .496E+03
PARTIAL F VALUE FOR VARIABLE   2 IS   .573E+02
PARTIAL F VALUE FOR VARIABLE   3 IS   .124E+04
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .496E+03
PARTIAL F VALUE FOR VARIABLE   2 IS   .573E+02
PARTIAL F VALUE FOR VARIABLE   3 IS   .124E+04
PERCENT VARIATION EXPLAINED IS  91.68
STD. DEVIATION OF RESIDUALS IS   .321E-01
TOTAL F VALUE IS  .86327E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.908E+00-.683E+01-.236E+010.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    .209E+00

 .357E-01 .715E+00 .564E-010.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
RESIDUAL MEAN IS  .68295E-13
SIGMA SQ OF RESIDUALS IS  .24271E+00


          MAXIMUM F VALUE IS   .103E+03 FOR VARIABLE  28
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .362E+03
PARTIAL F VALUE FOR VARIABLE   2 IS   .564E+02
PARTIAL F VALUE FOR VARIABLE   3 IS   .119E+04
PARTIAL F VALUE FOR VARIABLE  28 IS   .103E+03
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS   .362E+03
PARTIAL F VALUE FOR VARIABLE   2 IS   .564E+02
PARTIAL F VALUE FOR VARIABLE   3 IS   .119E+04
PARTIAL F VALUE FOR VARIABLE  28 IS   .103E+03
PERCENT VARIATION EXPLAINED IS  94.22
STD. DEVIATION OF RESIDUALS IS   .268E-01
TOTAL F VALUE IS  .95390E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.730E+00-.572E+01-.211E+010.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    -.140E+010.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    .173E+00

 .298E-01 .597E+00 .471E-010.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
0.    0.    .105E+000.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
RESIDUAL MEAN IS  .54179E-13
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SIGMA SQ OF RESIDUALS IS  .16858E+00


          MAXIMUM F VALUE IS    .554E+02 FOR VARIABLE  15
VARIABLES IN REGRESSION  1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0
VARIABLES IN REGRESSION  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE  1 IS   .215E+03
PARTIAL F VALUE FOR VARIABLE  2 IS   .119E+03
PARTIAL F VALUE FOR VARIABLE  3 IS   .103E+04
PARTIAL F VALUE FOR VARIABLE 15 IS   .552E+02
PARTIAL F VALUE FOR VARIABLE 28 IS   .179E+03
VARIABLES IN REGRESSION  1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0
VARIABLES IN REGRESSION  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE  1 IS   .215E+03
PARTIAL F VALUE FOR VARIABLE  2 IS   .119E+03
PARTIAL F VALUE FOR VARIABLE  3 IS   .103E+04
PARTIAL F VALUE FOR VARIABLE 15 IS   .552E+02
PARTIAL F VALUE FOR VARIABLE 28 IS   .179E+03
PERCENT VARIATION EXPLAINED IS  95.33
STD. DEVIATION OF RESIDUALS IS   .242E-01
TOTAL F VALUE IS  .95089E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.583E+00-.128E+02-.193E+010.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     .107E+0
0.      0.      0.      0.        0.     0.     0.     0.     0.     0.
0.      0.      -.186E+010.       0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     .138E+0

 .269E-01 .538E+00 .425E-010.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     .650E+0
0.      0.      0.      0.        0.     0.     0.     0.     0.     0.
0.      0.      .944E-010.        0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
RESIDUAL MEAN IS  .43231E-13
SIGMA SQ OF RESIDUALS IS  .13630E+00


          MAXIMUM F VALUE IS    .369E+02 FOR VARIABLE  31
VARIABLES IN REGRESSION  1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0
VARIABLES IN REGRESSION  0  0  0  1  0  0  1  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE  1 IS   .262E+03
PARTIAL F VALUE FOR VARIABLE  2 IS   .132E+03
PARTIAL F VALUE FOR VARIABLE  3 IS   .109E+04
PARTIAL F VALUE FOR VARIABLE 15 IS   .717E+02
PARTIAL F VALUE FOR VARIABLE 28 IS   .118E+03
PARTIAL F VALUE FOR VARIABLE 31 IS   .367E+02
VARIABLES IN REGRESSION  1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0
VARIABLES IN REGRESSION  0  0  0  1  0  0  1  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE  1 IS   .262E+03
PARTIAL F VALUE FOR VARIABLE  2 IS   .132E+03
PARTIAL F VALUE FOR VARIABLE  3 IS   .109E+04
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PARTIAL F VALUE FOR VARIABLE  15 IS    .717E+02
PARTIAL F VALUE FOR VARIABLE  28 IS    .118E+03
PARTIAL F VALUE FOR VARIABLE  31 IS    .367E+02
PERCENT VARIATION EXPLAINED IS  95.97
STD. DEVIATION OF RESIDUALS IS    .225E-01
TOTAL F VALUE IS   .92011E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.601E+00-.125E+02-.212E+010.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .114E+02
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        -.153E+010.        0.        -.944E+010.        0.        0.        0.        0.        0.        0.        0.        .142E+00

 .250E-01 .501E+00 .395E-010.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .605E+00
0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
0.        0.        .879E-010.        0.        .113E+010.        0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS  .44016E-13
SIGMA SQ OF RESIDUALS IS  .11766E+00


          MAXIMUM F VALUE IS    .205E+02 FOR VARIABLE  20
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   1   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   0   0   1   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS    .644E+02
PARTIAL F VALUE FOR VARIABLE   2 IS    .163E+03
PARTIAL F VALUE FOR VARIABLE   3 IS    .120E+04
PARTIAL F VALUE FOR VARIABLE  15 IS    .939E+02
PARTIAL F VALUE FOR VARIABLE  20 IS    .205E+02
PARTIAL F VALUE FOR VARIABLE  28 IS    .235E+02
PARTIAL F VALUE FOR VARIABLE  31 IS    .457E+02
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   1   0   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   0   0   1   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS    .644E+02
PARTIAL F VALUE FOR VARIABLE   2 IS    .163E+03
PARTIAL F VALUE FOR VARIABLE   3 IS    .120E+04
PARTIAL F VALUE FOR VARIABLE  15 IS    .939E+02
PARTIAL F VALUE FOR VARIABLE  20 IS    .205E+02
PARTIAL F VALUE FOR VARIABLE  28 IS    .235E+02
PARTIAL F VALUE FOR VARIABLE  31 IS    .457E+02
PERCENT VARIATION EXPLAINED IS  96.30
STD. DEVIATION OF RESIDUALS IS    .216E-01
TOTAL F VALUE IS  .85774E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.425E+00-.142E+02-.218E+010.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .130E+02
0.        0.        0.        0.        -.519E+000.        0.        0.        0.        0.
0.        0.        -.921E+000.        0.        -.102E+020.        0.        0.        0.        0.        0.        0.        0.        .110E+00

 .241E-01 .481E+00 .380E-010.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .581E+00
0.        0.        0.        0.        .412E-010.        0.        0.        0.        0.
0.        0.        .844E-010.        0.        .109E+010.        0.        0.        0.        0.        0.        0.        0.
```

```
RESIDUAL MEAN IS  .33002E-13
SIGMA SQ OF RESIDUALS IS  .10808E+00

           MAXIMUM F VALUE IS   .153E+02 FOR VARIABLE  21
VARIABLES IN REGRESSION   1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  1  1  0  0  0
VARIABLES IN REGRESSION   0  0  0  1  0  0  1  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE   1 IS   .701E+02
PARTIAL F VALUE FOR VARIABLE   2 IS   .175E+03
PARTIAL F VALUE FOR VARIABLE   3 IS   .102E+04
PARTIAL F VALUE FOR VARIABLE  15 IS   .355E+02
PARTIAL F VALUE FOR VARIABLE  20 IS   .168E+02
PARTIAL F VALUE FOR VARIABLE  21 IS   .152E+02
PARTIAL F VALUE FOR VARIABLE  28 IS   .336E+02
PARTIAL F VALUE FOR VARIABLE  31 IS   .557E+02
VARIABLES IN REGRESSION   1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  1  1  0  0  0
VARIABLES IN REGRESSION   0  0  0  1  0  0  1  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE   1 IS   .701E+02
PARTIAL F VALUE FOR VARIABLE   2 IS   .175E+03
PARTIAL F VALUE FOR VARIABLE   3 IS   .102E+04
PARTIAL F VALUE FOR VARIABLE  15 IS   .355E+02
PARTIAL F VALUE FOR VARIABLE  20 IS   .168E+02
PARTIAL F VALUE FOR VARIABLE  21 IS   .152E+02
PARTIAL F VALUE FOR VARIABLE  28 IS   .336E+02
PARTIAL F VALUE FOR VARIABLE  31 IS   .557E+02
PERCENT VARIATION EXPLAINED IS  96.52
STD. DEVIATION OF RESIDUALS IS   .210E-01
TOTAL F VALUE IS  .79856E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.430E+00-.143E+02-.209E+010.      0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .947E+0
0.        0.        0.        0.        -.461E+00 .600E+010.     0.        0.        0.
0.        0.        -.110E+010.      0.        -.110E+020.     0.        0.        0.        0.        0.        0.        0.        .110E+0

 .233E-01 .467E+00 .369E-010.      0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .564E+0
0.        0.        0.        0.        .400E-01 .642E+000.     0.        0.        0.
0.        0.        .820E-010.      0.        .105E+010.      0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS  .33479E-13
SIGMA SQ OF RESIDUALS IS  .10138E+00

           MAXIMUM F VALUE IS   .100E+02 FOR VARIABLE  29
VARIABLES IN REGRESSION   1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  1  1  0  0  0
VARIABLES IN REGRESSION   0  0  0  1  1  0  1  0  0  0  0  0  0  0  0
PARTIAL F VALUE FOR VARIABLE   1 IS   .709E+02
PARTIAL F VALUE FOR VARIABLE   2 IS   .182E+03
PARTIAL F VALUE FOR VARIABLE   3 IS   .101E+04
PARTIAL F VALUE FOR VARIABLE  15 IS   .374E+02
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```
PARTIAL F VALUE FOR VARIABLE  20 IS    .207E+02
PARTIAL F VALUE FOR VARIABLE  21 IS    .190E+02
PARTIAL F VALUE FOR VARIABLE  28 IS    .250E+02
PARTIAL F VALUE FOR VARIABLE  29 IS    .100E+02
PARTIAL F VALUE FOR VARIABLE  31 IS    .771E+01
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   1   1   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   1   0   1   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS    .709E+02
PARTIAL F VALUE FOR VARIABLE   2 IS    .182E+03
PARTIAL F VALUE FOR VARIABLE   3 IS    .101E+04
PARTIAL F VALUE FOR VARIABLE  15 IS    .374E+02
PARTIAL F VALUE FOR VARIABLE  20 IS    .207E+02
PARTIAL F VALUE FOR VARIABLE  21 IS    .190E+02
PARTIAL F VALUE FOR VARIABLE  28 IS    .250E+02
PARTIAL F VALUE FOR VARIABLE  29 IS    .100E+02
PARTIAL F VALUE FOR VARIABLE  31 IS    .771E+01
PERCENT VARIATION EXPLAINED IS  96.67
STD. DEVIATION OF RESIDUALS IS    .206E-01
TOTAL F VALUE IS  .73873E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.425E+00-.143E+02-.216E+010.       0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .952E+01
0.        0.        0.        0.       -.506E+00 .664E+010.        0.        0.        0.
0.        0.       -.961E+00-.694E+010.        -.597E+010.        0.        0.        0.        0.        0.        0.        0.        .109E+00

 .229E-01 .458E+00 .362E-010.       0.        0.        0.        0.        0.        0.        0.        0.        0.        0.        .553E+00
0.        0.        0.        0.        .392E-01 .630E+000.        0.        0.        0.
0.        0.        .804E-01 .904E+000.         .103E+010.        0.        0.        0.        0.        0.        0.        0.
RESIDUAL MEAN IS  .32614E-13
SIGMA SQ OF RESIDUALS IS  .97141E-01
```



```
          MAXIMUM F VALUE IS    .610E+01 FOR VARIABLE  13
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   1   0   1   0   0   0   0   1   1   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   1   0   1   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS    .534E+02
PARTIAL F VALUE FOR VARIABLE   2 IS    .169E+03
PARTIAL F VALUE FOR VARIABLE   3 IS    .103E+04
PARTIAL F VALUE FOR VARIABLE  13 IS    .607E+01
PARTIAL F VALUE FOR VARIABLE  15 IS    .697E+01
PARTIAL F VALUE FOR VARIABLE  20 IS    .250E+02
PARTIAL F VALUE FOR VARIABLE  21 IS    .195E+02
PARTIAL F VALUE FOR VARIABLE  28 IS    .244E+02
PARTIAL F VALUE FOR VARIABLE  29 IS    .103E+02
PARTIAL F VALUE FOR VARIABLE  31 IS    .785E+01
VARIABLES IN REGRESSION   1   1   1   0   0   0   0   0   0   0   0   0   1   0   1   0   0   0   0   1   1   0   0   0
VARIABLES IN REGRESSION   0   0   0   1   1   0   1   0   0   0   0   0   0   0   0
PARTIAL F VALUE FOR VARIABLE   1 IS    .534E+02
PARTIAL F VALUE FOR VARIABLE   2 IS    .169E+03
```

```
PARTIAL F VALUE FOR VARIABLE   3 IS   .103E+04
PARTIAL F VALUE FOR VARIABLE  13 IS   .607E+01
PARTIAL F VALUE FOR VARIABLE  15 IS   .697E+01
PARTIAL F VALUE FOR VARIABLE  20 IS   .250E+02
PARTIAL F VALUE FOR VARIABLE  21 IS   .195E+02
PARTIAL F VALUE FOR VARIABLE  28 IS   .244E+02
PARTIAL F VALUE FOR VARIABLE  29 IS   .103E+02
PARTIAL F VALUE FOR VARIABLE  31 IS   .785E+01
PERCENT VARIATION EXPLAINED IS  96.76
STD. DEVIATION OF RESIDUALS IS   .204E-01
TOTAL F VALUE IS  .68020E+03
NEW PARAMETER ESTIMATES AND STD. DEV. ARE
-.384E+00-.158E+02-.216E+010.      0.       0.       0.       0.       0.       0.       0.       0.       .530E+010.      .574E+0
0.       0.       0.       0.      -.561E+00 .665E+010.       0.       0.       0.
0.       0.       -.939E+00-.698E+010.      -.596E+010.      0.       0.       0.       0.       0.       0.       0.       .101E+0

 .227E-01 .453E+00 .358E-010.      0.       0.       0.       0.       0.       0.       0.       0.       .525E+000.      .547E+0
0.       0.       0.       0.       .388E-01 .623E+000.       0.       0.       0.
0.       0.       .795E-01 .894E+000.       .102E+010.       0.       0.       0.       0.       0.       0.       0.
RESIDUAL MEAN IS  .30831E-13
SIGMA SQ OF RESIDUALS IS  .94620E-01


          MAXIMUM F VALUE IS   .396E+01 FOR VARIABLE  30
```

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APPENDIX 7

This appendix presents three optional forms for the model structure determination basis in SUBROUTINE DATASET. One longitudinal option and two lateral options are given.

The longitudinal option given here is an example of the second-order spline which gives a smoother representation than the first or zeroth-order spline. The example here provides for a second-order spline in C_{z_q}. When this basis is used for the C_m equation, it provides a second-order spline for C_{m_q}.

an example for C_z

$$C_z = C_z(\alpha)_{\beta = q = \delta_e = 0} + C_{z_q}(\alpha)\ q\bar{c}/2V + C_{z_{\delta e}}(\alpha)\ \delta_e$$

where

$$C_z(\alpha) = C_z(0) + C_{z_\alpha} + \sum_{i=1}^{17} D_{\alpha_i}(\alpha - \alpha_i)_+$$

$$C_{z_q}(\alpha) = C_{z_q} + C_{z_{q\alpha}}\alpha + C_{z_{q\alpha^2}}\alpha^2$$

$$+ \sum_{i=1}^{17} D_{q\alpha^2_i}(\alpha - \alpha_i)^2_+$$

$$C_{z_{\delta e}}(\alpha) = C_{z_{\delta e}} + \sum_{i=1}^{3} D_{\delta e_i}(\alpha - \alpha_i)^0_+$$

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```
C      LONGITUDINAL EQUATIONS:  SECOND OPTION

      DO 906 I=1,NPTS
      X(1,I)=ALPH(I)
      X(2,I)=C/(2*VEL(I))*Q(I)
      X(3,I)=DELE(I)
      DO 907 III=4,39
  907 X(III,I)=0.
      IF(ALPH(I).GE.XKNOT(1)) X(4,I)=ALPH(I)-XKNOT(1)
      X(5,I)=X(2,I)*ALPH(I)
      IF(ALPH(I).GE.XKNOT(2)) X(6,I)=ALPH(I)-XKNOT(2)
      X(7,I)=X(2,I)*ALPH(I)**2
      IF(ALPH(I).GE.XKNOT(3)) X(8,I)=ALPH(I)-XKNOT(3)
      IF(ALPH(I).GE.XKNOT(1)) X(9,I)=(ALPH(I)-XKNOT(1))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(4)) X(10,I)=ALPH(I)-XKNOT(4)
      IF(ALPH(I).GE.XKNOT(3)) X(11,I)=(ALPH(I)-XKNOT(3))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(5)) X(12,I)=ALPH(I)-XKNOT(5)
      IF(ALPH(I).GE.XKNOT(4)) X(13,I)=(ALPH(I)-XKNOT(4))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(6)) X(14,I)=ALPH(I)-XKNOT(6)
      IF(ALPH(I).GE.XKNOT(5)) X(15,I)=(ALPH(I)-XKNOT(5))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(7)) X(16,I)=ALPH(I)-XKNOT(7)
      IF(ALPH(I).GE.XKNOT(6)) X(17,I)=(ALPH(I)-XKNOT(6))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(8)) X(18,I)=ALPH(I)-XKNOT(8)
      IF(ALPH(I).GE.XKNOT(7)) X(19,I)=(ALPH(I)-XKNOT(7))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(9)) X(20,I)=ALPH(I)-XKNOT(9)
      IF(ALPH(I).GE.XKNOT(8)) X(21,I)=(ALPH(I)-XKNOT(8))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(10)) X(22,I)=ALPH(I)-XKNOT(10)
      IF(ALPH(I).GE.XKNOT(9)) X(23,I)=(ALPH(I)-XKNOT(9))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(11)) X(24,I)=ALPH(I)-XKNOT(11)
      IF(ALPH(I).GE.XKNOT(10)) X(25,I)=(ALPH(I)-XKNOT(10))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(12)) X(26,I)=ALPH(I)-XKNOT(12)
      IF(ALPH(I).GE.XKNOT(11)) X(27,I)=(ALPH(I)-XKNOT(11))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(13)) X(28,I)=ALPH(I)-XKNOT(13)
      IF(ALPH(I).GE.XKNOT(12)) X(29,I)=(ALPH(I)-XKNOT(12))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(14)) X(30,I)=ALPH(I)-XKNOT(14)
      IF(ALPH(I).GE.XKNOT(13)) X(31,I)=(ALPH(I)-XKNOT(13))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(15)) X(32,I)=ALPH(I)-XKNOT(15)
      IF(ALPH(I).GE.XKNOT(14)) X(33,I)=(ALPH(I)-XKNOT(14))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(16)) X(34,I)=ALPH(I)-XKNOT(16)
      IF(ALPH(I).GE.XKNOT(15)) X(35,I)=(ALPH(I)-XKNOT(15))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(17)) X(36,I)=ALPH(I)-XKNOT(17)
      IF(ALPH(I).GE.XKNOT(17)) X(37,I)=(ALPH(I)-XKNOT(17))**2*X(2,I)
      IF(ALPH(I).GE.XKNOT(7)) X(38,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(13)) X(39,I)=X(3,I)
  906 CONTINUE
      GO TO [illegible]
```

Next, we give an example of a first option for the lateral equations. This simple version incorporating zeroth-order splines in α and first-order splines in β should be used for the first approximations to the lateral coefficients.

LATERAL EQUATIONS: FIRST OPTION

An example for C_n

$$C_n = C_n(\alpha, \beta)_{\substack{p = r = 0 \\ \delta_a = \delta_r = 0}} + C_{n_p}(\alpha)\ pb/2V + C_{n_r}(\alpha)\ rb/2V$$

$$+ C_{n_{\delta a}}(\alpha)\ \delta_a + C_{n_{\delta r}}(\alpha)\ \delta_r$$

where

$$C_n(\alpha, \beta) = C_0 + C_1\beta + \sum_{i=7}^{9} B_i(\beta - \beta_i)_{\substack{+ \\ +}}$$

$$+ C_{n_\alpha}\alpha + \sum_{i=1}^{6} C_{n_{\beta_i}}(\alpha - \alpha_i)^0_+$$

$$C_{n_p}(\alpha) = C_{n_p} + \sum_{i=1}^{6} C_{n_{p_i}}(\alpha - \alpha_i)^0_+$$

$$C_{n_r}(\alpha) = C_{n_r} + \sum_{i=1}^{6} C_{n_{r_i}}(\alpha - \alpha_i)^0_+$$

$$C_{n_{\delta a}}(\alpha) = C_{n_{\delta a}} + \sum_{i=1}^{6} C_{n_{\delta a_i}}(\alpha - \alpha_i)^0_+$$

$$C_{n_{\delta r}}(\alpha) = C_{n_{\delta r}} + \sum_{i=1}^{6} C_{n_{\delta r_i}}(\alpha - \alpha_i)^0_+$$

and

$$(\beta - \beta_i)_{\substack{+ \\ +}} = \begin{cases} 0 \text{ for } |\beta| < \beta_i \\ \beta - \beta_i \text{ for } \beta \geq \beta_i \\ \beta + \beta_i \text{ for } \beta \leq \beta_i \end{cases}$$

```
C     LATERAL EQUATIONS: FIRST OPTION
      DO 807 I=1,NPTS
      X(1,I)=BETA(I)
      X(2,I)=P(I)*B/(2.*VEL(I))
      X(3,I)=R(I)*B/(2.*VEL(I))
      X(4,I)=DELA(I)
      X(5,I)=DELR(I)
      DO 899 III=6,39
  899 X(III,I)=0.
      IF(ALPH(I).GE.XKNOT(1))  X(6,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(1))  X(7,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(1))  X(8,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(1))  X(9,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(1))  X(10,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(2))  X(11,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(2))  X(12,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(2))  X(13,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(2))  X(14,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(2))  X(15,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(3))  X(16,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(3))  X(17,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(3))  X(18,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(3))  X(19,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(3))  X(20,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(4))  X(21,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(4))  X(22,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(4))  X(23,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(4))  X(24,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(4))  X(25,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(5))  X(26,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(5))  X(27,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(5))  X(28,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(5))  X(29,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(5))  X(30,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(6))  X(31,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(6))  X(32,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(6))  X(33,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(6))  X(34,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(6))  X(35,I)=X(5,I)
      IF(BETA(I).GE.XKNOT(7))  X(36,I)=BETA(I)-XKNOT(7)
      IF(BETA(I).LE.-XKNOT(7)) X(36,I)=BETA(I)+XKNOT(7)
      IF(BETA(I).GE.XKNOT(8))  X(37,I)=BETA(I)-XKNOT(8)
      IF(BETA(I).LE.-XKNOT(8)) X(37,I)=BETA(I)+XKNOT(8)
      IF(BETA(I).GE.XKNOT(9))  X(38,I)=BETA(I)-XKNOT(9)
      IF(BETA(I).LE.-XKNOT(9)) X(38,I)=BETA(I)+XKNOT(9)
      X(39,I)=ALPH(I)
  807 CONTINUE
```

If the first option given for the lateral equations indicates a need for a two-degree spline in (α, β), the following lateral option can be used.

and example for C_n

$$C_n(\alpha,\beta) = C_0 + C_1\beta + \sum_{i=1}^{4} (A_{0_i} + A_{1_i}\beta)(\alpha - \alpha_i)_+^0$$

$$+ \sum_{j=6}^{7} B_{0_j}(\beta - \beta_j)_+^+ + \sum_{i=1}^{4}\sum_{j=6}^{7} D_{ij}(\beta - \beta_j)_+^+ (\alpha - \alpha_i)_+^0$$

Note: for the analysis it was assumed that $A_{0_i} = 0$, $i = 1, 2, 3, 4$. This assumption was confirmed by the later analysis using partitioned data.

$$C_{n_p}(\alpha) = C_{n_p} + \sum_{i=1}^{5} C_{n_{p_i}} (\alpha - \alpha_i)_+^0$$

$$C_{n_r}(\alpha) = C_{n_r} + \sum_{i=1}^{5} C_{n_{r_i}} (\alpha - \alpha_i)_+^0$$

$$C_{n_{\delta a}}(\alpha) = C_{n_{\delta a}} + \sum_{i=1}^{5} C_{n_{\delta a_i}} (\alpha - \alpha_i)_+^0$$

$$C_{n_{\delta r}}(\alpha) = C_{n_{\delta r}} + \sum_{i=1}^{5} C_{n_{\delta r_i}} (\alpha - \alpha_i)_+^0$$

```
C     LATERAL EQUATIONS: SECOND OPTION
      DO 904 I=1,NPTS
      X(1,I)=BETA(I)
      X(2,I)=P(I)*B/(2.*VEL(I))
      X(3,I)=R(I)*B/(2.*VEL(I))
      X(4,I)=DELA(I)
      X(5,I)=DELR(I)
      DO 905 III=6,39
  905 X(III,I)=0.
      IF(ALPH(I).GE.XKNOT(1)) X(6,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(1)) X(7,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(1)) X(8,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(1)) X(9,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(1)) X(10,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(2)) X(11,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(2)) X(12,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(2)) X(13,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(2)) X(14,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(2)) X(15,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(3)) X(16,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(3)) X(17,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(3)) X(18,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(3)) X(19,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(3)) X(20,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(4)) X(21,I)=X(1,I)
      IF(ALPH(I).GE.XKNOT(4)) X(22,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(4)) X(23,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(4)) X(24,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(4)) X(25,I)=X(5,I)
      IF(ALPH(I).GE.XKNOT(5)) X(26,I)=X(2,I)
      IF(ALPH(I).GE.XKNOT(5)) X(27,I)=X(3,I)
      IF(ALPH(I).GE.XKNOT(5)) X(28,I)=X(4,I)
      IF(ALPH(I).GE.XKNOT(5)) X(29,I)=X(5,I)
      IF(BETA(I).GE.XKNOT(6)) X(30,I)=BETA(I)-XKNOT(6)
      IF(BETA(I).LE.-XKNOT(6)) X(30,I)=BETA(I)+XKNOT(6)
      IF(BETA(I).GE.XKNOT(7)) X(31,I)=BETA(I)-XKNOT(7)
      IF(BETA(I).LE.-XKNOT(7)) X(31,I)=BETA(I)+XKNOT(7)
      IF(BETA(I).GE.XKNOT(6).AND.ALPH(I).GE.XKNOT(1))
     *                                X(32,I)=BETA(I)-XKNOT(6)
      IF(BETA(I).LE.-XKNOT(6).AND.ALPH(I).GE.XKNOT(1))
     *                                X(32,I)=BETA(I)+XKNOT(6)
      IF(BETA(I).GE.XKNOT(7).AND.ALPH(I).GE.XKNOT(1))
     *                                X(33,I)=BETA(I)-XKNOT(7)
      IF(BETA(I).LE.-XKNOT(7).AND.ALPH(I).GE.XKNOT(1))
     *                                X(33,I)=BETA(I)+XKNOT(7)
      IF(BETA(I).GE.XKNOT(6).AND.ALPH(I).GE.XKNOT(2))
     *                                X(34,I)=BETA(I)-XKNOT(6)
      IF(BETA(I).LE.-XKNOT(6).AND.ALPH(I).GE.XKNOT(2))
     *                                X(34,I)=BETA(I)+XKNOT(6)
```

```
      IF(BETA(I).GE.XKNOT(7).AND.ALPH(I).GE.XKNOT(2))
     *                                   X(35,I)=BETA(I)-XKNOT(7)
      IF(BETA(I).LE.-XKNOT(7).AND.ALPH(I).GE.XKNOT(2))
     *                                   X(35,I)=BETA(I)+XKNOT(7)
      IF(BETA(I).GE.XKNOT(6).AND.ALPH(I).GE.XKNOT(3))
     *                                   X(36,I)=BETA(I)-XKNOT(6)
      IF(BETA(I).LE.-XKNOT(6).AND.ALPH(I).GE.XKNOT(3))
     *                                   X(36,I)=BETA(I)+XKNOT(6)
      IF(BETA(I).GE.XKNOT(7).AND.ALPH(I).GE.XKNOT(3))
     *                                   X(37,I)=BETA(I)-XKNOT(7)
      IF(BETA(I).LE.-XKNOT(7).AND.ALPH(I).GE.XKNOT(3))
     *                                   X(37,I)=BETA(I)+XKNOT(7)
      IF(BETA(I).GE.XKNOT(6).AND.ALPH(I).GE.XKNOT(4))
     *                                   X(38,I)=BETA(I)-XKNOT(6)
      IF(BETA(I).LE.-XKNOT(6).AND.ALPH(I).GE.XKNOT(4))
     *                                   X(38,I)=BETA(I)+XKNOT(6)
      IF(BETA(I).GE.XKNOT(7).AND.ALPH(I).GE.XKNOT(4))
     *                                   X(39,I)=BETA(I)-XKNOT(7)
      IF(BETA(I).LE.-XKNOT(7).AND.ALPH(I).GE.XKNOT(4))
     *                                   X(39,I)=BETA(I)+XKNOT(7)
  904 CONTINUE
```

TABLE 1

α	α^2	$\alpha\beta^2$	α^3	β	$\beta\alpha$	$\beta\alpha^2$	β^2	α
q	αq	$\alpha^2\beta^2$	α^4	p	$p\alpha$	$p\alpha^2$	β^3	α^2
δ_e	$\alpha\delta_e$		α^5	r	$r\alpha$	$r\alpha^2$	β^4	α^3
			α^6	δ_a	$\delta_a\alpha$	$\delta_a\alpha^2$	β^5	
			α^7	δ_r	$\delta_r\alpha$	$\delta_r\alpha^2$	$\beta^2\alpha^2$	
			α^8					

TABLE 2

	TRUE VALUE	ESTIMATED VALUE	ESTIMATED STANDARD ERROR
C_{m_o}	.105	.101	------
C_{m_α}	-.400	-.384	(.023)
C_{m_q}	-15.0	-15.8	(0.4)
$C_{m_{\delta e}}$	-2.00	-2.16	(.04)
$C_{m(\Delta\alpha)_{+,13°}}$	-.600	-.561	(.039)
$C_{m(\Delta\alpha)_{+,17°}}$	0.00	-.939	(.080)
$C_{m(\Delta\alpha)_{+,18°}}$	-1.00	0.00	------
$C_{m_{q(\Delta\alpha)^o_{+,9°}}}$	0.00	5.30	(.52)
$C_{m_{q(\Delta\alpha)^o_{+,10°}}}$	+10.0	5.74	(.55)
$C_{m_{q(\Delta\alpha)^o_{+,13°}}}$	+10.0	+6.65	(.62)
$C_{m_{q(\Delta\alpha)^o_{+17°}}}$	0.00	-6.98	(.89)
$C_{m_{q(\Delta\alpha)^o_{+,18°}}}$	-10.0	-5.96	(1.0)

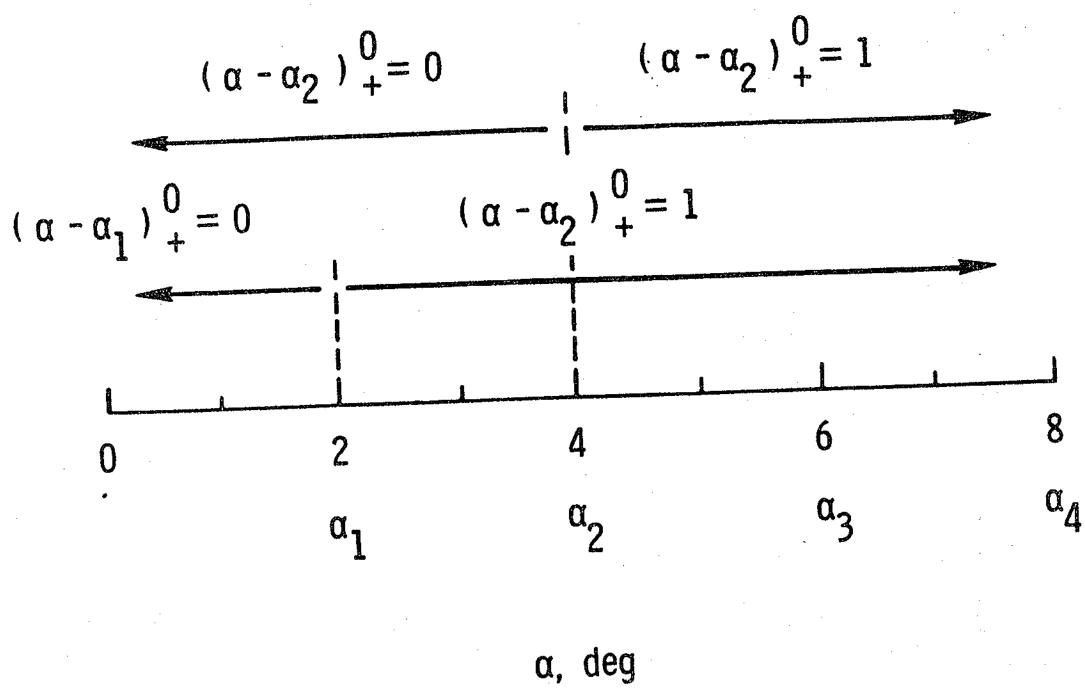
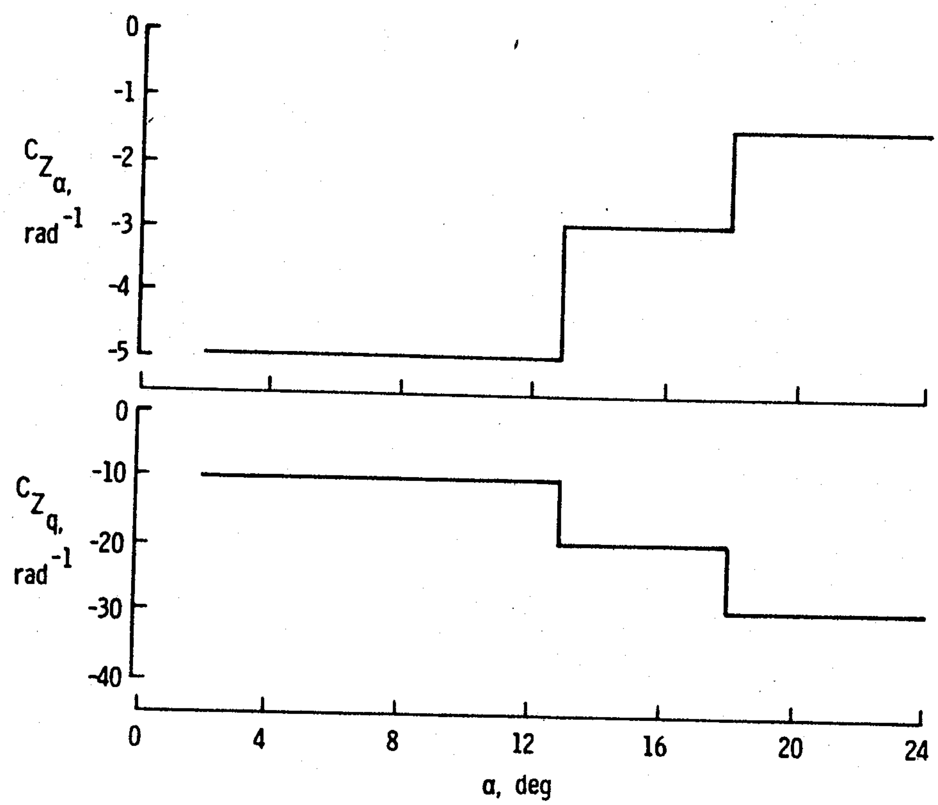
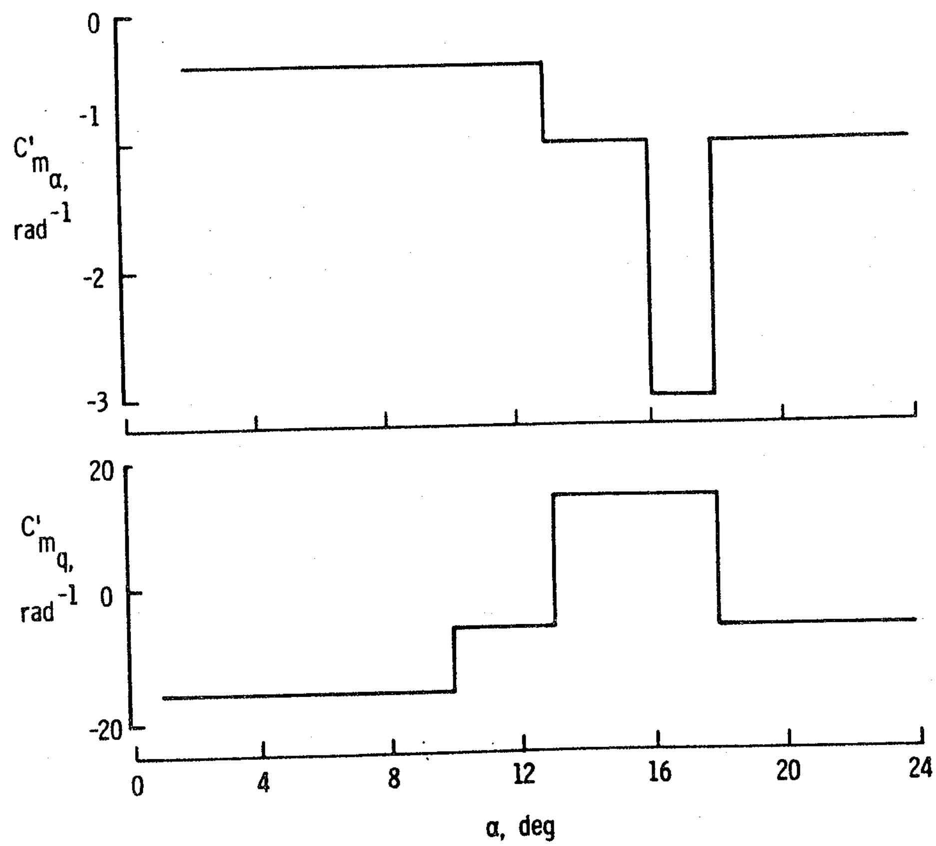


Figure 1.- Illlustration of regions of support for spline "plus" function.



(a) Z-force derivatives.

Figure 2.- Aerodynamic math model for example 1.



(b) Pitching moment derivatives.

Figure 2.- Concluded.

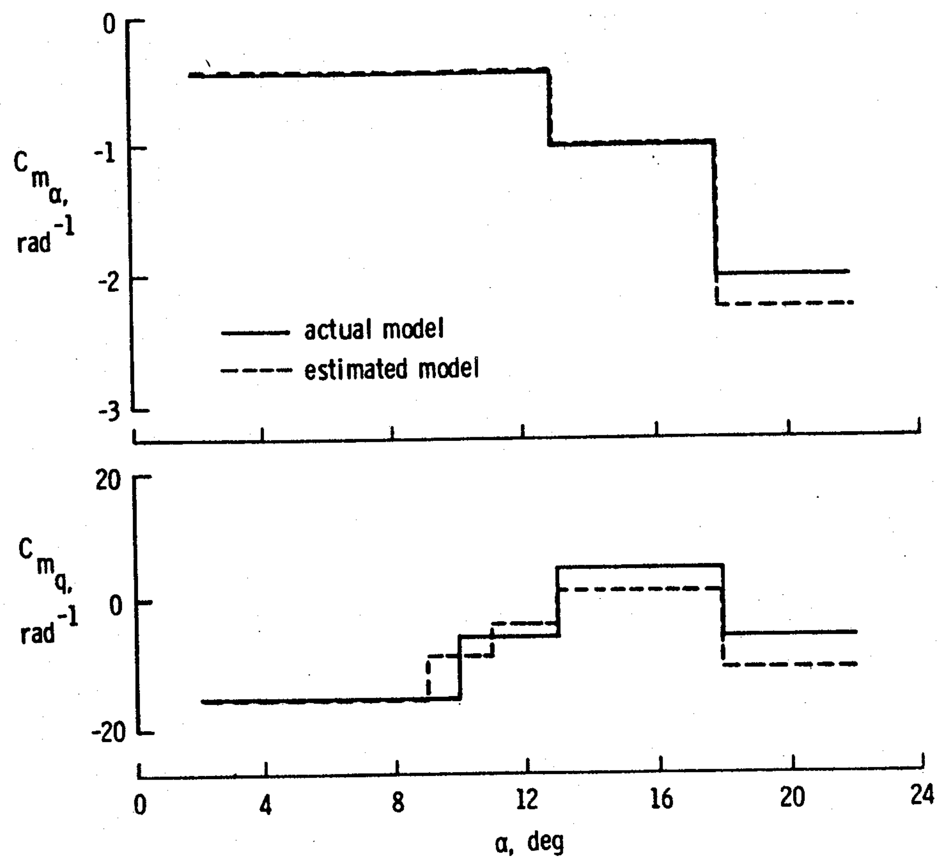
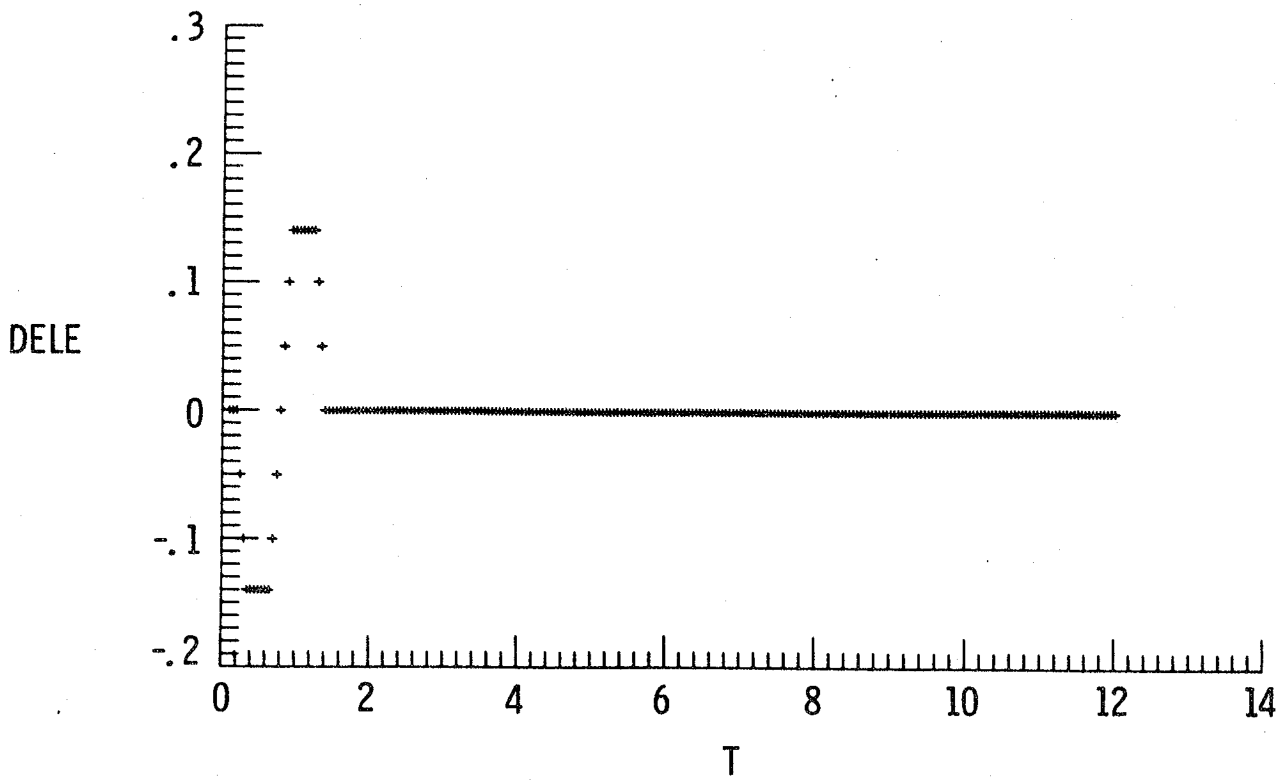
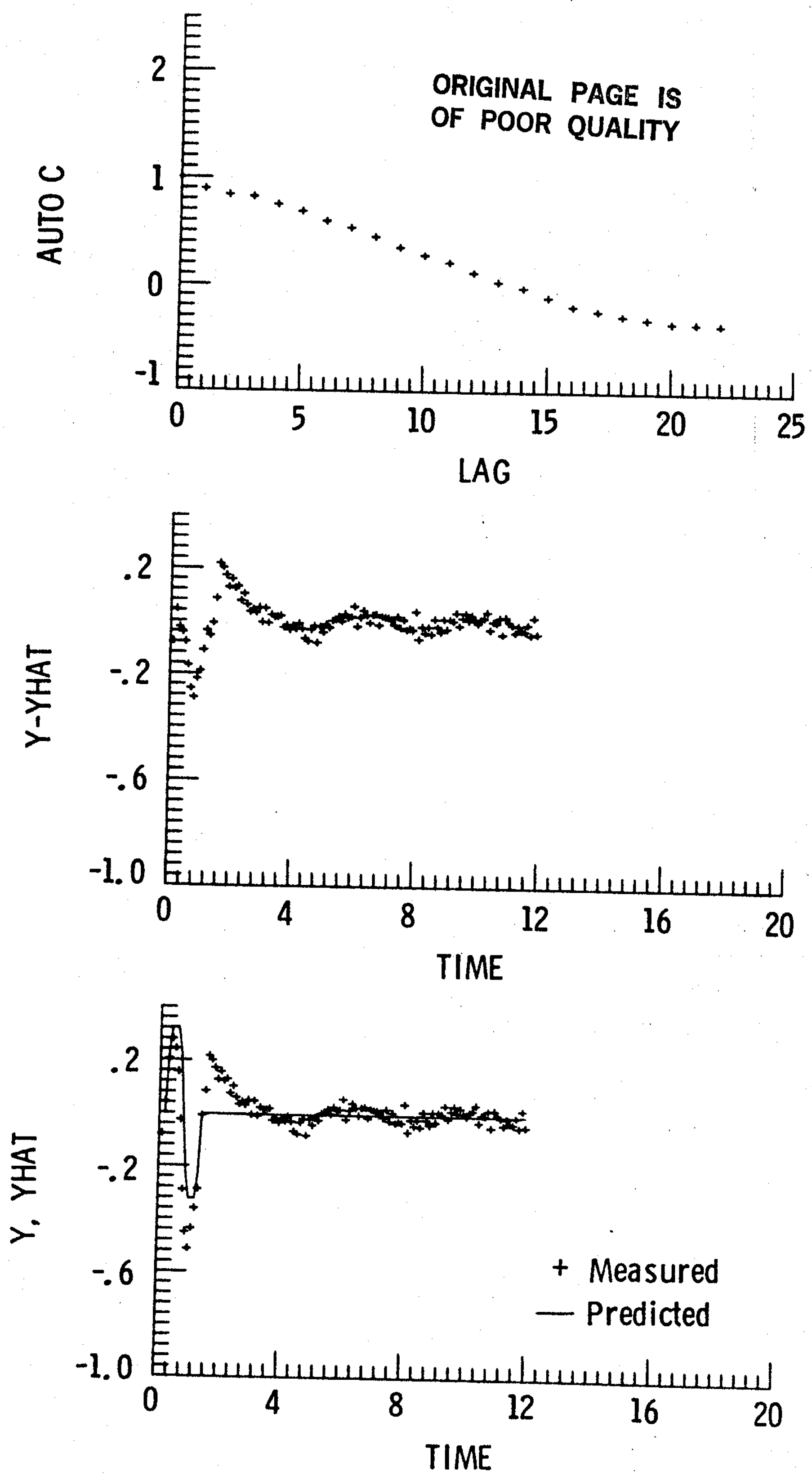


Figure 3.- Results of analysis of noisy pitching moment simulated data compared with true model.



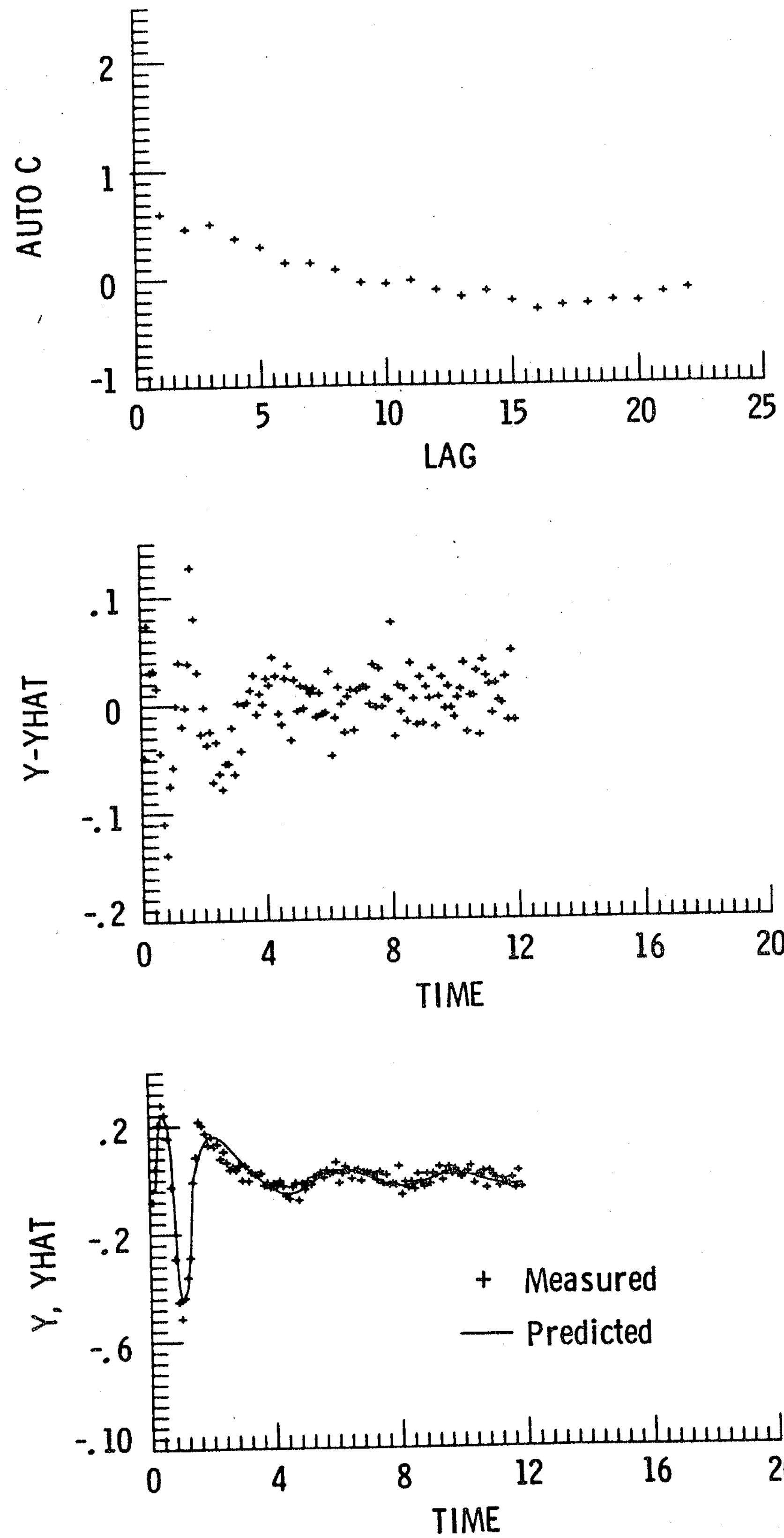
(a) Elevator input.

Figure 4.- Calcomp plotter output for STEPSPL in example 2.



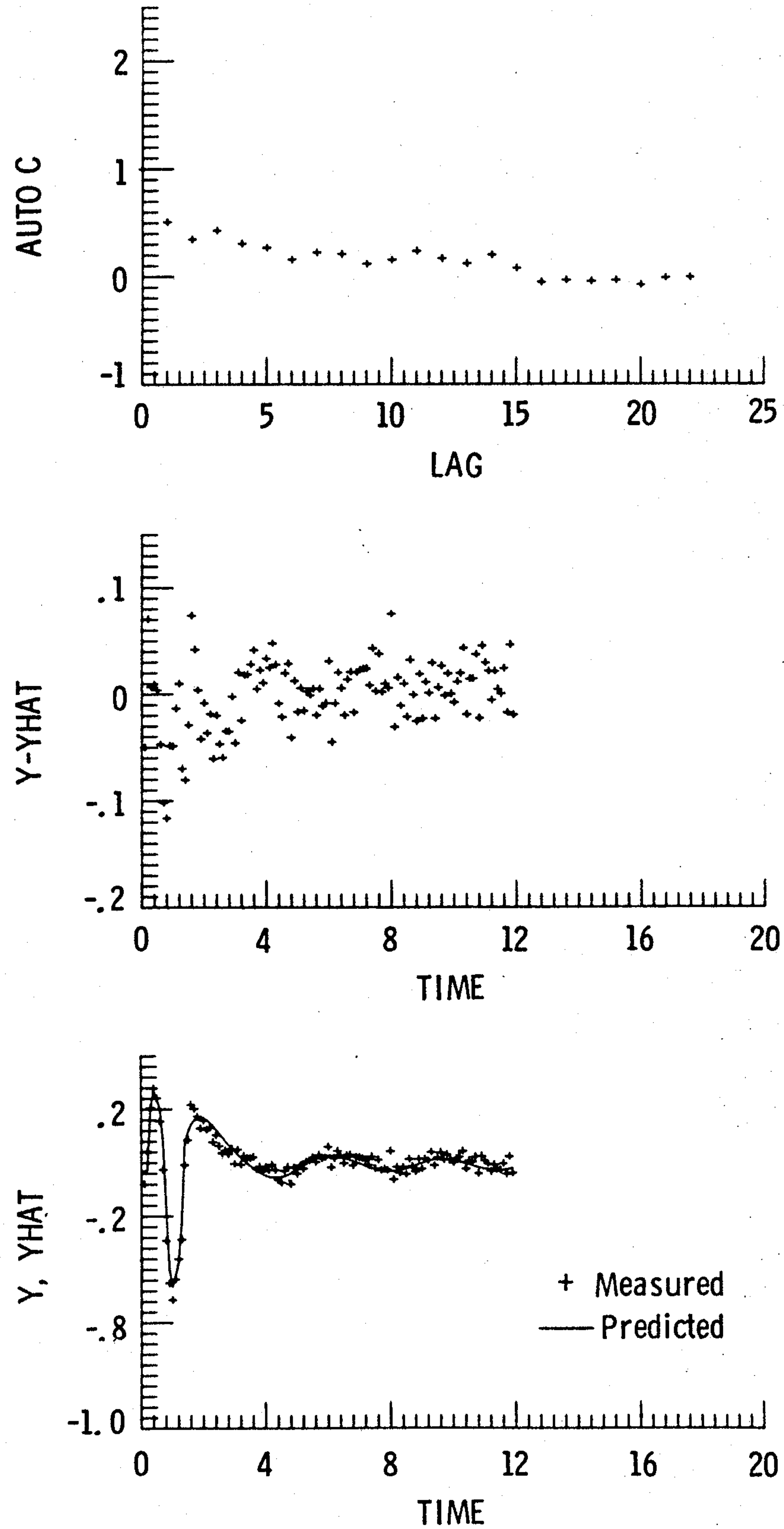
(b) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for one variable model.

Figure 4.- Continued.



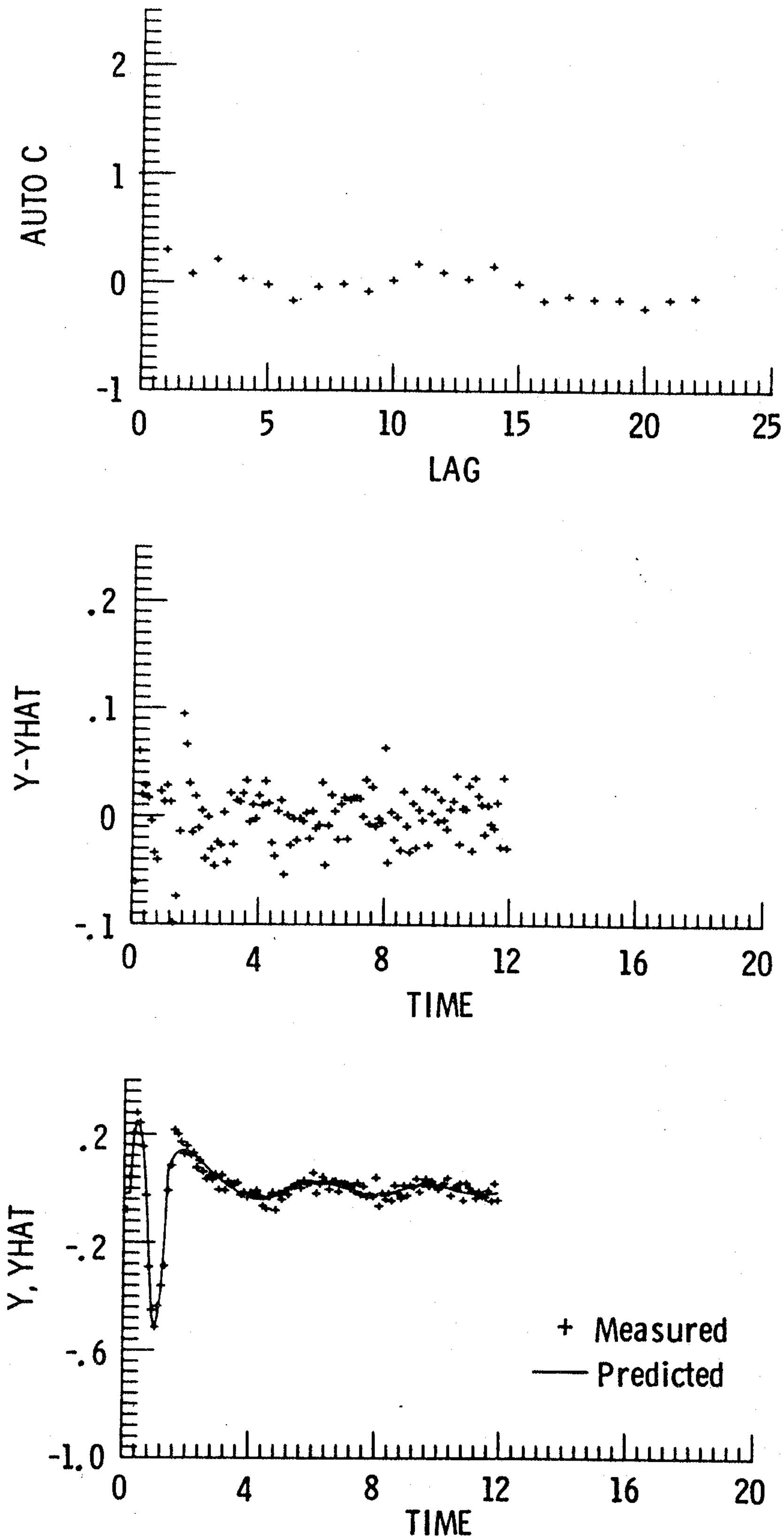
(c) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for two variable model.

Figure 4.- Continued.



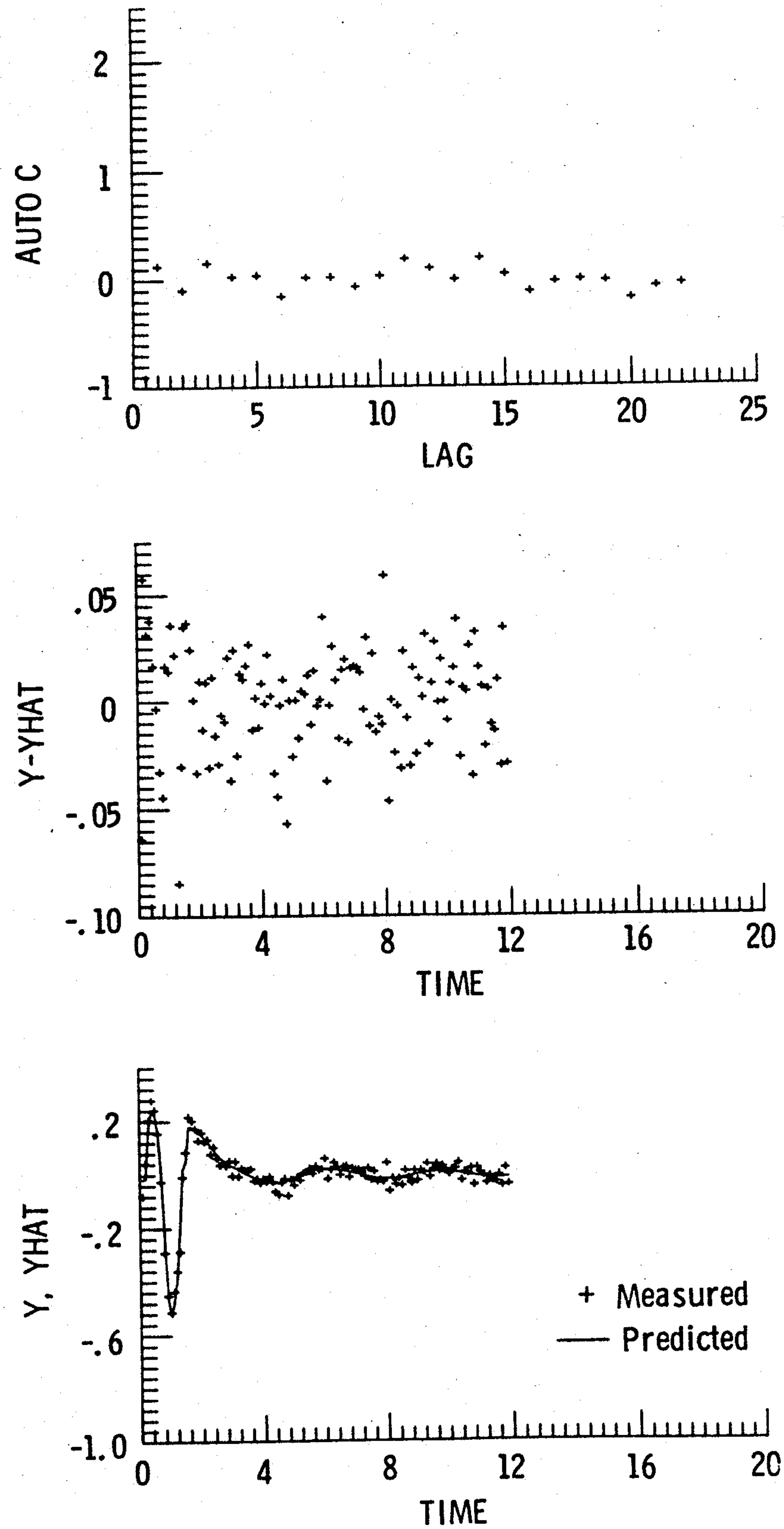
(d) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for three variable model.

Figure 4.- Continued.



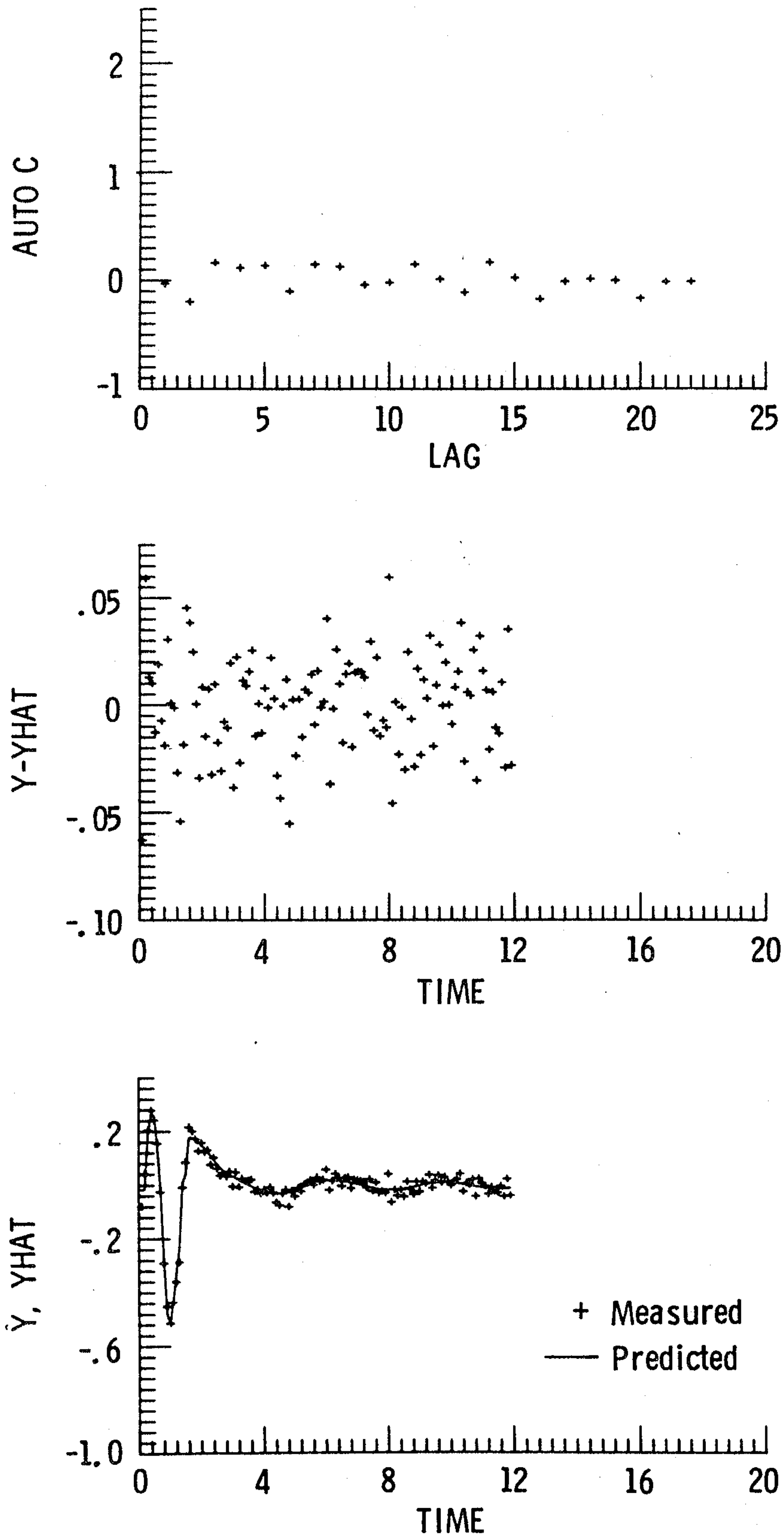
(e) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for four variable model.

Figure 4.- Continued.



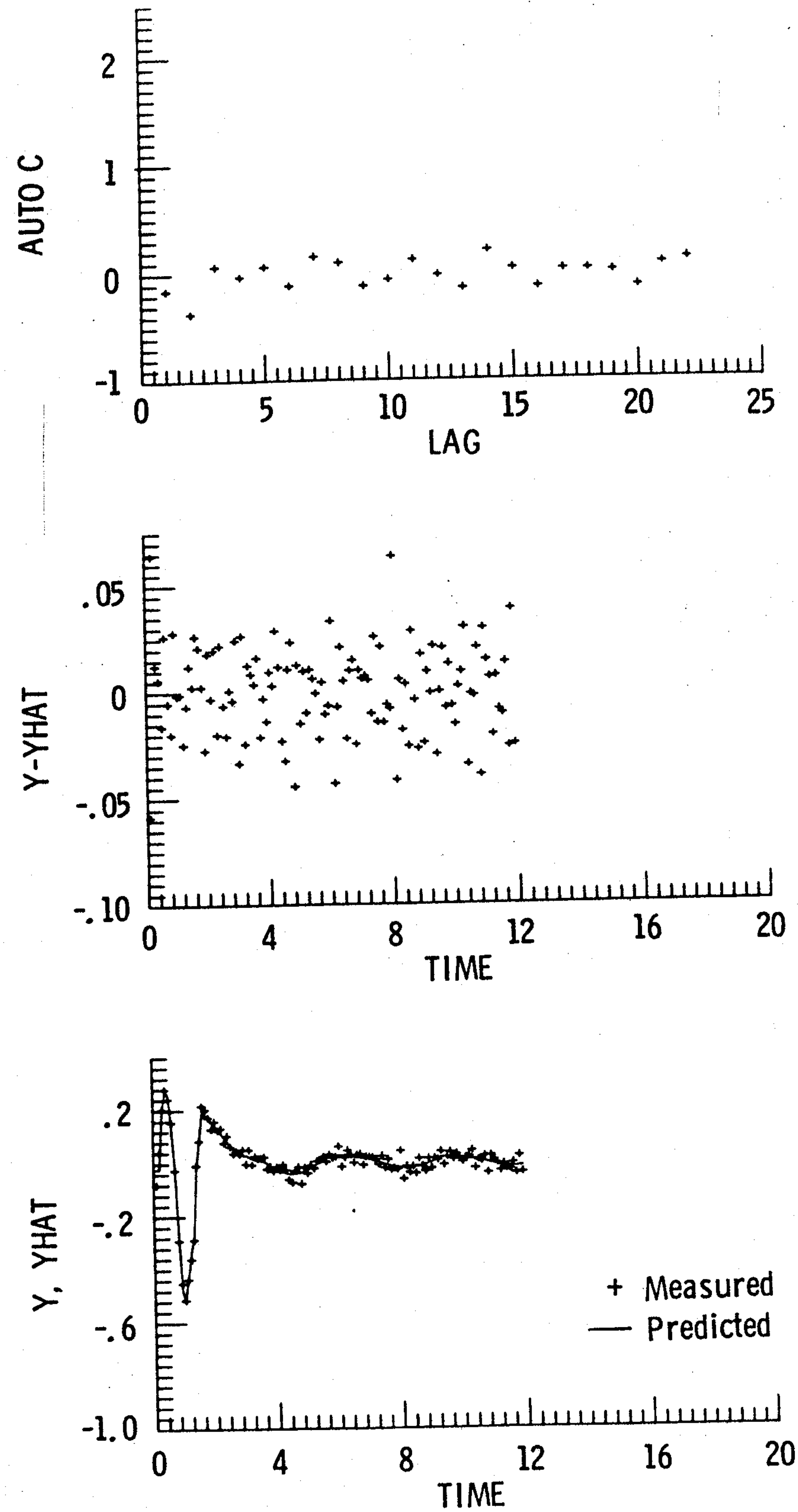
(f) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for five variable model.

Figure 4.- Continued.



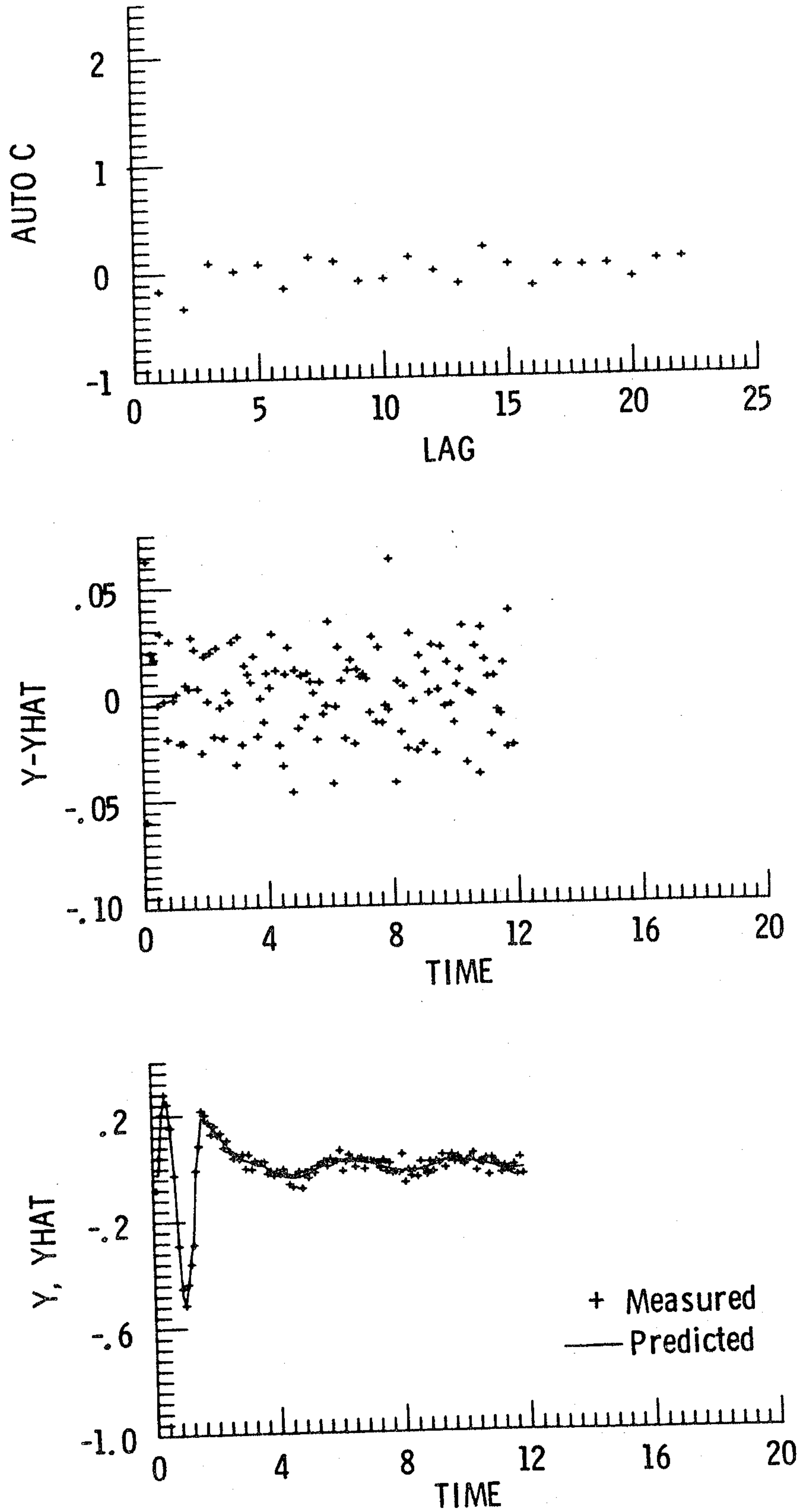
(g) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for six variable model.

Figure 4.- Continued.



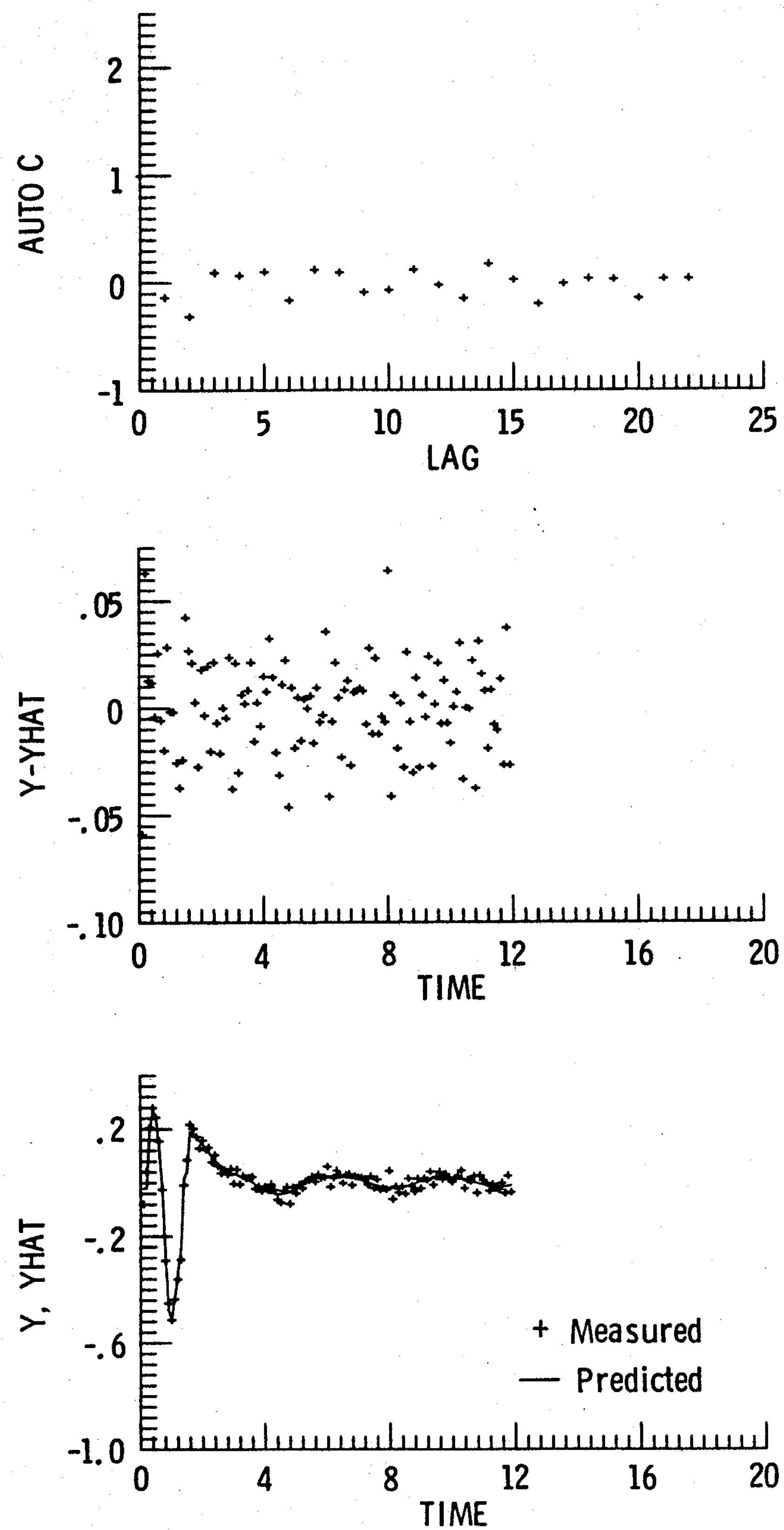
(h) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for seven variable model.

Figure 4.- Continued.



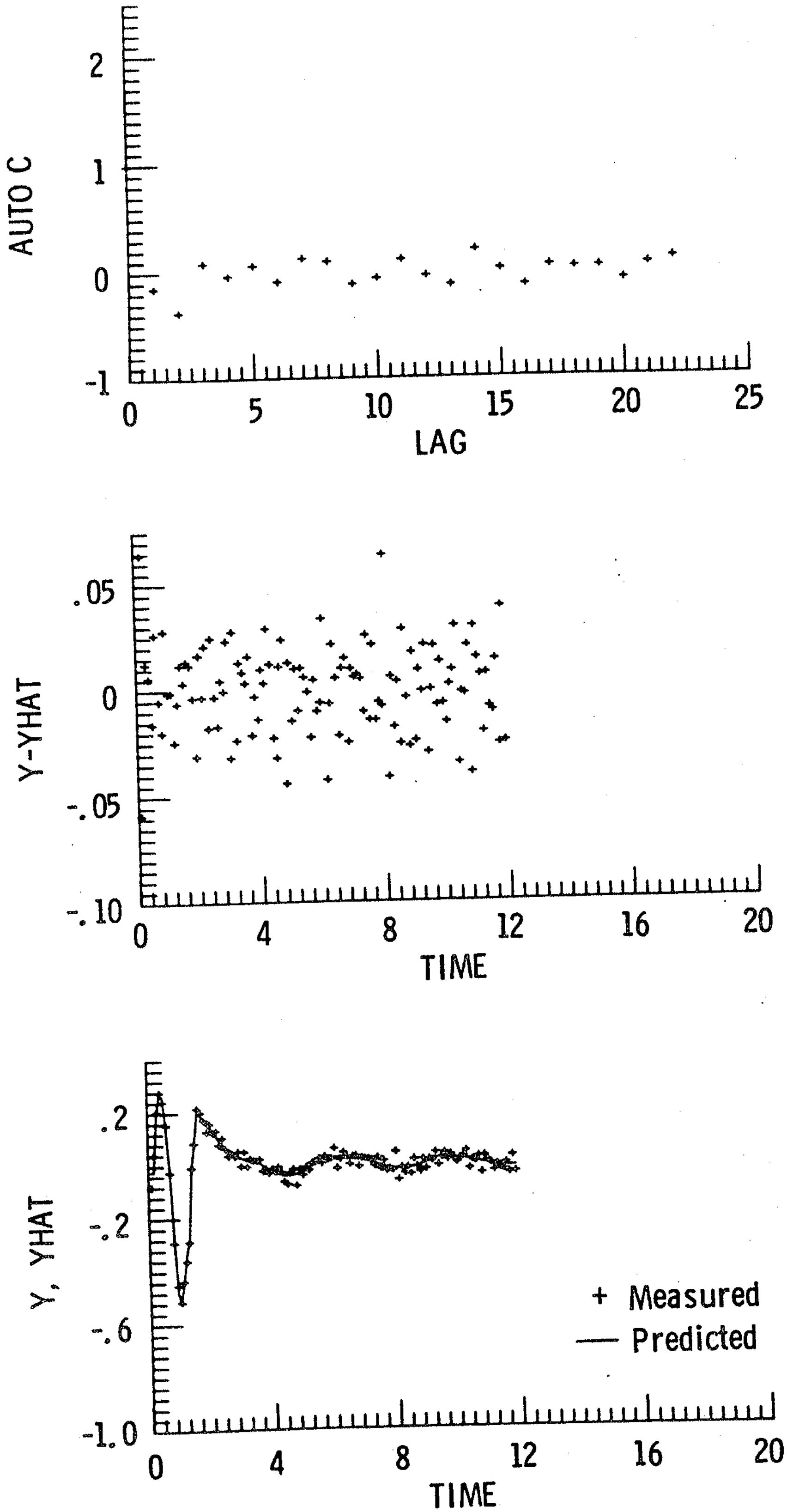
(i) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for eight variable model.

Figure 4.- Continued.



(j) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for nine variable model.

Figure 4.- Continued.



(k) Predicted and estimated pitching moment coefficients, residual sequence, and autocorrelation function for ten variable model.

Figure 4.- Concluded.

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16. Abstract

The successful parametric modeling of the aerodynamics for an airplane operating at high angles of attack or sideslip is performed in two phases. First the aerodynamic model structure must be determined and second the associated aerodynamic parameters (stability and control derivatives) must be estimated for that model. The purpose of this paper is to document two versions of a stepwise regression computer program which were developed for the determination of airplane aerodynamic model structure and to provide two examples of their use on computer generated data. References are provided for the application of the programs to real flight data. The two computer programs that are the subject of this report, STEP and STEPSPL, are written in FORTRAN IV (ANSI 1966) compatible with a CDC FTN4 compiler. Both programs are adaptations of a standard forward stepwise regression algorithm. The purpose of the adaptation is to facilitate the selection of an adequate mathematical model of the aerodynamic force and moment coefficients of an airplane from flight test data. The major difference between STEP and STEPSPL is in the basis for the model. The basis for the model in STEP is the standard polynomial Taylor's series expansion of the aerodynamic function about some steady-state trim condition. Program STEPSPL utilizes a set of spline basis functions.

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