Digital Analysis of Liquid Sloshing In Rotationally Symmetric Tanks Under Weak Gravitational Fields

UNIDEV, INC. HOLIDAY OFFICE CENTER, HUNTSVILLE, ALABAMA

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Volume II

COMPUTATIONAL APPLICATION

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UNIDEV, INC.
Huntsville, Alabama

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UNIDEV Report UR-00010

Submitted to

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FOREWORD

This report was prepared by UNIDEV, INC., Huntsville, Alabama, under Contract NAS8-21272 for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under technical direction of the Aero-Astrodynamics Laboratory, George C. Marshall Space Flight Center, with Mr. Frank Bugg, acting as Project Manager.

This document deals with the computational aspects of the problem. Theoretical considerations are presented in Volume I.

Technical contributions and helpful suggestions were made by Dr. D. O. Lomen, University of Arizona.

This study was executed under the direction of Dr. L. L. Fontenot, Program Manager and Principal Investigator; Mr. T. S. Chandler developed the Digital Computer Program described herein.

ABSTRACT

This document describes the Digital Computer Program used to determine eigenfrequencies, eigenfunctions, forces, and moments for propellant "sloshing" in rotationally symmetric tanks under weak gravitational fields. The description of the analysis is given in /1/.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

NOTATIONS*

η	Total free surface displacement.
η'	Free surface displacement in the absence of surface tension.
ζ	Free surface displacement due to surface tension and contact angle effects.
$(\delta\overline{F}_{01})_y$	Total force resulting from action of liquid on the tank wall(s) in the y(or x_2)-direction.
F_2'	Force resulting from action of liquid on the tank wall(s) in the x_2-direction, in the absence of surface tension.
F_y	Force resulting from action of liquid on the tank wall(s) in the y(or x_2)-direction, due to surface tension and contact angle effects.
$(\delta\overline{F}_{01})_z$	Total force resulting from action of liquid on the tank wall(s) in the z(or x_3)-direction.
F_3'	Force resulting from action of liquid on the tank wall(s) in the x_3-direction, in the absence of surface tension.
F_2	Force resulting from action of liquid on the tank wall(s) in the x_3-direction, due to surface tension and contact angle effects.
$(\delta\overline{N}_{01})_x$	Total moment of the forces exerted on the tank wall(s) about the x(or x_1) axis.
T_1'	Moment of the forces exerted on the tank wall(s) about the x_1-axis, in the absence of surface tension.
T_y	Moment of the forces exerted on the tank wall(s) about the x(or x_1) axis, due to surface tension and contact angle effects.
q_n	Time dependent amplitudes of free surface displacement Fourier expansion.

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* See /2/ for notations not given herein.

ξ_n	Time dependent amplitudes of free surface displacement Fourier expansion, in the absence of surface tension.
λ_n	Time dependent amplitudes of free surface displacement Fourier expansion, corresponding to surface tension and contact angle effects.
α_2	Acceleration in the x_2-direction.
α_3	Acceleration in the x_3-direction (assumed constant).
$\ddot{D}$	Angular acceleration of tank about the x_2-axis.
M	Mass of the liquid.
B_0	Bond Number = $\rho\alpha_3 a^2/\sigma$
V	Undisturbed volume of the liquid.
σ	Surface tension.
ρ	Density of the liquid.
a	Distance from point B to the z-axis (see Fig. 1).
r, θ	Polar coordinates.
γ	Contact angle.
L	Distance from the center of gravity of the liquid to the undisturbed free surface, in the absence of surface tension.
L_1	Distance from the center of gravity of the liquid to an arbitrary point along an extension of the line AC (see Fig. 1), in the absence of surface tension.
β	Angle between the tangent line and local horizontal (see Fig. 1).
Φ_n	Antisymmetric eigenfunctions associated with the "high-g" eigenoscillation problem.
ω_n	Eigenfrequencies
K_n	Non-dimensional parameter = $L\omega_n^2/\alpha_3$

$b_n, h_n, \gamma_n, I'_{11}$ — Liquid parameters associated with the "high-g" slosh problem /2/ defined in (1.8).

$A^*_{nm}, B^*_{nm}, a^*_n$

b^*_n, c^*_n, e^*_n

f^*_n, g^*_n, h^*_n — Additional liquid parameters resulting from surface tension and contact angle effects defined in (1.4) and (1.5).

ℓ^*_n, B, β_{nm}

$\overline{\beta}_{nm}, \tau_{nm}, \nu_{nm}$

ρ_n

ψ_1 — Stokes' potential determined from system (1.7).

$\frac{\omega - \omega_n}{\omega_n}$ — Frequency correction $= -\beta_{nn}/2B_0$

INTRODUCTION

In /1/, the equations governing the behavior of liquids in moving tanks under conditions of weightlessness and weak gravitational fields were derived.

The objective of this document is to develop a Digital Computer Program to calculate the pertinent liquid parameters derived in / 2 / for rotationally symmetric tanks, wherein the axis of symmetry coincides with the vector of effective mass forces.

SECTION 1

SYNTHESIS OF FUNDAMENTAL EQUATIONS

The equations which govern the motion of liquids enclosed in moving tanks under weak gravitational fields are derived in /1/. In particular, the equations are specialized to rotationally symmetric vessels, wherein the axis of symmetry coincides with the vector of effective mass forces. The forces, moments and free boundary displacement are given in terms of non-dimensional coefficients, which are expressible by means of the geometry of the vessel, properties of the liquid, contact angle and parameters associated with the "high-g" eigenoscillation problem. In the notation of /2/, these equations are

$$\eta = \eta' + \zeta/B_0 ,$$

$$(\delta\overline{F}_{01})_y = F_2' + F_y/B_0 ,$$

$$(\delta\overline{F}_{01})_z = F_3' + F_z/B_0 , \qquad (1.1)$$

$$(\delta\overline{N}_{01})_x = T_1' + T_x/B_0 ,$$

$$q_n = \xi_n + \lambda_n/B_0 ;$$

$$\eta' = \sin\theta \sum_{n=1}^{\infty} \Phi_n(r,L)\xi_n(t) ,$$

$$F_2' = -M\alpha_2 + ML_1(-\ddot{D}) - M\sum_{n=1}^{\infty}\gamma_n c_n^* ,$$

$$F_3' = -M\alpha_3 , \qquad (1.2)$$

$$T_1' = ML_1\alpha_2 - I_{11}'(-\ddot{D}) - M\sum_{n=1}^{\infty}\gamma_n[\alpha_3 c_n^*\xi_n + a_n^*\ddot{\xi}_n] ,$$

$$\ddot{\xi}_n + \frac{\alpha_3}{L}\kappa_n\xi_n = -\kappa_n[a_n^*(-\ddot{D}) + c_n^*\alpha_3] ;$$

$$\zeta = \sin\theta\sum_{n=1}^{\infty}[\Phi_n(r,L)\lambda_n(t) + \sum_{\substack{m=1\\ n\neq m}}^{\infty} B_{nm}^*\Phi_m(r,L)\xi_n(t)] ,$$

$$F_y = -M\sum_{n=1}^{\infty}\gamma_n c_n^*\ddot{\lambda}_n - M\sum_{n=1}^{\infty}\gamma_n[e_n^*\ddot{\xi}_n + \alpha_3 f_n\xi_n] ,$$

$$F_z = 0 , \qquad (1.3)$$

$$T_x = -B(-\ddot{D}) - M\sum_{n=1}^{\infty}\gamma_n[\alpha_3 c_n^*\lambda_n + a_n^*\ddot{\lambda}_n]$$

$$- M\sum_{n=1}^{\infty}\gamma_n[(b_n^* + g_n^*)\ddot{\xi}_n + \alpha_3(e_n^* + h_n^* - (L+L_1)f_n^*)\xi_n] ,$$

$$\ddot{\lambda}_n + \frac{\alpha_3}{L}\kappa_n\lambda_n = -\sum_{m=1}^{\infty}(A_{nm}^*\ddot{\xi}_m + \frac{\alpha_3}{L}\kappa_n B_{nm}^*\xi_m) - \kappa_n b_n^*(-\ddot{D}) ;$$

where

$$A_{nm}^* = \frac{\kappa_n}{\kappa_n - \kappa_m}\bar{\beta}_{nm} + \frac{\pi a^3\kappa_n}{V\gamma_n}\nu_{nm}\cos\gamma, \qquad n\neq m$$

$$= \frac{\pi a L^2}{V\gamma_n\kappa_n}(2\tau_{nn} - \nu_{nn})\cos\gamma + \frac{\kappa_n a}{L}\left(\frac{\pi a^2 L}{V\gamma_n}\nu_{nn} - 2\right)\cos\gamma, \qquad n=m ,$$

$$B^*_{nm} = \frac{\kappa_n}{\kappa_n - \kappa_m}\, \beta_{nm} + \frac{\pi a^2 L}{V\gamma_n}\, \tau_{nm} , \quad n \neq m ,$$

$$= \frac{\pi a^2 L}{V\gamma_n}\, \tau_{nn}, \quad n = m$$

$$a^*_n = L(b_n - h_n) - L_1 b_n ,$$

$$b^*_n = \frac{\pi a L^3}{V\gamma_n \kappa_n} (\Phi_n(a,L)\Psi_1(a,L) - 2\rho_n)\cos\gamma +$$

$$\frac{\pi a^4}{V\gamma_n} \left(\Phi_n(a,L) - \frac{2V\gamma_n}{\pi a^3}\, b_n \right) \cos\gamma ,$$

$$c^*_n = b_n ,$$

$$e^*_n = - \sum_{\substack{m=1 \\ n \neq m}}^{\infty} B^*_{nm} c^*_m , \qquad (1.4)$$

$$f^*_n = \frac{\pi a^2}{V\gamma_n}\, \Phi_n(a,L)\cos\gamma ,$$

$$g^*_n = - \sum_{\substack{m=1 \\ n \neq m}}^{\infty} B^*_{nm} a^*_m ,$$

$$h^*_n = \frac{\pi a^3}{V\gamma_n}\, \Phi_n(a,L) ,$$

$$\ell^*_n = \frac{\pi a L^4}{V\gamma_n} (\Phi_n(a,L)\Psi_1(a,L) - 2\rho_n)(b_n + \frac{1}{2} h_n)\cos\gamma ,$$

$$B = M \left[\frac{\pi a^5}{2V} \cos\gamma + 2 \sum_{n=1}^{\infty} \gamma_n \ell^*_n \right] ,$$

with

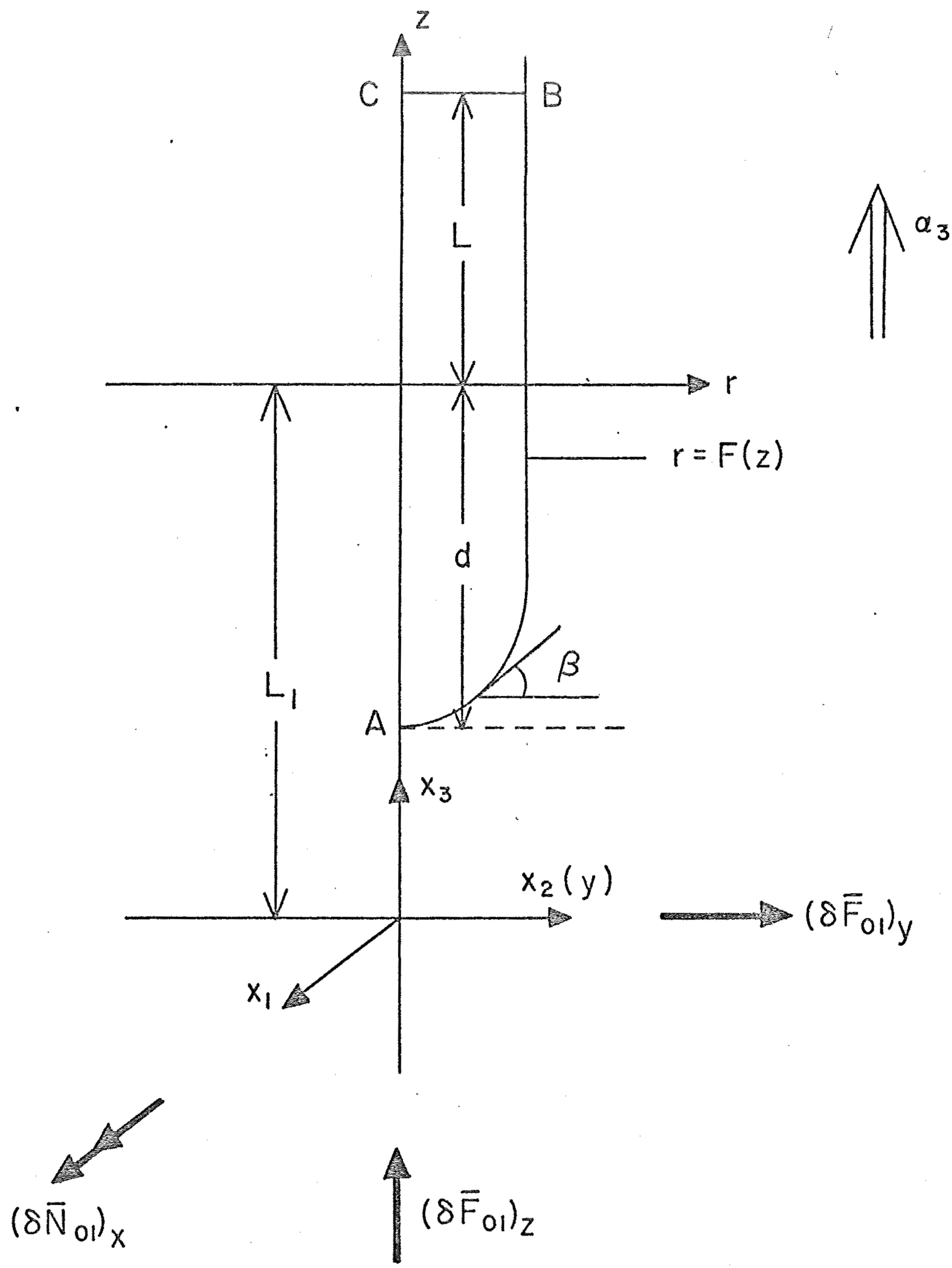


Figure 1. Rotationally Symmetric Vessel, Notation

$$\beta_{nm} = -\frac{\pi a^2 L}{V\gamma_n}\tau_{nm} - \frac{\kappa_m a}{K}\left[2\sqrt{\frac{\gamma_m}{\gamma_n}}\,\delta_{nm} - \frac{2\eta L^3}{V\gamma_n\kappa_n\kappa_m}\tau_{nm} + \frac{\pi L^3}{V\gamma_n}\left(\frac{1}{\kappa_n\kappa_m} - \frac{a^2}{L^2}\right)\nu_{nm}\right]\cos\gamma\ ,$$

$\overline{\beta}_{nm} = \beta_{nm}$ with κ_n replaced by κ_m ,

$$\tau_{nm} = \int_C^B \left[\frac{\partial\Phi_n(r,L)}{\partial r}\,\frac{\partial\Phi_m(r,L)}{\partial r} + \frac{\Phi_n(r,L)\Phi_m(r,L)}{r^2}\right] r\,dr\ , \tag{1.5}$$

$$\nu_{nm} = \Phi_n(a,L)\Phi_m(a,L),$$

$$\rho_n = \int_C^B \left[\frac{\partial\Phi_n(r,L)}{\partial r}\,\frac{\partial\Psi_1(r,L)}{\partial r} + \frac{\Phi_n(r,L)\Psi_1(r,L)}{r^2}\right] r\,dr\ .$$

The eigenfrequencies κ_n and functions Φ_n satisfy the boundary value problem (see Fig. 1)

$$\frac{\partial^2\Phi_n}{\partial r^2} + \frac{1}{r}\frac{\partial\Phi_n}{\partial r} - \frac{1}{r^2}\Phi_n + \frac{\partial^2\Phi_n}{\partial z^2} = 0,\ \text{(interior to ABCOA)},$$

$$\frac{\partial\Phi_n}{\partial z} = \frac{\kappa_n}{L}\Phi_n\ ,\ \text{(along BC)}, \tag{1.6}$$

$$\sin\beta\,\frac{\partial\Phi_n}{\partial r} - \cos\beta\,\frac{\partial\Phi_n}{\partial z} = 0,\ \text{(along AB)},$$

while the Stokes potential is determined from

$$\frac{\partial^2\Psi_1}{\partial r^2} + \frac{1}{r}\frac{\partial\Psi_1}{\partial r} - \frac{1}{r^2}\Psi_1 + \frac{\partial^2\Psi_1}{\partial z^2} = 0,\ \text{(interior to ABCOA)}, \tag{1.7}$$

$$\sin\beta \frac{\partial \Psi_1}{\partial r} - \cos\beta \frac{\partial \Psi_1}{\partial z} = \frac{2z}{L^2} \sin\beta, \quad \text{(on ABC)}.$$

Finally, the coefficients

$$b_n = \frac{\pi}{V\gamma_n} \int_C^B r^2 \Phi_n(r,L)\, dr,$$

$$h_n = \frac{2\pi}{V\gamma_n\kappa_n} \int_A^B zr\, \Phi_n(r,z)\, dz,$$

$$\gamma_n = \frac{\pi L}{V} \int_C^B r[\Phi_n(r,L)]^2\, dr, \tag{1.8}$$

$$I'_{11} = \rho \int_{UV} (r^2\sin^2\theta+z^2)dV - 4\rho \int_{UV} z^2 dV$$

$$+ 2\rho L^2 \pi \int_A^B zr\Psi_1(r,z)\, dz + M\, L_1^2$$

are parameters associated with the equations of motion in the absence of surface tension, and therefore can be found once Φ_n, κ_n and Ψ_1 are known.

In the absence of surface tension ($B_0=\infty$), the motion of the liquid in the moving tank is completely determined by equations (1.2) whose coefficients are expressible by means of the solutions of (1.6) and (1.7) and parameters (1.8). The NASA-MSFC Digital Computer Program /2/ is available for solving (1.6) and (1.7) and calculating (1.8) for rotationally symmetric vessels. The program and computational procedure are well documented in /2/, and not repeated here.

To find the corrections due to surface tension and contact angle effects, we must compute the additional matrices and vectors in (1.3) which are expressible by means of (1.4) and (1.5). However, an examination of (1.3-5) and the Digital Computer Program /2 / shows that the required quantities can be formed readily if the additional integrations τ_{nn} and ρ_n are known. Therefore, we shall extend the Digital Computer Program to calculate these parameters and the resulting matrices and vectors called for in (1.3). In addition, we shall compute the frequency correction

$$\varepsilon^2 \mu_n = - \beta_{nn}/2B_0. \tag{1.9}$$

SECTION 2

PROGRAM DESCRIPTION

The existing program (Tank Sloshing Version 1, 3712) was modified to accept the equations described in Section 1. To make the necessary changes, five routines were added and the matrix and main routines were modified.

Gauss's Quadrature Method was used as the integration scheme and was written as a new routine, INTG3. The integrands of τ and ρ were placed in the four remaining routines.

The program was written and checked out on the IBM 7094, Mod II, Version 13.

SECTION 3

UTILIZATION OF THE COMPUTER PROGRAM

3.1 DESCRIPTION OF INPUT. There are three sets of required input data, as described in Sections 3.1.1, 3.1.2 and 3.1.4. An optional fourth set is described in Section 3.1.3. Input is subject to the restrictions outlined in Section 3.1.5.

Data is entered in allocated spaces on a coding form. Each digit of a number, a decimal point, or a minus sign occupies 1 space. Unless otherwise specified in the following sections, a number must be entered with a decimal point. A number that must not contain a decimal point must be right-adjusted. That is, all digits must occupy the last of those spaces allocated for the number.

All coordinates required as input must be in inch units, from a system in which the r-coordinate of the tank centerline is zero and the z-coordinate increases upward. The origin may be anywhere on the centerline.

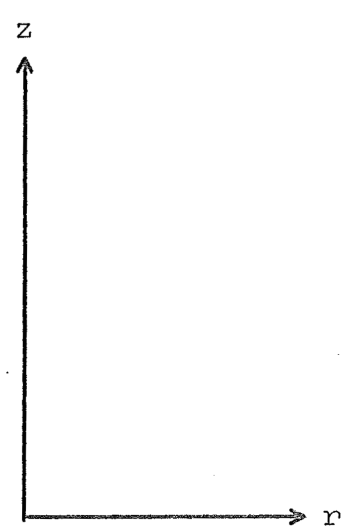


Figure 2. Coordinate System

3.1.1 Problem Input. The first three lines of the coding form contain general information about the problem. On the first line:

Spaces	Data
1 through 72	Enter any desired characters to be used as an identification title.

On the second line:

Spaces	Data
1 through 10	Contact Angle (Radians)
11 through 20	Bond Number

On the third line:

Spaces	Data
1 through 10	Enter the number of segments of the curve. The number must be right-adjusted, without a decimal point.
11 through 20	Enter the number of modes of oscillation desired. The number must be right-adjusted, without a decimal point.
21 through 30	Enter the liquid density (in kilograms per cubic meter).
31 through 40	Enter the r-coordinate (in inches) of the beginning of the segments of the curve.
41 through 50	Enter the z-coordinate (in inches) of the beginning of the segments of the curve.
51 through 60	Enter the number of baffles. The number must be right-adjusted, without a decimal point.

3.1.2 Tank Geometry Input. Beginning with the fourth line of the coding form, a line of the data below is required for each segment of the curve. Segments must be ordered in a continuous, counterclockwise path around the curve. The number of these lines of input must equal the number entered in spaces 1 through 10 of the third line of Problem Input (Section 3.1.1).

Spaces	Data
1 through 10	Enter the r-coordinate (in inches) of the end of the particular segment, having proceeded along the segment in a counterclockwise direction around the curve.
11 through 20	Enter the z-coordinate (in inches) of the end of the particular segment, having proceeded along the segment in a counterclockwise direction around the curve.

Spaces	Data
21 through 30	Leave blank for a straight line segment; otherwise, enter as follows, depending on the type of segment: Elliptical. Enter the r-coordinate (in inches) of the center of the ellipse. Circular. Enter the r-coordinate (in inches) of the center of the circle. Parabolic. Enter the r-coordinate (in inches) of the vertex of the parabola.
31 through 40	Leave blank for a straight line segment; otherwise, enter as follows, depending on the type of segment: Elliptical. Enter the z-coordinate (in inches) of the center of the ellipse. Circular. Enter the z-coordinate (in inches) of the center of the circle. Parabolic. Enter the z-coordinate (in inches) of the vertex of the parabola.
41 through 50	Leave blank for a straight line segment; otherwise enter, depending on the type of the segment, as follows: Elliptical. Enter the semimajor axis (in inches) of the ellipse. Circular. Enter the radius (in inches) of the circle. Parabolic. Enter the directrix (in inches) of the parabola.
51 through 60	Leave blank for a straight line or parabolic segment; otherwise enter, depending on the type of the segment, as follows: Elliptical. Enter the semiminor axis (in inches) of the ellipse. Circular. Enter the radius (in inches) of the circle.

Spaces	Data
61 through 70	Leave blank for a straight line or circular segment; enter the amount of counterclockwise rotation (in degrees) from the norm (as shown in Figure 3) of the ellipse if the segment is elliptical, or of the parabola if the segment is parabolic. It may be left blank for an angle of zero degrees.

3.1.3 Baffle Input. This data is entered only if a number is entered in spaces 51 through 60 of the third line of Problem Input (Section 3.1.1). Beginning with the next line of the coding form, a line of the data below is required for each baffle. The number of these lines must equal the number entered in spaces 51 through 60 of the third line of Problem Input (Section 3.1.1).

Spaces	Data
1 through 10	Enter the z-coordinate (in inches) of the baffle.
11 through 20	Enter the r-coordinate (in inches) of the inner end of the baffle.
21 through 30	Enter the r-coordinate (in inches) of the outer end of the baffle.

Normal Orientation of an Ellipse

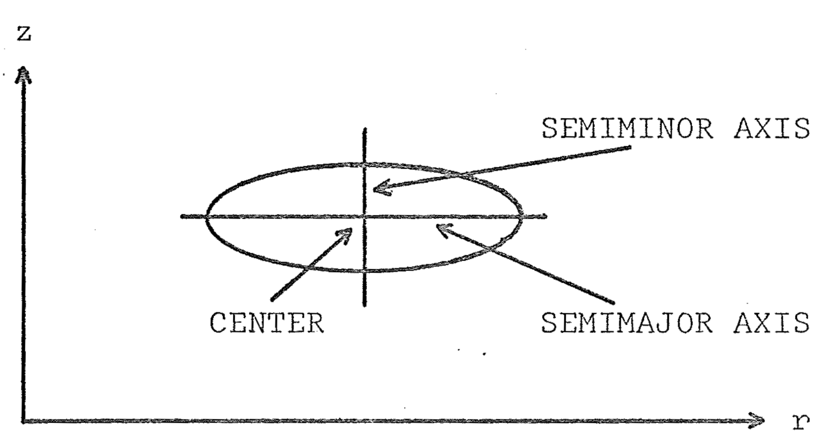
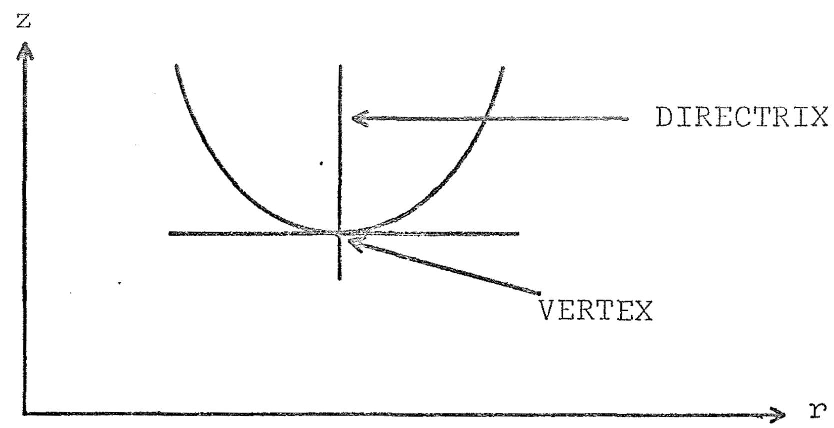


Figure 3. Normal Orientations for Tank Geometries

Normal Orientation of a Parabola



3.1.4 Case Input. Each case to be run requires a line of input as listed below. Any number of cases may be specified.

Space(s)	Data
1 through 10	Enter the z-coordinate (in inches) of the undisturbed free surface.
20	Leave blank to indicate three degrees of freedom; otherwise, enter the digit 6 to indicate six degrees of freedom.
21 through 30	Leave blank to indicate no force distribution coefficients; otherwise, enter the z-coordinate (in inches) of the point dividing the liquid into an UPPER and a LOWER region of partitions.
31 through 40	Leave blank to indicate no force distribution coefficients; otherwise, enter the increment (in inches) along the z-axis between force distribution partitions in the UPPER region of liquid.
41 through 50	Leave blank to indicate no force distribution coefficients; otherwise, enter the increment (in inches) along the z-axis between force distribution partitions in the LOWER region of liquid.

3.1.5 Restrictions on Input.

1. There can be no more than 50 segments.

2. There can be no more than 30 baffles.

3. There can be no more than 5 modes of oscillation.

4. Do not enter the tank centerline as a segment unless it is a segment of the curve.

5. The tank must not be completely full.

6. Each segment must be defined such that for a given r-coordinate, there is only a single value of the z-coordinate.

   i.e. A toroid must be described by 4 segments of the same circle:

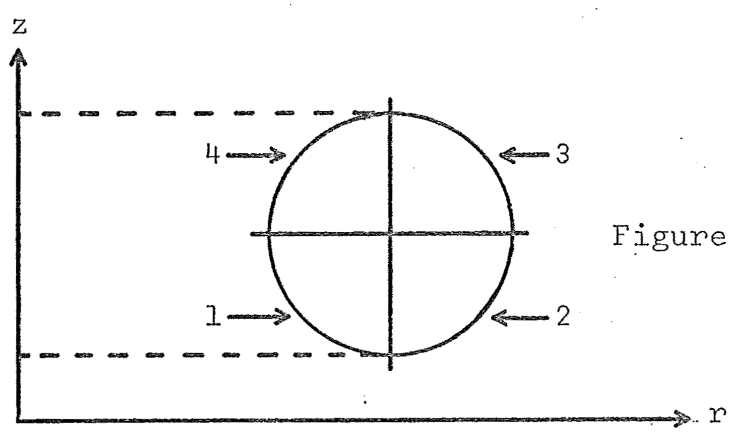


Figure 4. Toroid Geometry

3.2 DESCRIPTION OF OUTPUT. Program output consists of the following printed information:

A. Title Page

1. Name of the computer program

2. Identification title

3. Liquid density (in kilograms per cubic meter)

4. Contact Angle (radians)

5. Bond Number

6. Tank geometry - a description of all segments (in inches and degrees)

7. Lowest point in the tank (in inches)

B. Case Information (each case begins on a new page)

1. Identification title

2. Undisturbed free surface (in inches)

3. Mass of the liquid (in kg)

4. Undisturbed center of gravity (in inches)

5. Number of degrees of freedom

6. Eigenvalue statistics for each mode used - eigenvalue, and eigenvector and its normalizing factor

7. Force and moment equation nondimensional coefficients for each mode used:

K_n	γ_n	b_n	h_n
$a_n^* + L_1 b_n$	b_n^*	e_n^*	f_n^*
$g_n^* + L_1 e_n^*$	h_n^*	ℓ_n^*	

a_n $(=b_n)$, d_n — for 6 degrees of freedom only

8. Maximum wave height at the outer radius of the undisturbed free surface/x_1

9. Kinetic energy/$\dot{x}_1^2$ (in kg)

10. I'_{11} and its 4 terms (in kg-m^2)

11. I'_{22} and its 4 terms (in kg-m^2) — for 6 degrees of freedom only

12. I'_{33} (in kg-m^2) — for 6 degrees of freedom only

13. Force distribution coefficients for each partition used:

z-coordinates of partition (in inches)

α_2 coefficient (in kg), [${}_nA_\alpha$ of (5.17)]

$\ddot{\upsilon}$ coefficient (in kg-m), [${}_nB_\upsilon$ of (5.17)]

$\alpha_3\xi_1$ coefficient (in kg/m), [${}_nC_\xi$ of (5.17)]

$\alpha_3 x_1$ coefficient (in kg/m), [${}_nC_\xi K_1 b_1$ of (5.22)]

$\ddot{\xi}_1$ coefficient (in kg), [Q_n of (5.24)]*

14. Undisturbed center of pressure (in inches) only if force distribution coefficients have been calculated in the LOWER region of the liquid

15. Spring-mass analogy parameters for each mode used:

m_n (in kg)

ℓ_n (in inches)

K_n^*/α_3 (in kg/m)

16. Spring-mass analogy parameters for ALL modes used:

m_o (in kg)

ℓ_o (in inches)

I_o (in kg-m^2)

17.

τ

ν

β

$\overline{\beta}$

A^*

B^*

18. Baffle effect on energy for each baffle used:

Baffle z-coordinate (in inches)

Baffle r-coordinates (in inches)

Instantaneous dE/dt factor (in kg/m$^{3/4}$)
(see (4.23) of Reference 2)

---

* See Reference 2

Average dE/dt factor (in $kg/m^{3/4}$)
(see (4.27) of Reference 2)

C. Diagnostics

If normal program calculations cannot be continued, an appropriate diagnostic comment is printed out and either execution is terminated or continued with assumptions, or a new case is begun.

SECTION 4

REFERENCES

1. On the Motion of Liquids Enclosed in Aerospace Vehicle Tanks Under Weak Gravitational Fields, Vol. I, Theory, UNIDEV Report UR-00010, March 4, 1970.

2. D. O. Lomen, Analysis of Fluid Sloshing, General Dynamics Report GDC-DDE66-018, June 20, 1966.

SECTION 5

SAMPLE INPUT

```
ATLAS LØX TANK WITH RING BAFFLE      ALSØ A BAFFLE TØ SHØW BAFFLE ØUTPUT
0.7854    10.0
        7          3 114.3363        0.0       43.5        1
     60.0       0.0       0.0      00.0      60.0      43.5
     60.0      46.0
     56.0      46.0
     56.0      47.0
     60.0      47.0
     60.0      75.0
      0.0      75.0
     50.0      50.0      60.0
     55.0
```

SECTION 6

SAMPLE OUTPUT

ATLAS LOX TANK ...

LIQUID DENSITY = 0.11434E 03 KG/M**3

CONTACT ANGLE = 0.78540E 00 RADIANS

BOND NUMBER = 0.10000E 02

TANK GEOMETRY
LENGTH UNIT IS INCHES

SEGMENT	TYPE	FROM	TO	CHARACTERISTICS		ROTATED BY
1	ELLIPTICAL	R = 0.0000 Z = 43.5000	R = 60.0000 Z = 0.0000	SEMI-MAJOR AXIS = SEMI-MINOR AXIS = CENTER AT R =	60.0000 43.5000 0.0000 AND Z =	-0.0 DEGREES 0.0000
2	STRAIGHT LINE	R = 60.0000 Z = 0.0000	R = 60.0000 Z = 46.0000			
3	STRAIGHT LINE	R = 60.0000 Z = 46.0000	R = 56.0000 Z = 46.0000			
4	STRAIGHT LINE	R = 56.0000 Z = 46.0000	R = 56.0000 Z = 47.0000			
5	STRAIGHT LINE	R = 56.0000 Z = 47.0000	R = 60.0000 Z = 47.0000			
6	STRAIGHT LINE	R = 60.0000 Z = 47.0000	R = 60.0000 Z = 75.0000			
7	STRAIGHT LINE	R = 60.0000 Z = 75.0000	R = 0.0000 Z = 75.0000			

LOWEST POINT IN THE TANK IS AT 0.0000 INCHES

UNDISTURBED FREE SURFACE IS AT 55.0000 INCHES

MASS OF THE LIQUID = 0.54822E 03 KG

UNDISTURBED CENTER OF GRAVITY IS AT 39.9459 INCHES

3 DEGREES OF FREEDOM

EIGENVALUE = 0.10398E 01 EIGENVECTOR NORMALIZING FACTOR = -0.40660E-01 EIGENVECTOR

0.58104E 00
-0.88389E 00
0.10000E 01
-0.65231E 00
0.18270E 00
0.26805E 00
-0.27167E-01
0.16994E-02
-0.94783E-03
0.10035E-02

EIGENVALUE = 0.49273E 01 EIGENVECTOR NORMALIZING FACTOR = -0.12481E 02 EIGENVECTOR

0.96838E-01
-0.52558E 00
0.10000E 01
-0.83875E 00
0.26206E 00
-0.29099E-02
0.12808E 00
-0.30529E-02
0.19078E-02
0.33567E-03

EIGENVALUE = 0.83917E 01 EIGENVECTOR NORMALIZING FACTOR = -0.74610E-01 EIGENVECTOR

0.56773E-01
-0.42327E 00
0.10000E 01
-0.97724E 00
0.34132E 00
0.30848E-02
-0.14342E-01
0.23121E 00
0.20139E-02
0.25987E-02

COEFFICIENTS	MODE	KN	GAMMAN	BN	HN
	1	0.26088E 00	0.33850E-01	0.81729E 01	0.32318E 01
	2	0.12363E 01	0.75811E-03	-0.76397E 01	-0.39208E 01
	3	0.21055E 01	0.12456E-02	0.17484E 01	0.18011E 01

COEFFICIENTS	MODE	AN**L1BN	BN*	EN*	FN*
	1	0.18894E 01	0.15029E 02	-0.24434E 02	0.12519E 02
	2	-0.14220E 01	-0.16165E 03	0.26267E 03	-0.74753E 02
	3	-0.20175E-01	0.13395E 03	-0.31853E 03	0.58406E 02

```
COEFFICIENTS     MODE       GN*LIEN*        HN*                    LN*

                   1      -0.59155E 01     0.26981E 02     0.34842E 01
                   2       0.62411E 02    -0.16111E 03     0.20404E 02
                   3      -0.37547E 02     0.12588E 03     0.43988E 01

MAX. ETA/XN(1) =  0.83967E 00

KINETIC ENERGY/XN(1)**2 =  0.16169E 03 KG

IIIP =  0.89746E 03 KG-M**2 WHERE THE TERMS ARE    0.42813E 03    -0.15958E 03    0.64551E 02    0.56437E 03

B   =  0.10500E 04

SPRING-MASS PARAMETERS    MODE        MN              LN          KNSTAR/ALPHA(3)
                                     IN KG         IN INCHES        IN KG/M

                           1      0.32338E 03     0.30845E 02     0.22063E 03
                           2      0.29989E 02     0.32618E 02     0.96958E 02
                           3      0.43950E 01     0.40400E 02     0.24200E 02

                          MO =  0.19046E 03 KG
                          LO =  0.56542E 02 INCHES
                          IO =  0.28093E 03 KG-M**2


                                  TAU
                  0.19934691E 00  0.83717520E-02  0.20401593E-02
                  0.83717520E-02  0.37083925E-01  0.29440123E-02
                  0.20401593E-02  0.29440123E-02  0.15585736E 00

                                  NU
                  0.15508641E 00 -0.20740109E-01  0.26625504E-01
                 -0.20740109E-01  0.27736289E-02 -0.35606982E-02
                  0.26625504E-01 -0.35606982E-02  0.45711130E-02

                                  BETA
                 -0.89343667E-01 -0.94790910E 00  0.24172866E 01
                 -0.14001254E 02 -0.20150661E 02 -0.17436213E 02
                  0.75043588E 01 -0.67987229E 01 -0.59914721E 02

                                BETA BAR
                  0.00000000E-38 -0.12936326E 01  0.26481892E 01
                  0.14354215E 01  0.00000000E-38 -0.17865881E 02
                  0.10295697E 01 -0.65372191E 01  0.00000000E-38

                                   A*
                  0.33374813E 01  0.83870851E-01 -0.36014792E-01
                 -0.53644845E 02  0.83131278E 01  0.15887732E 02
                  0.74980173E 02 -0.25704973E 02  0.12893250E 02

                                   B*
                  0.34268251E 01  0.39744631E 00 -0.30680469E 00
                 -0.11320369E 02  0.28463806E 02  0.27058501E 02
                  0.92904601E 01 -0.15092991E 02  0.72807970E 02

                        NATURAL FREQUENCY CORRECTION
```

0.44671833E-02 0.10075340E 01 0.29957366E 01

BAFFLE	Z-COORDINATE IN INCHES	R-COORDINATES IN INCHES		INST. DE/DT FACTOR IN KG/M**(3./4.)	AVG. DE/DT FACTOR IN KG/M**(3./4.)
1	50.0000	50.0000	60.0000	-0.55007E 02	-0.14476E 02

SECTION 7

PROGRAM LISTING

```
C
C
C          SLOSH, LOW GRAVITY CORRECTION
C
C
C
      DIMENSION TITLE(12),TEMP(3)
      COMMON/GAMBO/GAMMAA,BO
      COMMON/CON/CON1,CON2,CON3,CON4,CON5,CON6,CON7,CON8,CON9
      COMMON/CCON/CCON10,CON11,CON14,CON15,CON16
      COMMON /GAUSS/NORD,X(8),W(8)
      COMMON/XW/XG(8),WG(8)
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /BAF/NBAF,ZBAF(30),RBAFI(30),RBAFO(30)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      COMMON /SEG/TYPE(50),BEGRPT,RPOINT(50),BEGZPT,ZPOINT(50),RC(50),
     2ZC(50),A(50),B(50),GAMMA(50),GAM(50)
      INTEGER TYPE
      REAL LEVEL,L,JN
      EXTERNAL F1,F2
      PI=3.14159265
      DO 1 I=1,NORD
      XG(I)=0.5*X(I)
      WG(I)=0.5*W(I)
    1 CONTINUE
C
C
C         PROBLEM DESCRIPTION
C
      READ (5,2) TITLE
    2 FORMAT (12A6)
      WRITE (6,3) TITLE
    3 FORMAT(1H1,24X,12A6)
      READ(5,10) GAMMAA,BO
      READ (5,5) NSEG,MODES,RHO,BEGRPT,BEGZPT,NBAF
    5 FORMAT (2I10,3F10.0,I10)
      IF (NSEG.GE.2.AND.NSEG.LE.50) GO TO 1005
      WRITE (6,8) NSEG
    8 FORMAT (1H0,I10,22H SEGMENT(S) IS INVALID)
      CALL EXIT
 1005 WRITE (6,1010) RHO
 1010 FORMAT (1H0,17HLIQUID DENSITY = ,E12.5,8H KG/M**3)
      WRITE(6,4) GAMMAA,BO
    4 FORMAT(/17H CONTACT ANGLE = ,E12.5,8H RADIANS//
     $          15H BOND NUMBER = ,E12.5)
C
C
      ZBOT=BEGZPT
      WRITE (6,1015)
 1015 FORMAT (1H0,52X,13HTANK GEOMETRY/
     249X,21HLENGTH UNIT IS INCHES//
     31X,7HSEGMENT,6X,4HTYPE,13X,4HFROM,18X,2HTO,26X,15HCHARACTERISTICS)
C
C
```

```
C         TANK GEOMETRY DESCRIPTION
C
          DO 50 I=1,NSEG
          READ (5,10) RPOINT(I),ZPOINT(I),RC(I),ZC(I),A(I),B(I),GAMMA(I)
       10 FORMAT (7F10.0)
          IF (RPOINT(I-1).LT.0.0.OR.RPOINT(I).LT.0.0.OR.RC(I).LT.0.0.OR.
         2A(I).LT.0.0.OR.B(I).LT.0.0.OR.GAMMA(I).LT.0.0.OR.GAMMA(I).GT.360.0
         3) GO TO 65
          IF (ZPOINT(I).LT.ZBOT) ZBOT=ZPOINT(I)
          IF (B(I).EQ.0.0) GO TO 30
          TYPE(I)=1
          IF (A(I).NE.B(I)) GO TO 20
          WRITE (6,15) I,RPOINT(I-1),RPOINT(I),A(I),ZPOINT(I-1),ZPOINT(I),RC
         2(I),ZC(I)
       15 FORMAT (1H0,2X,I2,7X,8HCIRCULAR,6X,4HR = ,F10.4,7X,
         24HR = ,F10.4,5X,          9HRADIUS = ,F10.4           /26X,4HZ = ,
         3F10.4,7X,            4HZ = ,F10.4,5X,           14HCENTER AT R = ,
         4F10.4,9H AND Z = ,F10.4)
          GO TO 50
       20 WRITE (6,25) I,RPOINT(I-1),RPOINT(I),A(I),ZPOINT(I-1),ZPOINT(I),
         2B(I),GAMMA(I),RC(I),ZC(I)
       25 FORMAT (1H0,2X,I2,6X,10HELLIPTICAL,5X,4HR = ,F10.4,7X,
         24HR = ,F10.4,5X,          18HSEMI-MAJOR AXIS = ,F10.4,9X,
         310HROTATED BY/26X,4HZ = ,F10.4,7X,          4HZ = ,F10.4,
         45X,18HSEMI-MINOR AXIS = ,F10.4,7X,          F6.1,8H DEGREES/66X,
         514HCENTER AT R = ,F10.4,9H AND Z = ,F10.4)
          GO TO 50
       30 IF (A(I).NE.0.0) GO TO 40
          TYPE(I)=2
          WRITE (6,35) I,RPOINT(I-1),RPOINT(I),ZPOINT(I-1),ZPOINT(I)
       35 FORMAT (1H0,2X,I2,4X,13HSTRAIGHT LINE,4X,4HR = ,F10.4,7X,
         24HR = ,F10.4          /26X,4HZ = ,F10.4,7X,4HZ = ,F10.4)
          GO TO 50
       40 TYPE(I)=3
          WRITE (6,45) I,RPOINT(I-1),RPOINT(I),A(I),ZPOINT(I-1),ZPOINT(I),GA
         2MMA(I),RC(I),ZC(I)
       45 FORMAT (1H0,2X,I2,6X,9HPARABOLIC,6X,4HR = ,F10.4,7X,
         24HR = ,F10.4,5X,          12HDIRECTRIX = ,F10.4,9X,
         310HROTATED BY/26X,4HZ = ,F10.4,7X,          4HZ = ,F10.4,
         436X,F6.1,8H DEGREES/66X,14HVERTEX AT R = ,F10.4,9H AND Z = ,F10.4)
       50 CONTINUE
          WRITE (6,55) ZBOT
       55 FORMAT (1H0,31HLOWEST POINT IN THE TANK IS AT ,F10.4,7H INCHES)
          IF (BEGZPT.EQ.ZPOINT(NSEG).AND.BEGRPT.EQ.RPOINT(NSEG).OR.
         2BEGZPT.NE.ZPOINT(NSEG).AND.BEGRPT.EQ.0.0.AND.RPOINT(NSEG).EQ.0.0)
         3GO TO 75
          WRITE (6,60)
       60 FORMAT (1H0, 18HTANK IS NOT CLOSED)
          CALL EXIT
       65 WRITE (6,70) I
       70 FORMAT (1H0, 15HSEGMENT NUMBER ,I2,11H IS INVALID)
          CALL EXIT
       75 ZBOT=ZBOT*0.0254
          BEGRPT=BEGRPT*0.0254
          BEGZPT=BEGZPT*0.0254
          DO 80 I=1,NSEG
```

```
      RPOINT(I)=RPOINT(I)*0.0254
      ZPOINT(I)=ZPOINT(I)*0.0254
      RC(I)=RC(I)*0.0254
      ZC(I)=ZC(I)*0.0254
      A(I)=A(I)*0.0254
      B(I)=B(I)*0.0254
      GAM(I)=GAMMA(I)*PI/180.0
   80 CONTINUE
C
C
C        READ BAFFLE INPUT CARD(S)
C
      IF (NBAF.LT.1.OR.NBAF.GT.30) GO TO 100
      DO 95 I=1,NBAF
      READ (5,90) ZBAF(I),RBAFI(I),RBAFO(I)
   90 FORMAT (3F10.0)
      ZBAF(I)=ZBAF(I)*0.0254
      RBAFI(I)=RBAFI(I)*0.0254
      RBAFO(I)=RBAFO(I)*0.0254
   95 CONTINUE
C
C
C        READ A CASE INPUT CARD AND BEGIN A NEW CASE OR TERMINATE RUN
C
  100 READ (5,105) LEVEL,IDEGR,ZDIV,DZ(1),DZ(2)
  105 FORMAT (F10.0,I10,3F10.0)
      LEVEL=LEVEL*0.0254
      ZDIV=ZDIV*0.0254
      DZ(1)=DZ(1)*0.0254
      DZ(2)=DZ(2)*0.0254
      IF (LEVEL.LE.ZBOT) GO TO 170
      IF (IDEGR.NE.6) IDEGR=3
C
C
C        FIND THE OUTER RADIUS AND THE RATIO OF THE INNER RADIUS TO THE
C
C        OUTER RADIUS OF THE UNDISTURBED FREE SURFACE
      AS=0.0
      TEMP(1)=0.0
      IFLAG=0
      DO 130 I=1,NSEG
      IF (ZPOINT(I).EQ.ZPOINT(I-1)) GO TO 130
      IF (IFLAG.EQ.0) GO TO 115
      IFLAG=0
      GO TO 130
  115 ARG1=LEVEL-ZPOINT(I)
      ARG2=LEVEL-ZPOINT(I-1)
      IF (ARG1.NE.0.0) GO TO 120
      RR=RPOINT(I)
      IFLAG=1
      GO TO 125
  120 IF (ARG1/ABS(ARG1).EQ.ARG2/ABS(ARG2)) GO TO 130
      CALL FINDR (I,LEVEL,RR)
  125 IF (AS.LT.RR) AS=RR
      IF (TEMP(1).GT.0.0) GO TO 135
      TEMP(1)=RR
```

```
  130 CONTINUE
      IF (AS.LE.0.0) GO TO 170
      EPSL=0.0
      GO TO 140
  135 IF (TEMP(1).GT.RR) TEMP(1)=RR
      EPSL=TEMP(1)/AS
C
C
C        FIND THE UNDISTURBED CENTER OF GRAVITY AND THE LIQUID VOLUME
C
  140 ZCG=0.0
      CALL INTG1 (F1,LEVEL,ZBOT)
      ZCG=ANS
      CALL INTG1 (F2,LEVEL,ZBOT)
      ZCG=ZCG/ANS
      VOL=ANS*PI
C
C
      L=LEVEL-ZCG
      D=ZCG-ZBOT
      H=LEVEL-ZBOT
C
C
C        ESTABLISH THE CENTER OF ROTATION
C
      G1=0.0
      G2=0.0
      G3=D
C
C
C        DETERMINE THE NUMBER OF EIGENFUNCTIONS TO BE USED FOR THE
C        EIGENVALUE PROBLEM
C
      TEMP(1)=88.0296927(2.0*L/AS)
      DO 145 I=1,5
      J=6-I
      IF (JN(J).LT.TEMP(1)) GO TO 150
  145 CONTINUE
      GO TO 170
  150 MORDER=MPOLY+J
C
C
C        CHECK VALIDITY OF MODES
C
      IF (MODES.LT.1.OR.MODES.GT.J) MODES=J
C
C
      TEMP(1)=LEVEL/0.0254
      TEMP(2)=RHO*VOL
      TEMP(3)=ZCG/0.0254
      WRITE (6,165) TITLE,TEMP,IDEGR
  165 FORMAT (1H1,23X,12A6///
     21X,31HUNDISTURBED FREE SURFACE IS AT ,F10.4,7H INCHES///
     35X,21HMASS OF THE LIQUID = ,E12.5,3H KG//
     45X,36HUNDISTURBED CENTER OF GRAVITY IS AT ,F10.4,7H INCHES//
     55X,I1,1X,18HDEGREES OF FREEDOM)
```

```
C
C
      CON1=AS*COS(GAMMAA)
      CON2=PI*AS**2*L/VOL
      CON3=CON1/L
      CON4=PI*L**3/VOL
      CON5=2.0*CON4
      CON6=(AS/L)**2
      CON7=CON1*PI*L**2/VOL
      CON8=PI*AS**2/VOL
      CON9=L/2.0
      CCON10=PI*AS/VOL
      CON11=AS*AS
      CON14=COS(GAMMAA)
      CON15=L**2
      CON16=L**3
      CALL MATRIX
      GO TO 100
C
C
  170 TEMP(1)=LEVEL/0.0254
      WRITE (6,175) TITLE,TEMP(1)
  175 FORMAT (1H1,23X,12A6///1X,28HUNDISTURBED FREE SURFACE AT ,F10.4,
     218H INCHES IS INVALID)
      GO TO 100
C
C
      END
```

```
$IBFTC MATRIX  LIST,DECK
```

```
      SUBROUTINE MATRIX
      DIMENSION BETA(10,10),BETAB(10,10),Q(10),QB(10),OMEGAC(10)
      DIMENSION XINT(10,10),XINT2(10,10),TAU(10,10),XNU(10,10),
     $SUMM(10)
      DIMENSION ZFORCE(3),ALPHIN(10),           CCALC(5),CPRINT(5)
      DIMENSION JJN(5)
      DIMENSION AMN(10,10),BMN(10,10),A(10,10),B(10,10)
      DIMENSION CNK(10,10),LAMBDA(10),HNSTAR(10)
      DIMENSION KN(5),GAMMAN(5),BN(5),HN(5),LN(5),MN(5),KNSTAR(5),ON(5)
      DIMENSION LTMAT(10,10),RTSIDE(10),QN(10),TERM(4)
      DIMENSION RHON(10),ASCOEF(10,10),BSCOEF(10,10),AACOEF(10),
     $BCOEF(10),ECOEF(10),FCOEF(10),GCOEF(10),HCOEF(10),XLCOEF(10)
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON/GAMBO/GAMMAA,BO
      COMMON/CON/CON1,CON2,CON3,CON4,CON5,CON6,CON7,CON8,CON9
      COMMON/CCON/CCON10,CON11,CON14,CON15,CON16
      COMMON /BAF/NBAF,ZBAF(30),RBAFI(30),RBAFO(30)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /GAUSS/NORD,X(8),W(8)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      COMMON/BES/BII,BID1,BIJ,BIDJ,XI1,XJ1,I,J,J1,II,JJ
      REAL JN,JNM,JNN,JJN
      REAL L,LAMBDA,KN,KNSTAR,LN,MN,MO,LO,IO,LEVEL
      REAL I11P,I33P,LTMAT
      EXTERNAL F1,F2,F4,F5,F6,F7,F8,F9,F12,     F14,F15,F16,F17,F18
      EXTERNAL F28,F29,F30,F31
      DATA JJN/0.58186522,-0.3461262,0.27329994,-0.23330442,0.20701265/
C
C
C        EIGENVALUE PROBLEM
C
      DO 60 M=1,MORDER
      DO 60 N=M,MORDER
      IF (M.GT.MPOLY) GO TO 35
      IF (N.GT.MPOLY) GO TO 15
      CALL INIG2 (F6,LEVEL,ZBOT)
      AMN(M,N)=-(4.*FLOAT(M*N)-2.*FLOAT(M+N)+2.)*ANS
      BMN(M,N)=(1.-EPSL**(2*(M+N)))/(2.*FLOAT(M+N))
      GO TO 50
   15 I=N-MPOLY
      JNN=JN(I)
      CALL INTG2 (F7,LEVEL,ZBOT)
      AMN(M,N)=-EXP(-JNN*L/AS)/JNN*ANS
      CALL BESSEL (JNN,BIP,BID)
      ARG=JNN*EPSL
      CALL BESSEL (ARG,BI,BID)
      IF (M.GT.1) GO TO 25
      BMN(1,N)=1./JNN**3*(JNN*BIP-ARG*BI+ARG**2*BID)
      GO TO 50
   25 BMN(M,N)=1./JNN**2*(FLOAT(2*M-1)*BIP-EPSL**(2*M-1)*(FLOAT(2*M-1)*
     2BI-ARG*BID)-4.*FLOAT(M*(M-1))*BMN(M-1,N))
      GO TO 50
   35 I=M-MPOLY
      JNM=JN(I)
```

```
      I=N-MPOLY
      JNN=JN(I)
      CALL INTG2 (F8,LEVEL,ZBOT)
      SUMJ=JNM+JNN
      AMN(M,N)=-EXP(-SUMJ*L/AS)/SUMJ*ANS
      IF (M.EQ.N) GO TO 45
      ARG1=JNN*EPSL
      CALL BESSEL (ARG1,B1N,B1DN)
      ARG2=JNM*EPSL
      CALL BESSEL (ARG2,B1M,B1DM)
      BMN(M,N)=(ARG2*B1N*B1DM-ARG1*B1M*B1DN)/(ARG2**2-ARG1**2)*EPSL**2
      GO TO 50
   45 CALL BESSEL (JNN,B1P,B1D)
      ARG=JNN*EPSL
      CALL BESSEL (ARG,B1,B1D)
      BMN(M,N)=((JNN**2-1.)*B1P**2-(ARG*B1D)**2-(ARG**2-1.)*B1**2)/
     2(2.*JNN**2)
   50 AMN(N,M)=AMN(M,N)
      BMN(N,M)=BMN(M,N)
      A(M,N)=AMN(M,N)
      A(N,M)=AMN(M,N)
      B(M,N)=BMN(M,N)
      B(N,M)=BMN(M,N)
   60 CONTINUE
C
      CALL JACOBI (10,MORDER,IERR,B,A,CNK,LAMBDA,MODES)
      IF (IERR.EQ.0) GO TO 100
      WRITE (6,80)
   80 FORMAT (1H0,35HEIGENVALUE PROBLEM CANNOT BE SOLVED)
      RETURN
C
C
C         NON-DIMENSIONAL COEFFICIENTS
C
  100 DO 105 N=1,MODES
      GAMMAN(N)=0.0
      DO 105 K=1,MORDER
      DO 105 J=1,MORDER
  105 GAMMAN(N)=GAMMAN(N)+PI*L*AS**2/VOL*CNK(K,N)*CNK(J,N)*BMN(K,J)
      DO 110 M=1,MORDER
      CALL INTG1 (F9,LEVEL,ZBOT)
  110 HNSTAR(M)=ANS
      DO 115 N=1,MODES
      HN(N)=0.0
      BN(N)=0.0
      KN(N)=L/(LAMBDA(N)*AS)
      DO 115 M=1,MORDER
      HN(N)=HN(N)+2.*PI*AS**3/(VOL*GAMMAN(N)*KN(N))*CNK(M,N)*HNSTAR(M)
  115 BN(N)=BN(N)+PI*AS**3/(VOL*GAMMAN(N))*CNK(M,N)*BMN(1,M)
      IF (IDEGR.NE.6) GO TO 295
      WRITE (6,130)
  130 FORMAT (1H0,4X,21HCOEFFICIENTS      MODE,10X,2HKN,14X,6HGAMMAN,12X,
     27HAN  =  BN,13X,2HHN,16X,2HDN//)
      DO 140 N=1,MODES
      DN(N)=2.0*BN(N)-HN(N)
  140 WRITE (6,145) N,KN(N),GAMMAN(N),BN(N),HN(N),DN(N)
```

```
  145 FORMAT (24X,I1,5E18.5)
      GO TO 750
  295 WRITE (6,300)
  300 FORMAT (1H0,4X,21HCOEFFICIENTS       MODE,10X,2HKN,14X,6HGAMMAN,14X,
     22HBN,16X,2HHN//)
      DO 305 N=1,MODES
  305 WRITE (6,310)  N,KN(N),GAMMAN(N),BN(N),HN(N)
  310 FORMAT (24X,I1,4E18.5)
C
C
C        MAXIMUM WAVE HEIGHT AT THE OUTER RADIUS OF THE UNDISTURBED
C        FREE SURFACE AND THE KINETIC ENERGY
C
  750 TERM(1)=0.0
      DO 770 J=1,MORDER
      IF (J.GT.MPOLY) GO TO 760
      TERM(1)=TERM(1)+CNK(J,1)
      GO TO 770
  760 I=J-MPOLY
      TERM(1)=TERM(1)+CNK(J,1)*JJN(I)
  770 CONTINUE
      TERM(1)=TERM(1)*KN(1)*BN(1)
      TERM(2)=0.0
      DO 780 J=1,MORDER
      DO 780 K=1,MORDER
  780 TERM(2)=TERM(2)+CNK(J,1)*CNK(K,1)*AMN(J,K)
      TERM(2)=TERM(2)*RHO*PI*AS*L**2*BN(1)**2/2.0
      TERM1=TERM(1)
      TERM2=TERM(2)
C
C
C        CALCULATE THE POLYNOMIAL COEFFICIENTS OF THE EIGENFUNCTIONS
C        ASSUMED FOR THE BVP NOS. 1 AND 2
C
      DO 800 N=1,NPOLY
  800 ACOEF(N,1)=1.0
      DO 805 N=2,NPOLY
      DO 805 K=2,N,2
  805 ACOEF(N,K)=0.0
      DO 810 N=3,NPOLY
      DO 810 K=3,N,2
  810 ACOEF(N,K)=-FLOAT((N-K+2)*(N-K+1))/FLOAT(K**2-1)*ACOEF(N,K-2)
C
C
C        BOUNDARY VALUE PROBLEM NO. 1
C
      CALL INTG2 (F4,LEVEL,ZBOT)
      TERM(1)=-PI*RHO*ANS
C
      CALL INTG2 (F5,LEVEL,ZBOT)
      TERM(2)=8./3.*PI*RHO*ANS
C
      TERM(3)=0.0
      DO 223 M=1,NORDER
      CALL INTG1 (F18,LEVEL,ZBOT)
      RTSIDE(M)=2.0*AS**2/L**2*ANS
```

```
      DO 223 N=M,NORDER
      IF (M.GT.NPOLY) GO TO 222
      IF (N.GT.NPOLY) GO TO 220
      CALL INTG2 (F16,LEVEL,ZBOT)
      LTMAT(M,N)=-ANS
      GO TO 223
  220 CALL INTG2 (F17,LEVEL,ZBOT)
      LTMAT(M,N)=-ANS
      GO TO 223
  222 CALL INTG2 (F15,LEVEL,ZBOT)
      LTMAT(M,N)=ANS
  223 LTMAT(N,M)=LTMAT(M,N)
      CALL SOLVE (NORDER,LTMAT,RTSIDE,1,1.0E-8,25,QN,IERR)
      IF (IERR.GT.0) GO TO 245
      WRITE (6,230)
  230 FORMAT (1H0,4X,65HTHIRD TERM OF I11P CANNOT BE CALCULATED - IT IS
     2SET EQUAL TO ZERO)
      GO TO 255
  245 DO 250 M=1,NORDER
      CALL INTG1 (F18,LEVEL,ZBOT)
  250 TERM(3)=TERM(3)+2.0*RHO*PI*L**2*AS**3*QN(M)*ANS
C
  255 TERM(4)=(G2**2+G3**2)*RHO*VOL
C
      I11P=TERM(1)+TERM(2)+TERM(3)+TERM(4)
      TERM11=TERM(1)
      TERM12=TERM(2)
      TERM13=TERM(3)
      TERM14=TERM(4)
C
C     COMPUTE PSI1
      PSI1=0.0
      DO 819 N=1,NORDER
      IF(N.GT.NPOLY) GO TO 817
      PSUM=0.0
      DO 815 J=1,N
      PSUM=PSUM+ACOEF(N,J)*(L/AS)**(N-J)
  815 CONTINUE
      PSI1=PSI1+QN(N)*PSUM
      GO TO 819
  817 ARG=FLOAT(N-6)*PI/H
      ARG1=ARG*AS
      CALL FMODBS(ARG1,PBS,PBSP)
      PSI1=PSI1+PBS*COS(ARG*(L+D))*QN(N)
  819 CONTINUE
C
C     COMPUTE RHON
      DO 827 I=1,MODES
      RHON(I)=0.0
      DO 827 M=1,MORDER
      II=M-NPOLY
      JNM=JN(II)
      RHOSUM=0.0
      DO 825 N=1,NORDER
      IF(N.GT.NPOLY) GO TO 821
      CALL INTG3(F30)
```

```
      GO TO 823
  821 CALL INTG3(F31)
  823 RHOSUM=RHOSUM*QN(N)*ANS
  825 CONTINUE
      RHON(I)=RHON(I)+CNK(M,I)*RHOSUM
  827 CONTINUE
C
C
      IF (IDEGR.NE.6) GO TO 2950
C
C
C        BOUNDARY VALUE PROBLEM NO. 2
C
C
C        I22P IS THE SAME AS I11P
C
C        TERM(1) FOR THE BOUNDARY VALUE PROBLEM NO. 2 IS THE SAME
C        AS FOR THE BOUNDARY VALUE PROBLEM NO. 1
C
      CALL INTG2 (F14,LEVEL,ZBOT)
      TERM(2)=4.0*RHO*PI*ANS
C
      TERM(4)=(G1**2+G3**2)*RHO*VOL
C
      IF (IERR.GT.0) GO TO 425
      WRITE (6,410)
  410 FORMAT (1H0,4X,65HTHIRD TERM OF I22P CANNOT BE CALCULATED - IT IS
     2SET EQUAL TO ZERO)
      TERM(3)=0.0
      GO TO 435
  425 TERM(3)=I11P-TERM(1)-TERM(2)-TERM(4)
C
  435 WRITE (6,450) I11P,(TERM(I),I=1,4)
  450 FORMAT (1H0,4X,7HI22P = ,E12.5,28H KG-M**2 WHERE THE TERMS ARE,
     24E16.5)
C
C
C        BOUNDARY VALUE PROBLEM NO. 3
C
      I33P=(G1**2+G2**2)*RHO*VOL
      WRITE (6,500) I33P
  500 FORMAT (1H0,4X,7HI33P = ,E12.5,8H KG-M**2)
C
C
      RETURN
C
C
C        FORCE DISTRIBUTION COEFFICIENTS
C
 2950 IF (DZ(1).EQ.0.0.AND.DZ(2).EQ.0.0) GO TO 200
      ARG4=0.0
      ARG5=0.0
      DO 2955 J=1,5
 2955 CCALC(J)=0.0
      IF (DZ(1).NE.0.0) GO TO 2960
      I=2
```

```
      ZFORCE(1)=ZDIV-DZ(2)
      ZFORCE(2)=ZDOT
      GO TO 2965
 2960 I=1
      ZFORCE(1)=LEVEL-DZ(1)
      ZFORCE(2)=ZDIV
 2965 ZFORCE(3)=LEVEL
      ARG3=LEVEL/0.0254
      WRITE (6,2970) ARG3
 2970 FORMAT (1H0,4X,31HFORCE DISTRIBUTION COEFFICIENTS//
     26X,12HZ-COORDINATE,
     35X,14HALPHA(2) COEF.,
     46X,13HTHETA.. COEF.,
     52X,20HALPHA(3)*XI(1) COEF.,
     61X,20HALPHA(3)*XN(1) COEF.,
     71X,13HXI(1).. COEF./
     88X,9HIN INCHES,
     911X,5HIN KG,
     213X,7HIN KG-M,
     321X,7HIN KG/M,
     423X,5HIN KG//
     5F17.4)
C
 3000 M=1
      ARG3=ZFORCE(1)/0.0254
      DO 3015 N=1,MORDER
      IF (N.GT.MPOLY) GO TO 3010
      CALL INTG2 (F6,LEVEL,ZFORCE(1))
      ALPHIN(N)=-(4.*FLOAT(N)-2.*FLOAT(N+1)+2.)*ANS
      GO TO 3015
 3010 J=N-MPOLY
      JNN=JN(J)
      CALL INTG2 (F7,LEVEL,ZFORCE(1))
      ALPHIN(N)=-EXP(-JNN*L/AS)/JNN*ANS
 3015 CONTINUE
      ARG1=0.0
      DO 3020 N=1,MORDER
 3020 ARG1=ARG1+PI*AS**2*CNK(N,1)*ALPHIN(N)
      CALL INTG1 (F2,LEVEL,ZFORCE(1))
      VM=PI*ANS
C
      CPRINT(1)=CCALC(1)
      CCALC(1)=-RHO*(VM-BN(1)*L*ARG1)
      CPRINT(1)=CCALC(1)-CPRINT(1)
C
      CPRINT(3)=CCALC(3)
      CCALC(3)=RHO*ARG1
      CPRINT(3)=CCALC(3)-CPRINT(3)
C
      CPRINT(4)=CCALC(4)
      CCALC(4)=CCALC(3)*KN(1)*BN(1)
      CPRINT(4)=CCALC(4)-CPRINT(4)
C
      CPRINT(5)=CCALC(5)
      CCALC(5)=-L/KN(1)*CCALC(3)
      CPRINT(5)=CCALC(5)-CPRINT(5)
```

```
      IF (DZ(2).EQ.0.0) GO TO 3025
      CALL INTG1 (F1,ZFORCE(3),ZFORCE(1))
      ZCGM=ANS
      CALL INTG1 (F2,ZFORCE(3),ZFORCE(1))
      ZCGM=ZCGM/ANS+ZCG
      ARG4=ARG4+CPRINT(5)*ZCGM
      ARG5=ARG5+CPRINT(5)
C
 3025 IF (IERR.GT.0) GO TO 3045
      WRITE (6,3030) CPRINT(1),(CPRINT(J),J=3,5),ARG3
 3030 FORMAT (17X,E19.5,19X,3E19.5/F17.4)
      GO TO 3995
 3045 ARG2=0.0
      DO 3060 N=1,NORDER
      IF (N.GT.NPOLY) GO TO 3050
      CALL INTG2 (F16,LEVEL,ZFORCE(1))
      GO TO 3060
 3050 CALL INTG2 (F17,LEVEL,ZFORCE(1))
 3060 ARG2=ARG2-PI*(AS*L)**2*QN(N)*ANS
C
      CPRINT(2)=CCALC(2)
      CALL INTG1 (F1,LEVEL,ZFORCE(1))
      CCALC(2)=RHO*(PI*ANS-G3*VM-ARG2+(G3*BN(1)-L*(BN(1)-HN(1)))*L*ARG1)
      CPRINT(2)=CCALC(2)-CPRINT(2)
C
      WRITE (6,3980) (CPRINT(J),J=1,5),ARG3
 3980 FORMAT (17X,5E19.5/F17.4)
C
 3995 ZFORCE(3)=ZFORCE(1)
      ZFORCE(1)=ZFORCE(1)-DZ(I)
      IF (ZFORCE(1).GE.ZFORCE(2)) GO TO 3000
      IF (ZFORCE(2).EQ.ZFORCE(3)) GO TO 4000
      ZFORCE(1)=ZFORCE(2)
      GO TO 3000
 4000 IF (DZ(2).EQ.0.0) GO TO 200
      IF (I.EQ.2) GO TO 4005
      I=2
      ZFORCE(1)=ZDIV-DZ(2)
      ZFORCE(2)=ZBOT
      GO TO 3000
C
 4005 ZCP=ARG4/ARG5/0.0254
      WRITE (6,4010) ZCP
 4010 FORMAT (1H0,4X,37HUNDISTURBED CENTER OF PRESSURE IS AT ,F10.4,
     27H INCHES)
C
C
C          SPRING-MASS ANALOGY PARAMETERS
C
  200 DO 205 N=1,MODES
      LN(N)=G3-L+L*HN(N)/BN(N)
      MN(N)=RHO*VOL*GAMMAN(N)*BN(N)**2*KN(N)
  205 KNSTAR(N)=MN(N)*KN(N)/L
      MO=RHO*VOL
      DO 210 N=1,MODES
  210 MO=MO-MN(N)
```

```
      LO=G3*RHO*VOL/MO
      DO 215 N=1,MODES
  215 LO=LO-RHO*VOL*(GAMMAN(N)*BN(N)*KN(N)*(G3*BN(N)-L*(BN(N)-HN(N))))
     2/MO
      IO=I11P-MO*LO**2
      DO 290 N=1,MODES
  290 IO=IO-MN(N)*LN(N)**2
C
C     COMPUTE INTEGRAL FOR TAU
C
      DO 75 I=1,MORDER
      XI1=2*I-1
      DO 75 J=1,MORDER
      J1=2*J-1
      XJ1=J1
      IF(I.GT.MPOLY) GO TO 65
      IF(J.GT.MPOLY) GO TO 70
      ANS=((XI1*XJ1+1.0)/(XI1+XJ1))
      XINT(I,J)=ANS
      GO TO 75
   65 I1=I-MPOLY
      JNN=JN(I1)
      JJ=J-MPOLY
      JNM=JN(JJ)
      CALL INTG3(F28)
      XINT(I,J)=ANS
      GO TO 75
   70 JJ=J-MPOLY
      JNM=JN(JJ)
      CALL INTG3(F29)
      XINT(I,J)=ANS
   75 CONTINUE
C
C     COMPUTE TAU AND XNU
C
      DO 95 M=1,MODES
      DO 87 N=M,MODES
      TAU(M,N)=0.0
      DO 87 I=1,MORDER
      DO 87 J=1,MORDER
      IF(I.GT.J) GO TO 81
      XINT2(I,J)=XINT(I,J)
      GO TO 85
   81 XINT2(I,J)=XINT(J,I)
   85 TAU(M,N)=TAU(M,N)+CNK(I,N)*CNK(J,M)*XINT2(I,J)
   87 TAU(N,M)=TAU(M,N)
      SUMM(M)=0.0
      DO 90 I=1,MPOLY
      SUMM(M)=SUMM(M)+CNK(I,M)
   90 CONTINUE
      M1=MPOLY+1
      DO 92 I=M1,MORDER
      I1=I-MPOLY
      JNN=JN(I1)
      CALL BESSEL(JNN,B1,B10)
      SUMM(M)=SUMM(M)+CNK(I,M)*B1
```

```
   92 CONTINUE
      AACOEF(M)=L*(BN(M)-HN(M))
   95 CONTINUE
      DO 128 N=1,MODES
      ECOEF(N)=0.0
      GCOEF(N)=0.0
      BCCOEF=0.0
      CON10=CCON10/GAMMAN(N)
      CON13=CON2/GAMMAN(N)
      DO 126 M=1,MODES
      XNU(N,M)=SUMM(N)*SUMM(M)
      IF(N.EQ.M) GO TO 116
      DELNM=0.0
      CON12=KN(N)/(KN(N)-KN(M))
      GO TO 118
  116 DELNM=1.0
      BETAB(N,M)=0.0
      ASCOEF(N,M)=CON10*CON15*CON14*(2.0*TAU(N,N)-XNU(N,N))/KN(N)
     $+KN(N)*CON1*(CON13*XNU(N,N)-2.0)/L
      BSCOEF(N,M)=CON13*TAU(N,N)
      GO TO 120
  118 BETAB(N,M)=-CON2*TAU(N,M)/GAMMAN(N)-CON3*KN(M)*
     $(-CON5*TAU(N,M)/(KN(M)*KN(M)*GAMMAN(N))+CON4*(1.0/(KN(M)*KN(M))
     $-CON6)*XNU(N,M)/GAMMAN(N))
  120 BETA(N,M)=-CON2*TAU(N,M)/GAMMAN(N)-CON3*KN(M)*(2.0*SQRT
     $(GAMMAN(M)/GAMMAN(N))*DELNM-CON5*TAU(N,M)/(KN(N)*KN(M)*GAMMAN(N))
     $+CON4*(1.0/(KN(N)*KN(M))-CON6)*XNU(N,M)/GAMMAN(N))
      IF(N.EQ.M) GO TO 124
      ASCOEF(N,M)=CON12*BETAB(N,M)+CON10*CON11*KN(N)*XNU(N,M)*CON14
      BSCOEF(N,M)=CON12*BETA(N,M)+CON13*TAU(N,M)
  124 CONTINUE
      ECOEF(N)=-BSCOEF(N,M)*BN(M)+ECOEF(N)
      GCOEF(N)=-BSCOEF(N,M)*AACOEF(M)+GCOEF(N)
  126 CONTINUE
      OMEGAC(N)=-0.5*BETA(N,N)/BO
      TEMP=(SUMM(N)*PSI1-2.0*RHON(N))*CON15*CON14/AS
      BCOEF(N)=CON13 * TEMP/KN(N)+CON10*CON11*CON1*(SUMM(N)-2.0*VOL
     $*GAMMAN(N)*BN(N)/(PI*AS**3))
      FCOEF(N)=CON10*CON1*SUMM(N)
      HCOEF(N)=CON10*CON11*SUMM(N)
      XLCOEF(N)=CON13*L*TEMP*(BN(N)+0.5*HN(N))
      BCCOEF=BCCOEF+GAMMAN(N)*XLCOEF(N)
  128 CONTINUE
      BCCOEF=RHO*VOL*(PI*AS**5*CON14/(2.0*VOL)+2.0*BCCOEF)
      WRITE(6,11110)
11110 FORMAT(1H0,4X,21HCOEFFICIENTS      MODE,8X,8HAN*+L1BN,12X,3HBN*,
     $15X,3HEN*,15X,3HFN*//)
      DO 829 N=1,MODES
  829 WRITE(6,11111)N,AACOEF(N),BCOEF(N),ECOEF(N),FCOEF(N)
11111 FORMAT(24X,I1,4E18.5)
      WRITE(6,11112)
11112 FORMAT(1H0,4X,21HCOEFFICIENTS      MODE,7X,9HGN*+L1EN*,12X,3HHN*,
     $15X,3HLN*//)
      DO 831 N=1,MODES
  831 WRITE(6,11113)N,GCOEF(N),HCOEF(N),XLCOEF(N)
11113 FORMAT(24X,I1,3E18.5)
```

```
      WRITE(6,785) TERM1,TERM2
  785 FORMAT (1H0,4X,17HMAX. ETA/XN(1) = ,E12.5//
     125X,27HKINETIC ENERGY/XN(1).**2 = ,E12.5,3H KG)
      WRITE(6,260) I11P,TERM11,TERM12,TERM13,TERM14
  260 FORMAT (1H0,4X,7HI11P = ,E12.5,28H KG-M**2 WHERE THE TERMS ARE,
     24E16.5)
      WRITE(6,11116)BCCOEF
11116 FORMAT(1H0,4X,7HB   . = ,E12.5)
      WRITE (6,315)
  315 FORMAT (1H0,4X,31HSPRING-MASS PARAMETERS      MODE,9X,2HMN,15X,
     22HLN,9X,15HKNSTAR/ALPHA(3)/
     343X,5HIN KG,10X,9HIN INCHES,10X,7HIN KG/M//)
      DO 320 N=1,MODES
      LN(N)=LN(N)/0.0254
  320 WRITE (6,325) N,MN(N),LN(N),KNSTAR(N)
  325 FORMAT (34X,I1,3E17.5)
      LO=LO/0.0254
      WRITE (6,330) MO,LO,IO
  330 FORMAT (1H0,31X,5HMO = ,E12.5,3H KG/
     232X,5HLO = ,E12.5,7H INCHES/
     332X,5HIO = ,E12.5,8H KG-M**2)
      WRITE(6,11117) ((TAU(I,J),J=1,MODES),I=1,MODES)
      WRITE(6,11118) ((XNU(I,J),J=1,MODES),I=1,MODES)
      WRITE(6,11119)((BETA(I,J),J=1,MODES),I=1,MODES)
      WRITE(6,11120)((BETAB(I,J),J=1,MODES),I=1,MODES)
      WRITE(6,11114)((ASCOEF(I,J),J=1,MODES),I=1,MODES)
      WRITE(6,11115)((BSCOEF(I,J),J=1,MODES),I=1,MODES)
      WRITE(6,11123)(OMEGAC(I),I=1,MODES)
11114 FORMAT(//50X,2HA*/(25X,3E16.8))
11115 FORMAT(//50X,2HB*/(25X,3E16.8))
11117 FORMAT(//50X,3HTAU/(25X,3E16.8))
11118 FORMAT(//50X,2HNU/(25X,3E16.8))
11119 FORMAT(//49X,4HBETA/(25X,3E16.8))
11120 FORMAT(//47X,8HBETA BAR/(25X,3E16.8))
11123 FORMAT(//35X,28HNATURAL FREQUENCY CORRECTION/(25X,3E16.8))
C
C
C         BAFFLE EFFECT ON ENERGY
C
      IF (NBAF.LT.1.OR.NBAF.GT.30) RETURN
      WRITE (6,335)
  335 FORMAT (1H0,6X,6HBAFFLE,6X,12HZ-COORDINATE,16X,13HR-COORDINATES,
     214X,18HINST. DE/DT FACTOR,4X,17HAVG. DE/DT FACTOR/
     321X,9HIN INCHES,19X,9HIN INCHES,28X,16HIN KG/M**(3./4.)//)
      DO 400 I=1,NBAF
      ARG3=ZBAF(I)/0.0254
      ARG4=RBAFI(I)/0.0254
      ARG5=RBAFO(I)/0.0254
      IF (ZBAF(I).LT.LEVEL.AND.ZBAF(I).GE.ZBOT.AND.RBAFI(I).NE.RBAFO(I).
     2AND.RBAFI(I).GE.0.0.AND.RBAFO(I).GE.0.0) GO TO 345
      WRITE (6,340) I,ARG3,ARG4,ARG5
  340 FORMAT (9X,I2,3F19.4,21X,9HNO EFFECT)
      GO TO 400
  345 ARG1=RBAFI(I)
      ARG2=RBAFO(I)
      IF (ARG1.LT.ARG2) GO TO 350
```

```
      ARG1=RBAFO(I)
      ARG2=RBAFI(I)
  350 SUM=0.0
      DO 390 JJ=1,2
      DO 390 J=1,NORD
      GO TO (355,360),JJ
  355 II=NORD-J+1
      T=0.5*W(II)
      S=0.5-0.5*X(II)
      GO TO 370
  360 T=0.5*W(J)
      S=0.5+0.5*X(J)
  370 RR=(ARG2-ARG1)*S+ARG1
      TERM(1)=0.0
      K1=MPOLY+1
      DO 380 K=K1,MORDER
      KK=K-MPOLY
      ARG=JN(KK)*RR/AS
      CALL BESSEL (ARG,B1,B1D)
  380 TERM(1)=TERM(1)+CNK(K,I)*JN(KK)*B1*EXP(-JN(KK)*(LEVEL-ZBAF(I))/AS)
      SUM=SUM+ABS(TERM(1))**(5./2.)*RR*T*(ARG2-ARG1)
  390 CONTINUE
      TERM(1)=-SUM*RHO*18.0*1.23*(KNSTAR(1)/MN(1))**(1./4.)*
     2SQRT((ARG2-ARG1)/PI)*(L*BN(1)/AS)**(5./2.)
      TERM(2)=TERM(1)*(KNSTAR(1)/MN(1))**(5./4.)*4.0/3.0/PI
      WRITE (6,395) I,ARG3,ARG4,ARG5,TERM(1),TERM(2)
  395 FORMAT (9X,I2,3F19.4,2E21.5)
  400 CONTINUE
C
C
      RETURN
      END
```

```
$IBFTC INTG1    LIST,DECK
```

```
      SUBROUTINE INTG1 (F,LEV1,LEV2)
C
C
C        ROUTINE EVALUATES A CLOSED LINE INTEGRAL WITH RESPECT TO THE
C        Z-COORDINATE FOR THAT PORTION OF THE TANK BETWEEN TWO LEVELS
C        (LEV1 AND LEV2), WHERE F IS THE SUBROUTINE CONTAINING
C        THE INTEGRAND
C
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /GAUSS/NORD,X(8),W(8)
      COMMON /PARAM/M,N,JNM,JNN,RN,ZZ,FUNC,ANS
      COMMON /SEG/TYPE(50),BEGRPT,RPOINT(50),BEGZPT,ZPOINT(50),RC(50),
     2ZC(50),A(50),B(50),GAMMA(50),GAM(50)
      REAL LEV1,LEV2
C
C
      ANS=0.0
      DO 1999 I=1,NSEG
C
C
C        LOCATE THE PORTION OF THE SEGMENT BETWEEN THE TWO LEVELS
C
      IF (ZPOINT(I-1).EQ.ZPOINT(I)) GO TO 1999
      IF (ZPOINT(I-1).LE.LEV2.AND.ZPOINT(I).LE.LEV2) GO TO 1999
      IF (ZPOINT(I-1).GE.LEV1.AND.ZPOINT(I).GE.LEV1) GO TO 1999
      IF (ZPOINT(I-1).LE.LEV2.AND.ZPOINT(I).GT.LEV2) GO TO 10
      IF (ZPOINT(I-1).LT.LEV1.AND.ZPOINT(I).GE.LEV1) GO TO 20
      IF (ZPOINT(I-1).LT.LEV1.AND.ZPOINT(I).LE.LEV2) GO TO 25
      IF (ZPOINT(I-1).LT.LEV1.AND.ZPOINT(I).LT.LEV1) GO TO 30
      BEG=LEV1
      IF (ZPOINT(I).LE.LEV2) GO TO 5
      END=ZPOINT(I)
      GO TO 1035
    5 END=LEV2
      GO TO 1035
   10 BEG=LEV2
      IF (ZPOINT(I).GE.LEV1) GO TO 15
      END=ZPOINT(I)
      GO TO 1035
   15 END=LEV1
      GO TO 1035
   20 BEG=ZPOINT(I-1)
      END=LEV1
      GO TO 1035
   25 BEG=ZPOINT(I-1)
      END=LEV2
      GO TO 1035
   30 BEG=ZPOINT(I-1)
      END=ZPOINT(I)
C
C
C        EVALUATE THE INTEGRAL ALONG THE SEGMENT BETWEEN THE TWO LEVELS
C
 1035 SUM=0.0
```

```
      DO 1040 JJ=1,2
      DO 1040 J=1,NORD
      GO TO (1036,1037),JJ
 1036 II=NORD-J+1
      T=0.5*W(II)
      IF (END.GT.BEG) GO TO 2012
      S=0.5+0.5*X(II)
      GO TO 1038
 2012 S=0.5-0.5*X(II)
      GO TO 1038
 1037 T=0.5*W(J)
      IF (END.GT.BEG) GO TO 2022
      S=0.5-0.5*X(J)
      GO TO 1038
 2022 S=0.5+0.5*X(J)
 1038 ZZ=(END-BEG)*S+BEG
      CALL FINDR (I,ZZ,RR)
      CALL F
 1040 SUM=SUM+FUNC*T
      ANS=ANS+SUM*(END-BEG)
C
C
 1999 CONTINUE
C
C
      RETURN
      END
```

```
$IBFTC INTG2   LIST,DECK
```

```
      SUBROUTINE INTG2 (F,LEV1,LEV2)
C
C
C       ROUTINE EVALUATES A CLOSED LINE INTEGRAL WITH RESPECT TO THE
C       R-COORDINATE FOR THAT PORTION OF THE TANK BETWEEN TWO LEVELS
C       (LEV1 AND LEV2), WHERE F IS THE SUBROUTINE CONTAINING
C       THE INTEGRAND
C
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /GAUSS/NORD,X(8),W(8)
      COMMON /PARAM/M,N,JNM,JMN,RR,ZZ,FUNC,ANS
      COMMON /SEG/TYPE(50),BEGRPT,RPOINT(50),BEGZPT,ZPOINT(50),RC(50),
     2ZC(50),A(50),B(50),GAMMA(50),GAM(50)
      REAL LEV1,LEV2
C
C
C       SET UP LOGIC FLAGS
C
      IBEGR=0
      IF (RPOINT(NSEG).EQ.BEGRPT.AND.ZPOINT(NSEG).NE.BEGZPT.AND.
     2LEV2.GE.BEGZPT.AND.LEV2.GE.ZPOINT(1)) IBEGR=1
      IOUTI=0
      IFLAG=0
C
C
      TEMP=0.0
      BEGR=0.0
      ENDR=0.0
      ANS=0.0
      DO 130 I=1,NSEG
C
C
C       LOCATE THE PORTION OF THE SEGMENT BETWEEN THE TWO LEVELS
C
    1 ILEV=0
      IF (ZPOINT(I-1).LE.LEV2.AND.ZPOINT(I).LE.LEV2) GO TO 110
      IF (ZPOINT(I-1).GE.LEV1.AND.ZPOINT(I).GE.LEV1) GO TO 110
      IF (ZPOINT(I-1).LE.LEV2.AND.ZPOINT(I).GT.LEV2) GO TO 20
      IF (ZPOINT(I-1).LT.LEV1.AND.ZPOINT(I).GE.LEV1) GO TO 30
      IF (ZPOINT(I-1).LT.LEV1.AND.ZPOINT(I).LE.LEV2) GO TO 40
      IF (ZPOINT(I-1).LT.LEV1.AND.ZPOINT(I).LT.LEV1) GO TO 50
      IF (ZPOINT(I).LE.LEV2) GO TO 10
      IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 7
      CALL FINDR (I,LEV1,ENDR)
      IF (IOUTI.EQ.0) GO TO 6
    5 IOUTI=0
      BEG=OUTI
      END=ENDR
      ILEV=1
      GO TO 80
    6 BEG=ENDR
      END=RPOINT(I)
      GO TO 80
    7 ENDR=RPOINT(I)
```

```
      IF (IOUT1.EQ.0) GO TO 1,0
      GO TO 5
   10 IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 15
      CALL FINDR (I,LEV1,ENDR)
      IF (IOUT1.NE.0) GO TO 5
      CALL FINDR (I,LEV2,BEGR)
      IBEGR=1
      BEG=ENDR
      END=BEGR
      GO TO 80
   15 ENDR=RPOINT(I)
      IF (IOUT1.NE.0) GO TO 5
      BEGR=RPOINT(I)
      IBEGR=1
      GO TO 110
   20 IF (ZPOINT(I).LT.LEV1) GO TO 25
      IOUT1=1
      IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 23
      CALL FINDR (I,LEV1,OUT1)
      CALL FINDR (I,LEV2,OUT2)
      IF (IBEGR.EQ.0) GO TO 22
   21 IBEGR=0
      BEG=BEGR
      END=OUT2
      ILEV=2
      GO TO 80
   22 IF (BEGR.EQ.0.0) TEMP=OUT2
      BEG=OUT2
      END=OUT1
      GO TO 80
   23 OUT1=RPOINT(I)
   24 OUT2=RPOINT(I)
      IF (IBEGR.NE.0) GO TO 21
      IF (BEGR.EQ.0.0) TEMP=OUT2
      GO TO 110
   25 IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 24
      CALL FINDR (I,LEV2,OUT2)
      IF (IBEGR.NE.0) GO TO 21
      IF (BEGR.EQ.0.0) TEMP=OUT2
      BEG=OUT2
      END=RPOINT(I)
      GO TO 80
   30 IOUT1=1
      IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 35
      CALL FINDR (I,LEV1,OUT1)
      BEG=RPOINT(I-1)
      END=OUT1
      GO TO 80
   35 OUT1=RPOINT(I)
      GO TO 110
   40 IBEGR=1
      IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 45
      CALL FINDR (I,LEV2,BEGR)
      BEG=RPOINT(I-1)
      END=BEGR
      GO TO 80
```

```
   45 BEGR=RPOINT(I)
      GO TO 110
   50 IF (RPOINT(I).EQ.RPOINT(I-1)) GO TO 110
      BEG=RPOINT(I-1)
      END=RPOINT(I)
C
C
C        EVALUATE THE INTEGRAL ALONG THE SEGMENT BETWEEN THE TWO LEVELS
C        OR ALONG ONE OF THE TWO LEVELS
C
   80 SUM=0.0
      DO 90 JJ=1,2
      DO 90 J=1,NORD
      GO TO (1001,1002),JJ
 1001 II=NORD-J+1
      T=0.5*W(II)
      IF (END.GT.BEG) GO TO 1010
      S=0.5+0.5*X(II)
      GO TO 85
 1010 S=0.5-0.5*X(II)
      GO TO 85
 1002 T=0.5*W(J)
      IF (END.GT.BEG) GO TO 1020
      S=0.5-0.5*X(J)
      GO TO 85
 1020 S=0.5+0.5*X(J)
   85 RR=(END-BEG)*S+BEG
      IF (ILEV.EQ.0) CALL FINDZ (I,RR,ZZ)
      IF (ILEV.EQ.1) ZZ=LEV1
      IF (ILEV.EQ.2) ZZ=LEV2
      CALL F
      SUM=SUM+FUNC*T
   90 CONTINUE
      ANS=ANS+SUM*(END-BEG)
C
C
C        CHECK IF INTEGRATION HAS BEEN COMPLETED ALONG THE SEGMENT
C
      IF (ILEV.NE.0.AND.IFLAG.EQ.0) GO TO 1
C
C
C        CHECK IF INTEGRATION HAS BEEN PERFORMED ON THE TWO LEVELS
C
  110 IF (I.LT.NSEG) GO TO 130
      IFLAG=1
      IF (IBEGR.EQ.0) GO TO 115
      IBEGR=0
      BEG=BEGR
      END=TEMP
      ILEV=2
      GO TO 80
  115 IF (IOUT1.EQ.0) GO TO 130
      IOUT1=0
      BEG=OUT1
      END=ENDR
      ILEV=1
```

```
      GO TO 80
C
C
  130 CONTINUE
C
C
      RETURN
      END
```

SLOSH 0274

```
$IBFTC INT3     LIST,DECK
```

```
      SUBROUTINE INTG3(F)
      COMMON/XW/XG(8),WG(8)
      COMMON /GAUSS/NORD,X(8),W(8)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      ANS=0.0
      DO 10 I=1,2
      DO 10 J=1,NORD
      GO TO (2,4),I
    2 U=-XG(J)
      GO TO 5
    4 U=XG(J)
    5 RR=U+0.5
      CALL F
   10 ANS=ANS+FUNC*WG(J)
      RETURN
      END
```

```
$IBFTC FINDR    LIST,DECK
```

```
      SUBROUTINE FINDR (I,ZZ,RR)
      COMMON /SEG/TYPE(50),BEGRPT,RPOINT(50),BEGZPT,ZPOINT(50),RC(50),
     2ZC(50),A(50),B(50),GAMMA(50),GAM(50)
      INTEGER TYPE,ARG
      IF (ZZ-ZPOINT(I)) 2,1,2
    1 RR=RPOINT(I)
      RETURN
    2 IF (ZZ-ZPOINT(I-1)) 4,3,4
    3 RR=RPOINT(I-1)
      RETURN
    4 R1=0.0
      R2=0.0
      ARG=TYPE(I)
      GO TO (5,35,40),ARG
    5 C1=ZZ-ZC(I)
      C2=SIN(GAM(I))
      C3=COS(GAM(I))
      C4=(C2*B(I))**2+(C3*A(I))**2
      C5=(C3*B(I))**2+(C2*A(I))**2
      C6=2.*C2*C3*(B(I)**2-A(I)**2)
      C7=(C1*C6)**2-4.*C5*(C4*C1**2-(A(I)*B(I))**2)
      IF (C7) 100,10,10
   10 R1=RC(I)+(-C1*C6+SQRT(C7))/(2.*C5)
      R2=RC(I)+(-C1*C6-SQRT(C7))/(2.*C5)
      GO TO 70
   35 RR=RPOINT(I-1)+(RPOINT(I)-RPOINT(I-1))/(ZPOINT(I)-ZPOINT(I-1))*(ZZ
     2-ZPOINT(I-1))
      RETURN
   40 C1=ZZ-ZC(I)
      IF (GAMMA(I).EQ.90.0) GO TO 50
      IF (GAMMA(I).NE.270.0) GO TO 55
      RR=RC(I)+C1**2/(2.0*A(I))
      RETURN
   50 RR=RC(I)-C1**2/(2.0*A(I))
      RETURN
   55 C2=SIN(GAM(I))
      C3=COS(GAM(I))
      C4=2.0*C2*C3
      C5=C1*C4+2.*A(I)*C2
      C6=C5**2-4.*C3**2*((C1*C2)**2-2.*A(I)*C1*C3)
      IF (C6) 100,60,60
   60 R1=RC(I)+(-C5+SQRT(C6))/(2.*C3**2)
      R2=RC(I)+(-C5-SQRT(C6))/(2.*C3**2)
      GO TO 70
  100 WRITE (6,101) I
  101 FORMAT (1H0,15HSEGMENT NUMBER ,I2,11H IS INVALID)
      CALL EXIT
   70 IF (R1.LT.0.0) R1=0.0
      IF (R2.LT.0.0) R2=0.0
      IF ((R1-RPOINT(I))/ABS(R1-RPOINT(I))-(R1-RPOINT(I-1))/ABS(R1-RPOIN
     2T(I-1))) 94,96,94
   94 RR=R1
      RETURN
   96 IF ((R2-RPOINT(I))/ABS(R2-RPOINT(I))-(R2-RPOINT(I-1))/ABS(R2-RPOIN
     2T(I-1))) 98,100,98
```

```
   98 RR=R2
      RETURN
      END
```

$IBFTC FINDZ LIST,DECK

```
      SUBROUTINE FINDZ (I,RR,ZZ)
      COMMON /SEG/TYPE(50),BEGRPT,RPOINT(50),BEGZPT,ZPOINT(50),RC(50),
     2ZC(50),A(50),B(50),GAMMA(50),GAM(50)
      INTEGER TYPE,ARG
      IF (RR-RPOINT(I)) 2,1,2
    1 ZZ=ZPOINT(I)
      RETURN
    2 IF (RR-RPOINT(I-1)) 4,3,4
    3 ZZ=ZPOINT(I-1)
      RETURN
    4 Z1=0.0
      Z2=0.0
      ARG=TYPE(I)
      GO TO (5,20,25),ARG
    5 C1=RR-RC(I)
      C2=SIN(GAM(I))
      C3=COS(GAM(I))
      C4=(C2*B(I))**2+(C3*A(I))**2
      C5=(C3*B(I))**2+(C2*A(I))**2
      C6=2.*C2*C3*(B(I)**2-A(I)**2)
      C7=(C1*C6)**2-4.*C4*(C1**2*C5-(A(I)*B(I))**2)
      IF (C7) 100,10,10
   10 Z1=ZC(I)+(-C1*C6+SQRT(C7))/(2.*C4)
      Z2=ZC(I)+(-C1*C6-SQRT(C7))/(2.*C4)
      GO TO 50
   20 ZZ=ZPOINT(I-1)+(ZPOINT(I)-ZPOINT(I-1))/(RPOINT(I)-RPOINT(I-1))*(RR
     2-RPOINT(I-1))
      RETURN
   25 C1=RR-RC(I)
      IF (GAMMA(I).EQ.0.0.OR.GAMMA(I).EQ.360.0) GO TO 35
      IF (GAMMA(I).NE.180.0) GO TO 40
      ZZ=ZC(I)-C1**2/(2.0*A(I))
      RETURN
   35 ZZ=ZC(I)+C1**2/(2.*A(I))
      RETURN
   40 C2=SIN(GAM(I))
      C3=COS(GAM(I))
      C4=2.0*C2*C3
      C5=C1*C4-2.*A(I)*C3
      C6=C5**2-4.*C2**2*((C1*C3)**2+2.*A(I)*C1*C2)
      IF (C6) 100,45,45
   45 Z1=ZC(I)+(-C5+SQRT(C6))/(2.*C2**2)
      Z2=ZC(I)+(-C5-SQRT(C6))/(2.*C2**2)
      GO TO 50
  100 WRITE (6,101) I
  101 FORMAT (1H0,15HSEGMENT NUMBER ,I2,11H IS INVALID)
      CALL EXIT
   50 IF ((Z1-ZPOINT(I))/ABS(Z1-ZPOINT(I))-(Z1-ZPOINT(I-1))/ABS(Z1-ZPOIN
     2T(I-1))) 55,60,55
   55 ZZ=Z1
      RETURN
   60 IF ((Z2-ZPOINT(I))/ABS(Z2-ZPOINT(I))-(Z2-ZPOINT(I-1))/ABS(Z2-ZPOIN
     2T(I-1))) 65,100,65
   65 ZZ=Z2
      RETURN
```

```
SLOSH                                                                    0./2
    FINDZ        -  EFN   SOURCE STATEMENT  -  IFN(S)  -

  END
```

SLOSH 05/2

```
$IBFTC F1        LIST,DECK
```

```
      SUBROUTINE F1
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JMN,RR,ZZ,FUNC,ANS
      FUNC=RR**2*(ZZ-ZCG)
      RETURN
      END
```

$IBFTC F2 LIST,DECK

```
SUBROUTINE F2
COMMON /PARAM/M,N,JNM,JMN,RR,ZZ,FUNC,ANS
FUNC=RR**2
RETURN
END
```

SLOSH 02/

$IBFTC F4 LIST,DECK

```
      SUBROUTINE F4
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      FUNC=RR**3*(ZZ-ZCG)+2./3.*RR*(ZZ-ZCG)**3
      RETURN
      END
```

```
$IBFTC F5      LIST,DECK
```

```
SUBROUTINE F5
COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
2G1,G2,G3,ZDIV,DZ(2)
COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
FUNC=RR*(ZZ-ZCG)**3
RETURN
END
```

```
$IBFTC F6        LIST,DECK
```

```
      SUBROUTINE F6
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      FUNC=(RR/AS)**(2*(M+N)-3)*(ZZ-ZCG)/AS**2
      RETURN
      END
```

SLOSH 0272

$IBFTC F7 LIST,DECK

```
      SUBROUTINE F7
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      REAL JNN
      ARG=JNN*RR/AS
      CALL BESSEL (ARG,BI,BID)
      FUNC=(FLOAT(2*M-1)*(RR/AS)**(2*M-1)*JNN*BID+(RR/AS)**(2*M-2)*BI)*
     2EXP(JNN*(ZZ-ZCG)/AS)/AS
      RETURN
      END
```

```
$IBFTC F8        LIST,DECK
```

```
      SUBROUTINE F8
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      REAL JNM,JNN
      RNON=RR/AS
      ARG=JNM*RNON
      CALL BESSEL (ARG,BIM,BIDM)
      ARG=JNN*RNON
      CALL BESSEL (ARG,BIN,BIDN)
      FUNC=((ARG*JNM*BIDM*BIDN+BIM*BIN/RNON+ARG*JNM*BIM*BIN)/AS)*
     2EXP((JNM+JNN)*(ZZ-ZCG)/AS)
      RETURN
      END
```

$IBFTC F9 LIST,DECK

```
      SUBROUTINE F9
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      REAL JN,JNM,L
      I=M-MPOLY
      IF (I) 5,5,10
    5 FUNC=((ZZ-ZCG)*RR**(2*M))/AS**(2*M+2)
      RETURN
   10 JNM=JN(I)
      ARG=JNM*RR/AS
      CALL BESSEL (ARG,B1,B,D)
      FUNC=(ZZ-ZCG)*RR*B1*EXP(JNM*(ZZ-ZCG-L)/AS)/AS**3
      RETURN
      END
```

```
$IBFTC F12     LIST,DECK
```

```
      SUBROUTINE F12
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      IF (M.GT.NPOLY) GO TO 10
      FUNC=0.0
      IF (ZZ.EQ.ZCG) RETURN
      DO 5 I=1,M
    5 FUNC=FUNC+ACOEF(M,I)*(RR/AS)**(I+2)*((ZZ-ZCG)/AS)**(M-I)/AS
      RETURN
   10 ARG=FLOAT(M-NPOLY)*PI*RR/H
      CALL PMODBS (ARG,PBS,PBSP)
      FUNC=PBS*COS(FLOAT(M-NPOLY)*PI/H*(ZZ-ZCG+D))*RR**2/AS**3
      RETURN
      END
```

$IBFTC F14 LIST,DECK

```
      SUBROUTINE F14
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      FUNC=RR**3*(ZZ-ZCG)
      RETURN
      END
```

```
$IBFTC F15     LIST,DECK
```

```
      SUBROUTINE F15
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      C=FLOAT(N-NPOLY)*PI/H
      ARG=C*RR
      CALL PMODBS (ARG,PBSN,PBSPN)
      IF (M.EQ.N) GO TO 5
      ZARG=(ZZ-ZCG)/AS
      DD=FLOAT(M-NPOLY)*PI/H
      ARG=DD*RR
      CALL PMODBS (ARG,PBSM,PBSPM)
      A=(PBSPM*PBSPN*RR*C*DD+PBSM*PBSN/RR)*AS
      B=C*DD*RR*AS*PBSM*PBSN
      P=SIN(C*D)
      Q=SIN(DD*D)
      R=COS(C*D)
      S=COS(DD*D)
      E=A*P*Q+B*R*S
      F=A*R*S+B*Q*P
      G=B*R*Q-A*P*S
      HH=B*P*S-A*R*Q
      P=(C+DD)*AS
      Q=(C-DD)*AS
      R=P*ZARG
      S=Q*ZARG
      FUNC=((E-F)/P*SIN(R)-(E+F)/Q*SIN(S)+(G+HH)/P*COS(R)+(G+HH)/Q*
     2COS(S))/AS/2.0
      RETURN
    5 A=(RR*PBSPN**2*C**2+PBSN**2/RR)*AS
      B=RR*PBSN**2*C**2*AS
      FUNC=(-A*(ZZ-ZCG)/AS+(A-B)/(C*AS)*(C*(ZZ-ZCG+D)/2.0-0.25*SIN(2.0*C
     2*(ZZ-ZCG+D))))/AS
      RETURN
      END
```

```
$IBFTC F16      LIST,DECK
```

```
      SUBROUTINE F1A
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      ZARG=(ZZ-ZCG)/AS
      FUNC=0.0
      DO 5 K=1,N
      DO 5 I=1,M
    5 FUNC=FUNC+FLOAT(K*I+1)/FLOAT(M+N-I-K+1)*ACOEF(N,K)*ACOEF(M,I)*
     2(RR/AS)**(K+I-1)*ZARG**(M+N-I-K+1)/AS
      DO 10 K=1,N
      DO 10 I=1,M
      IF (N.EQ.K.OR.M.EQ.I) GO TO 10
      FUNC=FUNC+FLOAT((N-K)*(M-I))/FLOAT(N+M-K-I-1)*ACOEF(N,K)*
     2ACOEF(M,I)*(RR/AS)**(K+I+1)*ZARG**(N+M-K-I-1)/AS
   10 CONTINUE
      RETURN
      END
```

$IBFTC F17 LIST,DECK

```
      SUBROUTINE F17
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      FUNC=0.0
      ZARG=(ZZ-ZCG)/AS
      IF (ZARG.EQ.0.0) RETURN
      STOR=FLOAT(N-NPOLY)*PI*AS/H
      ARG=FLOAT(N-NPOLY)*PI*RR/H
      CALL PMODBS (ARG,PBS,PBSP)
      ARG=FLOAT(N-NPOLY)*PI/H*(ZZ-ZCG+D)
      DO 50 I=1,M
      TEMP=0.0
      MM=M-I
      IF (MM.EQ.0) GO TO 35
      GO TO     (30,25,20,15,10,5),MM
    5 TEMP=TEMP-FLOAT((MM)*(MM-1)*(MM-2)*(MM-3)*(MM-4)*(MM-5))/STOR**7*
     2ZARG**(MM-6)*SIN(ARG)
   10 TEMP=TEMP+FLOAT((MM)*(MM-1)*(MM-2)*(MM-3)*(MM-4))/STOR**6*ZARG**
     2(MM-5)*COS(ARG)
   15 TEMP=TEMP+FLOAT((MM)*(MM-1)*(MM-2)*(MM-3))/STOR**5*ZARG**(MM-4)*
     2SIN(ARG)
   20 TEMP=TEMP-FLOAT((MM)*(MM-1)*(MM-2))/STOR**4*ZARG**(MM-3)*COS(ARG)
   25 TEMP=TEMP-FLOAT((MM)*(MM-1))/STOR**3*ZARG**(MM-2)*SIN(ARG)
   30 TEMP=TEMP+FLOAT(MM)/STOR**2*ZARG**(MM-1)*COS(ARG)
   35 TEMP=TEMP+ZARG**MM/STOR*SIN(ARG)
   50 FUNC=FUNC+(STOR*PBSP*FLOAT(I)*(RR/AS)**I+PBS*(RR/AS)**(I-1))*
     2ACOEF(M,I)*TEMP/AS
      DO 100 I=1,M
      IF (M.EQ.1) RETURN
      TEMP=0.0
      MM=M-I-1
      IF (MM.EQ.0) GO TO 80
      GO TO (75,70,65,60,55),MM
   55 TEMP=TEMP+FLOAT((MM)*(MM-1)*(MM-2)*(MM-3)*(MM-4))/STOR**6*ZARG**
     2(MM-5)*SIN(ARG)
   60 TEMP=TEMP-FLOAT((MM)*(MM-1)*(MM-2)*(MM-3))/STOR**5*ZARG**(MM-4)*
     2COS(ARG)
   65 TEMP=TEMP-FLOAT((MM)*(MM-1)*(MM-2))/STOR**4*ZARG**(MM-3)*SIN(ARG)
   70 TEMP=TEMP+FLOAT((MM)*(MM-1))/STOR**3*ZARG**(MM-2)*COS(ARG)
   75 TEMP=TEMP+FLOAT(MM)/STOR**2*ZARG**(MM-1)*SIN(ARG)
   80 TEMP=TEMP-ZARG**MM/STOR*COS(ARG)
  100 FUNC=FUNC-STOR*PBS*ACOEF(M,I)*FLOAT(M-I)*(RR/AS)**(I+1)*TEMP/AS
      RETURN
      END
```

```
$IBFTC F18      LIST,DECK
BEGIN COMPILING  224018
```

```
      SUBROUTINE F18
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      IF (M.GT.NPOLY) GO TO 10
      FUNC=0.0
      DO 5 I=1,M
    5 FUNC=FUNC+ACOEF(M,I)*(RR/AS)**(I+1)*((ZZ-ZCG)/AS)**(M-I+1)/AS
      RETURN
   10 ARG=FLOAT(M-NPOLY)*PI*RR/H
      CALL PMODBS (ARG,PBS,PBSP)
      FUNC=RR/AS*(ZZ-ZCG)/AS*PBS*COS(FLOAT(M-NPOLY)*PI/H*(ZZ-ZCG+D))/AS
      RETURN
      END
```

```
$IBFTC F28D    LIST,DECK
```

```
      SUBROUTINE F28
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      COMMON/BES/BII,BIDI,BIJ,BIDJ,XII,XJI,I,J,JI,II,JJ
      COMMON /ELEM/HORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      REAL JN,JNN,JNM
      ARG=JNN*RR
      CALL BESSEL(ARG,BII,BIDI)
      ARG=JNM*RR
      CALL BESSEL(ARG,BIJ,BIDJ)
      FUNC=(JN(II)*JN(JJ)*BIDI*BIDJ*RR     +BII*BIJ     /RR)
      RETURN
      END
```

```
$IBFTC F29D    LIST,DECK
```

```
      SUBROUTINE F29
      COMMON NSEG,LEVEL,ZCG,L,D,H,AS,VOL,PI,EPSL,RHO,MODES,ZBOT,IDEGR,
     2G1,G2,G3,ZDIV,DZ(2)
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /PARAM/M,N,JNM,JNN,RR,ZZ,FUNC,ANS
      COMMON/BES/BII,BIDI,BIJ,BIDJ,XII,XJI,I,J,JI,II,JJ
      REAL JN,JNM
      ARG=JNM*RR
      CALL BESSEL(ARG,BIJ,BIDJ)
      IF(RR)1,2,1
    1 FUNC=(XII*ARG*BIDJ+BIJ)*(RR     )**(2*I-2)
      GO TO 3
    2 FUNC=0.0
    3 CONTINUE
      RETURN
      END
```

```
$IBFTC JACOBI  LIST,DECK
```

```
CJACOBI              BUFFERING ROUTINE BETWEEN FORTRAN AND EG2F (SHARE)
      SUBROUTINE JACOBI (MAX,NACT,NOGO,A,B,VECTOR,VALUE,MODES)
C
C                    CALL JACOBI (MAX,NACT,NOGO,A,B,VECTOR,VALUE,MODES)
C                    WHERE
C           MAX      DIMENSIONED ORDER OF A AND B MATRICES (LIMIT IS 40)
C           NACT     WORKING ORDER OF A AND B MATRICES
C           NOGO     =0 METHOD SUCESSFULL
C           NOGO     =1 MATRIX B IS NOT POSITIVE DEFINITE
C           NOGO     =-1 ILL CONDITIONED MATRIX F (SEE SHARE WRITEUP-NYEVV)
C           A        MATRIX A OF  AX=(LAMBDA)BX
C           B        MATRIX B OF  AX=(LAMBDA)BX
C           VECTOR   EIGENVECTOR STORAGE MATRIX - VECTORS BY COLUMNS
C           VALUE    EIGENVALUE STORAGE VECTOR
C           MODES    NUMBER OF EIGENVALUES DESIRED
C
C                    THIS ROUTINE SOLVES THE EIGENVALUE PROBLEM
C                    AX=(LAMBDA)BX
C           WHERE A AND B MUST BE SYMMETRIC AND B MUST BE POSITIVE DEFINITE
C
C                    THE ORIGINAL A AND B MATRICES ARE DESTROYED BY THE
C           EXECUTION OF SUBROUTINE EG2F
C
C .                  A RESTRICTION IN EG2F LIMITS DIMENSION OF A AND B
C               MATRICES TO 40X40 MAXIMUM. TO CHANGE THIS RESTRICTION
C               CHANGE LOCATION COMMON OF EG2F  (NOW SET AT BSS 54) (N+14)
C
C                    SUBROUTINES INCLUDED IN THIS PACKAGE ARE
C           JACOBI
C           RWEG2F
      DIMENSION A(MAX,1),B(MAX,1),VECTOR(MAX,1),VALUE(1)
      N=NACT
      I1=0
C                    READY A MATRIX FOR EG2F
      DO 10 I2=1,N
      DO 10 I3=1,N
      I1=I1+1
   10 A(I1,1)=A(I3,I2)
C                    READY B MATRIX FOR EG2F
      I4=0
      DO 20 I5=1,N
      DO 20 I6=1,I5
      I4=I4+1
   20 B(I4,1)=B(I6,I5)
C                    RWEG2F-CALLING SEQUENCE TO EG2F
      CALL RWEG2F (A,B,VECTOR,N,NOGO)
      IF(NOGO) 100,25,100
C                    EG2F STORAGE TO FORTRAN STORAGE
   25 K1=0
      DO 27 I7=1,N
      DO 26 I8=1,N
      K1=K1+1
   26 B(I8,I7)=VECTOR(K1,1)
      K2=(I7-1)*N+I7
   27 A(I7,1)=A(K2,1)
```

```
C                ARRANGE EIGENVALUES IN DECREASING ORDER
C          REARRANGE EIGENVECTORS TO CORRESPOND TO EIGENVALUES
C          NORMALIZE EIGENVECTORS W.R.T. THEIR LARGEST ELEMENT
      DO 90 J1=1,MODES
      VALUE(J1)=0.
      DO 40 J2=J1,N
      IF(VALUE(J1)-A(J2,1)) 30,40,40
   30 VALUE(J1)=A(J2,1)
      L1=J2
   40 CONTINUE
      A(L1,1)=A(J1,1)
      DO 50 J3=1,N
      VECTOR(J3,J1)=B(J3,L1,
   50 B(J3,L1)=B(J3,J1)
      FNORM=0.
      DO 70 J4=1,N
      IF(ABS(FNORM)-ABS(VECTOR(J4,J1))) 60,70,70
   60 FNORM=VECTOR(J4,J1)
   70 CONTINUE
      DO 80 J5=1,N
   80 VECTOR(J5,J1)=VECTOR(J5,J1)/FNORM
      VALP=1./VALUE(J1)
      WRITE (6,85) VALP,FNORM,(VECTOR(J5,J1),J5=1,N)
   85 FORMAT (1H0,4X,13HEIGENVALUE = ,E12.5,10X,33HEIGENVECTOR NORMALIZI
     2NG FACTOR = ,E12.5,10X,11HEIGENVECTOR//(E106.5))
   90 CONTINUE
  100 RETURN
      END
```

```
$IBFTC BLK      LIST,DECK
```

```
      BLOCK DATA
      COMMON /ELEM/MORDER,MPOLY,JN(5),NORDER,NPOLY,ACOEF(10,10)
      COMMON /GAUSS/NORD,X(8),W(8)
      REAL JN
      DATA MPOLY/5/
      DATA NORDER,NPOLY/9,6/
      DATA JN/1.8411837,5.3314427,8.5363163,11.706004,14.863588/
      DATA NORD,X,W/8,0.095012509,0.28160355,0.45801677,0.61787624,
     20.7554044,0.8656312,0.94457502,0.98940093,0.18945061,0.18260341,
     30.16915651,0.14959598,0.12462897,0.095158511,0.062253623,
     40.027152459/
      END
```

```
$IBFTC BESSEL  LIST,DECK
```

BESSEL - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE BESSEL(ARG,B1,DBDX)
      DIMENSION A(7),B(7),C(7),D(7),E(7),F(7)
      DOUBLE PRECISION DPARG,DPSUM,DPTH ,DPTHP ,DP1,DPSUM1
      DATA (A(I),I=1,7)/.5 ,-.56249985 ,.21093573 ,-.03954289 ,.0044331
     *9 ,-.00031761 ,.00001109 /
      DATA (B(I),I=1,7)/.79788456 ,.00000156 ,.01659667 ,.00017105 ,-.00
     *249511 ,.00113653 ,-.00020033 /
      DATA (C(I),I=1,7)/-2.35619449 ,.12499612 ,.00005650 ,-.00637879 ,.
     *00074348 ,.00079824 ,-.00029166 /
      DATA (D(I),I=1,7)/1.0 ,-2.2499997 ,1.2656208 ,-.3163866 ,.0444479
     *,-.0039444 ,.0002100 /
      DATA (E(I),I=1,7)/.79788456 ,-.00000077 ,-.00552740 ,-.00009512 ,
     *.00137237 ,-.00072805 ,.00014476/
      DATA (F(I),I=1,7)/-.78539816 ,-.04166397 ,-.00003954 .00262573 ,
     *-.00054125 ,-.00029333 ,.00013558 /
      DPTH =0.0
      DPSUM=0.0
      IF (ARG)9990,1000,100
  100 IF (ARG-3.) 200,200,500
  200 DPARG=ARG/3.0
      DO 300 I=1,7
      DPTH=DPTH+D(I)*DPARG**(2*I-2)
  300 DPSUM=DPSUM+A(I)*DPARG**(2*I-2)
      B1=      ARG*DPSUM
      DBDX=DPTH-B1/ARG
      GO TO 10000
  500 DPARG=3.0/ARG
      DPSUM1=0.0
      DPTHP=0.0
      DO 600 I=1,7
      DP1=DPARG**(I-1)
      DPTHP=DPTHP+F(I)*DP1
      DPSUM1=DPSUM1+E(I)*DP1
      DPTH =DPTH +C(I)*DP1
  600 DPSUM=DPSUM+B(I)*DP1
      DUM=SQRT(1.0/ARG)
      DPTH=ARG+DPTH
      DPTHP=DPTHP+ARG
      B1=DUM          *DPSUM*DCOS(DPTH)
      DBDX=DUM*DPSUM1*DCOS(DPTHP)-B1/ARG
      GO TO 10000
 1000 B1=0.0
      DBDX=.5
      GO TO 10000
 9990 WRITE (6,9991) ARG
 9991 FORMAT (1H0,4X,28HBESSEL FUNCTION ARGUMENT OF ,E12.5,
     211H IS INVALID)
      CALL EXIT
10000 RETURN
      END
```

```
$IBFTC PMODBS  LIST,DECK
```

```
      SUBROUTINE PMODBS( X,BMI,BMID )
C     COMPUTES MODIFIED BESSEL FCN I AND ITS DERIVATIVE BY POLY. APPROX.
      DIMENSION A(6),B(6),C(9),D(9)
      DOUBLE PRECISION T,S,Z,BMO
      DATA  A/.00032411,.00301532,.02658733,.15084934,.51498869,.8789059
     *4 /,B /.0045813,.0360768,.2659732,1.2067492,3.0899424,3.5156229 /
      DATA C/-.00420059,.01787654,-.02895312,.02282967,-.01031555,
     *.00163801,-.00362018,-.03988024, .39894228 /,       D/ .00392377,-.
     *01647633,.02635537,-.02057706,.00916281,-.00157565,.00225319,
     *.01328592, .39894228    /
      IF ( X .EQ. 0. ) GO TO 600
  100 T = X/3.75
  120 S = T*T
  150 IF ( X .GT. 3.75 ) GO TO 200
  160 BMI =X*((((((A(1)   )*S+A(2))*S+A(3))*S+A(4))*S+A(5))*S+A(6))*S+.5
     *)
      BMO=    ((((((B(1)  )*S+B(2))*S+B(3))*S+B(4))*S+B(5))*S+B(6))*S+1.
      GO TO 400
  200 Z=X
      BMI=DEXP (Z)/DSQRT (Z) *    (   ((((((((C(1)/T  +C(2))/T+C(3))/T+C(4))
     */T+C(5))/T+C(6))/T+C(7))/T+C(8))/T+C(9)   )
      BMO=DEXP (Z)/DSQRT (Z) *    (   ((((((((D(1)/T  +D(2))/T+D(3))/T+D(4))
     */T+D(5))/T+D(6))/T+D(7))/T+D(8))/T+D(9)   )
  400 BMID = BMO-BMI/X
  500 RETURN
  600 BMI = 0.
      BMID= .5
      GO TO 500
      END
```

```
$IBFTC SOLVE   LIST,DECK
```

```
CSOLVE   LINEAR EQUATION SOLVER WITH ITERATIVE IMPROVEMENT   VERSION IV SLV
      SUBROUTINE SOLVE(NN,A,B,IN,EPS,ITMAX,X,IT)                        SLV
C     SOLVES AX=B WHERE A IS NXN MATRIX AND B IS NX1 VECTOR             SLV
C     IN=                                                               SLV
C           1 FOR FIRST ENTRY                                           SLV
C           2 FOR SUBSEQUENT ENTRIES WITH NEW B                         SLV
C           3 TO RESTORE A AND B                                        SLV
C     EPS AND ITMAX ARE PARAMETERS IN THE ITERATION                     SLV
C     IT=                                                               SLV
C           -1 IF A IS SINGULAR                                         SLV
C           0 IF NOT CONVERGENT                                         SLV
C           NUMBER OF ITERATIONS IF CONVERGENT                          SLV
C     CALLS MAP SUBROUTINES ILOG2,DOT,SDOT AND DAD                      SLV
C                                                                       SLV
C     TO MODIFY DIMENSIONS, CHANGE THE NEXT 3 (NOT 2 BUT 3) CARDS.      SLV
      DIMENSION A(10,10),B(10),X(10),AA(10,10),DX(10),R(10),
     2          Z(10),RM(10),IRP(10)
      MA=10
C     MA MUST = DECLARED DIMENSION OF SYSTEM                            SLV
      EQUIVALENCE(R,DX)                                                 SLV
      GO TO (1000,2000,3000),IN                                         SLV
 1000 N=NN                                                              SLV
      NM1=N-1                                                           SLV
      NP1=N+1                                                           SLV
C                                                                       SLV
C     EQUILIBRATION                                                     SLV
C                                                                       SLV
      DO 510 I=1,N                                                      SLV
         KTOP=ILOG2(A(I,1))                                             SLV
         DO 503 J=2,N                                                   SLV
  503    KTOP=MAX0(KTOP,ILOG2(A(I,J)))                                  SLV
         RM(I)=2.0**(-KTOP)                                             SLV
         DO 509 J=1,N                                                   SLV
  509    A(I,J)=A(I,J)*RM(I)                                            SLV
  510 CONTINUE                                                          SLV
C                                                                       SLV
C     SAVE EQUILIBRATED DATA                                            SLV
C                                                                       SLV
      DO 548 I=1,N                                                      SLV
      DO 548 J=1,N                                                      SLV
  548 AA(I,J)=A(I,J)                                                    SLV
C                                                                       SLV
C     GAUSSIAN ELIMINATION WITH PARTIAL PIVOTING                        SLV
C                                                                       SLV
      DO 99 M=1,NM1                                                     SLV
         TOP=ABS (A(M,M))                                               SLV
         IMAX=M                                                         SLV
         DO 12 I=M,N                                                    SLV
              IF(TOP-ABS (A(I,M)))10,12,12                              SLV
   10         TOP=ABS (A(I,M))                                          SLV
              IMAX=I                                                    SLV
   12    CONTINUE                                                       SLV
         IF(TOP)14,13,14                                                SLV
   13    IT=-1                                                          SLV
C        *SINGULAR*                                                     SLV
```

```
      RETURN                                                            SLV
   14 IRP(M)=IMAX                                                       SLV
   23 IF(IMAX-M)20,29,24                                                SLV
   24 DO 25 J=1,N                                                       SLV
         TEMP=A(M,J)                                                    SLV
         A(M,J)=A(IMAX,J)                                               SLV
   25    A(IMAX,J)=TEMP                                                 SLV
   29 MP1=M+1                                                           SLV
      DO 33 I=MP1,N                                                     SLV
         EM=A(I,M)/A(M,M)                                               SLV
         A(I,M)=EM                                                      SLV
         IF(EM)31,33,31                                                 SLV
   31    DO 32 J=MP1,N                                                  SLV
   32    A(I,J)=A(I,J)-A(M,J)*EM                                        SLV
   33 CONTINUE                                                          SLV
   99 CONTINUE                                                          SLV
      IRP(N)=N                                                          SLV
      IF (A(N,N))120,113,120                                            SLV
  113 IT=-1                                                             SLV
      RETURN                                                            SLV
  120 CONTINUE                                                          SLV
C     STORAGE FOR A NOW CONTAINS TRIANGULAR L AND U SO THAT (L+I)*U=A   SLV
C                                                                       SLV
C     DUPLICATE INTERCHANGES IN DATA                                    SLV
C                                                                       SLV
      DO 229 I=1,N                                                      SLV
         IP=IRP(I)                                                      SLV
         IF(I-IP)221,229,221                                            SLV
  221    DO 222 J=1,N                                                   SLV
            TEMP=AA(I,J)                                                SLV
            AA(I,J)=AA(IP,J)                                            SLV
  222       AA(IP,J)=TEMP                                               SLV
  229 CONTINUE                                                          SLV
C                                                                       SLV
C     PROCESS RIGHT HAND SIDE                                           SLV
C                                                                       SLV
 2000 CONTINUE                                                          SLV
      DO 601 I=1,N                                                      SLV
  601    B(I)=B(I)-RM(I)                                                SLV
      DO 609 I=1,NM1                                                    SLV
         IP=IRP(I)                                                      SLV
         TEMP=B(I)                                                      SLV
         B(I)=B(IP)                                                     SLV
         B(IP)=TEMP                                                     SLV
  609 CONTINUE                                                          SLV
C                                                                       SLV
C     SOLVE FOR FIRST APPROXIMATION TO X                                SLV
C                                                                       SLV
  199 DO 200 I=1,N                                                      SLV
  200 Z(I)=-SDOT(I-1,A(I,1),MA,Z(1),1,-B(I))                            SLV
      DO 201 K=1,N                                                      SLV
      I=NP1-K                                                           SLV
  201 X(I)=-SDOT(N-I,A(I,I+1),MA,X(I+1),1,-Z(I))/A(I,I)                 SLV
C                                                                       SLV
C     ITERATIVE IMPROVEMENT                                             SLV
C                                                                       SLV
```

```
      IF(ITMAX)370,370,300                                          SLV
  300 TOP=0.0                                                       SLV
      DO 303 I=1,N                                                  SLV
  303 TOP=AMAX1(TOP,ABS(X(I)))                                      SLV
      EPSX=EPS*TOP                                                  SLV
      DO 369 IT=1,ITMAX                                             SLV
C         FIND RESIDUALS                                            SLV
          DO 319 I=1,N                                              SLV
  319     R(I)=-DOT(N,AA(I,1),MA,X(1),1,-B(I))                      SLV
C         FIND INCREMENT                                            SLV
          DO 329 I=1,N                                              SLV
  329     Z(I)=-SDOT(I-1,A(I,1),MA,Z(1),1,-R(I))                    SLV
          DO 339 K=1,N                                              SLV
          I=NP1-K                                                   SLV
  339     DX(I)=-SDOT(N-I,A(I,I+1),MA,DX(I+1),1,-Z(I))/A(I,I)       SLV
C         INCREMENT AND TEST CONVERGENCE                            SLV
          TOP=0.0                                                   SLV
          DO 342 I=1,N                                              SLV
              TEMP=X(I)                                             SLV
              X(I)=DAD(X(I),DX(I))                                  SLV
              DELX=ABS (X(I)-TEMP)                                  SLV
              TOP=AMAX1(TOP,DELX)                                   SLV
  342     CONTINUE                                                  SLV
          IF(TOP-EPSX)381,381,369                                   SLV
  369 CONTINUE                                                      SLV
  370 IT=0                                                          SLV
  381 RETURN                                                        SLV
C                                                                   SLV
C     RESTORE A AND B                                               SLV
C                                                                   SLV
 3000 CONTINUE                                                      SLV
      DO 709 K=1,N                                                  SLV
          I=NP1-K                                                   SLV
          IP=IRP(I)                                                 SLV
          IF(I-IP)701,709,701                                       SLV
  701     TEMP=B(I)                                                 SLV
          B(I)=B(IP)                                                SLV
          B(IP)=TEMP                                                SLV
          DO 702 J=1,N                                              SLV
              TEMP=AA(I,J)                                          SLV
              AA(I,J)=AA(IP,J)                                      SLV
  702         AA(IP,J)=TEMP                                         SLV
  709 CONTINUE                                                      SLV
      DO 729 I=1,N                                                  SLV
          B(I)=B(I)/RM(I)                                           SLV
          DO 729 J=1,N                                              SLV
          A(I,J)=AA(I,J)/RM(I)                                      SLV
  729 CONTINUE                                                      SLV
      RETURN                                                        SLV
      END                                                           SLV
```

```
$IBMAP DØT      84,DECK,LIST
*    DØT AND FRIENDS         RØUTINES FØR USE WITH SØLVE
        ENTRY    DØT (N,A(1),MA,B(1),MB,C)    DØUBLE INNER PRØDUCT
        ENTRY    SDØT (N,A(1),MA,B(1),MB,C)   INNER PRØDUCT
        ENTRY    ILØG2 (A)    FLØATING PØINT EXPØNENT
        ENTRY    DAD (A,B)    ADD WITH RØUND
*
SNAD    MACRØ    M       STØRE NEGATIVE ØF ADDRESS IN DECREMENT
        SUB      =Ø100000          CØMPLEMENT IF PØSITIVE
        ALS      18
        STD      M
        ENDM     SNAD
*
DØT     SAVE     1,2,4
        STZ      S
        STZ      S+1
        CLA*     8,4               C
        LDQ      C+1
        STØ      C
        CLA*     3,4               N
        TZE      NØNE              SKIP LØØP IF N = 0
        STØ      N
        CLA      4,4               BASE ADDRESS ØF A
        PAC      ,1                X1=-(BASE ØF A)
        CLA*     5,4               MA
        SNAD     MA
        CLA      6,4               BASE ADDRESS ØF B
        PAC      ,2                X2=-(BASE ØF B)
        CLA*     7,4               MB
        SNAD     MB
        LXA      N,4               X4=N
LØØP    LDQ      0,1               A(I)
        FMP      0,2               B(I)
        DFAD     S
        DST      S
MA      TXI      *+1,1,**          (X1)=(X1)+MA
MB      TXI      *+1,2,**          (X2)=(X2)+MB
        TIX      LØØP,4,1          END ØF MAIN LØØP
NØNE    DFAD     C
        FRN
        RETURN   DØT

SDØT    SAVE     1,2,4
        STZ      S
        CLA*     8,4
        STØ      C
        CLA*     3,4
        TZE      SNØNE
        STØ      N
        CLA      4,4
        PAC      ,1
        CLA*     5,4
        SNAD     SMA
        CLA      6,4
        PAC      ,2
        CLA*     7,4
        SNAD     SMB
        LXA      N,4
SLØØP   LDQ      0,1
        FMP      0,2
        FAD      S
```

```
        STØ     S                                                    DØT40610
SMA     TXI     *+1,1,**                                             DØT40620
SMB     TXI     *+1,2,**                                             DØT40630
        TIX     SLØØP,4,1                                            DØT40640
SNØNE   FAD     C                                                    DØT40650
        RETURN  SDØT                                                 DØT40660
*                                                                    DØT40670
ILØG2   CAL*    3,4                                                  DØT40680
        ANA     =Ø377000000000                                       DØT40690
        SUB     =Ø200000000000                                       DØT40700
        ARS     27                                                   DØT40710
        TRA     1,4                                                  DØT40720
*                                                                    DØT40730
DAD     CLA*    3,4                                                  DØT40740
        FAD*    4,4                                                  DØT40750
        FRN                                                          DØT40760
        TRA     1,4                                                  DØT40770
*                                                                    DØT40780
        EVEN                                                         DØT40790
C       PZE                                                          DØT40800
        PZE                                                          DØT40810
S       PZE                                                          DØT40820
        PZE                                                          DØT40830
N       PZE                                                          DØT40840
        END                                                          DØT40850
$IBMAP RWEG2F   800,LIST,REF,DECK,M90,RELMØD,NØ(),NØMFTC           RWEG2F0000
*RWEG2F                  RØUTINE BETWEEN JACØBI AND EG2F           RWEG2F0000
*               TØ SET UP SYMBØLIC CALLING SEQUENCE                RWEG2F0000
        ENTRY   RWEG2F                                             RWEG2F0000
RWEG2F  SAVE    (1,2,4)         SAVE INDEX REGISTERS.              RWEG2F0000
        CLA     3,4                                                RWEG2F0000
        STA     SUB+1                                              RWEG2F0000
        CLA     4,4             B.                                 RWEG2F0000
        PAX     ,2                                                 RWEG2F0000
        SXD     SUB+1,2         A.                                 RWEG2F0000
        CLA     5,4             VECTØR.                            RWEG2F0000
        STA     SUB+2                                              RWEG2F0000
        CLA*    6,4             N.                                 RWEG2F0000
        PAX     ,2                                                 RWEG2F0000
        SXD     SUB+2,2                                            RWEG2F0000
        CLA     7,4             NØGØ.                              RWEG2F0000
        STA     TEMP                                               RWEG2F0000
        ØCT     476000000016    ENTM ØN 7094 CØMPUTER, NØP ØN 7090 RWEG2F0000
 SUB    TSX     EG2F,4          EG2F CALLING SEQUENCE.             RWEG2F0000
        PZE     **,,**          A,,B.                              RWEG2F0000
        PZE     **,,**          V,,N.                              RWEG2F0000
        TRA     ERRØR           ERRØR EXIT.                        RWEG2F0000
        STZ*    TEMP            NØRMAL EXIT.                       RWEG2F0000
 RET1   ØCT     076000000016    LNTM ØN 7094 CØMPUTER, NØP ØN 7090 RWEG2F0000
        RETURN  RWEG2F                                             RWEG2F0000
 TEMP   PZE                                                        RWEG2F0000
 ERRØR  TZE     ACC                                                RWEG2F0000
        CLS     =1              NØGØ                               RWEG2F0000
        STØ*    TEMP            =-1.                               RWEG2F0000
        TRA     RET1                                               RWEG2F0000
 ACC    CLA     =1              NØGØ                               RWEG2F0000
        STØ*    TEMP            =1.                                RWEG2F0000
        TRA     RET1                                               RWEG2F0000
        EJECT                                                      RWEG2F0000
        TTL     SHARE SUBRØUTINE EG2F                              RWEG2F0000
EG2F    SXD EG2F+0209,4                                              EG2F0003
```

```
      SXD EG2F+0210,1                                          EG2F0004
      SXD EG2F+0211,2                                          EG2F0005
      CLA 1,4                                                  EG2F0006
      STA EG2F+0215          LØC A MATRIX                      EG2F0007
      STA EG2F+0042                                            EG2F0008
      STA EG2F+0066                                            EG2F0009
      STA EG2F+0068                                            EG2F0010
      ARS 18                                                   EG2F0011
      STA EG2F+0029          LØC B MATRIX                      EG2F0012
      STA EG2F+0214                                            EG2F0013
      CLA 2,4                                                  EG2F0014
      STA EG2F+0216          LØC V MATRIX                      EG2F0015
      STA EG2F+0030                                            EG2F0016
      STD EG2F+0207                                            EG2F0017
      ALS 18                                                   EG2F0018
      STD EG2F+0042                                            EG2F0019
      LDQ EG2F+0207                                            EG2F0020
      MPY EG2F+0207                                            EG2F0021
      ALS 17                                                   EG2F0022
      CØM                                                      EG2F0023
      ADD EG2F+0208                                            EG2F0024
      STD EG2F+0213          -(N SQUARED)                      EG2F0025
      CLA EG2F+0207                                            EG2F0026
      CØM                                                      EG2F0027
      ADD EG2F+0208                                            EG2F0028
      STD EG2F+0029                                            EG2F0029
      STD EG2F+0212                                            EG2F0030
      TSX EG2F+0217,4                                          EG2F0031
      PZE *,0,*                                                EG2F0032
      PZE *                                                    EG2F0033
      TRA EG2F+0053                                            EG2F0034
      TSX EG2F+0072,4           FØRM M(-1)TAM(-1)              EG2F0035
      LXD EG2F+0209,4                                          EG2F0036
      CLA 1,4                                                  EG2F0037
      TPL EG2F+0038                                            EG2F0038
      CLS EG2F+0207                                            EG2F0039
      TRA EG2F+0039                                            EG2F0040
      CLA EG2F+0207                                            EG2F0041
      ARS 18                                                   EG2F0042
      STØ EG2F+0043                                            EG2F0043
      TSX EG2F+0370,4                                          EG2F0044
      PZE *,0,*                                                EG2F0045
      PZE *                                                    EG2F0046
      TRA EG2F+0055                                            EG2F0047
      TRA EG2F+0060                                            EG2F0048
      TSX EG2F+0181,4                                          EG2F0049
      TSX EG2F+0132,4                                          EG2F0050
      TSX EG2F+0191,4                                          EG2F0051
      LXD EG2F+0209,4                                          EG2F0052
      LXD EG2F+0210,1                                          EG2F0053
      LXD EG2F+0211,2                                          EG2F0054
      TRA 4,4                                                  EG2F0055
      PXD                                                      EG2F0056
      TRA EG2F+0056                                            EG2F0057
      CLA EG2F+0344                                            EG2F0058
      LXD EG2F+0210,1                                          EG2F0059
      LXD EG2F+0211,2                                          EG2F0060
      LXD EG2F+0209,4                                          EG2F0061
      TRA 3,4                                                  EG2F0062
      STØ CØMMØN+000                                           EG2F0063
      CLA EG2F+0207                                            EG2F0064
```

```
      PDX 0,1                    N                                    EG2F0065
      CØM                                                             EG2F0066
      STD EG2F+0069                                                   EG2F0067
      LXD EG2F+0342,2                                                 EG2F0068
      CLA *,2                                                         EG2F0069
      FDP CØMMØN+000                                                  EG2F0070
      STQ *,2                                                         EG2F0071
      TXI EG2F+0070,2,*                                               EG2F0072
      TIX EG2F+0066,1,1                                               EG2F0073
      TRA EG2F+0049                                                   EG2F0074
      SXD CØMMØN+004,4                                                EG2F0075
      CLA EG2F+0213                                                   EG2F0076
      STD EG2F+0101                                                   EG2F0077
      STD EG2F+0124                                                   EG2F0078
      STD EG2F+0127                                                   EG2F0079
      CLA EG2F+0212                                                   EG2F0080
      STD EG2F+0126                                                   EG2F0081
      CLA EG2F+0214                                                   EG2F0082
      STA EG2F+0116                                                   EG2F0083
      CLA EG2F+0215                                                   EG2F0084
      STA EG2F+0117                                                   EG2F0085
      CLA EG2F+0216                                                   EG2F0086
      STA EG2F+0099                                                   EG2F0087
      STA EG2F+0118                                                   EG2F0088
      STA EG2F+0119                                                   EG2F0089
      TSX EG2F+0097,4                                                 EG2F0090
      CLA EG2F+0216                                                   EG2F0091
      STA EG2F+0117                                                   EG2F0092
      CLA EG2F+0215                                                   EG2F0093
      STA EG2F+0099                                                   EG2F0094
      STA EG2F+0118                                                   EG2F0095
      STA EG2F+0119                                                   EG2F0096
      TSX EG2F+0097,4                                                 EG2F0097
      LXD CØMMØN+004,4                                                EG2F0098
      TRA 1,4                                                         EG2F0099
      SXD CØMMØN+003,4                                                EG2F0100
      LXA EG2F+0342,4                                                 EG2F0101
      STZ *,4                                                         EG2F0102
      TXI EG2F+0101,4,-1                                              EG2F0103
      TXH EG2F+0099,4,*                                               EG2F0104
      CLA EG2F+0341                                                   EG2F0105
      STØ CØMMØN+002                                                  EG2F0106
      LXA EG2F+0342,4                                                 EG2F0107
      SXD EG2F+0122,4                                                 EG2F0108
      CLA EG2F+0122                                                   EG2F0109
      STD CØMMØN+001                                                  EG2F0110
      ADD CØMMØN+002                                                  EG2F0111
      STD EG2F+0122                                                   EG2F0112
      CLA CØMMØN+002                                                  EG2F0113
      ADD EG2F+0341                                                   EG2F0114
      STD CØMMØN+002                                                  EG2F0115
      STZ CØMMØN+000                                                  EG2F0116
      LXD CØMMØN+000,2        00                                      EG2F0117
      LXD CØMMØN+001,1                                                EG2F0118
      LDQ *,1                                                         EG2F0119
      FMP *,2                                                         EG2F0120
      FAD *,4                                                         EG2F0121
      STØ *,4                                                         EG2F0122
      TXI EG2F+0121,1,-1                                              EG2F0123
      TXI EG2F+0122,2,-1                                              EG2F0124
      TXH EG2F+0116,1,*                                               EG2F0125
```

```
      TXI  EG2F+0124,4,-1                                         EG2F0126
      TXL  EG2F+0130,4,*                                          EG2F0127
      LXD  CØMMØN+000,2       00                                  EG2F0128
      TXI  EG2F+0127,2,*                                          EG2F0129
      TXL  EG2F+0106,2,*                                          EG2F0130
      SXD  CØMMØN+000,2       00                                  EG2F0131
      TRA  EG2F+0114                                              EG2F0132
      LXD  CØMMØN+003,4                                           EG2F0133
      TRA  1,4                                                    EG2F0134
      SXD  CØMMØN+004,4                                           EG2F0135
      CLA  EG2F+0214                                              EG2F0136
      STA  EG2F+0154                                              EG2F0137
      CLA  EG2F+0216                                              EG2F0138
      STA  EG2F+0155                                              EG2F0139
      STA  EG2F+0165                                              EG2F0140
      CLA  EG2F+0213                                              EG2F0141
      STD  EG2F+0163                                              EG2F0142
      STD  EG2F+0168                                              EG2F0143
      CLA  EG2F+0212                                              EG2F0144
      STD  EG2F+0162                                              EG2F0145
      STD  EG2F+0169                                              EG2F0146
      CLA  EG2F+0341                                              EG2F0147
      STD  CØMMØN+002                                             EG2F0148
      STZ  CØMMØN+000                                             EG2F0149
      STZ  CØMMØN+001                                             EG2F0150
      LXA  EG2F+0342,4                                            EG2F0151
      LXD  CØMMØN+001,1                                           EG2F0152
      LXD  CØMMØN+000,2       00                                  EG2F0153
      CLA  CØMMØN+002                                             EG2F0154
      STD  EG2F+0158                                              EG2F0155
      STZ  CØMMØN+003                                             EG2F0156
      LDQ  *,1                                                    EG2F0157
      FMP  *,2                                                    EG2F0158
      FAD  CØMMØN+003                                             EG2F0159
      STØ  CØMMØN+003                                             EG2F0160
      TXI  EG2F+0159,1,*                                          EG2F0161
      CLA  EG2F+0158                                              EG2F0162
      ADD  EG2F+0341                                              EG2F0163
      STD  EG2F+0158                                              EG2F0164
      TXI  EG2F+0163,2,*                                          EG2F0165
      TXH  EG2F+0154,2,*                                          EG2F0166
      CLA  CØMMØN+003                                             EG2F0167
      STØ  *,4                                                    EG2F0168
      TXI  EG2F+0167,4,-1                                         EG2F0169
      SXD  CØMMØN+000,4       00                                  EG2F0170
      TXL  EG2F+0179,4,*                                          EG2F0171
      TXH  EG2F+0149,4,*                                          EG2F0172
      CLA  EG2F+0169                                              EG2F0173
      ADD  EG2F+0212                                              EG2F0174
      STD  EG2F+0169                                              EG2F0175
      CLA  CØMMØN+002                                             EG2F0176
      ADD  EG2F+0341                                              EG2F0177
      STD  CØMMØN+002                                             EG2F0178
      ADD  CØMMØN+001                                             EG2F0179
      STD  CØMMØN+001                                             EG2F0180
      TRA  EG2F+0149                                              EG2F0181
      LXD  CØMMØN+004,4                                           EG2F0182
      TRA  1,4                                                    EG2F0183
      CLA  EG2F+0212                                              EG2F0184
      STD  EG2F+0199                                              EG2F0185
      CLA  EG2F+0213                                              EG2F0186
```

```
      STD EG2F+0200                                                   EG2F0187
      STD EG2F+0205                                                   EG2F0188
      CLA EG2F+0216                                                   EG2F0189
      STA EG2F+0194                                                   EG2F0190
      STA EG2F+0195                                                   EG2F0191
      STA EG2F+0196                                                   EG2F0192
      STA EG2F+0197                                                   EG2F0193
      STZ CØMMØN+000                                                  EG2F0194
      LXD CØMMØN+000,1       00                                       EG2F0195
      LXD CØMMØN+000,2       00                                       EG2F0196
      CLA *,1                                                         EG2F0197
      LDQ *,2                                                         EG2F0198
      STQ *,1                                                         EG2F0199
      STØ *,2                                                         EG2F0200
      TXI EG2F+0199,1,-1                                              EG2F0201
      TXI EG2F+0200,2,*                                               EG2F0202
      TXH EG2F+0194,2,*                                               EG2F0203
      CLA CØMMØN+000                                                  EG2F0204
      ADD EG2F+0212                                                   EG2F0205
      ADD EG2F+0341                                                   EG2F0206
      STD CØMMØN+000                                                  EG2F0207
      TXH EG2F+0192,1,*                                               EG2F0208
      TRA 1,4                                                         EG2F0209
      PZE                                                             EG2F0210
      PZE 0,0,1                                                       EG2F0211
      PZE                                                             EG2F0212
      PZE                                                             EG2F0213
      PZE                                                             EG2F0214
      PZE                                                             EG2F0215
      PZE                                                             EG2F0216
      PZE                                                             EG2F0217
      PZE                                                             EG2F0218
      PZE                                                             EG2F0219
      SXD CØMMØN+010,1                                                EG2F0220
      SXD CØMMØN+011,2                                                EG2F0221
      CLA 2,4                                                         EG2F0222
      STA EG2F+0295                                                   EG2F0223
      STA EG2F+0296                                                   EG2F0224
      SUB EG2F+0344                                                   EG2F0225
      STA EG2F+0266                                                   EG2F0226
      STA EG2F+0283                                                   EG2F0227
      CLA 1,4                                                         EG2F0228
      STD EG2F+0311                                                   EG2F0229
      SXD CØMMØN+004,4                                                EG2F0230
      LXD EG2F+0341,2                                                 EG2F0231
      STA EG2F+0282                                                   EG2F0232
      STA EG2F+0236                                                   EG2F0233
      STA EG2F+0239                                                   EG2F0234
      STA EG2F+0326                                                   EG2F0235
      STA EG2F+0328                                                   EG2F0236
      STA EG2F+0258                                                   EG2F0237
      STA EG2F+0259                                                   EG2F0238
      CLA *                                                           EG2F0239
      STØ CØMMØN+013,2                                                EG2F0240
      CLA EG2F+0343                                                   EG2F0241
      STØ *                                                           EG2F0242
      CLA EG2F+0342                                                   EG2F0243
      STØ CØMMØN+005                                                  EG2F0244
      CLA CØMMØN+005                                                  EG2F0245
      ADD EG2F+0344                                                   EG2F0246
      STØ CØMMØN+005                                                  EG2F0247
```

```
ADD EG2F+0259                                   EG2F0248
STA EG2F+0259                                   EG2F0249
STA EG2F+0273                                   EG2F0250
STA EG2F+0285                                   EG2F0251
STA EG2F+0284                                   EG2F0252
STA EG2F+0308                                   EG2F0253
STA EG2F+0304                                   EG2F0254
SXD EG2F+0267,2          COMP LAMBDA            EG2F0255
LXD EG2F+0342,4                                 EG2F0256
LXD EG2F+0341,1                                 EG2F0257
SXD EG2F+0264,1                                 EG2F0258
LXD EG2F+0342,1                                 EG2F0259
STZ COMMON+006                                  EG2F0260
LDQ *,4                                         EG2F0261
FMP *,1                                         EG2F0262
FAD COMMON+006                                  EG2F0263
STO COMMON+006                                  EG2F0264
TXI EG2F+0263,4,-1                              EG2F0265
TXI EG2F+0264,1,-1                              EG2F0266
TXH EG2F+0258,1,*                               EG2F0267
FDP COMMON+013,1                                EG2F0268
STQ *,1                                         EG2F0269
TXH EG2F+0269,1,*                               EG2F0270
TRA EG2F+0271                                   EG2F0271
LXD EG2F+0264,1                                 EG2F0272
TXI EG2F+0255,1,-1                              EG2F0273
SXD EG2F+0275,2                                 EG2F0274
LXD EG2F+0342,4                                 EG2F0275
STZ *,4                                         EG2F0276
TXI EG2F+0275,4,-1                              EG2F0277
TXH EG2F+0273,4,*                               EG2F0278
TXI EG2F+0277,2,-1                              EG2F0279
SXD EG2F+0290,2                                 EG2F0280
LXD EG2F+0342,4                                 EG2F0281
LXD EG2F+0341,2                                 EG2F0282
LXD EG2F+0342,1                                 EG2F0283
SXD EG2F+0288,2                                 EG2F0284
LDQ *,4              A LAMBDA TIMES A ROW       EG2F0285
FMP *,2                                         EG2F0286
FAD *,1              VECTOR WHICH WILL BE       EG2F0287
STO *,1              THE NEW ROW                EG2F0288
TXI EG2F+0287,4,-1                              EG2F0289
TXI EG2F+0288,1,-1                              EG2F0290
TXH EG2F+0282,1,*                               EG2F0291
TXI EG2F+0290,2,-1                              EG2F0292
TXH EG2F+0280,2,*          END COMP. NEW ROW    EG2F0293
STZ COMMON+008                                  EG2F0294
LXD EG2F+0288,2                                 EG2F0295
SXD EG2F+0303,2                                 EG2F0296
LXD EG2F+0342,4                                 EG2F0297
LDQ *,4                                         EG2F0298
FMP *,4                                         EG2F0299
STO COMMON+007                                  EG2F0300
LDQ COMMON+007                                  EG2F0301
FMP COMMON+014,4                                EG2F0302
FAD COMMON+008                                  EG2F0303
STO COMMON+008                                  EG2F0304
TXI EG2F+0303,4,-1                              EG2F0305
TXH EG2F+0295,4,*                               EG2F0306
CLA *,1                                         EG2F0307
FSB COMMON+008                                  EG2F0308
```

```
STØ CØMMØN+014,2                                        EG2F0309
CLA EG2F+0343                                           EG2F0310
STØ *,1                                                 EG2F0311
TXI EG2F+0310,2,-1                                      EG2F0312
LXD EG2F+0267,1                                         EG2F0313
TXH EG2F+0242,2,*                                       EG2F0314
SXD EG2F+0321,2                                         EG2F0315
TXI EG2F+0314,2,-2          -(N+2)                      EG2F0316
SXD EG2F+0334,2                                         EG2F0317
LXD EG2F+0342,1                                         EG2F0318
CLA CØMMØN+014,1                                        EG2F0319
TSX EG2F+0345,4                                         EG2F0320
TRA EG2F+0339                                           EG2F0321
STØ CØMMØN+014,1                                        EG2F0322
TXI EG2F+0321,1,-1                                      EG2F0323
TXH EG2F+0316,1,*                                       EG2F0324
LXD EG2F+0341,6                                         EG2F0325
LXD EG2F+0342,1                                         EG2F0326
TXI EG2F+0325,2,-1                                      EG2F0327
SXD EG2F+0330,4                                         EG2F0328
CLA *,1                                                 EG2F0329
FDP CØMMØN+012,2                                        EG2F0330
STQ *,1                                                 EG2F0331
TXI EG2F+0330,1,-1                                      EG2F0332
TXH EG2F+0326,1,*                                       EG2F0333
SXD EG2F+0332,2                                         EG2F0334
TXI EG2F+0333,4,*                                       EG2F0335
TXI EG2F+0334,2,-1                                      EG2F0336
TXH EG2F+0325,2,*                                       EG2F0337
LXD CØMMØN+010,1                                        EG2F0338
LXD CØMMØN+011,2                                        EG2F0339
LXD CØMMØN+004,4                                        EG2F0340
TRA 4,4                                                 EG2F0341
LXD CØMMØN+004,4                                        EG2F0342
TRA 3,4                                                 EG2F0343
PZE 1,0,-1                                              EG2F0344
PZE                                                     EG2F0345
DEC -1.                                                 EG2F0346
PZE 1                                                   EG2F0347
STØ CØMMØN+000          SAVE ARGUMENT SIGN              EG2F0348
SSP                     N                               EG2F0349
TZE EG2F+0365           GØ TØ EXIT IF ZERØ              EG2F0350
STØ CØMMØN+001          SAVE N                          EG2F0351
ANA EG2F+0368           CØMPUTE TRIAL VALUE, X          EG2F0352
LRS 1                   X                               EG2F0353
ADD CØMMØN+001          X                               EG2F0354
LRS 1                   X                               EG2F0355
ADD EG2F+0369           X                               EG2F0356
SXD CØMMØN+000,4         00 RETURN ADDRESS              EG2F0357
LXA EG2F+0346,4            SET INDEX FØR 3 ITERATIØNS   EG2F0358
STØ CØMMØN+002          SAVE X                          EG2F0359
CLA CØMMØN+001          CØMPUTE SQUARE RØØT             EG2F0360
FDH CØMMØN+002          X N/X                           EG2F0361
STQ CØMMØN+003          X                               EG2F0362
CLA CØMMØN+003          X N/X                           EG2F0363
FAD CØMMØN+002          X + X                           EG2F0364
SUB EG2F+0368           X DIVIDE BY 2                   EG2F0365
TIX EG2F+0356,4,1        REPEAT LØØP                    EG2F0366
LXD CØMMØN+000,4         OOØRE EXIT ADDRESS             EG2F0367
LDQ CØMMØN+000          TEST SIGN ØF ARGUMENT           EG2F0368
TQP 2,4                 IF + , SKIP ØNE                 EG2F0369
```

```
      TRA 1,4             IF - , DØ NØT SKIP ØNE                        EG2F0370
      DEC 134217728,8657043456 0*2 EXP -127, 1/2 * EXP -64              EG2F0371
      REM NYEVV   328 CARDS EIGENVALUES AND EIGENVECTØRS                EG2F0372
      SXD CØMMØN+000,1      00     SAVE IRS                             EG2F0373
      SXD CØMMØN+001,2                                                  EG2F0374
      SXD CØMMØN+002,4                                                  EG2F0375
      PXD                          SAVE SLTS                            EG2F0376
      LXA EG2F+0694,1                                                   EG2F0377
      ALS 1                                                             EG2F0378
      SLT 5,1                                                           EG2F0379
      ADD EG2F+0375                                                     EG2F0380
      TIX EG2F+0375,1,1                                                 EG2F0381
      STA EG2F+0373                                                     EG2F0382
      CLA 1,4                      M                                    EG2F0383
      PAX 0,1                                                           EG2F0384
      STA EG2F+0488                                                     EG2F0385
      STA EG2F+0534                                                     EG2F0386
      STA EG2F+0536                                                     EG2F0387
      STA EG2F+0538                                                     EG2F0388
      STA EG2F+0558                                                     EG2F0389
      ADM 2,4                      M+N                                  EG2F0390
      STA EG2F+0482                                                     EG2F0391
      STA EG2F+0489                                                     EG2F0392
      STA EG2F+0539                                                     EG2F0393
      STA EG2F+0543                                                     EG2F0394
      CAL 2,4                      N                                    EG2F0395
      STA EG2F+0381                                                     EG2F0396
      ADD EG2F+0375                N+1                                  EG2F0397
      STA EG2F+0464                                                     EG2F0398
      ALS 18                                                            EG2F0399
      STD EG2F+0604                                                     EG2F0400
      SUB EG2F+0695                N-1                                  EG2F0401
      STD EG2F+0465                                                     EG2F0402
      CØM                          -N                                   EG2F0403
      STD EG2F+0560                                                     EG2F0404
      STD EG2F+0561                                                     EG2F0405
      SUB EG2F+0696                -(N+1)                               EG2F0406
      STD EG2F+0567                                                     EG2F0407
      LDQ 2,4                      N**2                                 EG2F0408
      MPY 2,4                                                           EG2F0409
      STQ CØMMØN+003                                                    EG2F0410
      CLA 1,4                      M+N**2                               EG2F0411
      ADD CØMMØN+003                                                    EG2F0412
      STA EG2F+0441                                                     EG2F0413
      STA EG2F+0442                                                     EG2F0414
      STA EG2F+0611                                                     EG2F0415
      STA EG2F+0623                                                     EG2F0416
      STA EG2F+0625                                                     EG2F0417
      STA EG2F+0638                                                     EG2F0418
      STA EG2F+0641                                                     EG2F0419
      CØM                          -V                                   EG2F0420
      ADD EG2F+0696                                                     EG2F0421
      STØ CØMMØN+004                                                    EG2F0422
      PXD 0,1                                                           EG2F0423
      ADD CØMMØN+004               -(V-M)                               EG2F0424
      STD CØMMØN+004                                                    EG2F0425
      ADM EG2F+0567                -(V-M)-N                             EG2F0426
      STD CØMMØN+005                                                    EG2F0427
      CLA 2,4                      FLØAT N                              EG2F0428
      SSP                                                               EG2F0429
      ADD EG2F+0697                                                     EG2F0430
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      FAD EG2F+0697                                                  EG2F0431
      STØ CØMMØN+006                                                 EG2F0432
      CLA 2,4                      SET NØ VECTØRS                    EG2F0433
      TPL EG2F+0594                                                  EG2F0434
      CLA EG2F+0689                                                  EG2F0435
      STØ EG2F+0528                                                  EG2F0436
      CLA EG2F+0704                                                  EG2F0437
      STØ CØMMØN+007                                                 EG2F0438
      CLA EG2F+0690                                                  EG2F0439
      STØ EG2F+0593                                                  EG2F0440
      TØV EG2F+0439                                                  EG2F0441
      STZ CØMMØN+008               CALCULATE NØRM                    EG2F0442
      LXA CØMMØN+003,7                                               EG2F0443
      LDQ 0,1                                                        EG2F0444
      FMP 0,1                                                        EG2F0445
      TØV EG2F+0611                                                  EG2F0446
      FAD CØMMØN+008                                                 EG2F0447
      TØV EG2F+0651                                                  EG2F0448
      STØ CØMMØN+008                                                 EG2F0449
      TIX EG2F+0441,1,1                                              EG2F0450
      SLF                                                            EG2F0451
      TSX EG2F+0655,4                                                EG2F0452
      FDH CØMMØN+006                                                 EG2F0453
      STQ CØMMØN+006                                                 EG2F0454
      CLA CØMMØN+006                                                 EG2F0455
      SUB EG2F+0698                                                  EG2F0456
      STØ CØMMØN+008               FINAL NØRM                        EG2F0457
      CLA CØMMØN+006                                                 EG2F0458
      SUB EG2F+0699                                                  EG2F0459
      STØ CØMMØN+006               PRØVISIØNAL NØRM                  EG2F0460
      LXA EG2F+0569,1                  SET -(J-2)N-(K-1)=0           EG2F0461
      CLA EG2F+0534                UNDERSET J=1                      EG2F0462
      STA EG2F+0487                                                  EG2F0463
      STA EG2F+0522                                                  EG2F0464
      CLA EG2F+0696                SET J-1=1                         EG2F0465
      STØ CØMMØN+003                                                 EG2F0466
      PDX 0,2                      SET J-K=1                         EG2F0467
      TXH EG2F+0576,2                  J-K GREATER THAN N-1          EG2F0468
      CLA EG2F+0522                J TØ J+1                          EG2F0469
      ADD EG2F+0381                                                  EG2F0470
      STA EG2F+0522                                                  EG2F0471
      STA EG2F+0525                                                  EG2F0472
      STA EG2F+0557                                                  EG2F0473
      CLA EG2F+0487                                                  EG2F0474
      ADM EG2F+0464                                                  EG2F0475
      STA EG2F+0487                                                  EG2F0476
      STA EG2F+0540                                                  EG2F0477
      STA EG2F+0542                                                  EG2F0478
      LXA EG2F+0569,4                  SET (1-K)(N+1)=0              EG2F0479
      CLA EG2F+0534                SET K=1                           EG2F0480
      STA EG2F+0521                                                  EG2F0481
      STA EG2F+0524                                                  EG2F0482
      STA EG2F+0555                                                  EG2F0483
      CLA CØMMØN+006               NØRM                              EG2F0484
      SBM 0,1                      -A(J,K)                           EG2F0485
      TPL EG2F+0564                GREATER THAN 0                    EG2F0486
      SLN 4                        SMALLER                           EG2F0487
      SXD EG2F+0689,2                   SAVE IRS                     EG2F0488
      SXD EG2F+0654,4                                                EG2F0489
      CLA                          A(J,J)                            EG2F0490
      FSB 0,4                      -A(K,K)                           EG2F0491
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```
      FDH 0,1                        /A(J,K)                                  EG2F0492
      STQ CØMMØN+011                                                          EG2F0493
      CLA CØMMØN+011                                                          EG2F0494
      TMI EG2F+0494                                                           EG2F0495
      SLN 3                          SL3 ØN IF G PØSITIVE                     EG2F0496
      SSP                                                                     EG2F0497
      SUB EG2F+0699                  G                                        EG2F0498
      STØ CØMMØN+011                                                          EG2F0499
      LDQ CØMMØN+011                 G**2                                     EG2F0500
      FMP CØMMØN+011                                                          EG2F0501
      FAD EG2F+0704                  1+G**2                                   EG2F0502
      STØ CØMMØN+012                                                          EG2F0503
      TSX EG2F+0655,4                     (1+G**2)**1/2                       EG2F0504
      LRS 35                                                                  EG2F0505
      FMP CØMMØN+011                 G(1+G**2)**1/2                           EG2F0506
      FAD CØMMØN+012                 +1+G**2                                  EG2F0507
      STØ CØMMØN+011                                                          EG2F0508
      CLA EG2F+0705                  (SINT)**2                                EG2F0509
      FDH CØMMØN+011                                                          EG2F0510
      STQ CØMMØN+011                                                          EG2F0511
      CLA CØMMØN+011                                                          EG2F0512
      TSX EG2F+0655,4                     SIN T                               EG2F0513
      SLT 3                                                                   EG2F0514
      SSM                                                                     EG2F0515
      STØ CØMMØN+012                                                          EG2F0516
      CLA EG2F+0704                                                           EG2F0517
      FSB CØMMØN+011                                                          EG2F0518
      TSX EG2F+0655,4                     CØST                                EG2F0519
      STØ CØMMØN+011                                                          EG2F0520
      LXA EG2F+0569,2                     SET MAIN MATRIX                     EG2F0521
      CLA EG2F+0560                                                           EG2F0522
      STD EG2F+0527                  SET I-1=0                                EG2F0523
      CLA 0,2                        A(K,I)                                   EG2F0524
      LDQ 0,2                        A(J,I)                                   EG2F0525
      TSX EG2F+0673,4                     B(K,I),B(J,I)                       EG2F0526
      STØ 0,2                                                                 EG2F0527
      STQ 0,2                                                                 EG2F0528
      TXI EG2F+0527,2,-1                  I TØ I+1                            EG2F0529
      TXH EG2F+0521,2                     I=N                                 EG2F0530
      HTR 0                                                                   EG2F0531
      TRA EG2F+0607                                                           EG2F0532
      CAL EG2F+0689                  J-K                                      EG2F0533
      CØM                                                                     EG2F0534
      ADM EG2F+0654                  +(1-K)(N+1)                              EG2F0535
      PDX 0,4                                                                 EG2F0536
      LDQ 0,4                        A(K,J) IN MQ                             EG2F0537
      LXD EG2F+0654,2                     (1-K)(N+1)                          EG2F0538
      CLA 0,2                        A(K,K) IN AC                             EG2F0539
      TSX EG2F+0673,4                                                         EG2F0540
      STØ 0,2                        B(K,K)                                   EG2F0541
      CLA 0,1                        A(J,K) IN AC                             EG2F0542
      LDQ                            A(J,J) IN MQ                             EG2F0543
      TSX EG2F+0673,4                                                         EG2F0544
      STQ                            B(J,J)                                   EG2F0545
      STØ 0,1                        B(J,K)                                   EG2F0546
      CLA CØMMØN+003                 J                                        EG2F0547
      CØM                                                                     EG2F0548
      ADD EG2F+0696                                                           EG2F0549
      PDX 0,2                                                                 EG2F0550
      CAL EG2F+0689                  K-J                                      EG2F0551
      CØM                                                                     EG2F0552
```

```
ADD EG2F+0696           M+K-J                                      EG2F0553
ARS 18                                                             EG2F0554
ADD EG2F+0534                                                      EG2F0555
STA EG2F+0556                                                      EG2F0556
LXA EG2F+0569,4             SET I-1=0                              EG2F0557
CLA 0,4                 A(K,I)                                     EG2F0558
STØ 0,2                 A(I,K)                                     EG2F0559
CLA 0,4                 A(J,I)                                     EG2F0560
STØ 0,2                 A(I,J)                                     EG2F0561
TXI EG2F+0560,4,-1          I TØ I+1                               EG2F0562
TXL EG2F+0562,4             I=N                                    EG2F0563
TXI EG2F+0555,2                                                    EG2F0564
LXD EG2F+0689,2              RESTØRE IRS                           EG2F0565
LXD EG2F+0654,4                                                    EG2F0566
TNX EG2F+0569,2,1           J-K=1                                  EG2F0567
CLA EG2F+0521           K TØ K+1                                   EG2F0568
ADD EG2F+0381                                                      EG2F0569
TXI EG2F+0568,4                                                    EG2F0570
TXI EG2F+0478,1,-1                                                 EG2F0571
PXD 0,1                 M TØ M+1                                   EG2F0572
ADD CØMMØN+003          AND K=1                                    EG2F0573
ADD EG2F+0567                                                      EG2F0574
PDX 0,1                                                            EG2F0575
CLA CØMMØN+003                                                     EG2F0576
ADD EG2F+0696                                                      EG2F0577
TRA EG2F+0463                                                      EG2F0578
SLT 4                   IS ITERATIØN IDLE                          EG2F0579
TRA EG2F+0579                                                      EG2F0580
TRA EG2F+0458                                                      EG2F0581
CLA CØMMØN+006          IS NØRM FINAL                              EG2F0582
LDQ CØMMØN+008                                                     EG2F0583
TLQ EG2F+0456                                                      EG2F0584
LXA EG2F+0694,1                RESTØRE SLTS                        EG2F0585
CLA EG2F+0373                                                      EG2F0586
LRS 3                                                              EG2F0587
LBT                                                                EG2F0588
SLN 5,1                                                            EG2F0589
LLS 1                                                              EG2F0590
TIX EG2F+0585,1,1                                                  EG2F0591
LXD CØMMØN+000,1      00    RESTØRE IRS                            EG2F0592
LXD CØMMØN+001,2                                                   EG2F0593
LXD CØMMØN+002,4                                                   EG2F0594
CLA CØMMØN+007                                                     EG2F0595
HTR 0                                                              EG2F0596
CLA 1,4                 SETTING FØR VECTØRS                        EG2F0597
ARS 18                                                             EG2F0598
ADD CØMMØN+003                                                     EG2F0599
STA EG2F+0600                                                      EG2F0600
STA EG2F+0603                                                      EG2F0601
LXA CØMMØN+003,3        SET IDENTITY MATRIX                        EG2F0602
STZ 0,1                                                            EG2F0603
TIX EG2F+0600,1,1                                                  EG2F0604
CLA EG2F+0704                                                      EG2F0605
STØ 0,2                                                            EG2F0606
TIX EG2F+0603,2                                                    EG2F0607
CLA EG2F+0691                                                      EG2F0608
TRA EG2F+0433                                                      EG2F0609
SLN 2                   SET MT TØ VECTØRS                          EG2F0610
LXD CØMMØN+004,2                                                   EG2F0611
CLA CØMMØN+005                                                     EG2F0612
TRA EG2F+0520                                                      EG2F0613
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```
CAL 0,1                              UNDERFLØW                                EG2F0614
ANA EG2F+0701                                                                 EG2F0615
SUB EG2F+0702                                                                 EG2F0616
TPL EG2F+0646                                                                 EG2F0617
SLN 3                                SLN3 FØR UNDERFLØW                       EG2F0618
SLT 2                                TEST FØR PREVIØUS ØVERFLØW               EG2F0619
TRA EG2F+0632                                                                 EG2F0620
PXD 3                                                                         EG2F0621
STD EG2F+0627                                                                 EG2F0622
CLA EG2F+0692                        SET ERRØR RETURN                         EG2F0623
STØ EG2F+0593                                                                 EG2F0624
SLF                                                                           EG2F0625
CLA 0,4                              UNSCALE MATRIX                           EG2F0626
FDH CØMMØN+007                                                                EG2F0627
STQ 0,4                                                                       EG2F0628
TNX EG2F+0582,4,1                                                             EG2F0629
TXH EG2F+0623,4                                                               EG2F0630
CLA CØMMØN+007                                                                EG2F0631
FDH CØMMØN+013                                                                EG2F0632
STQ CØMMØN+007                                                                EG2F0633
TRA EG2F+0618                                                                 EG2F0634
CHS                                  SCALE MATRIX                             EG2F0635
ADD EG2F+0704                                                                 EG2F0636
STØ CØMMØN+013                                                                EG2F0637
LDQ CØMMØN+013                                                                EG2F0638
FMP CØMMØN+007                                                                EG2F0639
STØ CØMMØN+007                                                                EG2F0640
LDQ 0,2                                                                       EG2F0641
FMP CØMMØN+013                                                                EG2F0642
TØV EG2F+0653                                                                 EG2F0643
STØ 0,2                                                                       EG2F0644
TIX EG2F+0638,2,1                                                             EG2F0645
CLA EG2F+0693                                                                 EG2F0646
STØ EG2F+0593                                                                 EG2F0647
TRA EG2F+0439                                                                 EG2F0648
SUB EG2F+0703                        FMP ØVERFLØW                             EG2F0649
SLN 2                                                                         EG2F0650
SLT 3                                                                         EG2F0651
TRA EG2F+0632                        SCALE                                    EG2F0652
TRA EG2F+0618                        UNSCALE                                  EG2F0653
CLA EG2F+0699                        FAD ØVERFLØW                             EG2F0654
TRA EG2F+0647                                                                 EG2F0655
SXD EG2F+0627,2                          SCALING ØVERFLØW                     EG2F0656
TXL EG2F+0623                                                                 EG2F0657
SXD EG2F+0694,4                            SQUARE RØØT                        EG2F0658
LXA EG2F+0618,4                                                               EG2F0659
STØ CØMMØN+013                                                                EG2F0660
ANA EG2F+0699                                                                 EG2F0661
ARS 1                                                                         EG2F0662
ADD CØMMØN+013                                                                EG2F0663
ARS 1                                                                         EG2F0664
ADD EG2F+0700                                                                 EG2F0665
STØ CØMMØN+009                                                                EG2F0666
CLA CØMMØN+013                                                                EG2F0667
FDH CØMMØN+009                                                                EG2F0668
CLA CØMMØN+009                                                                EG2F0669
STQ CØMMØN+009                                                                EG2F0670
FAD CØMMØN+009                                                                EG2F0671
SUB EG2F+0699                                                                 EG2F0672
TIX EG2F+0663,4,1                                                             EG2F0673
LXD EG2F+0694,4                                                               EG2F0674
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```
      TRA 1,4                                                      EG2F0675
      STØ CØMMØN+013         MATRIX TRANSFØRMATIØN                 EG2F0676
      STQ CØMMØN+009                                               EG2F0677
      FMP CØMMØN+011                                               EG2F0678
      STØ CØMMØN+010                                               EG2F0679
      LDQ CØMMØN+013                                               EG2F0680
      FMP CØMMØN+012                                               EG2F0681
      FAD CØMMØN+010                                               EG2F0682
      STØ CØMMØN+010                                               EG2F0683
      LDQ CØMMØN+009                                               EG2F0684
      FMP CØMMØN+012                                               EG2F0685
      STØ CØMMØN+009                                               EG2F0686
      LDQ CØMMØN+013                                               EG2F0687
      FMP CØMMØN+011                                               EG2F0688
      FSB CØMMØN+009                                               EG2F0689
      LDQ CØMMØN+010                                               EG2F0690
      TRA 1,4                                                      EG2F0691
      TXL EG2F+0530                                                EG2F0692
      TRA 5,4                                                      EG2F0693
      SLT 2                                                        EG2F0694
      TRA 3,4                                                      EG2F0695
      TRA 4,4                                                      EG2F0696
      ØCT 4,2000000,1000000,233000000000,33000000000,1000000000    EG2F0697
      ØCT 100400000000,377000000000,101000000000,176000000000      EG2F0698
      DEC 1.,.5                                                    EG2F0691
CØMMØN BSS    54                                                 RWEG2F1000
      END                                                        RWEG2F100-
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MSFC—RSA, Ala