NUMERICAL INTEGRATION OF SYSTEMS OF DIFFERENTIAL EQUATIONS ARISING IN CELESTIAL MECHANICS

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I hereby signal my most heartfelt gratitude to my research supervisor, Professor John S. Griffith, and to others associated with Lakehead University for having given me the opportunity to carry out this work.

PREFACE

My interest in Astronomy in general and in Celestial Mechanics (CM) in particular dates from prior to 1955. When asked to define CM I sometimes assert, although somewhat facetiously, that "It is the study of the motions of the heavenly bodies!". The reactions from my interlocutors to the preceding range quite widely: from a deadly silent and suspicion - filled glare to hearty and jovial laughter. But, I maintain, that when taken in its strictly scientific sense, it is a fairly good and encompassing definition. It is, indeed, an all-encompassing one when the Earth is admitted to the class of heavenly bodies, as, of course, it should.

As an undergraduate at McGill University I was introduced to and inspired by the awesome "number-crunching" capabilities of digital computers. These machines represented a significant advance in the state of the art of performing scientific calculations, especially when compared to myself even with the aid of Chambers's Seven-Figure Mathematical Tables [1]*!

This thesis, therefore, represents a significant portion of the work I have carried out during the past two years in the consolidated fields of Numerical Analysis, Computer Science, and CM.

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* Numbers in brackets refer to items in the Bibliography.

ABSTRACT

This thesis deals primarily with solving systems of autonomous ordinary nonlinear differential equations arising in Celestial Mechanics initial value problems using various finite-difference techniques. Those methods investigated are the classical Runge-Kutta, Gill's modification to the classical Runge-Kutta, Runge-Kutta-Nyström, rational extrapolation à la Bulirsch and Stoer, and Taylor's series.

For the Two-Body Problem, the Taylor's series technique is about 2.9 times faster (for approximately maximum attainable precision) than rational extrapolation, which was the second fastest of those algorithms investigated. Taylor's series is capable of yielding the most precise results of those methods scrutinized.

In the case of the Eleven-Body Problem in which the Solar System is simulated for over 60 years, rational extrapolation is about 8.5 times faster than the Taylor's series technique for approximately maximum attainable precision in results. The model is strictly based on Newtonian mechanics, using point masses. The angle with vertex at the heliocentre and subtended by the positions of Mercury based on Newtonian mechanics and Einsteinian General Relativity was about 29.35 seconds of arc in the wrong direction, while the corresponding secular excess perihelion shift predicted by Einstein was about 25.89 seconds. The total error angle was, therefore, about 55.24 seconds. Error angles for the other planets

were less by much more than an order of magnitude. Coordinate uncertainties in the initial conditions (especially in the velocity components) severely limit the predictive capability of a Solar System treatment as an initial value problem.

Acceleration components in the Eleven-Body Problem were evaluated with considerable effort to minimize load module execution times, within the constraints imposed by the FORTRAN language - an advance in the state of the art may well have been achieved therein.

A lunar ephemeris of geocentric radii vectores was prepared from the software of the Eleven-Body Problem. The maximum residual observed with respect to the widely available $j = 2$ ephemeris was about 11 km (in a mean distance of 384,400 km), over a 4 year interval.

CONTENTS

CHAPTER 1

A SUCCINCT SURVEY OF CELESTIAL MECHANICS

1.1. INTRODUCTION

Celestial Mechanics (CM) applied to the Solar System has been a considerable impetus in the development of mathematics [2,3]. For those who may be naive in the former we supply a brief treatment, with emphasis on those aspects bearing most heavily on this thesis.

1.2. GENESIS

Assuming an evolutionary development of the species Homo sapiens, probably two salient features thereof at least facilitated his contemplation of the cosmos, namely: his progressing intellect and his transition from quadruped to biped. The former characteristic is facetiously illustrated in a set of cartoons [7]. It is reasonable to suspect that the ancient Egyptian builders of the Great Pyramids of Giza (about 2500 B.C.) strove for an astronomical orientation thereof [11]. Hoyle believes that Stonehenge was employed as an observatory for the Sun and Moon (about 1500 B.C. or earlier) [12], and, indeed, that it may have served as a repository of such information [4]. Numerous other sites seem to support the corresponding former premise [13,14]. An excellent recent discussion pertaining to many aspects of Astronomy in the ancient world is available [5]. Further information on the history of Astronomy may be obtained [96].

1.3. THE GREEKS

The writings of Aristotle surely point out the interdisciplinary characteristic of his great intellect. Unfortunately, although he must have observed falling bodies travelling close to the Earth, he does not seem to have carried out rigorous experiments upon which to base his conclusions [15]. He strongly differentiates between terrestrial and heavenly motion [25], in clear contradistinction to the teachings of Newton [70]. However, care must be exercised when attempting a critical analysis of Aristotle's philosophy: that this is so is evident from a study of two translations regarding his thoughts on falling bodies - the words adjacent to "gold or lead" possess a radically different precise mathematical meaning [26]. Supporting evidence is available [27]. Indeed, it seems that Aristotle has even been mis-quoted by the great Galileo [29]! The preceding demonstrates that historical works, by the passage of time, and derived literature, by the prejudices of its authors, should not necessarily be construed as fiducial representations of their sources of reference: they, therefore, should be considered with some suspicion. We would probably do well to apply the same principle to even contemporary scientific literature also, but in so doing we admit a measure of prejudice. It shall be our intent to be as objective as possible throughout the thesis. Continuing then, Aristotle advocated the geocentric theory, the deferent-epicyclic theory of planetary motion (the "Spheres of Eudoxus") [8,10], the immutability of the heavens [16], and diurnal motion caused by rotation of the celestial sphere [30].

Heracleides considered the possibility of diurnal motion resulting from terrestrial rotation [17].

Aristarchus advanced the heliocentric theory, with circular orbits [8,41].

Ptolemy, in his Almagest [31], synthesized contemporary theories, in essential agreement with Aristotle [9]. We note in passing that the astrolabe [34], known in his time, still serves as a practical device in the U.S. Navy [35].

1.4. NICOLAUS COPERNICUS

Copernicus [18,50] advocated the heliocentric theory [36], which is probably his outstanding astronomical contribution [37]. He also advanced, in "De revolutionibus orbium coelestium", diurnal motion caused by Earth's rotation, and the deferent-epicyclic theory of planetary motion [32]. Although the motivation for his researches is not clear [38], calendar reform could have been responsible [42].

1.5. TYCHO BRAHE

Tycho's great contribution to CM was his naked-eye observations of Solar System bodies: tables (correct to 2 minutes of arc [45,46,48,172], compared with Ptolemy's 10) thereof were given to Kepler [19]. His "nova" did little to further the cause of Aristotelian immutability [51], but he advocated an essentially geocentric theory, complete with epicycles [43]. His lunar theory was impressive [44].

1.6. GALILEO GALILEI

Galileo [20,52] applied the refracting telescope to observe the heavens [45], and by consequence strongly advocated the heliocentric theory, albeit with circular orbits. His observations demonstrated the falsity of Aristotelian immutability and the differentiation between terrestrial and heavenly motion. He supported the notion of the rotation of the Earth, and wielded together mathematics and physics (based on empiricism). Although it is possible that he did not perform his falling-body experiments from the leaning tower at Pisa [28], he was quite familiar with the kinematics involved [47].

1.7. JOHANNES KEPLER

Kepler [21,53,81] is primarily remembered for his three laws of planetary motion. His study of the Martian orbit led to the first two [48]. Mars' rapid motion in right ascension at present (May, '74) [229] and its proximity to Castor and Pollux in Gemini yield a spectacularly discernable shift in position (to the naked eye) on a daily basis. No doubt similar motions inspired both Tycho [51] and Kepler. The predictive advantage of the Keplerian theory over those of Ptolemy and Copernicus is readily apparent [49]. His heliocentric and heliodynamic theories [33], therefore, represented a significant advance in the state of the art of CM, and they certainly aided the grand synthesis established by Newton.

1.8. SIR ISAAC NEWTON

Newton's [22,54,67,68,77,78] three laws of motion and his law of universal gravitation, obtained through inductive reasoning, were skillfully employed to explain a host of phenomena, not the least of which was the Two-Body Problem in his "Philosophiae Naturalis Principia Mathematica" [69]. An excellent introduction to the Principia is available [71], as is an excellent treatment of the development of CM up to about 1850 [72], while his early development is aptly traced [74]. We find it difficult to attempt to improve upon the references cited; in summary Newton "stood on the shoulders of giants" (Kepler [75,239],etc.), supported the heliocentric and heliodynamic theories, related terrestrial and heavenly phenomena (to the point of predicting artificial Earth satellites [70]), relied on telescopic observations, and, of course, employed his powerful intellect to effect his grand synthesis.

The Principia was not initially received with open arms: on the continent, "Il n'a peut-être pas été accueilli avec la considération qu'il méritait.", while at his alma mater, "Newton's system was introduced in Cambridge under the aegis of Cartesian theory" [76]. Descartes' "Théorie des Tourbillons" or, more descriptively, his vortex theory of planetary motions, published in his "Principia philosophiae", and the demise thereof are aptly described [79].

There exists extremely powerful evidence that Newton "fudged", that is: he manipulated data to suit his purposes [80]. Although such action can hardly be condoned, his "System of the World" nevertheless remains a very close approximation to macroscopic reality.

1.9. URBAIN-JEAN-JOSEPH LE VERRIER

Le Verrier's [23] work was of extreme importance in the advance of CM: his prediction of Neptune [55,73,82,83] served strikingly Newton's concept of universal gravitation (although in retrospect the discovery must be labelled somewhat fortuitous), while his (Le Verrier's) inability to account for the excess perihelion motion of Mercury sowed the seeds for the ultimate demonstration of the shortcomings thereof [56,58,85,86].

1.10. ALBERT EINSTEIN

Einstein [24,57,84] published a paper [88] explaining the observed motion of Mercury. The scientific community continues to display considerable respect for his work [87,89,238], although the situation is far from being empirically, and, indeed, possibly theoretically resolved [86,242].

1.11. HELIOCENTRIC UNIQUENESS

Considerable effort has been carried out in the preceding sections to trace the development of the heliocentric and heliodynamic theories. However, in the remote past it seems plausible that the Sun and Jupiter formed a binary stellar system [118]. The origin and evolution of the Solar System, under the preceding hypothesis, make possible a novel plethora of theories indeed, although Kuiper [175] has, at least in part, anticipated Drobyshevski [118].

1.12. NUMERICAL INTEGRATION

Due to the paucity of closed-form [60] solutions in CM [59], a popular quantitative approach is numerical integration [121]. This class of techniques is not recent: it dates since at least 1800 [126]. Bond (1849) and Encke (1852) employed it [91]. Dirichlet (1858) supposedly applied it to mechanics in general [204]. Watson (1868) used it in his study of comets and asteroids [92]. Cowell and Crommelin (1910) used the method known by the former author to study the motion of Halley's Comet [93]. Taylor's series are becoming popular (See Section 2.7.). Modern digital computers have certainly encouraged the employment of numerical integration [61,93, 94,95,97,104,172] as well as analytical techniques [106,165,166].

1.13. THE SPACE PROGRAM

The Soviet Union first realized Newton's prediction of artificial Earth satellites (See Section 1.8.) with the launching of Sputnik I on 4 October 1957 [63]. With that event CM became an extremely important and practical field of knowledge [65]. The U.S.A. landed the first man on the Moon on 20 July 1969 and brought him safely back [64]. The principles of CM have been successfully applied to increasingly sophisticated planetary exploration: Mariner 9 to Mars [197], Pioneer 10 to Jupiter [198], Mariner 10 to Venus [199] and Mercury [200], etc. Earth satellites, such as: ERTS-1 [201] and SMS-1 [202] have provided invaluable information regarding man's abode. With such developments, CM has become an experimental as well as the classical passive field [94]. There can be little doubt that CM will continue to play an important role in man's efforts in space [203,208,209].

1.14. POSSIBLE RELATIONSHIPS WITH CLIMATOLOGY

The powerful predictive attribute of CM could have important consequences in climatology. There is evidence, albeit far from conclusive at present, that the planetary positions are related to sunspot cycles, and that the latter are related to the Earth's climate [109,110,111,112]. Gribbin [109] felt that climatic prediction might ease the impact of drought conditions in several areas of the world. However, a more recent assessment of the situation in the Sahel downgrades the importance of climate thereon [113]. Contradictory evidence is available [114]. In more general terms, the astronomical influence on terrestrial climate has both its protagonists [115] and antagonists [116]. Clearly, more research is required in climatology and is being carried out [117,240]. Research in CM would seem to be justified solely on the possibility that it might shed some light on conditions in man's abode.

CHAPTER 2

THE TWO-BODY PROBLEM

2.1. INTRODUCTION

This problem was solved by Newton in his Principia [69], in an effort to explain the motions of the planets in the Solar System. As the Solar System is sparsely populated, and the Sun is by far the largest mass, the motion of a particular planet referred to the Sun can be well approximated through a consideration of just these two bodies. An analytical development (based on Newtonian mechanics) will be presented and we shall discuss the salient properties of the motion. Then we shall solve the system of differential equations by various finite-difference techniques. Cowell's method of numerical integration will be employed (See section 1.12.).

2.2 ANALYTICAL DEVELOPMENT

The vector differential equation of the Two-Body Problem may be written [119]

$$\frac{d^2 \bar{r}}{d\, t^2} + \frac{\mu \bar{r}}{r^3} = 0 , \tag{1}$$

where $$\mu = G(m_1 + m_2) . \tag{2}$$

The symbolism employed is normal in CM and is defined in the reference.

Kepler's first law may be stated: a closed orbit ($\bar{r}(t + T) = \bar{r}(t)$, where $t, T < \infty$ and T is the period defined below) is an ellipse with m_1 at a focus. His second law asserts: the areal velocity of the radius vector is constant. The third law relates the period T to various orbital parameters:

$$T = 2\pi \sqrt{\frac{a^3}{\mu}} \tag{3}$$

We rewrite (1) :

$$\frac{d^2 \bar{r}}{d t^2} = - \frac{\mu \bar{r}}{r^3} \tag{4}$$

Since the motion is planar, two Cartesian coordinates suffice to uniquely define $\bar{r}$. We write (4) as two scalar equations:

$$\ddot{x} = - \frac{\mu x}{(x^2 + y^2)^{3/2}} \tag{5}$$

$$\ddot{y} = - \frac{\mu y}{(x^2 + y^2)^{3/2}} \tag{6}$$

Putting $\mu = 1$ in (5) and (6) gives

$$\ddot{x} = -\frac{x}{(x^2 + y^2)^{3/2}} , \qquad (7)$$

$$\ddot{y} = -\frac{y}{(x^2 + y^2)^{3/2}} \qquad (8)$$

With

$$x(0) = 1,\ y(0) = 0,\ \dot{x}(0) = 0,\ \dot{y}(0) = 1, \qquad (9)$$

the exact analytical solution of the system (7) and (8) is [127]

$x(t) = \cos t$, $y(t) = \sin t$, which is the parametric representation of a circle with radius 1 unit and center at the origin. In this case, the semimajor axis is 1 unit in length, and from equation (3)

$$T = 2\pi. \qquad (10)$$

In order to treat elliptic motion we introduce the eccentricity e $(0 \leq e < 1)$. Circular motion is a special case of elliptic motion with $e = 0$. The motion is started at pericenter with

$$x(0) = 1,\ y(0) = 0,\ \dot{x}(0) = 0. \qquad (11)$$

We need to determine $\dot{y}(0)$ as a function of e.

Writing $x(0)=1 = r_p = a(1 - e)$, we obtain

$$a = \frac{1}{1 - e} . \tag{12}$$

Now $$V = \sqrt{\frac{2}{r_p} - \frac{1}{a}}$$

$$= \sqrt{2 - (1 - e)} \quad . \text{ Therefore,}$$

$$\dot{y}(0) = V = \sqrt{1 + e} \tag{13}$$

Equation (13) relates the magnitude of the pericentric velocity to the eccentricity.

To determine the period of the motion, we use (3) with $\mu = 1$,

$$T = 2\pi a^{3/2} . \tag{14}$$

Equation (13), although quite simple, caused some consternation while perusing related literature [137] (See Appendix 3.).

In a Banach space, the solution of the system (7) and (8), subject to initial conditions (11) and (13) ($0 \leq e < 1$), exists and is unique. This follows implicitly and is, therefore, by no means mathematically rigorous [119].

2.3. THE CLASSICAL RUNGE-KUTTA TECHNIQUE

This technique [122,125] remains popular, probably due to its simplicity. We shall integrate the system (7) and (8), subject to (9), over 10 orbits to study the performance of the algorithm.

2.3.1. THE COMPUTING ENVIRONMENT

Appendix 1 includes most of the system output for the example with discretization interval $\pi \times 4 \times 10^{-4}$ (STP=PI*4D-4). The computer employed throughout work on this thesis was the one at the Lakehead University Computer Centre, an IBM System/360 Model JH50 (with 1024K of LCS (Large Core Storage) and 256K of Main Storage), running under Release 21.7 (Most of the work done for this thesis was run under this release.) of Operating System/360 MVT (with HASP) [134,135].

Appendix 1 A shows the JCL, allocation-deallocation messages, and accounting routine output conveniently displayable within an 8.5 x 11'' page size. The load module resided in a region of LCS.

Appendix 1 B shows the FORTRAN source employed [123,130], which was written to produce a reasonably efficient load module (One whose core requirement and execution time would tend to be minimal, although these are somewhat conflicting characteristics. Wherever possible this philosophy has been applied to all FORTRAN programs. Also wherever possible the H level compiler with option OPT=2 [133] was employed. It should be noted at this point that the optimized load module was regarded with an element of suspicion as it can produce incorrect results: runs with OPT=0 were employed to verify proper output in some cases.).

Appendix 1 C shows the SYSOUT=A information produced by the execution of the load module in the GO step. The top line shows the values of the initial conditions as

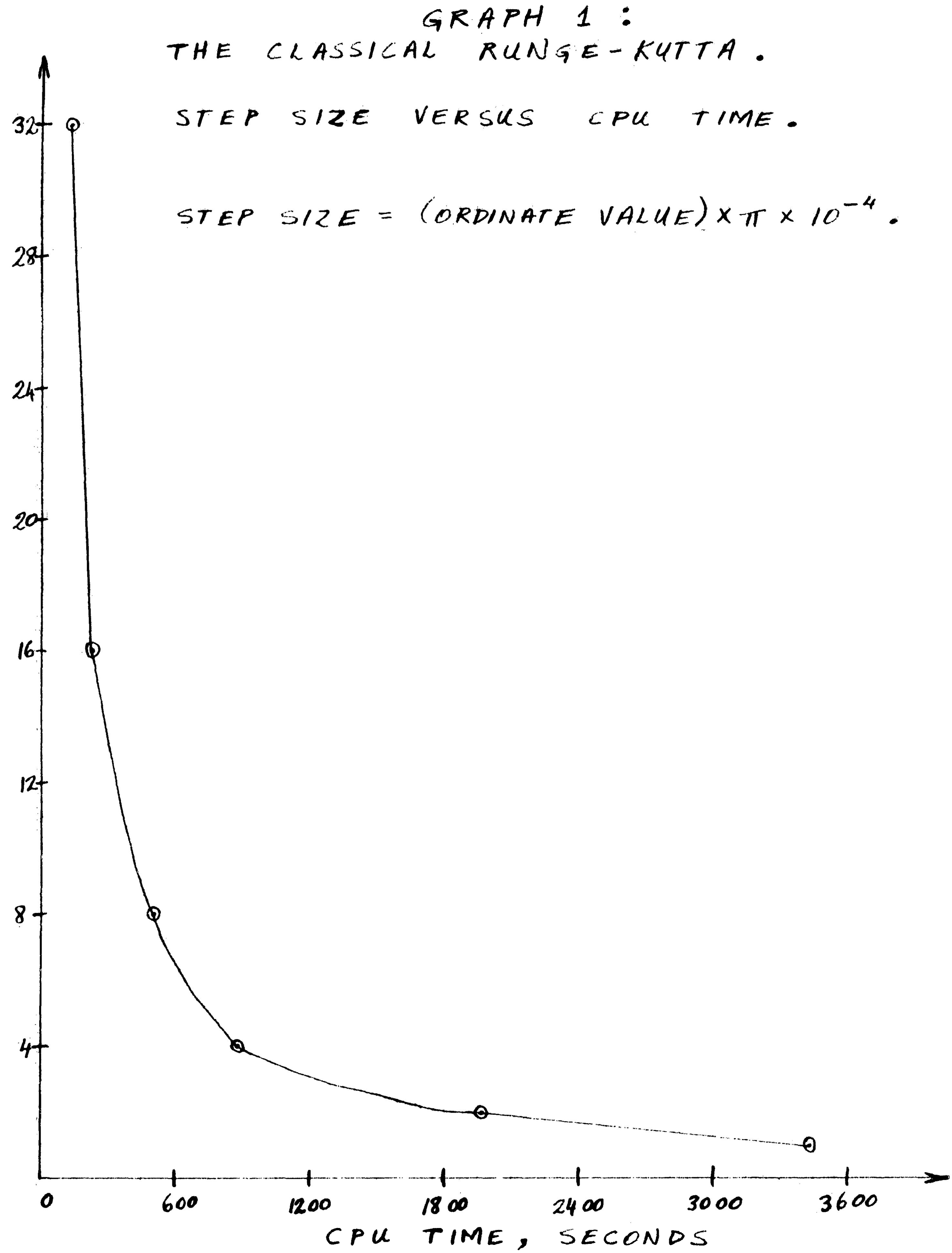
$$x(0) = 1, \; y(0) = 1, \; \dot{x}(0) = 0, \; \dot{y}(0) = 1.$$

The next lower line lists the values of the variables for $t = 2\pi$, and so on for t up to and including 20π (corresponding to the end of the tenth orbit). The gap between the y and $\dot{x}$ columns was reduced for convenient display, and hand printed annotations (to clearly distinguish between system output and the annotations) were added.

We choose Appendix 1 for detailed display because the results, for the step sizes examined, are the most accurate, and the accuracy criterion is of paramount interest in CM. The same program, except for the value of FORTRAN variable STP (the step size), was also run. Graph 1 is a plot of the step size versus the CPU time of the GO step (Appendix 1 A) for 10 orbits.

2.3.2. ANALYSIS OF OUTPUT

Appendix 1 C shows a general trend: the combination of algorithm error and roundoff error increases with the integration interval. These two sources of error merit prime consideration in numerical analysis; they usually must be tolerated and their effect is to limit the accuracy of results. Algorithm errors [124] can be reduced by employing "better" (in the sense of decreasing these errors; notwithstanding the circular reasoning involved) algorithms. We shall study this aspect later. Roundoff errors [136] can be reduced


GRAPH 1 :
THE CLASSICAL RUNGE-KUTTA.
STEP SIZE VERSUS CPU TIME.
STEP SIZE = (ORDINATE VALUE) × π × 10^-4.
32
28
24
20
16
12
8
4
0
600
1200
1800
2400
3000
3600
CPU TIME, SECONDS

in at least 2 ways: an improved hardware-software arithmetic capability (single-precision (approx. 7 decimal digits)→double-precision (approx. 16)→extended-precision (approx. 34) [130,131,132]), and software which yields a multiple-precision capability from a limited hardware-software capability (See Appendix 2.). As double-precision arithmetic was the best available from the computer, and time was lacking to develop multiple-precision software, only the former was employed throughout most of the arithmetic required for the thesis.

Let us now concentrate on algorithm errors; in general, analysis of such errors is difficult [127,129]. Even for our rather simple problem, equations (6) [128] prove to be of little utility. Perhaps, however, this criticism is unwarranted as it is difficult to isolate algorithm and roundoff errors. Rewriting equations (6) [128], and maintaining symbolic consistency we obtain

$$\Delta x \doteq -\frac{1}{2880} h^4[66t \sin t + \frac{45}{2} (\cos 2t + 2\cos t - 3)], \qquad (15)$$

$$\Delta y \doteq \frac{1}{2880} h^4[66t \cos t - \frac{45}{2} (\sin 2t + 2\sin t)]. \qquad (16)$$

At the end of complete orbits, $t = 2\pi n$, n integral and ≥ 1,

$$\Delta x \doteq 0, \qquad (17)$$

$$\Delta y \doteq \frac{1}{2880} h^4[66t]. \qquad (18)$$

For the example of Appendix 1, after 10 orbits x, admittedly, has not decreased too much, while $y \doteq 8.22 \times 10^{-11}$. Δy in this case is about 0.359×10^{-11}. After 1 orbit x is closer to its ideal value than before, while $y \doteq 1.136 \times 10^{-12}$, and $\Delta y \doteq 0.359 \times 10^{-12}$. Therefore, equations (17) and (18) improve as the integration interval decreases, which is borne out by Fig. 7 [127].

For the case of $STP=32\pi \times 10^{-4}$ the agreement of equations (17) and (18) is significantly better than in the former. From the first to the tenth orbit x changes less. At the end of the first orbit $y \doteq 1.555 \times 10^{-9}$, while equation (18) gives $\Delta y \doteq 1.470 \times 10^{-9}$. Even in this case, however, at the end of the 10th orbit $y \doteq 2.316 \times 10^{-8}$, while (18) gives $\Delta y \doteq 1.470 \times 10^{-8}$.

In summary, x is much better behaved (in the usual mathematical sense) than y for orbit closing studies. This has also been borne out using other algorithms, therefore, we shall concentrate our attention on $y \rightarrow$ (approaching) 0 rather than on $x \rightarrow 1$. The radius vector is to be avoided as it takes undue advantage of the value of x in presenting itself in a favourable light (since $y \ll x$).

Data related to Appendix 1 were plotted on Graphs 1 and 4. Graph 1 is a plot of step size versus CPU time required to execute the load module. Some words of caution regarding the abscissa values are in order. Although the interval timer has a resolution of approximately 16.67 msec. [138,139], subsequent executions of the GO step (Appendix 1 A) will not, in general, yield equal CPU times within that resolution. Indeed, a study was carried out on a similar load module and the ratio between the longest and shortest runtimes observed was about 1.31. Generally the ratio is about 1.10 or less. The explanation, however, is quite straightforward: the MVT option of OS/360 was in use (See section 2.3.1 and references.). With only 1 job executing in a possible multiprogramming environment, the observed runtimes should be almost constant and minimum. When MVT is exploited I/O operations involving the multiplexor channel occur asynchronously with the CPU, the channel has some circuitry in common with the CPU and degrades the CPU performance, while the interval timer continues to chalk up time inappropriately attributed to a load module. Even selector channel operation can contribute to increased CPU times for an unrelated load module as only one set of core addressing lines effectively exists: the selector channel generally has precedence over the CPU for this resource. In summary, therefore, runtimes in general are far from constant for subsequent executions of identical load modules.

Graph 1 vividly reinforces an intuitively obvious concept: as the step size decreases, the computational effort required to complete a fixed integration interval increases. Graph 4 is a plot of the absolute value of the logarithm (to base 10) of the absolute value of y after 10 orbits versus the logarithm of the CPU time, for various integration schemes. The classical Runge-Kutta technique curve is labelled RK4, and is displayed with the other curves for facile comparison. The RK4 data were obtained from Appendix 1, and similar runs (further information available from the author on these and other details). Graph 4 readily shows that as the step size decreases from $32\pi \times 10^{-4}$ to $4\pi \times 10^{-4}$ the technique performs better, but from $4\pi \times 10^{-4}$ to $\pi \times 10^{-4}$ the technique degrades in that increased computational effort results in less accurate y values. The most probable explanation for this latter performance is the effect of roundoff.

2.3.3. ADVANTAGES

1. Simplicity. A perusal of Appendix 1 B shows that the program is short and is very easy to write. Subroutines are avoided to speed up execution times by reducing modular programming linkage requirements [140].

2. Accuracy. Graph 4 demonstrates that the algorithm can close (reproduce) y to better than 10^{-10} in an equivalent arithmetic environment of about 16 significant decimal digits.

2.3.4. DISADVANTAGES

1. No accuracy criterion. Although the algorithm is capable of highly accurate results (See section 2.3.3.), it possesses no such automatic capabilities. Results, therefore, warrant the closest scrutiny on the part of the user. With modern high speed hardware, there is little justification for excluding an accuracy criterion, although user scrutiny is still required.

2. Discontinuous step size availability. In order to close the integration interval at multiples of 2π (of the independent variable, time), a step size which is a submultiple thereof is required. This disadvantage can be circumvented by more sophisticated programming

to allow a final step to be taken, not necessarily with the value used throughout the interval of integration, to close that interval.

3. Speed. The algorithm is slow, especially when compared with rational extrapolation and Taylor's series (See Graph 4.), except for very low closing accuracies.

2.4. THE CLASSICAL RUNGE-KUTTA (GILL'S MODIFICATION) TECHNIQUE

This technique also remains popular [141,142]; additional theory may be found [143].

2.4.1. ALGORITHM IMPLEMENTATION

Appendix 4 shows details in a similar fashion to Appendix 1. Subroutine DRKGS [141] was employed essentially as received, except that the DIMENSION statement was appropriately coded, and the FORTRAN statement with statement number 7 was removed to prevent unwanted output values, and the statement immediately following was given statement number 7 (See Appendix 4 B.). Unfortunately the subroutine was written using BCDIC instead of EBCDIC (See conversion table [144].), which yields a rather strange-appearing listing. The driving program and subroutines FCT and OUTP were written to accommodate subroutine DRKGS. Other runs were carried out using an accuracy criterion of 10^{-14} (variable PRMT(4)) and various initial step sizes (variable PRMT(3)).

2.4.2. ANALYSIS OF OUTPUT

Graph 2 presents the corresponding data to Graph 1 (See section 2.3.2.), while Graph 4 presents a relevant curve labelled DRKGS. DRKGS is slower than RK4, but is capable of producing essentially the same maximum accuracy value of y.

2.4.3. ADVANTAGES

1. Simplicity. Appendix 4 B shows that subroutine DRKGS is reasonably short and efficiently written.

2. Flexibility. The employment of subroutine FCT to define the system of differential equations represents a marked advance in the state of the art over RK4. Although execution speed will suffer as a result, the storage requirement could be greatly reduced especially for a complicated system.

3. Accuracy. Graph 4 shows that the algorithm can close y to better than 10^{-10}, as for RK4. A built-in accuracy criterion, coupled with an essentially continuous step size capability represent significant advantages over RK4. Results, however, still require user scrutiny (See section 2.3.4.).

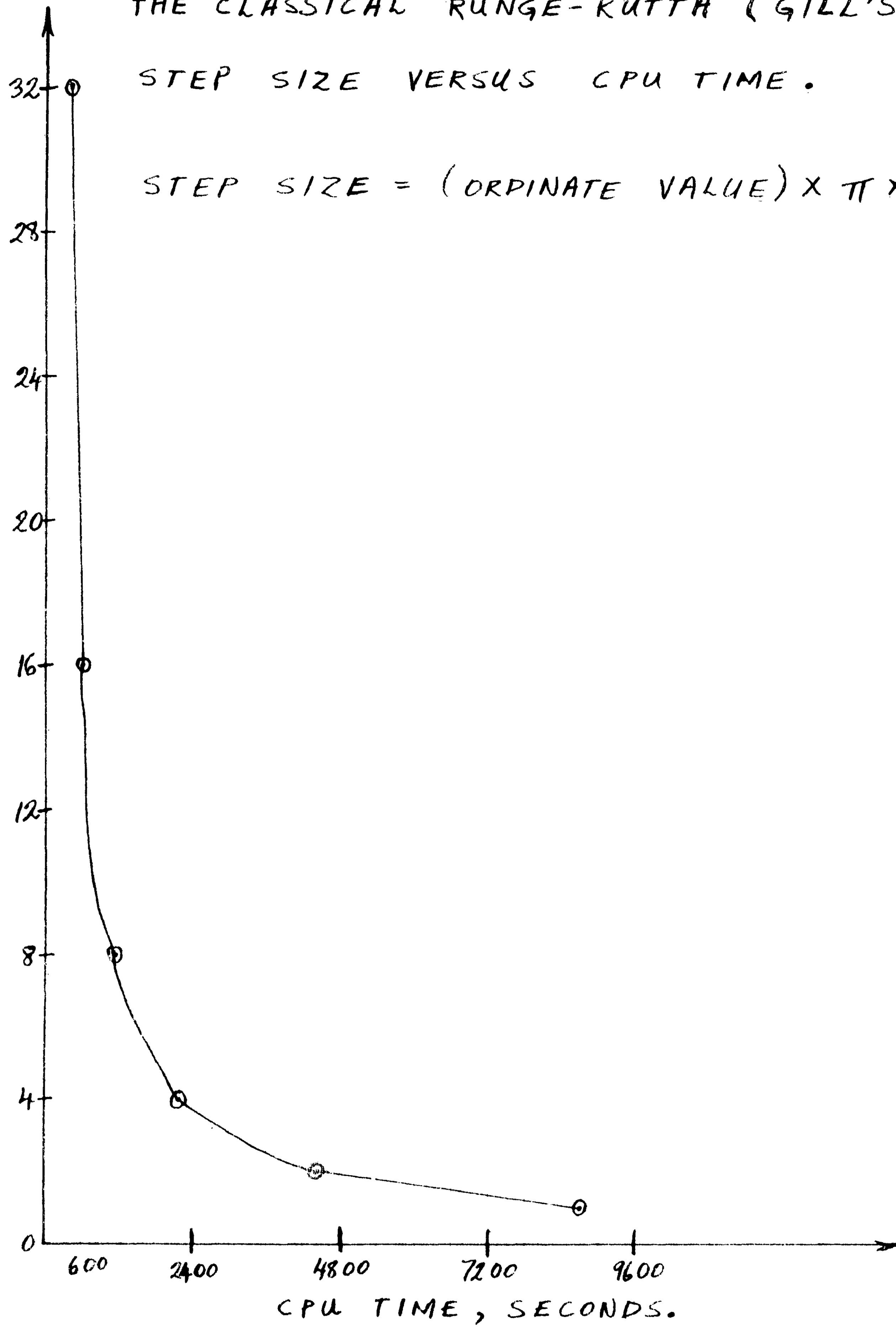
2.4.4. DISADVANTAGES

1. Speed. The algorithm is slow (Graph 4) compared with RK4, due to its increased complexity.

GRAPH 2:
THE CLASSICAL RUNGE-KUTTA (GILL'S MOD.).

STEP SIZE VERSUS CPU TIME.

STEP SIZE = (ORDINATE VALUE) × $\pi \times 10^{-4}$.



2.5. THE RUNGE-KUTTA-NYSTRÖM TECHNIQUE

The two previous techniques share a salient characteristic: the second order system (7) and (8) is reduced to a first order system, which is then solved. We wonder if a direct numerical integration of the original system might be advantageous: Henrici [126] reports no significant benefit in general for single step methods, however, Fehlberg [145] asserts that execution times can be reduced by a factor of 2 or more. This situation obviously requires further investigation.

2.5.1. ALGORITHM IMPLEMENTATION

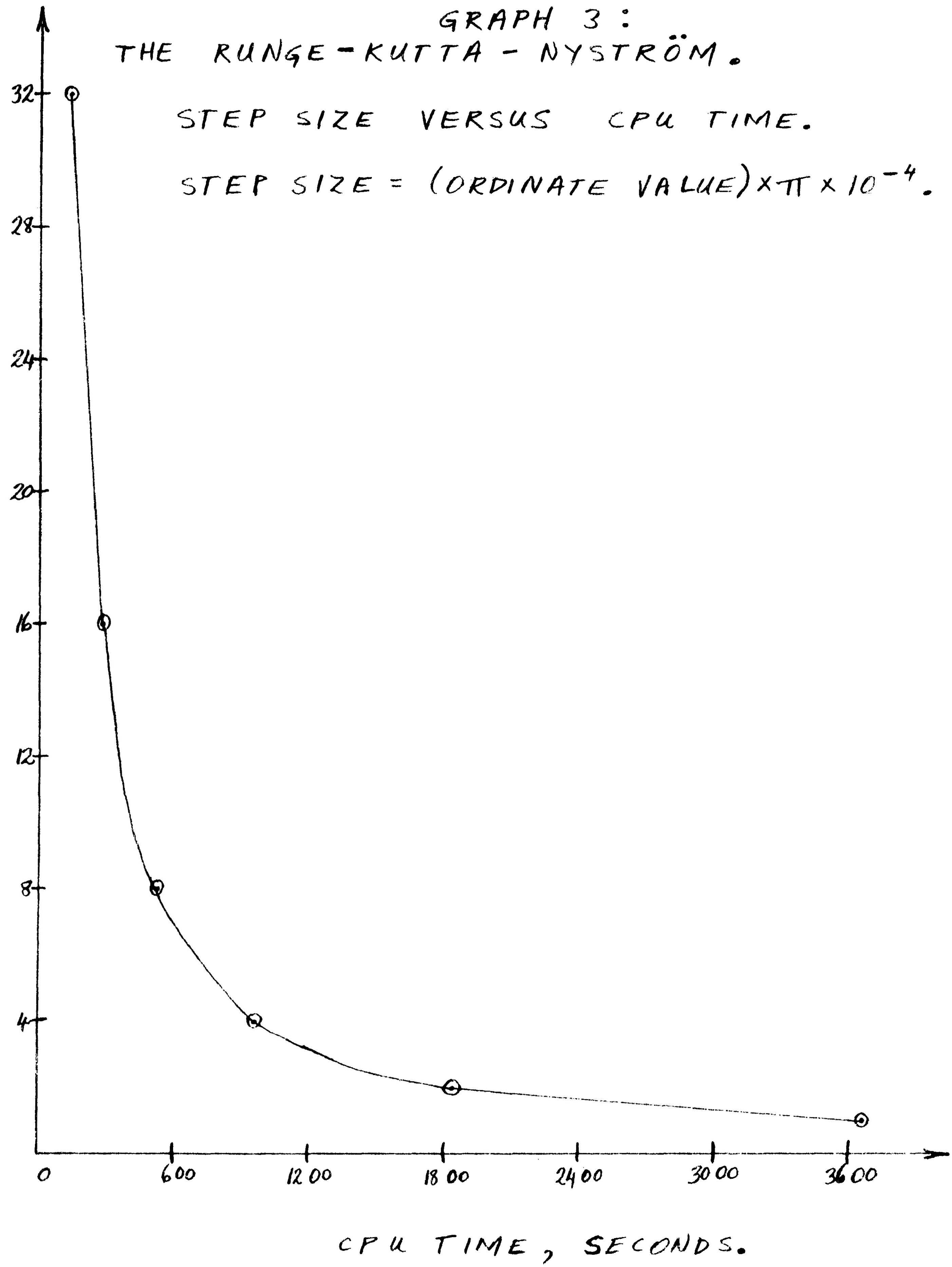
The algorithm employed [146] was the complete fourth-order one (K = 0, 1, 2, 3), with f_K and g_K corrected to f_λ and g_λ, respectively, in the RHSs of equations 70. Appendix 5 displays details as usual.

2.5.2. ANALYSIS OF OUTPUT

Graph 3 is virtually identical to Graph 1, while the output listings are so close, for a given step size, to those of RK4 that they were not plotted on Graph 4, in order to avoid confusion.

2.5.3. SUMMARY

The present algorithm performs virtually identically to RK4 for the system (7) and (8), although it is slightly more accurate for large step sizes, and slightly less accurate for small.


GRAPH 3:
THE RUNGE-KUTTA-NYSTRÖM.
STEP SIZE VERSUS CPU TIME.
STEP SIZE = (ORDINATE VALUE) × π × 10⁻⁴.
32
28
24
20
16
12
8
4
0
600
1200
1800
2400
3000
3600
CPU TIME, SECONDS.

2.6. THE RATIONAL EXTRAPOLATION TECHNIQUE

This technique commands considerable respect [147,148,149,150,156, 157] from the numerical analysis community: it therefore merits our close scrutiny.

2.6.1. ALGORITHM IMPLEMENTATION

Appendix 6 shows details for the Two-Body Problem. The double-precision version of the software [149] was, in essence, employed (See Appendix 6 B.). Appendix 6 C shows most of the load module output.

Appendix 6 A shows the JCL, etc. The load module resided in a region of LCS.

Appendix 6 B shows the FORTRAN employed. Most of the FORTRAN was taken from the double-precision version of DESUB (See Fig.5 [151]), and punched into cards. Comments [130] were not included. Since portions of the DESUB listings were hard to read, the software was tested using Fig. 3 [152], and debugged. The software was then applied to solve the system (7) and (8) (reduced to a first-order system), subject to initial conditions (9). The driving program is the first displayed. Variable EPS = 3.6×10^{-11} and is the local error tolerance [153]. Other jobs were run using various values of EPS.

Subroutine FCT (Appendix 6 B) was renamed from FEVAL [152], and advantage was taken of the IMPLICIT statement [130], and these changes, along with appropriate subsequent ones, were propagated throughout the software.

In subroutine DDESP (Appendix 6 B), variable DERR was omitted, and variable DDEOUT was renamed from XOUTX [151].

In subroutine XDDE (Appendix 6 B), the DIMENSION statement was appropriately coded, variables DEMAX and NMAX were altered, and statement 20 was so labelled after the two preceding statements were omitted from the original [151]. In the assignment statement for XP (second statement following statement 40), FLOAT was omitted (not required).

In subroutine DDESUB (Appendix 6 B), the COMMON statement variables were reordered to force double-word boundary alignment [130], and the DIMENSION statement was appropriately coded.

In subroutine DREDIF, the above two changes were incorporated.

In subroutine DDERSB, the above two changes were made. The DATA statement is redundant for the compiler employed. The execution times for the assignment statements for D(2), D(4), and D(6) (starting at the second statement preceding statement 201) could be reduced somewhat by cutting down on the number of divisions required, but this was not done. In the assignment for DT(I,1) (third statement following statement 206) there is no need to make the constant .5 become .5D0 to ensure double-precision results [130]. Statement 242 was altered and two statements following it were added to eliminate the need for subroutine DERR, and carry out an absolute-error convergence test [151,154]. In the statement immediately following statement 30, double-precision results are maintained [130], while the execution time could have been reduced by coding H=H*.5 instead of H=H/2.

In subroutine DDEOUT, the DIMENSION statement was appropriately coded, the COMMON statement labelled UNITS was redundant, the printing of the title was suppressed, and statement 85 was altered to provide a convenient output format [151].

Subroutine DERROR was essentially unchanged.

The enumeration of the preceding changes, etc. should facilitate a comparison with the reference [151].

2.6.2. ANALYSIS OF OUTPUT

The curve labelled R.E. on Graph 4 passes through relevant data from Appendix 6, etc. As can readily be seen the behaviour is the most complicated of the techniques investigated. Indeed, the curve seems to possess a cusp (at about EPS = $4x10^{-11}$). An abrupt increase in accuracy occurs from EPS = $3.65x10^{-11}$ to $3.649x10^{-11}$. A stable region occurs from EPS= $3.649x10^{-11}$ to about $2.5x10^{-11}$, and the curve continues to drop with decreasing values of EPS, probably due to roundoff.

While such an interesting behaviour would merit a theoretical investigation, such was not attempted primarily because the details of the behaviour (timewise) are subject to the factor of about 1.31 (See section 2.3.2.). The corresponding error in the abscissae is $\log_{10} 1.31 \doteq 0.117$, which is plotted, certainly does not have a possible insignificant effect upon the shape of the curve. The cusp, for example, could be wiped out. It would be possible to effectively eliminate this error by having only 1 job executing: a dedicated computer. Unfortunately this concept had to be abandoned as the Computer

Centre was designed to cater to several users simultaneously. It should be obvious that the abscissa error applies to all curves, not to just the one labelled R.E. Strictly speaking,this error is directly applicable to the curves only if they are representative of minimal times, and the error can be positive or negative. In summary, it is unfortunate that the abscissae are quite inaccurate (and irrelevant) when considered as a set. A theoretical investigation thereof is deemed worthless.

In the driving program, H was arbitrarily set to 1. Tests were carried out using various values of H for a fixed value of EPS. Results indicate that since H is an initial step size which is automatically modified by the software to meet the specified convergence criterion [149], its value has only a slight impact on results (Details are not included but may be obtained from the author.).

2.6.3. ADVANTAGES

1. Speed. The technique is the fastest investigated, save for Taylor's series (Graph 4).

2. Accuracy. The algorithm can close y to better than 0.41×10^{-11}. A built-in continuous accuracy criterion is available. However, results, as usual,must be srutinized (See section 2.3.4.).

2.6.4. DISADVANTAGES

1. Complexity. The software is the most involved that has so far been investigated.

2.6.5. INTEGRATION OF A HIGH ECCENTRICITY ORBIT

Appendix 7 shows details (not available in Appendix 6) for the integration of (7) and (8) subject to the initial conditions (11) and (13) with eccentricity $e = 0.8$. The period of the motion is given by (14), which is variable SP (for specified point) in the driving program (See Appendix 7 A.). Appendix 7 software is similar to that of Appendix 6.

Results show (Appendix 7 B) that the algorithm can adequately integrate an orbit whose eccentricity is much higher than any considered in the Solar System model (See section 3.2.), but that more degradation is present than for $e = 0$. Results, as usual, warrant user scrutiny.

2.7. THE TAYLOR'S SERIES TECHNIQUE

Brook Taylor [158], a contemporary of Sir Isaac Newton, in his "Methodus incrementorum directa et inversa" beqeathed to the mathematical world the extremely important infinite series now known as Taylor's series [159]. The closely related power series has been shown to be an effective device for the solution of differential equations arising in CM [160,161,162], while Taylor's series per se are also valuable [155,163]. As a general purpose technique, Taylor's series, until recently, has not faired too well. However, with the advent of more powerful digital computers nonnumeric applications, specifically algebraic manipulations, have breathed new life into an old series for solving systems of ordinary differential equations [99,108,137,155,164,165]. The highly encouraging work of Norman [166] prompted investigation of the technique.

2.7.1. ALGORITHM IMPLEMENTATION

Appendix 9 records most of the rather extensive private communication involved. Appendix 8 shows details for the Two-Body Problem.

A good description of the use of the TAYLOR system is available [168]. In essence, a FORTRAN-like description of the differential equations, along with initial conditions is supplied (See Appendix 8 B.). The TAYLOR system then produces a set of subroutines driven by an externally supplied main program (Appendix 8 C). Appendix 8 D shows the load module output.

Appendix 8 A shows the JCL, etc. From Norman's tape and considerable processing thereof, a load module called TAYLORIV was added to JOBLIB [167]. In the first job step the input is shown in Appendix 8 B (along with some generated output), while the salient output is shown in Appendix 8 C (followed by the driving program). The second job step was required to bypass a problem involving concatenation of data sets with unlike attributes [167]. A standard cataloged procedure invoking the H level FORTRAN compiler, etc. concludes the JCL.

Although the step size is not readily available to the user, a parameter known as EPSILON (the local error-per-step) is [168]. In Appendix 8 B, EPSILON = 10^{-6}. Other jobs were prepared using various values of EPSILON. The load modules resided in regions of LCS.

2.7.2. ANALYSIS OF OUTPUT

The curve labelled T.S. on Graph 4 passes through relevant data. For the values of y investigated, Taylor's series is clearly the fastest technique, and it is capable of producing the most accurate output.

2.7.3. ADVANTAGES

1. Speed. The technique is the fastest of those investigated (Graph 4).

2. Accuracy. Graph 4 shows that the algorithm can close y to better than 10^{-12} (actually to better than $0.48\text{x}10^{-12}$. A built-in continuous accuracy criterion is included. Results, as usual, still require user scrutiny.

3. Simplicity. The technique is clearly simple to use: the system of equations along with initial conditions is supplied virtually in their mathematical form in a FORTRAN-like language. A simple FORTRAN driving program is also required. From these two inputs, results from a powerful technique follow: the TAYLOR system represents a significant advance in the state of the art of solving systems of ordinary differential equations arising from initial value problems, from the viewpoint of simplicity.

4. Flexibility. The TAYLOR system can handle an extremely varied system of differential equations [168].

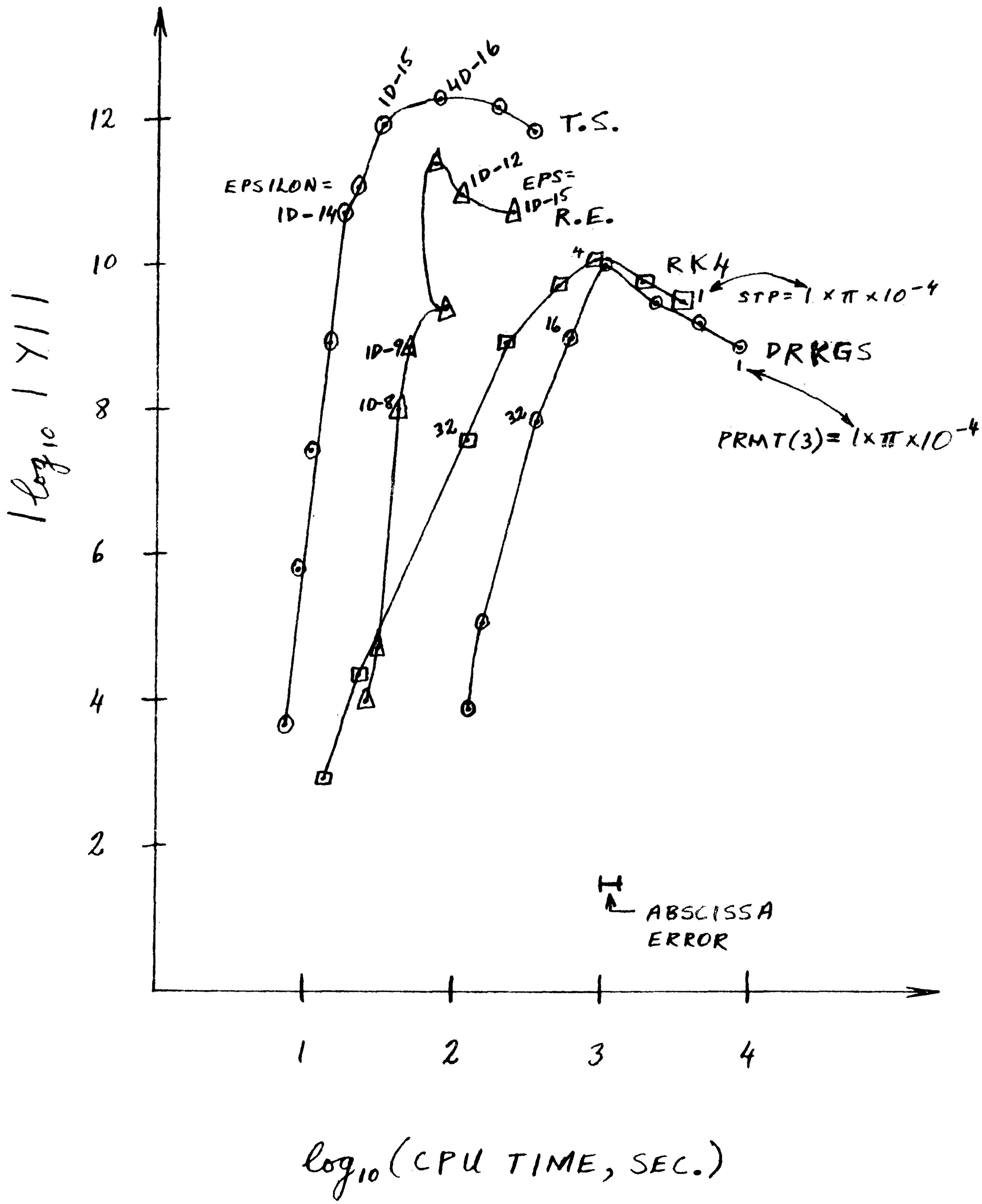
2.7.4. DISADVANTAGES

1. Complexity. The simplicity and flexibility features (See section 2.7.3.) from the user's viewpoint are offset somewhat by increased resources of implementation: Appendix 8 A shows that the first job step ran in a region of storage of 350K (although the same input (Appendix 8 B) has been successfully handled in 292K), which is greater than the region required for the H level FORTRAN compiler (250K). This should not pose undue difficulties, however, in a modern scientific computing environment.

The subroutines generated by the TAYLOR system (Appendix 8 C) can be speeded up somewhat by careful modification over the optimized version of the object module (See section 2.3.1.). This was not attempted as the technique is already the fastest investigated.

In some of the high accuracy runs the message IHC208I was produced, indicating that an exponent underflow had occurred [133]. An exponent underflow occurs when an attempt is made to represent a magnitude which is too small (less than about 10^{-78} [133]) to be handled by floating-point arithmetic [138]. One possible method to reduce exponent underflows would be to use a lower value for the keyword TERMS (default and maximum value is 16) [168], without losing accuracy. However, an investigation did not greatly substantiate this premise (details not included but are available). A related problem is that of overflows [169].

GRAPH 4:
ACCURACY CRITERION VERSUS CPU TIME.



CHAPTER 3

THE ELEVEN-BODY PROBLEM

3.1. INTRODUCTION

A model of the Solar System will be discussed. An analytical development of the model will be made, and the resulting system of differential equations will be solved using the techniques of rational extrapolation and Taylor's series from Chapter 2. Results will be extensively discussed.

3.2. SOLAR SYSTEM MODEL

The Solar System is complicated [38,62,104,105,170,174,175]. In order to study the motions of the bodies therein, the system will have to be simplified in order to render it both mathematically and computationally tractable. Of course, the simplifications will play their role in downgrading the interpretive utility of results [107, 172,173]. The simplifying assumptions are as follows:

1) the model is based on Newtonian mechanics,

2) the bodies are treated as point masses,

3) only gravitational interactions are considered, and

4) only the 9 principal planets, the Sun, and one optional body are involved.

For our purposes the optional body is the Moon, although it could be Toro [178], Halley's comet[173,179,180], Mariner 10 [197], etc., as long as the preceding assumptions hold. The optional body interacts fully with the others: it is not considered massless. This is an important consideration when the optional body is the Moon since the lunar perturbation of the terrestrial orbit is not negligible [171]. However, the influence of the three latter optional bodies on the rest of the system would normally be quite insensible. The Moon was treated as the optional body because its motion is of great interest to us.

The shortcomings of the model are not negligible. In order to be reasonably complete we discuss the following theories and effects which have not been included:

1) Einsteinian General Relativity (See section 1.10.).

Although this theory produces results that differ greatest from Newtonian mechanics in the case of the planet Mercury, it affects the others as well [243]. It would have been mathematically tractable to include an approximation to this theory [185], and, indeed, highly desirable and instructive.

In order to treat the 11-Body Problem (the 9 principal planets, the Moon, and the Sun) as an initial value problem it was natural to employ the latest available sets of initial conditions [181,189]. These were available for 1913 August 21d.0 UT, 1971 September 6d.0 UT, 1972 October 10d.0 UT, and 1973 November 14d.0 UT, and at intervals of 400 days [184,190]. Unfortunately, the standard deviations (Line 2 [189]) for $\dot{x}$, $\dot{y}$, and $\dot{z}$ for Mercury give rise to differences in results which far exceed the relativistic effects (See section 3.4.3.).

2) Asphericities, Mascons, etc.

Assumption 2 neatly neglects all these relevant effects since all bodies are treated as point masses. These effects, of course, can be treated by Newtonian mechanics, and are probably of greatest importance for the Earth and Moon [185,187]. Solar oblateness, however, could prove to be of crucial importance in denigrating Einsteinian General Relativity [86,187,191].

3) Solar Radiation Pressure and the Solar Wind.

Solar radiation pressure in the case of the planets may be neglected[183]. It might be of importance if the optional body were of the type of the Echo 2 satellite. The solar wind might be of importance if the optional body were like Echo 2 or the present geosynchronous satellites [192].

4) Tidal Friction.

This effect has a long-term significance for the Earth-Moon system [6,40,182,186,194,195]. The secular increase in the Earth-Moon radius vector is about 3 cm/year [194]. An excellent treatise on the short-term analysis of tides is available [193].

5) Temporal Decrease of the Universal Gravitational Constant.

Van Flandern believes "... that gravity is decreasing", accounting for a 4 cm/yr. secular increase in the Earth-Moon distance [196]. This figure would appear to be at odds with Goldreich's (See 4) above.). Clearly, the implications for cosmology are of crucial importance and further work on separating these effects is necessary [90,191, 196].

3.3. ANALYTICAL DEVELOPMENT

The vector differential equation of the Eleven-Body Problem may be written [120]

$$\ddot{\bar{r}}_i = -\frac{G(m + m_i)\,\bar{r}_i}{r_i^3} + \sum_{j=2}^{11} Gm_j\left(\frac{\bar{r}_j - \bar{r}_i}{r_{ij}^3} - \frac{\bar{r}_j}{r_j^3}\right), \qquad (19)$$

$$j \neq i, \quad i = 2, 3, \ldots, 11,$$

where $r_{ij} = [(x_j - x_i)^2 + (y_j - y_i)^2 + (z_j - z_i)^2]^{1/2}$. (20)

Equations (19) are a rewritten form of equations (5.63) of the reference. The system (19) of autonomous nonlinear ordinary differential equations has 10 known independent classical algebraic integrals in Euclidean three-space. Since 60 independent integrals are required for a solution in general, numerical integration techniques would seem to be a reasonable approach for an approximate solution (See section 1.12.) [98,100,101,121,176,177,204,244]. As an approximation to the Solar System, solutions of the system (19) would seem to exist and be unique [205].

The origin of the Euclidean three-space is the Sun, which is a noninertial frame of reference. The heliocentric and heliodynamic theories, as developed in Chapter 1, will be employed. In the system (19), m represents, therefore, the solar mass.

3.4. THE RATIONAL EXTRAPOLATION TECHNIQUE

The success achieved using this method on the Two-Body Problem (See section 2.6.) led to its utilization on the Eleven-Body Problem.

3.4.1. ALGORITHM IMPLEMENTATION

Appendix 11 shows details in a similar fashion to Appendix 6 (See section 2.6.1.).

Appendix 11 A shows the JCL, etc. with the load module module in a region of Main Storage rather than LCS (See section 2.3.1.).

Appendix 11 B shows the FORTRAN used. The main program has variable EPS = 10^{-11}, and H was arbitrarily set to FB. The array YSTART initially contains the 60 initial conditions required (See section 3.3.), which were taken from Line 3 [189] (See section 3.2.). Corrected values were used (See Appendix 10 D.). YSTART(1) through YSTART (6) contain x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$, respectively, for Mercury (i = 2, in the system (19). See section 3.3.). YSTART(7) through YSTART(12) contain the corresponding values for Venus (i = 3). The YSTART array continues with values for Earth (i = 4), Moon (i = 5), Mars (i = 6), Jupiter (i = 7), Saturn (i = 8), Uranus (i = 9), Neptune (i = 10), and Pluto (i = 11).

The heliocentric gravitational constant (-GM1) was obtained from the defining equation [207], using the Gaussian gravitational constant [206,188] and the improved conversion factor for the AU [188]. Variables GM2 through GM11 are the gravitational constants for Mercury through Pluto, obtained through the reciprocal solar masses [103,188]. When variable J of the DO loop is 1, the integration proceeds from time = 0 (XSTART=0) to time = 800 days (XEND=SP*2). When J = 2, the integration proceeds from time = 0 to 800 and then back to 0 to determine how well the initial conditions can be reproduced.

The Systѐme Internationale D'Unités [66] has been employed, except for time [184].

Subroutine FCT is rather extensive, nevertheless it was coded to execute about as fast as possible. The system (19) was reduced to a first-order system (as in Appendix 6 B) using statements DY(1)=Y(4) through DY(57)=Y(60). R 2 through R11 are the r_i^{-3} for Mercury through Pluto. RX 2 3 through RZ1011 constitute a minimum necessary set of values for $(x_j - x_i)$, $(y_j - y_i)$, and $(z_j - z_i)$ to be used for equations (20). RX 2 3 is the x-component of the distance from body 2 (Mercury) to body 3 (Venus), and similarly for the remaining components. These components correspond to $(\bar{r}_j - \bar{r}_i)$ in the system (19). Notice that no RX 3 2, etc. is evaluated, since RX 3 2 = - RX 2 3, RX 3 2 is effectively available through complementation rather than through the slower but obvious subtraction, etc. Machine Language combination. The saving in execution time throughout the system should be substantial, although no test therefor was carried out. R 2 3 through R1011 correspond to a minimum necessary set of r_{ij}^{-3} in the system (19).Multiplications instead of exponentiations (e.g., RX 2 3*RX 2 3 instead of RX 2 3**2) were employed to possibly reduce execution time.

A few words about the coordinate system [189] would seem to be in order at this point. The system probably has its origin at the center of mass of the Sun. The reference plane is probably the mean Equator of the Earth and the reference direction (x) is probably the mean vernal equinox. Both references probably include luni-solar precession but not nutation at the beginning of the Besselian solar year 1950.0. The y-direction is probably in the reference plane perpendicular and counterclockwise to the x-direction. The z-direction is probably perpendicular to the x-y plane, and probably in the same direction pointed to by the Earth's mean North pole at 1950.0. Further information on coordinate systems, etc. is available [210].

The evaluation of the RHSs of the system (19) requires considerable explanation. DY(4), DY(5), and DY(6) are the acceleration ($\ddot{x}$, $\ddot{y}$, $\ddot{z}$, respectively) components for Mercury. Corresponding sets of components were written for the remaining bodies (i = 3-11). The computer's floating-point arithmetic capability only approximates the real number system (See section 2.3.2.). In order to reduce the computational effort and hence the execution time related to (19) within the confines of FORTRAN, the distributive law, etc. of the field postulates valid for the real number system will be exploited [211]. The system (19) may then be rewritten

$$\ddot{\bar{r}}_i = -\frac{Gm\bar{r}_i}{r_i^3} - \frac{Gm_i\bar{r}_i}{r_i^3} + \left[\sum_{j=2}^{11} Gm_j\left(\frac{\bar{r}_j - \bar{r}_i}{r_{ij}^3}\right)\right] - \left[\sum_{j=2}^{11} \frac{Gm_j\bar{r}_j}{r_j^3}\right], \tag{21}$$

$$j \neq i, \quad i = 2, 3, \ldots, 11.$$

Combining the second and fourth terms yields

$$\ddot{\bar{r}}_i = -\frac{Gm\bar{r}_i}{r_i^3} - \left[\sum_{j=2}^{11} \frac{Gm_j\bar{r}_j}{r_j^3}\right] + \left[\sum_{j=2}^{11} Gm_j\left(\frac{\bar{r}_j - \bar{r}_i}{r_{ij}^3}\right), \; j \neq i\right], \tag{22}$$

$$i = 2, 3, \ldots, 11.$$

The corresponding partial components of acceleration represented by the second term of (22) are WAX, WAY, and WAZ. These are common throughout the system and are evaluated once per execution of the subroutine. The first term in (22) represents the heliocentric effect (clearly the dominant term), and is the term immediately to the left of WAX, WAY, and WAZ in the FORTRAN statements for the acceleration components. The right-most term in (22) is represented by the remaining terms (all those except the last two) in the FORTRAN statements for the acceleration components.

Except for increased DIMENSION statement constants, etc., subroutines DDESP, XDDE, DDESUB, and DREDIF are identical to their counterparts in Appendix 6 B. Subroutine DDERSB, in addition to the above differences, uses a relative-error convergence test (in the statement immediately preceding statement 240) in Appendix 11 B rather than the absolute-error one (See section 2.6.1.).

Subroutine DDEOUT in Appendix 11 B, in addition to the above DIMENSION differences, outputs values in their original units and not in the Systѐme Internationale D'Unités, and title information was included (See section 2.6.1.).

Subroutines DERROR are identical in Appendices 11 B and 6 B.

3.4.2. ANALYSIS OF OUTPUT

Appendix 11 C shows the output. The corrected (See Appendix 10 D.) Line 3 values [189] are available immediately below the title and subtitle. They are, of course, the initial values from the main program at time = 0 (variable X, denoted by the subtitle). The first line contains coordinates x, y, z, while the second line gives $\dot{x}$, $\dot{y}$, $\dot{z}$. These two lines give the 6 coordinates for Mercury. Similarly, pairs of lines follow for Venus, Earth, Moon, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Unless otherwise advised, this system of coordinate display will be rigidly adhered to.

At time = $0.3456\dot{0}\times10^8$ seconds (UT) or 400 days later, the set of coordinates appears directly under the set for time = 0. At time = 800 days, the coordinates are similarly displayed. The results of the backward integration are similarly displayed, following those of the forward one.

3.4.2.1. EFFECT OF VARIABLE EPS

Variable EPS was of extreme importance for the Two-Body Problem (See section 2.6.2.), as is also the case here.

We compare Appendix 11 C (forward integration at time = 400 days; x, y, z) with the corresponding corrected Line 4 values [189]. Agreement in all cases is very good: the values from our integration fall within the corresponding Line 2 standard deviations [189] of the Line 4 values. The Line 2 deviations are applied, without modification, to the Line 3,4, and 5 values (See Appendix 10 D for justification.). In all cases, the angles with vertices at the heliocenter and subtended by our position of a particular body and that of Line 4 are much less than 1 second of arc (See Appendix 12. Incidental calculations, such as this one have been carried out using the University of Waterloo's WATFIV [212] instead of FORTRAN IV in order to reduce turnaround time. Unfortunately, however, arithmetic results from the former are not as reliable as those from the latter in general. This calculation uses the Cosine Law to determine the maximum error angle (in seconds of arc) caused by the standard deviations applied to the Line 5 coordinates (x, y, z) of Mercury.).

We now compare our values at time = 800 days with the corresponding Line 5 values [189], as above. Again agreement is good: our values fall within the standard deviations of the Line 5 values, except for Mercury and the Moon. In the two latter cases, it seems that the shortcomings of our Solar System model are starting to rear their ugly heads (See section 3.2.).

We now compare the initial values (x, y, z) in Appendix 11 C with the corresponding ones that were produced by the backward integration. Algorithm and roundoff errors should produce some degradation in the latter. Agreement in all cases is quite good: for Mercury agreement is exact for 9 significant digits, Venus has 9, Earth has 10, Moon has 9, Mars has 10, Jupiter has 12, Saturn has 11, Uranus has 11, Neptune has 11, and Pluto has 12. The degradation is as expected: the faster bodies have more in general than the slower ones. This problem is somewhat analogous to that encountered in solving "stiff" systems of differential equations [148], on which much literature has been written. Appendices 13 through 16 contain the output as in Appendix 11 C, except for various other values of EPS. The best overall performance seems to be had from EPS in the range 10^{-10} to 10^{-11}. Something seems to be limiting the number of significant digits obtainable.

3.4.2.2. EFFECT OF INTERCHANGING BODIES

A job identical to Appendix 11, except that Mercury and Pluto were interchanged, was run (details not included). We compared results of the backward integrations at time = 0 (for x, y, z). In general, an extra significant digit was obtained, compared with the results of section 3.4.2.1. (between initial values and corresponding backward integration results). Therefore it would seem that most of the degradation in the previous section is simply beyond our control with the available arithmetic capability (See section 2.3.2.).

3.4.2.3. EFFECT OF AN ALGORITHM ERROR ON THE RESULTS OF A BACKWARD INTEGRATION

A job (results in Appendix 17) identical to that which produced Appendix 14, except that in subroutine FCT the statement for DY(4) had "-UE*RX 2 7" instead of "+UE*RX 2 7" (the partial effect of Jupiter on Mercury's $\ddot{x}$ was deliberately made erroneous), was run. For Appendix 17, as in section 3.4.2.1 , agreement for Mercury is exact for 9 significant digits, while agreement on the forward integration at time = 800 days for Mercury's x is exact for only 2 significant digits (when compared with the corresponding value of Line 5 [189]). For Appendix 14, agreement for Mercury is exact for 9 significant digits for the backward integration, while the agreement corresponding to the above comparison is 5 significant digits (which is much better than 2).

We, therefore, conclude that a good closing in a backward integration is no assurance that the algorithm is correct. From section 3.4.2.1 we can conclude that if the algorithm is correct then backward integration values agree well with the corresponding initial values. The results of the present section indicate that the converse of the preceding statement is not, in general, true.

3.4.3. EXTENDED MODELLING OF THE SOLAR SYSTEM

Appendix 18 shows part of the output of a job similar to Appendix 14, except that the integration used Line 1 [189] instead of Line 3 for initial values and the integration yielded values at 200 day intervals through 1976 Jan. 23d.0 UT. The CPU time was 1382 min. 21.84 sec. and the job charge was $7,246.75! The computational requirements of extended (timewise) and accurate Solar System modelling are certainly not trivial.

The initial conditions are shown, as well as values corresponding to Lines 3, 4, 5, and values corresponding to 1975 July 7d.0 UT and 1976 Jan. 23d.0 UT.

We compared corresponding Line 5 values in a similar fashion to Appendix 12 (See section 3.4.2.1.). Appendix 19 shows results for Mercury: 29.35^{+} seconds of arc is the heliocentric error angle, while the corresponding secular excess perihelion motion predicted by Einstein (See section 3.2, and references.) is 25.88^{+} seconds of arc. Recall that Appendix 18 results are based on Newtonian mechanics: at first glance, the near equality of the two values of the error angle is highly encouraging. Further recall that Mercury should be ahead of its position in orbit under General Relativity than under Newtonian mechanics. Examination of the coordinates reveals, unfortunately, that the opposite is actually the case. Therefore, a more realistic error angle is the sum of the two values, or about 55.24 seconds of arc.

Mercury caused even greater problems before the receipt of Oesterwinter's letter (See Appendix 10 D.). The presence of errors in Table X [189], in addition to those listed, was suspected (See Appendix 10 C.). The glaring error for Venus, it must be admitted, was not noticed. A run similar to Appendix 13, except that Line 3 [189] values for initial conditions were used, instead of the corrected value for $\dot{z}$, etc. (See Appendix 10 D.). Appendix 13 results for x, y, and z, respectively, for Mercury (forward integration, time = 800 days) are (with the similar run results directly under in parentheses)

0.1071 8638 4705 9226D 00, 0.2588 7886 9163 8346D 00, and

(0.1071 7208 3814 4920D 00)(0.2588 8267 7961 2633D 00)

0.1276 2946 9455 9271D 00.

(0.1276 3290 3940 0052D 00)

The values in parentheses were obtained using a value of $\dot{z}$ which differed by only 1 standard deviation from the value used in Appendix 13. This difference causes effects much greater than those due to General Relativity, unfortunately. Coordinate uncertainties in the initial conditions (especially in the velocity components), therefore, severely limit the predictive ability of a Solar System treatment as an initial value problem. Clearly, this aspect of the problem warrants further research: model differences might be a culprit (See Appendix 10 D.).

Similar runs to Appendix 19 were carried out for the other bodies for the heliocentric error angles: Venus, $3.28^{+}x10^{-2}$ seconds of arc; Earth, $1.67^{+}x10^{-2}$; Moon, 1.55^{+}; Mars, $1.78^{+}x10^{-1}$; Jupiter, $3.43^{+}x10^{-3}$; Saturn, $2.66^{+}x10^{-3}$; Uranus, 0.0; Neptune, $2.17^{+}x10^{-3}$; and Pluto, $2.17^{+}x10^{-3}$. The large angle for the Moon probably is due to model deficiencies (such as: terrestrial oblateness, see section 3.2.). Consideration of the General Relativistic effect for the other bodies has not been attempted, due to the rather dismal performance for

Mercury (discussed in the preceding paragraphs).

An identical run which produced the results of Appendix 18 was carried out, except that Mercury and Pluto were interchanged. The number of exact significant digits was recorded for 1976 Jan. 23d.0 UT between the two runs: Mercury, 8; Venus, 7; Earth, 8; Moon, 7; Mars, 9; Jupiter, 7; Saturn, 9; Uranus, 9; Neptune, 9; and Pluto, 10. Algorithm and roundoff errors are now producing significant degradation of results (See sections 3.4.2.1 and 3.4.2.2.), but the General Relativistic effect for Mercury should still be observed (if sufficiently accurate initial conditions be available). An extended-precision arithmetic (See section 2.3.2.) run corresponding to Appendix 18 with considerably more favourable agreement with a corresponding run with Mercury and Pluto interchanged than above would add more confidence to the results than is presently the case. However, comparisons, where possible, gave good agreement [241].

3.4.4. LUNAR EPHEMERIS OF GEOCENTRIC RADII VECTORES

The optional body in our Solar System model is the Moon (See section 3.2.). The motion of the Moon presented a challenge to the ancients [5,13,61], Newton [69,71], Pierre Simon (Marquis De Laplace) [214], and modern investigators. A good summary of the situation is provided in the following quote: "Our old friend and neighbor, the Moon, is once again an embarrassment to those philosophical fundamentalists who believe that simplicity is a measure of credibility in physical description." [216]. The most recent lunar research does not rely in whole on the positions as tabulated in the national ephemerides [217]. Probably the best lunar ephemeris presently widely available through joint publications of NAO and HMNAO is that designated j = 2 [218]. Residuals in the geocentric radii vectores therein seem to have been at least 6 km [218,215]. However, recent work from the LURE gave residuals of about 5 m, with prospects for centimetric residuals [219,220].

The j = 2 ephemeris for 1972-1975 is available [222,226,230,236]. In order to limit the computational requirement, we attempted to reproduce only the geocentric radii vectores [221,225,228,234]. A reasonably good explanation of the ephemerides is available [235], while a more thorough discussion is, unfortunately, somewhat dated [210]. A good tutorial on astronomical time systems [237], and an overall appraisal of astronomical systems of units [102] warrant perusal.

3.4.4.1. ALGORITHM IMPLEMENTATION

Appendix 20 shows some of the details,and is similar to Appendix 11. Appendix 20 A shows only the FORTRAN source which is different from Appendix 11 B. In the driving program, the initial conditions are those of Line 3 corrected (See section 3.4.1.), but the integration proceeded for 1600 days, with printout at intervals of 0.5 day, and only a forward integration was carried out. In subroutine DDEOUT, only variables U (time from epoch of initial conditions, in days) and R (the Earth-Moon radius vector (the Euclidean norm), in units of the Earth's equatorial radius [234]) were printed out (See Appendix

20 A and compare with Appendix 11 B.).

3.4.4.2. ANALYSIS OF OUTPUT

Appendix 20 B shows the output only from 1975 Sept. 11d.5 UT (1466.5 days from 1971 Sept. 6d.0 UT) to 1976 Jan. 23d.0 UT (1600.0 days from epoch). Only this portion of the ephemeris was displayed in Appendix 20 B for space requirements and also because probably the maximum residuals with respect to the j = 2 ephemeris occurred in this range. Probably the maximum absolute value of the residuals throughout the 1600 day interval occurred at 1975 Nov. 7d.5 UT (See Appendix 21.), and was about 11.11 km.

The independent variable for the initial conditions [189] was UT [184,210,235,237], as it was for Appendix 20. The independent variable for [234], etc. was ET. In order to compare residuals the common time base, UT, was employed since interpolation in [234], etc. was very convenient. In Appendix 21 variable DT represents the approximate value of ΔT = ET - UT, applicable at 1975 Nov. 7d.5 UT [232]. Variable DUT represents the geocentric distance at 1975 Nov. 7d.5 UT, interpolated from the corresponding ET value [236]. Variable DNE represents the distance from North's ephemeris (See Appendix 20 B at time 0.1523500D 04.). The remainder of Appendix 21 is self-explanatory. The difference (DUT - A0) is about 3.26 km in this case, which is not negligible.

Attention is called to the fact of the corrections for the equatorial horizontal parallax of the Moon [233], applicable to [223, 227,231] and which were noted in Appendix 10 E A. Attention is also called to the important correction for Earth's equatorial radius = 6 378 160 m, not 6 378 160 km [224], applicable to [221]. Both of these errors caused some consternation.

The residual, with respect to the j = 2 ephemeris, was about -11.11 km. Probably the maximum positive residual was about 8.3 km and it occurred at 1975 Oct. 28d.5 UT. The qualifier "probably" is required in the preceding because a rigorous comparison was not carried out throughout the 1600 day integration. This could have easily been done: the j = 2 ephemeris is available in machine readable form (At least cards could be prepared from [234], etc.), and a program could easily have been written (somewhat more sophisticated than that in Appendix 21) to compare the distances. Lack of time was the prime reason for abandoning this approach. Another reason is that the j = 2 ephemeris is not very good: it seems to possess residuals with respect to reality of at least 6 km (See section 3.4.4.). Another reason is that the Line 2 [189] standard deviations relevant to the Earth-Moon system can give rise to a maximum residual of just over 89.755 km, with respect to coordinates without Line 2 values applied (A run similar to Appendix 20 revealed this.).

A better ephemeris than the j = 2 one was sought to test Appendix 20, therefore (See Appendices 10 E and 10 E A.). Unfortunately, we did not receive any LURE results (See also section 3.4.4.). These results, no doubt, would have revealed a model shortcoming, namely: that the terrestrial oblateness was neglected (See section 3.2.).

It would have been most interesting to attempt to isolate this effect and explain its magnitude theoretically.

Several runs similar to Appendix 20 were carried out using various values of EPS (See section 3.4.2.1.) and interchanging of bodies (See section 3.4.2.2.). Again a rigorous inspection has not been carried out, but it seems highly probable that throughout the range, 6 exact significant digits can be obtained, giving a maximum uncertainty in a particular value of the radius vector of about 0.64 km (algorithm and roundoff error). Of course, in order to fully exploit this capability, much better initial conditions would be required (lower Line 2 values [189]), and at least the effect of terrestrial oblateness would have to be included in our model. Indeed, it would be a great privilege to continue doing such interesting lunar research!

3.5. THE TAYLOR'S SERIES TECHNIQUE

The outstanding success achieved with this method on the Two-Body Problem (See section 2.7.) certainly necessitated an evaluation of its performance on the Eleven-Body Problem.

3.5.1. ALGORITHM IMPLEMENTATION

Appendix 22 shows most of the details for generating the FORTRAN source (See section 2.7.). Considerable difficulties were encountered in applying Norman's software [166] to the Eleven-Body Problem. His assistance is gratefully acknowledged (See Appendix 9.). In Appendix 9 G the following quotations are of interest: "I'm terrified by the pages & pages of equations you are feeding my program! I can, however, explain some of the storage problems- which are my fault.", "For big problems you are rather more liable to have trouble with the amount of code TAYLOR generates: your 11 body thing is (by some way) the biggest problem it has ever met and, as you see, although I can generate FORTRAN the FORTRAN compilers don't like routines that long.", and "At least you can console yourself that my program doesn't make your research project trivial & unchallenging!".

Appendix 22 A shows the JCL, etc. The effort required was considerably greater than that for the Two-Body Problem (See section 2.7.1 and Appendix 8.). Tape NORMAN was also copied on tape LUT177 (See Appendix 9 F.). The first job step copied the second file to a data set on disk storage and sequence numbered that data set (See Appendix 22 B.) [213]. The data set was not listed in this job step because it consisted of 4698 source records (SYSIN) of Assembler Language.

The second job step altered the statement with sequence number 0013290 to make the change recommended by Norman (See Appendix 9 G.) at the actual location 380_{16}, not $37C_{16}$ (See Appendix 22 C.).

The third job step bypassed a problem with OS/360 (involving concatenation of data sets with unlike attributes (See section 2.7.1.)).

The catalogued procedure ASMFCLG, etc. ultimately generated the FORTRAN source in the catalogued data set FOR74092, corresponding to the TAYLOR input (See Appendix 22 D.). The TAYLOR input was prepared using parts of subroutine FCT and the driving program (See Appendix 11 B.) according to the rules [168]. The number of terms employed was 8, instead of the default value of 16 because, with the latter value, execution times of over 1000 minutes of CPU time of the load modules ultimately generated no significant output (as compared with Appendix 23 E.).

The procedure FORTGCLG, etc. failed during compilation since one of the generated subroutines was too large (See Appendix 9 G.). Details of the failure are not included.

Appendix 23 gives details of a successful run. Appendix 23 A shows the JCL, etc. The first job step essentially sequence numbered the data set from FOR74092, similarly to the first job step of Appendix 22 A (See Appendix 23 B.). The second job step made changes to the data set from FOR74092 to allow a successful execution (See Appendix 23 C.). As should be readily apparent, a lot of effort was required.

The modified source (See Appendix 23 C.) and the driving program (See Appendix 23 D.) were successfully executed using the procedure FORTGCLG, etc. (See Appendix 23 E.). Many underflows (511 or over) were produced during execution (message: IHC208I [133]), but no attempt was made to eliminate them (See Appendix 9 G.). Underflows and overflows seem to be a fact of life when employing Taylor's series (See section 2.7.4.).

In Appendix 22 D, EPSILON = 10^{-6} (See section 2.7.1.), which was effectively reduced to 10^{-14} in Appendix 23 C (See sequence numbers 00058060, 00058210, 00058390, 00058900, and 00059080.

Also in Appendix 23 C, at sequence number 00061780, the corrected value for Mercury's $\dot{z}$ was employed (See Appendix 10 D.).

Appendix 24 used an effective EPSILON = 10^{-15}. Appendix 24 A shows only the FORTRAN employed which is different from that in Appendix 23. Routines not shown are exactly as in Appendix 23. The driving program, in addition to printing results at time = 400 days, punched a deck of cards for input to the job of Appendix 25. The CPU time for the load module (which resided in LCS) was 1024 min. 17.04 sec.

The job of Appendix 25, using an effective EPSILON = 10^{-15}, integrated the system from time = 400 days to 800 days. Appendix 25 A shows the FORTRAN using the same scheme as for Appendix 24. The deck of cards from the job of Appendix 24 was read in subroutine SETUP. Results are shown in Appendix 25 B. The CPU time for the load module (residing in a region of LCS) was 1010 min. 05.55 sec.

3.5.2. ANALYSIS OF OUTPUT

The output (See Appendices 23 E, 24 B, and 25 B.) is only for a forward integration because of the excessive load module execution times involved. At a given time, the coordinates x, y, and z are printed for the 10 bodies as a set, followed by $\dot{x}$, $\dot{y}$, and $\dot{z}$ printed as a set. The alternation described in section 3.4.2 does not apply here. At time = 800 days (See Appendix 25 B.), x, y, and z for Mercury through Pluto are printed, and are followed by $\dot{x}$, $\dot{y}$, and $\dot{z}$ for Mercury through Pluto.

As in section 3.4.2 agreement for forward integrations at time = 400 days and 800 days is very good with Line 4 (corrected) and 5 values [189], respectively.

We now compare the forward integration values (x, y, z) at time = 800 days in Appendix 11 C with the corresponding ones in Appendix 25 B. Agreement in all cases is quite good: for Mercury agreement is exact for 11 significant digits, Venus has 8 (a small z-component is the culprit), Earth has 12, Moon has 11, Mars has 11, Jupiter has 10, Saturn has 11, Uranus has 13, Neptune has 12, and Pluto has 12. A similar comparison of Appendices 11 C and 23 E yields 10, 10, 11, 10, 9, 10, 11, 11, 13, and 12.

3.5.3. CONCLUSIONS

It is difficult to ascertain which set of values is better, algorithm and roundoff errors seem to be affecting both techniques to about the same degree (See section 3.5.2.).

There is little doubt about which technique is faster: the load module of Appendix 23 ran for 975 min. 48.22 sec. of CPU time in a region of LCS, while only a forward integration of Appendix 11 required 114 min. 47.82 sec. of CPU time in a region of LCS (The load module was created using procedure FORTGCLG to be entirely compatible.). Therefore, for approximately maximum attainable precision, the rational extrapolation technique is about 8.5 times faster than the Taylor's series technique. In the case of the Two-Body Problem the latter was about 2.9 times faster (See Graph 4.).

The principal disadvantage of Taylor's series is the size of the load module generated, and the accompanying long execution time (See Appendixes 9 F and G.). It would have been possible, through careful reprogramming, to speed up the Taylor's series technique, but it is doubtful that a factor of about 8.5 could even be halved. Experimentation with the TERMS keyword [168] showed that 8 was about the optimal value (execution timewise) for the Eleven-Body Problem. Similar studies regarding the number of terms employed have been made [137,169].

CHAPTER 4

MATHEMATICAL ASPECTS OF THE ALGORITHMS

4.1. THE CLASSICAL RUNGE-KUTTA TECHNIQUE

4.1.1. INTRODUCTION

This technique can be employed to solve systems of ordinary differential equation [143]. We are given the system

$$y_i = f_i(y_1(t), y_2(t), \ldots, y_n(t)), \tag{23}$$

subject to the initial conditions

$$y_i(t_0) = y_{i0}, \tag{24}$$

and we seek approximate values $\bar{y}_i(t_0 + h)$ to $y_i(t_0 + h)$.

The independent variable t does not appear explicitly in the RHSs of the system (23) (See the system (7) and (8), section 2.2.) and is incremented by h, and $i = 1, 2, \ldots, n$. The increment h (not necessarily constant) is successively applied to advance the solution to the desired value of t. Existence and uniqueness properties of the solutions are assumed [122, 125].

4.1.2. ALGORITHM FOR A SINGLE FIRST ORDER EQUATION

The method approximates the Taylor's series solutions,

$$y_i(t + h) = y_i(t_0) + h\dot{y}_i(t_0) + \frac{h^2}{2!}\ddot{y}_i(t_0) + \ldots ,$$

through terms of order h, without requiring derivatives beyond the first. Instead, four evaluations of the first derivatives are employed.

The solution may be obtained [143] by evaluating

$$
\begin{aligned}
A_1 &= hf(y_0) , \\
A_2 &= hf(y_0 + .5A_1) , \\
A_3 &= hf(y_0 + .5A_2) , \\
A_4 &= hf(y_0 + A_3) , \\
\bar{y}(t_0 + h) &= y(t_0) + \frac{1}{6}(A_1 + 2A_2 + 2A_3 + A_4) .
\end{aligned}
\tag{25}
$$

4.1.3. ALGORITHM FOR A SYSTEM OF FIRST ORDER EQUATIONS

For the system (23) with $i = 1, 2,$ the solution may be obtained from [122]

$$
\begin{aligned}
A_1 &= hf_1(y_{10}, y_{20}) , \\
B_1 &= hf_2(y_{10}, y_{20}) , \\
A_2 &= hf_1(y_{10} + .5A_1, y_{20} + .5B_1) , \\
B_2 &= hf_2(y_{10} + .5A_1, y_{20} + .5B_1) , \\
A_3 &= hf_1(y_{10} + .5A_2, y_{20} + .5B_2) , \\
B_3 &= hf_2(y_{10} + .5A_2, y_{20} + .5B_2) , \\
A_4 &= hf_1(y_{10} + A_3, y_{20} + B_3) ,
\end{aligned}
\tag{26}
$$

$$B_4 = hf_2(y_{10} + A_3, y_{20} + B_3) ,$$

$$\overline{y}_1(t_0 + h) = y_{10} + \frac{1}{6}(A_1 + 2A_2 + 2A_3 + A_4) ,$$

$$\overline{y}_2(t_0 + h) = y_{20} + \frac{1}{6}(B_1 + 2B_2 + 2B_3 + B_4)$$

Also, for the system (23) with $i = 1, 2, \ldots, n$, the solution (26) may be extended with n sets of formulae (A, B, C, ..., N) rather than 2 [122].

4.1.4. REDUCTION OF A SECOND ORDER SYSTEM TO ONE OF FIRST ORDER

The systems (7) and (8) and (22) are of second order. We may write them

$$\ddot{y}_i = g_i(y_1(t), y_2(t), \ldots, y_n(t)). \qquad (27)$$

Letting

$$\dot{y}_i = h_i(y_1(t), y_2(t), \ldots, y_n(t)), \qquad (28)$$

and differentiating (28) w. r. t. t we obtain

$$\ddot{y}_i = \dot{h}_i(y_1(t), y_2(t), \ldots, y_n(t)). \qquad (29)$$

Equating RHSs of (27) and (29) gives

$$\dot{h}_i(y_1(t), y_2(t), \ldots, y_n(t)) = g_i(y_1(t), y_2(t), \ldots, y_n(t)). \qquad (30)$$

Through the introduction of the auxiliary variables h_i, the system (27) of n equations may be considered reduced to the system (28) and (30) of $2n$ first order equations. The former system may now be solved by the algorithms of section 4.1.3., etc.

4.1.5. ALGORITHM IMPLEMENTATION

The system (7) and (8), with initial conditions (9) was solved

(See section 2.3.). Appendix 1 B was prepared by reducing the system to a first order one (See section 4.1.4.), and applying the algorithm of section 4.1.3., using initial value variables (X1, Y1, DX1DT, DY1DT) and increment variables (X2, Y2, DX2DT, DY2DT). Variables STP, A1, etc. correspond to h, A_1, respectively. The rest of the program should be reasonably self-explanatory.

4.2. THE CLASSICAL RUNGE-KUTTA (GILL'S MODIFICATION) TECHNIQUE

4.2.1. INTRODUCTION

The objective is as in section 4.1.1., but the accumulation of roundoff errors is limited along with reducing storage requirements [143].

4.2.2. ALGORITHM FOR A SINGLE FIRST ORDER EQUATION

The following calculations are required [143]

$$A_1 = \frac{1}{2}, \; A_2 = 1 - \sqrt{.5}, \; A_3 = 1 + \sqrt{.5}, \; A_4 = \frac{1}{6},$$

$$k_1 = hf(y_0), \; y_A = y_0 + A_1(k_1 - 2q_0),$$

$$k_2 = hf(y_A), \; y_B = y_A + A_2(k_2 - q_1),$$

$$k_3 = hf(y_B), \; y_C = y_B + A_3(k_3 - q_2),$$

$$k_4 = hf(y_C), \; \bar{y}(t_0 + h) = y_C + A_4(k_4 - 2q_3), \tag{31}$$

$$q_1 = q_0 + 3A_1(k_1 - 2q_0) - A_1 k_1,$$

$$q_2 = q_1 + 3A_2(k_2 - q_1) - A_2k_2,$$

$$q_3 = q_2 + 3A_3(k_3 - q_2) - A_3k_3,$$

$$q_4 = q_3 + 3A_4(k_4 - 2q_3) - A_1k_4$$

with q_0 initially zero. For the next step q_0 is the immediately prior q_4, and y_0 is $\bar{y}$.

4.2.3. ALGORITHM FOR A SYSTEM OF FIRST ORDER EQUATIONS

The algorithm is an extension of that of section 4.2.2., and details, along with a flow chart for the FORTRAN program (subroutine DRKGS) of section 2.4.1., are available [143].

4.3. THE RUNGE-KUTTA-NYSTRÖM TECHNIQUE

4.3.1. INTRODUCTION

We are given a system such as that of (7) and (8)

$$\ddot{x} = f(x, y), \ \ddot{y} = g(x, y), \tag{32}$$

and the goal is to solve the system without prior reduction to a first order one (See sections 4.1.4. and 2.5.).

4.3.2. ALGORITHM DEVELOPMENT

The solution of the system (32) may be written [146]

$$\begin{aligned} x &= \dot{x}_0 + x_0h + h^2 \sum_{k=0}^{3} c_k f_K + 0(h^5), \\ \dot{x} &= \dot{x} + h \sum_{K=0}^{3} \dot{c}_K f_K + 0(h^5) , \end{aligned} \tag{33}$$

$$f_0 = f(x_0, y_0),\ (K = 0),$$

$$f_K = f(x_0 + \dot{x}_0\alpha_K h + h^2 \sum_{\lambda=0}^{K-1} \gamma_{K\lambda} f_\lambda, \qquad (34)$$

$$\dot{y}_0\alpha_K h + h^2 \sum_{=0}^{K-1} \gamma_{K\lambda} g_\lambda),\ (K = 1, 2, 3)$$

with analogous expressions for y. In (33) and (34) x_0, y_0, $\dot{x}_0$, $\dot{y}_0$ are the initial values for the integration step, and h is the step size.

The coefficients α_K, γ_K , c_K, c_K must be found such that the RHSs of (33) are of fourth order. Equations of condition for the coefficients are available by equating corresponding terms of a Taylor's series solution of (32) and the RHSs of (33). From these equations a set of coefficients can be had: results are in Table 1.

TABLE 1

Coefficients For A Fourth Order Formula

K \ λ	α_K	$\gamma_{K\lambda}$			c_K	c_K
		0	1	2		
0	0				$\frac{13}{120}$	$\frac{1}{8}$
1	$\frac{1}{3}$	$\frac{1}{18}$			$\frac{3}{10}$	$\frac{3}{8}$
2	$\frac{2}{3}$	0	$\frac{2}{9}$		$\frac{3}{40}$	$\frac{3}{8}$
3	1	$\frac{1}{3}$	0	$\frac{1}{6}$	$\frac{1}{60}$	$\frac{1}{8}$

4.4. THE RATIONAL EXTRAPOLATION TECHNIQUE

4.4.1. INTRODUCTION

An approximate solution to the system (23) subject to (24) (See section 4.1.1.) based on a discretization method (the midpoint-rule) can be improved by extrapolation [157].

4.4.2. ALGORITHM DEVELOPMENT

Suppose the discretization method [157] yields $T(h)$ for the n th equation for a nonzero step size, then the true value $T(0)$ can usually be better approximated by the extrapolated value $\hat{T}_m(0)$ of a rational function $\hat{T}_m(h)$ such that

$$\hat{T}_m(h_j) = T(h_j),\ j = 0,\ \dots,\ m,\ h_j \to 0. \tag{35}$$

The extrapolated values associated with the midpoint-rule (which determines i)

$$T_m^{(i)} = \hat{T}_m^{(i)}(0), \tag{36}$$

are obtained with the aid of

$$\Delta T_0^{(m)} = C_0^{(m)} = T(h_m),$$

$$\Delta T_k^{(m-k)} = \frac{C_{k-1}^{(m-k+1)} W_{k-1}^{(m-k+1)}}{\left(\frac{h_{m-k}}{h_m}\right)^2 \Delta T_{k-1}^{(m-k)} - C_{k-1}^{(m-k+1)}},\quad k = 1,\ 2,\ \dots,\ m,$$

$$C_k^{(m-k)} = \frac{\left(\frac{h_{m-k}}{h_m}\right)^2 \Delta T_{k-1}^{(m-k)} W_{k-1}^{(m-k+1)}}{\left(\frac{h_{m-k}}{h_m}\right)^2 \Delta T_{k-1}^{(m-k)} - C_{k-1}^{(m-k+1)}},\quad k = 1,\ 2,\ \dots,\ m, \tag{37}$$

$$= W_{k-1}^{(m-k+1)} + \Delta T_k^{(m-k)},$$

$$T_m^{(0)} = \sum_{k=0}^{m} \Delta T_k^{(m-k)},$$

with

$$W_k^{(i)} = C_k^{(i)} - \Delta T_k^{(i-1)} \quad (\equiv T_k^{(i)} - T_k^{(i-1)}),$$

and

$$\Delta T_k^{(i)} = T_k^{(i)} - T_{k-1}^{(i+1)},$$

$$C_k^{(i)} = T_k^{(i)} - T_{k-1}^{(i)},$$

successively for $m = 0, 1, 2, \ldots$. See section 2.6.1. for programming details.

4.4.3. CONVERGENCE CRITERION

The extrapolation has converged [154] when every y_i, at each integration step, has met a user specified convergence criterion. The test consists of comparing two successive extrapolation values at the end of the integration step. We define the difference between the two values for $i = j$ to be D_j, and the error tolerance given in the calling sequence to be EPS ($10^{-18} \le \text{EPS} \le 1$, in Appendices 6 and 11). The absolute error criterion (See Appendix 6 B 10.) is $|D_j| < \text{EPS}$, $j = 1, 2, \ldots, n$, while the relative error criterion is (See Appendix 11 B 18.) $|D_j/y_j| < \text{EPS}$, $j = 1, 2, \ldots, n$.

4.5. THE TAYLOR'S SERIES TECHNIQUE

4.5.1. INTRODUCTION

Taylor's series can be directly employed to yield an approximate solution to the system (23) subject to (24) (See section 4.1.1.).

4.5.2. ALGORITHM DEVELOPMENT

The Taylor's series

$$y_i(t) = \sum_{j=0}^{\infty} \frac{y_i^{(j)}(t_0)\,(t - t_0)^j}{j!}, \tag{38}$$

are successively evaluated in a sequence of overlapping domains (t_1 replaces t_0, etc.) [155]. The principal difficulty (See section 2.7.) lies in procuring $y_i^{(j)}$, the j th derivative of y_i, from a set of recurrence relations. These relations follow after reduction of the system (23) to a canonical form.

The local error-per-step ϵ (EPSILON) for p terms for each y_i is readily specified (See section 2.7.1.). The required step size $h = t - t_k$ at time t_k can be obtained from the truncation error

$$E(t) = \frac{y_i^{(p+1)}(t_{kk})\,(t - t_k)^{p+1}}{(p+1)!}, \quad t_k \le t_{kk} \le t, \tag{39}$$

by setting

$$E(t) = R(t)h^{p+1} = \epsilon, \tag{40}$$

where R(t) is approximated by the constant

$$R = \max_{\substack{1\le i\le n \\ p-2\le j\le p}} |y_i^{(j)}|. \tag{41}$$

An estimate can be had from (40) and (41)

$$h_1 = C_k \left(\frac{\epsilon}{R}\right)^{\frac{1}{p+1}} , \qquad (42)$$

where C_k came from the immediately prior step. Subsequently a sequence h_1 can be obtained such that (40) is satisfied by one or more members of the set. See Appendices 8 C, 23 C, and 24 A.

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APPENDICES

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//RMARN005 JOB '1610125,0030,3,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC FORTHCLG,PARM.FORT='OPT=2,ID'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN    DD  DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARN005 FORT
IEF237I 362   ALLOCATED TO SYSPRINT
IEF237I 331   ALLOCATED TO SYSPUNCH
IEF237I 135   ALLOCATED TO SYSUT1
IEF237I 136   ALLOCATED TO SYSUT2
IEF237I 135   ALLOCATED TO SYSLIN
IEF237I 314   ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74042.T084244.RV000.RMARN005.R0001402      DELETED
IEF285I   VOL SER NOS= ADMP02.
IEF285I   SYS74042.T084244.RV000.RMARN005.R0001403      DELETED
IEF285I   VOL SER NOS= SPLU02.
IEF285I   SYS74042.T084244.RV000.RMARN005.LOADSET       PASSED
IEF285I   VOL SER NOS= ADMP02.
IEF373I STEP /FORT     / START 74043.0431
IEF374I STEP /FORT     / STOP  74043.0434 CPU    0MIN 24.77SEC MAIN 250K
CHARGE    $          1.49 CPU TIME 00.00.25    REGION REQUESTED 0250K    STA
                     DISK    READER  PRINTER  PUNCH
I/O COUNTS              33       53       60        0
NO. OF DD CARDS          3        1        1        1
XXLKED    EXEC  PGM=IEWL,REGION=96K,PARM=(MAP,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB    DD  DSN=SYS1.FORTLIB,DISP=SHR
XX          DD  DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1    DD  SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD   DD  DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX              SPACE=(CYL,(2,,1))
XXSYSLIN    DD  DSN=&LOADSET,DISP=(OLD,DELETE)
XX          DD  DDNAME=SYSIN
IEF236I ALLOC. FOR RMARN005 LKED
IEF237I 131   ALLOCATED TO SYSLIB
IEF237I 132   ALLOCATED TO
IEF237I 362   ALLOCATED TO SYSPRINT
IEF237I 135   ALLOCATED TO SYSUT1
IEF237I 136   ALLOCATED TO SYSLMOD
IEF237I 135   ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                  KEPT
IEF285I   VOL SER NOS= MVT21A.
IEF285I   FORTSUB                                       KEPT
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74042.T084244.RV000.RMARN005.R0001406      DELETED
IEF285I   VOL SER NOS= ADMP02.
IEF285I   SYS74042.T084244.RV000.RMARN005.GOSET         PASSED
IEF285I   VOL SER NOS= SPLU02.
IEF285I   SYS74042.T084244.RV000.RMARN005.LOADSET       DELETED
IEF285I   VOL SER NOS= ADMP02.
IEF373I STEP /LKED     / START 74043.0434
IEF374I STEP /LKED     / STOP  74043.0435 CPU    0MIN 08.65SEC MAIN  96K
CHARGE    $          0.70 CPU TIME 00.00.09    REGION REQUESTED 0096K    STA
```

```
                       DISK    READER  PRINTER
I/O COUNTS               143        0       39
NO. OF DD CARDS            5        1        1
XXGO      EXEC  PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFT05F001 DD   DDNAME=SYSIN
XXFT06F001 DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXFT07F001 DD   SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN005 GO
IEF237I 136    ALLOCATED TO PGM=*.DD
IEF237I 362    ALLOCATED TO FT06F001
IEF237I 331    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74042.T084244.RV000.RMARN005.GOSET           PASSED
IEF285I   VOL SER NOS= SPLU02.
IEF373I STEP /GO       / START 74043.0435
IEF374I STEP /GO       / STOP  74043.0457 CPU  14MIN 40.92SEC MAIN  28K
CHARGE    $         27.19 CPU TIME 00.14.41   REGION REQUESTED 0062K   STA
                       DISK    READER  PRINTER  PUNCH
I/O COUNTS                 0        0       11      0
NO. OF DD CARDS            1        1        1      1
IEF285I   SYS74042.T084244.RV000.RMARN005.GOSET           DELETED
IEF285I   VOL SER NOS= SPLU02.
IEF375I  JOB /RMARN005/ START 74043.0431
IEF376I  JOB /RMARN005/ STOP  74043.0457 CPU  15MIN 14.34SEC
RMARN005 JOB CHARGE $       30.90
```

APPENDIX 1 B

```
LEVEL 21 ( NOV 71 )                                             OS/360  FORTRAN H

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOED
                       IMPLICIT REAL*8(A-H,O-Z)
                       PI=3.14159265358979323846D0
                       FR=1D0/6D0
                       X1=1
                       Y1=0
                       DX1DT=0
                       DY1DT=1
                       WRITE(6,2)X1,Y1,DX1DT,DY1DT
                2      FORMAT(' '   ,4F30.16)
                       STP=PI*4D-4
                       NN=5D3
                       DO3M=1,10
                       DO1N=1,NN
                       A1=STP*DX1DT
                       B1=STP*DY1DT
                       XY=-STP*(X1*X1+Y1*Y1)**(-1.5)
                       C1=X1*XY
                       D1=Y1*XY
                       A2=STP*(DX1DT+.5D0*C1)
                       B2=STP*(DY1DT+.5D0*D1)
                       XX=X1+.5D0*A1
                       YY=Y1+.5D0*B1
                       XY=-STP*(XX*XX+YY*YY)**(-1.5)
                       C2=XX*XY
                       D2=YY*XY
                       A3=STP*(DX1DT+.5D0*C2)
                       B3=STP*(DY1DT+.5D0*D2)
                       XX=X1+.5D0*A2
                       YY=Y1+.5D0*B2
                       XY=-STP*(XX*XX+YY*YY)**(-1.5)
                       C3=XX*XY
                       D3=YY*XY
                       A4=STP*(DX1DT+C3)
                       B4=STP*(DY1DT+D3)
                       XX=X1+A3
                       YY=Y1+B3
                       XY=-STP*(XX*XX+YY*YY)**(-1.5)
                       C4=XX*XY
                       D4=YY*XY
                       X2=X1+(A1+A2+A2+A3+A3+A4)*FR
                       Y2=Y1+(B1+B2+B2+B3+B3+B4)*FR
                       DX2DT=DX1DT+(C1+C2+C2+C3+C3+C4)*FR
                       DY2DT=DY1DT+(D1+D2+D2+D3+D3+D4)*FR
                       X1=X2
                       Y1=Y2
                       DX1DT=DX2DT
                       DY1DT=DY2DT
                1      CONTINUE
                3      WRITE(6,2)X2,Y2,DX2DT,DY2DT
                       STOP
                       END

*OPTIONS IN EFFECT*     NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

*OPTIONS IN EFFECT*     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,
```

APPENDIX 1 C

X	Y	$\dot{X}$	$\dot{Y}$
1.0000000000000000	0.0	0.0	1.0000000000000000
0.9999999999998341	0.0000000000011359	-0.0000000000011352	1.0000000000000830
0.9999999999996569	0.0000000000038470	-0.0000000000038467	1.0000000000001650
0.9999999999995010	0.0000000000081332	-0.0000000000081332	1.0000000000002480
0.9999999999993334	0.0000000000139943	-0.0000000000139941	1.0000000000003320
0.9999999999991655	0.0000000000214302	-0.0000000000214305	1.0000000000004160
0.9999999999989979	0.0000000000304513	-0.0000000000304514	1.0000000000005000
0.9999999999988304	0.0000000000410424	-0.0000000000410428	1.0000000000005840
0.9999999999986641	0.0000000000532126	-0.0000000000532122	1.0000000000006670
0.9999999999984981	0.0000000000669447	-0.0000000000559441	1.0000000000007510
0.9999999999983302	0.0000000000822442	-0.0000000000822435	1.0000000000008350

APPENDIX 2A.

April 8, 1974

Professor T. E. Hull
Chairman, Dept. of Computer Science
University of Toronto
Toronto 181, Ontario

Dear Professor Hull:

Thank you for your letter dated July 27, 1973. I would appreciate the opportunity of applying the Fortran version preprocessor (Ref. 1), especially to the software of Ref. 2 in order to study the effect of roundoff on my 11-body Newtonian graviational problem.

Please use the following mailing address exactly as shown:
Mr. Roy D. North
c/o Professor John Griffith
Department of Mathematical Sciences
Lakehead University
Thunder Bay, 'P', Ontario
P7B 5E1

Yours sincerely,

Roy D. North

References:

1: Hull, T. E. & Hofbauer, J. J. (1974): Technical Report No. 63, Dept. of Computer Science, University of Toronto, page ii.

2: Rice, John R. (Editor) (1971): Mathematical Software, ACM Monograph Series, Academic Press, New York and London, Chapter 9.

APPENDIX 3A.

January 2, 1973

Dr. W. Black
Department of Astronomy
University of Glasgow
GLASGOW
SCOTLAND

Dear Dr. Black:

Your recent paper (Ref. 1) is of interest as I am working for my M.Sc. under Professor John S. Griffith in numerical integration of Solar System orbits. I would appreciate a copy of the Fortran source for "the equations of motion expressed relative to a dominant mass in the group of N bodies" (Ref. 2), as well as that for the program outlined in the paper (Ref. 3). Papers describing comparisons of methods (Ref. 3) would be of special value. I am aware of Refs. 4 and 5.

I have implemented the software (Ref. 6) for the solutions of the 11-body heliocentric problem, and could supply the source. I have attempted to apply the software (Ref. 7) to the same problem: I wonder if you have any experience with this program.

We thank you for program Victor. The last two decimal places for PI (enclosure #1, at interval statement number 0060) should be 64, instead of 52 (Ref. 8). This is mentioned only in passing and would be of importance only if Victor were run with extended-precision arithmetic. Further information on "a differential corrections method", especially with regard to speed of execution compared with other methods, would be welcome.

The last two initial conditions do not seem to be correct (Ref. 9). Using formulae (4.72) and (4.67) (Ref. 10)

$$Vel = 2\pi \sqrt{1 + e}.$$

A possible solution is to make

APPENDIX 3A, CONTINUED.

$$\dot{z} = \sqrt{\frac{1}{2}}\, V, \text{ instead of } \dot{z} = \frac{1}{2} V$$

and

$$V = \pi\sqrt{2(1+e)}, \text{ instead of } V = 2\pi(1+e) \text{ in Ref. 9.}$$

The significance of the small numbers accompanying the data points in Figs. 1-4 is of interest.

Please use the following mailing address exactly as shown:

Mr. Roy D. North
Graduate Student
Department of Mathematical Sciences
Lakehead University
Thunder Bay 'P', Ontario, Canada
P7B 5E1.

Yours sincerely

Roy D. North

RDN/sb
Encl.

APPENDIX 3A, CONTINUED.

REFERENCES

1. Black, W. (1973): Celestial Mechanics, Vol. 8, No. 3, Page 357.

2. Ibid., Page 358.

3. Ibid., Page 359.

4. Hull, T.E., et al (1972): SIAM J. Numer. Anal., Vol. 9, No. 4, Page 603.

5. Rice, John R. (Editor)(1971): Mathematical Software, ACM Monograph Series, Academic Press, New York and London, Page 369.

6. Ibid., Chapter 9.

7. Norman, Arthur C. (1972): Proceedings of the ACM, Annual Conference, Vol. 2, Page 826.

8. Knuth, Donald E. (1969): Volume 1, Fundamental Algorithms, The Art of Computer Programming, Addison-Wesley Publishing Company, Reading, Mass., Second Printing, Page 613.

9. Roy, A.E., et al (1972): Celestial Mechanics, Vol. 6, Page 472.

10. Roy, A.E., (1967): The Foundations Of Astrodynamics, The Macmillan Company, New York, Second Printing, Page 90.

APPENDIX 3B.

DEPARTMENT OF ASTRONOMY
Professor P. A. SWEET

THE UNIVERSITY
Glasgow G12 8QQ
TEL: 339 8855

11th February, 1974

Mr. Roy D. North,
Graduate Student,
Department of Mathematical Sciences,
Lakehead University,
Thunder Bay 'P',
ONTARIO, Canada.
P7B 5E1

Dear Mr. North,

Thank you for your letter of 2nd January, and for your interest in our work. I shall try to deal in turn with each point you raised.

I enclose a FORTRAN listing of a program which integrates the motion of 4 bodies relative to a fifth. This was in actual fact generated by a general purpose macro processor which myself and two colleagues developed in Glasgow. I described this in the paper, a reprint of which I enclose. It allows one to generate a program for any number of bodies up to 10 (this limit could be extended by slight reprogramming) from the one common text by simply changing one card. As you will see the program uses essentially singly subscripted variables. The result of this is that the program length becomes enormous for large numbers of bodies. Although the use of singly subscripted variables certainly speeds up the program, the saving in cost might be offset by the expense of extra core usage. If you have any ideas on this I would be interested.

Unfortunately I seem to be unable to lay my hands on a copy of the program which integrates the motion with respect to some fixed reference frame as described in the enclosed paper. This was written several years ago and I think I revised it to remove some inefficiencies. Although it is the correct formulation for star cluster type problems where no particular dominant mass can be singled out, it is my experience that the relative equations should be used in Solar System problems where the Sun dominates, and it would seem essential to use it in the case of Earth-Moon-Sun, with Earth being the dominant mass.

I append a list of references which you may already know. The first 3 describe the use of high order (12th) Cowell predictor-corrector methods and give quite interesting applications of Solar System integration programs. Williams and Benson's paper uses a smoothing technique on Lagrange's Planetary equations and allows long term integrations to be made. Perhaps the smoothing technique "throws out the baby with the bathwater" since it may be the small interactions which drive changes in the system over $\sim 10^{8-9}$ years.

In fact the papers by Ovenden might interest you as an application of long term integration programs. His numerical work, however, is too crude to be definitive at this stage. Merson's report comes down in favour of multistep methods, especially the Gauss-Jackson one and ~~more~~ I agree with the use of these high order multistep algorithms when step changing need not be done too often. Rosser's paper describes a method which

APPENDIX 3B, CONTINUED.

REFERENCES

Cohen, C.J., Hubbard, E.C., Oesterwinter, C., 1972: Elements of the Outer Planets for 1 million years; Astron. Paps. Am.Eph., 22.

Cohen, C.J., Hubbard, E.C.: 1965: Libration of the close approaches of Pluto to Neptune. Astron.,J., 70, 10.

Oesterwinter, C., Cohen, C.J.: 1972: New orbital elements for Moon and Planets: N.W.L. Technical report, TR-2693; U.S. Naval Weapons Lab., Dahlgren, Virginia.

Williams, J.G., Benson, G.S. 1971: Resonances in the Neptune - Pluto System. Astron. J., 76, 167.

Ovenden, M.W.: 1972: Bodes law and the missing planet. Nature, 239, 508.

Ovenden, M.W.: 1973: Recent Advances - Dynamical Astronomy: (V.Szebehely, B.D. Tapley eds.) D. Reidel, Holland.

Merson, R.H., 1973: Numerical Integration of the Differential Equations of Celestial Mechanics; Royal Aircraft Establishment Report; Farnborough, England.

Rosser, J.B., 1967; A Runge-Kutta for all seasons; SIAM Review, 9, 417.

Rice, J.R. (Ed), 1971: Mathematical Software; ACM Monograph.

Roy, A.E. et al, 1972: Cel. Mechs., 6, 472.

LAKEHEAD UNIVERSITY COMPUTER CENTRE

APPENDIX 4 A 1

```
//RMARN003 JOB 'I610125,0200,3,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC FORTHC,PARM.FORT='BCD,OPT=2'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN    DD  DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARN003 FORT
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 331    ALLOCATED TO SYSPUNCH
IEF237I 130    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSUT2
IEF237I 130    ALLOCATED TO SYSLIN
IEF237I 310    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74054.T091815.RV000.RMARN003.R0000580        DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74054.T091815.RV000.RMARN003.R0000581        DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74054.T091815.RV000.RMARN003.LOADSET         PASSED
IEF285I   VOL SER NOS= SPLU06.
IEF373I STEP /FORT     / START 74054.2231
IEF374I STEP /FORT     / STOP  74054.2233 CPU    0MIN 58.79SEC MAIN 250K
CHARGE    $          3.23 CPU TIME 00.00.59   REGION REQUESTED 0250K    STA
                    DISK    READER   PRINTER   PUNCH
I/O COUNTS             47      157       165       0
NO. OF DD CARDS         3        1         1       1
// EXEC FORTHCLG,PARM.FORT='OPT=2'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN    DD  DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARN003 FORT
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 331    ALLOCATED TO SYSPUNCH
IEF237I 130    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSUT2
IEF237I 130    ALLOCATED TO SYSLIN
IEF237I 311    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74054.T091815.RV000.RMARN003.R0000585        DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74054.T091815.RV000.RMARN003.R0000586        DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74054.T091815.RV000.RMARN003.LOADSET         PASSED
IEF285I   VOL SER NOS= SPLU06.
IEF373I STEP /FORT     / START 74054.2233
IEF374I STEP /FORT     / STOP  74054.2234 CPU    0MIN 18.24SEC MAIN 250K
CHARGE    $          1.23 CPU TIME 00.00.18   REGION REQUESTED 0250K    STA
                    DISK    READER   PRINTER   PUNCH
I/O COUNTS             54       40        63       0
NO. OF DD CARDS         3        1         1       1
XXLKED    EXEC  PGM=IEWL,REGION=96K,PARM=(MAP,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB    DD  DSN=SYS1.FORTLIB,DISP=SHR
```

LAKEHEAD UNIVERSITY COMPUTER CENTRE

APPENDIX 4 A 2

```
XX              DD   DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1    DD   SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD  DD   DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX               SPACE=(CYL,(2,,1))
XXSYSLIN    DD   DSN=&LOADSET,DISP=(OLD,DELETE)
XX          DD   DDNAME=SYSIN
IEF236I ALLOC. FOR RMARN003 LKED
IEF237I 131    ALLOCATED TO SYSLIB
IEF237I 132    ALLOCATED TO
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 130    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSLMOD
IEF237I 130    ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                          KEPT
IEF285I   VOL SER NOS= MVT21A.
IEF285I   FORTSUB                                               KEPT
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74054.T091815.RV000.RMARN003.R0000589              DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74054.T091815.RV000.RMARN003.GOSET                 PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74054.T091815.RV000.RMARN003.LOADSET               DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF373I STEP /LKED     / START 74054.2234
IEF374I STEP /LKED     / STOP  74054.2235 CPU    0MIN 10.15SEC MAIN  96K
CHARGE    $          0.80 CPU TIME 00.00.10   REGION REQUESTED 0096K   STA
                    DISK    READER   PRINTER
I/O COUNTS            223       0         42
NO. OF DD CARDS         5       1          1
XXGO       EXEC  PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFT05F001 DD   DDNAME=SYSIN
XXFT06F001 DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXFT07F001 DD   SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN003 GO
IEF237I 132    ALLOCATED TO PGM=*.DD
IEF237I 360    ALLOCATED TO FT06F001
IEF237I 331    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74054.T091815.RV000.RMARN003.GOSET                 PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /GO       / START 74054.2235
IEF374I STEP /GO       / STOP  74055.0134 CPU 145MIN 1[illegible]SEC MAIN  30K
CHARGE    $        267.10 CPU TIME 02.25.16   REGION REQUESTED 006?K   STA
                    DISK    READER   PRINTER   PUNCH
I/O COUNTS              0       0         10       0
NO. OF DD CARDS         1       1          1       1
IEF285I   SYS74054.T091815.RV000.RMARN003.GOSET                 DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF375I  JOB /RMARN003/ START 74054.2231
IEF376I  JOB /RMARN003/ STOP  74055.0134 CPU 146MIN 43.38SEC
RMARN003 JOB CHARGE $     286.032
```

```
     COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                       SOURCE,BCD,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,NOXREF
0002             SUBROUTINE DRKGS%PRMT,Y,DERY,NDIM,IHLF,FCT,OUTP,AUX<
          C
          C
0003             DIMENSION Y%4<,DERY%4<,AUX%8,4<,A%4<,B%4<,C%4<,PRMT%5<
0004             DOUBLE PRECISION PRMT,Y,DERY,AUX,A,B,C,X,XEND,H,AJ,BJ,CJ,R1,R2,
                1DELT
0005             DO 1 I#1,NDIM
0006           1 AUX%8,I<#.06666666666666667D0*DERY%I<
0007             X#PRMT%1<
0008             XEND#PRMT%2<
0009             H#PRMT%3<
0010             PRMT%5<#0.D0
0011             CALL FCT%X,Y,DERY<
          C
          C      ERROR TEST
0012             IF%H*%XEND-X<<38,37,2
          C
          C      PREPARATIONS FOR RUNGE-KUTTA METHOD
0013           2 A%1<#.5D0
0014             A%2<#.2928932188134524D0
0015             A%3<#1.707106781186547D0
0016             A%4<#.1666666666666667D0
0017             B%1<#2.D0
0018             B%2<#1.D0
0019             B%3<#1.D0
0020             B%4<#2.D0
0021             C%1<#.5D0
0022             C%2<#.2928932188134524D0
0023             C%3<#1.707106781186547D0
0024             C%4<#.5D0
          C
          C      PREPARATIONS OF FIRST RUNGE-KUTTA STEP
0025             DO 3 I#1,NDIM
0026             AUX%1,I<#Y%I<
0027             AUX%2,I<#DERY%I<
0028             AUX%3,I<#0.D0
0029           3 AUX%6,I<#0.D0
0030             IREC#0
0031             H#H&H
0032             IHLF#-1
0033             ISTEP#0
0034             IEND#0
          C
          C
          C      START OF A RUNGE-KUTTA STEP
0035           4 IF%%X&H-XEND<*H<7,6,5
0036           5 H#XEND-X
0037           6 IEND#1
          C
          C      RECORDING OF INITIAL VALUES OF THIS STEP
0038           7 IF%PRMT%5<<40,8,40
0039           8 ITEST#0
0040           9 ISTEP#ISTEP&1
          C
          C
          C      START OF INNERMOST RUNGE-KUTTA LOOP
```

```
      J#1
   10 AJ#A%J<
      BJ#B%J<
      CJ#C%J<
      DO 11 I#1,NDIM
      R1#H*DERY%I<
      R2#AJ*%R1-BJ*AUX%6,I<<
      Y%I<#Y%I<&R2
      R2#R2&R2&R2
   11 AUX%6,I<#AUX%6,I<&R2-CJ*R1
      IF%J-4<12,15,15
   12 J#J&1
      IF%J-3<13,14,13
   13 X#X&.5D0*H
   14 CALL FCT%X,Y,DERY<
      GOTO 10
C     END OF INNERMOST RUNGE-KUTTA LOOP
C
C
C     TEST OF ACCURACY
   15 IF%ITEST<16,16,20
C
C     IN CASE ITEST#0 THERE IS NO POSSIBILITY FOR TESTING OF ACCURACY
   16 DO 17 I#1,NDIM
   17 AUX%4,I<#Y%I<
      ITEST#1
      ISTEP#ISTEP&ISTEP-2
   18 IHLF#IHLF&1
      X#X-H
      H#.5D0*H
      DO 19 I#1,NDIM
      Y%I<#AUX%1,I<
      DERY%I<#AUX%2,I<
   19 AUX%6,I<#AUX%3,I<
      GOTO 9
C
C     IN CASE ITEST#1 TESTING OF ACCURACY IS POSSIBLE
   20 IMOD#ISTEP/2
      IF%ISTEP-IMOD-IMOD<21,23,21
   21 CALL FCT%X,Y,DERY<
      DO 22 I#1,NDIM
      AUX%5,I<#Y%I<
   22 AUX%7,I<#DERY%I<
      GOTO 9
C
C     COMPUTATION OF TEST VALUE DELT
   23 DELT#0.D0
      DO 24 I#1,NDIM
   24 DELT#DELT&AUX%8,I<*DABS%AUX%4,I<-Y%I<<
      IF%DELT-PRMT%4<<28,28,25
C
C     ERROR IS TOO GREAT
   25 IF%IHLF-10<26,36,36
   26 DO 27 I#1,NDIM
   27 AUX%4,I<#AUX%5,I<
      ISTEP#ISTEP&ISTEP-4
      X#X-H
      IEND#0
```

APPENDIX 4 B 3

```
0087             GOTO 18
          C
          C      RESULT VALUES ARE GOOD
0088          28 CALL FCT%X,Y,DERY<
0089             DO 29 I#1,NDIM
0090             AUX%1,I<#Y%I<
0091             AUX%2,I<#DERY%I<
0092             AUX%3,I<#AUX%6,I<
0093             Y%I<#AUX%5,I<
0094          29 DERY%I<#AUX%7,I<
0095             IF%PRMT%5<<40,30,40
0096          30 DO 31 I#1,NDIM
0097             Y%I<#AUX%1,I<
0098          31 DERY%I<#AUX%2,I<
0099             IREC#IHLF
0100             IF%IEND<32,32,39
          C
          C      INCREMENT GETS DOUBLED
0101          32 IHLF#IHLF-1
0102             ISTEP#ISTEP/2
0103             H#H&H
0104             IF%IHLF<4,33,33
0105          33 IMOD#ISTEP/2
0106             IF%ISTEP-IMOD-IMOD<4,34,4
0107          34 IF%DELT-.02D0*PRMT%4<<35,35,4
0108          35 IHLF#IHLF-1
0109             ISTEP#ISTEP/2
0110             H#H&H
0111             GOTO 4
          C
          C
          C      RETURNS TO CALLING PROGRAM
0112          36 IHLF#11
0113             CALL FCT%X,Y,DERY<
0114             GOTO 39
0115          37 IHLF#12
0116             GOTO 39
0117          38 IHLF#13
0118          39 CALL OUTP%X,Y,DERY,IHLF,NDIM,PRMT<
0119          40 RETURN
0120             END

S IN EFFECT*        NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*        SOURCE,BCD,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,NOXREF

TICS*      SOURCE STATEMENTS =      119 ,PROGRAM SIZE =      2286

TICS*  NO  DIAGNOSTICS GENERATED

END OF COMPILATION ******                                    93K BYTES OF CO
```

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,N
   ISN 0002            IMPLICIT REAL*8(A-H,O-Z)
   ISN 0003            DIMENSION PRMT(5),Y(4),AUX(8,4),DERY(4)
   ISN 0004            EXTERNAL FCT,OUTP
   ISN 0005            PRMT(1)=0D0
   ISN 0006            PI=3.14159265358979323846D0
   ISN 0007            PRMT(2)=2D0*PI
   ISN 0008            PRMT(3)=PI* 1D-4
   ISN 0009            PRMT(4)=1D-14
   ISN 0010            Y(1)=1D0
   ISN 0011            Y(2)=0D0
   ISN 0012            Y(3)=0D0
   ISN 0013            Y(4)=1D0
   ISN 0014            DERY(1)=.25D0
   ISN 0015            DERY(2)=.25D0
   ISN 0016            DERY(3)=.25D0
   ISN 0017            DERY(4)=.25D0
   ISN 0018            NDIM=4
   ISN 0019            DO1N=1,10
   ISN 0020            CALL DRKGS(PRMT,Y,DERY,NDIM,IHLF,FCT,OUTP,AUX)
   ISN 0021            STOP
   ISN 0022            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,N

*STATISTICS*     SOURCE STATEMENTS =       21 ,PROGRAM SIZE =      806

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                     117K
```

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,
  ISN 0002          SUBROUTINE FCT(X,Y,DERY)
  ISN 0003          IMPLICIT REAL*8(A-H,O-Z)
  ISN 0004          DIMENSION DERY(4),Y(4)
  ISN 0005          DERY(1)=Y(3)
  ISN 0006          DERY(2)=Y(4)
  ISN 0007          XY=-     (Y(1)*Y(1)+Y(2)*Y(2))**(-1.5)
  ISN 0008          DERY(3)=Y(1)*XY
  ISN 0009          DERY(4)=Y(2)*XY
  ISN 0010          RETURN
  ISN 0011          END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,NO

*STATISTICS*     SOURCE STATEMENTS =       10 ,PROGRAM SIZE          450

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                        117K BY
```

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,N
ISN 0002             SUBROUTINE OUTP(X,Y,DERY,IHLF,NDIM,PRMT)
ISN 0003             IMPLICIT REAL*8(A-H,O-Z)
ISN 0004             DIMENSION Y(4),DERY(4),PRMT(5)
ISN 0005             WRITE(6,1)(Y(I),I=1,4)
ISN 0006             FORMAT(' ',4F30.16)
ISN 0007             RETURN
ISN 0008             END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,N

*STATISTICS*     SOURCE STATEMENTS =        7 ,PROGRAM SIZE =       394

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    117K B

*STATISTICS*  NO  DIAGNOSTICS THIS STEP
```

APPENDIX 4 C

X	Y	Ẋ	Ẏ
0.9999999999974046	0.0000000000222705	-0.0000000000222710	1.000000000012930
0.9999999999948163	0.0000000000689717	-0.0000000000689723	1.000000000025910
0.9999999999922203	0.0000000001401020	-0.0000000001401032	1.000000000038900
0.9999999999896213	0.0000000002356920	-0.0000000002356957	1.000000000051900
0.9999999999870256	0.0000000003557631	-0.0000000003557681	1.000000000064870
0.9999999999844220	0.0000000005003560	-0.0000000005003599	1.000000000077900
0.9999999999818192	0.0000000006694632	-0.0000000006694667	1.000000000090920
0.9999999999792174	0.0000000008630632	-0.0000000008630685	1.000000000103940
0.9999999999766136	0.0000000010811774	-0.0000000010811833	1.000000000116970
0.9999999999740173	0.0000000013237853	-0.0000000013237924	1.000000000129970

APPENDIX 5 A 1

```
//RMARN005 JOB '1010125,0010,3,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC FORTHCLG,PARM.FORT='OPT=2,ID'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN    DD  DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARN005 FORT
IEF237I 365   ALLOCATED TO SYSPRINT
IEF237I 330   ALLOCATED TO SYSPUNCH
IEF237I 130   ALLOCATED TO SYSUT1
IEF237I 135   ALLOCATED TO SYSUT2
IEF237I 136   ALLOCATED TO SYSLIN
IEF237I 310   ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74066.T090324.RV000.RMARN005.R0001193      DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74066.T090324.RV000.RMARN005.R0001194      DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74066.T090324.RV000.RMARN005.LOADSET       PASSED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /FORT     / START 74066.2211
IEF374I STEP /FORT     / STOP  74066.2213 CPU    0MIN 33.45SEC MAIN 248K
CHARGE    $         2.09 CPU TIME 00.00.33   REGION REQUESTED 0250K    STA
                    DISK   READER  PRINTER  PUNCH
I/O COUNTS            42       78       85      0
NO. OF DD CARDS        3        1        1      1
XXLKED    EXEC  PGM=IEWL,REGION=96K,PARM=(MAP,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB    DD  DSN=SYS1.FORTLIB,DISP=SHR
XX          DD  DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1    DD  SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD   DD  DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX              SPACE=(CYL,(2,,1))
XXSYSLIN    DD  DSN=&LOADSET,DISP=(OLD,DELETE)
XX          DD  DDNAME=SYSIN
IEF236I ALLOC. FOR RMARN005 LKED
IEF237I 131   ALLOCATED TO SYSLIB
IEF237I 132   ALLOCATED TO
IEF237I 365   ALLOCATED TO SYSPRINT
IEF237I 130   ALLOCATED TO SYSUT1
IEF237I 135   ALLOCATED TO SYSLMOD
IEF237I 136   ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                  KEPT
IEF285I   VOL SER NOS= MVT217.
IEF285I   FORTSUB                                       KEPT
IEF285I   VOL SER NOS= MVTRIF.
IEF285I   SYS74066.T090324.RV000.RMARN005.R0001197      DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74066.T090324.RV000.RMARN005.GOSET         PASSED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74066.T090324.RV000.RMARN005.LOADSET       DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /LKED     / START 74066.2213
IEF374I STEP /LKED     / STOP  74066.2214 CPU    0MIN 07.25SEC MAIN   68K
CHARGE    $         0.67 CPU TIME 00.00.07   REGION REQUESTED 0096K    STA
```

APPENDIX 5 A 2

```
                         DISK    READER  PRINTER
I/O COUNTS                156       0       39
NO. OF DD CARDS             5       1        1
XXGO      EXEC  PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFTC5F001 DD   DDNAME=SYSIN
XXFTC6F001 DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXFTC7F001 DD   SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN005 GO
IEF237I 135    ALLOCATED TO PGM=*.DD
IEF237I 365    ALLOCATED TO FT06F001
IEF237I 330    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74066.T090324.RV000.RMARN005.GOSET        PASSED
IEF285I   VOL SER NOS= ADMP03.
IEF373I STEP /GO       / START 74066.2214
IEF374I STEP /GO       / STOP  74066.2224 CPU   2MIN 14.90SEC MAIN  28K
CHARGE    $          4.36 CPU TIME 00.02.15   REGION REQUESTED 0062K   STA
                        DISK    READER  PRINTER  PUNCH
I/O COUNTS                0       0       11       0
NO. OF DD CARDS           1       1        1       1
IEF285I   SYS74066.T090324.RV000.RMARN005.GOSET        DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF375I  JOB /RMARN005/ START 74066.2211
IEF376I  JOB /RMARN005/ STOP  74066.2224 CPU   2MIN 55.60SEC
RMARN005 JOB CHARGE $        7.89
```

APPENDIX 5 B 1

LEVEL 21.7 (JAN 73)   OS/360 FORTRAN H

```
             COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                                  SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDI
ISN 0002          IMPLICIT REAL*8(A-H,O-Z)
ISN 0003          PI=3.14159265358979323846D0
ISN 0004          X1=1
ISN 0005          Y1=0
ISN 0006          DX1=0
ISN 0007          DY1=1
ISN 0008          WRITE(6,2)X1,Y1,DX1,DY1
ISN 0009          FORMAT(' '   ,4F30.16)
ISN 0010          H   =PI*32D-4
ISN 0011          NN=625
ISN 0012          H2=H*H
ISN 0013          A1=1D0/3
ISN 0014          A2=2D0/3
ISN 0015          A3=1
ISN 0016          G10=1D0/18
ISN 0017          G21=2D0/9
ISN 0018          G30=1D0/3
ISN 0019          G32=1D0/6
ISN 0020          G40=13D0/120
ISN 0021          G41=.3D0
ISN 0022          G42=3D0/40
ISN 0023          G43=1D0/60
ISN 0024          C0=13D0/120
ISN 0025          C1=.3D0
ISN 0026          C2=3D0/40
ISN 0027          C3=1D0/60
ISN 0028          CD0=1D0/8
ISN 0029          CD1=3D0/8
ISN 0030          CD2=3D0/8
ISN 0031          CD3=1D0/8
ISN 0032          H2G10=H2*G10
ISN 0033          H2G21=H2*G21
ISN 0034          H2G30=H2*G30
ISN 0035          H2G32=H2*G32
ISN 0036          A1H=A1*H
ISN 0037          A2H=A2*H
ISN 0038          DO3M=1,10
ISN 0039          DO1N=1,NN
ISN 0040          FXY=-(X1*X1+Y1*Y1)**(-1.5)
ISN 0041          F=X1*FXY
ISN 0042          G=Y1*FXY
ISN 0043          F0=F
ISN 0044          G0=G
ISN 0045          X1I=X1+DX1*A1 H+H2 G10*F0
ISN 0046          Y1I=Y1+DY1*A1 H+H2 G10*G0
ISN 0047          FXY=-(X1I*X1I+Y1I*Y1I)**(-1.5)
ISN 0048          F=X1I*FXY
ISN 0049          G=Y1I*FXY
ISN 0050          F1=F
ISN 0051          G1=G
ISN 0052          X1I=X1+DX1*A2 H+H2 G21*F1
ISN 0053          Y1I=Y1+DY1*A2 H+H2 G21*G1
ISN 0054          FXY=-(X1I*X1I+Y1I*Y1I)**(-1.5)
ISN 0055          F=X1I*FXY
ISN 0056          G=Y1I*FXY
ISN 0057          F2=F
```

APPENDIX 5 B 2

```
ISN 0058                  G2=G
ISN 0059                  X1I=X1+DX1*A3*H+H2   G30*F0+H2G32*F2
ISN 0060                  Y1I=Y1+DY1*A3*H+H2   G30*G0+H2G32*G2
ISN 0061                  FXY=-(X1I*X1I+Y1I*Y1I)**(-1.5)
ISN 0062                  F=X1I*FXY
ISN 0063                  G=Y1I*FXY
ISN 0064                  F3=F
ISN 0065                  G3=G
ISN 0066                  X2=X1+DX1*H+H2*(C0*F0+C1*F1+C2*F2+C3*F3)
ISN 0067                  Y2=Y1+DY1*H+H2*(C0*G0+C1*G1+C2*G2+C3*G3)
ISN 0068                  DX2=DX1+H*(CD0*F0+CD1*F1+CD2*F2+CD3*F3)
ISN 0069                  DY2=DY1+H*(CD0*G0+CD1*G1+CD2*G2+CD3*G3)
ISN 0070                  X1=X2
ISN 0071                  Y1=Y2
ISN 0072                  DX1=DX2
ISN 0073                  DY1=DY2
ISN 0074          1       CONTINUE
ISN 0075          3       WRITE(6,2)X2,Y2,DX2,DY2
ISN 0076                  STOP
ISN 0077                  END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID

*STATISTICS*     SOURCE STATEMENTS =      76 ,PROGRAM SIZE =      2074

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******
```

APPENDIX 5 C

X	Y	$\dot{X}$	$\dot{Y}$
1.0000000000000000	0.0	0.0	1.0000000000000000
1.0000000000055450	-0.0000000007391609	0.0000000007391609	0.9999999999972273
1.0000000000110890	-0.0000000015305735	0.0000000015305741	0.9999999999944551
1.0000000000166320	-0.0000000023742360	0.0000000023742363	0.9999999999916835
1.0000000000221760	-0.0000000032701432	0.0000000032701434	0.9999999999889116
1.0000000000277190	-0.0000000042182969	0.0000000042182969	0.9999999999861400
1.0000000000332630	-0.0000000052186914	0.0000000052186920	0.9999999999833680
1.0000000000388060	-0.0000000062713312	0.0000000062713321	0.9999999999805964
1.0000000000443500	-0.0000000073762205	0.0000000073762213	0.9999999999778249
1.0000000000498940	-0.0000000085333592	0.0000000085333600	0.9999999999750524
1.0000000000554380	-0.0000000097427497	0.0000000097427509	0.9999999999722806

```
//RMARN031 JOB '1610125,020,4,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=C,MSGLEVEL=(1,1)
// EXEC FORTHCLG,PARM.FORT='OPT=2,ID'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN    DD  DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARN031 FORT
IEF237I 362    ALLOCATED TO SYSPRINT
IEF237I 331    ALLOCATED TO SYSPUNCH
IEF237I 136    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSUT2
IEF237I 136    ALLOCATED TO SYSLIN
IEF237I 310    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74176.T090841.RV000.RMARN031.R0000665       DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF285I   SYS74176.T090841.RV000.RMARN031.R0000666       DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74176.T090841.RV000.RMARN031.LOADSET        PASSED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /FORT     / START 74176.1849
IEF374I STEP /FORT     / STOP  74176.1854 CPU    2MIN 16.54SEC MAIN 248K
CHARGE    $          7.99 CPU TIME 00.02.17   REGION REQUESTED 0250K   STA
                    DISK    READER   PRINTER   PUNCH
I/O COUNTS            283      351       426        0
NO. OF DD CARDS         3        1         1        1
XXLKED    EXEC  PGM=IEWL,REGION=96K,PARM=(MAP,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB    DD  DSN=SYS1.FORTLIB,DISP=SHR
XX          DD  DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1    DD  SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD   DD  DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX              SPACE=(CYL,(2,,1))
XXSYSLIN    DD  DSN=&LOADSET,DISP=(OLD,DELETE)
XX          DD  DDNAME=SYSIN
IEF236I ALLOC. FOR RMARN031 LKED
IEF237I 131    ALLOCATED TO SYSLIB
IEF237I 132    ALLOCATED TO
IEF237I 362    ALLOCATED TO SYSPRINT
IEF237I 135    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSLMOD
IEF237I 136    ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                   KEPT
IEF285I   VOL SER NOS= MVT217.
IEF285I   FORTSUB                                        KEPT
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74176.T090841.RV000.RMARN031.R0000669       DELETED
IEF285I   VOL SER NOS= ADMP02.
IEF285I   SYS74176.T090841.RV000.RMARN031.GOSET          PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74176.T090841.RV000.RMARN031.LOADSET        DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /LKED     / START 74176.1854
IEF374I STEP /LKED     / STOP  74176.1856 CPU    0MIN 11.55SEC MAIN  68K
CHARGE    $          0.89 CPU TIME 00.00.12   REGION REQUESTED 0096K   STA
```

```
                              DISK    READER   PRINTER
I/O COUNTS                     410       0       57
NO. OF DD CARDS                  5       1        1
XXGO       EXEC  PGM=*.LKED.SYSLMOD,COND=((4.LT.FORT),(4.LT.LKED))
XXFT05F001 DD   DDNAME=SYSIN
XXFT06F001 DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXFT07F001 DD   SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN031 GO
IEF237I 132    ALLOCATED TO PGM=*.DD
IEF237I 362    ALLOCATED TO FT06F001
IEF237I 331    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I    SYS74176.T090841.RV000.RMARN031.GOSET          PASSED
IEF285I    VOL SER NOS= MVTRIP.
IEF373I STEP /GO        / START 74176.1856
IEF374I STEP /GO        / STOP  74176.1859 CPU    1MIN 15.59SEC MAIN   36K I
CHARGE     $          2.58 CPU TIME 00.01.16   REGION REQUESTED 0062K   STA
                              DISK    READER   PRINTER  PUNCH
I/O COUNTS                       0       0       23       0
NO. OF DD CARDS                  1       1        1       1
IEF285I    SYS74176.T090841.RV000.RMARN031.GOSET          DELETED
IEF285I    VOL SER NOS= MVTRIP.
IEF375I  JOB /RMARN031/ START 74176.1849
IEF376I  JOB /RMARN031/ STOP  74176.1859 CPU    3MIN 43.68SEC
RMARN031 JOB CHARGE $      12.66
```

```
   CCMPILER CPTICNS - NAME=  MAIN,CPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
             IMPLICIT REAL*8(A-H,O-Z)
             DIMENSION YSTART(4)
             COMMON NOFNS
             EXTERNAL FCT,DDEOUT
             NOFNS=0
             PI=3.14159265358979323846D0
             SP=PI*2
             N=4
             YSTART(1)=1
             YSTART(2)=0
             YSTART(3)=0
             YSTART(4)=1
             XSTART=0
             XEND=SP*10
             H=1
             EPS=3.6D-11
             CALL DDESP(SP,FCT,N,YSTART,XSTART,XEND,H,EPS,     DDEOUT)
             WRITE(6,97)NOFNS
        97   FORMAT(1H0,5X,36HTOTAL NO OF FUNCTION EVALUATIONS IS ,I6)
             STOP
             END
 IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
 IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ICS*     SOURCE STATEMENTS =       21 ,PROGRAM SIZE =      592
ICS*   NO  DIAGNOSTICS GENERATED
ND OF COMPILATION ******                                  93K BYTES OF COR
```

EHEAD UNIVERSITY COMPUTER CENTRE APPENDIX 6 B 2

```
1.7 ( JAN 73 )                                OS/360  FORTRAN H

   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              SUBROUTINE FCT(Y,X,DERY)
              IMPLICIT REAL*8(A-H,O-Z)
              DIMENSION DERY(4),Y(4)
              COMMON NOFNS
              NOFNS=NOFNS+1
              DERY(1)=Y(3)
              DERY(2)=Y(4)
              XY=-     (Y(1)*Y(1)+Y(2)*Y(2))**(-1.5D0)
              DERY(3)=Y(1)*XY
              DERY(4)=Y(2)*XY
              RETURN
              END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*     SOURCE STATEMENTS =       12 ,PROGRAM SIZE =       456

ICS*  NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                    93K BYTES OF COR
```

APPENDIX 6 B 3

```
?1.7 ( JAN 73 )                                    OS/360   FORTRAN H

    CCMPILER CPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
0002            SUBROUTINE DDESP(SP,FCT,N,Y,XI,XF,HI,EPS,     DDEOUT)
0003            IMPLICIT REAL*8(A-H,O-Z)
0004            DIMENSICN Y(4)
0005            EXTERNAL FCT,     DDEOUT
0006            COMMCN/DDESPC/NP,KOUNT
0007            NP=1
0008            KOUNT=0
0009            IF(SP*(XF-XI))2,4,10
0010      2     SP=DSIGN(SP,XF-XI)
0011            GOTO10
0012      4     IF(SP.NE.0D0)GOTO10
0014            NP=0
0015     10     CALL XDDE(SP,FCT,N,Y,XI,XF,HI,EPS,     DDEOUT)
0016            RETURN
0017            END

S IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NCMAP,NOEDIT,ID,NOXREF

TICS*     SOURCE STATEMENTS =       16 ,PROGRAM SIZE =       568

TICS*   NC  DIAGNCSTICS GENERATED

END OF COMPILATION ******                                    93K BYTES OF COR
```

```
 COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=C000K,
                   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
          SUBROUTINE XDDE(SP,FCT,N,Y,XI,XF,HI,EPS,     DDEOUT)
          IMPLICIT REAL*8(A-H,O-Z)
          DIMENSION Y(4),DY(4 ),S(4 ),F(4 ),YR(4 )
          COMMON/DDESPC/NP,KOUNT
          COMMON/IPARAM/M,NMAX
          COMMON/DPARAM/DZOT,DP2,DEMAX,DEMIN,DHDIV,DZOTUP
          COMMON/DINFO/EX,ER,EH,NE,NERR
          COMMON/DCTPLT/SPPRT,HIPRT,XIPRT,XFPRT,EPSPRT,NPPRT,TITLE
          LOGICAL STYPE,KONVF,TITLE
          EXTERNAL FCT,     DDEOUT
          DZOT=2.77D-17
          DP2=32768
          DEMAX=1
          DEMIN=1D-18
          DHDIV=1024
          DZOTUP=3.6D16
          M=6
          NMAX=60
          TITLE=.TRUE.
          STYPE=.TRUE.
          NPPRT=NP
          SPPRT=SP
          HIPRT=HI
          XIPRT=XI
          XFPRT=XF
          EPSPRT=EPS
          IF((N.LE.0).OR.(N.GT.NMAX))GOTO84
          IF((EPS.LT.DEMIN).OR.(EPS.GT.DEMAX))GOTO85
          TTL=XF-XI
          H=HI
          IF(TTL*H)86,87,12
    12    IF(((H/TTL)*DP2.LT.1.).OR.((H/TTL).GT.1.))GOTO88
          DO14I=1,N
          S(I)=DABS(Y(I))
    14    CONTINUE
          KONVF=.TRUE.
          HMIN=H/DHDIV
          HMAX=TTL
          HP=0
          XP=XI
          X=XI
    20    IF((NP.EQ.0).AND.(.NOT.STYPE))GOTO50
          XPMX=XP-X
          FH=XPMX/H
          IF(FH.GT.DZOT)GOTO50
    30    IF(DABS(FH).GT.DZOT)GOTO34
          DO32I=1,N
          YR(I)=Y(I)
    32    CONTINUE
          HQ=HP
          XR=X
          GOTO36
    34    HQ=XPMX+HP
          HR=HQ
          XR=XT
          CALL DREDIF(N,XR,YR,DY,HR,HQ,EPS,M,S,F,KONVF,FCT)
```

```
          HQ=XR-XT
   36     CALL FCT(YR,XR,DY)
          STYPE=.TRUE.
          CALL DDEOUT(YR,DY,N,XR,STYPE)
          STYPE=.FALSE.
          IF(KCNVF)GOTC40
   38     IF(KONVF)GOTO70
          GOTO82
   40     IF((XF-XR)/TTL.LE.0.)GOTO70
          KOUNT=KOUNT+1
          XP=XI+      (KCUNT)*SF
          IF((XP-XF)/H.GT.0.)XP=XF
          GCTO20
   50     IF((DABS((X-XR)/H)).LE.DZOT)GOTO60
          CALL FCT(Y,X,DY)
          CALL DDEOUT(Y,DY,N,X,STYPE)
   60     IF((XF-X)/TTL.LE.0.)GOTO70
          IF(DABS(H).LT.HMIN)H=DSIGN(HMIN,H)
          IF(CABS(H).GT.HMAX)H=DSIGN(HMAX,H)
          IF((XF-X-H)/TTL.LT.0.)H=XF-X
          XT=X
          CALL DDESUB(N,X,Y,CY,H,HMIN,EPS,M,S,R,KONVF)
          HP=X-XT
          IF(KCNVF)GCTC20
          GOTO80
   70     RETURN
   80     NERR=1
          ER=0
          DC81I=1,N
          IF(ER*S(I).GT.R(I))GCTO81
          ER=R(I)/S(I)
          NE=I
   81     CCNTINUE
          EH=HP
          EX=X
          CALL FCT(Y,X,DY)
          CALL DDEOUT(Y,DY,N,X,STYPE)
          GCTC92
   82     NERR=1
          ER=0
          DO83I=1,N
          IF(ER*S(I).GE.R(I))GOTO83
          ER=R(I)/S(I)
          NE=I
   83     CONTINUE
          EH=HC
          EX=XR
          GCTC92
   84     NERR=2
          GOTO90
   85     NERR=3
          GOTO90
   86     NERR=4
          GCTO90
   87     NERR=5
          GOTO90
   88     NERR=6
   90     CALL FCT(Y,XI,DY)
```

APPENDIX 6 B 6

```
          CALL DDEOUT(Y,DY,N,XI,STYPE)
   92     CALL DERROR
          RETURN
          END
```

```
S IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TICS*     SOURCE STATEMENTS =      136 ,PROGRAM SIZE =      2356

TICS*   NO  DIAGNOSTICS GENERATED

END OF COMPILATION ******                                    77K BYTES OF CO
```

```
   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              SUBROUTINE DDESUB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF)
              IMPLICIT REAL*8(A-H,O-Z)
              LOGICAL KONVF
              DIMENSION Y(4),S(4),YA(4 ),SA(4 ),DZ(4 ),DY(4),R(4)
              COMMON/DDERCM/YA,SA,DZ,JMAX
              EXTERNAL FCT
              JMAX=JM+4
              DO100I=1,N
              YA(I)=Y(I)
              SA(I)=S(I)
        100   CONTINUE
              CALL FCT(Y,X,DZ)
              CALL DDERSB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
              RETURN
              END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*      SOURCE STATEMENTS =       15 ,PROGRAM SIZE =       686

ICS*   NO   DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                       93K BYTES OF COR
```

APPENDIX 6 B 8


```
    CCMPILER CPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
               SUBROUTINE DREDIF(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
               IMPLICIT REAL*8(A-H,O-Z)
               LCGICAL KONVF
               DIMENSION Y(4),YA(4 ),SA(4 ),DZ(4 ),DY(4),S(4),R(4)
               CCMMCN/DDERCM/YA,SA,DZ,JMAX
               EXTERNAL FCT
               DO300I=1,N
               Y(I)=YA(I)
         300   CONTINLE
               CALL DDERSB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
               RETURN
               END
 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
 IN EFFECT*       SCURCE,EECDIC,NCLIST,NCDECK,LOAD,NOMAP,NCEDIT,ID,NOXREF
ICS*      SOURCE STATEMENTS =        12 ,PROGRAM SIZE =       654
ICS*   NC  DIAGNCSTICS GENERATED
ND OF CCMPILATICN ******                                     93K BYTES OF COR
```

```
   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              SUBROUTINE DDERSB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KCNVF,FCT)
              IMPLICIT REAL*8(A-H,O-Z)
              DIMENSICN  Y(4),DY(4),S(4),R(4),YA(4 ),YL(4 ),YM(4 ),DZ(4 ),
             1SA(4 ),D(7),DT(4 ,7),YG(4 ,8),YH(4 ,8),SG(4 ,8)
              COMMON/DDERCM/YA,SA,DZ,JMAX
              COMMON/DPARAM/DZOT,DP2,DEMAX,DEMIN,DHDIV,DZCTUP
              LOGICAL KONVF,KONV,BO,BH
              EXTERNAL FCT
              DATA DT/28  *0D0/
       10     BH=.FALSE.
              KONVF=.TRUE.
       20     A=H+X
              BO=.FALSE.
              M=1
              JR=2
              JS=3
              JJ=0
              DO200J=1,JMAX
              IF(.NOT.BO)GOTO201
              D(2)=16D0/9D0
              D(4)=64D0/9D0
              D(6)=256D0/9D0
              GOTO202
      201     D(2)=9D0/4D0
              D(4)=9D0
              D(6)=36D0
      202     KONV=.TRUE.
              IF(J.LE.(JM/2))KONV=.FALSE.
              IF(J.LE.(JM+1))GOTO203
              L=JM+1
              DL=4D0*D(L-2)
              FC=.7071068D0*FC
              GOTO204
      203     L=J
              D(L)=M*M
              FC=1D0+      (JM+1-J)/6D0
      204     M=M+M
              G=H/M
              B=G+G
              IF((.NOT.BH).OR.(J.GE.(JMAX-1)))GOTO205
              DO210I=1,N
              YM(I)=YH(I,J)
              YL(I)=YG(I,J)
              S(I)=SG(I,J)
      210     CONTINUE
              GOTO206
      205     DO220I=1,N
              YL(I)=YA(I)
              YM(I)=YA(I)+G*DZ(I)
              S(I)=SA(I)
      220     CONTINUE
              KH=M/2
              XU=X
              DO230K=2,M
              XU=XU+G
              CALL FCT(YM,XU,DY)
```

```
      DO231I=1,N
      U=YL(I)+B*DY(I)
      YL(I)=YM(I)
      YM(I)=U
      U=DABS(U)
      IF(U.GT.S(I))S(I)=U
  231 CONTINUE
      IF((K.NE.KH).OR.(K.EQ.3))GOTO230
      JJ=1+JJ
      DO232I=1,N
      YH(I,JJ)=YM(I)
      YG(I,JJ)=YL(I)
      SG(I,JJ)=S(I)
  232 CONTINUE
  230 CONTINUE
  206 CALL FCT(YM,A,DY)
      DO240I=1,N
      V=DT(I,1)
      DT(I,1)=(YM(I)+YL(I)+G*DY(I))*.5D0
      C=DT(I,1)
      TA=C
      IF(L.LT.2)GOTO242
      IF((DABS(V)*DZOTUP.LT.DABS(C)).AND.(H.NE.HMIN).AND.(J.GT.JM/2+1))
     1GOTO30
      DO241K=2,L
      B1=D(K)*V
      B=B1-C
      U=V
      IF(B.EQ.0.)GOTO243
      B=(C-V)/B
      U=C*B
      C=B1*B
  243 V=DT(I,K)
      DT(I,K)=U
      TA=U+TA
  241 CONTINUE
  242 R(I)=DABS(Y(I)-TA)
      Y(I)=TA
      IF(R(I).GT.EPS                )KONV=.FALSE.
  240 CONTINUE
      IF(KONV)GOTO40
      D(3)=4D0
      D(5)=16
      BO=(.NOT.BO)
      M=JR
      JR=JS
      JS=M+M
  200 CONTINUE
      BH=(.NOT.BH)
   30 IF(DABS(H).LE.HMIN)GOTO50
      H=H/2
      IF(DABS(H).GE.HMIN)GOTO20
      H=DSIGN(HMIN,H)
      GOTO10
   50 KONVF=.FALSE.
   40 H=FC*H
      X=A
      RETURN
```

```
'127            END
, IN EFFECT*        NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
; IN EFFECT*        SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ICS*     SOURCE STATEMENTS =      126 ,PROGRAM SIZE =      3490
'ICS*  NO  DIAGNOSTICS GENERATED
ND OF COMPILATION ******                                  73K BYTES OF COF
```

```
1.7 ( JAN 73 )                                    OS/360  FORTRAN H

   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
002              SUBROUTINE DDEOUT(Y,DY,N,X,STYPE)
003              IMPLICIT REAL*8(A-H,O-Z)
004              DIMENSION Y(4),DY(4)
005              LOGICAL STYPE,TITLE
006              COMMON/OUTPUT/SP,H,XI,XF,EPS,NP,TITLE
007              COMMON/UNITS/AR,FBC
008              IF(.NOT.TITLE)GOTO10
010              TITLE=.FALSE.
011       10     IF((NP.EQ.1).AND.STYPE)GOTO20
013              RETURN
014       20     WRITE(6,85)X,(Y(I),I=1,N)
015              RETURN
016       85     FORMAT (1H ,4X,1H*,5X,4(D25.16    )/(36X,3(D25.16    )))
017              END

S IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*     SOURCE STATEMENTS =        16 ,PROGRAM SIZE =        466

ICS*   NO  DIAGNOSTICS GENERATED

END OF COMPILATION ******                                      93K BYTES OF COI
```

```
21.7 ( JAN 73 )                                         OS/360  FORTRAN H

    CCMPILEF CPTICNS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                          SOURCE,EBCDIC,NOLIST,NODECK,LCAD,NOMAP,NOEDIT,ID,NOXREF
0002             SUBROUTINE DERROR
0003             IMPLICIT REAL*8(A-H,O-Z)
0004             COMMON/DINFO/EX,ER,EH,NE,NERR
0005             GOTO(10,20,30,40,50,60),NERR
0006      10     WRITE(6,91)EX,EH,ER,NE
0007      91     FORMAT (5H0****,5X,35HNO CONVERGENCE IN ABOVE STEP TO X =,D12.5,
                1H WITH H=,D12.5, 1H,,5X, 4H****,/10X,22HTHE LIMITING ERROR IS ,
                2D12.5,13H IN EQUATICN ,I2//)
0008             RETURN
0009      20     WRITE(6,92)
0010      92     FORMAT(
                1        5H0****,5X,19HN.LT.0 .OR. N.GT.20,5X,4H****)
0011             RETURN
0012      30     WRITE(6,93)
0013      93     FORMAT (5H0****,5X,29HEP.LT.1.D-18 .OR. EP.GT.1.D-2,5X,4H****)
0014             RETURN
0015      40     WRITE(6,94)
0016      94     FCRMAT (5H0****,5X,22HH*( XEND-XSTART).LT. 0,5X,4H****)
0017             RETURN
0018      50     WRITE(6,95)
0019      95     FORMAT (5H0****,5X,21HH=0. .OR. XEND=XSTART,5X,4H****)
0020             RETURN
0021      60     WRITE(6,96)
0022      96     FORMAT (5H0****,5X,48HH.LT.(XEND-XSTART)/2**15 .OR. H.GT.(XEND-XS
                1ART),5X,4H****)
0023             RETURN
0024             END

S IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*       SCURCE,EECDIC,NCLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TICS*     SOURCE STATEMENTS =       23 ,PROGRAM SIZE =       796

TICS*  NC  DIAGNOSTICS GENERATED

END OF CCMPILATION ******                                        93K BYTES OF COF

TICS*  NO  DIAGNOSTICS THIS STEP
```

LAKEHEAD UNIVERSITY COMPUTER CENTRE

APPENDIX 6 C

TIME	$X, \dot{Y}$	Y	$\dot{X}$
0.0	0.1000000000000000D 01	0.0	0.0
	0.1000000000000000D 01		
0.6283185307179586D 01	0.9999999999999925D 00	0.3698262510531200D-13	-0.3831836588259104D-13
	0.1000000000000004D 01		
0.1256637061435917D 02	0.1000000000000213D 01	0.1424213162210415D-12	0.5988799415736928D-13
	0.9999999999998707D 00		
0.1884955592153875D 02	0.1000000000000198D 01	-0.1383171265656244D-11	0.1577031900149061D-11
	0.9999999999998750D 00		
0.2513274122871834D 02	0.1000000000000168D 01	-0.2593509584608089D-11	0.2797911438223304D-11
	0.9999999999998939D 00		
0.3141592653589793D 02	0.1000000000000120D 01	-0.3657249345319115D-11	0.3775342913949615D-11
	0.9999999999999457D 00		
0.3769911184307751D 02	0.1000000000000110D 01	-0.4275411516564499D-11	0.4474454948493093D-11
	0.9999999999999229D 00		
0.4398229715025710D 02	0.9999999999999411D 00	-0.4293681730754816D-11	0.4495374473170079D-11
	0.1000000000000039D 01		
0.5026548245743669D 02	0.9999999999999338D 00	-0.3863457580905437D-11	0.4064199100758438D-11
	0.1000000000000043D 01		
0.5654866776461627D 02	0.1000000000000031D 01	-0.3897768920871849D-11	0.4077032654032946D-11
	0.9999999999999798D 00		
0.6283185307179586D 02	0.1000000000000030D 01	-0.4045799064747678D-11	0.4223534998099373D-11
	0.9999999999999872D 00		

TOTAL NO OF FUNCTION EVALUATIONS IS 9684

UNIVERSITY COMPUTER CENTRE **APPENDIX 7 A**

```
:1.7 ( JAN 73 )                                     OS/360  FORTRAN H

    COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              IMPLICIT REAL*8(A-H,O-Z)
              DIMENSION YSTART(4)
              COMMON NOFNS
              EXTERNAL FCT,DDEOUT
              NOFNS=0
              PI=3.14159265358979323846D0
              E=.8D0
              A=1D0/(1D0-E)
              SP=2D0*PI*A**1.5D0
              N=4
              YSTART(1)=1
              YSTART(2)=0
              YSTART(3)=0
              YSTART(4)=(1D0+E)**.5D0
              XSTART=0
              XEND=SP*10
              H=1
              EPS=1D-13
              CALL DDESP(SP,FCT,N,YSTART,XSTART,XEND,H,EPS,      DDEOUT)
              WRITE(6,97)NOFNS
       97     FORMAT(1H0,5X,36HTOTAL NO OF FUNCTION EVALUATIONS IS ,I6)
              STOP
              END

S IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TICS*     SOURCE STATEMENTS =       23 ,PROGRAM SIZE =       712

TICS*  NO  DIAGNOSTICS GENERATED

END OF COMPILATION ******                                   93K BYTES OF CO
```

APPENDIX 7 B

TIME	X, Ẏ	Y	X
0.0	0.1000000000000000D 01	0.0	0.0
	0.1341640786498730D 01		
0.7024814731040722D 02	0.9999999999999125D 00	0.2358397459696163D-10	-0.1757516814789714D-10
	0.1341640786499914D 01		
0.1404962946208144D 03	0.9999999999998533D 00	0.9410138086020018D-10	-0.7012925982362985D-10
	0.1341640786499932D 01		
0.2107444419312217D 03	0.9999999999997826D 00	0.2097516103295411D-09	-0.1553239312610180D-09
	0.1341640786499965D 01		
0.2809925892416289D 03	0.9999999999996916D 00	0.3675031249230126D-09	-0.2738909227205067D-09
	0.1341640786500009D 01		
0.3512407365520361D 03	0.9999999999996230D 00	0.5726521985069476D-09	-0.4267847050335783D-09
	0.1341640786500039D 01		
0.4214888838624433D 03	0.9999999999995487D 00	0.8199136952381218D-09	-0.6110758420893921D-09
	0.1341640786500065D 01		
0.4917370311728506D 03	0.9999999999994714D 00	0.1117920726048350D-08	-0.8331907370699799D-09
	0.1341640786500100D 01		
0.5619851784832577D 03	0.9999999999993976D 00	0.1454753990020454D-08	-0.1084243974566097D-08
	0.1341640786500137D 01		
0.6322333257936650D 03	0.9999999999993099D 00	0.1837151735791054D-08	-0.1369259420563716D-08
	0.1341640786500176D 01		
0.7024814731040722D 03	0.9999999999992239D 00	0.2268880545647492D-08	-0.1691047644222103D-08
	0.1341640786500215D 01		

TOTAL NO OF FUNCTION EVALUATIONS IS 23892

```
//RMARN007 JOB '1610125,0010,3,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC PGM=TAYLORIV,REGION=350K,PARM='$0$LIST'
//STEPLIB DD DSN=JOBLIB,DISP=SHR
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=121,BLKSIZE=847)
//SYSPNCH DD DSN=&&TAYLOR,UNIT=2314,SPACE=(CYL,(1,1)),DISP=(MOD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSIDUMP DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=121,BLKSIZE=847)
//SYSIN DD *
IEF236I ALLOC. FOR RMARN007
IEF237I 132    ALLOCATED TO STEPLIB
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 132    ALLOCATED TO SYSPNCH
IEF237I 361    ALLOCATED TO SYSIDUMP
IEF237I 310    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   JOBLIB                                        KEPT
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74163.T090046.RV000.RMARN007.TAYLOR        PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /        / START 74164.0159
IEF374I STEP /        / STOP  74164.0200 CPU   0MIN 15.20SEC MAIN 272K I
CHARGE    $         1.03 CPU TIME 00.00.15   REGION REQUESTED 0350K   STA
                    DISK    READER   PRINTER
I/O COUNTS             21       14        17
NO. OF DD CARDS         2        1         2
// EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT1  DD *
//SYSUT2 DD DSN=&&TAYLOR,DISP=(MOD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
IEF236I ALLOC. FOR RMARN007
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 311    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSUT2
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74163.T090046.RV000.RMARN007.TAYLOR        PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /        / START 74164.0200
IEF374I STEP /        / STOP  74164.0200 CPU   0MIN 02.92SEC MAIN  34K I
CHARGE    $         0.33 CPU TIME 00.00.03   REGION REQUESTED 0062K   STA
                    DISK    READER   PRINTER
I/O COUNTS              2       12         3
NO. OF DD CARDS         1        2         1
// EXEC FORTHCLG,PARM.FORT='OPT=2,ID'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2    DD  UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN    DD  DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD DSN=&&TAYLOR,DISP=OLD
IEF648I INVALID DISP FIELD- PASS SUBSTITUTED
IEF236I ALLOC. FOR RMARN007 FORT
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 330    ALLOCATED TO SYSPUNCH
IEF237I 132    ALLOCATED TO SYSUT1
IEF237I 134    ALLOCATED TO SYSUT2
IEF237I 135    ALLOCATED TO SYSLIN
```

```
IEF237I 132    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74163.T090046.RV000.RMARN007.R0001303      DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74163.T090046.RV000.RMARN007.R0001304      DELETED
IEF285I   VOL SER NOS= ADMP04.
IEF285I   SYS74163.T090046.RV000.RMARN007.LOADSET       PASSED
IEF285I   VOL SER NCS= SPLU03.
IEF285I   SYS74163.T090046.RV000.RMARN007.TAYLOR        PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /FORT      / START 74164.0200
IEF374I STEP /FORT      / STOP  74164.0202 CPU    1MIN 29.79SEC MAIN 250K
CHARGE    $          4.44 CPU TIME 00.01.30   REGICN REQUESTED 0250K    STA
                    DISK    PRINTER   PUNCH
I/O CCUNTS            163      264       0
NO. CF DD CARDS         4        1       1
XXLKED     EXEC  PGM=IEWL,REGICN=96K,PARM=(MAP,LET,LIST),CCND=(4,LT,FORT)
XXSYSLIB    DD   DSN=SYS1.FORTLIB,DISP=SHR
XX          DD   DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD    SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1    DD   SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD   DD   DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX               SPACE=(CYL,(2,,1))
XXSYSLIN    DD   DSN=&LOADSET,DISP=(OLD,DELETE)
XX          DD   DDNAME=SYSIN
IEF236I ALLOC. FOR RMARN007 LKED
IEF237I 131    ALLOCATED TO SYSLIB
IEF237I 132    ALLOCATED TO
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 132    ALLOCATED TO SYSUT1
IEF237I 134    ALLOCATED TO SYSLMOD
IEF237I 135    ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - CCND CODE 0000
IEF285I   SYS1.FORTLIB                                  KEPT
IEF285I   VOL SER NCS= MVT217.
IEF285I   FORTSUB                                       KEPT
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74163.T090046.RV000.RMARN007.R0001306      DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74163.T090046.RV000.RMARN007.GOSET         PASSED
IEF285I   VOL SER NCS= ADMP04.
IEF285I   SYS74163.T090046.RV000.RMARN007.LOADSET       DELETED
IEF285I   VOL SER NCS= SPLU03.
IEF373I STEP /LKED      / START 74164.0202
IEF374I STEP /LKED      / STOP  74164.0203 CPU    0MIN 10.15SEC MAIN  68K
CHARGE    $          0.80 CPU TIME 00.00.10   REGICN REQUESTED 0096K    STA
                    DISK    READER   PRINTER
I/O COUNTS            255      0        44
NO. CF DD CARDS         5      1         1
XXGO       EXEC  PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFT05F001 DD    DDNAME=SYSIN
XXFT06F001 DD    SYSOUT=A,SPACE=(CYL,(1,1))
XXFT07F001 DD    SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN007 GO
IEF237I 134    ALLOCATED TO PGM=*.DD
IEF237I 360    ALLOCATED TO FT06F001
IEF237I 330    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74163.T090046.RV000.RMARN007.GOSET         PASSED
```

```
IEF285I   VOL SER NOS= ADMP04.
IEF373I  STEP /GO       / START 74164.0203
IEF374I  STEP /GO       / STOP  74164.0203 CPU   0MIN 07.44SEC MAIN  34K (
CHARGE    $         0.47 CPU TIME 00.00.07   REGION REQUESTED 0062K   STA
                    DISK    READER   PRINTER   PUNCH
I/O COUNTS             0       0        10        0
NO. OF DD CARDS        1       1         1        1
IEF285I   SYS74163.T090046.RV000.RMARN007.TAYLOR        DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74163.T090046.RV000.RMARN007.GOSET         DELETED
IEF285I   VOL SER NOS= ADMP04.
IEF375I  JOB /RMARN007/ START 74164.0159
IEF376I  JOB /RMARN007/ STOP  74164.0203 CPU   2MIN 05.50SEC
RMARN007 JOB CHARGE $       7.48
```

```
***TAYLOR SERIES SYSTEM***
DOUBLE
EPSILON=1D-6
INIT SETUP
YX(0)=1
YY(0)=0
YX'(0)=0
YY'(0)=1
ADVANCE VALUES(X,YX,YY,YX',YY')
EQUATIONS
XY=-(YX*YX+YY*YY)**(-1.5D0)
YX''=YX*XY
YY''=YY*XY
END

COMPILED WITH DOUBLEPRECISION OPTIONS
STORE=1289/15836
TIME=6.14 SECS
```

1.7 (JAN 73)   OS/360 FORTRAN H

```
   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
002              SUBROUTINE XTAY02(J1,J2,L1)
003              DOUBLEPRECISION R1,R2,A1,C1
004              LOGICAL L2
005              COMMON/TAYLOR/R2,R1,C1,A1(374),L2
006              DOUBLEPRECISION F1,V1,V2,F2
007              LOGICAL L1
008              DIMENSION F1(18),F2(18)
009              DATA F2(1),F2(2),F2(3),F2(4),F2(5),F2(6),F2(7),F2(8),F2(9),F2(10),
                CF2(11),F2(12),F2(13),F2(14),F2(15),F2(16),F2(17),F2(18)/1.D0,2.D0,
                C3.D0,4.D0,5.D0,6.D0,7.D0,8.D0,9.D0,10.D0,11.D0,12.D0,13.D0,14.D0,1
                C5.D0,16.D0,17.D0,18.D0/
010              DATA F1(1),F1(2),F1(3),F1(4),F1(5),F1(6)/1.D0,5.D-1,3.33333333333
                C3333D-1,2.5D-1,2.D-1,1.6666666666666667D-1/
011              DATA F1(7),F1(8),F1(9),F1(10),F1(11),F1(12)/1.428571428571428 6D-1,
                C1.25D-1,1.1111111111111111D-1,1.D-1,9.0909090909090909D-2,8.33333
                C3333333333D-2/
012              DATA F1(13),F1(14),F1(15),F1(16),F1(17),F1(18)/7.692307692307692 3
                C-2,7.142857142857142 9D-2,6.6666666666666667D-2,6.25D-2,5.882352941
                C1764706D-2,5.5555555555555556D-2/
013              GOTO 1
014        2     V2=(A1(J1+1)-A1(J2+1))
015              A1(J1+18)=0.D0
016              A1(J1+35)=0.D0
017              A1(J1+52)=0.D0
018              A1(J1+69)=0.D0
019              K1=J2+N1
020              DO 3 K2=1,N1
021              A1(J1+18)=A1(J1+18)*V2+A1(K1+17)
022              A1(J1+35)=A1(J1+35)*V2+A1(K1+34)
023              A1(J1+52)=A1(J1+52)*V2+A1(K1+51)
024              A1(J1+69)=A1(J1+69)*V2+A1(K1+68)
025        3     K1=K1-1
026              N1=J1+1
027              A1(N1+119)=(A1(N1+34)*A1(N1+34)+A1(N1+17)*A1(N1+17))
028              IF(A1(J1+120))5,5,4
029        4     A1(N1+102)=A1(J1+120)**(-1.5D0)
030              A1(N1+170)=((-1.5D0)/A1(N1+119))
031              DO 6 N2=1,16
032              A1(N1+18)=(A1(N1+51)*F1(N2))
033              A1(N1+35)=(A1(N1+68)*F1(N2))
034              A1(N1+85)=(-A1(N1+102))
035              A1(N1+52)=0.D0
036              A1(N1+69)=0.D0
037              A1(N1+120)=(A1(N1+35)*A1(J1+35)+A1(N1+18)*A1(J1+18))
038              N3=N2
039              N4=J1
040              K2=J1+N2
041              A1(N1+52)=A1(N1+52)+(A1(N4+18)*A1(K2+85))
042              A1(N1+69)=A1(N1+69)+(A1(N4+35)*A1(K2+85))
043              A1(N1+120)=A1(N1+120)+(A1(N4+35)*A1(K2+35)+A1(N4+18)*A1(K2+18))
044              N4=N4+1
045              K2=K2-1
046              N3=N3-1
047              IF(N3)7,8,7
048        8     A1(N1+52)=(A1(N1+52)*F1(N2))
049              A1(N1+69)=(A1(N1+69)*F1(N2))
```

```
              A1(N1+153)=(A1(N1+120)*F2(N2))
              A1(N1+136)=0.D0
              A1(N1+171)=0.D0
              N3=N2
              N4=J1
              K2=J1+N2
       9      A1(N1+136)=A1(N1+136)+(A1(N4+154)*A1(K2+170))
              A1(N1+171)=A1(N1+171)+(A1(K2+120)*A1(N4+171))
              N4=N4+1
              K2=K2-1
              N3=N3-1
              IF(N3)9,10,9
      10      A1(N1+171)=(-A1(N1+171)/A1(J1+120))
              A1(N1+103)=0.D0
              N3=N2
              N4=J1
              K2=J1+N2
      11      A1(N1+103)=A1(N1+103)+(A1(N4+103)*A1(K2+136))
              N4=N4+1
              K2=K2-1
              N3=N3-1
              IF(N3)11,12,11
      12      A1(N1+103)=(A1(N1+103)*F1(N2))
       6      N1=N1+1
              L1=.FALSE.
              RETURN
       5      L1=.TRUE.
              RETURN
       1      N1=16
              GOTO 2
              END
```

```
 IN EFFECT*        NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*        SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*      SOURCE STATEMENTS =       79 ,PROGRAM SIZE =      1532

ICS*   NO   DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                       77K BYTES OF COR
```

```
1.7 ( JAN 73 )                                   OS/360  FORTRAN H

   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
002              SUBROUTINE VALUES(X,YX,YY,A2,A3)
003              DOUBLEPRECISION R1,R2,A1,C1
004              LOGICAL L2
005              COMMON/TAYLOR/R2,R1,C1,A1(374),L2
006              DOUBLEPRECISION X1,X2,X,YX,YY,A2,A3
007        10    IF(X-R1)1,2,2
008        2     IF(R2-X)4,3,3
009        4     IF(A1(1)-A1(188))6,5,5
010        1     IF(X-R2)7,3,3
011        7     IF(A1(1)-A1(188))9,8,8
012        6     CALL XTAY01(187,0,.FALSE.)
013              L2=.TRUE.
014              GOTO10
015              CALL XTAY01(0,187,.FALSE.)
016              L2=.FALSE.
017              GOTO10
018        9     CALL XTAY01(0,187,.TRUE.)
019              L2=.FALSE.
020              GOTO10
021        8     CALL XTAY01(187,0,.TRUE.)
022              L2=.TRUE.
023              GOTO10
024              N5=0
025              IF(L2)N5=187
027              YX=0.D0
028              YY=0.D0
029              A2=0.D0
030              A3=0.D0
031              X2=(X-A1(N5+1))
032              N5=N5+16
033              DO 11 N4=1,16
034              YX=YX*X2+A1(N5+34)
035              YY=YY*X2+A1(N5+17)
036              A2=A2*X2+A1(N5+68)
037              A3=A3*X2+A1(N5+51)
038        11    N5=N5-1
039              RETURN
040              END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*     SOURCE STATEMENTS =        39 ,PROGRAM SIZE =        762

ICS*   NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                    93K BYTES OF COR
```

```
   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
002             SUBROUTINE XTAY01(J1,J2,Z1)
003             DOUBLEPRECISION R1,R2,A1,C1
004             LOGICAL L2
005             COMMON/TAYLCR/R2,R1,C1,A1(374),L2
006             DOUBLEPRECISION DABS,DMAX1,DEXP,DLOG,Z2,Z3,E1,E2,E3,Z4,Z5,T1,T2
007             LOGICAL Z1,L1
008             DIMENSION T2(16)
009             DATA T2(1),T2(2),T2(3),T2(4),T2(5),T2(6),T2(7),T2(8),T2(9),T2(10),
               CT2(11),T2(12),T2(13),T2(14),T2(15),T2(16)/1.D0,3.D0,7.D0,15.D0,31.
               CD0,63.D0,127.D0,255.D0,511.D0,1023.D0,2047.D0,4095.D0,8191.D0,1638
               C3.D0,32767.D0,65535.D0/
010             Z2=1.D-8*1.D-6
011             K2=J1+31
012             DO 6 N4=1,4
013             Z2=DMAX1(Z2,DABS(A1(K2)),DABS(A1(K2+1)),DABS(A1(K2+2)))
014       6     K2=K2+17
015             Z3=DEXP(C1+0.058823D0*(DLOG(1.D-6)-DLOG(Z2)))
016             R1=0.5D0*(A1(J1+1)+A1(J2+1))
017             IF(Z1) Z3=-Z3
019             A1(J2+1)=A1(J1+1)+Z3
020             CALL XTAY02(J2,J1,L1)
021             IF(L1)GOTO 5
023             E2=1.D-6*1.D-8
024             K2=J1+17
025             J3=J2+17
026             DO 7 N4=1,4
027             E3=0.D0
028             N3=15
029             Z5=5.D-1*Z3
030             Z4=-1.D0
031             N6=16+K2
032             N7=16+J3
033       8     E1=E3
034             E3=Z5*((A1(N6)*T2(N3)+Z4*A1(N7))+E3)
035             Z4=-Z4
036             N3=N3-1
037             N6=N6-1
038             N7=N7-1
039             IF(N3)8,9,8
040       9     Z4=DABS(E3+E1*1.D-6*1.D-16)
041             Z4=Z4/DMAX1(1.D0,Z4,DABS(A1(K2+1)),DABS(A1(J3+1)))
042             IF(E2-Z4)10,11,11
043      10     E2=Z4
044      11     K2=K2+17
045       7     J3=J3+17
046             T1=0.058823D0*(DLOG(2.D-1)+DLOG(1.D-6)-DLOG(E2))
047             IF(E2-1.D-6)4,4,2
048             Z3=Z3*DEXP(T1)
049             C1=C1+T1
050             GOTO3
051             C1=C1+T1
052             R2=A1(J2+1)
053             RETURN
054       5     Z3=0.5D0*Z3
055             C1=C1-1.D-1
056             GOTO 3
```

```
057            END

 IN EFFECT*        NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*        SOURCE,EECDIC,NCLIST,NCDECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*     SOURCE STATEMENTS =        56 ,PROGRAM SIZE =      1514

ICS*   NC  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                         85K BYTES OF COR
```

1.7 (JAN 73)   OS/360 FORTRAN H

```
   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              SUBROUTINE SETUP
              DOUBLEPRECISION R1,R2,A1,C1
              LOGICAL L2
              COMMON/TAYLOR/R2,R1,C1,A1(374),L2
              LOGICAL L1
              DO 1 N8=1,374
              A1(N8)=0.D0
              A1(205)=0.D0
              A1(239)=1.D0
              A1(222)=1.D0
              A1(256)=0.D0
              A1(1)=0.D0
              A1(188)=0.D0
              A1(2)=1.D0
              A1(189)=1.D0
              CALL XTAY02(0,187,L1)
              IF(.NOT.L1)GOTO 3
              WRITE(6,4)
        4     FORMAT(36H1TAY003 - ILLEGAL INITIAL CONDITIONS)
              STOP 3
        3     DO 2 N8=1,187
        2     A1(N8+187)=A1(N8)
              R2=A1(1)
              R1=R2
              L2=.TRUE.
              C1=0.D0
              RETURN
              END
 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*      SOURCE STATEMENTS =      29 ,PROGRAM SIZE =      502

ICS*  NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                    93K BYTES OF COR
```

```
1.7 ( JAN 73 )                                  OS/360  FORTRAN H

   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              IMPLICIT REAL*8(A-H,O-Z)
              PI=3.14159265358979323846264338327950288D0
              SP=PI*2
              CALL SETUP
              DO1I=1,10
              X=I*SP
              CALL VALUES(X,YX,YY,YXP,YYP)
       1      WRITE(6,2)  YX,YY,YXP,YYP
       2      FORMAT(1H ,4F26.16)
              STOP
              END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*      SOURCE STATEMENTS =       11 ,PROGRAM SIZE =      480

ICS*   NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                  93K BYTES OF COR

ICS*   NO  DIAGNOSTICS THIS STEP
```

APPENDIX 8 D

X	Y	$\dot{X}$	$\dot{Y}$
1.0000007006495140	-0.0000007738774209	0.0000011293719927	0.9999995534532413
1.0000011253749640	-0.0000079127927949	0.0000082736836048	0.9999993632441671
1.0000015292111430	-0.0000189284056577	0.0000192406434419	0.9999992071302809
1.0000019118222590	-0.0000337705837665	0.0000341681280420	0.9999989841776513
1.0000023746678020	-0.0000526045161667	0.0000530032259860	0.9999987423946120
1.0000027929870290	-0.0000754385181373	0.0000757832470503	0.9999985032454313
1.0000032103150310	-0.0001021649485765	0.0001025310761945	0.9999983084986364
1.0000036126767880	-0.0001328320944064	0.0001331577786703	0.9999981452770696
1.0000039950884540	-0.0001673473248762	0.0001677368942049	0.9999979108310752
1.0000044329050420	-0.0002057680051635	0.0002061609719828	0.9999976788004703

APPENDIX 9 A

July 23, 1973

Dr. Arthur C. Norman
University of Cambridge Computer Laboratory
Corn Exchange Street
Cambridge, England
CB2 3QG

Dear Dr. Norman

As I am presently working for my M.Sc. under Professor John S. Griffith related to the numerical integration of the orbits of the principal bodies of our Solar System, I would sincerely appreciate having the opportunity to implement the software described [Norman (1972): Proceedings of the ACM, Annual Conference, p. 826]. Comprehensive information, including, possibly, a minireel (9 track, 800 bpi) containing source programs would, therefore, be required. I could send you a minireel. The computing facility here is an IBM System /360 Model 50, running under OS/360.

My research goals involve surveying the available numerical integration algorithms for systems of ordinary differential equations, utilizing the most "efficient" available, and, if possible, advancing the state of the art.

Please use the follwoing mailing address exactly as shown:

Mr. Roy D. North
Graduate Student
Department of Mathematical Sciences
Lakehead University
Thunder Bay 'P', Ontario, Canada
P7B 5E1

Yours most sincerely

Roy D. North

APPENDIX 9 C

September 19, 1973

Dr. Arthur C. Norman
c/o IBM Thomas J. Watson Research Centre
P.O. Box 218
Yorktown Heights, New York 10598
U. S. A.

Dear Dr. Norman:

Thank you for your letter dated August 15, 1973 and the accompanying Taylor User's Manual, in response to mine dated July 23, 1973, a pseudo copy of which is enclosed.

I have available a mini reel of length 600 feet and would sincerely appreciate the BCPL files and your program (250 K and 200 K versions) recorded thereon. Additional relevant literature, especially pertaining to BCPL (I could contact Dr. Richards therefor) required to get all the software on the air would also be appreciated.

Version identifications (Taylor User's Manual, page 18) would be required as I would hope to be able to correspond with you and Dr. D. Barton [Barton, et al (1971): The Computer Journal, Vol. 14, No. 3, Page 243].

The mini reel eagerly awaits your mailing request! Please use the address per my letter dated July 23, 1973.

Yours sincerely

Roy D. North

APPENDIX 9 F 1

January 16, 1974

Dr. Arthur C. Norman
c/o IBM Thomas J. Watson Research Center
P. O. Box 218
YORKTOWN HEIGHTS, New York 10598
U. S. A.

Dear Arthur:

Thank you for your letters dated Oct. 23, 1973 and Oct. 31, 1973, and the tape. Please find enclosed 9 listings and the tape. I am having difficulties with the system (only DSNAMES = MCLIB and TEXT have been employed), and would appreciate your expert assistance. In response to your request in your second letter, it took me about a week (only about 1 run/day due to the high core requirement) to get output approximating that of Listing #3. This delay was entirely my fault, due to JCL errors, etc.

Please refer to Listing #3. A few words about the JCL are in order, as it is similar to that supplied in some of the other listings. Tape NORMAN was copied on LUT065. File 7 contained the F Level Assembler object module created by DSNAME = MCLIB. The F Level Linkage Editor was employed in the first procstep (LKED) to create the load module. The subsequent procstep (GO) executed that module. I have omitted your DD statement with ddname = SYSIDUMP: please advise if that be all right. The rest of the JCL is self explanatory. The Taylor output is highly encouraging: the system of differential equations solved arises from the circular planar 2-body problem, and the load module executed about 3 times faster, for a comparable accuracy, than the corresponding module created by my implementation of the software (Ref. 1).

With this success behind me, I then proceeded to attack the three dimensional 11-body problem. Please see Listing #1: unfortunately Taylor's LIST option (which listed all input) is

APPENDIX 9 F 2

followed by an "insufficient storage" error message. I have been unsuccessful in overcoming that condition. Please note that Taylor had 600K, and an initial substring which caused the default algorithm (see Listing #4) to be used. Please refer to Listing #2: the initial substring consisted of $004K$, but this did not seem to help.

Allow me to summarize several runs, which were done to experiment with the initial substring: a study of the Assembler listing (from which Listing #4 originates) has certainly not revealed the function of the initial substring to me. Listing #5 is representative of part of the JCL: in the runs, only the value in the initial substring was varied; the Taylor input was similar to that in Listing #7. The values 500, 400, 300 and 200 resulted in a System Completion Code = 60A (see Listing #5), with no Taylor input printed. Values 100, 80 and 40 gave the perennial error message (see Listing #1), with part of the input printed. Values 20 and 10 gave the error message (see Listing #1), with all of the input printed. I decided not to attempt to debug this problem because of its seemingly complex nature, and because the turnaround would be too slow.

You might be interested in the following tidbit. Please see Listing #4, STMT 865, B and C underlined in pencil. I would be interested in knowing the significance of those letters, as a study of the Assembler processing the initial substring revealed that, upon encountering the B, the default algorithm would be used. This perplexed me greatly! I went so far as to list STMT 865 (using IEBPTPCH) in hexadecimal, and the B was really X'42', while C was X'43', instead of the expected X'C2' and X'C3', respectively.

The following possible inconsistency in Taylor's input processing might be of interest. Listing #6 gave only the very beginning of the input supplied (which was similar to that supplied in Listing #1), followed by an error message. The first initial condition in Listing #3 occupied two cards (as in Listing #6) and was accepted.

Please explain what I have done wrong in Listing #7.

I would certainly like to continue using Taylor, but I, obviously, require some assistance. The Taylor input and the Fortran program of Listing #1 were intended to reconcile Listing #8. The latter listing was created by my implementation of the software (Ref. 1) using initial conditions (Ref. 2). Listing #8

APPENDIX 9 F 3

values are correct to at least 8 significant digits and should be readily reconcilable with the successful Taylor - Fortran run of Listing #1. There is a minor difference in format, however. Listing #8 (excluding the titles) shows the value of the time on the extreme LHS pertaining to the relevant set of coordinates to the right and below, delimited by the next value of the time. The distance coordinates are followed immediately below by their corresponding velocity coordinates. The lines of distance coordinates have been connected by red lines. A successful run of Listing #1 should print the set of red line values, followed by the set of intervening velocity coordinates. This should be obvious from a brief perusal of the Fortran program in Listing #1 (Y1, etc. are distance coordinates, while Y1P, etc. are velocity coordinates). Listing #9 supplies pertinent information for attempting a successful run: I would be most grateful if you tested it. Also a run with EPSILON = 1D-14 would be interesting for comparison later here, while one employing extended-precision (about 30 significant digits throughout) would prove enlightening.

I hope to apply ASN = BVTEXT to sets of boundary values from Ref. 2.

I would appreciate your comments comparing execution times of TAYLOR's output and that resulting from a meticulous human programmed effort (in Fortran): a perusal of Listing #3 leads me to suspect that the latter would run faster.

Please use the address per my letter dated July 23, 1973.

Yours sincerely

Roy D. North

RDN/sb
Encl.

APPENDIX 9 F 4

REFERENCES

1. Rice, John R. (editor) (1971): Mathematical Software, ACM Monograph Series, Academic Press, New York and London, Chapter 9 (In essence, a Fortran version of Richardsonian extrapolation as utilized in Bulirsch and Stoer (1966): Numer. Math., Vol. 8, Page 1).

2. Oesterwinter, Claus and Cohen, Charles J. (1972): Celestial Mechanics, Vol. 5, No. 3, Pages 374-375 (Misprints seem to be present).

APPENDIX 9 G 1 2/07/74.

Dear Roy,

I will try to sort out some of the confusions and messes you have been getting into. I'll try to cover the points in your letter in the order you made them.

1) SYSIDUMP is a local (partial) equivalent of SYSUDUMP and would get a hex dump written to it in case of catastrophe. It is very reasonable to remove it as (hopefully) other information will be available when picking up pieces.

2) I'm terrified by the pages & pages of equations you are feeding my program! I can, however, explain some of the storage problems — which are my fault.
When I brought the machine-code library MCLIB here from Cambridge I had a certain amount of trouble with it, caused by differences between version of O.S. In particular I got errors returned by the GETMAINS which I didn't understand. To get round this I modified

the program at (or about) LOWCORE APPENDIX 9 q 2 (location 37C) to change the parameters for the GETMAIN that grabs as much store as possible. In the Cambridge version this was set up to get some amount of store between 12K and 512K for the BCPL stack (& hence my program) I altered it to make sure it never got more than about 100K, and thereby left room for fiddling about in. The original stuff should be left in the source program in the form of a comment. You can try restoring it (with a limit of more than 512K if you are allowed to run in a bigger partition than that), and with luck you should get more store. You can see from your JCL reflection output that TAYLOR has only been using about 275K, however much you give it. Sorry about that. You can see from comments in the m/c code that I didn't write it, and I don't wish to get myself too bogged down in OS internals. I should probably chase the inconsistency between OS 20·6 & OS 21·7 further!

) The initial substring nnK (X'C2' & X'C3' are Cambridge codes for [and] to show that the 'K' is optional. They don't print on the print-chain I have here so I didn't notice them).

MCLIB behaves as follows:

1) It allocates space for a stack
2) It runs the users program.

The users pgm will want to do I/O & so will have to set up buffers & the like. These have to come out of the users core, and if all that had been allocated to stack he would be in a mess. MCLIB ∴ grabs less than the maximum amount that it could to us as a stack. The amount <u>left</u> (i.e. available for building IO control blocks & buffers in) is what is controled by nK. The facility should only be necessary for BCPL programs that use lots & lots of ~~sta~~ datasets, or huge block-sizes.

) Listing 6. With LIST set TAYLOR echoes characters as read to the listing dataset SYSPRINT. When it melts an error it echoes the last couple of lines processed, including any part of the current line that hasn't yet been scanned (+ thus listed)).

5) When TAYLOR finds

name(integer)

it expects name to be something it knows about like SIN or COS, or one of the dependent variables in the equations. You can't write A(Ø) & FBCR(Ø) as parameters, it will have to be AØ and FBCRØ.

In the extended version of TAYLOR you can also have name(integer) meaning an array element:

```
ADVANCE VALUES(X,Y,DY)
DIMENSION Y(30),DY(30)
Y(1) = Y1
Y(2) = Y'2
Y(3) = Y3
 :
DY(30) = Y30'
EQUATIONS
 :
```

(The lines Y(1) = Y1 through DY(30) = Y30' sets up correspondence between array elements & quantities in the equations)

This can only be done with BVTEXT, and almost certainly contains bugs since I haven't really had an opportunity to test it much. If it helps you & if it works — good luck!

6) ∃ bug in the system. If you write

a ** n in your equations

where a is a constant expression and n is an integer ≥4 TAYLOR fails to process the equations, bombing out with the message "System Failure". The fix is not large, but the effort involved in getting any such thing to you is probably such that sending it isn't worth the trouble. (If a is a number the problem doesn't arise. Thus

```
INIT SET(A)
Y(0) = 1
ADV VAL(X,Y)
EQNS
Y' = A**7 * Y
```

will be the sort of thing that will die. You can write 7.3192 ** 23(eg) as much as you like without trouble)

7) OK now I have got your equations off tape, run them through TAYLOR on VM370 & compiled & run the generated Fortran: my results agree with yours (sigh of relief). Your problem strains my

system a bit : one a 370/158 TAYLOR takes 350 seconds

to process the problem, and uses ~ 50000 words of store for the data : hopefully that means the whole system uses ~ 500K bytes. Around 2000 lines of Fortran are generated, and almost all of these are in one subroutine (XTAYØ2). To compile this Fortran I had to split XTAYO2 into two (manually). This involved copying some declarations of common blocks, but is not (conceptually) hard since the bulk of the routine is fairly straight-line solid computational code. I also preceeded your input to TAYLOR with "SCALED" : this makes the generated code deal with power series with a normalized time-scale : since you take steps of $\sim 10^5$ in X this helps to control [illegible] precision/scaling the the works. Also by hand I changed two lines in the generated routine SET :

one reads A1(2) = 1.DØ the next is A1(nnn) = 1.DØ where nnn is some number (9930 ?) The 1.DO in each case is an initial guess for the time-scale and hence effective steplength to be used. When the default is wrong (as here) by a factor of 10^6 it can usefully be changed : thus

A1(2) = 1.D6
A1(9930) = 1.D6.

further experiments show that this is quite unnecessary. The $\varepsilon = 10^{-12}$ trace output shows that TAYLOR gets the step-length right after

In all normal circumstances (i.e. when the total range of half a dozen steps anyway.

integration will be ~ 1 (within 2 or 3 orders of magnitude) this fix would be irrelevant.

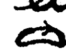
APPENDIX 9 G 7

I compiled the program with the G1 compiler (which took a couple of minutes to swallow it). To make the results fit on my console I altered the format statement in the main program to cut out some space & print 2 less places in each number. Subject to these alterations, and the ordering of outputs $y_1\ y_2 \cdots\ y_{30}\ y_1'\ y_2' \cdots$ as against $y_1\ y_2\ y_3\ y_1'\ y_2'\ y_3' \cdot \quad y_{29}\ y_{30}\ y_{28}'\ y_{29}'\ y_{30}'$ the results I obtain seem to be in agreement with yours. My program seems to take a step-length of between 3 and 4.10^5 on the problem. I should also mention that I seem to be getting lots of underflows: these will be in the computation of high order derivatives of some of the small cross-coupling terms between the planets. With the SCALED option my program (should) try hard to keep important quantities decently under control. The program reproduces your answers in ~ 6 mins computing (again on the 158). Looking at the underflows: they could be made to go away be scaling the problem so that the integration is done in terms of Astronomic units and years, rather than calculating in the 'real' values then scaling for output. (perhaps).

I am (right now) regenerating the FORTRAN to try a run with $\varepsilon = 1.E-12$. We don't have REAL*16 hardware either on the 158 or the 91 and so, in view of the time that would be taken, I'm not going to try it. I am however running the double-precision one ong the 91 to compare the time it takes.

I believe that the FORTRAN generated by TAYLOR is not too bad. In any particular instance a competent human programmer could (of course) do better, but would equally certainly make a certain number of coding (+ typing!) errors. TAYLOR's code tends to be rather ugly, but should not contain unnecessary loops or too many grossly redundant calculations. For big problems you are rather more liable to have trouble with the amount of code TAYLOR generates: your 11 body thing is (by some way) the biggest problem it has ever met and, as you see, although I can generate FORTRAN the FORTRAN compilers don't like routines that long.

I've now just looked up Oesterwinter et al. The solar system as a boundary value problem looks big to me. Again I can quote good results for TAYLOR on 3-body planar closed orbits: I've spent some time doing one shaped like

and one like 

APPENDIX 10 A

July 16, 1973

Dr. Charles ~~Ø~~J. Cohen
Naval Weapons Laboratory
DAHLGREN, Virginia 22448
U. S. A.

Dear Dr. Cohen:

As I am presently working for my M.Sc. under Professor John S. Griffith related to the numerical integration of the orbits of the principal bodies of our Solar System, I would sincerely welcome any additional information you could supply pertinent to section "6.2. Numerical Integration Routine" (Ref. 1). In particular, I have been unable to locate reports of the work of Hubbard and Broadwater: explicit references to the work mentioned in the opening paragraph could, therefore, be sufficient to satisfy my request. Possibly you might be aware of more recent relevant activities: these would be of interest also, as my goals would be to utilize the most "efficient" algorithm available and, if possible, to advance the state of the art.

Please use the following mailing address exactly as shown:

Mr. Roy D. North
Graduate Student
Department of Mathematical Sciences
Lakehead University
Thunder Bay 'P', Ontario, Canada
P7B 5E1

Yours most sincerely

Roy D. North

Reference

[1] Cohen and Oesterwinter (1972): Celestial Mechanics, Vol. 5, No. 3, Page 317.

February 22, 1974

Dr. C. Oesterwinter
Naval Weapons Laboratory
DAHLGREN, Va. 22448
U. S. A.

Dear Dr. Oesterwinter:

Thank you for your letter dated 1 August 1973 and the enclosures.

I have found your paper (Ref. 1) to be most valuable, especially as a source of precise initial values for velocity coordinates (Ref. 2). However, I would gratefully appreciate some further information.

Please refer to equations (1) and (2) (Ref. 3). In order to successfully implement these algorithms on an IBM System /360 Model HJ50, I had to evaluate equation (1) in double-precision, instead of evaluating the RHS in single and then converting to an integer value, as it stands. Compare Listing #1 (yielding incorrect results for 1974 Jan. 1 d.0.U.T.) with Listing #2 (correct results). I used Ref. 7. Your comments are welcome.

In Ref. 2 I believe I have found 3 errors. For the Moon line 4, x should be 0.9556 6103 2436 13 instead of 0.9956 6103 2436 13.

For Earth line 3, y should be -0.2787 9403 8580 68 instead of 0.2787 9403 8580 68.

For Uranus line 3, z should be -0.1621 2038 1396 26 instead of 0.1621 2038 1396 26.

I would be extremely interested to learn of any additional errors. I believe the independent variable to be much closer to 0h.0 E.T. instead of 0h.0 U.T.: please advise. Should the conversion factor 1 AU = 149 597 900 km (Ref. 4) be employed in favour of 1 AU = 149 600 × 10^6 metres (Ref. 6)? Since the observations only span to JD2440000.5 (Ref. 4), clearly lines 3-5 are extrapolated

APPENDIX 10 C 2

values and related sigmas should be considerably greater than those of line 2. I would be interested in what the more recent sigmas might be, or better still, in improved values for lines 3-5. My prime motivation for such detailed information is that I am trying to reconcile lunar radii vectores, to the nearest 6 km or better, from my numerical integrations with those of Ref. 5, or hopefully with those of LURE (I have written to Dr. J. Derral Mulholland.). Please be advised that my model is strictly a Newtonian point mass gravitational one. In your experience, would you consider my accuracy criterion to be realistic (using line 3 values as input to the initial value problem) for the period 1971 Sept. 6 d.0 E.T. to 1974 Dec. 31 d.0 E.T.)? Preliminary results are in the affirmative: I can supply the details if requested. Of course, even the sigmas in line 2 can wipe out my criterion (± 6 km) by well over an order of magnitude (about ± 80 km)!

Please use the following mailing address exactly as shown:

Mr. Roy D. North
Graduate Student
Department of Mathematical Sciences
Lakehead University
THUNDER BAY 'P', Ontario, Canada
P7B 5E1

Yours sincerely

Roy D. North

RDN/sb

APPENDIX 10 C 3

REFERENCES

(1): Oesterwinter & Cohen (1972): Celestial Mechanics, Vol. 5, Page 317.

(2): Ibid., Table X, Pages 374-5.

(3): Ibid., Page 327.

(4): Ibid., Page 322.

(4A): Ibid., Page 372.

(5) : The Astronomical Ephemeris For the Year 1972, HMSO, Pages 190-197, and those for subsequent years.

(6) : Supplement To the A.E. 1968, USNO, Page 45.

(7) : The Astronomical Ephemeris For the Year 1974, HMSO, Pages 12 and 20.

```
      PI=3.14159265358979323846D0
**WARNING**  REAL CONSTANT HAS MORE THAN 16 DIGITS. TRUNCATED TO 16
      F=180/PI
      I=1974
      J=1
      K=1
      JD0=1721074+K+1461*(I+(J-14)/12)/4+367*(J-2-12*
     1((J-14)/12))/12+(24002-12*I-J)/1200-0.5
      EPS=(23D0+26D0/60D0+32.906D0/3600D0)/F
      DPSI=17.551D0
      GAST0=0.27649045D0+0.00273790929800*(JD0-2431090.5D0)
     1+0.000 000 7716D0*DPSI*DCOS(EPS)
      IGAST0=GAST0
      GAST0=GAST0-IGAST0
      GAST0=GAST0*86400
      FGAST0=6*3600+41*60+03.521D0
      PRINT1,JD0
      PRINT2,GAST0
      PRINT2,FGAST0
      FORMAT(' ',I10)
      FORMAT(' ',F30.16)
      STOP
      END

    $ENTRY
 2442048
     23945.2422393950300000   J.D.
     24063.5210000000000000   
```

CORE USAGE   OBJECT CODE=   1648 BYTES,ARRAY AREA=   0 BYTES,TO

DIAGNOSTICS   NUMBER OF ERRORS=   0, NUMBER OF WARNINGS=

COMPILE TIME=   1.39 SEC,EXECUTION TIME=   0.06 SEC,   WATFIV - VERS

APPENDIX 10 C 4

LISTING #1.

```
    $JOB
      IMPLICIT REAL*8(A-H,O-Z)
      PI=3.14159265358979323846D0
**WARNING**  REAL CONSTANT HAS MORE THAN 16 DIGITS. TRUNCATED TO 16
      F=180/PI
      I=1974
      J=1
      K=1
      D0=1721074+K+1461*(I+(J-14)/12)/4+367*(J-2-12*
     1((J-14)/12))/12+(24002-12*I-J)/1200-0.5D0
      EPS=(23D0+26D0/60D0+32.906D0/3600D0)/F
      DPSI=17.551D0
      GAST0=0.27649045D0+0.00273790929810*( D0-2431090.5D0)
     1+0.000 000 7716D0*DPSI*DCOS(EPS)
      IGAST0=GAST0
      GAST0=GAST0-IGAST0
      GAST0=GAST0*86400
      FGAST0=6*3600+41*60+03.521D0
      PRINT2, D0
      PRINT2,GAST0
      PRINT2,FGAST0
      FORMAT(' ',F30.16)
      STOP
      END

    $ENTRY
   2442048.5000000000000000   J.D.
     24063.5199210688700000   
     24063.5210000000600000   
```

CORE USAGE   OBJECT CODE=   1616 BYTES,ARRAY AREA=   0 BYTES,T

DIAGNOSTICS   NUMBER OF ERRORS=   0, NUMBER OF WARNINGS=

COMPILE TIME=   1.31 SEC,EXECUTION TIME=   0.06 SEC,   WATFIV - VERSI

LISTING #2.

APPENDIX 10 D 1

NAVAL WEAPONS LABORATORY

DAHLGREN, VA. 22448

IN REPLY REFER TO
KA-1:CO:wjc
13300
9 May 1974

Mr. Roy D. North
Graduate Student
Department of Mathematical Sciences
Lakehead University
THUNDER BAY 'P', Ontario, Canada
P7B 5E1

Dear Mr. North:

Please accept my apologies for being late again. There is just so much to do.

I find, however, that your letter is easily answered. As it happens, you will be able to take care of several of your questions quite readily, if I am allowed to give a few hints.

With respect to the Julian Date, it does not really matter how it is obtained. Once you set your own accuracy goal (ours was 0".01), it will be easy to calculate how good the JD has to be in order to meet this criterion. - In addition to the typos you found, there are at least two other errors. An errata sheet is enclosed.

I am not sure I understand your comment on the independent variable. If we are talking about the same clocks, the difference between ET and UT is as much as 40 sec. An error of this magnitude would be easily visible. If you will check again, you will see that we calculated our observation times from the published ("observed") right ascensions. Such times are clearly related to the earth's rotation and, I believe, are properly labeled UT. They have nothing to do with ET. We have then proceeded, in our solution, to find the differences between the UT's and a backward extrapolation of the atomic clock.

In regard to the conversion from AU to km, keep in mind that this figure is needed only in aberration calculations. Knowing the design accuracy, it will be easy to compute how many significant figures you need. Besides, we wanted to use the best available constants, not those adopted IAU values. Your next comment probably addresses Ref. 2, not

APPENDIX 10 D 3

KA:CO:jmb
31 Aug 1972

MEMORANDUM

From: C. Oesterwinter
To: Addressee

Subj: Errata to Celestial Mechanics 5 (1972) 374-375

1. The diligence of our friends has uncovered the following errors:

Planet	Time	Coordinate	Correct Value
Moon	244 1600.5	x [AU]	0.9556 6103 2436 13
Venus	244 1600.5	$\dot{y}$ [AU/100 d]	-0.0029 4566 6254 8
Earth	244 1200.5	y [AU]	-0.2787 9403 8580 68
Uranus	244 1200.5	$\dot{z}$ [AU/100 d]	-0.1621 2038 1396 26
Mercury	244 1200.5	$\dot{z}$	1.4383 5767 49307

C. OESTERWINTER

cc: C. J. Cohen

18 July 1973

APPENDIX 10 E 1

June 19, 1974

Dr. C. Oesterwinter
Naval Weapons Laboratory
DAHLGREN, Va. 22448
U. S. A.

Dear Dr. Oesterwinter:

Thank you very much for your letter (KA-1:CO:wjc 13300) dated 9 May 1974 and the enclosure: you neatly resolved my problem with Mercury.

I am, however, still having difficulties reconciling my ephemeris of lunar radii vectores with that of Ref. 1 (Residuals are about 6 km, which are well less by an order of magnitude that the sigmas in line 2 can produce; the sigmas applied to the initial conditions could have much more effect). As you are collaborating with Dr. Mulholland, I wonder if you might be able to satisfy my request for a table based on LURE work (See an enclosed copy of a letter recent dated 17 June 1974).

I have a further request. I wonder if you could put me in contact with someone (connected with Computer Sciences Corporation, etc.) who might be able to employ me as a scientific programmer, preferably related to Celestial Mechanics. I possess 10 years' experience in FORTRAN programming, and am presently writing up my M.Sc. thesis (topic: numerical integration of systems of differential equations arising in Celestial Mechanics). My chances of employment in Canada are almost zero, and the U.S. Senate has a bill before it which may make Western hemisphere immigration easier. I held a U.S. Immigrant Visa from October 1971 to February 1972, but the Army and USAF would not guarantee employment in scientific computing: if conditions are relaxed I should have no difficulty getting another visa. My situation is quite unfortaunte: I almost daily lament the fact that I was born less than 40 miles north of the greatest nation in science and technology. And generally the best jobs are reserved for U.S. citizens. I do believe I

... page 2

APPENDIX 10 E 2

possess above average computational ability: in the Graduate Record Examination (ETS) (April 1973), Aptitude Test, Quantitative Ability, I scored in the 93rd percentile rank. Any assistance would be gratefully appreciated.

Please use the mailing address exactly as shown in my recent letter dated 17 June 1974.

Sincerely yours

Roy D. North

RDN/sb

Reference

(1) The Astronomical Ephemeris For The Year 1972, HMSO, pages 190-197, and those for subsequent years.

APPENDIX 10 E A 1

February 12, 1974

Dr. J. Derral Mulholland
Department of Astronomy
University of Texas
AUSTIN, Texas 78712
U. S. A.

Dear Dr. Mulholland:

Thank you for your letter dated Oct. 18, 1973 (de l'Observatoire de Meudon).

I would sincerely appreciate a table of lunar radii vectores based on the LURE work, and superseding Ref. 1. The table should be accurate to at least 4 decimal places (± 637.816 metres), and cover the period from 1972 Jan. 1d.0 E.T. to as close to the present as possible.

Please advise if COSPAR (Ref. 4) can satisfy this request.

The equatorial horizontal parallax is given as 57'02".08 in Ref. 2, while in Ref. 3 it is 3422".608. I believe the latter value to be correct: I imagine that Dr. R.L. Duncombe (USNO) would be the best person to contact regarding rectification thereof. The same error is repeated in the A.E.'s for 1973 and 1974.

Please use the following mailing address exactly as shown:

Mr. Roy D. North
Graduate Student
Department of Mathematical Sciences
Lakehead University
THUNDER BAY 'P', Ontario, Canada P7B 5E1

Yours sincerely

Roy D. North

RDN/sb

APPENDIX 10 E A 2

REFERENCES

1. The Astronomical Ephemeris For The Year 1972, HMSO, Pages 190-197.

2. Ibid., Page 540.

3. Supplement to the A.E. 1968, USNO, Page 7s, Note 21.

4. Abbot, R.I., et al (1973): A.J., Vol. 78, No. 8, Page 793.

```
//RMARNO05 JOB '1610125,0600,5,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC FORTHCLG,PARM.FORT='ID,OPT=2',REGION.GO=71K
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1   DD   UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2   DD   UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN   DD   DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARNO05 FORT
IEF237I 360   ALLOCATED TO SYSPRINT
IEF237I 330   ALLOCATED TO SYSPUNCH
IEF237I 132   ALLOCATED TO SYSUT1
IEF237I 135   ALLOCATED TO SYSUT2
IEF237I 135   ALLOCATED TO SYSLIN
IEF237I 310   ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74175.T085303.RV000.RMARN005.R0000712      DELETED
IEF285I   VOL SER NOS= MVTRIF.
IEF285I   SYS74175.T085303.RV000.RMARN005.R0000713      DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF285I   SYS74175.T085303.RV000.RMARN005.LOADSET       PASSED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /FORT     / START 74176.0035
IEF374I STEP /FORT     / STOP  74176.0046 CPU   10MIN 20.30SEC MAIN 248K
CHARGE    $        28.63 CPU TIME 00.10.20   REGION REQUESTED 0250K   STA
                   DISK   READER  PRINTER  PUNCH
I/O COUNTS          605     869     952      0
NO. OF DD CARDS      3       1       1       1
XXLKED    EXEC  PGM=IEWL,REGION=96K,PARM=(MAP,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB   DD   DSN=SYS1.FORTLIB,DISP=SHR
XX         DD   DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1   DD   SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD  DD   DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX              SPACE=(CYL,(2,,1))
XXSYSLIN   DD   DSN=&LOADSET,DISP=(OLD,DELETE)
XX         DD   DDNAME=SYSIN
IEF236I ALLOC. FOR RMARNO05 LKED
IEF237I 131   ALLOCATED TO SYSLIB
IEF237I 132   ALLOCATED TO
IEF237I 360   ALLOCATED TO SYSPRINT
IEF237I 132   ALLOCATED TO SYSUT1
IEF237I 136   ALLOCATED TO SYSLMOD
IEF237I 135   ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                  KEPT
IEF285I   VOL SER NOS= MVT217.
IEF285I   FORTSUB                                       KEPT
IEF285I   VOL SER NOS= MVTRIF.
IEF285I   SYS74175.T085303.RV000.RMARN005.R0000716      DELETED
IEF285I   VOL SER NOS= MVTRIF.
IEF285I   SYS74175.T085303.RV000.RMARN005.GOSET         PASSED
IEF285I   VOL SER NOS= ADMF02.
IEF285I   SYS74175.T085303.RV000.RMARN005.LOADSET       DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /LKED     / START 74176.0046
IEF374I STEP /LKED     / STOP  74176.0047 CPU    0MIN 16.02SEC MAIN  68K
CHARGE    $         1.14 CPU TIME 00.00.16   REGION REQUESTED 0096K   STA
```

```
                         DISK     READER   PRINTER
I/O COUNTS                775       0        57
NO. OF DD CARDS             5       1         1
XXGO      EXEC  PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFT05F001 DD   DDNAME=SYSIN
XXFT06F001 DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXFT07F001 DD   SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN005 GO
IEF237I 136   ALLOCATED TO PGM=*.DD
IEF237I 360   ALLOCATED TO FT06F001
IEF237I 330   ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74175.T085303.RV000.RMARN005.GOSET          PASSED
IEF285I   VOL SER NOS= ADMP02.
IEF373I STEP /GO       / START 74176.0047
IEF374I STEP /GO       / STOP  74176.0742 CPU 414MIN 43.02SEC MAIN   70K
CHARGE    $      2181.36 CPU TIME 06.54.43   REGION REQUESTED 0071K   STA
                         DISK     READER   PRINTER   PUNCH
I/O COUNTS                  0       0       135       0
NO. OF DD CARDS             1       1         1       1
IEF285I   SYS74175.T085303.RV000.RMARN005.GOSET          DELETED
IEF285I   VOL SER NOS= ADMP02.
IEF375I  JOB /RMARN005/ START 74176.0035
IEF376I  JOB /RMARN005/ STOP  74176.0743 CPU 425MIN 19.34SEC
RMARN005 JOB CHARGE $   2321.743
```

```
COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                  SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YSTART(60)
      COMMON GM1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,NOFNS
      COMMON/UNITS/AR,FBC
      EXTERNAL FCT,ODECUT
      NOFNS=0
      N=60
      A=149597.9D6
      AR=1/A
      FB=86400
      FBC=FB*100
      FBCR=1/FBC
      XSTART=0
      SP=FB*400
      XEND=SP*2
      H=FB
      EPS=1D-11
      YSTART( 1)=A*( 0.31108140323844D0)
      YSTART( 2)=A*( 0.11449436182489D0)
      YSTART( 3)=A*( 0.02935912952266D0)
      YSTART( 4)=A*(-1.5331764888883D0)*FBCR
      YSTART( 5)=A*( 2.3917341877147D0)*FBCR
      YSTART( 6)=A*( 1.4383576749307D0)*FBCR
      YSTART( 7)=A*(-0.70382500973515D0)
      YSTART( 8)=A*( 0.11422571133584D0)
      YSTART( 9)=A*( 0.09592622740956D0)
      YSTART(10)=A*(-0.4132516063867D0)*FBCR
      YSTART(11)=A*(-1.8248851317911D0)*FBCR
      YSTART(12)=A*(-0.7962545666767D0)*FBCR
      YSTART(13)=A*( 0.96117879082728D0)
      YSTART(14)=A*(-0.27879403858068D0)
      YSTART(15)=A*(-0.12089770946864D0)
      YSTART(16)=A*( 0.4903573919908D0)*FBCR
      YSTART(17)=A*( 1.4987412182028D0)*FBCR
      YSTART(18)=A*( 0.6498347082385D0)*FBCR
      YSTART(19)=A*( 0.96256034373703D0)
      YSTART(20)=A*(-0.27907250279848D0)
      YSTART(21)=A*(-0.12086492978622D0)
      YSTART(22)=A*( 0.4962575385149D0)*FBCR
      YSTART(23)=A*( 1.5547478089230D0)*FBCR
      YSTART(24)=A*( 0.6788960737467D0)*FBCR
      YSTART(25)=A*( 1.2369892194946D0)
      YSTART(26)=A*(-0.5459472778250D0)
      YSTART(27)=A*(-0.2837925248384D0)
      YSTART(28)=A*( 0.6771081393610D0)*FBCR
      YSTART(29)=A*( 1.2539423985805D0)*FBCR
      YSTART(30)=A*( 0.5574096890441D0)*FBCR
      YSTART(31)=A*(-1.8610023309678D0)
      YSTART(32)=A*(-4.6105770804981D0)
      YSTART(33)=A*(-1.9324470947180D0)
      YSTART(34)=A*( 0.69923349853960D0)*FBCR
      YSTART(35)=A*(-0.20356349716635D0)*FBCR
      YSTART(36)=A*(-0.10441878303368D0)*FBCR
      YSTART(37)=A*( 4.5772282304695D0)
      YSTART(38)=A*( 7.3220809648558D0)
      YSTART(39)=A*( 2.8296311997242D0)
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          YSTART(40)=A*(-0.51146110540291D0)*FBCR
          YSTART(41)=A*( 0.25094791298046D0)*FBCR
          YSTART(42)=A*( 0.12588742437226D0)*FBCR
          YSTART(43)=A*(-17.862756257709D0)
          YSTART(44)=A*(-03.942997000301D0)
          YSTART(45)=A*(-01.475239412803D0)
          YSTART(46)=A*( 0.08743863144754D0)*FBCR
          YSTART(47)=A*(-0.36717358597909D0)*FBCR
          YSTART(48)=A*(-0.16212038139626D0)*FBCR
          YSTART(49)=A*(-14.217971166151D0)
          YSTART(50)=A*(-24.904770511434D0)
          YSTART(51)=A*(-09.844178452524D0)
          YSTART(52)=A*( 0.27580291303922D0)*FBCR
          YSTART(53)=A*(-0.13221274540371D0)*FBCR
          YSTART(54)=A*(-0.06110233341757D0)*FBCR
          YSTART(55)=A*(-30.133707975330D0)
          YSTART(56)=A*(-03.049032175568D0)
          YSTART(57)=A*( 08.168431948738D0)
          YSTART(58)=A*( 0.05155204581539D0)*FBCR
          YSTART(59)=A*(-0.31348842589775D0)*FBCR
          YSTART(60)=A*(-0.11451069390685D0)*FBCR
          GM1=-A**3* (.01720209895D0/FB)**2
          GM2=-GM1/5983000D0
          GM3=-GM1/408522D0
          GM4=-GM1/332945.56192544D0
          GM5=-GM1/27068807.130100D0
          GM6=-GM1/3098700D0
          GM7=-GM1/1047.3908D0
          GM8=-GM1/3499.2D0
          GM9=-GM1/22930D0
          GM10=-GM1/19260D0
          GM11=-GM1/1812000D0
          DO1J=1,2
          IF(J-1)1,1,2
    2     XSTART=XEND
          XEND=0
          H=-H
    1     CALL DDESP(SP,FCT,N,YSTART,XSTART,XEND,H,EPS,      DDEOUT)
          WRITE(6,97)NCFNS
   97     FORMAT(1H0,5X,36HTOTAL NO OF FUNCTION EVALUATIONS IS ,I6)
          STOP
          END
```

IN EFFECT*   NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

IN EFFECT*   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*   SOURCE STATEMENTS =   98 ,PROGRAM SIZE =   3108

ICS* NO DIAGNOSTICS GENERATED

ND OF COMPILATION ******   77K BYTES OF CORE

```
COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
      SUBROUTINE FCT(Y,X,DY)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DY(60),Y(60)
      COMMON GM1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,NOFNS
      NOFNS=NOFNS+1
      DY(1)=Y(4)
      DY(2)=Y(5)
      DY(3)=Y(6)
      DY(7)=Y(10)
      DY(8)=Y(11)
      DY(9)=Y(12)
      DY(13)=Y(16)
      DY(14)=Y(17)
      DY(15)=Y(18)
      DY(19)=Y(22)
      DY(20)=Y(23)
      DY(21)=Y(24)
      DY(25)=Y(28)
      DY(26)=Y(29)
      DY(27)=Y(30)
      DY(31)=Y(34)
      DY(32)=Y(35)
      DY(33)=Y(36)
      DY(37)=Y(40)
      DY(38)=Y(41)
      DY(39)=Y(42)
      DY(43)=Y(46)
      DY(44)=Y(47)
      DY(45)=Y(48)
      DY(49)=Y(52)
      DY(50)=Y(53)
      DY(51)=Y(54)
      DY(55)=Y(58)
      DY(56)=Y(59)
      DY(57)=Y(60)
      CA=-1.5D0
      R 2=(Y( 1)*Y( 1)+Y( 2)*Y( 2)+Y( 3)*Y( 3))**CA
      R 3=(Y( 7)*Y( 7)+Y( 8)*Y( 8)+Y( 9)*Y( 9))**CA
      R 4=(Y(13)*Y(13)+Y(14)*Y(14)+Y(15)*Y(15))**CA
      R 5=(Y(19)*Y(19)+Y(20)*Y(20)+Y(21)*Y(21))**CA
      R 6=(Y(25)*Y(25)+Y(26)*Y(26)+Y(27)*Y(27))**CA
      R 7=(Y(31)*Y(31)+Y(32)*Y(32)+Y(33)*Y(33))**CA
      R 8=(Y(37)*Y(37)+Y(38)*Y(38)+Y(39)*Y(39))**CA
      R 9=(Y(43)*Y(43)+Y(44)*Y(44)+Y(45)*Y(45))**CA
      R10=(Y(49)*Y(49)+Y(50)*Y(50)+Y(51)*Y(51))**CA
      R11=(Y(55)*Y(55)+Y(56)*Y(56)+Y(57)*Y(57))**CA
      RX 2 3=Y( 7)-Y( 1)
      RY 2 3=Y( 8)-Y( 2)
      RZ 2 3=Y( 9)-Y( 3)
      RX24  =Y(13)-Y( 1)
      RY24  =Y(14)-Y( 2)
      RZ24  =Y(15)-Y( 3)
      RX25  =Y(19)-Y( 1)
      RY25  =Y(20)-Y( 2)
      RZ25  =Y(21)-Y( 3)
      RX26  =Y(25)-Y( 1)
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      RY26  =Y(26)-Y( 2)
      RZ26  =Y(27)-Y( 3)
      RX27  =Y(31)-Y( 1)
      RY27  =Y(32)-Y( 2)
      RZ27  =Y(33)-Y( 3)
      RX28  =Y(37)-Y( 1)
      RY28  =Y(38)-Y( 2)
      RZ28  =Y(39)-Y( 3)
      RX29  =Y(43)-Y( 1)
      RY29  =Y(44)-Y( 2)
      RZ29  =Y(45)-Y( 3)
      RX 210=Y(49)-Y( 1)
      RY 210=Y(50)-Y( 2)
      RZ 210=Y(51)-Y( 3)
      RX211 =Y(55)-Y( 1)
      RY211 =Y(56)-Y( 2)
      RZ211 =Y(57)-Y( 3)
      RX34  =Y(13)-Y( 7)
      RY34  =Y(14)-Y( 8)
      RZ34  =Y(15)-Y( 9)
      RX35  =Y(19)-Y( 7)
      RY35  =Y(20)-Y( 8)
      RZ35  =Y(21)-Y( 9)
      RX36  =Y(25)-Y( 7)
      RY36  =Y(26)-Y( 8)
      RZ36  =Y(27)-Y( 9)
      RX37  =Y(31)-Y( 7)
      RY37  =Y(32)-Y( 8)
      RZ37  =Y(33)-Y( 9)
      RX38  =Y(37)-Y( 7)
      RY38  =Y(38)-Y( 8)
      RZ38  =Y(39)-Y( 9)
      RX39  =Y(43)-Y( 7)
      RY39  =Y(44)-Y( 8)
      RZ39  =Y(45)-Y( 9)
      RX310 =Y(49)-Y( 7)
      RY310 =Y(50)-Y( 8)
      RZ310 =Y(51)-Y( 9)
      RX311 =Y(55)-Y( 7)
      RY311 =Y(56)-Y( 8)
      RZ311 =Y(57)-Y( 9)
      RX45  =Y(19)-Y(13)
      RY45  =Y(20)-Y(14)
      RZ45  =Y(21)-Y(15)
      RX46  =Y(25)-Y(13)
      RY46  =Y(26)-Y(14)
      RZ46  =Y(27)-Y(15)
      RX47  =Y(31)-Y(13)
      RY47  =Y(32)-Y(14)
      RZ47  =Y(33)-Y(15)
      RX48  =Y(37)-Y(13)
      RY48  =Y(38)-Y(14)
      RZ48  =Y(39)-Y(15)
      RX49  =Y(43)-Y(13)
      RY49  =Y(44)-Y(14)
      RZ49  =Y(45)-Y(15)
      RX410 =Y(49)-Y(13)
      RY410 =Y(50)-Y(14)
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      RZ410 =Y(51)-Y(15)
      RX411 =Y(55)-Y(13)
      RY411 =Y(56)-Y(14)
      RZ411 =Y(57)-Y(15)
      RX56  =Y(25)-Y(19)
      RY56  =Y(26)-Y(20)
      RZ56  =Y(27)-Y(21)
      RX57  =Y(31)-Y(19)
      RY57  =Y(32)-Y(20)
      RZ57  =Y(33)-Y(21)
      RX58  =Y(37)-Y(19)
      RY58  =Y(38)-Y(20)
      RZ58  =Y(39)-Y(21)
      RX59  =Y(43)-Y(19)
      RY59  =Y(44)-Y(20)
      RZ59  =Y(45)-Y(21)
      RX510 =Y(49)-Y(19)
      RY510 =Y(50)-Y(20)
      RZ510 =Y(51)-Y(21)
      RX511 =Y(55)-Y(19)
      RY511 =Y(56)-Y(20)
      RZ511 =Y(57)-Y(21)
      RX67  =Y(31)-Y(25)
      RY67  =Y(32)-Y(26)
      RZ67  =Y(33)-Y(27)
      RX68  =Y(37)-Y(25)
      RY68  =Y(38)-Y(26)
      RZ68  =Y(39)-Y(27)
      RX69  =Y(43)-Y(25)
      RY69  =Y(44)-Y(26)
      RZ69  =Y(45)-Y(27)
      RX610 =Y(49)-Y(25)
      RY610 =Y(50)-Y(26)
      RZ610 =Y(51)-Y(27)
      RX611 =Y(55)-Y(25)
      RY611 =Y(56)-Y(26)
      RZ611 =Y(57)-Y(27)
      RX78  =Y(37)-Y(31)
      RY78  =Y(38)-Y(32)
      RZ78  =Y(39)-Y(33)
      RX79  =Y(43)-Y(31)
      RY79  =Y(44)-Y(32)
      RZ79  =Y(45)-Y(33)
      RX710 =Y(49)-Y(31)
      RY710 =Y(50)-Y(32)
      RZ710 =Y(51)-Y(33)
      RX711 =Y(55)-Y(31)
      RY711 =Y(56)-Y(32)
      RZ711 =Y(57)-Y(33)
      RX89  =Y(43)-Y(37)
      RY89  =Y(44)-Y(38)
      RZ89  =Y(45)-Y(39)
      RX810 =Y(49)-Y(37)
      RY810 =Y(50)-Y(38)
      RZ810 =Y(51)-Y(39)
      RX811 =Y(55)-Y(37)
      RY811 =Y(56)-Y(38)
      RZ811 =Y(57)-Y(39)
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```
      RX910 =Y(49)-Y(43)
      RY910 =Y(50)-Y(44)
      RZ910 =Y(51)-Y(45)
      RX911 =Y(55)-Y(43)
      RY911 =Y(56)-Y(44)
      RZ911 =Y(57)-Y(45)
      RX1011=Y(55)-Y(49)
      RY1011=Y(56)-Y(50)
      RZ1011=Y(57)-Y(51)
      R 2 3=(RX 2 3*RX 2 3+RY 2 3*RY 2 3+RZ 2 3*RZ 2 3)**CA
      R 2 4=(RX 2 4*RX 2 4+RY 2 4*RY 2 4+RZ 2 4*RZ 2 4)**CA
      R 2 5=(RX 2 5*RX 2 5+RY 2 5*RY 2 5+RZ 2 5*RZ 2 5)**CA
      R 2 6=(RX 2 6*RX 2 6+RY 2 6*RY 2 6+RZ 2 6*RZ 2 6)**CA
      R 2 7=(RX 2 7*RX 2 7+RY 2 7*RY 2 7+RZ 2 7*RZ 2 7)**CA
      R 2 8=(RX 2 8*RX 2 8+RY 2 8*RY 2 8+RZ 2 8*RZ 2 8)**CA
      R 2 9=(RX 2 9*RX 2 9+RY 2 9*RY 2 9+RZ 2 9*RZ 2 9)**CA
      R 210=(RX 210*RX 210+RY 210*RY 210+RZ 210*RZ 210)**CA
      R 211=(RX 211*RX 211+RY 211*RY 211+RZ 211*RZ 211)**CA
      R 3 4=(RX 3 4*RX 3 4+RY 3 4*RY 3 4+RZ 3 4*RZ 3 4)**CA
      R 3 5=(RX 3 5*RX 3 5+RY 3 5*RY 3 5+RZ 3 5*RZ 3 5)**CA
      R 3 6=(RX 3 6*RX 3 6+RY 3 6*RY 3 6+RZ 3 6*RZ 3 6)**CA
      R 3 7=(RX 3 7*RX 3 7+RY 3 7*RY 3 7+RZ 3 7*RZ 3 7)**CA
      R 3 8=(RX 3 8*RX 3 8+RY 3 8*RY 3 8+RZ 3 8*RZ 3 8)**CA
      R 3 9=(RX 3 9*RX 3 9+RY 3 9*RY 3 9+RZ 3 9*RZ 3 9)**CA
      R 310=(RX 310*RX 310+RY 310*RY 310+RZ 310*RZ 310)**CA
      R 311=(RX 311*RX 311+RY 311*RY 311+RZ 311*RZ 311)**CA
      R 4 5=(RX 4 5*RX 4 5+RY 4 5*RY 4 5+RZ 4 5*RZ 4 5)**CA
      R 4 6=(RX 4 6*RX 4 6+RY 4 6*RY 4 6+RZ 4 6*RZ 4 6)**CA
      R 4 7=(RX 4 7*RX 4 7+RY 4 7*RY 4 7+RZ 4 7*RZ 4 7)**CA
      R 4 8=(RX 4 8*RX 4 8+RY 4 8*RY 4 8+RZ 4 8*RZ 4 8)**CA
      R 4 9=(RX 4 9*RX 4 9+RY 4 9*RY 4 9+RZ 4 9*RZ 4 9)**CA
      R 410=(RX 410*RX 410+RY 410*RY 410+RZ 410*RZ 410)**CA
      R 411=(RX 411*RX 411+RY 411*RY 411+RZ 411*RZ 411)**CA
      R 5 6=(RX 5 6*RX 5 6+RY 5 6*RY 5 6+RZ 5 6*RZ 5 6)**CA
      R 5 7=(RX 5 7*RX 5 7+RY 5 7*RY 5 7+RZ 5 7*RZ 5 7)**CA
      R 5 8=(RX 5 8*RX 5 8+RY 5 8*RY 5 8+RZ 5 8*RZ 5 8)**CA
      R 5 9=(RX 5 9*RX 5 9+RY 5 9*RY 5 9+RZ 5 9*RZ 5 9)**CA
      R 510=(RX 510*RX 510+RY 510*RY 510+RZ 510*RZ 510)**CA
      R 511=(RX 511*RX 511+RY 511*RY 511+RZ 511*RZ 511)**CA
      R 6 7=(RX 6 7*RX 6 7+RY 6 7*RY 6 7+RZ 6 7*RZ 6 7)**CA
      R 6 8=(RX 6 8*RX 6 8+RY 6 8*RY 6 8+RZ 6 8*RZ 6 8)**CA
      R 6 9=(RX 6 9*RX 6 9+RY 6 9*RY 6 9+RZ 6 9*RZ 6 9)**CA
      R 610=(RX 610*RX 610+RY 610*RY 610+RZ 610*RZ 610)**CA
      R 611=(RX 611*RX 611+RY 611*RY 611+RZ 611*RZ 611)**CA
      R 7 8=(RX 7 8*RX 7 8+RY 7 8*RY 7 8+RZ 7 8*RZ 7 8)**CA
      R 7 9=(RX 7 9*RX 7 9+RY 7 9*RY 7 9+RZ 7 9*RZ 7 9)**CA
      R 710=(RX 710*RX 710+RY 710*RY 710+RZ 710*RZ 710)**CA
      R 711=(RX 711*RX 711+RY 711*RY 711+RZ 711*RZ 711)**CA
      R 8 9=(RX 8 9*RX 8 9+RY 8 9*RY 8 9+RZ 8 9*RZ 8 9)**CA
      R 810=(RX 810*RX 810+RY 810*RY 810+RZ 810*RZ 810)**CA
      R 811=(RX 811*RX 811+RY 811*RY 811+RZ 811*RZ 811)**CA
      R 910=(RX 910*RX 910+RY 910*RY 910+RZ 910*RZ 910)**CA
      R 911=(RX 911*RX 911+RY 911*RY 911+RZ 911*RZ 911)**CA
      R1011=(RX1011*RX1011+RY1011*RY1011+RZ1011*RZ1011)**CA
      WA=GM 2*R 2
      WB=GM 3*R 3
      WC=GM 4*R 4
      WD=GM 5*R 5
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```
0232          WE=GM 6*R 6
0233          WF=GM 7*R 7
0234          WG=GM 8*R 8
0235          WH=GM 9*R 9
0236          WI=GM10*R10
0237          WJ=GM11*R11
0238          WAX=Y( 1)*WA+Y( 7)*WB+Y(13)*WC+Y(19)*WD+Y(25)*WE+
             1     Y(31)*WF+Y(37)*WG+Y(43)*WH+Y(49)*WI+Y(55)*WJ
0239          WAY=Y( 2)*WA+Y( 8)*WB+Y(14)*WC+Y(20)*WD+Y(26)*WE+
             1     Y(32)*WF+Y(38)*WG+Y(44)*WH+Y(50)*WI+Y(56)*WJ
0240          WAZ=Y( 3)*WA+Y( 9)*WB+Y(15)*WC+Y(21)*WD+Y(27)*WE+
             1     Y(33)*WF+Y(39)*WG+Y(45)*WH+Y(51)*WI+Y(57)*WJ
0241          UA=GM 3*R 2 3
0242          UB=GM 4*R 2 4
0243          UC=GM 5*R 2 5
0244          UD=GM 6*R 2 6
0245          UE=GM 7*R 2 7
0246          UF=GM 8*R 2 8
0247          UG=GM 9*R 2 9
0248          UH=GM10*R 210
0249          UI=GM11*R 211
0250          UJ=GM1*R 2
0251          DY( 4)= UA*RX 2 3+UB*RX 2 4+UC*RX 2 5+UD*RX 2 6+
             1        UE*RX 2 7+UF*RX 2 8+UG*RX 2 9+UH*RX 210+
             2        UI*RX 211+Y( 1)*UJ      -WAX
0252          DY( 5)= UA*RY 2 3+UB*RY 2 4+UC*RY 2 5+UD*RY 2 6+
             1        UE*RY 2 7+UF*RY 2 8+UG*RY 2 9+UH*RY 210+
             2        UI*RY 211+Y( 2)*UJ      -WAY
0253          DY( 6)= UA*RZ 2 3+UB*RZ 2 4+UC*RZ 2 5+UD*RZ 2 6+
             1        UE*RZ 2 7+UF*RZ 2 8+UG*RZ 2 9+UH*RZ 210+
             2        UI*RZ 211+Y( 3)*UJ      -WAZ
0254          UA=GM 2*R 2 3
0255          UB=GM 4*R 3 4
0256          UC=GM 5*R 3 5
0257          UD=GM 6*R 3 6
0258          UE=GM 7*R 3 7
0259          UF=GM 8*R 3 8
0260          UG=GM 9*R 3 9
0261          UH=GM10*R 310
0262          UI=GM11*R 311
0263          UJ=GM1*R 3
0264          DY(10)=-UA*RX 2 3+UB*RX 3 4+UC*RX 3 5+UD*RX 3 6+
             1       UE*RX 3 7+UF*RX 3 8+UG*RX 3 9+UH*RX 310+
             2       UI*RX 311+Y( 7)*UJ      -WAX
0265          DY(11)=-UA*RY 2 3+UB*RY 3 4+UC*RY 3 5+UD*RY 3 6+
             1       UE*RY 3 7+UF*RY 3 8+UG*RY 3 9+UH*RY 310+
             2       UI*RY 311+Y( 8)*UJ      -WAY
0266          DY(12)=-UA*RZ 2 3+UB*RZ 3 4+UC*RZ 3 5+UD*RZ 3 6+
             1       UE*RZ 3 7+UF*RZ 3 8+UG*RZ 3 9+UH*RZ 310+
             2       UI*RZ 311+Y( 9)*UJ      -WAZ
0267          UA=GM 2*R 2 4
0268          UB=GM 3*R 3 4
0269          UC=GM 5*R 4 5
0270          UD=GM 6*R 4 6
0271          UE=GM 7*R 4 7
0272          UF=GM 8*R 4 8
0273          UG=GM 9*R 4 9
0274          UH=GM10*R 410
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```
275        UI=GM11*R 411
276        UJ=GM1*R 4
277        DY(16)=-UA*RX 2 4-UB*RX 3 4+UC*RX 4 5+UD*RX 4 6+
          1         UE*RX 4 7+UF*RX 4 8+UG*RX 4 9+UH*RX 410+
          2         UI*RX 411+Y(13)*UJ      -WAX
278        DY(17)=-UA*RY 2 4-UB*RY 3 4+UC*RY 4 5+UD*RY 4 6+
          1         UE*RY 4 7+UF*RY 4 8+UG*RY 4 9+UH*RY 410+
          2         UI*RY 411+Y(14)*UJ      -WAY
279        DY(18)=-UA*RZ 2 4-UB*RZ 3 4+UC*RZ 4 5+UD*RZ 4 6+
          1         UE*RZ 4 7+UF*RZ 4 8+UG*RZ 4 9+UH*RZ 410+
          2         UI*RZ 411+Y(15)*UJ      -WAZ
280        UA=GM 2*R 2 5
281        UB=GM 3*R 3 5
282        UC=GM 4*R 4 5
283        UD=GM 6*R 5 6
284        UE=GM 7*R 5 7
285        UF=GM 8*R 5 8
286        UG=GM 9*R 5 9
287        UH=GM10*R 510
288        UI=GM11*R 511
289        UJ=GM1*R 5
290        DY(22)=-UA*RX 2 5-UB*RX 3 5-UC*RX 4 5+UD*RX 5 6+
          1         UE*RX 5 7+UF*RX 5 8+UG*RX 5 9+UH*RX 510+
          2         UI*RX 511+Y(19)*UJ      -WAX
291        DY(23)=-UA*RY 2 5-UB*RY 3 5-UC*RY 4 5+UD*RY 5 6+
          1         UE*RY 5 7+UF*RY 5 8+UG*RY 5 9+UH*RY 510+
          2         UI*RY 511+Y(20)*UJ      -WAY
292        DY(24)=-UA*RZ 2 5-UB*RZ 3 5-UC*RZ 4 5+UD*RZ 5 6+
          1         UE*RZ 5 7+UF*RZ 5 8+UG*RZ 5 9+UH*RZ 510+
          2         UI*RZ 511+Y(21)*UJ      -WAZ
293        UA=GM 2*R 2 6
294        UB=GM 3*R 3 6
295        UC=GM 4*R 4 6
296        UD=GM 5*R 5 6
297        UE=GM 7*R 6 7
298        UF=GM 8*R 6 8
299        UG=GM 9*R 6 9
300        UH=GM10*R 610
301        UI=GM11*R 611
302        UJ=GM1*R 6
303        DY(28)=-UA*RX 2 6-UB*RX 3 6-UC*RX 4 6-UD*RX 5 6+
          1         UE*RX 6 7+UF*RX 6 8+UG*RX 6 9+UH*RX 610+
          2         UI*RX 611+Y(25)*UJ      -WAX
304        DY(29)=-UA*RY 2 6-UB*RY 3 6-UC*RY 4 6-UD*RY 5 6+
          1         UE*RY 6 7+UF*RY 6 8+UG*RY 6 9+UH*RY 610+
          2         UI*RY 611+Y(26)*UJ      -WAY
305        DY(30)=-UA*RZ 2 6-UB*RZ 3 6-UC*RZ 4 6-UD*RZ 5 6+
          1         UE*RZ 6 7+UF*RZ 6 8+UG*RZ 6 9+UH*RZ 610+
          2         UI*RZ 611+Y(27)*UJ      -WAZ
306        UA=GM 2*R 2 7
307        UB=GM 3*R 3 7
308        UC=GM 4*R 4 7
309        UD=GM 5*R 5 7
310        UE=GM 6*R 6 7
311        UF=GM 8*R 7 8
312        UG=GM 9*R 7 9
313        UH=GM10*R 710
314        UI=GM11*R 711
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0315      UJ=GM1*R 7
0316      DY(34)=-UA*RX 2 7-UB*RX 3 7-UC*RX 4 7-UD*RX 5 7-
         1          UE*RX 6 7+UF*RX 7 8+UG*RX 7 9+UH*RX 710+
         2          UI*RX 711+Y(31)*UJ       -WAX
0317      DY(35)=-UA*RY 2 7-UB*RY 3 7-UC*RY 4 7-UD*RY 5 7-
         1          UE*RY 6 7+UF*RY 7 8+UG*RY 7 9+UH*RY 710+
         2          UI*RY 711+Y(32)*UJ       -WAY
0318      DY(36)=-UA*RZ 2 7-UB*RZ 3 7-UC*RZ 4 7-UD*RZ 5 7-
         1          UE*RZ 6 7+UF*RZ 7 8+UG*RZ 7 9+UH*RZ 710+
         2          UI*RZ 711+Y(33)*UJ       -WAZ
0319      UA=GM 2*R 2 8
0320      UB=GM 3*R 3 8
0321      UC=GM 4*R 4 8
0322      UD=GM 5*R 5 8
0323      UE=GM 6*R 6 8
0324      UF=GM 7*R 7 8
0325      UG=GM 9*R 8 9
0326      UH=GM10*R 810
0327      UI=GM11*R 811
0328      UJ=GM1*R 8
0329      DY(40)=-UA*RX 2 8-UB*RX 3 8-UC*RX 4 8-UD*RX 5 8-
         1          UE*RX 6 8-UF*RX 7 8+UG*RX 8 9+UH*RX 810+
         2          UI*RX 811+Y(37)*UJ       -WAX
0330      DY(41)=-UA*RY 2 8-UB*RY 3 8-UC*RY 4 8-UD*RY 5 8-
         1          UE*RY 6 8-UF*RY 7 8+UG*RY 8 9+UH*RY 810+
         2          UI*RY 811+Y(38)*UJ       -WAY
0331      DY(42)=-UA*RZ 2 8-UB*RZ 3 8-UC*RZ 4 8-UD*RZ 5 8-
         1          UE*RZ 6 8-UF*RZ 7 8+UG*RZ 8 9+UH*RZ 810+
         2          UI*RZ 811+Y(39)*UJ       -WAZ
0332      UA=GM 2 *R 2 9
0333      UB=GM 3 *R 3 9
0334      UC=GM 4 *R 4 9
0335      UD=GM 5 *R 5 9
0336      UE=GM 6 *R 6 9
0337      UF=GM 7 *R 7 9
0338      UG=GM 8 *R 8 9
0339      UH=GM10 *R 910
0340      UI=GM11 *R 911
0341      UJ=GM1 *R 9
0342      DY(46)=-UA*RX 2 9-UB*RX 3 9-UC*RX 4 9-UD*RX 5 9-
         1          UE*RX 6 9-UF*RX 7 9-UG*RX 8 9+UH*RX 910+
         2          UI*RX 911+Y(43)*UJ       -WAX
0343      DY(47)=-UA*RY 2 9-UB*RY 3 9-UC*RY 4 9-UD*RY 5 9-
         1          UE*RY 6 9-UF*RY 7 9-UG*RY 8 9+UH*RY 910+
         2          UI*RY 911+Y(44)*UJ       -WAY
0344      DY(48)=-UA*RZ 2 9-UB*RZ 3 9-UC*RZ 4 9-UD*RZ 5 9-
         1          UE*RZ 6 9-UF*RZ 7 9-UG*RZ 8 9+UH*RZ 910+
         2          UI*RZ 911+Y(45)*UJ       -WAZ
0345      UA=GM 2*R 210
0346      UB=GM 3*R 310
0347      UC=GM 4*R 410
0348      UD=GM 5*R 510
0349      UE=GM 6*R 610
0350      UF=GM 7*R 710
0351      UG=GM 8*R 810
0352      UH=GM 9*R 910
0353      UI=GM11*R1011
0354      UJ=GM1*R10
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0355          DY(52)=-UA*RX 210-UB*RX 310-UC*RX 410-UD*RX 510-
             1          UE*RX 610-UF*RX 710-UG*RX 810-UH*RX 910+
             2          UI*RX1011+Y(49)*UJ      -WAX
0356          DY(53)=-UA*RY 210-UB*RY 310-UC*RY 410-UD*RY 510-
             1          UE*RY 610-UF*RY 710-UG*RY 810-UH*RY 910+
             2          UI*RY1011+Y(50)*UJ      -WAY
0357          DY(54)=-UA*RZ 210-UB*RZ 310-UC*RZ 410-UD*RZ 510-
             1          UE*RZ 610-UF*RZ 710-UG*RZ 810-UH*RZ 910+
             2          UI*RZ1011+Y(51)*UJ      -WAZ
0358          UA=GM 2*R 211
0359          UB=GM 3*R 311
0360          UC=GM 4*R 411
0361          UD=GM 5*R 511
0362          UE=GM 6*R 611
0363          UF=GM 7*R 711
0364          UG=GM 8*R 811
0365          UH=GM 9*R 911
0366          UI=GM10*R1011
0367          UJ=GM1*R11
0368          DY(58)=-UA*RX 211-UB*RX 311-UC*RX 411-UD*RX 511-
             1          UE*RX 611-UF*RX 711-UG*RX 811-UH*RX 911-
             2          UI*RX1011+Y(55)*UJ      -WAX
0369          DY(59)=-UA*RY 211-UB*RY 311-UC*RY 411-UD*RY 511-
             1          UE*RY 611-UF*RY 711-UG*RY 811-UH*RY 911-
             2          UI*RY1011+Y(56)*UJ      -WAY
0370          DY(60)=-UA*RZ 211-UB*RZ 311-UC*RZ 411-UD*RZ 511-
             1          UE*RZ 611-UF*RZ 711-UG*RZ 811-UH*RZ 911-
             2          UI*RZ1011+Y(57)*UJ      -WAZ
0371          RETURN
0372          END
S IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TICS*      SOURCE STATEMENTS =      371 ,PROGRAM SIZE =     12792

TICS*   NO  DIAGNOSTICS GENERATED

END OF COMPILATION ******
```

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1.7 ( JAN 73 )                                     OS/360  FORTRAN H

   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
002             SUBROUTINE DDESP(SP,FCT,N,Y,XI,XF,HI,EPS,      DDEOUT)
003             IMPLICIT REAL*8(A-H,O-Z)
004             DIMENSION Y(60)
005             EXTERNAL FCT,      DDEOUT
006             COMMON/DDESPC/NP,KOUNT
007             NP=1
008             KOUNT=0
009             IF(SP*(XF-XI))2,4,10
010      2      SP=DSIGN(SP,XF-XI)
011             GOTO10
012      4      IF(SP.NE.0D0)GOTO10
014             NP=0
015      10     CALL XDDE(SP,FCT,N,Y,XI,XF,HI,EPS,      DDEOUT)
016             RETURN
017             END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*      SOURCE STATEMENTS =      16 ,PROGRAM SIZE =       568

ICS*  NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                     93K BYTES OF CORE
```

```
     COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
0002             SUBROUTINE XDDE(SP,FCT,N,Y,XI,XF,HI,EPS,      DDEOUT)
0003             IMPLICIT REAL*8(A-H,O-Z)
0004             DIMENSION Y(60),
               1                     DY(60),S(60),R(60),YR(60)
0005             COMMON/DDESPC/NP,KCUNT
0006             COMMON/IPARAM/M,NMAX
0007             COMMON/DPARAM/DZOT,DP2,DEMAX,DEMIN,DHDIV,DZOTUP
0008             COMMON/DINFO/EX,ER,EH,NE,NERR
0009             COMMON/DOTPUT/SPPRT,HIPRT,XIPRT,XFPRT,EPSPRT,NPPRT,TITLE
0010             LOGICAL STYPE,KCNVF,TITLE
0011             EXTERNAL FCT,      DDEOUT
0012             DZOT=2.77D-17
0013             DP2=327680
0014             DEMAX=1
0015             DEMIN=1D-18
0016             DHDIV=1024
0017             DZOTUP=3.6D16
0018             M=6
0019             NMAX=60
0020             TITLE=.TRUE.
0021             STYPE=.TRUE.
0022             NPPRT=NP
0023             SPPRT=SP
0024             HIPRT=HI
0025             XIPRT=XI
0026             XFPRT=XF
0027             EPSPRT=EPS
0028             IF((N.LE.0).OR.(N.GT.NMAX))GOTO84
0030             IF((EPS.LT.DEMIN).OR.(EPS.GT.DEMAX))GOTO85
0032             TTL=XF-XI
0033             H=HI
0034             IF(TTL*H)86,87,12
0035       12    IF(((H/TTL)*DP2.LT.1.).OR.((H/TTL).GT.1.))GOTO88
0037             DO14I=1,N
0038             S(I)=DABS(Y(I))
0039       14    CONTINUE
0040             KCNVF=.TRUE.
0041             HMIN=H/DHDIV
0042             HMAX=TTL
0043             HP=0
0044             XP=XI
0045             X=XI
0046       20    IF((NP.EQ.0).AND.(.NOT.STYPE))GOTO50
0048             XPMX=XP-X
0049             FH=XPMX/H
0050             IF(FH.GT.DZOT)GOTO50
0052       30    IF(DABS(FH).GT.DZOT)GOTO34
0054             DO32I=1,N
0055             YR(I)=Y(I)
0056       32    CONTINUE
0057             HQ=HP
0058             XR=X
0059             GOTO36
0060       34    HQ=XPMX+HP
0061             HR=HQ
0062             XR=XT
```

```
      CALL DFEDIF(N,XR,YR,DY,HR,HQ,EPS,M,S,R,KONVF,FCT)
      HQ=XR-XT
   36 CALL FCT(YR,XR,DY)
      STYPE=.TRUE.
      CALL DDEOUT(YR,DY,N,XR,STYPE)
      STYPE=.FALSE.
      IF(KONVF)GOTO40
   38 IF(KONVF)GOTO70
      GOTO82
   40 IF((XF-XR)/TTL.LE.0.)GOTO70
      KOUNT=KOUNT+1
      XP=XI+      (KOUNT)*SP
      IF((XP-XF)/H.GT.0.)XP=XF
      GOTO20
   50 IF((DABS((X-XP)/H)).LE.DZOT)GOTO60
      CALL FCT(Y,X,DY)
      CALL DDEOUT(Y,DY,N,X,STYPE)
   60 IF((XF-X)/TTL.LE.0.)GOTO70
      IF(DABS(H).LT.HMIN)H=DSIGN(HMIN,H)
      IF(DABS(H).GT.HMAX)H=DSIGN(HMAX,H)
      IF((XF-X-H)/TTL.LT.0.)H=XF-X
      XT=X
      CALL DDESUB(N,X,Y,DY,H,HMIN,EPS,M,S,R,KONVF)
      HP=X-XT
      IF(KONVF)GOTO20
      GOTO80
   70 RETURN
   80 NERR=1
      ER=0
      DO81I=1,N
      IF(ER*S(I).GT.R(I))GOTO81
      ER=R(I)/S(I)
      NE=I
   81 CONTINUE
      EH=HP
      EX=X
      CALL FCT(Y,X,DY)
      CALL DDEOUT(Y,DY,N,X,STYPE)
      GOTO92
   82 NERR=1
      ER=0
      DO83I=1,N
      IF(ER*S(I).GE.R(I))GOTO83
      ER=R(I)/S(I)
      NE=I
   83 CONTINUE
      EH=HQ
      EX=XR
      GOTO92
   84 NERR=2
      GOTO90
   85 NERR=3
      GOTO90
   86 NERR=4
      GOTO90
   87 NERR=5
      GOTO90
   88 NERR=6
```

```
      90    CALL FCT(Y,XI,DY)
            CALL DDEOUT(Y,DY,N,XI,STYPE)
      92    CALL DERROR
            RETURN
            END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*      SOURCE STATEMENTS =      136 ,PROGRAM SIZE =      4148

ICS*   NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                        77K BYTES OF COR
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```
1.7 ( JAN 73 )                                    OS/360  FORTRAN H

   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
              SUBROUTINE DDESUB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF)
              IMPLICIT REAL*8(A-H,O-Z)
              LOGICAL KONVF
              DIMENSION Y(60),S(60),YA(60),SA(60),DZ(60),DY(60),R(60)
              COMMON/DDERCM/YA,SA,DZ,JMAX
              EXTERNAL FCT
              JMAX=JM+4
              DO100I=1,N
              YA(I)=Y(I)
              SA(I)=S(I)
        100   CONTINUE
              CALL FCT(Y,X,DZ)
              CALL DDERSB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
              RETURN
              END
 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
TICS*      SOURCE STATEMENTS =       15 ,PROGRAM SIZE =       686
TICS*  NO  DIAGNOSTICS GENERATED
END OF COMPILATION ******                                   93K BYTES OF COR
```

```
?1.7 ( JAN 73 )                                     OS/360  FORTRAN H

     CCMPILER CPTICNS - NAME=  MAIN,CPT=02,LINECNT=60,SIZE=C000K,
                          SOURCE,EBCDIC,NOLIST,NODECK,LCAD,NOMAP,NOEDIT,ID,NOXREF
0002            SUBRCUTINE CREDIF(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
0C03            IMPLICIT REAL*8(A-H,C-Z)
0004            LOGICAL KONVF
0005            DIMENSIGN Y(60),YA(60),SA(60),DZ(60),DY(6C),S(60),R(60)
0C06            COMMON/DDERCM/YA,SA,DZ,JMAX
0C07            EXTERNAL FCT
0C08            DO300I=1,N
0009            Y(I)=YA(I)
0010      300   CCNTINUE
0011            CALL DDERSB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
0012            RETURN
0013            END
S IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TICS*     SCLRCE STATEMENTS =      12 ,PROGRAM SIZE =      654

TICS*  NO  DIAGNOSTICS GENERATED

END CF CCMFILATICN ******                                     93K BYTES OF COR
```

```
  COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
            SUBROUTINE DDERSB(N,X,Y,DY,H,HMIN,EPS,JM,S,R,KONVF,FCT)
            IMPLICIT REAL*8(A-H,O-Z)
            DIMENSION Y(60),DY(60),S(60),R(60),YA(60),YL(60),YM(60),DZ(60),
           1SA(60),D(7),DT(60,7),YG(60,8),YH(60,8),SG(60,8)
            COMMON/DDERCM/YA,SA,DZ,JMAX
            COMMON/DPARAM/DZCT,DF2,DEMAX,DEMIN,DHDIV,DZOTUP
            LOGICAL KONVF,KONV,BO,BH
            EXTERNAL FCT
            DATA DT/420 *0D0/
      10    BH=.FALSE.
            KONVF=.TRUE.
      20    A=H+X
            BO=.FALSE.
            M=1
            JR=2
            JS=3
            JJ=0
            DO200J=1,JMAX
            IF(.NOT.BO)GOTO201
            D(2)=16D0/9D0
            D(4)=64D0/9D0
            D(6)=256D0/9D0
            GOTO202
     201    D(2)=9D0/4D0
            D(4)=9D0
            D(6)=36D0
     202    KONV=.TRUE.
            IF(J.LE.(JM/2))KONV=.FALSE.
            IF(J.LE.(JM+1))GOTO203
            L=JM+1
            DL=4D0*D(L-2)
            FC=.7071068D0*FC
            GOTO204
     203    L=J
            D(L)=M*M
            FC=1D0+        (JM+1-J)/6D0
     204    M=M+M
            G=H/M
            B=G+G
            IF((.NOT.BH).OR.(J.GE.(JMAX-1)))GOTO205
            DO210I=1,N
            YM(I)=YH(I,J)
            YL(I)=YG(I,J)
            S(I)=SG(I,J)
     210    CONTINUE
            GOTO206
     205    DO220I=1,N
            YL(I)=YA(I)
            YM(I)=YA(I)+G*DZ(I)
            S(I)=SA(I)
     220    CONTINUE
            KH=M/2
            XU=X
            DO230K=2,M
            XU=XU+G
            CALL FCT(YM,XU,DY)
```

```
            DO231I=1,N
            U=YL(I)+B*DY(I)
            YL(I)=YM(I)
            YM(I)=U
            U=DABS(U)
            IF(U.GT.S(I))S(I)=U
      231   CONTINUE
            IF((K.NE.KH).OR.(K.EQ.3))GOTO230
            JJ=1+JJ
            DO232I=1,N
            YH(I,JJ)=YM(I)
            YG(I,JJ)=YL(I)
            SG(I,JJ)=S(I)
      232   CONTINUE
      230   CONTINUE
      206   CALL FCT(YM,A,DY)
            DO240I=1,N
            V=DT(I,1)
            DT(I,1)=(YM(I)+YL(I)+G*DY(I))*.5D0
            C=DT(I,1)
            TA=C
            IF(L.LT.2)GOTO242
            IF((DABS(V)*DZOTUP.LT.DABS(C)).AND.(H.NE.HMIN).AND.(J.GT.JM/2+1))
           1GOTO30
            DO241K=2,L
            B1=D(K)*V
            B=B1-C
            U=V
            IF(B.EQ.0.)GOTO243
            B=(C-V)/B
            U=C*B
            C=B1*B
      243   V=DT(I,K)
            DT(I,K)=U
            TA=U+TA
      241   CONTINUE
      242   R(I)=DABS(Y(I)-TA)
            Y(I)=TA
            IF(R(I).GT.EPS*DABS(Y(I)))KONV=.FALSE.
      240   CONTINUE
            IF(KONV)GOTO40
            D(3)=4D0
            D(5)=16
            BO=(.NOT.BO)
            M=JR
            JR=JS
            JS=M+M
      200   CONTINUE
            BH=(.NOT.BH)
      30    IF(DABS(H).LE.HMIN)GOTO50
            H=H/2
            IF(DABS(H).GE.HMIN)GOTO20
            H=DSIGN(HMIN,H)
            GOTO10
      50    KONVF=.FALSE.
      40    H=FC*H
            X=A
            RETURN
```

```
C127            END
S IN EFFECT*        NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
S IN EFFECT*        SOURCE,EECDIC,NCLIST,NODECK,LOAC,NOMAP,NOEDIT,ID,NOXREF
TICS*      SOURCE STATEMENTS =      126 ,PROGRAM SIZE =     18356
TICS*  NC  DIAGNCSTICS GENERATED
END OF COMPILATION ******                                    73K BYTES OF COR
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```
     CCMPILER CPTICNS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                       SCURCE,EECDIC,NOLIST,NCDECK,LCAD,NOMAP,NOEDIT,ID,NOXREF
0002              SUBROUTINE DDEOUT(Y,DY,N,X,STYPE)
0003              IMPLICIT REAL*8(A-H,O-Z)
0004              DIMENSION Y(60),DY(60),Z(60)
0005              LOGICAL STYPE,TITLE
0006              CCMMCN/DCTPUT/SP,H,XI,XF,EPS,NP,TITLE
0007              COMMON/UNITS/AR,FBC
0008              IF(.NCT.TITLE)GOTO10
0010              TITLE=.FALSE.
0011              WRITE(6,89)N,XI,XF,EPS,H
0012              IF(NP.EQ.1)WRITE(6,88)SP
0014              WRITE(6,87)
0015      10      IF((NP.EQ.1).AND.STYPE)GOTO20
0017              RETURN
0018      20      DO999J=1,60
0019      999     Z(J)=Y(J)*AR
0020              DO998J=4,60,6
0021              Z(J)=Z(J)*FBC
0022              Z(J+1)=Z(J+1)*FBC
0023      998     Z(J+2)=Z(J+2)*FBC
0024              WRITE(6,85)X,(Z(I),I=1,N)
0025              RETURN
0026      89      FORMAT (1H1,10X,19HDE SCLUTICN FOR N =,I2,24H EQUATIONS FROM XSTAR
                 1T =,D12.5,10H TO XEND =,D12.5/8X,31HWITH LOCAL ERROR TOLERANCE EP
                 2=,1PD12.5,26H AND INITIAL STEP SIZE H =,0PD12.5, 1H./8X,44HPRINTIN
                 3G OCCURS AT EACH NATURAL STEP IN TIME)
0027      88      FCRMAT (1H+,52X,37HAND AT SPECIFIED POINTS (XSTART+K*SP)/8X,22HFOR
                 1 K=0,1.... AND SP =,D12.5,42H (SPECIFIED POINTS ARE IDENTIFIED WIT
                 2H *).)
0028      87      FCRMAT (1H0,14X,47HTHE OUTPUT COLUMNS ARE  X, Y(1), Y(2),...., Y(N)
                 1/)
0029      85      FCRMAT (1H ,4X,1H*,5X,4(D25.16   )/(36X,3(D25.16   )))
0030              END
 IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
 IN EFFECT*      SCURCE,EECDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ICS*     SOURCE STATEMENTS =       29 ,PROGRAM SIZE =      1560
ICS*  NO  DIAGNOSTICS GENERATED
ND OF CCMPILATICN ******                                   89K BYTES OF CORE
```

21.7 (JAN 73) OS/360 FORTRAN H

```
     COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
0002                 SUBROUTINE DERROR
0003                 IMPLICIT REAL*8(A-H,O-Z)
0004                 COMMON/DINFO/EX,ER,EH,NE,NERR
0005                 GOTO(10,20,30,40,50,60),NERR
0006        10       WRITE(6,91)EX,EH,ER,NE
0007        91       FORMAT (5H0****,5X,35HNO CONVERGENCE IN ABOVE STEP TO X =,D12.5, 
               1H WITH H=,D12.5, 1H,,5X, 4H****,/10X,22HTHE LIMITING ERROR IS ,
               2D12.5,13H IN EQUATION ,I2//)
0008                 RETURN
0009        20       WRITE(6,92)
0010        92       FORMAT(
               1        5H0****,5X,19HN.LT.0 .OR. N.GT.20,5X,4H****)
0011                 RETURN
0012        30       WRITE(6,93)
0013        93       FORMAT (5H0****,5X,29HEP.LT.1.D-18 .OR. EP.GT.1.D-2,5X,4H****)
0014                 RETURN
0015        40       WRITE(6,94)
0016        94       FORMAT (5H0****,5X,22HH*( XEND-XSTART).LT. 0,5X,4H****)
0017                 RETURN
0018        50       WRITE(6,95)
0019        95       FORMAT (5H0****,5X,21HH=0. .OR. XEND=XSTART,5X,4H****)
0020                 RETURN
0021        60       WRITE(6,96)
0022        96       FORMAT (5H0****,5X,48HH.LT.(XEND-XSTART)/2**15 .OR. H.GT.(XEND-XST
               1ART),5X,4H****)
0023                 RETURN
0024                 END

S IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

S IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TICS*     SOURCE STATEMENTS =       23 ,PROGRAM SIZE =       796

TICS*   NO  DIAGNOSTICS GENERATED

END OF COMPILATION ******                                        93K BYTES OF COR

TICS*   NO  DIAGNOSTICS THIS STEP
```

LAKEHEAD UNIVERSITY COMPUTER CENTRE

APPENDIX II C 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-11 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

* 0.0	0.311081403238440OD 00	0.114494361824890OD 00	0.293591295226599D-01
	-0.153317648888830OD 01	0.239173418771469SD 01	0.143835767493069D 01
	-0.703825009735149D 00	0.114225711335840OD 00	0.959262274095600OD-01
	-0.413251663866999D 00	-0.182488513179109D 01	-0.796254566676699 8D 00
	0.961178790827279D 00	-0.278794038580680OD 00	-0.120897709468640OD 00
	0.490357391990799 8D 00	0.149874121820280OD 01	0.649834708238499 7D 00
	0.963560343737029 9D 00	-0.279072502798480OD 00	-0.120864929786220OD 00
	0.496257538514899 9D 00	0.155474780892299SD 01	0.678896073746699 8D 00
	0.123698921949460OD 01	-0.545947277824999 9D 00	-0.283792524838400OD 00
	0.677108139360999 7D 00	0.125394239858049 9D 01	0.557409689044099 8D 00
	-0.186100233096779 9D 01	-0.461057708049810OD 01	-0.193244709471800OD 01
	0.699233498539599 7D 00	-0.203563497166349 9D 00	-0.104418783033680OD 00
	0.457722823046950OD 01	0.732208096485580OD 01	0.282963119972420OD 01
	-0.511461105402909 8D 00	0.250947912980459 9D 00	0.125887424372260OD 00
	-0.178627562577089 9D 02	-0.394299700030100OD 01	-0.147523941280300OD 01
	0.874386314475400OD-01	-0.367173585979089 9D 00	-0.162120381396259 9D 00
	-0.142179711661510OD 02	-0.249047705114339 9D 02	-0.984417845252400OD 01
	0.275802913039219 9D 00	-0.132212745403710OD 00	-0.611023334175699 7D-01
	-0.301337079753299 9D 02	-0.304903217556800OD 01	0.816843194873799 9D 01
	0.515520458153899 8D-01	-0.313488425897749 9D 00	-0.114510693906850OD 00

APPENDIX II C 2 (FORWARD INTEGRATION)

0.3456000000000000D 08	-0.2164575662130261D 00	-0.3695222102119170D 00	-0.1756572182848127D 00
	0.1921645829763880D 01	-0.9677389367414244D 00	-0.7156562332942281D 00
	0.2076299658117966D-01	0.6563621767947567D 00	0.2944686172892042D 00
	-0.2028855174956765D 01	-0.2945682245700744D-02	0.1268082361876220D 00
	0.9575404454246404D 00	0.2596598222540813D 00	0.1125943368369819D 00
	-0.5162937965622018D 00	0.1508593953120979D 01	0.6541409423366817D 00
	0.9556608771062695D 00	0.2579656946565440D 00	0.1116253027697306D 00
	-0.4765854795672406D 00	0.1471463724416111D 01	0.6401886828225953D 00
	-0.1650919483943023D 01	0.1200050124778341D-01	0.4980539622998984D-01
	0.2784378054684580D-01	-0.1163641888341726D 01	-0.5348782564249056D 00
	0.1077085121763585D 01	-0.4663516175829318D 01	-0.2026967979915026D 01
	0.7302877110644235D 00	0.1828255831268119D 00	0.6058337022355771D-01
	0.2408520871035908D 01	0.8084533650030353D 01	0.3238716455811828D 01
	-0.5673292132632202D 00	0.1279146961053474D 00	0.7743670157058940D-01
	-0.1744499221457130D 02	-0.5394093895942373D 01	-0.2116976892331349D 01
	0.1212386618795079D 00	-0.3579112232373830D 00	-0.1585417784022855D 00
	-0.1310287494650797D 02	-0.2541162818772212D 02	-0.1007986345552210D 02
	0.2816243722953693D 00	-0.1211715078790831D 00	-0.5671854470281350D-01
	-0.2990417074196513D 02	-0.4299652085852626D 01	0.7704474832339773D 01
	0.6319480076682760D-01	-0.3117281716732395D 00	-0.1174424055887005D 00
0.6912000000000000D 08	0.1071863847033992D 00	0.2588788691644700D 00	0.1276294694565397D 00
	-0.3198780312809992D 01	0.8533607585190308D 00	0.7855807940943204D 00
	0.7156604725246687D 00	0.1211967143244669D 00	0.9418073771930544D-02
	-0.3284784381027692D 00	0.1805033788646566D 01	0.8341595493246438D 00
	0.6207244596902459D 00	0.7067536284434595D 00	0.3064635086713453D 00
	-0.1367053738897797D 01	0.9848215333289814D 00	0.4271230629583776D 00
	0.6203973739721057D 00	0.7089778313887989D 00	0.3073902728113385D 00
	-0.1428731402935161D 01	0.9804607840121464D 00	0.4191320822067855D 00
	0.1071241351193261D 01	0.9098943193009693D 00	0.3889201860595466D 00
	-0.8943378178062505D 00	0.1033394508893351D 01	0.4983415566761101D 00
	0.3648442423716826D 01	-0.3188562856024265D 01	-0.1457059413799878D 01
	0.5145873917359681D 00	0.5377057856977590D 00	0.2180989033756610D 00
	0.8608120082137410D-01	0.8332391503469182D 01	0.3441685246858880D 01
	-0.5877184401314679D 00	-0.4807795349857341D-02	0.2344003627022172D-01
	-0.1689458032111245D 02	-0.6802790274459306D 01	-0.2742015202541743D 01
	0.1537100024682420D 00	-0.3460060959213858D 00	-0.1537841459139520D 00
	-0.1196586398024916D 02	-0.2587393439550515D 02	-0.1029782202811567D 02
	0.2867508698937584D 00	-0.1099528178381677D 00	-0.5224555223254537D-01
	-0.2962825533620474D 02	-0.5542237950566645D 01	0.7229040993877287D 01
	0.7472897676381620D-01	-0.3094819951574382D 00	-0.1202522856286949D 00

LAKEHEAD UNIVERSITY COMPUTER CENTRE APPENDIX II C 3

```
DE SOLUTION FOR N =60 EQUATICNS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-11 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEF IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

      THE CLTPUT CCLUMNS ARE  X, Y(1), Y(2),.... Y(N)

     0.6912000000000000D 08   0.1071863847033992D 00   0.2568788691644700D 00   0.1276294694565397D 00
                             -0.3198780312809992D 01   0.8533607585190308D 00   0.7855807940943204D 00
                              0.7156604725246687D 00   0.1211967143244669D 00   0.9418073771930544D-02
                             -0.3284784381027692D 00   C.1805033788646566D 01   0.8341559549324643 8D 00
                              0.6207244596902459D 00   0.7067536284434995D 00   0.3064635086713453D 00
                             -0.1367053738697797D 01   0.9848215333289814D 00   0.4271230629583776D 00
                              0.6203973739721057D 00   0.7089778313887989D 00   0.3073902728113385D 00
                             -0.1428731402935161D 01   0.9804607840121464D 00   0.4191320822067855D 00
                              0.1071241351193261D 01   0.9098943193009693D 00   0.3889201860595466D 00
                             -0.8943378178062505D 00   0.1033394508893351D 01   0.4983415566761101D 00
                              0.3648442423716826D 01  -0.3188562856024265D 01  -0.1457059413799878D 01
                              0.5145873917359681D 00   0.5377057856977590D 00   0.2180989033756610D 00
                              0.8608120082137410D-01   0.8332391503469182D 01   0.3441685246858880D 01
                             -0.5877184401314679D 00  -0.4807795349857341D-02   0.2344003627022172D-01
                             -0.1689458032111245D 02  -0.6802790274459306D 01  -0.2742015202541743D 01
                              0.1537100024682420D 00  -0.3460060959213858D 00  -0.1537841459139520D 00
                             -0.1196586398024916D 02  -0.2587393439550515D 02  -0.1029782202811567D 02
                              0.2867508698937584D 00  -0.1099528178381677D 00  -0.5224555223254537D-01
                             -0.2962825533620474D 02  -0.5542237950566645D 01   0.7229040993877287D 01
                              0.7472897676381620D-01  -0.3094819951574382D 00  -0.1202522856286949D 00
```

APPENDIX II C 4
(BACK WARD
INTEGRATION)

0.3456000000000000D 08	-0.2164575662157363D 00	-0.3695222102103281D 00	-0.1756572182836715D 00
	0.1921645829754686D 01	-0.9677389367578839D 00	-0.7156562333020621D 00
	0.2076299658692520D-01	0.6563621767940632D 00	0.2944686172886743D 00
	-0.2028855174957419D 01	-0.2945682231021953D-02	0.1268082361944734D 00
	0.9575404454253802D 00	0.2596598222494686D 00	0.1125943368349974D 00
	-0.5162937965518719D 00	0.1508593953126049D 01	0.6541409423392292D 00
	0.9556608770974608D 00	0.2579656946610735D 00	0.1116253027711814D 00
	-0.4765854797595054D 00	0.1471463724232405D 01	0.6401886827174060D 00
	-0.1650919483941644D 01	0.1200050125002105D-01	0.4980539623105345D-01
	0.2784378054444265D-01	-0.1163641888342333D 01	-0.5348782564249279D 00
	0.1077085121763481D 01	-0.4663516175828564D 01	-0.2026967979914833D 01
	0.7302877110642797D 00	0.1828255831266417D 00	0.6058337022352432D-01
	0.2408520871035417D 01	0.8084533650028168D 01	0.3238716455811554D 01
	-0.5673292132630152D 00	0.1279146961053818D 00	0.7743670157060930D-01
	-0.1744499221456672D 02	-0.5394093895942606D 01	-0.2116976892331169D 01
	0.1212386618794880D 00	-0.3579112232372016D 00	-0.1585417784022772D 00
	-0.1310287494649997D 02	-0.2541162818771578D 02	-0.1007986345551740D 02
	0.2816243722952009D 00	-0.1211715078790775D 00	-0.5671854470280620D-01
	-0.2990417074196079D 02	-0.4299652085852660D 01	0.7704474832336269D 01
	0.6319480076681620D-01	-0.3117281716729450D 00	-0.1174424055886876D 00
0.0	0.3110814032473133D 00	0.1144943618103811D 00	0.2935912951397758D-01
	-0.1533176488739047D 01	0.2391734187771502D 01	0.1438357674945523D 01
	-0.7038250097336290D 00	0.1142257113426654D 00	0.9592622741252770D-01
	-0.4132516064074929D 00	-0.1824885131787302D 01	-0.7962545666734542D 00
	0.9611787908200452D 00	-0.2787940385968307D 00	-0.1208977094756040D 00
	0.4903573920128588D 00	0.1498741218196015D 01	0.6498347082350195D 00
	0.9635603437266820D 00	-0.2790725028441757D 00	-0.1208649298084081D 00
	0.4962575393499132D 00	0.1554747808827264D 01	0.6788960737544604D 00
	0.1236989219487102D 01	-0.5459472778352515D 00	-0.2837925248427487D 00
	0.6771081393736786D 00	0.1253942398575844D 01	0.5574096890414952D 00
	-0.1861002330966465D 01	-0.4610577080495782D 01	-0.1932447094717437D 01
	0.6992334985390775D 00	-0.2035634971667348D 00	-0.1044187830338125D 00
	0.4577228230467218D 01	0.7322080964846491D 01	0.2829631199723461D 01
	-0.5114611054024420D 00	0.2509479129806176D 00	0.1258874243723615D 00
	-0.1786275625769927D 02	-0.3942997000301720D 01	-0.1475239412802386D 01
	0.8743863144749040D-01	-0.3671735859787552D 00	-0.1621203813962405D 00
	-0.1421797116615261D 02	-0.2490477051142227D 02	-0.9844178452516945D 01
	0.2758029130389431D 00	-0.1322127454037050D 00	-0.6110233341755460D-01
	-0.3013370797532401D 02	-0.3049032175569368D 01	0.8168431948730529D 01
	0.5155204581536405D-01	-0.3134884258972575D 00	-0.1145106939068290D 00

TOTAL NO OF FUNCTION EVALUATIONS IS 164126

```
$ 20.35.22 JOB   67 -- RMARN008 -- BEGINNING EXEC - INIT 8 - CLASS M
 *20.35.29 JOB   67 IEC020I 001-5,LUMON,330,FT05F001,330
 *20.35.30 JOB   67 IEC020I GET OR READ ISSUED AFTER END-OF-FILE
$ 20.35.37 JOB   67 END EXECUTION.
```

```
 HASP-II JOB STATISTICS --      25 CARDS READ --        33 LINES PRINTED -
```

APPENDIX 12

```
          $JOB
      1            IMPLICIT REAL*8(A-H,O-Z)
      2            PI=3.14159265358979323846D0
**WARNING**     REAL CONSTANT HAS MORE THAN 16 DIGITS. TRUNCATED TO 16
      3            F=180/PI
      4            XO= 0.1071 8782 8756 78D0
      5            YO= 0.2588 7850 9684 44D0
      6            ZO= 0.1276 2912 8612 58D0
      7            A=.0000 004D0
      8            B=.0000 005D0
      9            C=.0000 003D0
     10            XA= 0.1071 8782 8756 78D0-A
     11            YA= 0.2588 7850 9684 44D0+B
     12            ZA= 0.1276 2912 8612 58D0-C
     13            RO=(XO**2+YO**2+ZO**2)**.5D0
     14            RA=(XA**2+YA**2+ZA**2)**.5D0
     15            RB=((XO-XA)**2+(YO-YA)**2+(ZO-ZA)**2)**.5D0
     16            TH=DARCOS((RO**2+RA**2-RB**2)/(2D0*RO*RA))
     17            TH=TH*F*3600D0
     18            PRINT1,TH
     19      1     FORMAT(' ',F30.16)
     20            STOP
     21            END

          $ENTRY
             0.4619256923056402

CORE USAGE          OBJECT CODE=     1776 BYTES,ARRAY AREA=         0 BYTES,TO

DIAGNOSTICS           NUMBER OF ERRORS=        0, NUMBER OF WARNINGS=

COMPILE TIME=      1.29 SEC,EXECUTION TIME=      0.03 SEC,  WATFIV - VERSI
```

APPENDIX 13

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-12 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0.1,.... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.3110814032384400D 00	0.1144943618248900D 00	0.2935912952265999D-01
	-0.1533176488888300D 01	0.2391734187714699D 01	0.1438357674930699D 01
	-0.7038250097351499D 00	0.1142257113358400D 00	0.9592622740956000D-01
	-0.4132516063866999D 00	-0.1824885131791099D 01	-0.7962545666766998D 00
	0.9611787908272799D 00	-0.2787940385806800D 00	-0.1208977094686400D 00
	0.4903573919907998D 00	0.1498741218202800D 01	0.6498347082384997D 00
	0.9635603437370299D 00	-0.2790725027984800D 00	-0.1208649257862200D 00
	0.4962575385148999D 00	0.1554747808922999D 01	0.6788960737466998D 00
	0.1236989219494600D 01	-0.5459472778249999D 00	-0.2837925248384000D 00
	0.6771081393609997D 00	0.1253942398580499D 01	0.5574096890440998D 00
	-0.1861002330967799D 01	-0.4610577080498100D 01	-0.1932447094718000D 01
	0.6992334985395997D 00	-0.2035634971663499D 00	-0.1044187830336800D 00
	0.4577228230469500D 01	0.7322080964855800D 01	0.2829631199724200D 01
	-0.5114611054029098D 00	0.2509479129804599D 00	0.1258874243722600D 00
	-0.1786275625770899D 02	-0.3942997000301000D 01	-0.1475239412803000D 01
	0.8743863144754000D-01	-0.3671735859790899D 00	-0.1621203813962599D 00
	-0.1421797116615100D 02	-0.2490477051143399D 02	-0.9844178452524000D 01
	0.2758029130392199D 00	-0.1322127454037100D 00	-0.6110233341756997D-01
	-0.3013370797532999D 02	-0.3049032175568000D 01	0.8168431948737999D 01
	0.5155204581538998D-01	-0.3134884258977499D 00	-0.1145106939068500D 00

APPENDIX 13 2

0.3456000000000000D 08	-0.2164575662134224D 00	-0.3695222102117801D 00	-0.1756572182847081D 00
	0.1921645829762496D 01	-0.9677389367434614D 00	-0.7156562332951301D 00
	0.2076299657781490D-01	0.6563621767934984D 00	0.2944686172890416D 00
	-0.2028855174959226D 01	-0.2945682255585331D-02	0.1268082361836625D 00
	0.9575404454242832D 00	0.2596598222546835D 00	0.1125943368372436D 00
	-0.5162937965635200D 00	0.1508593953120699D 01	0.6541409423365461D 00
	0.9556608771061545D 00	0.2579656946568939D 00	0.1116253027699103D 00
	-0.4765854795635072D 00	0.1471463724420663D 01	0.6401886828253769D 00
	-0.1650919483942834D 01	0.1200050124764083D-01	0.4980539622995926D-01
	0.2784378054705053D-01	-0.1163641888341782D 01	-0.5348782564249268D 00
	0.1077085121763617D 01	-0.4663516175829269D 01	-0.2026967979915159D 01
	0.7302877110644130D 00	0.1828255831268021D 00	0.6058337022356177D-01
	0.2408520871035984D 01	0.8084533650026955D 01	0.3238716455811712D 01
	-0.5673292132632374D 00	0.1279146961053159D 00	0.7743670157057690D-01
	-0.1744499221457144D 02	-0.5394093895942436D 01	-0.2116976892331530D 01
	0.1212386618795056D 00	-0.3579112232373906D 00	-0.1585417784022842D 00
	-0.1310287494648196D 02	-0.2541162818772362D 02	-0.1007986345551656D 02
	0.2816243722953068D 00	-0.1211715078790746D 00	-0.5671854470281132D-01
	-0.2990417074196276D 02	-0.4299652085852598D 01	0.7704474832337997D 01
	0.6319480076682930D-01	-0.3117281716732851D 00	-0.1174424055886987D 00
0.6912000000000000D 08	0.1071863847059226D 00	0.2587886916383460D 00	0.1276294694559271D 00
	-0.3198780312801299D 01	0.8533607585393185D 00	0.7855807941045872D 00
	0.7156604725199683D 00	0.1211967143456120D 00	0.9418073781730362D-02
	-0.3284784381692720D 00	0.1805033788635835D 01	0.8341595493241903D 00
	0.6207244596879059D 00	0.7067536284448985D 00	0.3064635086719537D 00
	-0.1367053738900972D 01	0.9848215333254998D 00	0.4271230629568608D 00
	0.6203973739702310D 00	0.7089778313902178D 00	0.3073902728119898D 00
	-0.1428731402940536D 01	0.9804607840198589D 00	0.4191320822099250D 00
	0.1071241351191766D 01	0.9058943193020503D 00	0.3889201860602238D 00
	-0.8943378178077591D 00	0.1033394508892267D 01	0.4983415566757270D 00
	0.3648442423716668D 01	-0.3188562856024214D 01	-0.1457059413799920D 01
	0.5145873917359475D 00	0.5377057856977439D 00	0.2180989033756775D 00
	0.8608120082124430D-01	0.8332391503465552D 01	0.3441685246858358D 01
	-0.5877184401315445D 00	-0.4807795349971860D-02	0.2344003627015438D-01
	-0.1689458032111129D 02	-0.6802790274459277D 01	-0.2742015202541828D 01
	0.1537100024682370D 00	-0.3460060959213495D 00	-0.1537841459139454D 00
	-0.1196586398022581D 02	-0.2587393439550725D 02	-0.1029782202810930D 02
	0.2867508698936800D 00	-0.1099528178381470D 00	-0.5224555223253498D-01
	-0.2962825533620181D 02	-0.5542237950566922D 01	0.7229040993873661D 01
	0.7472897676382010D-01	-0.3094819951576309D 00	-0.1202522856286918D 00

LAKEHEAD UNIVERSITY COMPUTER CENTRE

APPENDIX 13 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EF = 1.00000D-12 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),..., Y(N)

0.69120000000000D 08	0.1071863847059226D 00	0.2588788691638346D 00	0.1276294694559271D 00
	-0.3198780312801299D 01	0.8533607585393185D 00	0.7855807941045872D 00
	0.7156604725199683D 00	0.1211967143456120D 00	0.9418073781730362D-02
	-0.3284784381692720D 00	0.1805033788635835D 01	0.8341599549324190 3D 00
	0.6207244596879059D 00	0.7067536284448985D 00	0.3064635086719537D 00
	-0.1367053738900972D 01	0.9848215333254998D 00	0.4271230629568608D 00
	0.6203973739702310D 00	0.7089778313902178D 00	0.3073902728119898D 00
	-0.1428731402940536D 01	0.9804607840198589D 00	0.4191320822099250D 00
	0.1071241351191766D 01	0.9098943193020503D 00	0.3889201860602238D 00
	-0.8943378178077591D 00	0.1033394508892267D 01	0.4983415566757270D 00
	0.3648442423716668D 01	-0.3188562856024214D 01	-0.1457059413799920D 01
	0.5145873917359475D 00	0.5377057856977439D 00	0.2180989033756775D 00
	0.8608120082124430D-01	0.8332391503465552D 01	0.3441685246858358D 01
	-0.5877184401315445D 00	-0.4807795349971860D-02	0.2344003627015438D-01
	-0.1689458032111129D 02	-0.6802790274459277D 01	-0.2742015202541828D 01
	0.1537100024682370D 00	-0.3460060959213495D 00	-0.1537841459139454D 00
	-0.1196586398022581D 02	-0.2587393439550725D 02	-0.1029782202810930D 02
	0.2867508698936800D 00	-0.1099528178381470D 00	-0.5224555223253498D-01
	-0.2962825533620181D 02	-0.5542237950566922D 01	0.7229040993873661D 01
	0.7472897676382010D-01	-0.3094819951576309D 00	-0.1202522856286918D 00

APPENDIX 13 4

0.3456000000000000D 08	-0.2164575662164594D 00	-0.3695222102099010D 00	-0.1756572182833528D 00
	0.1921645829752551D 01	-0.9677389367620644D 00	-0.7156562333042653D 00
	0.2076299658310582D-01	0.6563621767926482D 00	0.2944686172883652D 00
	-0.2028855174960371D 01	-0.2945682241826817D-02	0.1268062361898328D 00
	0.9575404454256349D 00	0.2596598222474243D 00	0.1125943368341098D 00
	-0.5162937965500685D 00	0.1508593953125337D 01	0.6541409423387606D 00
	0.9556608771052766D 00	0.2579656946517746D 00	0.1116253027675730D 00
	-0.4765854795968278D 00	0.1471463724381955D 01	0.6401886828027825D 00
	-0.1650919483941172D 01	0.1200050125038187D-01	0.4980539623114998D-01
	0.2784378054409794D-01	-0.1163641888342531D 01	-0.5348782564250559D 00
	0.1077085121763528D 01	-0.4663516175828391D 01	-0.2026967979914773D 01
	0.7302877110642577D 00	0.1828255831266003D 00	0.6058337022352464D-01
	0.2408520871035143D 01	0.8084533650020413D 01	0.3238716455811163D 01
	-0.5673292132629852D 00	0.1279146961053997D 00	0.7743670157062220D-01
	-0.1744495221456618D 02	-0.5394093895942203D 01	-0.2116976892331229D 01
	0.1212386618794806D 00	-0.3579112232372590D 00	-0.1585417784022711D 00
	-0.1310287494647499D 02	-0.2541162818771927D 02	-0.1007986345551176D 02
	0.2816243722951127D 00	-0.1211715078790681D 00	-0.5671854470279748D-01
	-0.2990417074195889D 02	-0.4299652085852395D 01	0.7704474832332031D 01
	0.6319480076681560D-01	-0.3117281716731266D 00	-0.1174424055886829D 00
0.0	0.3110814032486045D 00	0.1144943618083626D 00	0.2935912951273796D-01
	-0.1533176488717525D 01	0.2391734187779309D 01	0.1438357674947716D 01
	-0.7038250097280770D 00	0.1142257113588716D 00	0.9592622741947930D-01
	-0.4132516064594510D 00	-0.1824885131781798D 01	-0.7962545666681092D 00
	0.9611787908171751D 00	-0.2787940386042680D 00	-0.1208977094788997D 00
	0.4903573920335305D 00	0.1498741218191401D 01	0.6498347082335118D 00
	0.9635603437259664D 00	-0.2790725028312110D 00	-0.1208649298012071D 00
	0.4962575388092541D 00	0.1554747808882494D 01	0.6788960737450972D 00
	0.1236989219485265D 01	-0.5459472778377826D 00	-0.2837925248439049D 00
	0.6771081393766984D 00	0.1253942398574748D 01	0.5574096890408260D 00
	-0.1861002330966789D 01	-0.4610577080495272D 01	-0.1932447094717026D 01
	0.6992334985392544D 00	-0.2035634971668252D 00	-0.1044187830338372D 00
	0.4577228230466619D 01	0.7322080964841160D 01	0.2829631199722869D 01
	-0.5114611054023319D 00	0.2509479129807539D 00	0.1258874243724479D 00
	-0.1786275625769841D 02	-0.3942997000301164D 01	-0.1475239412802463D 01
	0.8743863144747640D-01	-0.3671735859788028D 00	-0.1621203813962357D 00
	-0.1421797116612886D 02	-0.2490477051142626D 02	-0.9844178452507915D 01
	0.2758029130388489D 00	-0.1322127454037025D 00	-0.6110233341754644D-01
	-0.3013370797531913D 02	-0.3049032175568375D 01	0.8168431948724659D 01
	0.5155204581535712D-01	-0.3134884258973793D 00	-0.1145106939068248D 00

TOTAL NO OF FUNCTION EVALUATIONS IS 205686

APPENDIX 14 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.3110814032238440D 00	0.1144943618248900D 00	0.2935912952265999D-01
	-0.1533176488888300D 01	0.2391734187714699D 01	0.1438357674930699D 01
	-0.7038250097351499D 00	0.1142257113358400D 00	0.9592622740956000D-01
	-0.4132516063866999D 00	-0.1824885131791099D 01	-0.7962545666766998D 00
	0.9611787908272799D 00	-0.2787940385806800D 00	-0.1208977094686400D 00
	0.4903573919907998D 00	0.1498741218202800D 01	0.6498347082384997D 00
	0.9635603437370299D 00	-0.2790725027984800D 00	-0.1208649297862200D 00
	0.4962575385148999D 00	0.1554747808922999D 01	0.6788960737466998D 00
	0.1236989219494600D 01	-0.5459472778249999D 00	-0.2837925248384000D 00
	0.6771081393609997D 00	0.1253942398580499D 01	0.5574096890440998D 00
	-0.1861002330967799D 01	-0.4610577080498100D 01	-0.1932447094718000D 01
	0.6992334985395997D 00	-0.2035634971663499D 00	-0.1044187830336800D 00
	0.4577228230469500D 01	0.7322080964855800D 01	0.2829631199724200D 01
	-0.5114611054029098D 00	0.2509479129804599D 00	0.1258874243722600D 00
	-0.1786275625770899D 02	-0.3942997000301000D 01	-0.1475239412803000D 01
	0.8743863144754000D-01	-0.3671735859790899D 00	-0.1621203813962599D 00
	-0.1421797116615100D 02	-0.2490477051143399D 02	-0.9844178452524000D 01
	0.2758029130392199D 00	-0.1322127454037100D 00	-0.6110233341756997D-01
	-0.3013370797532999D 02	-0.3049032175568000D 01	0.8168431948737999D 01
	0.5155204581538998D-01	-0.3134884258977499D 00	-0.1145106939068500D 00

APPENDIX 14 2

0.3456000000000000D 08	-0.2164575662139254D 00	-0.3695222102115106D 00	-0.1756572182845117D 00
	0.1921645829760743D 01	-0.9677389367464828D 00	-0.7156562332967041D 00
	0.2076299657905860D-01	0.6563621767937512D 00	0.2944686172890727D 00
	-0.2028855174958721D 01	-0.2945682252313790D-02	0.1268082361851052D 00
	0.9575404454247131D 00	0.2596598222539336D 00	0.1125943368369157D 00
	-0.5162937965638474D 00	0.1508593953118992D 01	0.6541409423355327D 00
	0.9556608771150984D 00	0.2579656946483746D 00	0.1116253027666283D 00
	-0.4765854793855641D 00	0.1471463724584434D 01	0.6401886829191565D 00
	-0.1650919483943335D 01	0.1200050124832476D-01	0.4980539623028157D-01
	0.2784378054629025D-01	-0.1163641888341580D 01	-0.5348782564248036D 00
	0.1077085121763646D 01	-0.4663516175829589D 01	-0.2026967979915169D 01
	0.7302877110644570D 00	0.1828255831267706D 00	0.6058337022354771D-01
	0.2408520871036282D 01	0.8084533650030387D 01	0.3238716455811825D 01
	-0.5673292132632183D 00	0.1279146961053417D 00	0.7743670157058900D-01
	-0.1744499221457150D 02	-0.5394093895942526D 01	-0.2116976892331633D 01
	0.1212386618795022D 00	-0.3579112232374344D 00	-0.1585417784022926D 00
	-0.1310287494649424D 02	-0.2541162818772238D 02	-0.1007986345552190D 02
	0.2816243722953592D 00	-0.1211715078790752D 00	-0.5671854470281349D-01
	-0.2990417074196545D 02	-0.4299652085852697D 01	0.7704474832337289D 01
	0.6319480076683140D-01	-0.3117281716733125D 00	-0.1174424055887027D 00
0.6912000000000000D 08	0.1071863847076324D 00	0.2588788691633868D 00	0.1276294694555381D 00
	-0.3198780312795425D 01	0.8533607585533371D 00	0.7855807941112823D 00
	0.7156604725214943D 00	0.1211967143394187D 00	0.9418073778824160D-02
	-0.3284784381495202D 00	0.1805033788638665D 01	0.8341595493242187D 00
	0.6207244596928686D 00	0.7067536284426916D 00	0.3064635086710958D 00
	-0.1367053738899143D 01	0.9848215333546908D 00	0.4271230629691368D 00
	0.6203973738887392D 00	0.7089778313812867D 00	0.3073902727996567D 00
	-0.1428731402644418D 01	0.9804607821031007D 00	0.4191320814127341D 00
	0.1071241351194715D 01	0.9098943192994793D 00	0.3889201860589891D 00
	-0.8943378178047018D 00	0.1033394508894656D 01	0.4983415566766946D 00
	0.3648442423717173D 01	-0.3188562856024824D 01	-0.1457059413800090D 01
	0.5145873917360564D 00	0.5377057856976610D 00	0.2180989033756276D 00
	0.8608120082160630D-01	0.8332391503470678D 01	0.3441685246858872D 01
	-0.5877184401315311D 00	-0.4807795349835673D-02	0.2344003627023598D-01
	-0.1689458032111380D 02	-0.6802790274459683D 01	-0.2742015202542084D 01
	0.1537100024682340D 00	-0.3460060959213934D 00	-0.1537841459139551D 00
	-0.1196586398023899D 02	-0.2587393439550687D 02	-0.1029782202811748D 02
	0.2867508698937790D 00	-0.1099528178381574D 00	-0.5224555223249745D-01
	-0.2962825533620499D 02	-0.5542237950567332D 01	0.7229040993874146D 01
	0.7472897676381930D-01	-0.3094819951576984D 00	-0.1202522856286983D 00

APPENDIX 14 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),..., Y(N)

0.69120000000000000D 08	0.1071863847076324D 00	0.2568788691633868D 00	0.1276294694555381D 00
	-0.3198780312795425D 01	0.8533607585533371D 00	0.7855807941112823D 00
	0.7156604725214943D 00	0.1211967143394187D 00	0.9418073778824160D-02
	-0.3284784381495202D 00	0.1805033788638665D 01	0.8341595493242187D 00
	0.6207244596928686D 00	0.7067536284426916D 00	0.3064635086710958D 00
	-0.1367053738899143D 01	0.9848215333546908D 00	0.4271230629691368D 00
	0.6203973738887392D 00	0.7089778313812867D 00	0.3073902727996567D 00
	-0.1423731402644418D 01	0.9804607821031007D 00	0.4191320814127341D 00
	0.1071241351194715D 01	0.9098943192994793D 00	0.3889201860589891D 00
	-0.8943378178047018D 00	0.1033394508894656D 01	0.4983415566766946D 00
	0.3648442423717173D 01	-0.3188562856024824D 01	-0.1457059413800090D 01
	0.5145873917360564D 00	0.5377057856976610D 00	0.2180989033756276D 00
	0.8608120082160630D-01	0.8332391503470678D 01	0.3441685246858872D 01
	-0.5877184401315311D 00	-0.4807795349835673D-02	0.2344003627023598D-01
	-0.1689458032111330D 02	-0.6802790274459683D 01	-0.2742015202542084D 01
	0.1537100024682340D 00	-0.3460060959213934D 00	-0.1537841459139551D 00
	-0.1196586398023899D 02	-0.2587393439550687D 02	-0.1029782202811748D 02
	0.2867508698937790D 00	-0.1099528178381574D 00	-0.5224552232497450D-01
	-0.2962825533620499D 02	-0.5542237950567332D 01	0.7229040993874146D 01
	0.7472897676381930D-01	-0.3094819951576984D 00	-0.1202522856286983D 00

APPENDIX 14 4

0.3456000000000000D 08	-0.2164575662160106D 00	-0.3695222102102750D 00	-0.1756572182836377D 00
	0.1921645829753833D 01	-0.9677389367591237D 00	-0.7156562333027496D 00
	0.2076299658232295D-01	0.6563621767937036D 00	0.2944686172887605D 00
	-0.2028855174958491D 01	-0.2945682244413411D-02	0.1268082361888499D 00
	0.9575404454233378D 00	0.2596598222511878D 00	0.1125943368356666D 00
	-0.5162937966018293D 00	0.1508593953077860D 01	0.6541409423119499D 00
	0.3556608772950769D 00	0.2579656944703101D 00	0.1116253026991751D 00
	-0.4765854756043468D 00	0.1471463728117481D 01	0.6401886849394545D 00
	-0.1650919483942424D 01	0.1200050124972617D-01	0.4980539623080731D-01
	0.2784378054472515D-01	-0.1163641888341979D 01	-0.5348782564248210D 00
	0.1077085121763712D 01	-0.4663516175829006D 01	-0.2026967979914936D 01
	0.7302877110643405D 00	0.1828255831266327D 00	0.6058337022353552D-01
	0.2408520871035562D 01	0.8084533650028551D 01	0.3238716455811585D 01
	-0.5673292132631276D 00	0.1279146961053627D 00	0.7743670157059600D-01
	-0.1744499221456910D 02	-0.5394093895942461D 01	-0.2116976892331434D 01
	0.1212386618754869D 00	-0.3579112232373247D 00	-0.1585417784022782D 00
	-0.1310287494648956D 02	-0.2541162818771957D 02	-0.1007986345551841D 02
	0.2816243722952450D 00	-0.1211715078790697D 00	-0.5671854470275985D-01
	-0.2990417074195861D 02	-0.4299652085852600D 01	0.7704474832333922D 01
	0.6319480076681690D-01	-0.3117281716731952D 00	-0.1174424055886924D 00
0.0	0.3110814032450446D 00	0.1144943618141521D 00	0.2935912951623049D-01
	-0.1533176488777543D 01	0.2391734187756560D 01	0.1438357674941719D 01
	-0.7038250097322811D 00	0.1142257113444529D 00	0.9592622741333800D-01
	-0.4132516064137909D 00	-0.1824885131788302D 01	-0.7962545666734651D 00
	0.9611787908345940D 00	-0.2787940385635082D 00	-0.1208977094606108D 00
	0.4903573917925390D 00	0.1498741218221026D 01	0.6498347082341742D 00
	0.9635603436672378D 00	-0.2790725033059275D 00	-0.1208649300515515D 00
	0.4962575534249072D 00	0.1554747807530536D 01	0.6788960741694208D 00
	0.1236989219487105D 01	-0.5459472778345122D 00	-0.2837925248424181D 00
	0.6771081393730258D 00	0.1253942398576543D 01	0.5574096890417887D 00
	-0.1861002330966920D 01	-0.4610577080495737D 01	-0.1932447094717318D 01
	0.6992334985393290D 00	-0.2035634971666895D 00	-0.1044187830337789D 00
	0.4577228230467907D 01	0.7322080964849883D 01	0.2829631199723673D 01
	-0.5114611054026134D 00	0.2509479129805487D 00	0.1258874243723117D 00
	-0.1786275625770259D 02	-0.3942997000301208D 01	-0.1475239412802607D 01
	0.8743863144749950D-01	-0.3671735859788828D 00	-0.1621203813962408D 00
	-0.1421797116614291D 02	-0.2490477051142701D 02	-0.9844178452517989D 01
	0.2758029130389555D 00	-0.1322127454036963D 00	-0.6110233341751142D-01
	-0.3013370797531926D 02	-0.3049032175568310D 01	0.8168431948729586D 01
	0.5155204581539639D-01	-0.3134884258975163D 00	-0.1145106939067878D 00

TOTAL NO OF FUNCTION EVALUATIONS IS 137481

APPENDIX 15 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-09 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,.... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.3110814032384400D 00	0.1144943618248900D 00	0.2935912952265999D-01
	-0.1533176488888300D 01	0.2391734187714699D 01	0.1438357674930699D 01
	-0.7038250097351499D 00	0.1142257113358400D 00	0.9592622740956000D-01
	-0.4132516063866999D 00	-0.1824885131791099D 01	-0.7962545666766998D 00
	0.9611787908272799D 00	-0.2787940385806800D 00	-0.1208977094686400D 00
	0.4903573919907998D 00	0.1498741218202800D 01	0.6498347082384997D 00
	0.9635603437370299D 00	-0.2790725027984800D 00	-0.1208649297862200D 00
	0.4962575385148999D 00	0.1554747808922999D 01	0.6788960737466998D 00
	0.1236989219494600D 01	-0.5459472778249999D 00	-0.2837925248384000D 00
	0.6771081393609997D 00	0.1253942398580499D 01	0.5574096890440998D 00
	-0.1861002330967799D 01	-0.4610577080493100D 01	-0.1932447094718000D 01
	0.6992334985395997D 00	-0.2035634971663499D 00	-0.1044187830336800D 00
	0.4577228230469500D 01	0.7322080964855800D 01	0.2829631199724200D 01
	-0.5114611054029098D 00	0.2509479129804599D 00	0.1258874243722600D 00
	-0.1786275625770899D 02	-0.3942997000301000D 01	-0.1475239412803000D 01
	0.8743363144754000D-01	-0.3671735859790899D 00	-0.1621203813962599D 00
	-0.1421797116615100D 02	-0.2490477051143399D 02	-0.9844178452524000D 01
	0.2758029130392199D 00	-0.1322127454037100D 00	-0.6110233341756997D-01
	-0.3013370797532999D 02	-0.3049032175568000D 01	0.8168431948737999D 01
	0.5155204581538998D-01	-0.3134864258977499D 00	-0.1145106939068500D 00

APPENDIX 15 2

0.3456000000000000D 08	-0.2164575662139891D 00	-0.3695222102116035D 00	-0.1756572182845479D 00
	0.1921645829760245D 01	-0.9677389367465243D 00	-0.7156562332966375D 00
	0.2076299657913974D-01	0.6563621767937986D 00	0.2944686172890899D 00
	-0.2028855174958575D 01	-0.2945682251988717D-02	0.1268082361852263D 00
	0.9575404454267241D 00	0.2596598222484721D 00	0.1125943368342996D 00
	-0.5162937965652947D 00	0.1508593953107433D 01	0.6541409423278994D 00
	0.9556608771759190D 00	0.2579656945794845D 00	0.1116253027372854D 00
	-0.4765854783310157D 00	0.1471463725778308D 01	0.6401886836323152D 00
	-0.1659919483943432D 01	0.1200050124842676D-01	0.4980539623029324D-01
	0.2784378054616287D-01	-0.1163641888341525D 01	-0.5348782564248544D 00
	0.1077085121763593D 01	-0.4663516175829547D 01	-0.2026967979915184D 01
	0.7302877110644590D 00	0.1828255831267881D 00	0.6058337022355037D-01
	0.2408520871036130D 01	0.8084533650031203D 01	0.3238716455811848D 01
	-0.5673292132632371D 00	0.1279146961053486D 00	0.7743670154844440D-01
	-0.1744499221457333D 02	-0.5394093895942560D 01	-0.2116976892331483D 01
	0.1212386618795038D 00	-0.3579112232374464D 00	-0.1585417784022961D 00
	-0.1310287494649667D 02	-0.2541162818772100D 02	-0.1007986345552218D 02
	0.2816243722953646D 00	-0.1211715078790765D 00	-0.5671854470281399D-01
	-0.2990417074196706D 02	-0.4299652085852686D 01	0.7704474832339776D 01
	0.6319480076683160D-01	-0.3117281716733418D 00	-0.1174424055887017D 00
0.6912000000000000D 08	0.1071863847117597D 00	0.2588788691623170D 00	0.1276294694545322D 00
	-0.3198780312781505D 01	0.8533607585869726D 00	0.7855807941278521D 00
	0.7156604725215964D 00	0.1211967143386728D 00	0.9418073778485513D-02
	-0.3284784381472378D 00	0.1805033788639248D 01	0.8341595493242539D 00
	0.6207244597204069D 00	0.7067536284262361D 00	0.3064635086632312D 00
	-0.1367053738854740D 01	0.9848215333705437D 00	0.4271230629764930D 00
	0.6203973740131328D 00	0.7089778313644495D 00	0.3073902727991099D 00
	-0.1428731403136203D 01	0.9804607839787479D 00	0.4191320821555530D 00
	0.1071241351197116D 01	0.9098943192978607D 00	0.3889201860582275D 00
	-0.8943378178023948D 00	0.1033394508895896D 01	0.4983415566771731D 00
	0.3648442423717250D 01	-0.3188562856024706D 01	-0.1457059413800089D 01
	0.5145873917361157D 00	0.5377057856976967D 00	0.2180989033756373D 00
	0.8608120082126340D-01	0.8332391503471161D 01	0.3441685246858999D 01
	-0.5877184401315941D 00	-0.4807795349807858D-02	0.2344003627025920D-01
	-0.1689458032111614D 02	-0.6802790274459785D 01	-0.2742015202542079D 01
	0.1537100024682311D 00	-0.3460060959214237D 00	-0.1537841459139609D 00
	-0.1196586398024376D 02	-0.2587393439550496D 02	-0.1029782202811686D 02
	0.2867508698938128D 00	-0.1099528178381603D 00	-0.5224555223254522D-01
	-0.2962825533620807D 02	-0.5542237950567614D 01	0.7229040993877732D 01
	0.7472897676382010D-01	-0.3094819951577302D 00	-0.1202522856286968D 00

APPENDIX 15 3

OF SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-09 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.6912000000000000D 08	0.1071863847117597D 00	0.2588788691623170D 00	0.1276294694545322D 00
	-0.3198780312781505D 01	0.8533607585269726D 00	0.7855807941278521D 00
	0.7156604725215964D 00	0.1211967143386728D 00	0.9418073778485513D-02
	-0.3284784381472378D 00	0.1805033788639248D 01	0.8341595493242539D 00
	0.6207244597204069D 00	0.7067536284262361D 00	0.3064635086632312D 00
	-0.1367053738854740D 01	0.9848215333705437D 00	0.4271230629764930D 00
	0.6203973740131328D 00	0.7089778313644495D 00	0.3073902727991099D 00
	-0.1428731403136203D 01	0.9304607839787479D 00	0.4191320821555530D 00
	0.1071241351197116D 01	0.9098943192978607D 00	0.3889201860582275D 00
	-0.8943378178023948D 00	0.1033394508895896D 01	0.4983415566771731D 00
	0.3648442423717250D 01	-0.3188562856024706D 01	-0.1457059413800089D 01
	0.5145873917361157D 00	0.5377057856976967D 00	0.2180989033756373D 00
	0.8608120082126340D-01	0.8332391503471161D 01	0.3441685246858999D 01
	-0.5877184401315941D 00	-0.4807795349807858D-02	0.2344003627025920D-01
	-0.1689458032111614D 02	-0.6802790274459785D 01	-0.2742015202542079D 01
	0.1537100024682311D 00	-0.3460060959214237D 00	-0.1537841459139609D 00
	-0.1136586398024376D 02	-0.2587393439550496D 02	-0.1029782202811686D 02
	0.2867508698938128D 00	-0.1099528178321603D 00	-0.5224555223254522D-01
	-0.2962825533629807D 02	-0.5542237950567614D 01	0.7229040993877732D 01
	0.7472897676382010D-01	-0.3094819951577302D 00	-0.1202522856286968D 00

APPENDIX 15 4

0.34560000000000000D 08	-0.21645756621553950 00	-0.36952221021068800 00	-0.17555721828389450 00
	0.1321645829755061D 01	-0.9677389367559836D 00	-0.7156562333011436D 00
	0.2076299658306265D-01	0.6563621767933197D 00	0.2944661728861350 00
	-0.2028855174959087D 01	-0.2945682241790881D-02	0.1268082361898720D 00
	0.9575404454484378D 00	0.2596598222436620D 00	0.1125943368323200D 00
	-0.5162937961068198D 00	0.1508593953567241D 01	0.6541409425947563D 00
	0.9556608753171325D 00	0.2579656964607258D 00	0.1116253034843033D 00
	-0.4765855179427342D 00	0.1471463686869486D 01	0.6401886614885455D 00
	-0.1650919483942477D 01	0.1200050125012925D-01	0.4980539623094858D-01
	0.2784378054448127D-01	-0.1163641888342106D 01	-0.5348782564249052D 00
	0.1077085121763495D 01	-0.4663516175828918D 01	-0.2026967979913199D 01
	0.7302577110644503D 00	0.1828255831265942D 00	0.6058337022357657D-01
	0.2408520871035766D 01	0.8084533650023597D 01	0.3238716455811686D 01
	-0.5673292132631655D 00	0.1279146961053795D 00	0.7743670157061820D-01
	-0.1744499221457150D 02	-0.5394093895942585D 01	-0.2116976892331433D 01
	0.1212386618794912D 00	-0.3579112232372891D 00	-0.1585417784022849D 00
	-0.1310287494649573D 02	-0.2541162818771744D 02	-0.1007986345551788D 02
	0.2816243722952947D 00	-0.1211715078790750D 00	-0.5671854470280809D-01
	-0.2990417074196497D 02	-0.4299652085852682D 01	0.7704474832337496D 01
	0.6319480076681750D-01	-0.3117281716732453D 00	-0.1174424055886914D 00
0.0	0.3110814032423113D 00	0.1144943618185337D 00	0.2935912951885752D-01
	-0.1533176488823272D 01	0.2391734187739495D 01	0.1438357674937192D 01
	-0.7038250097305772D 00	0.1142257113510246D 00	0.9592622741613030D-01
	-0.4132516064344336D 00	-0.1824885131784869D 01	-0.7962545666708684D 00
	0.9611787908544116D 00	-0.2787940384642232D 00	-0.1208977094118111D 00
	0.4903573893532225D 00	0.1498741218507575D 01	0.6498347082115210D 00
	0.9635603429705523D 00	-0.2790725104696642D 00	-0.1208649337819113D 00
	0.4962577492802464D 00	0.1554747784064009D 01	0.6788960759975048D 00
	0.1236989219490965D 01	-0.5459472778305571D 00	-0.2837925248406791D 00
	0.6771081393577069D 00	0.1253942398577755D 01	0.5574096890426141D 00
	-0.1861002330968151D 01	-0.4610577080495745D 01	-0.1932447094715918D 01
	0.6992334985394623D 00	-0.2035634971668693D 00	-0.1044187830336698D 00
	0.4577228230468234D 01	0.7322080964850053D 01	0.2829631199723792D 01
	-0.5114611054026061D 00	0.2509479129805847D 00	0.1258874243723439D 00
	-0.1786275625770070D 02	-0.3942997000301497D 01	-0.1475239412802668D 01
	0.8743863144750610D-01	-0.3671735859788374D 00	-0.1621203813962480D 00
	-0.1421797116614702D 02	-0.2490477051142472D 02	-0.9844178452517126D 01
	0.2758029130390472D 00	-0.1322127454036975D 00	-0.6110233341755988D-01
	-0.3013370797539524D 02	-0.3049032175563348D 01	0.8168431948732178D 01
	0.5165204581533039D-01	-0.3134884258975679D 00	-0.1145106939068307D 00

TOTAL NO OF FUNCTION EVALUATIONS IS 113542

APPENDIX 16 1

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   DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0          TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-08 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

      THE OUTPUT COLUMNS ARE  X, Y(1), Y(2),...., Y(N)

     0.0                  0.311081403238440D 00   0.114494361824890D 00   0.293591295226599D-01
                         -0.153317646888830D 01   0.239173418771469D 01   0.143835767493069D 01
                         -0.703825009735149D 00   0.114225711335840D 00   0.959262274095600D-01
                         -0.413251606386699D 00  -0.182488513179109D 01  -0.796254566676699D 00
                          0.961178790827279D 00  -0.278794038580680D 00  -0.120897709468640D 00
                          0.490357391990799D 00   0.145874121820280D 01   0.649834708238499D 00
                          0.963560343737029D 00  -0.279072502798480D 00  -0.120864929786220D 00
                          0.496257538514899D 00   0.155474780892299D 01   0.678896073746699D 00
                          0.123698921949460D 01  -0.545947277824999D 00  -0.283792524838400D 00
                          0.677108139360999D 00   0.125394239858049D 01   0.557409689044099D 00
                         -0.186100233096779D 01  -0.461057708049810D 01  -0.193244709471800D 01
                          0.699233498539599D 00  -0.203563497166349D 00  -0.104418783033680D 00
                          0.457722823046950D 01   0.732208096485580D 01   0.282963119972420D 01
                         -0.511461105402909D 00   0.250947912980459D 00   0.125887424372260D 00
                         -0.178627562577089D 02  -0.394299700030100D 01  -0.147523941280300D 01
                          0.874386314475400D-01  -0.367173585979089D 00  -0.162120381396259D 00
                         -0.142179711661510D 02  -0.249047705114339D 02  -0.984417845252400D 01
                          0.275802913039219D 00  -0.132212745403710D 00  -0.611023334175699D-01
                         -0.301337079753299D 02  -0.304903217556800D 01   0.816843194873799D 01
                          0.515520458153899D-01  -0.313488425897749D 00  -0.114510693906850D 00
```

APPENDIX 16 2

0.3456000000000000D 08	-0.2164575662174339D 00	-0.3695222102099728D 00	-0.1756572182833286D 00
	0.1921645829748961D 01	-0.9677389367651896D 00	-0.7156562333055083D 00
	0.2076299658033820D-01	0.6563621767939402D 00	0.2944686172890766D 00
	-0.2028855174958254D 01	-0.2945682248920516D-02	0.1268082361865679D 00
	0.9575404454287843D 00	0.2596598222382838D 00	0.1125943368300320D 00
	-0.5162937966846498D 00	0.1508593952975738D 01	0.6541409422500718D 00
	0.9556608778342366D 00	0.2579656939900312D 00	0.1116253024863215D 00
	-0.4765854657459316D 00	0.1471463736962020D 01	0.6401886901179546D 00
	-0.1650919483943365D 01	0.1200050124829110D-01	0.4980539623025225D-01
	0.2784378054627139D-01	-0.1163641888341598D 01	-0.5348782564248107D 00
	0.1077085121763602D 01	-0.4663516175829667D 01	-0.2026967979915234D 01
	0.7302877110644640D 00	0.1828255831267785D 00	0.6058337022354291D-01
	0.2408520871036083D 01	0.8084533650031182D 01	0.3238716455811835D 01
	-0.5673292132632681D 00	0.1279146961053563D 00	0.7743670157059900D-01
	-0.1744499221455850D 02	-0.5394093895942553D 01	-0.2116976892331664D 01
	0.1212386618795422D 00	-0.3579112232374286D 00	-0.1585417784022837D 00
	-0.1310287494649518D 02	-0.2541162818772382D 02	-0.1007986345552204D 02
	0.2816243722953630D 00	-0.1211715078790748D 00	-0.5671854470281589D-01
	-0.2990417074196626D 02	-0.4299652085852822D 01	0.7704474832340192D 01
	0.6319480076682900D-01	-0.3117281716733359D 00	-0.1174424055887030D 00
0.6912000000000000D 08	0.1071863847063291D 00	0.2588788691636587D 00	0.1276294694558395D 00
	-0.3198780312799511D 01	0.8533607585441303D 00	0.7855807941068429D 00
	0.7156604725223390D 00	0.1211967143355803D 00	0.9418073777053460D-02
	-0.3284784381375262D 00	0.1805033788640688D 01	0.8341595493243303D 00
	0.6207244599073216D 00	0.7067536284163798D 00	0.3064635086755976D 00
	-0.1367053739329973D 01	0.9848215369680505D 00	0.4271230644914610D 00
	0.6203973613578820D 00	0.7089778302700729D 00	0.3073902710343829D 00
	-0.1428731361132629D 01	0.9804604960304697D 00	0.4191319614687406D 00
	0.1071241351195643D 01	0.5098943192988515D 00	0.3889201860586827D 00
	-0.8943378178038031D 00	0.1033394508895122D 01	0.4983415566769468D 00
	0.3648442423717226D 01	-0.3188562856024957D 01	-0.1457059413800210D 01
	0.5145873917361015D 00	0.5377057856976665D 00	0.2180989033756274D 00
	0.8608120082122390D-01	0.8332391503471554D 01	0.3441685246859118D 01
	-0.5877184401315981D 00	-0.4807795349799364D-02	0.2344003627026014D-01
	-0.1689458032110024D 02	-0.6802790274459741D 01	-0.2742015202542086D 01
	0.1537100024683174D 00	-0.3460060959213906D 00	-0.1537841459139420D 00
	-0.1196558639802408 9D 02	-0.2587293439550395D 02	-0.1029782202811684D 02
	0.2867508698938031D 00	-0.1099528178381568D 00	-0.5224555223254672D-01
	-0.2962825533620735D 02	-0.5542237950567598D 01	0.7229040993878018D 01
	0.7472897676382030D-01	-0.3094819951577379D 00	-0.1202522856287004D 00

APPENDIX 16 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-08 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.6912000000000000D 08	0.1071863847063291D 00	0.2588788691636587D 00	0.1276294694558395D 00
	-0.3198780312799511D 01	0.8533607585441303D 00	0.7855807941068429D 00
	0.7156604725223390D 00	0.1211967143355803D 00	0.9418073777053460D-02
	-0.3284784381375262D 00	0.1805033788640688D 01	0.8341595493243303D 00
	0.5207244599073216D 00	0.7067536284163798D 00	0.3064635086755976D 00
	-0.1367053739329973D 01	0.9848215369680505D 00	0.4271230644914610D 00
	0.6203973613578820D 00	0.7089778302700729D 00	0.3073902710343829D 00
	-0.1428731361132629D 01	0.9804604960304697D 00	0.4191319614687406D 00
	0.1071241351195643D 01	0.9098943192988515D 00	0.3889201860586827D 00
	-0.8943378178038081D 00	0.1033394508895122D 01	0.4983415566769468D 00
	0.3648442423717226D 01	-0.3188562856024957D 01	-0.1457059413800210D 01
	0.5145873917361015D 00	0.5377057856976665D 00	0.2180989033756274D 00
	0.8608120082122390D-01	0.8332391503471554D 01	0.3441685246859118D 01
	-0.5877184401315981D 00	-0.4807795349799364D-02	0.2344003627026014D-01
	-0.1689458032110024D 02	-0.6802790274459741D 01	-0.2742015202542086D 01
	0.1537100024683174D 00	-0.3460060959213906D 00	-0.1537841459139420D 00
	-0.1196586398024089D 02	-0.2587393439550395D 02	-0.1029782202811684D 02
	0.2867508698938081D 00	-0.1099528178381568D 00	-0.5224555223254672D-01
	-0.2962825533620735D 02	-0.5542237950567598D 01	0.7229040993878018D 01
	0.7472897676382030D-01	-0.3094819951577379D 00	-0.1202522856287004D 00

APPENDIX 16 4

0.3456000000000000D 03

-0.2164575662199221D 00	-0.3695222102081263D 00	-0.1756572182820989D 00
0.1921645829741574D 01	-0.9677389367809214D 00	-0.7156562333132721D 00
0.2076299658296141D-01	0.6563621767935337D 00	0.2944661728872 75D 00
-0.2028855174958720D 01	-0.2945682241869934D-02	0.1268082361897794D 00
0.9575404454597732D 00	0.2596598222794592D 00	0.1125943368485442D 00
-0.5162937956738630D 00	0.1508593954007148D 01	0.6541409428348423D 00
0.9555660873317981D 00	0.2579656982962523D 00	0.1116253041398056D 00
-0.4765855605600802D 00	0.1471463649051850D 01	0.6401886411833327D 00
-0.1650919483944551D 01	0.1200050124667918D-01	0.4980539622858167D-01
0.2784378054812741D-01	-0.1163641888340526D 01	-0.5348782564251279D 00
0.1077085121763728D 01	-0.4663516175829350D 01	-0.2026967979914948D 01
0.7302877110643754D 00	0.1828255831266823D 00	0.6058337022353811D-01
0.2408520871035818D 01	0.8084533650028900D 01	0.3238716455811778D 01
-0.5673292132631728D 00	0.1279146961053760D 00	0.7743670157060790D-01
-0.1744499221455602D 02	-0.5394093895942492D 01	-0.2116976892331515D 01
0.1212386618795298D 00	-0.3579112232373778D 00	-0.1565417784022781D 00
-0.1310287494649328D 02	-0.2541162818769034D 02	-0.1007986345558189D 02
0.2816243722952815D 00	-0.1211715078790691D 00	-0.5671854470282642D-01
-0.2990417074196445D 02	-0.4299652085852672D 01	0.7704474832337694D 01
0.6319480076682070D-01	-0.3117281716732548D 00	-0.1174424055886957D 00
0.3110814032511256D 00	0.1144943618043509D 00	0.2935912951035532D-01
-0.1533176488674933D 01	0.2391734187795389D 01	0.1438357674952155D 01
-0.7038250097319848D 00	0.1142257113467920D 00	0.9592622741429130D-01
-0.4132516064210529D 00	-0.1824885131786320D 01	-0.7962545666724001D 00
0.9611787909751840D 00	-0.2787940382888041D 00	-0.1208977093419997D 00
0.4903573935728720D 00	0.1498741218070166D 01	0.6498347083404815D 00
0.9635603446426234D 00	-0.2790724956656894D 00	-0.1208649260587883D 00
0.4962573562205512D 00	0.1554747833255374D 01	0.6788960714170567D 00
0.1236989219494513D 01	-0.5459472778228146D 00	-0.2837925248369975D 00
0.6771081393593086D 00	0.1253942398581891D 01	0.5574096890459514D 00
-0.1861002330967101D 01	-0.4610577080496957D 01	-0.1932447094717449D 01
0.6992334985394332D 00	-0.2035634971665663D 00	-0.1044167830337322D 00
0.4577228230469208D 01	0.7322080964850157D 01	0.2829631199723831D 01
-0.5114611054026681D 00	0.2509479129805609D 00	0.1258874243723188D 00
-0.1786275625769033D 02	-0.3942997000300918D 01	-0.1475239412802658D 01
0.8743863144734540D-01	-0.3671735859789617D 00	-0.1621203813962538D 00
-0.1421797116614550D 02	-0.2490477051139755D 02	-0.9844178452580995D 01
0.2758029130390530D 00	-0.1322127454036894D 00	-0.6110233341760492D-01
-0.3013370797532028D 02	-0.3049032175568151D 01	0.8168431948734626D 01
0.5155204541530658D-01	-0.3134884258975739D 00	-0.1145106939068373D 00

TOTAL NO OF FUNCTION EVALUATIONS IS 95391

APPENDIX 17 I

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),..., Y(N)

0.0	0.311081403238440OD 00	0.114494361824890OD 00	0.293591295226599 9D-01
	-0.153317648888830OD 01	0.239173418771469 9D 01	0.143835767493069 9D 01
	-0.703825009735149 9D 00	0.114225711335840OD 00	0.959262274095600OD-01
	-0.413251606386699 9D 00	-0.182488513179109 9D 01	-0.796254556676699 8D 00
	0.961178790827279 9D 00	-0.278794038580680OD 00	-0.120897709468640OD 00
	0.490357391990799 8D 00	0.149874121820280OD 01	0.649834708238499 7D 00
	0.963560343737029 9D 00	-0.279072502798480OD 00	-0.120864929786220OD 00
	0.496257538514899 9D 00	0.155474780892299 9D 01	0.678896073746699 8D 00
	0.123698921949460OD 01	-0.545947277824999 9D 00	-0.283792524838400OD 00
	0.677108139360999 7D 00	0.125394239858049 9D 01	0.557409689044099 8D 00
	-0.186100233096779 9D 01	-0.461057708049810OD 01	-0.193244709471800OD 01
	0.699233498539599 7D 00	-0.203563497166349 9D 00	-0.104418783033680OD 00
	0.457722823046950OD 01	0.732208096485580OD 01	0.282963119972420OD 01
	-0.511461105402909 8D 00	0.250947912980459 9D 00	0.125887424372260OD 00
	-0.178627562577089 9D 02	-0.394299700030100OD 01	-0.147523941280300OD 01
	0.874386314475400OD-01	-0.367173585979089 9D 00	-0.162120381396259 9D 00
	-0.142179711661510OD 02	-0.249047705114339 9D 02	-0.984417845252400OD 01
	0.275802913039219 9D 00	-0.132212745403710OD 00	-0.611023334175699 7D-01
	-0.301337079753299 9D 02	-0.304903217556800OD 01	0.816843194873799 9D 01
	0.515520458153899 8D-01	-0.313488425897749 9D 00	-0.114510693906850OD 00

APPENDIX 17 2

0.3456000000000000D 08	-0.2164556722104797D 00	-0.3695132430306454D 00	-0.1756531139413282D 00
	0.1921713214362119D 01	-0.9677376375940266D 00	-0.7156622347637460D 00
	0.2076299688515633D-01	0.6563621768370971D 00	0.2944686172879184D 00
	-0.2028855174839124D 01	-0.2945681641980245D-02	0.1268082364290601D 00
	0.9575404454380087D 00	0.2596598222140366D 00	0.1125943368209093D 00
	-0.5162937964662771D 00	0.1508593953156202D 01	0.6541409423509479D 00
	0.9556608771249843D 00	0.2579656946114165D 00	0.1116253027517440D 00
	-0.4765854793576759D 00	0.1471463724560604D 01	0.6401886828996562D 00
	-0.1650919483953163D 01	0.1200050121417639D-01	0.4980539621478157D-01
	0.2784378057755823D-01	-0.1163641888336532D 01	-0.5348782564235636D 00
	0.1077085121720327D 01	-0.4663516175828233D 01	-0.2026967979914564D 01
	0.7302877110678587D 00	0.1828255831271619D 00	0.6058337022261973D-01
	0.2408520870991426D 01	0.8084533650031897D 01	0.3238716455812372D 01
	-0.5673292132610953D 00	0.1279146961052929D 00	0.7743670156948590D-01
	-0.1744499221461713D 02	-0.5394093895941128D 01	-0.2116976892330929D 01
	0.1212386618813904D 00	-0.3579112232372370D 00	-0.1585417784032975D 00
	-0.1310287494653924D 02	-0.2541162818772165D 02	-0.1007986345552351D 02
	0.2816243722973010D 00	-0.1211715078788675D 00	-0.5671854470381798D-01
	-0.2990417074201137D 02	-0.4299652085851236D 01	0.7704474832334901D 01
	0.6319480076875910D-01	-0.3117281716730976D 00	-0.1174424055896972D 00
0.6912000000000000D 08	0.1069025736596909D 00	0.2588741294695102D 00	0.1276557850777989D 00
	-0.3200406804142215D 01	0.8512994278571465D 00	0.7846654442323958D 00
	0.7156604723597588D 00	0.1211967139863208D 00	0.9418073632892441D-02
	-0.3284784378216000D 00	0.1805033788554591D 01	0.8341595492229852D 00
	0.6207244596459275D 00	0.7067536284551237D 00	0.3064635086803205D 00
	-0.1367053739112090D 01	0.9848215330743598D 00	0.4271230628499464D 00
	0.6203973738627560D 00	0.7089778313950051D 00	0.3073902728115397D 00
	-0.1428731402936854D 01	0.9804607822986243D 00	0.4191320814900227D 00
	0.1071241351328306D 01	0.9098943192675592D 00	0.3889201860446231D 00
	-0.8943378178607806D 00	0.1033394508625566D 01	0.4983415565526972D 00
	0.3648442423717801D 01	-0.3188562856019387D 01	-0.1457059413792970D 01
	0.5145873915310483D 00	0.5377057853550966D 00	0.2180989032234971D 00
	0.8608120081305840D-01	0.8332391503466620D 01	0.3441685246862381D 01
	-0.5877184403385515D 00	-0.4807795694928280D-02	0.2344003611702415D-01
	-0.1689458032112481D 02	-0.6802790274461372D 01	-0.2742015202537717D 01
	0.1537100022605107D 00	-0.3460060962661736D 00	-0.1537841460669669D 00
	-0.1196586398025030D 02	-0.2587393439550934D 02	-0.1029782202811445D 02
	0.2867508696861640D 00	-0.1099528181827119D 00	-0.5224555238554131D-01
	-0.2962825533621729D 02	-0.5542237950569220D 01	0.7229040993877655D 01
	0.7472897655621160D-01	-0.3094819955022458D 00	-0.1202522857816694D 00

APPENDIX 17 3

```
   DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0.1.... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

      THE OUTPUT COLUMNS ARE  X. Y(1). Y(2)..... Y(N)

    0.6912000000000000D 08   0.1069025736596909D 00   0.2588741294695102D 00   0.1276557850777989D 00
                            -0.3200406804142215D 01   0.8512994278571465D 00   0.7846654442323958D 00
                             0.7156604723597588D 00   0.1211967139863208D 00   0.9418073632892441D-02
                            -0.3284784378216000D 00   0.1805033788554591D 01   0.8341595492229852D 00
                             0.6207244596459275D 00   0.7067536284551237D 00   0.3064635086803205D 00
                            -0.1367053739112090D 01   0.9848215330743598D 00   0.4271230628499464D 00
                             0.6203973738627560D 00   0.7089778313950051D 00   0.3073902728115397D 00
                            -0.1428731402936854D 01   0.9804607822986243D 00   0.4191320814900227D 00
                             0.1071241351328306D 01   0.9098943192675592D 00   0.3889201860446231D 00
                            -0.8943378178607806D 00   0.1033394508625566D 01   0.4983415565526972D 00
                             0.3648442423717801D 01  -0.3188562856019387D 01  -0.1457059413792970D 01
                             0.5145873915310483D 00   0.5377057853550966D 00   0.2180989032234971D 00
                             0.8608120081305840D-01   0.8332391503466620D 01   0.3441685246862331D 01
                            -0.5877184403385515D 00  -0.4807795694928280D-02   0.2344003611702415D-01
                            -0.1689458032112481D 02  -0.6802790274461372D 01  -0.2742015202537717D 01
                             0.1537100022605107D 00  -0.3460060962661736D 00  -0.1537841460669669D 00
                            -0.1196586398025030D 02  -0.2587393439550934D 02  -0.1029782202811445D 02
                             0.2867508696861640D 00  -0.1099528181827119D 00  -0.5224555238554131D-01
                            -0.2962825533621729D 02  -0.5542237950569220D 01   0.7229040993877655D 01
                             0.7472897655621160D-01  -0.3094819955022458D 00  -0.1202522857816694D 00
```

APPENDIX 17 4

0.3456000000000000D 08	-0.2164556722122615D 00	-0.3695132430295786D 00	-0.1756531139405710D 00
	0.1921713214356202D 01	-0.9677376376048796D 00	-0.7156622347689824D 00
	0.2076299688672022D-01	0.6563621768366254D 00	0.2944686172876125D 00
	-0.2028855174839984D 01	-0.2945681637578411D-02	0.1268082364310865D 00
	0.9575404454366100D 00	0.2596598222116670D 00	0.1125943368198460D 00
	-0.5162937965039756D 00	0.1508593953115699D 01	0.6541409423277311D 00
	0.9556608773008849D 00	0.2579656944373456D 00	0.1116253026857313D 00
	-0.4765854756597538D 00	0.1471463728023303D 01	0.6401886848781851D 00
	-0.1650919483952394D 01	0.1200050121628502D-01	0.4980539621569310D-01
	0.2784378057571782D-01	-0.1163641888336863D 01	-0.5348782564236538D 00
	0.1077085121720206D 01	-0.4663516175827741D 01	-0.2026967979914332D 01
	0.7302877110678186D 00	0.1828255831270259D 00	0.6058337022260080D-01
	0.2408520870991081D 01	0.8084533650027939D 01	0.3238716455811924D 01
	-0.5673292132609809D 00	0.1279146961053369D 00	0.7743670156950970D-01
	-0.1744499221461213D 02	-0.5394093895940928D 01	-0.2116976892330723D 01
	0.1212386618813741D 00	-0.3579112232372975D 00	-0.1585417784032843D 00
	-0.1310287494653498D 02	-0.2541162818771830D 02	-0.1007986345551964D 02
	0.2816243722971496D 00	-0.1211715078788659D 00	-0.5671854470380913D-01
	-0.2990417074200776D 02	-0.4299652085852015D 01	0.7704474832333256D 01
	0.6319480076875780D-01	-0.3117281716730351D 00	-0.1174424055896837D 00
0.0	0.3110814032445912D 00	0.1144943618148615D 00	0.2935912951665270D-01
	-0.1533176488784946D 01	0.2391734187753811D 01	0.1438357674941032D 01
	-0.7038250097304972D 00	0.1142257113496677D 00	0.9592622741550640D-01
	-0.4132516064304248D 00	-0.1824885131785813D 01	-0.7962545666719978D 00
	0.9611787908350734D 00	-0.2787940385623353D 00	-0.1208977094601003D 00
	0.4903573917935865D 00	0.1498741218221499D 01	0.6498347082347007D 00
	0.9635603436699390D 00	-0.2790725032942797D 00	-0.1208649300457559D 00
	0.4962575531342518D 00	0.1554747807552696D 01	0.6788960741529912D 00
	0.1236989219490630D 01	-0.5459472778305230D 00	-0.2837925248407569D 00
	0.6771081393678908D 00	0.1253942398577898D 01	0.5574096890426568D 00
	-0.1861002330967458D 01	-0.4610577080496373D 01	-0.1932447094717250D 01
	0.6992334985393975D 00	-0.2035634971666420D 00	-0.1044187830337610D 00
	0.4577228230461200D 01	0.7322080964847184D 01	0.2829631199723351D 01
	-0.5114611054026092D 00	0.2509479129806751D 00	0.1258874243723634D 00
	-0.1786275625769985D 02	-0.3942597000300462D 01	-0.1475239412802648D 01
	0.8743863144749440D-01	-0.3671735859790388D 00	-0.1621203813962367D 00
	-0.1421797116614271D 02	-0.2490477051142700D 02	-0.9844178452520201D 01
	0.2758029130389407D 00	-0.1322127454037027D 00	-0.6110233341755492D-01
	-0.3013370797532467D 02	-0.3049032175569044D 01	0.8168431948726667D 01
	0.5155204581537201D-01	-0.3134884258975646D 00	-0.1145106939068298D 00

TOTAL NO OF FUNCTION EVALUATIONS IS 138421

LAKEHEAD UNIVERSITY COMPUTER CENTRE

LEVEL 21.7 (JAN 73)   OS/360 FORTRAN H

APPENDIX 18 A 1

```
COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                   SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOX
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YSTART(60)
      COMMON GM1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,NOFNS
      COMMON/UNITS/AR,FBC
      EXTERNAL FCT,DDEOUT
      NOFNS=0
      N=60
      A=149597.9D6
      AR=1/A
      FB=86400
      FBC=FB*100
      FBCR=1/FBC
      XSTART=0
      SP=FB*200
      XEND=SP*114
      H=FB
      EPS=1D-10
      YSTART( 1)=A*( 0.30141266825389D0)
      YSTART( 2)=A*( 0.12859494717822D0)
      YSTART( 3)=A*( 0.03784152564682D0)
      YSTART( 4)=A*(-1.6616680780981D0)*FECR
      YSTART( 5)=A*( 2.3334600378444D0)*FBCR
      YSTART( 6)=A*( 1.4224592371709D0)*FBCR
      YSTART( 7)=A*( 0.53597737967419D0)
      YSTART( 8)=A*( 0.45447200930360D0)
      YSTART( 9)=A*( 0.17083667172630D0)
      YSTART(10)=A*(-1.3634142279940D0)*FBCR
      YSTART(11)=A*( 1.3285266921316D0)*FBCR
      YSTART(12)=A*( 0.6845979909917D0)*FECR
      YSTART(13)=A*( 0.85619698332307D0)
      YSTART(14)=A*(-0.49406304572379D0)
      YSTART(15)=A*(-0.21430905076233D0)
      YSTART(16)=A*( 0.8879834391807D0)*FBCR
      YSTART(17)=A*( 1.3300025378028D0)*FECR
      YSTART(18)=A*( 0.5768781098964D0)*FBCR
      YSTART(19)=A*( 0.85883367524752D0)
      YSTART(20)=A*(-0.49353999194523D0)
      YSTART(21)=A*(-0.21395780249152D0)
      YSTART(22)=A*( 0.8744280088091D0)*FBCR
      YSTART(23)=A*( 1.3777613069774D0)*FBCR
      YSTART(24)=A*( 0.6028704705912D0)*FBCR
      YSTART(25)=A*( 1.2054059827236D0)
      YSTART(26)=A*( 0.72720270174070D0)
      YSTART(27)=A*( 0.30126927769550D0)
      YSTART(28)=A*(-0.7092835268749D0)*FECR
      YSTART(29)=A*( 1.1656043764443D0)*FBCR
      YSTART(30)=A*( 0.5541349661214D0)*FBCR
      YSTART(31)=A*( 1.5413706201915D0)
      YSTART(32)=A*(-4.5249958636625D0)
      YSTART(33)=A*(-1.9791722571698D0)
      YSTART(34)=A*( 0.7124662329600D0)*FBCR
      YSTART(35)=A*( 0.2456541072521 8D0)*FBCR
      YSTART(36)=A*( 0.08796486314030D0)*FECR
      YSTART(37)=A*( 2.9214711965716D0)
      YSTART(38)=A*( 7.9536057652255D0)
      YSTART(39)=A*( 3.1615878484025D0)
```

```
ISN 0058             YSTART(40)=A*(-0.55781909539019D0)*FBCR
ISN 0059             YSTART(41)=A*( 0.15713268473582D0)*FBCR
ISN 0060             YSTART(42)=A*( 0.08904565749596D0)*FBCR
ISN 0061             YSTART(43)=A*( 11.745570448084D0)
ISN 0062             YSTART(44)=A*(-14.571664100264D0)
ISN 0063             YSTART(45)=A*(-06.551175794430D0)
ISN 0064             YSTART(46)=A*( 0.31421052276808D0)*FBCR
ISN 0065             YSTART(47)=A*( 0.19859135659266D0)*FBCR
ISN 0066             YSTART(48)=A*( 0.08256797677439D0)*FBCR
ISN 0067             YSTART(49)=A*(-13.352744302403D0)
ISN 0068             YSTART(50)=A*( 24.725635823790D0)
ISN 0069             YSTART(51)=A*( 10.464581607667D0)
ISN 0070             YSTART(52)=A*(-0.28232710470241D0)*FBCR
ISN 0071             YSTART(53)=A*(-0.12983396336339D0)*FBCR
ISN 0072             YSTART(54)=A*(-0.04606982260127D0)*FBCR
ISN 0073             YSTART(55)=A*(- 0.196808380477D0)
ISN 0074             YSTART(56)=A*( 42.677391270856D0)
ISN 0075             YSTART(57)=A*( 13.539165170838D0)
ISN 0076             YSTART(58)=A*(-0.22401847395799D0)*FBCR
ISN 0077             YSTART(59)=A*(-0.06860971572225D0)*FBCR
ISN 0078             YSTART(60)=A*( 0.04640707700421D0)*FBCR
ISN 0079             GM1=-A**3* (.01720209895D0/FB)**2
ISN 0080             GM2=-GM1/5983000D0
ISN 0081             GM3=-GM1/408522D0
ISN 0082             GM4=-GM1/332945.56192544D0
ISN 0083             GM5=-GM1/27068807.130100D0
ISN 0084             GM6=-GM1/3098700D0
ISN 0085             GM7=-GM1/1047.3908D0
ISN 0086             GM8=-GM1/3499.2D0
ISN 0087             GM9=-GM1/22930D0
ISN 0088             GM10=-GM1/19260D0
ISN 0089             GM11=-GM1/1812000D0
ISN 0090             DO1J=1,1
ISN 0091             IF(J-1)1,1,2
ISN 0092       2     XSTART=XEND
ISN 0093             XEND=0
ISN 0094             H=-H
ISN 0095       1     CALL DDESP(SP,FCT,N,YSTART,XSTART,XEND,H,EPS,      DDFOUT)
ISN 0096             WRITE(6,97)NCFNS
ISN 0097      97     FORMAT(1H0,5X,36HTOTAL NO OF FUNCTION EVALUATIONS IS ,I6)
ISN 0098             STOP
ISN 0099             END

TIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

TIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ATISTICS*     SOURCE STATEMENTS =       98 ,PROGRAM SIZE =      3096

ATISTICS*  NO  DIAGNOSTICS GENERATED

*** END OF COMPILATION ******                                          77K BYTES C
```

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.19699D 10
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.17280D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

APPENDIX 18 B 1

0.0 = 1913 AUGUST 21^d.0UT

0.3014126682538900D 00	0.1265949471782200D 00	0.3784152564681999D-01
-0.1681668078098099D 01	0.2333460037844399D 01	0.1422459237170899D 01
0.5359773796741900D 00	0.4544720093036000D 00	0.1708366717263000D 00
0.1363414227993999D 01	0.1328526692131599D 01	0.6845979909916997D 00
0.8561969833230699D 00	-0.4940630457237899D 00	-0.2143090507623300D 00
0.8879834391606997D 00	0.1330002537802799D 01	0.5768781098963997D 00
0.8588336752475199D 00	-0.4935399919452299D 00	-0.2139978024915200D 00
0.8744280088090997D 00	0.1377761306977399D 01	0.6028704705911998D 00
0.1205405982723599D 01	0.7272027017407000D 00	0.3012692776955000D 00
-0.7092835268748998D 00	0.1165604376444299D 01	0.5541349661213998D 00
0.1541370620191500D 01	-0.4524995863662500D 01	-0.1979172257169800D 01
0.7124662329599998D 00	0.2456541072521799D 00	0.8796486314030000D-01
0.2921471195571600D 01	0.7953605765225499D 01	0.3161587848402500D 01
-0.5578190953901898D 00	0.1571326847358200D 00	0.8904565749596000D-01
0.1174557044808400D 02	-0.1457166410026400D 02	-0.6551175794430000D 01
0.3142105227680799D 00	0.1985913565926599D 00	0.8256797677439000D-01
-0.1335274430240300D 02	0.2472563582378999D 02	0.1046458160766700D 02
-0.2823271047024099D 00	-0.1298339633633900D 00	-0.4606982260126997D-01
-0.1968083804770000D 00	0.4267739127085600D 02	0.1353916517083800D 02
-0.2240184739979899D 00	-0.6860971572225000D-01	0.4640707700420998D-01

0.1831680000000000D 10 = 1971 SEPT. 6^d.0 UT

0.3110594086642583D 00	0.1145175302068891D 00	0.2937379539286403D-01
-0.1533424327620864D 01	0.2391697865272904D 01	0.1438363682861081D 01
-0.7038251212589963D 00	0.1142255420763392D 00	0.9592615813677220D-01
-0.4132512698289209D 00	-0.1824884996908958D 01	-0.7962545272793743D 00
0.9611785331930000D 00	-0.2787942448427997D 00	-0.1208977860803314D 00
0.4903548553623926D 00	0.1498741685851408D 01	0.6498346154713371D 00
0.5635590272749183D 00	-0.2790818541366114D 00	-0.1208701180933758D 00
0.4965135466520003D 00	0.1554716762794207D 01	0.6789065752632285D 00
0.1236990044086219D 01	-0.5459457259081769D 00	-0.2837918345997245D 00
0.6771068775513574D 00	0.1253942969840599D 01	0.5574099851417444D 00
-0.1861002346401783D 01	-0.4610577037628110D 01	-0.1932447075847635D 01
0.6992335032837503D 00	-0.2035634994886706D 00	-0.1044187841180473D 00
0.4577228160424188D 01	0.7322080989152762D 01	0.2829631212793234D 01
-0.5114611077902946D 00	0.2509479103354469D 00	0.1258874233844928D 00
-0.1786275625966163D 02	-0.3942997007829721D 01	-0.1475239416107365D 01
0.6743863144564300D-01	-0.3671735859306097D 00	-0.1621203813716868D 00
-0.1421797116650465D 02	-0.2490477051194110D 02	-0.9844178452665191D 01
0.2758029129981776D 00	-0.1322127454194239D 00	-0.6110233342058069D-01
-0.3013370797744436D 02	-0.3049032180856080D 01	0.8168431947431324D 01
0.5155204575554061D-01	-0.3134884259445574D 00	-0.1145106939137084D 00

0.1866624000000000D 10	-0.2164618804953057D 00	-0.3695237574716468D 00	-0.1756576024042961D 00
	0.1921653326333662D 01	-0.9676931172518284D 00	-0.7156324689847362D 00
= 1972 OCT. 10^{d}.0 UT	0.2076280916520111D-01	0.6563621040024267D 00	0.2944685963623036D 00
	-0.2028855407278674D 01	-0.2945933153870781D-02	0.1268081376538628D 00
	0.9575404203638395D 00	0.2596595143096504D 00	0.1125942088438092D 00
	-0.5162917656674539D 00	0.1508595865564750D 01	0.6541421180808676D 00
	0.9556538700395069D 00	0.2579719333612767D 00	0.1116274566121395D 00
	-0.4767276461590455D 00	0.1471338848702895D 01	0.6401063944678061D 00
	-0.1650919236355247D 01	0.1200078642917819D-01	0.4980552046520972D-01
	0.2784396423075109D-01	-0.1163642069606783D 01	-0.5348783445680665D 00
	0.1077085129958320D 01	-0.4663516130617607D 01	-0.2026967960538504D 01
	0.7302877168272827D 00	0.1828255870222619D 00	0.6058337176803060D-01
	0.2408520793505999D 01	0.8084533662324767D 01	0.3238716464244146D 01
	-0.5673292146028916D 00	0.1279146928110271D 00	0.7743670026827920D-01
	-0.1744499221640387D 02	-0.5394093903231677D 01	-0.2116976895532594D 01
	0.1212386619010958D 00	-0.3579112231613681D 00	-0.1585417783683963D 00
APPENDIX 18 B 2	-0.1310287494684872D 02	-0.2541162818827669D 02	-0.1007986345567837D 02
	0.2816243722960336D 00	-0.1211715078761352D 00	-0.5671854470073770D-01
	-0.2990417074415883D 02	-0.4299652091296808D 01	0.7704474831004964D 01
	0.6319480074717980D-01	-0.3117281716992093D 00	-0.1174424055890476D 00
0.1900800000000000D 10	0.1071463534453097D 00	0.2588888284636441D 00	0.1276389141385161D 00
	-0.3198899032205192D 01	0.8530954091575027D 00	0.7854508917970798D 00
= 1973 NOV. 14^{d}.0 UT	0.7156603914275266D 00	0.1211965915272549D 00	0.9418023614309227D-02
	-0.3284783310385525D 00	0.1805034067838477D 01	0.8341596684621304D 00
	0.6207242618594275D 00	0.7067535180257447D 00	0.3064634423036578D 00
	-0.1367053343272213D 01	0.9848190379761512D 00	0.4271220337716970D 00
	0.6204071793781118D 00	0.7089781826592158D 00	0.3073918503686383D 00
	-0.1428767792464231D 01	0.9806878372435912D 00	0.4192263706844409D 00
	0.1071240949347834D 01	0.9098954647848427D 00	0.3889207226531664D 00
	-0.8943382138071716D 00	0.1033393604706842D 01	0.4983411522493610D 00
	0.3648442443265316D 01	-0.3188562784655061D 01	-0.1457059383458562D 01
	0.5145873905158126D 00	0.5377057937604362D 00	0.2180989068572912D 00
	0.8608112035858390D-01	0.8332391501892662D 01	0.3441685249687068D 01
	-0.5877184402508003D 00	-0.4807798951854450D-02	0.2344003478276351D-01
	-0.1689458032292184D 02	-0.6802790281453313D 01	-0.2742015205612211D 01
	0.1537100024416679D 00	-0.3460060958873328D 00	-0.1537841459009487D 00
	-0.1196586398061414D 02	-0.2587393439607030D 02	-0.1029782202827481D 02
	0.2867508698664533D 00	-0.1099528178829799D 00	-0.5224555225420625D-01
	-0.2962825533850399D 02	-0.5542237956131788D 01	0.7229040992532324D 01
	0.7472897671426520D-01	-0.3094819952291349D 00	-0.1202522856512674D 00

APPENDIX 18 B 3

= 1975 JULY 7d.OUT

0.19526400000000000D 10	0.3580636557467855D 00	-0.7629126381179080D-01	-0.7763554543234620D-01
	0.2186342982079826D 00	0.2521568524587962D 01	0.1327951232581908D 01
	-0.2278654377396116D 00	-0.6335686978831496D 00	-0.2711235214730905D 00
	0.1906473291715786D 01	-0.5429467439854474D 00	-0.3650719766563802D 00
	0.2447547326684251D 00	-0.9053889319202418D 00	-0.3925952995921230D 00
	0.1642455597263842D 01	0.3742157907327996D 00	0.1623236138151982D 00
	0.2453913011227849D 00	-0.9031157820249755D 00	-0.3916758467689299D 00
	0.1583720644706904D 01	0.3868021932953772D 00	0.1622204139258748D 00
	0.1364188845550968D 01	-0.2031373459927703D 00	-0.1298395615534209D 00
	0.2958204754967344D 00	0.1363985844290502D 01	0.6181621504189882D 00
	0.4872648170257767D 01	0.8536257936163610D 00	0.2471180024906894D 00
	-0.1429960401271596D 00	0.7142644099244056D 00	0.3099140342657323D 00
	-0.3363348015312384D 01	0.7706910608267444D 01	0.3332272861626394D 01

= 1976 JAN. 23d.OUT

	-0.5482586057273394D 00	-0.2009226465318519D 00	-0.5936819353664243D-01
	-0.1583316807619868D 02	-0.8814643190022577D 01	-0.3638549126663989D 01
	0.1994846307151182D 00	-0.3237801739180461D 00	-0.1446866113767260D 00
	-0.1022525226586702D 02	-0.2648312010295147D 02	-0.1059109086304369D 02
	0.2932426215245933D 00	-0.9312120637650020D-01	-0.4551195052081741D-01
	-0.2912838716588476D 02	-0.7387448892885744D 01	0.6495194278181383D 01
	0.9189015182622780D-01	-0.3054654461106500D 00	-0.1243395382116470D 00
0.19699200000000000D 10	-0.1636247847415748D 00	0.2381723765660813D 00	0.1443582739184913D 00
	-0.2985140616230615D 01	-0.1274767300674314D 01	-0.3760770451265466D 00
	-0.6104475376706533D 00	-0.3653888397962530D 00	-0.1261124962345273D 00
	0.1065513887577085D 01	-0.1543574316934863D 01	-0.7628978870649721D 00
	-0.5177463337941513D 00	0.7679422713259385D 00	0.3329967347608214D 00
	-0.1491453316242526D 01	-0.8352878046665768D 00	-0.3622432647950139D 00
	-0.5200800551496317D 00	0.7672512129390083D 00	0.3325799072069835D 00
	-0.1473057956365821D 01	-0.8905413230856378D 00	-0.3811559605214446D 00
	-0.3139024892080843D 00	0.1421118829959697D 01	0.6607423918975399D 00
	-0.1317229118775075D 01	-0.1554275229545391D 00	-0.3600988475446260D-01
	0.4355692459707933D 01	0.2217800315430902D 01	0.8449829823157661D 00
	-0.3695814261794688D 00	0.6388676448231574D 00	0.2831063558110403D 00
	-0.4430359654303085D 01	0.7244634533939224D 01	0.3187267359184316D 01
	-0.5173624474427334D 00	-0.2606783425355638D 00	-0.8541870828773570D-01
	-0.1541972810643659D 02	-0.9453818336765988D 01	-0.3924449417116025D 01
	0.2138963219431845D 00	-0.3153234413572125D 00	-0.1411818281582600D 00
	-0.9636865266051392D 01	-0.2666378162694996D 02	-0.1067987787465886D 02
	0.2951389305340469D 00	-0.8755617503353390D-01	-0.4328221953400820D-01
	-0.2893889584767776D 02	-0.7996900968311918D 01	0.6245178977655379D 01
	0.9761368263537690D-01	-0.3039863408541074D 00	-0.1256793136486888D 00

TAL NO OF FUNCTION EVALUATIONS IS 535440

```
$ 20.28.51 JOB   66 -- RMARN008 -- BEGINNING EXEC - INIT 8 - CLASS M
 *20.28.58 JOB   66 IEC020I  001-5,LUMON,330,FT05F001,330
 *20.28.59 JOB   66 IEC020I GET OR READ ISSUED AFTER END-OF-FILE
$ 20.29.06 JOB   66 END EXECUTION.
```

```
 HASP-II JOB STATISTICS --     25 CARDS READ --        34 LINES PRINTEC
```

APPENDIX 19

```
        $JOB
                IMPLICIT REAL*8(A-H,O-Z)
                PI=3.14159265358979323846D0
**WARNING**   REAL CONSTANT HAS MORE THAN 16 DIGITS. TRUNCATED TO 16
                F=180/PI
                XO= 0.1071 8782 8756 78D0
                YO= 0.2588 7850 9684 44D0
                ZO= 0.1276 2912 8612 58D0
                XA=  .1071 4635 3445 3097D0
                YA=  .2588 8882 8463 6441D0
                ZA=  .1276 3891 4138 5161D0
                RO=(XO**2+YO**2+ZO**2)**.5D0
                RA=(XA**2+YA**2+ZA**2)**.5D0
                RB=((XO-XA)**2+(YO-YA)**2+(ZO-ZA)**2)**.5D0
                TH=DARCOS((RO**2+RA**2-RB**2)/(2D0*RO*RA))
                TH=TH*F*3600D0
                PRINT1,TH
                TA=22000
                TH=TA    /36525D0*42.9818D0
                PRINT1,TH
          1     FORMAT(' ',F30.16)
                STOP
                END

        $ENTRY
          29.3513463077994200
          25.8891060917179900

CORE USAGE        OBJECT CODE=     1784 BYTES,ARRAY AREA=        0 BYTES,

DIAGNOSTICS         NUMBER OF ERRORS=         0, NUMBER OF WARNINGS=

COMPILE TIME=     1.24 SEC,EXECUTION TIME=     0.04 SEC,  WATFIV - VER
```

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                            SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NC
                      IMPLICIT REAL*8(A-H,O-Z)
                      DIMENSION YSTART(60)
                      COMMON GM1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,NOFNS
                      COMMON/UNITS/AR,FBC
                      EXTERNAL FCT,DDEOUT
                      NOFNS=0
                      N=60
                      A=149597.9D6
                      AR=1/A
                      FB=86400
                      FBC=FB*100
                      FBCR=1/FBC
                      XSTART=0
                      SP=FB*400
                      XEND=SP*4
                      SP=FB/2
                      H=FB/2
                      EPS=1D-11
                      YSTART( 1)=A*( 0.31108140323844D0)
                      YSTART( 2)=A*( 0.11449436182489D0)
                      YSTART( 3)=A*( 0.02935912952266D0)
                      YSTART( 4)=A*(-1.5331764888883D0)*FBCR
                      YSTART( 5)=A*( 2.3917341877147D0)*FBCR
                      YSTART( 6)=A*( 1.4383576749307D0)*FBCR
                      YSTART( 7)=A*(-0.70382500973515D0)
                      YSTART( 8)=A*( 0.11422571133584D0)
                      YSTART( 9)=A*( 0.09592622740956D0)
                      YSTART(10)=A*(-0.41325160063867D0)*FBCR
                      YSTART(11)=A*(-1.8248851317911D0)*FBCR
                      YSTART(12)=A*(-0.7962545666767D0)*FBCR
                      YSTART(13)=A*( 0.96117879082728D0)
                      YSTART(14)=A*(-0.27879403858068D0)
                      YSTART(15)=A*(-0.12089770946864D0)
                      YSTART(16)=A*( 0.4903573919908D0)*FBCR
                      YSTART(17)=A*( 1.4987412182028D0)*FBCR
                      YSTART(18)=A*( 0.6498347082385D0)*FBCR
                      YSTART(19)=A*( 0.96356034373703D0)
                      YSTART(20)=A*(-0.27907250279848D0)
                      YSTART(21)=A*(-0.12086492978622D0)
                      YSTART(22)=A*( 0.4962575385149D0)*FBCR
                      YSTART(23)=A*( 1.5547478089230D0)*FBCR
                      YSTART(24)=A*( 0.6788960737467D0)*FBCR
                      YSTART(25)=A*( 1.2369892194946D0)
                      YSTART(26)=A*(-0.5459472778250D0)
                      YSTART(27)=A*(-0.2837925248384D0)
                      YSTART(28)=A*( 0.6771081393610D0)*FBCR
                      YSTART(29)=A*( 1.2539423985805D0)*FBCR
                      YSTART(30)=A*( 0.5574096890441D0)*FBCR
                      YSTART(31)=A*(-1.8610023309678D0)
                      YSTART(32)=A*(-4.6105770804981D0)
                      YSTART(33)=A*(-1.9324470947180D0)
                      YSTART(34)=A*( 0.6992334985396D0)*FBCR
                      YSTART(35)=A*(-0.20356349716635D0)*FBCR
                      YSTART(36)=A*(-0.10441878303368D0)*FBCR
                      YSTART(37)=A*( 4.5772282304695D0)
                      YSTART(38)=A*( 7.3220809648558D0)
```

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```
ISN 0058          YSTART(39)=A*( 2.8296311997242D0)
ISN 0059          YSTART(40)=A*(-0.5114611054029 1D0)*FBCR
ISN 0060          YSTART(41)=A*( 0.2509479129804 6D0)*FBCR
ISN 0061          YSTART(42)=A*( 0.1258874243722 6D0)*FBCR
ISN 0062          YSTART(43)=A*(-17.862756257709D0)
ISN 0063          YSTART(44)=A*(-03.942997000301D0)
ISN 0064          YSTART(45)=A*(-01.475239412803D0)
ISN 0065          YSTART(46)=A*( 0.0874386314475 4D0)*FBCR
ISN 0066          YSTART(47)=A*(-0.3671735859790 9D0)*FBCR
ISN 0067          YSTART(48)=A*(-0.1621203813962 6D0)*FBCR
ISN 0068          YSTART(49)=A*(-14.217971166151D0)
ISN 0069          YSTART(50)=A*(-24.904770511434D0)
ISN 0070          YSTART(51)=A*(-09.844178452524D0)
ISN 0071          YSTART(52)=A*( 0.2758029130392 2D0)*FBCR
ISN 0072          YSTART(53)=A*(-0.1322127454037 1D0)*FBCR
ISN 0073          YSTART(54)=A*(-0.0611023334175 7D0)*FBCR
ISN 0074          YSTART(55)=A*(-30.133707975330D0)
ISN 0075          YSTART(56)=A*(-03.049032175568D0)
ISN 0076          YSTART(57)=A*( 08.168431948738D0)
ISN 0077          YSTART(58)=A*( 0.0515520458153 9D0)*FBCR
ISN 0078          YSTART(59)=A*(-0.3134884258977 5D0)*FBCR
ISN 0079          YSTART(60)=A*(-0.1145106939068 5D0)*FBCR
ISN 0080          GM1=-A**3* (.01720209895D0/FB)**2
ISN 0081          GM2=-GM1/5983000D0
ISN 0082          GM3=-GM1/408522D0
ISN 0083          GM4=-GM1/332945.56192544D0
ISN 0084          GM5=-GM1/27068807.130100D0
ISN 0085          GM6=-GM1/3098700D0
ISN 0086          GM7=-GM1/1047.3908D0
ISN 0087          GM8=-GM1/3499.2D0
ISN 0088          GM9=-GM1/22930D0
ISN 0089          GM10=-GM1/ 19260D0
ISN 0090          GM11=-GM1/1812000D0
ISN 0091          DO1J=1,1
ISN 0092          IF(J-1)1,1,2
ISN 0093    2     XSTART=XEND
ISN 0094          XEND=0
ISN 0095          H=-H
ISN 0096    1     CALL DDESP(SP,FCT,N,YSTART,XSTART,XEND,H,EPS,      DDEOUT)
ISN 0097          WRITE(6,97)NOFNS
ISN 0098    97    FORMAT(1H0,5X,36HTOTAL NO OF FUNCTION EVALUATIONS IS ,I6)
ISN 0099          STOP
ISN 0100          END

TIONS IN EFFECT*     NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

TIONS IN EFFECT*     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

TISTICS*    SOURCE STATEMENTS =        99 ,PROGRAM SIZE =      3116

TISTICS*  NO  DIAGNOSTICS GENERATED

** END OF COMPILATION ******                                        77K BYTES OF
```

```
   COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
002                SUBROUTINE DDEOUT(Y,DY,N,X,STYPE)
003                IMPLICIT REAL*8(A-H,O-Z)
004                DIMENSION Y(60),DY(60),Z(60)
005                LOGICAL STYPE,TITLE
006                COMMON/DOTPUT/SP,H,XI,XF,EPS,NP,TITLE
007                COMMON/UNITS/AR,FBC
008                IF(.NOT.TITLE)GOTO10
010                TITLE=.FALSE.
011                WRITE(6,89)N,XI,XF,EPS,H
012                IF(NP.EQ.1)WRITE(6,88)SP
014                WRITE(6,87)
015       10       IF((NP.EQ.1).AND.STYPE)GOTO20
017                RETURN
018       20       DO999J=1,60
019       999      Z(J)=Y(J)*AR
020                DO998J=4,60,6
021                Z(J)=Z(J)*FBC
022                Z(J+1)=Z(J+1)*FBC
023       998      Z(J+2)=Z(J+2)*FBC
024                DATA ARM    /23454.7110765487200/
025                R=((Z(13)-Z(19))**2+(Z(14)-Z(20))**2+(Z(15)-Z(21))**2)**.5D0*ARM
026                U=X/86400
027                WRITE(6,85)U,R
028                RETURN
029       89       FORMAT (1H1,10X,19HDE SOLUTION FOR N =,I2,24H EQUATIONS FROM XSTAR
              1T =,D12.5,10H TO XEND =,D12.5/8X,31HWITH LOCAL ERROR TOLERANCE EP
              2=,1PD12.5,26H AND INITIAL STEP SIZE H =,0PD12.5, 1H./8X,44HPRINTIN
              3G OCCURS AT EACH NATURAL STEP IN TIME)
030       88       FORMAT (1H+,52X,37HAND AT SPECIFIED POINTS (XSTART+K*SP)/8X,22HFOR
              1 K=0,1,... AND SP =,D12.5,42H (SPECIFIED POINTS ARE IDENTIFIED WIT
              2H *).)
031       87       FORMAT (1H0,14X,47HTHE OUTPUT COLUMNS ARE  X, Y(1), Y(2),...., Y(N)
              1/)
032       85       FORMAT (1H ,4X,1H*,5X,4(D25.16,5X)/(41X,3(D25.16,5X)))
033                END

 IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

 IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

ICS*     SOURCE STATEMENTS =      32 ,PROGRAM SIZE =      1724

ICS*  NO  DIAGNOSTICS GENERATED

ND OF COMPILATION ******                                   89K BYTES OF COR
```

*	0.1466500000000000D 04	0.5929188240746007D 02
*	0.1467000000000000D 04	0.5975137506413247D 02
*	0.1467500000000000D 04	0.6020128481413398D 02
*	0.1468000000000000D 04	0.6063542073741801D 02
*	0.1468500000000000D 04	0.6104864847748186D 02
*	0.1469000000000000D 04	0.6143687948327088D 02
*	0.1469500000000000D 04	0.6179702233339041D 02
*	0.1470000000000000D 04	0.6212690470569524D 02
*	0.1470500000000000D 04	0.6242517373229959D 02
*	0.1471000000000000D 04	0.6269118154316682D 02
*	0.1471500000000000D 04	0.6292486190015114D 02
*	0.1472000000000000D 04	0.6312660303510472D 02
*	0.1472500000000000D 04	0.6329712115553028D 02
*	0.1473000000000000D 04	0.6343733855847417D 02
*	0.1473500000000000D 04	0.6354826986614576D 02
*	0.1474000000000000D 04	0.6363091952596137D 02
*	0.1474500000000000D 04	0.6368619336091276D 02
*	0.1475000000000000D 04	0.6371482658169150D 02
*	0.1475500000000000D 04	0.6371733025210081D 02
*	0.1476000000000000D 04	0.6369395772690213D 02
*	0.1476500000000000D 04	0.6364469205221519D 02
*	0.1477000000000000D 04	0.6356925475049894D 02
*	0.1477500000000000D 04	0.6346713581978570D 02
*	0.1478000000000000D 04	0.6333764418701244D 02
*	0.1478500000000000D 04	0.6317997728742691D 02
*	0.1479000000000000D 04	0.6299330791233438D 02
*	0.1479500000000000D 04	0.6277685980977741D 02
*	0.1480000000000000D 04	0.6253015244160693D 02
*	0.1480500000000000D 04	0.6225286207214035D 02
*	0.1481000000000000D 04	0.6194521150199876D 02
*	0.1481500000000000D 04	0.6160796827447599D 02
*	0.1482000000000000D 04	0.6124259617789883D 02
*	0.1482500000000000D 04	0.6085137136358522D 02
*	0.1483000000000000D 04	0.6043748293462738D 02
*	0.1483500000000000D 04	0.6000511076281528D 02
*	0.1484000000000000D 04	0.5955947236146980D 02
*	0.1484500000000000D 04	0.5910682987337509D 02
*	0.1485000000000000D 04	0.5865444788109444D 02
*	0.1485500000000000D 04	0.5821049315494250D 02
*	0.1486000000000000D 04	0.5778386903323984D 02
*	0.1486500000000000D 04	0.5738398028062916D 02
*	0.1487000000000000D 04	0.5702042928043268D 02
*	0.1487500000000000D 04	0.5670265127970435D 02
*	0.1488000000000000D 04	0.5643950466208063D 02
*	0.1488500000000000D 04	0.5623884084136075D 02
*	0.1489000000000000D 04	0.5610708576472961D 02
*	0.1489500000000000D 04	0.5604886935431488D 02
*	0.1490000000000000D 04	0.5606673881923261D 02
*	0.1490500000000000D 04	0.5616098580285640D 02
*	0.1491000000000000D 04	0.5632960616876069D 02
*	0.1491500000000000D 04	0.5656839663596373D 02
*	0.1492000000000000D 04	0.5687117716290111D 02
*	0.1492500000000000D 04	0.5723011487175313D 02
*	0.1493000000000000D 04	0.5763611666548651D 02
*	0.1493500000000000D 04	0.5807925455822941D 02
*	0.1494000000000000D 04	0.5854918980183580D 02
*	0.1494500000000000D 04	0.5903556780998991D 02
*	0.1495000000000000D 04	0.5952836385579627D 02
*	0.1495500000000000D 04	0.6001816782610343D 02
*	0.1496000000000000D 04	0.6049640367661092D 02

*	0.1496500000000000D	04	0.6095548493534023D	02
*	0.1497000000000000D	04	0.6138891144898294D	02
*	0.1497500000000000D	04	0.6179131471861108D	02
*	0.1498000000000000D	04	0.6215845998163432D	02
*	0.1498500000000000D	04	0.6248721307411724D	02
*	0.1499000000000000D	04	0.6277547942654954D	02
*	0.1499500000000000D	04	0.6302212160954977D	02
*	0.1500000000000000D	04	0.6322686086649809D	02
*	0.1500500000000000D	04	0.6339016718771776D	02
*	0.1501000000000000D	04	0.6351314176529928D	02
*	0.1501500000000000D	04	0.6359739515047764D	02
*	0.1502000000000000D	04	0.6364492410711575D	02
*	0.1502500000000000D	04	0.6365798998746793D	02
*	0.1503000000000000D	04	0.6363900141217225D	02
*	0.1503500000000000D	04	0.6359040405675022D	02
*	0.1504000000000000D	04	0.6351458038744470D	02
*	0.1504500000000000D	04	0.6341376218973494D	02
*	0.1505000000000000D	04	0.6328995865205402D	02
*	0.1505500000000000D	04	0.6314490256413612D	02
*	0.1506000000000000D	04	0.6298001684208004D	02
*	0.1506500000000000D	04	0.6279640309118207D	02
*	0.1507000000000000D	04	0.6259485327179997D	02
*	0.1507500000000000D	04	0.6237588476160103D	02
*	0.1508000000000000D	04	0.6213979824600343D	02
*	0.1508500000000000D	04	0.6188675695224878D	02
*	0.1509000000000000D	04	0.6161688480554578D	02
*	0.1509500000000000D	04	0.6133038016067585D	02
*	0.1510000000000000D	04	0.6102764086395647D	02
*	0.1510500000000000D	04	0.6070939553461133D	02
*	0.1511000000000000D	04	0.6037683512414033D	02
*	0.1511500000000000D	04	0.6003173800870330D	02
*	0.1512000000000000D	04	0.5967658111356284D	02
*	0.1512500000000000D	04	0.5931462889021669D	02
*	0.1513000000000000D	04	0.5894999145869853D	02
*	0.1513500000000000D	04	0.5858764302634515D	02
*	0.1514000000000000D	04	0.5823339201565854D	02
*	0.1514500000000000D	04	0.5789379543614632D	02
*	0.1515000000000000D	04	0.5757601220850542D	02
*	0.1515500000000000D	04	0.5728759363041399D	02
*	0.1516000000000000D	04	0.5703621405427318D	02
*	0.1516500000000000D	04	0.5682935095938295D	02
*	0.1517000000000000D	04	0.5667393040437164D	02
*	0.1517500000000000D	04	0.5657596040687973D	02
*	0.1518000000000000D	04	0.5654017986950061D	02
*	0.1518500000000000D	04	0.5656975294332393D	02
*	0.1519000000000000D	04	0.5666603717256874D	02
*	0.1519500000000000D	04	0.5682844805922476D	02
*	0.1520000000000000D	04	0.5705443339218532D	02
*	0.1520500000000000D	04	0.5733955925659652D	02
*	0.1521000000000000D	04	0.5767769809050701D	02
*	0.1521500000000000D	04	0.5806129948720887D	02
*	0.1522000000000000D	04	0.5848171815935428D	02
*	0.1522500000000000D	04	0.5892957120697267D	02
*	0.1523000000000000D	04	0.5939509829305430D	02
* '75 NOV. 7 '5	0.1523500000000000D	04	0.5986850258867271D	02
*	0.1524000000000000D	04	0.6034025615339884D	02
*	0.1524500000000000D	04	0.6080135956255465D	02
*	0.1525000000000000D	04	0.6124355116119317D	02
*	0.1525500000000000D	04	0.6165946576577672D	02
*	0.1526000000000000D	04	0.6204274576567998D	02

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*	0.1526500000000000D	04	0.6238810944015310D	02
*	0.1527000000000000D	04	0.6269138214353063D	02
*	0.1527500000000000D	04	0.6294949607628387D	02
*	0.1528000000000000D	04	0.6316046393369093D	02
*	0.1528500000000000D	04	0.6332333103216011D	02
*	0.1529000000000000D	04	0.6343810973732542D	02
*	0.1529500000000000D	04	0.6350569928209138D	02
*	0.1530000000000000D	04	0.6352779345101017D	02
*	0.1530500000000000D	04	0.6350677817238933D	02
*	0.1531000000000000D	04	0.6344562081737926D	02
*	0.1531500000000000D	04	0.6334775296869420D	02
*	0.1532000000000000D	04	0.6321694856967495D	02
*	0.1532500000000000D	04	0.6305719967236873D	02
*	0.1533000000000000D	04	0.6287259242668161D	02
*	0.1533500000000000D	04	0.6266718643200912D	02
*	0.1534000000000000D	04	0.6244490103757916D	02
*	0.1534500000000000D	04	0.6220941254890664D	02
*	0.1535000000000000D	04	0.6196406649053912D	02
*	0.1535500000000000D	04	0.6171180901821535D	02
*	0.1536000000000000D	04	0.6145514120755403D	02
*	0.1536500000000000D	04	0.6119609924165396D	02
*	0.1537000000000000D	04	0.6093626248506519D	02
*	0.1537500000000000D	04	0.6067679010721377D	02
*	0.1538000000000000D	04	0.6041848538202826D	02
*	0.1538500000000000D	04	0.6016188514558771D	02
*	0.1539000000000000D	04	0.5990737024993709D	02
*	0.1539500000000000D	04	0.5965529132040909D	02
*	0.1540000000000000D	04	0.5940610279890233D	02
*	0.1540500000000000D	04	0.5916049721105637D	02
*	0.1541000000000000D	04	0.5891953088756294D	02
*	0.1541500000000000D	04	0.5868473203923796D	02
*	0.1542000000000000D	04	0.5845818218093563D	02
*	0.1542500000000000D	04	0.5824256247308826D	02
*	0.1543000000000000D	04	0.5804115767885213D	02
*	0.1543500000000000D	04	0.5785781220309104D	02
*	0.1544000000000000D	04	0.5769683516003877D	02
*	0.1544500000000000D	04	0.5756285463708173D	02
*	0.1545000000000000D	04	0.5746062520515601D	02
*	0.1545500000000000D	04	0.5739479705371588D	02
*	0.1546000000000000D	04	0.5736965949093552D	02
*	0.1546500000000000D	04	0.5738887539618260D	02
*	0.1547000000000000D	04	0.5745522586169274D	02
*	0.1547500000000000D	04	0.5757038510724352D	02
*	0.1548000000000000D	04	0.5773474436223162D	02
*	0.1548500000000000D	04	0.5794729972618067D	02
*	0.1549000000000000D	04	0.5820561340809400D	02
*	0.1549500000000000D	04	0.5850585098409653D	02
*	0.1550000000000000D	04	0.5884289040968128D	02
*	0.1550500000000000D	04	0.5921049252019426D	02
*	0.1551000000000000D	04	0.5960151843019412D	02
*	0.1551500000000000D	04	0.6000817704712716D	02
*	0.1552000000000000D	04	0.6042228581667553D	02
*	0.1552500000000000D	04	0.6083552947086139D	02
*	0.1553000000000000D	04	0.6123970437508804D	02
*	0.1553500000000000D	04	0.6162693944449257D	02
*	0.1554000000000000D	04	0.6198988797584173D	02
*	0.1554500000000000D	04	0.6232168771903398D	02
*	0.1555000000000000D	04	0.6261708886904433D	02
*	0.1555500000000000D	04	0.6287055131601530D	02
*	0.1556000000000000D	04	0.6307831348742143D	02

*	0.15565000000000000D 04	0.6323743554952654D 02
*	0.15570000000000000D 04	0.6334601973999713D 02
*	0.15575000000000000D 04	0.6340321031031544D 02
*	0.15580000000000000D 04	0.6340917508917898D 02
*	0.15585000000000000D 04	0.6336507013908877D 02
*	0.15590000000000000D 04	0.6327298845377093D 02
*	0.15595000000000000D 04	0.6313589320499312D 02
*	0.15600000000000000D 04	0.6295753575268849D 02
*	0.15605000000000000D 04	0.6274235853206942D 02
*	0.15610000000000000D 04	0.6249538306638509D 02
*	0.15615000000000000D 04	0.6222208375290925D 02
*	0.15620000000000000D 04	0.6192824874318645D 02
*	0.15625000000000000D 04	0.6161983016986170D 02
*	0.15630000000000000D 04	0.6130278711248327D 02
*	0.15635000000000000D 04	0.6098292594505019D 02
*	0.15640000000000000D 04	0.6066574393757782D 02
*	0.15645000000000000D 04	0.6035628300779710D 02
*	0.15650000000000000D 04	0.6005900114941398D 02
*	0.15655000000000000D 04	0.5977766910978853D 02
*	0.15660000000000000D 04	0.5951529921365420D 02
*	0.15665000000000000D 04	0.5927411177549283D 02
*	0.15670000000000000D 04	0.5905554235860551D 02
*	0.15675000000000000D 04	0.5886029039850184D 02
*	0.15680000000000000D 04	0.5868840667029988D 02
*	0.15685000000000000D 04	0.5853941407543320D 02
*	0.15690000000000000D 04	0.5841245357338850D 02
*	0.15695000000000000D 04	0.5830644507029495D 02
*	0.15700000000000000D 04	0.5822025188260765D 02
*	0.15705000000000000D 04	0.5815283709615695D 02
*	0.15710000000000000D 04	0.5810340071682412D 02
*	0.15715000000000000D 04	0.5807148785810776D 02
*	0.15720000000000000D 04	0.5805706019036340D 02
*	0.15725000000000000D 04	0.5806052533210403D 02
*	0.15730000000000000D 04	0.5808272164549749D 02
*	0.15735000000000000D 04	0.5812485886529172D 02
*	0.15740000000000000D 04	0.5818841800082829D 02
*	0.15745000000000000D 04	0.5827501684531234D 02
*	0.15750000000000000D 04	0.5838625002035058D 02
*	0.15755000000000000D 04	0.5852351456078730D 02
*	0.15760000000000000D 04	0.5868783338243012D 02
*	0.15765000000000000D 04	0.5887968937742280D 02
*	0.15770000000000000D 04	0.5909888222391785D 02
*	0.15775000000000000D 04	0.5934441827254900D 02
*	0.15780000000000000D 04	0.5961444122525825D 02
*	0.15785000000000000D 04	0.5990620802340795D 02
*	0.15790000000000000D 04	0.6021611080116406D 02
*	0.15795000000000000D 04	0.6053974234782870D 02
*	0.15800000000000000D 04	0.6087199964244330D 02
*	0.15805000000000000D 04	0.6120721794681025D 02
*	0.15810000000000000D 04	0.6153932680377260D 02
*	0.15815000000000000D 04	0.6186201906656028D 02
*	0.15820000000000000D 04	0.6216892464870615D 02
*	0.15825000000000000D 04	0.6245378180804697D 02
*	0.15830000000000000D 04	0.6271060022813706D 02
*	0.15835000000000000D 04	0.6293381169903955D 02
*	0.15840000000000000D 04	0.6311840564540871D 02
*	0.15845000000000000D 04	0.6326004797286738D 02
*	0.15850000000000000D 04	0.6335518263173726D 02
*	0.15855000000000000D 04	0.6340111590624852D 02
*	0.15860000000000000D 04	0.6339608373744153D 02

*	0.1586500000000000D 04	0.6333930241556330D 02
*	0.1587000000000000D 04	0.6323100277964040D 02
*	0.1587500000000000D 04	0.6307244769525350D 02
*	0.1588000000000000D 04	0.6286593210721177D 02
*	0.1588500000000000D 04	0.6261476444936443D 02
*	0.1589000000000000D 04	0.6232322771497923D 02
*	0.1589500000000000D 04	0.6199651813315900D 02
*	0.1590000000000000D 04	0.6164065926177978D 02
*	0.1590500000000000D 04	0.6126238950001643D 02
*	0.1591000000000000D 04	0.6086902165887377D 02
*	0.1591500000000000D 04	0.6046827439703946D 02
*	0.1592000000000000D 04	0.6006807708661391D 02
*	0.1592500000000000D 04	0.5967635199650902D 02
*	0.1593000000000000D 04	0.5930078043889926D 02
*	0.1593500000000000D 04	0.5894856244926606D 02
*	0.1594000000000000D 04	0.5862618226619068D 02
*	0.1594500000000000D 04	0.5833919384428377D 02
*	0.1595000000000000D 04	0.5809204136069228D 02
*	0.1595500000000000D 04	0.5788792875811069D 02
*	0.1596000000000000D 04	0.5772874961929674D 02
*	0.1596500000000000D 04	0.5761508423893235D 02
*	0.1597000000000000D 04	0.5754626513098120D 02
*	0.1597500000000000D 04	0.5752050614368525D 02
*	0.1598000000000000D 04	0.5753508472540067D 02
*	0.1598500000000000D 04	0.5758656248360623D 02
*	0.1599000000000000D 04	0.5767102655650637D 02
*	0.1599500000000000D 04	0.5778433367560421D 02
*	0.1600000000000000D 04	0.5792233999240884D 02

TOTAL NO OF FUNCTION EVALUATIONS IS 201089

```
$ 18.13.32 JOB  62 -- RMARN008 -- BEGINNING EXEC - INIT 8 - CLASS M
 *18.13.43 JOB  62 IEC020I 001-5,LUMON,330,FT05F001,330
 *18.13.43 JOB  62 IEC020I GET OR READ ISSUED AFTER END-OF-FILE
$ 18.13.55 JOB  62 END EXECUTION.
```

```
 HASP-II JOB STATISTICS --    18 CARDS READ --      25 LINES PRINTE
```

APPENDIX 21

```
        $JOB
                 IMPLICIT REAL*8(A-H,O-Z)
                 DT=46.60D0
                 P=DT/43200
                 A0=59.869 733D0
                 A1=  .474 131D0
                 A2= -.000 893D0
                 A3= -.001 503D0
                 DUT=A0+A1*P+A2*P**2+A3*P**3
                 DNE=59.868 502 588 672 71D0
                 D=(DNE-DUT)*6378.160D0
                 PRINT1,D
        1        FORMAT(' ',F30. 2)
                 STOP
                 END

        $ENTRY
                          -11.11
CORE USAGE        OBJECT CODE=      656 BYTES,ARRAY AREA=       0 BYTE:

DIAGNOSTICS        NUMBER OF ERRORS=       0, NUMBER OF WARNINGS=

COMPILE TIME=     0.71 SEC,EXECUTION TIME=     0.01 SEC,  WATFIV - VI
```

```
//RMARN034 JOB '1610125,0200,9,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC PGM=IEBUPDTE
//SYSPRINT DD SYSOUT=A
//SYSUT1 DD UNIT=2400,DCB=(DEN=2,RECFM=FB,LRECL=80,BLKSIZE=800),
// LABEL=(2,SL),DISP=(OLD,KEEP),VOL=SER=LUT177,DSN=MCLIB
//SYSUT2 DD DSN=&&ROY,UNIT=2314,DISP=(NEW,PASS),SPACE=(CYL,(5,1)),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSIN DD *
IEF236I ALLOC. FOR RMARN034
IEF237I 361    ALLOCATED TO SYSPRINT
IEF237I 182    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSUT2
IEF237I 313    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   MCLIB                                          KEPT
IEF285I   VOL SER NOS= LUT177.
IEF285I   SYS74088.T091002.RV000.RMARN034.ROY            PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /          / START 74092.0302
IEF374I STEP /          / STOP  74092.0307 CPU   0MIN 20.52SEC MAIN  28K
CHARGE   $          2.47 CPU TIME 00.00.21   REGION REQUESTED 0062K   STA
                    DISK   MAG TAPE  READER  PRINTER
I/O COUNTS           470      471        3        5
NO. OF DD CARDS       1        1         1        1
// EXEC PGM=IEBUPDTE
//SYSPRINT DD SYSOUT=A
//SYSUT1 DD DSN=&&ROY,UNIT=2314,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSIN DD *
IEF236I ALLOC. FOR RMARN034
IEF237I 361    ALLOCATED TO SYSPRINT
IEF237I 132    ALLOCATED TO SYSUT1
IEF237I 314    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74088.T091002.RV000.RMARN034.ROY            PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /          / START 74092.0307
IEF374I STEP /          / STOP  74092.0309 CPU   0MIN 11.09SEC MAIN  30K
CHARGE   $          0.67 CPU TIME 00.00.11   REGION REQUESTED 0062K   STA
                    DISK   READER  PRINTER
I/O COUNTS           472      3       6
NO. OF DD CARDS       1       1       1
// EXEC PGM=IEBGENER
//SYSIN  DD  DUMMY
//SYSPRINT  DD  SYSOUT=A
//SYSUT1 DD DSN=TEXT,UNIT=2400,DISP=OLD,LABEL=(3,SL),VOL=SER=LUT177,
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2 DD DISP=(,PASS),UNIT=2314,SPACE=(CYL,(3,1)),DSN=&T,
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
IEF236I ALLOC. FOR RMARN034
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 182    ALLOCATED TO SYSUT1
IEF237I 132    ALLOCATED TO SYSUT2
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   TEXT                                           KEPT
IEF285I   VOL SER NOS= LUT177.
IEF285I   SYS74088.T091002.RV000.RMARN034.T              PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /          / START 74092.0309
```

```
IEF374I STEP /          / STOP  74092.0311 CPU    0MIN 15.27SEC MAIN   36K
CHARGE    $          2.07 CPU TIME 00.00.15    REGION REQUESTED 0062K    STA
                    DISK   MAG TAPE READER  PRINTER
I/O COUNTS            291     292       0         3
NO. OF DD CARDS         1       1       1         1
// EXEC ASMFCLG,
//              PARM.ASM='NOLIST,NOXREF,LOAD,NODECK',
//               PARM.LKED='SIZE=(300K,100K)',REGION.LKED=350K,
// REGION.GO=500K,PARM.GO='$000$LIST'
XXASM       EXEC PGM=IEUASM,PARM='LOAD,NODECK'
XXSYSLIB DD      DSNAME=SYS1.MACLIB,DISP=SHR
XXSYSUT1    DD   UNIT=2314,SPACE=(CYL,(5,1))
XXSYSUT2    DD   UNIT=2314,SPACE=(CYL,(5,1))
XXSYSUT3    DD   UNIT=2314,
XX               SPACE=(1700,(400,50))
XXSYSPRINT DD    SYSOUT=A,SPACE=(CYL,(5,5))
XXSYSPUNCH DD    DUMMY
XXSYSGO     DD   DSNAME=&LOADSET,UNIT=2314,SPACE=(80,(100,50)),
XX               DISP=(MOD,PASS)
//ASM.SYSIN DD DISP=OLD,UNIT=2314,DSN=&&ROY,
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
IEF648I INVALID DISP FIELD- PASS SUBSTITUTED
IEF236I ALLOC. FOR RMARN034 ASM
IEF237I 131    ALLOCATED TO SYSLIB
IEF237I 134    ALLOCATED TO SYSUT1
IEF237I 134    ALLOCATED TO SYSUT2
IEF237I 135    ALLOCATED TO SYSUT3
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 136    ALLOCATED TO SYSGO
IEF237I 132    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.MACLIB                                    KEPT
IEF285I   VOL SER NOS= MVT217.
IEF285I   SYS74088.T091002.RV000.RMARN034.R0003563       DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74088.T091002.RV000.RMARN034.R0003564       DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74088.T091002.RV000.RMARN034.R0003565       DELETED
IEF285I   VOL SER NOS= SPLU02.
IEF285I   SYS74088.T091002.RV000.RMARN034.LOADSET        PASSED
IEF285I   VOL SER NOS= ADMP04.
IEF285I   SYS74088.T091002.RV000.RMARN034.ROY            PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /ASM      / START 74092.0311
IEF374I STEP /ASM      / STOP  74092.0321 CPU    6MIN 48.02SEC MAIN   62K
CHARGE    $         13.55 CPU TIME 00.06.48   REGION REQUESTED 0062K    STA
                    DISK   READER  PRINTER
I/O COUNTS           2990     0        0
NO. OF DD CARDS         6     1        1
XXLKED    EXEC  PGM=IEWL,PARM=(XREF,LET,LIST,NCAL),
XX              COND=(8,LT,ASM)
XXSYSLIN DD     DSNAME=&LOADSET,DISP=(OLD,DELETE)
XX        DD    DDNAME=SYSIN
//LKED.SYSLMOD DD SPACE=(CYL,(5,1,1))
X/SYSLMOD   DD  DSNAME=&TEMP(PDS),UNIT=2314,SPACE=(CYL,(1,,1)),
XX              DISP=(MOD,PASS)
//LKED.SYSUT1  DD SPACE=(CYL,(5,1))
X/SYSUT1    DD  UNIT=2314,SPACE=(1024,(50,20))
XXSYSPRINT DD   SYSOUT=A,DCB=(,BLKSIZE=121)
//LKED.TEXT DD DISP=OLD,DSN=&T
```

```
IEF648I INVALID DISP FIELD- PASS SUBSTITUTED
//LKED.SYSIN DD *
IEF236I ALLOC. FOR RMARN034 LKED
IEF237I 136    ALLOCATED TO SYSLIN
IEF237I 315    ALLOCATED TO
IEF237I 134    ALLOCATED TO SYSLMOD
IEF237I 134    ALLOCATED TO SYSUT1
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 132    ALLOCATED TO TEXT
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74088.T091002.RV000.RMARN034.LOADSET        DELETED
IEF285I   VOL SER NOS= ADMP04.
IEF285I   SYS74088.T091002.RV000.RMARN034.TEMP           PASSED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74088.T091002.RV000.RMARN034.R0003567       DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74088.T091002.RV000.RMARN034.T              PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /LKED    / START 74092.0321
IEF374I STEP /LKED    / STOP  74092.0322 CPU    0MIN 35.42SEC MAIN 306K
CHARGE    $          2.08 CPU TIME 00.00.35   REGION REQUESTED 0350K   STA
                     DISK   READER  PRINTER
I/O COUNTS            561        2        5
NO. OF DD CARDS         4        1        1
XXGO     EXEC  PGM=*.LKED.SYSLMOD,COND=((8,LT,ASM),(4,LT,LKED))
//GO.SYSPRINT DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=121,BLKSIZE=847)
//GO.SYSPNCH DD DSN=FOR74092,UNIT=2314,SPACE=(CYL,(2,1)),DISP=(,CATLG),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
// VOL=SER=SPLU06,LABEL=EXPDT=74365
//GO.SYSIN DD *
IEF236I ALLOC. FOR RMARN034 GO
IEF237I 134    ALLOCATED TO PGM=*.DD
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 130    ALLOCATED TO SYSPNCH
IEF237I 316    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74088.T091002.RV000.RMARN034.TEMP           PASSED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   FOR74092                                       CATALOGED
IEF285I   VOL SER NOS= SPLU06.
IEF373I STEP /GO      / START 74092.0322
IEF374I STEP /GO      / STOP  74092.0705 CPU 143MIN 48.52SEC MAIN 464K
CHARGE    $      453.68 CPU TIME 02.23.49   REGION REQUESTED 0500K   STA
                     DISK   READER  PRINTER
I/O COUNTS            209      481      484
NO. OF DD CARDS         2        1        1
// EXEC PGM=IEBGENER
//SYSIN  DD  DUMMY
//SYSPRINT  DD  SYSOUT=A
//SYSUT1 DD DSN=FOR74092,DISP=OLD
//SYSUT2 DD SYSOUT=A,
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
IEF236I ALLOC. FOR RMARN034
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 130    ALLOCATED TO SYSUT1
IEF237I 361    ALLOCATED TO SYSUT2
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   FOR74092                                       KEPT
IEF285I   VOL SER NOS= SPLU06.
IEF373I STEP /        / START 74092.0705
```

```
IEF374I STEP /        / STOP  74092.0706 CPU    0MIN 29.52SEC MAIN   34K I
CHARGE    $          5.34 CPU TIME 00.00.30   REGION REQUESTED 0062K    STA
                     DISK   READER  PRINTER
I/O COUNTS             210        0     2084
NO. CF DD CARDS          1        1        2
// EXEC FORTGCLG,PARM.FORT='ID',REGION.FORT=300K
XXFORT    EXEC  PGM=IEYFCRT,REGION=84K
XXSYSPRINT DD   SYSOUT=A
XXSYSPUNCH DD   SYSCUT=B
//FORT.SYSLIN   DD SPACE=(CYL,(20,10))
X/SYSLIN    DD  DSN=&LOADSET,DISP=(MOD,PASS),DCB=BLKSIZE=80,
XX              UNIT=2314,SPACE=(CYL,(1,1))
//FORT.SYSIN DD DSN=FOR74092,DISP=OLD
// DC *
IEF236I ALLOC. FOR RMARNO34 FORT
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 330    ALLOCATED TO SYSPUNCH
IEF237I 135    ALLOCATED TO SYSLIN
IEF237I 130    ALLOCATED TO SYSIN
IEF237I 317    ALLOCATED TO
IEF142I - STEP WAS EXECUTED - COND CODE 0016
IEF285I    SYS74088.T091002.RV000.RMARNO34.LOADSET       PASSED
IEF285I    VOL SER NCS= SPLU03.
IEF285I    FOR74092                                      KEPT
IEF285I    VOL SER NCS= SPLU06.
IEF373I STEP /FORT     / START 74092.0706
IEF374I STEP /FORT     / STOP  74092.0710 CPU   3MIN 57.12SEC MAIN 148K I
CHARGE    $        13.23 CPU TIME 00.03.57   REGION REQUESTED 0300K    STA
                   DISK   READER  PRINTER  PUNCH
I/O CCUNTS            444      88     1302        0
NO. CF DD CARDS         2       1        1        1
XXLKED    EXEC  PGM=IEWL,PARM=(XREF,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB    DD  DSNAME=SYS1.FORTLIB,DISP=SHR
XX          DD  DSN=FCRTSUB,DISP=SHR
XXSYSLMOD   DD  DSN=&GOSET(MAIN),DISP=(,PASS),
XX              UNIT=2314,SPACE=(CYL,(1,,1))
XXSYSPRINT DD   SYSOUT=A
XXSYSUT1    DD  UNIT=2314,SPACE=(CYL,(1,1)),DCB=BLKSIZE=1024
XXSYSLIN    DD  DSNAME=&LOADSET,DISP=(OLD,DELETE)
XX          DD  DDNAME=SYSIN
IEF202I - STEP - LKED     , WAS NOT RUN BECAUSE OF CONDITION CODES.
IEF236I ALLOC. FOR RMARNO34 LKED
IEF373I STEP /LKED     / START 74092.0710
IEF374I STEP /LKED     / STOP  74092.0710 CPU   0MIN 00.00SEC MAIN   0K I
CHARGE    $         0.09 CPU TIME 00.00.00   REGION REQUESTED 0062K    STA

I/C COUNTS
NO. CF DD CARDS
XXGO EXEC PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFT05F001 DD   DDNAME=SYSIN
XXFT06F001 DD   SYSOUT=A
XXFT07F001 DD   SYSOUT=B
//
IEF202I - STEP - GO        , WAS NOT RUN BECAUSE OF CONDITION CODES.
IEF236I ALLOC. FOR RMARNO34 GO
IEF373I STEP /GO       / START 74092.0710
IEF374I STEP /GO       / STOP  74092.0711 CPU   0MIN 00.00SEC MAIN   0K I
CHARGE    $         0.09 CPU TIME 00.00.00   REGION REQUESTED 0062K    STA

I/O COUNTS
```

```
NO. CF DD CARDS
IEF285I   SYS74088.T091002.RV000.RMARN034.ROY              DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74088.T091002.RV000.RMARN034.T                DELETED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74088.T091002.RV000.RMARN034.LOADSET          DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF285I   SYS74088.T091002.RV000.RMARN034.TEMP             DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF375I  JOB /RMARN034/ START 74092.0302
IEF376I  JOB /RMARN034/ STOP  74092.0711 CPU 156MIN 25.48SEC
RMARN034 JOB CHARGE $    517.995
```

SYSIN NEW MASTER

```
        ./ CHANGE
        ./ NUMBER NEW1=10,INCR=10
IEB818I HIGHEST CONDITION CODE WAS 00000000
IEB819I END OF JOB IEBUPDTE.
```

APPENDIX 22 C

```
D UNIVERSITY COMPUTER CENTRE
N                                   NEW MASTER                                              IEBUPDTE LOG PAGE 0001

HANGE            UPDATE=INPLACE
             DC     F'131072'       FOR NOW ACN DEMANDS THAT BCPL                00013290     *       REPLACI
             DC     F'327680'   *** ROY'S CHANGE ***                             00013290     *    REPLACEMEI
HEST CONDITION CODE WAS 00000000
 CF JOB IEBUPDTE.
```

```
***TAYLOR SERIES SYSTEM***
TERMS 8
DOUBLE
EPSILON=1D-6
INIT SETUP
    Y1(0)=        0.465371246535238 2D11
Y2(0)     =       0.17128116090843 71D11
Y3(0)     =       0.43920641224179 38D10
Y1'(0)    =      -0.26546294336465 62D05
Y2'(0)    =       0.41411653222259 82D05
Y3'(0)    =       0.24904529863497 14D05
Y4(0)     =      -0.10529074342385 80D12
Y5(0)     =       0.17087926541847 85D11
Y6(0)     =       0.14350362175392 61D11
Y4'(0)     =     -0.71552745934116 77D04
Y5'(0)     =     -0.31597104566802 29D05
Y6'(0)     =     -0.13786806833361 60D05
Y7(0)      =      0.14379032863230 03D12
Y8(0)      =     -0.41707002704188 70D11
Y9(0)      =     -0.18086043451318 65D11
Y7'(0)     =      0.84903282513079 25D04
Y8'(0)     =      0.25950062371132 01D05
Y9'(0)     =      0.11251609687452 81D05
Y10(0)     =      0.14414660394633 78D12
Y11(0)     =     -0.41748660366396 73D11
Y12(0)     =     -0.18081139679665 95D11
Y10'(0)    =      0.85924867616896 00D04
Y11'(0)    =      0.26919792505148 38D05
Y12'(0)    =      0.11754794785966 60D05
Y13(0)     =      0.18505098955903 12D12
Y14(0)     =     -0.81672566273336 56D11
Y15(0)     =     -0.42454765751522 48D11
Y13'(0)    =      0.11723837467744 55D05
Y14'(0)    =      0.21711475642199 73D05
Y15'(0)    =      0.96513100602604 57D04
Y16(0)     =     -0.27840204060788 78D12
Y17(0)     =     -0.68973264903064 66D12
Y18(0)     =     -0.28909002723091 38D12
Y16'(0)    =      0.12106928586941 80D05
Y17'(0)    =     -0.35246147792525 36D04
Y18'(0)    =     -0.18079665118511 75D04
Y19(0)     =      0.68474373109895 31D12
Y20(0)     =      0.10953679359724 01D13
Y21(0)     =      0.42330688525322 08D12
Y19'(0)    =     -0.88557300115687 46D04
Y20'(0)    =      0.43450556471365 21D04
Y21'(0)    =      0.21796868428818 18D04
Y22(0)     =     -0.26722308243651 25D13
Y23(0)     =     -0.58986407095513 289D12
Y24(0)     =     -0.22069271815256 19D12
Y22'(0)    =      0.15139624587298 54D04
Y23'(0)    =     -0.63574534025395 01D04
Y24'(0)    =     -0.28070449773240 23D04
Y25(0)     =     -0.21269786287167 40D13
Y26(0)     =     -0.37257013684924 52D13
Y27(0)     =     -0.14726684237228 40D13
Y25'(0)    =      0.47754093292303 15D04
Y26'(0)    =     -0.22892070677812 11D04
```

```
Y27'(0)   =     -0.10579607366167000D04
Y28(0)    =     -0.45079394323226190D13
Y29(0)    =     -0.45612881049740400D12
Y30(0)    =      0.12219802658241120D13
Y28'(0)   =      0.89260159660719100D03
Y29'(0)   =     -0.54279178459038200D04
Y30'(0)   =     -0.19827036268527260D04
ADVANCE VALUES(X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
Y1',Y2',Y3',Y4',Y5',Y6',Y7',Y8',Y9',Y10',Y11',Y12',Y13',Y14',Y15',Y16',
Y17',Y18',Y19',Y20',Y21',Y22',Y23',Y24',Y25',Y26',Y27',Y28',Y29',Y30')
EQUATIONS
A=149597.9D6
F1=86400
GM1=-A**3*(.01720209895D0/F1)**2
GM2=-GM1/5983000D0
GM3=-GM1/408522D0
GM4=-GM1/332945.56192544D0
GM5=-GM1/27068807.130100D0
GM6=-GM1/3098700D0
GM7=-GM1/1047.3908D0
GM8=-GM1/3499.2D0
GM9=-GM1/22930D0
GM10=-GM1/19260D0
GM11=-GM1/1812000D0
C1=-1.5D0
R2=(Y1   *Y1   +Y2   *Y2   +Y3   *Y3   )**C1
R3=(Y4   *Y4   +Y5   *Y5   +Y6   *Y6   )**C1
R4=(Y7   *Y7   +Y8   *Y8   +Y9   *Y9   )**C1
R5=(Y10  *Y10  +Y11  *Y11  +Y12  *Y12  )**C1
R6=(Y13  *Y13  +Y14  *Y14  +Y15  *Y15  )**C1
R7=(Y16  *Y16  +Y17  *Y17  +Y18  *Y18  )**C1
R8=(Y19  *Y19  +Y20  *Y20  +Y21  *Y21  )**C1
R9=(Y22  *Y22  +Y23  *Y23  +Y24  *Y24  )**C1
R10=(Y25   *Y25   +Y26   *Y26   +Y27   *Y27   )**C1
R11=(Y28   *Y28   +Y29   *Y29   +Y30   *Y30   )**C1
RX23=Y4-Y1
RY23=Y5-Y2
RZ23=Y6-Y3
RX24=Y7-Y1
RY24=Y8-Y2
RZ24=Y9-Y3
RX25=Y10-Y1
RY25=Y11-Y2
RZ25=Y12-Y3
RX26=Y13-Y1
RY26=Y14-Y2
RZ26=Y15-Y3
RX27=Y16-Y1
RY27=Y17-Y2
RZ27=Y18-Y3
RX28=Y19-Y1
RY28=Y20-Y2
RZ28=Y21-Y3
RX29=Y22-Y1
RY29=Y23-Y2
RZ29=Y24-Y3
RX210=Y25-Y1
RY210=Y26-Y2
RZ210=Y27-Y3
```

```
RX211=Y28-Y1
RY211=Y29-Y2
RZ211=Y30-Y3
RX34=Y7-Y4
RY34=Y8-Y5
RZ34=Y9-Y6
RX35=Y10-Y4
RY35=Y11-Y5
RZ35=Y12-Y6
RX36=Y13-Y4
RY36=Y14-Y5
RZ36=Y15-Y6
RX37=Y16-Y4
RY37=Y17-Y5
RZ37=Y18-Y6
RX38=Y19-Y4
RY38=Y20-Y5
RZ38=Y21-Y6
RX39=Y22-Y4
RY39=Y23-Y5
RZ39=Y24-Y6
RX310=Y25-Y4
RY310=Y26-Y5
RZ310=Y27-Y6
RX311=Y28-Y4
RY311=Y29-Y5
RZ311=Y30-Y6
RX45=Y10-Y7
RY45=Y11-Y8
RZ45=Y12-Y9
RX46=Y13-Y7
RY46=Y14-Y8
RZ46=Y15-Y9
RX47=Y16-Y7
RY47=Y17-Y8
RZ47=Y18-Y9
RX48=Y19-Y7
RY48=Y20-Y8
RZ48=Y21-Y9
RX49=Y22-Y7
RY49=Y23-Y8
RZ49=Y24-Y9
RX410=Y25-Y7
RY410=Y26-Y8
RZ410=Y27-Y9
RX411=Y28-Y7
RY411=Y29-Y8
RZ411=Y30-Y9
RX56=Y13-Y10
RY56=Y14-Y11
RZ56=Y15-Y12
RX57=Y16-Y10
RY57=Y17-Y11
RZ57=Y18-Y12
RX58=Y19-Y10
RY58=Y20-Y11
RZ58=Y21-Y12
RX59=Y22-Y10
RY59=Y23-Y11
RZ59=Y24-Y12
```

```
RX510=Y25-Y10
RY510=Y26-Y11
RZ510=Y27-Y12
RX511=Y28-Y10
RY511=Y29-Y11
RZ511=Y30-Y12
RX67=Y16-Y13
RY67=Y17-Y14
RZ67=Y18-Y15
RX68=Y19-Y13
RY68=Y20-Y14
RZ68=Y21-Y15
RX69=Y22-Y13
RY69=Y23-Y14
RZ69=Y24-Y15
RX610=Y25-Y13
RY610=Y26-Y14
RZ610=Y27-Y15
RX611=Y28-Y13
RY611=Y29-Y14
RZ611=Y30-Y15
RX78=Y19-Y16
RY78=Y20-Y17
RZ78=Y21-Y18
RX79=Y22-Y16
RY79=Y23-Y17
RZ79=Y24-Y18
RX710=Y25-Y16
RY710=Y26-Y17
RZ710=Y27-Y18
RX711=Y28-Y16
RY711=Y29-Y17
RZ711=Y30-Y18
RX89=Y22-Y19
RY89=Y23-Y20
RZ89=Y24-Y21
RX810=Y25-Y19
RY810=Y26-Y20
RZ810=Y27-Y21
RX811=Y28-Y19
RY811=Y29-Y20
RZ811=Y30-Y21
RX910=Y25-Y22
RY910=Y26-Y23
RZ910=Y27-Y24
RX911=Y28-Y22
RY911=Y29-Y23
RZ911=Y30-Y24
RX1011=Y28-Y25
RY1011=Y29-Y26
RZ1011=Y30-Y27
R23=(RX23*RX23+RY23*RY23+RZ23*RZ23)**C1
R24=(RX24*RX24+RY24*RY24+RZ24*RZ24)**C1
R25=(RX25*RX25+RY25*RY25+RZ25*RZ25)**C1
R26=(RX26*RX26+RY26*RY26+RZ26*RZ26)**C1
R27=(RX27*RX27+RY27*RY27+RZ27*RZ27)**C1
R28=(RX28*RX28+RY28*RY28+RZ28*RZ28)**C1
R29=(RX29*RX29+RY29*RY29+RZ29*RZ29)**C1
R210=(RX210*RX210+RY210*RY210+RZ210*RZ210)**C1
R211=(RX211*RX211+RY211*RY211+RZ211*RZ211)**C1
```

```
R34=(RX34*RX34+RY34*RY34+RZ34*RZ34)**C1
R35=(RX35*RX35+RY35*RY35+RZ35*RZ35)**C1
R36=(RX36*RX36+RY36*RY36+RZ36*RZ36)**C1
R37=(RX37*RX37+RY37*RY37+RZ37*RZ37)**C1
R38=(RX38*RX38+RY38*RY38+RZ38*RZ38)**C1
R39=(RX39*RX39+RY39*RY39+RZ39*RZ39)**C1
R310=(RX310*RX310+RY310*RY310+RZ310*RZ310)**C1
R311=(RX311*RX311+RY311*RY311+RZ311*RZ311)**C1
R45=(RX45*RX45+RY45*RY45+RZ45*RZ45)**C1
R46=(RX46*RX46+RY46*RY46+RZ46*RZ46)**C1
R47=(RX47*RX47+RY47*RY47+RZ47*RZ47)**C1
R48=(RX48*RX48+RY48*RY48+RZ48*RZ48)**C1
R49=(RX49*RX49+RY49*RY49+RZ49*RZ49)**C1
R410=(RX410*RX410+RY410*RY410+RZ410*RZ410)**C1
R411=(RX411*RX411+RY411*RY411+RZ411*RZ411)**C1
R56=(RX56*RX56+RY56*RY56+RZ56*RZ56)**C1
R57=(RX57*RX57+RY57*RY57+RZ57*RZ57)**C1
R58=(RX58*RX58+RY58*RY58+RZ58*RZ58)**C1
R59=(RX59*RX59+RY59*RY59+RZ59*RZ59)**C1
R510=(RX510*RX510+RY510*RY510+RZ510*RZ510)**C1
R511=(RX511*RX511+RY511*RY511+RZ511*RZ511)**C1
R67=(RX67*RX67+RY67*RY67+RZ67*RZ67)**C1
R68=(RX68*RX68+RY68*RY68+RZ68*RZ68)**C1
R69=(RX69*RX69+RY69*RY69+RZ69*RZ69)**C1
R610=(RX610*RX610+RY610*RY610+RZ610*RZ610)**C1
R611=(RX611*RX611+RY611*RY611+RZ611*RZ611)**C1
R78=(RX78*RX78+RY78*RY78+RZ78*RZ78)**C1
R79=(RX79*RX79+RY79*RY79+RZ79*RZ79)**C1
R710=(RX710*RX710+RY710*RY710+RZ710*RZ710)**C1
R711=(RX711*RX711+RY711*RY711+RZ711*RZ711)**C1
R89=(RX89*RX89+RY89*RY89+RZ89*RZ89)**C1
R810=(RX810*RX810+RY810*RY810+RZ810*RZ810)**C1
R811=(RX811*RX811+RY811*RY811+RZ811*RZ811)**C1
R910=(RX910*RX910+RY910*RY910+RZ910*RZ910)**C1
R911=(RX911*RX911+RY911*RY911+RZ911*RZ911)**C1
R1011=(RX1011*RX1011+RY1011*RY1011+RZ1011*RZ1011)**C1
WA=GM2*R2
WB=GM3*R3
WC=GM4*R4
WD=GM5*R5
WE=GM6*R6
WF=GM7*R7
WG=GM8*R8
WH=GM9*R9
WI=GM10*R10
WJ=GM11*R11
WAX=Y1*WA+Y4*WB+Y7*WC+Y10*WD+Y13*WE+
Y16*WF+Y19*WG+Y22*WH+Y25*WI+Y28*WJ
WAY=Y2*WA+Y5*WB+Y8*WC+Y11*WD+Y14*WE+
Y17*WF+Y20*WG+Y23*WH+Y26*WI+Y29*WJ
WAZ=Y3*WA+Y6*WB+Y9*WC+Y12*WD+Y15*WE+
Y18*WF+Y21*WG+Y24*WH+Y27*WI+Y30*WJ
AA=GM3*R23
AB=GM4*R24
AC=GM5*R25
AD=GM6*R26
AE=GM7*R27
AF=GM8*R28
AG=GM9*R29
AH=GM10*R210
```

```
AI=GM11*R211
AJ=GM1*R2
Y1** =AA*RX23+AB*RX24+AC*RX25+AD*RX26+
AE*RX27+AF*RX28+AG*RX29+AH*RX210+
AI*RX211+Y1   *AJ-WAX
Y2** =AA*RY23+AB*RY24+AC*RY25+AD*RY26+
AE*RY27+AF*RY28+AG*RY29+AH*RY210+
AI*RY211+Y2   *AJ-WAY
Y3** =AA*RZ23+AB*RZ24+AC*RZ25+AD*RZ26+
AE*RZ27+AF*RZ28+AG*RZ29+AH*RZ210+
AI*RZ211+Y3   *AJ-WAZ
BA=GM2*R23
BB=GM4*R34
BC=GM5*R35
BD=GM6*R36
BE=GM7*R37
BF=GM8*R38
BG=GM9*R39
BH=GM10*R310
BI=GM11*R311
BJ=GM1*R3
Y4**   =-BA*RX23+BB*RX34+BC*RX35+BD*RX36+
BE*RX37+BF*RX38+BG*RX39+BH*RX310+
BI*RX311+Y4   *BJ-WAX
Y5**   =-BA*RY23+BB*RY34+BC*RY35+BD*RY36+
BE*RY37+BF*RY38+BG*RY39+BH*RY310+
BI*RY311+Y5   *BJ-WAY
Y6**   =-BA*RZ23+BB*RZ34+BC*RZ35+BD*RZ36+
BE*RZ37+BF*RZ38+BG*RZ39+BH*RZ310+
BI*RZ311+Y6   *BJ-WAZ
CA=GM2*R24
CB=GM3*R34
CC=GM5*R45
CD=GM6*R46
CE=GM7*R47
CF=GM8*R48
CG=GM9*R49
CH=GM10*R410
CI=GM11*R411
CJ=GM1*R4
Y7**   =-CA*RX24-CB*RX34+CC*RX45+CD*RX46+
CE*RX47+CF*RX48+CG*RX49+CH*RX410+
CI*RX411+Y7    *CJ-WAX
Y8**   =-CA*RY24-CB*RY34+CC*RY45+CD*RY46+
CE*RY47+CF*RY48+CG*RY49+CH*RY410+
CI*RY411+Y8    *CJ-WAY
Y9**   =-CA*RZ24-CB*RZ34+CC*RZ45+CD*RZ46+
CE*RZ47+CF*RZ48+CG*RZ49+CH*RZ410+
CI*RZ411+Y9    *CJ-WAZ
DA=GM2*R25
DB=GM3*R35
DC=GM4*R45
DD=GM6*R56
DE=GM7*R57
DF=GM8*R58
DG=GM9*R59
DH=GM10*R510
DI=GM11*R511
DJ=GM1*R5
Y10** =-DA*RX25-DB*RX35-DC*RX45+DD*RX56+
```

```
DE*RX57+DF*RX58+DG*RX59+DH*RX510+
DI*RX511+Y10   *DJ-WAX
Y11** =-DA*RY25-DB*RY35-DC*RY45+DD*RY56+
DE*RY57+DF*RY58+DG*RY59+DH*RY510+
DI*RY511+Y11   *DJ-WAY
Y12** =-DA*RZ25-DB*RZ35-DC*RZ45+DD*RZ56+
DE*RZ57+DF*RZ58+DG*RZ59+DH*RZ510+
DI*RZ511+Y12   *DJ-WAZ
EA=GM2*R26
EB=GM3*R36
EC=GM4*R46
ED=GM5*R56
EE=GM7*R67
EF=GM8*R68
EG=GM9*R69
EH=GM10*R610
EI=GM11*R611
EJ=GM1*R6
Y13** =-EA*RX26-EB*RX36-EC*RX46-ED*RX56+
EE*RX67+EF*RX68+EG*RX69+EH*RX610+
EI*RX611+Y13   *EJ-WAX
Y14** =-EA*RY26-EB*RY36-EC*RY46-ED*RY56+
EE*RY67+EF*RY68+EG*RY69+EH*RY610+
EI*RY611+Y14   *EJ-WAY
Y15** =-EA*RZ26-EB*RZ36-EC*RZ46-ED*RZ56+
EE*RZ67+EF*RZ68+EG*RZ69+EH*RZ610+
EI*RZ611+Y15   *EJ-WAZ
FA=GM2*R27
FB=GM3*R37
FC=GM4*R47
FD=GM5*R57
FE=GM6*R67
FF=GM8*R78
FG=GM9*R79
FH=GM10*R710
FI=GM11*R711
FJ=GM1*R7
Y16** =-FA*RX27-FB*RX37-FC*RX47-FD*RX57-
FE*RX67+FF*RX78+FG*RX79+FH*RX710+
FI*RX711+Y16   *FJ-WAX
Y17** =-FA*RY27-FB*RY37-FC*RY47-FD*RY57-
FE*RY67+FF*RY78+FG*RY79+FH*RY710+
FI*RY711+Y17   *FJ-WAY
Y18** =-FA*RZ27-FB*RZ37-FC*RZ47-FD*RZ57-
FE*RZ67+FF*RZ78+FG*RZ79+FH*RZ710+
FI*RZ711+Y18   *FJ-WAZ
GA=GM2*R28
GB=GM3*R38
GC=GM4*R48
GD=GM5*R58
GE=GM6*R68
GF=GM7*R78
GG=GM9*R89
GH=GM10*R810
GI=GM11*R811
GJ=GM1*R8
Y19** =-GA*RX28-GB*RX38-GC*RX48-GD*RX58-
GE*RX68-GF*RX78+GG*RX89+GH*RX810+
GI*RX811+Y19   *GJ-WAX
Y20** =-GA*RY28-GB*RY38-GC*RY48-GD*RY58-
```

```
GE*RY68-GF*RY78+GG*RY89+GH*RY810+
GI*RY811+Y20   *GJ-WAY
Y21'' =-GA*RZ28-GB*RZ38-GC*RZ48-GD*RZ58-
GE*RZ68-GF*RZ78+GG*RZ89+GH*RZ810+
GI*RZ811+Y21   *GJ-WAZ
HA=GM2*R29
HB=GM3*R39
HC=GM4*R49
HD=GM5*R59
HE=GM6*R69
HF=GM7*R79
HG=GM8*R89
HH=GM10*R910
HI=GM11*R911
HJ=GM1*R9
Y22'' =-HA*RX29-HB*RX39-HC*RX49-HD*RX59-
HE*RX69-HF*RX79-HG*RX89+HH*RX910+
HI*RX911+Y22   *HJ-WAX
Y23'' =-HA*RY29-HB*RY39-HC*RY49-HD*RY59-
HE*RY69-HF*RY79-HG*RY89+HH*RY910+
HI*RY911+Y23   *HJ-WAY
Y24'' =-HA*RZ29-HB*RZ39-HC*RZ49-HD*RZ59-
HE*RZ69-HF*RZ79-HG*RZ89+HH*RZ910+
HI*RZ911+Y24   *HJ-WAZ
OA=GM2*R210
OB=GM3*R310
OC=GM4*R410
OD=GM5*R510
OE=GM6*R610
OF=GM7*R710
OG=GM8*R810
OH=GM9*R910
OI=GM11*R1011
OJ=GM1*R10
Y25'' =-OA*RX210-OB*RX310-OC*RX410-OD*RX510-
OE*RX610-OF*RX710-OG*RX810-OH*RX910+
OI*RX1011+Y25   *OJ-WAX
Y26'' =-OA*RY210-OB*RY310-OC*RY410-OD*RY510-
OE*RY610-OF*RY710-OG*RY810-OH*RY910+
OI*RY1011+Y26   *OJ-WAY
Y27'' =-OA*RZ210-OB*RZ310-OC*RZ410-OD*RZ510-
OE*RZ610-OF*RZ710-OG*RZ810-OH*RZ910+
OI*RZ1011+Y27   *OJ-WAZ
PA=GM2*R211
PB=GM3*R311
PC=GM4*R411
PD=GM5*R511
PE=GM6*R611
PF=GM7*R711
PG=GM8*R811
PH=GM9*R911
PI=GM10*R1011
PJ=GM1*R11
Y28'' =-PA*RX211-PB*RX311-PC*RX411-PD*RX511-
PE*RX611-PF*RX711-PG*RX811-PH*RX911-
PI*RX1011+Y28   *PJ-WAX
Y29'' =-PA*RY211-PB*RY311-PC*RY411-PD*RY511-
PE*RY611-PF*RY711-PG*RY811-PH*RY911-
PI*RY1011+Y29   *PJ-WAY
Y30'' =-PA*RZ211-PB*RZ311-PC*RZ411-PD*RZ511-
```

```
PE*RZ611-PF*RZ711-PG*RZ811-PH*RZ911-
PI*RZ1011+Y30   *PJ-WAZ
END

COMPILED WITH DOUBLEPRECISION OPTIONS
STORE=44230/9759
TIME=4310.80 SECS
```

```
//RMARNO34 JOB '1610125,1439,9,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1),REGION=200K
// EXEC PGM=IEBUPDTE
//SYSPRINT DD SYSOUT=A
//SYSUT1 DD DSN=FOR74092,DISP=OLD
//SYSUT2 DD DSN=&&ROA,UNIT=2314,DISP=(NEW,PASS),SPACE=(CYL,(5,1)),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSIN DD *
IEF236I ALLOC. FOR RMARNO34
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 130    ALLOCATED TO SYSUT1
IEF237I 135    ALLOCATED TO SYSUT2
IEF237I 310    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   FOR74092                                      KEPT
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74144.T154300.RV000.RMARNO34.ROA           PASSED
IEF285I   VOL SER NOS= SPLU05.
IEF373I STEP /          / START 74146.0316
IEF374I STEP /          / STOP  74146.0317 CPU    0MIN 10.42SEC MAIN   28K
CHARGE    $         0.75 CPU TIME 00.00.10   REGION REQUESTED 0200K   STA
                    DISK    READER   PRINTER
I/O COUNTS           419       3        5
NO. OF DD CARDS        2       1        1
// EXEC PGM=IEBUPDTE
//SYSPRINT DD SYSOUT=A
//SYSUT1 DD DSN=&&ROA,DISP=(OLD,PASS)
//SYSUT2 DD DSN=&&ROZ,UNIT=2314,DISP=(NEW,PASS),SPACE=(CYL,(5,1)),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSIN DD *
IEF236I ALLOC. FOR RMARNO34
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 135    ALLOCATED TO SYSUT1
IEF237I 135    ALLOCATED TO SYSUT2
IEF237I 311    ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74144.T154300.RV000.RMARNO34.ROA           PASSED
IEF285I   VOL SER NOS= SPLU05.
IEF285I   SYS74144.T154300.RV000.RMARNO34.ROZ           PASSED
IEF285I   VOL SER NOS= SPLU05.
IEF373I STEP /          / START 74146.0317
IEF374I STEP /          / STOP  74146.0318 CPU    0MIN 35.87SEC MAIN   28K
CHARGE    $         6.15 CPU TIME 00.00.36   REGION REQUESTED 0200K   STA
                    DISK    READER   PRINTER
I/O COUNTS           422      59     2183
NO. OF DD CARDS        2       1        1
// EXEC FORTGCLG,PARM.FORT='ID',TIME.GO=1439
XXFORT    EXEC  PGM=IEYFORT,REGION=84K
XXSYSPRINT DD   SYSOUT=A
XXSYSPUNCH DD   SYSOUT=B
//FORT.SYSLIN   DD SPACE=(CYL,(20,10))
X/SYSLIN    DD   DSN=&LOADSET,DISP=(MOD,PASS),DCB=BLKSIZE=80,
XX               UNIT=2314,SPACE=(CYL,(1,1))
//FORT.SYSIN DD DSN=&&ROZ,DISP=OLD
IEF648I INVALID DISP FIELD- PASS SUBSTITUTED
// DD *
IEF236I ALLOC. FOR RMARNO34 FORT
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 330    ALLOCATED TO SYSPUNCH
IEF237I 135    ALLOCATED TO SYSLIN
```

```
IEF237I 135    ALLOCATED TO SYSIN
IEF237I 312    ALLOCATED TO
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74144.T154300.RV000.RMARN034.LOADSET          PASSED
IEF285I   VOL SER NOS= SPLU05.
IEF285I   SYS74144.T154300.RV000.RMARN034.FOZ              PASSED
IEF285I   VOL SER NOS= SPLU05.
IEF373I STEP /FORT     / START 74146.0318
IEF374I STEP /FORT     / STOP  74146.0351 CPU   32MIN 37.25SEC MAIN 176K I
CHARGE    $        78.77 CPU TIME 00.32.37   REGION REQUESTED 0200K   STA
                    DISK   READER  PRINTER  PUNCH
I/O COUNTS          1640     88     2284      0
NO. OF DD CARDS       2       1       1       1
XXLKED    EXEC  PGM=IEWL,PARM=(XREF,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB    DD  DSNAME=SYS1.FORTLIB,DISP=SHR
XX          DD  DSN=FORTSUB,DISP=SHR
XXSYSLMOD   DD  DSN=&GOSET(MAIN),DISP=(,PASS),
XX              UNIT=2314,SPACE=(CYL,(1,,1))
XXSYSPRINT DD   SYSOUT=A
XXSYSUT1    DD  UNIT=2314,SPACE=(CYL,(1,1)),DCB=BLKSIZE=1024
XXSYSLIN    DD  DSNAME=&LOADSET,DISP=(OLD,DELETE)
XX          DD  DDNAME=SYSIN
IEF236I ALLOC. FOR RMARN034 LKED
IEF237I 131    ALLOCATED TO SYSLIB
IEF237I 132    ALLOCATED TO
IEF237I 132    ALLOCATED TO SYSLMOD
IEF237I 360    ALLOCATED TO SYSPRINT
IEF237I 135    ALLOCATED TO SYSUT1
IEF237I 135    ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                     KEPT
IEF285I   VOL SER NOS= MVT217.
IEF285I   FORTSUB                                          KEPT
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74144.T154300.RV000.RMARN034.GOSET            PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF285I   SYS74144.T154300.RV000.RMARN034.R0000864         DELETED
IEF285I   VOL SER NOS= SPLU05.
IEF285I   SYS74144.T154300.RV000.RMARN034.LOADSET          DELETED
IEF285I   VOL SER NOS= SPLU05.
IEF373I STEP /LKED     / START 74146.0351
IEF374I STEP /LKED     / STOP  74146.0353 CPU   0MIN 24.28SEC MAIN  68K I
CHARGE    $         1.96 CPU TIME 00.00.24   REGION REQUESTED 0200K   STA
                    DISK   READER  PRINTER
I/O COUNTS          1669      0     127
NO. OF DD CARDS       5       1       1
XXGO EXEC PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFT05F001 DD  DDNAME=SYSIN
XXFT06F001 DD  SYSOUT=A
XXFT07F001 DD  SYSOUT=B
//
IEF236I ALLOC. FOR RMARN034 GO
IEF237I 132    ALLOCATED TO PGM=*.DD
IEF237I 360    ALLOCATED TO FT06F001
IEF237I 330    ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74144.T154300.RV000.RMARN034.GOSET            PASSED
IEF285I   VOL SER NOS= MVTRIP.
IEF373I STEP /GO       / START 74146.0353
IEF374I STEP /GO       / STOP  74146.2106 CPU 975MIN 48.22SEC MAIN 182K I
```

```
CHARGE      $        2193.60 CPU TIME 16.15.48   REGION REQUESTED 0200K    STA
                        DISK    READER   PRINTER   PUNCH
I/O COUNTS                 0         0       102        C
NO. CF DD CARDS            1         1         1        1
IEF285I    SYS74144.T154300.RV000.RMARN034.ROA              DELETED
IEF285I    VOL SER NOS= SPLU05.
IEF285I    SYS74144.T154300.RV000.RMARN034.ROZ              DELETED
IEF285I    VOL SER NCS= SPLU05.
IEF285I    SYS74144.T154300.RV000.RMARN034.GOSET            DELETED
IEF285I    VOL SER NCS= MVTRIP.
IEF375I   JOB /RMARNO34/ START 74146.0316
IEF376I   JOB /RMARN034/ STOP  74146.2106 CPU1009MIN 36.04SEC
RMARN034  JOB CHARGE $    2281.282
```

APPENDIX 23 B

SYSIN NEW MASTER

```
    ./ CHANGE
    ./ NUMBER NEW1=10,INCR=30
IEB818I HIGHEST CONDITION CODE WAS 00000000
IEB819I END OF JOB IEBUPDTE.
```

APPENDIX 23 C 1


```
HANGE LIST=ALL
      SUBROUTINE XTAYO2(J1,J2,L1)                                      00000010
      DOUBLEPRECISION R1,R12,A1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM100000040
     C1,GM1,A,F1,C1,C2                                                 00000070
      LOGICAL L2                                                       00000100
      COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM100000130
     C,A,F1,C1,C2,A1(10512),L2                                         00000160
      DOUBLEPRECISION F2,V1,V2,F3                                      00000190
      LOGICAL L1                                                       00000220
      DIMENSION F2(10),F3(10)                                          00000250   *   REPLAC
      COMMON/F3ARRY/F3(10)                                             00000250   *   REPLACEME
      COMMON/F2ARRY/F2(10)                                             00000251   *   INSERT
      DATA F3(1),F3(2),F3(3),F3(4),F3(5),F3(6),F3(7),F3(8),F3(9),F3(10)/00000280  *   REPLAC
      F3( 1)=1                                                         00000280   *   REPLACEME
     C1.D0,2.D0,3.D0,4.D0,5.D0,6.D0,7.D0,8.D0,9.D0,10.D0/              00000310   *   REPLAC
      F3( 2)=2                                                         00000310   *   REPLACEME
      DATA F2(1),F2(2),F2(3),F2(4),F2(5),F2(6)/1.D0,5.D-1,3.33333333333300000340  *   REPLAC
      F3( 3)=3                                                         00000340   *   REPLACEME
     C3333D-1,2.5D-1,2.D-1,1.6666666666666667D-1/                      00000370   *   REPLAC
      F3( 4)=4                                                         00000370   *   REPLACEME
      F3( 5)=5                                                         00000371   *   INSERT
      F3( 6)=6                                                         00000372   *   INSERT
      F3( 7)=7                                                         00000373   *   INSERT
      F3( 8)=8                                                         00000374   *   INSERT
      F3( 9)=9                                                         00000375   *   INSERT
      F3(10)=10                                                        00000376   *   INSERT
      DATA F2(7),F2(8),F2(9),F2(10)/1.4285714285714286D-1,1.25D-1,1.11100000400   *   REPLAC
```

APPENDIX 23 C 2

```
      F2( 1)=1D0                                   00000400   *        REPLACEME
     C11111111111D-1,1.D-1/                        00000430   *          REPLAC
      F2( 2)=1D0/2                                 00000430   *        REPLACEME
      F2( 3)=1D0/3                                 00000431   *           INSERT
      F2( 4)=1D0/4                                 00000432   *           INSERT
      F2( 5)=1D0/5                                 00000433   *           INSERT
      F2( 6)=1D0/6                                 00000434   *           INSERT
      F2( 7)=1D0/7                                 00000435   *           INSERT
      F2( 8)=1D0/8                                 00000436   *           INSERT
      F2( 9)=1D0/9                                 00000437   *           INSERT
      F2(10)=1D0/10                                00000438   *           INSERT
      GOTO 1                                       00000460
2     V2=(A1(J1+1)-A1(J2+1))                       00000490
      A1(J1+10)=0.D0                               00000520
      A1(J1+19)=0.D0                               00000550
      A1(J1+28)=0.D0                               00000580
      A1(J1+37)=0.D0                               00000610
      A1(J1+46)=0.D0                               00000640
      A1(J1+55)=0.D0                               00000670
      A1(J1+64)=0.D0                               00000700
      A1(J1+73)=0.D0                               00000730
      A1(J1+82)=0.D0                               00000760
      A1(J1+91)=0.D0                               00000790
      A1(J1+100)=0.D0                              00000820
      A1(J1+109)=0.D0                              00000850
```

```
      A1(J1+118)=0.D0                                                   00000880
      A1(J1+127)=0.D0                                                   00000910
      A1(J1+136)=0.D0                                                   00000940
      A1(J1+145)=0.D0                                                   00000970
      A1(J1+154)=0.D0                                                   00001000
      A1(J1+163)=0.D0                                                   00001030
      A1(J1+172)=0.D0                                                   00001060
      A1(J1+181)=0.D0                                                   00001090
      A1(J1+190)=0.D0                                                   00001120
      A1(J1+199)=0.D0                                                   00001150
      A1(J1+208)=0.D0                                                   00001180
      A1(J1+217)=0.D0                                                   00001210
      A1(J1+226)=0.D0                                                   00001240
      A1(J1+235)=0.D0                                                   00001270
      A1(J1+244)=0.D0                                                   00001300
      A1(J1+253)=0.D0                                                   00001330
      A1(J1+262)=0.D0                                                   00001360
      A1(J1+271)=0.D0                                                   00001390
      A1(J1+280)=0.D0                                                   00001420
      A1(J1+289)=0.D0                                                   00001450
      A1(J1+298)=0.D0                                                   00001480
      A1(J1+307)=0.D0                                                   00001510
      A1(J1+316)=0.D0                                                   00001540
      A1(J1+325)=0.D0                                                   00001570
      A1(J1+334)=0.D0                                                   00001600
      A1(J1+343)=0.D0                                                   00001630
      A1(J1+352)=0.D0                                                   00001660
```

```
A1(J1+361)=0.D0                                 00001690
A1(J1+370)=0.D0                                 00001720
A1(J1+379)=0.D0                                 00001750
A1(J1+388)=0.D0                                 00001780
A1(J1+397)=0.D0                                 00001810
A1(J1+406)=0.D0                                 00001840
A1(J1+415)=0.D0                                 00001870
A1(J1+424)=0.D0                                 00001900
A1(J1+433)=0.D0                                 00001930
A1(J1+442)=0.D0                                 00001960
A1(J1+451)=0.D0                                 00001990
A1(J1+460)=0.D0                                 00002020
A1(J1+469)=0.D0                                 00002050
A1(J1+478)=0.D0                                 00002080
A1(J1+487)=0.D0                                 00002110
A1(J1+496)=0.D0                                 00002140
A1(J1+505)=0.D0                                 00002170
A1(J1+514)=0.D0                                 00002200
A1(J1+523)=0.D0                                 00002230
A1(J1+532)=0.D0                                 00002260
A1(J1+541)=0.D0                                 00002290
K1=J2+N1                                        00002320
DO 3 K2=1,N1                                    00002350
A1(J1+10)=A1(J1+10)*V2+A1(K1+9)                 00002380
A1(J1+19)=A1(J1+19)*V2+A1(K1+18)                00002410
```

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```
A1(J1+28)=A1(J1+28)*V2+A1(K1+27)                 00002440
A1(J1+37)=A1(J1+37)*V2+A1(K1+36)                 00002470
A1(J1+46)=A1(J1+46)*V2+A1(K1+45)                 00002500
A1(J1+55)=A1(J1+55)*V2+A1(K1+54)                 00002530
A1(J1+64)=A1(J1+64)*V2+A1(K1+63)                 00002560
A1(J1+73)=A1(J1+73)*V2+A1(K1+72)                 00002590
A1(J1+82)=A1(J1+82)*V2+A1(K1+81)                 00002620
A1(J1+91)=A1(J1+91)*V2+A1(K1+90)                 00002650
A1(J1+100)=A1(J1+100)*V2+A1(K1+99)               00002680
A1(J1+109)=A1(J1+109)*V2+A1(K1+108)              00002710
A1(J1+118)=A1(J1+118)*V2+A1(K1+117)              00002740
A1(J1+127)=A1(J1+127)*V2+A1(K1+126)              00002770
A1(J1+136)=A1(J1+136)*V2+A1(K1+135)              00002800
A1(J1+145)=A1(J1+145)*V2+A1(K1+144)              00002830
A1(J1+154)=A1(J1+154)*V2+A1(K1+153)              00002860
A1(J1+163)=A1(J1+163)*V2+A1(K1+162)              00002890
A1(J1+172)=A1(J1+172)*V2+A1(K1+171)              00002920
A1(J1+181)=A1(J1+181)*V2+A1(K1+180)              00002950
A1(J1+190)=A1(J1+190)*V2+A1(K1+189)              00002980
A1(J1+199)=A1(J1+199)*V2+A1(K1+198)              00003010
A1(J1+208)=A1(J1+208)*V2+A1(K1+207)              00003040
A1(J1+217)=A1(J1+217)*V2+A1(K1+216)              00003070
A1(J1+226)=A1(J1+226)*V2+A1(K1+225)              00003100
A1(J1+235)=A1(J1+235)*V2+A1(K1+234)              00003130
A1(J1+244)=A1(J1+244)*V2+A1(K1+243)              00003160
A1(J1+253)=A1(J1+253)*V2+A1(K1+252)              00003190
A1(J1+262)=A1(J1+262)*V2+A1(K1+261)              00003220
```

```
A1(J1+271)=A1(J1+271)*V2+A1(K1+270)
A1(J1+280)=A1(J1+280)*V2+A1(K1+279)
A1(J1+289)=A1(J1+289)*V2+A1(K1+288)
A1(J1+298)=A1(J1+298)*V2+A1(K1+297)
A1(J1+307)=A1(J1+307)*V2+A1(K1+306)
A1(J1+316)=A1(J1+316)*V2+A1(K1+315)
A1(J1+325)=A1(J1+325)*V2+A1(K1+324)
A1(J1+334)=A1(J1+334)*V2+A1(K1+333)
A1(J1+343)=A1(J1+343)*V2+A1(K1+342)
A1(J1+352)=A1(J1+352)*V2+A1(K1+351)
A1(J1+361)=A1(J1+361)*V2+A1(K1+360)
A1(J1+370)=A1(J1+370)*V2+A1(K1+369)
A1(J1+379)=A1(J1+379)*V2+A1(K1+378)
A1(J1+388)=A1(J1+388)*V2+A1(K1+387)
A1(J1+397)=A1(J1+397)*V2+A1(K1+396)
A1(J1+406)=A1(J1+406)*V2+A1(K1+405)
A1(J1+415)=A1(J1+415)*V2+A1(K1+414)
A1(J1+424)=A1(J1+424)*V2+A1(K1+423)
A1(J1+433)=A1(J1+433)*V2+A1(K1+432)
A1(J1+442)=A1(J1+442)*V2+A1(K1+441)
A1(J1+451)=A1(J1+451)*V2+A1(K1+450)
A1(J1+460)=A1(J1+460)*V2+A1(K1+459)
A1(J1+469)=A1(J1+469)*V2+A1(K1+468)
A1(J1+478)=A1(J1+478)*V2+A1(K1+477)
A1(J1+487)=A1(J1+487)*V2+A1(K1+486)
```

```
      A1(J1+496)=A1(J1+496)*V2+A1(K1+495)                                00004000
      A1(J1+505)=A1(J1+505)*V2+A1(K1+504)                                00004030
      A1(J1+514)=A1(J1+514)*V2+A1(K1+513)                                00004060
      A1(J1+523)=A1(J1+523)*V2+A1(K1+522)                                00004090
      A1(J1+532)=A1(J1+532)*V2+A1(K1+531)                                00004120
      A1(J1+541)=A1(J1+541)*V2+A1(K1+540)                                00004150
 3    K1=K1-1                                                            00004180
      N1=J1+1                                                            00004210
      A1(N1+1971)=(A1(N1+9)-A1(N1+36))                                   00004240
      A1(N1+1980)=(A1(N1+18)-A1(N1+45))                                  00004270
      A1(N1+1989)=(A1(N1+27)-A1(N1+54))                                  00004300
      A1(N1+3276)=(A1(N1+1989)*A1(N1+1989)+A1(N1+1980)*A1(N1+1980)+A1(N100004330
     C+1971)*A1(N1+1971))                                                00004360
      IF(A1(J1+3277))5,5,4                                               00004390
 4    A1(N1+1566)=A1(J1+3277)**C1                                        00004420
      A1(N1+1998)=(A1(N1+9)-A1(N1+63))                                   00004450
      A1(N1+2007)=(A1(N1+18)-A1(N1+72))                                  00004480
      A1(N1+2016)=(A1(N1+27)-A1(N1+81))                                  00004510
      A1(N1+3294)=(A1(N1+2016)*A1(N1+2016)+A1(N1+2007)*A1(N1+2007)+A1(N100004540
     C+1998)*A1(N1+1998))                                                00004570
      IF(A1(J1+3295))5,5,6                                               00004600
 6    A1(N1+1575)=A1(J1+3295)**C1                                        00004630
      A1(N1+2025)=(A1(N1+36)-A1(N1+63))                                  00004660
      A1(N1+2034)=(A1(N1+45)-A1(N1+72))                                  00004690
      A1(N1+2043)=(A1(N1+54)-A1(N1+81))                                  00004720
      A1(N1+3312)=(A1(N1+2043)*A1(N1+2043)+A1(N1+2034)*A1(N1+2034)+A1(N100004750
     C+2025)*A1(N1+2025))                                                00004780
```

```
      IF(A1(J1+3313))5,5,7                                               00004810
7     A1(N1+1584)=A1(J1+3313)**C1                                        00004840
      A1(N1+2052)=(A1(N1+9)-A1(N1+90))                                   00004870
      A1(N1+2061)=(A1(N1+18)-A1(N1+99))                                  00004900
      A1(N1+2070)=(A1(N1+27)-A1(N1+108))                                 00004930
      A1(N1+3330)=(A1(N1+2070)*A1(N1+2070)+A1(N1+2061)*A1(N1+2061)+A1(N100004960
     C+2052)*A1(N1+2052))                                                00004990
      IF(A1(J1+3331))5,5,8                                               00005020
8     A1(N1+1593)=A1(J1+3331)**C1                                        00005050
      A1(N1+2079)=(A1(N1+36)-A1(N1+90))                                  00005080
      A1(N1+2088)=(A1(N1+45)-A1(N1+99))                                  00005110
      A1(N1+2097)=(A1(N1+54)-A1(N1+108))                                 00005140
      A1(N1+3348)=(A1(N1+2097)*A1(N1+2097)+A1(N1+2088)*A1(N1+2088)+A1(N100005170
     C+2079)*A1(N1+2079))                                                00005200
      IF(A1(J1+3349))5,5,9                                               00005230
9     A1(N1+1602)=A1(J1+3349)**C1                                        00005260
      A1(N1+2106)=(A1(N1+63)-A1(N1+90))                                  00005290
      A1(N1+2115)=(A1(N1+72)-A1(N1+99))                                  00005320
      A1(N1+2124)=(A1(N1+81)-A1(N1+108))                                 00005350
      A1(N1+3366)=(A1(N1+2124)*A1(N1+2124)+A1(N1+2115)*A1(N1+2115)+A1(N100005380
     C+2106)*A1(N1+2106))                                                00005410
      IF(A1(J1+3367))5,5,10                                              00005440
10    A1(N1+1611)=A1(J1+3367)**C1                                        00005470
      A1(N1+2133)=(A1(N1+9)-A1(N1+117))                                  00005500
      A1(N1+2142)=(A1(N1+18)-A1(N1+126))                                 00005530
```

```
      A1(N1+2151)=(A1(N1+27)-A1(N1+135))                                00005560
      A1(N1+3384)=(A1(N1+2151)*A1(N1+2151)+A1(N1+2142)*A1(N1+2142)+A1(N100005590
     C+2133)*A1(N1+2133))                                               00005620
      IF(A1(J1+3385))5,5,11                                             00005650
11    A1(N1+1620)=A1(J1+3385)**C1                                       00005680
      A1(N1+2160)=(A1(N1+36)-A1(N1+117))                                00005710
      A1(N1+2169)=(A1(N1+45)-A1(N1+126))                                00005740
      A1(N1+2178)=(A1(N1+54)-A1(N1+135))                                00005770
      A1(N1+3402)=(A1(N1+2178)*A1(N1+2178)+A1(N1+2169)*A1(N1+2169)+A1(N100005800
     C+2160)*A1(N1+2160))                                               00005830
      IF(A1(J1+3403))5,5,12                                             00005860
12    A1(N1+1629)=A1(J1+3403)**C1                                       00005890
      A1(N1+2187)=(A1(N1+63)-A1(N1+117))                                00005920
      A1(N1+2196)=(A1(N1+72)-A1(N1+126))                                00005950
      A1(N1+2205)=(A1(N1+81)-A1(N1+135))                                00005980
      A1(N1+3420)=(A1(N1+2205)*A1(N1+2205)+A1(N1+2196)*A1(N1+2196)+A1(N100006010
     C+2187)*A1(N1+2187))                                               00006040
      IF(A1(J1+3421))5,5,13                                             00006070
13    A1(N1+1638)=A1(J1+3421)**C1                                       00006100
      A1(N1+2214)=(A1(N1+90)-A1(N1+117))                                00006130
      A1(N1+2223)=(A1(N1+99)-A1(N1+126))                                00006160
      A1(N1+2232)=(A1(N1+108)-A1(N1+135))                               00006190
      A1(N1+3438)=(A1(N1+2232)*A1(N1+2232)+A1(N1+2223)*A1(N1+2223)+A1(N100006220
     C+2214)*A1(N1+2214))                                               00006250
      IF(A1(J1+3439))5,5,14                                             00006280
14    A1(N1+1647)=A1(J1+3439)**C1                                       00006310
      A1(N1+2241)=(A1(N1+9)-A1(N1+144))                                 00006340
```

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```
      A1(N1+2250)=(A1(N1+18)-A1(N1+153))                                00006370
      A1(N1+2259)=(A1(N1+27)-A1(N1+162))                                00006400
      A1(N1+3456)=(A1(N1+2259)*A1(N1+2259)+A1(N1+2250)*A1(N1+2250)+A1(N100006430
     C+2241)*A1(N1+2241))                                               00006460
      IF(A1(J1+3457))5,5,15                                             00006490
15    A1(N1+1656)=A1(J1+3457)**C1                                       00006520
      A1(N1+2268)=(A1(N1+36)-A1(N1+144))                                00006550
      A1(N1+2277)=(A1(N1+45)-A1(N1+153))                                00006580
      A1(N1+2286)=(A1(N1+54)-A1(N1+162))                                00006610
      A1(N1+3474)=(A1(N1+2286)*A1(N1+2286)+A1(N1+2277)*A1(N1+2277)+A1(N100006640
     C+2268)*A1(N1+2268))                                               00006670
      IF(A1(J1+3475))5,5,16                                             00006700
16    A1(N1+1665)=A1(J1+3475)**C1                                       00006730
      A1(N1+2295)=(A1(N1+63)-A1(N1+144))                                00006760
      A1(N1+2304)=(A1(N1+72)-A1(N1+153))                                00006790
      A1(N1+2313)=(A1(N1+81)-A1(N1+162))                                00006820
      A1(N1+3492)=(A1(N1+2313)*A1(N1+2313)+A1(N1+2304)*A1(N1+2304)+A1(N100006850
     C+2295)*A1(N1+2295))                                               00006880
      IF(A1(J1+3493))5,5,17                                             00006910
17    A1(N1+1674)=A1(J1+3493)**C1                                       00006940
      A1(N1+2322)=(A1(N1+90)-A1(N1+144))                                00006970
      A1(N1+2331)=(A1(N1+99)-A1(N1+153))                                00007000
      A1(N1+2340)=(A1(N1+108)-A1(N1+162))                               00007030
      A1(N1+3510)=(A1(N1+2340)*A1(N1+2340)+A1(N1+2331)*A1(N1+2331)+A1(N100007060
     C+2322)*A1(N1+2322))                                               00007090
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      IF(A1(J1+3511))5,5,18                                              00007120
18    A1(N1+1683)=A1(J1+3511)**C1                                        00007150
      A1(N1+2349)=(A1(N1+117)-A1(N1+144))                                00007180
      A1(N1+2358)=(A1(N1+126)-A1(N1+153))                                00007210
      A1(N1+2367)=(A1(N1+135)-A1(N1+162))                                00007240
      A1(N1+3528)=(A1(N1+2367)*A1(N1+2367)+A1(N1+2358)*A1(N1+2358)+A1(N100007270
     C+2349)*A1(N1+2349))                                                00007300
      IF(A1(J1+3529))5,5,19                                              00007330
19    A1(N1+1692)=A1(J1+3529)**C1                                        00007360
      A1(N1+2376)=(A1(N1+9)-A1(N1+171))                                  00007390
      A1(N1+2385)=(A1(N1+18)-A1(N1+180))                                 00007420
      A1(N1+2394)=(A1(N1+27)-A1(N1+189))                                 00007450
      A1(N1+3546)=(A1(N1+2394)*A1(N1+2394)+A1(N1+2385)*A1(N1+2385)+A1(N100007480
     C+2376)*A1(N1+2376))                                                00007510
      IF(A1(J1+3547))5,5,20                                              00007540
20    A1(N1+1701)=A1(J1+3547)**C1                                        00007570
      A1(N1+2403)=(A1(N1+36)-A1(N1+171))                                 00007600
      A1(N1+2412)=(A1(N1+45)-A1(N1+180))                                 00007630
      A1(N1+2421)=(A1(N1+54)-A1(N1+189))                                 00007660
      A1(N1+3564)=(A1(N1+2421)*A1(N1+2421)+A1(N1+2412)*A1(N1+2412)+A1(N100007690
     C+2403)*A1(N1+2403))                                                00007720
      IF(A1(J1+3565))5,5,21                                              00007750
21    A1(N1+1710)=A1(J1+3565)**C1                                        00007780
      A1(N1+2430)=(A1(N1+63)-A1(N1+171))                                 00007810
      A1(N1+2439)=(A1(N1+72)-A1(N1+180))                                 00007840
      A1(N1+2448)=(A1(N1+81)-A1(N1+189))                                 00007870
      A1(N1+3582)=(A1(N1+2448)*A1(N1+2448)+A1(N1+2439)*A1(N1+2439)+A1(N100007900
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```
      C+2430)*A1(N1+2430))                                              00007930
       IF(A1(J1+3583))5,5,22                                            00007960
22     A1(N1+1719)=A1(J1+3583)**C1                                      00007990
       A1(N1+2457)=(A1(N1+90)-A1(N1+171))                               00008020
       A1(N1+2466)=(A1(N1+99)-A1(N1+180))                               00008050
       A1(N1+2475)=(A1(N1+108)-A1(N1+189))                              00008080
       A1(N1+3600)=(A1(N1+2475)*A1(N1+2475)+A1(N1+2466)*A1(N1+2466)+A1(N100008110
      C+2457)*A1(N1+2457))                                              00008140
       IF(A1(J1+3601))5,5,23                                            00008170
23     A1(N1+1728)=A1(J1+3601)**C1                                      00008200
       A1(N1+2484)=(A1(N1+117)-A1(N1+171))                              00008230
       A1(N1+2493)=(A1(N1+126)-A1(N1+180))                              00008260
       A1(N1+2502)=(A1(N1+135)-A1(N1+189))                              00008290
       A1(N1+3618)=(A1(N1+2502)*A1(N1+2502)+A1(N1+2493)*A1(N1+2493)+A1(N100008320
      C+2484)*A1(N1+2484))                                              00008350
       IF(A1(J1+3619))5,5,24                                            00008380
24     A1(N1+1737)=A1(J1+3619)**C1                                      00008410
       A1(N1+2511)=(A1(N1+144)-A1(N1+171))                              00008440
       A1(N1+2520)=(A1(N1+153)-A1(N1+180))                              00008470
       A1(N1+2529)=(A1(N1+162)-A1(N1+189))                              00008500
       A1(N1+3636)=(A1(N1+2529)*A1(N1+2529)+A1(N1+2520)*A1(N1+2520)+A1(N100008530
      C+2511)*A1(N1+2511))                                              00008560
       IF(A1(J1+3637))5,5,25                                            00008590
25     A1(N1+1746)=A1(J1+3637)**C1                                      00008620
       A1(N1+2538)=(A1(N1+9)-A1(N1+198))                                00008650
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      A1(N1+2547)=(A1(N1+18)-A1(N1+207))                                 00008680
      A1(N1+2556)=(A1(N1+27)-A1(N1+216))                                 00008710
      A1(N1+3654)=(A1(N1+2556)*A1(N1+2556)+A1(N1+2547)*A1(N1+2547)+A1(N100008740
     C+2538)*A1(N1+2538))                                                00008770
      IF(A1(J1+3655))5,5,26                                              00008800
26    A1(N1+1755)=A1(J1+3655)**C1                                        00008830
      A1(N1+2565)=(A1(N1+36)-A1(N1+198))                                 00008860
      A1(N1+2574)=(A1(N1+45)-A1(N1+207))                                 00008890
      A1(N1+2583)=(A1(N1+54)-A1(N1+216))                                 00008920
      A1(N1+3672)=(A1(N1+2583)*A1(N1+2583)+A1(N1+2574)*A1(N1+2574)+A1(N100008950
     C+2565)*A1(N1+2565))                                                00008980
      IF(A1(J1+3673))5,5,27                                              00009010
27    A1(N1+1764)=A1(J1+3673)**C1                                        00009040
      A1(N1+2592)=(A1(N1+63)-A1(N1+198))                                 00009070
      A1(N1+2601)=(A1(N1+72)-A1(N1+207))                                 00009100
      A1(N1+2610)=(A1(N1+81)-A1(N1+216))                                 00009130
      A1(N1+3690)=(A1(N1+2610)*A1(N1+2610)+A1(N1+2601)*A1(N1+2601)+A1(N100009160
     C+2592)*A1(N1+2592))                                                00009190
      IF(A1(J1+3691))5,5,28                                              00009220
28    A1(N1+1773)=A1(J1+3691)**C1                                        00009250
      A1(N1+2619)=(A1(N1+90)-A1(N1+198))                                 00009280
      A1(N1+2628)=(A1(N1+99)-A1(N1+207))                                 00009310
      A1(N1+2637)=(A1(N1+108)-A1(N1+216))                                00009340
      A1(N1+3708)=(A1(N1+2637)*A1(N1+2637)+A1(N1+2628)*A1(N1+2628)+A1(N100009370
     C+2619)*A1(N1+2619))                                                00009400
      IF(A1(J1+3709))5,5,29                                              00009430
29    A1(N1+1782)=A1(J1+3709)**C1                                        00009460
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      A1(N1+2646)=(A1(N1+117)-A1(N1+198))                               00009490
      A1(N1+2655)=(A1(N1+126)-A1(N1+207))                               00009520
      A1(N1+2664)=(A1(N1+135)-A1(N1+216))                               00009550
      A1(N1+3726)=(A1(N1+2664)*A1(N1+2664)+A1(N1+2655)*A1(N1+2655)+A1(N100009580
     C+2646)*A1(N1+2646))                                               00009610
      IF(A1(J1+3727))5,5,30                                             00009640
30    A1(N1+1791)=A1(J1+3727)**C1                                       00009670
      A1(N1+2673)=(A1(N1+144)-A1(N1+198))                               00009700
      A1(N1+2682)=(A1(N1+153)-A1(N1+207))                               00009730
      A1(N1+2691)=(A1(N1+162)-A1(N1+216))                               00009760
      A1(N1+3744)=(A1(N1+2691)*A1(N1+2691)+A1(N1+2682)*A1(N1+2682)+A1(N100009790
     C+2673)*A1(N1+2673))                                               00009820
      IF(A1(J1+3745))5,5,31                                             00009850
31    A1(N1+1800)=A1(J1+3745)**C1                                       00009880
      A1(N1+2700)=(A1(N1+171)-A1(N1+198))                               00009910
      A1(N1+2709)=(A1(N1+180)-A1(N1+207))                               00009940
      A1(N1+2718)=(A1(N1+189)-A1(N1+216))                               00009970
      A1(N1+3762)=(A1(N1+2718)*A1(N1+2718)+A1(N1+2709)*A1(N1+2709)+A1(N100010000
     C+2700)*A1(N1+2700))                                               00010030
      IF(A1(J1+3763))5,5,32                                             00010060
32    A1(N1+1809)=A1(J1+3763)**C1                                       00010090
      A1(N1+2727)=(A1(N1+9)-A1(N1+225))                                 00010120
      A1(N1+2736)=(A1(N1+18)-A1(N1+234))                                00010150
      A1(N1+2745)=(A1(N1+27)-A1(N1+243))                                00010180
      A1(N1+3780)=(A1(N1+2745)*A1(N1+2745)+A1(N1+2736)*A1(N1+2736)+A1(N100010210
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      C+2727)*A1(N1+2727))                                               00010240
       IF(A1(J1+3781))5,5,33                                             00010270
33     A1(N1+1818)=A1(J1+3781)**C1                                       00010300
       A1(N1+2754)=(A1(N1+36)-A1(N1+225))                                00010330
       A1(N1+2763)=(A1(N1+45)-A1(N1+234))                                00010360
       A1(N1+2772)=(A1(N1+54)-A1(N1+243))                                00010390
       A1(N1+3798)=(A1(N1+2772)*A1(N1+2772)+A1(N1+2763)*A1(N1+2763)+A1(N100010420
      C+2754)*A1(N1+2754))                                               00010450
       IF(A1(J1+3799))5,5,34                                             00010480
34     A1(N1+1827)=A1(J1+3799)**C1                                       00010510
       A1(N1+2781)=(A1(N1+63)-A1(N1+225))                                00010540
       A1(N1+2790)=(A1(N1+72)-A1(N1+234))                                00010570
       A1(N1+2799)=(A1(N1+81)-A1(N1+243))                                00010600
       A1(N1+3816)=(A1(N1+2799)*A1(N1+2799)+A1(N1+2790)*A1(N1+2790)+A1(N100010630
      C+2781)*A1(N1+2781))                                               00010660
       IF(A1(J1+3817))5,5,35                                             00010690
35     A1(N1+1836)=A1(J1+3817)**C1                                       00010720
       A1(N1+2808)=(A1(N1+90)-A1(N1+225))                                00010750
       A1(N1+2817)=(A1(N1+99)-A1(N1+234))                                00010780
       A1(N1+2826)=(A1(N1+108)-A1(N1+243))                               00010810
       A1(N1+3834)=(A1(N1+2826)*A1(N1+2826)+A1(N1+2817)*A1(N1+2817)+A1(N100010840
      C+2808)*A1(N1+2808))                                               00010870
       IF(A1(J1+3835))5,5,36                                             00010900
36     A1(N1+1845)=A1(J1+3835)**C1                                       00010930
       A1(N1+2835)=(A1(N1+117)-A1(N1+225))                               00010960
       A1(N1+2844)=(A1(N1+126)-A1(N1+234))                               00010990
       A1(N1+2853)=(A1(N1+135)-A1(N1+243))                               00011020
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      A1(N1+3852)=(A1(N1+2853)*A1(N1+2853)+A1(N1+2844)*A1(N1+2844)+A1(N1
     C+2835)*A1(N1+2835))
      IF(A1(J1+3853))5,5,37
37    A1(N1+1854)=A1(J1+3853)**C1
      A1(N1+2862)=(A1(N1+144)-A1(N1+225))
      A1(N1+2871)=(A1(N1+153)-A1(N1+234))
      A1(N1+2880)=(A1(N1+162)-A1(N1+243))
      A1(N1+3870)=(A1(N1+2880)*A1(N1+2880)+A1(N1+2871)*A1(N1+2871)+A1(N1
     C+2862)*A1(N1+2862))
      IF(A1(J1+3871))5,5,38
38    A1(N1+1863)=A1(J1+3871)**C1
      A1(N1+2889)=(A1(N1+171)-A1(N1+225))
      A1(N1+2898)=(A1(N1+180)-A1(N1+234))
      A1(N1+2907)=(A1(N1+189)-A1(N1+243))
      A1(N1+3888)=(A1(N1+2907)*A1(N1+2907)+A1(N1+2898)*A1(N1+2898)+A1(N1
     C+2889)*A1(N1+2889))
      IF(A1(J1+3889))5,5,39
39    A1(N1+1872)=A1(J1+3889)**C1
      A1(N1+2916)=(A1(N1+198)-A1(N1+225))
      A1(N1+2925)=(A1(N1+207)-A1(N1+234))
      A1(N1+2934)=(A1(N1+216)-A1(N1+243))
      A1(N1+3906)=(A1(N1+2934)*A1(N1+2934)+A1(N1+2925)*A1(N1+2925)+A1(N1
     C+2916)*A1(N1+2916))
      IF(A1(J1+3907))5,5,40
40    A1(N1+1881)=A1(J1+3907)**C1
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      A1(N1+2943)=(A1(N1+9)-A1(N1+252))                                 00011800
      A1(N1+2952)=(A1(N1+18)-A1(N1+261))                                00011830
      A1(N1+2961)=(A1(N1+27)-A1(N1+270))                                00011860
      A1(N1+3924)=(A1(N1+2961)*A1(N1+2961)+A1(N1+2952)*A1(N1+2952)+A1(N100011890
     C+2943)*A1(N1+2943))                                               00011920
      IF(A1(J1+3925))5,5,41                                             00011950
41    A1(N1+1890)=A1(J1+3925)**C1                                       00011980
      A1(N1+2970)=(A1(N1+36)-A1(N1+252))                                00012010
      A1(N1+2979)=(A1(N1+45)-A1(N1+261))                                00012040
      A1(N1+2988)=(A1(N1+54)-A1(N1+270))                                00012070
      A1(N1+3942)=(A1(N1+2988)*A1(N1+2988)+A1(N1+2979)*A1(N1+2979)+A1(N100012100
     C+2970)*A1(N1+2970))                                               00012130
      IF(A1(J1+3943))5,5,42                                             00012160
42    A1(N1+1899)=A1(J1+3943)**C1                                       00012190
      A1(N1+2997)=(A1(N1+63)-A1(N1+252))                                00012220
      A1(N1+3006)=(A1(N1+72)-A1(N1+261))                                00012250
      A1(N1+3015)=(A1(N1+81)-A1(N1+270))                                00012280
      A1(N1+3960)=(A1(N1+3015)*A1(N1+3015)+A1(N1+3006)*A1(N1+3006)+A1(N100012310
     C+2997)*A1(N1+2997))                                               00012340
      IF(A1(J1+3961))5,5,43                                             00012370
43    A1(N1+1908)=A1(J1+3961)**C1                                       00012400
      A1(N1+3024)=(A1(N1+90)-A1(N1+252))                                00012430
      A1(N1+3033)=(A1(N1+99)-A1(N1+261))                                00012460
      A1(N1+3042)=(A1(N1+108)-A1(N1+270))                               00012490
      A1(N1+3978)=(A1(N1+3042)*A1(N1+3042)+A1(N1+3033)*A1(N1+3033)+A1(N100012520
     C+3024)*A1(N1+3024))                                               00012550
      IF(A1(J1+3979))5,5,44                                             00012580
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44     A1(N1+1917)=A1(J1+3979)**C1                                        00012610
       A1(N1+3051)=(A1(N1+117)-A1(N1+252))                                00012640
       A1(N1+3060)=(A1(N1+126)-A1(N1+261))                                00012670
       A1(N1+3069)=(A1(N1+135)-A1(N1+270))                                00012700
       A1(N1+3996)=(A1(N1+3069)*A1(N1+3069)+A1(N1+3060)*A1(N1+3060)+A1(N100012730
      C+3051)*A1(N1+3051))                                                00012760
       IF(A1(J1+3997))5,5,45                                              00012790
45     A1(N1+1926)=A1(J1+3997)**C1                                        00012820
       A1(N1+3078)=(A1(N1+144)-A1(N1+252))                                00012850
       A1(N1+3087)=(A1(N1+153)-A1(N1+261))                                00012880
       A1(N1+3096)=(A1(N1+162)-A1(N1+270))                                00012910
       A1(N1+4014)=(A1(N1+3096)*A1(N1+3096)+A1(N1+3087)*A1(N1+3087)+A1(N100012940
      C+3078)*A1(N1+3078))                                                00012970
       IF(A1(J1+4015))5,5,46                                              00013000
46     A1(N1+1935)=A1(J1+4015)**C1                                        00013030
       A1(N1+3105)=(A1(N1+171)-A1(N1+252))                                00013060
       A1(N1+3114)=(A1(N1+180)-A1(N1+261))                                00013090
       A1(N1+3123)=(A1(N1+189)-A1(N1+270))                                00013120
       A1(N1+4032)=(A1(N1+3123)*A1(N1+3123)+A1(N1+3114)*A1(N1+3114)+A1(N100013150
      C+3105)*A1(N1+3105))                                                00013180
       IF(A1(J1+4033))5,5,47                                              00013210
47     A1(N1+1944)=A1(J1+4033)**C1                                        00013240
       A1(N1+3132)=(A1(N1+198)-A1(N1+252))                                00013270
       A1(N1+3141)=(A1(N1+207)-A1(N1+261))                                00013300
       A1(N1+3150)=(A1(N1+216)-A1(N1+270))                                00013330
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      A1(N1+4050)=(A1(N1+3150)*A1(N1+3150)+A1(N1+3141)*A1(N1+3141)+A1(N100013360
     C+3132)*A1(N1+3132))                                               00013390
      IF(A1(J1+4051))5,5,48                                             00013420
48    A1(N1+1953)=A1(J1+4051)**C1                                       00013450
      A1(N1+3159)=(A1(N1+225)-A1(N1+252))                               00013480
      A1(N1+3168)=(A1(N1+234)-A1(N1+261))                               00013510
      A1(N1+3177)=(A1(N1+243)-A1(N1+270))                               00013540
      A1(N1+4068)=(A1(N1+3177)*A1(N1+3177)+A1(N1+3168)*A1(N1+3168)+A1(N100013570
     C+3159)*A1(N1+3159))                                               00013600
      IF(A1(J1+4069))5,5,49                                             00013630
49    A1(N1+1962)=A1(J1+4069)**C1                                       00013660
      A1(N1+4086)=(A1(N1+27)*A1(N1+27)+A1(N1+18)*A1(N1+18)+A1(N1+9)*A1(N00013690
     C1+9))                                                             00013720
      IF(A1(J1+4087))5,5,50                                             00013750
50    A1(N1+3186)=A1(J1+4087)**C1                                       00013780
      A1(N1+4104)=(A1(N1+54)*A1(N1+54)+A1(N1+45)*A1(N1+45)+A1(N1+36)*A1(00013810
     CN1+36))                                                           00013840
      IF(A1(J1+4105))5,5,51                                             00013870
51    A1(N1+3195)=A1(J1+4105)**C1                                       00013900
      A1(N1+4122)=(A1(N1+81)*A1(N1+81)+A1(N1+72)*A1(N1+72)+A1(N1+63)*A1(00013930
     CN1+63))                                                           00013960
      IF(A1(J1+4123))5,5,52                                             00013990
52    A1(N1+3204)=A1(J1+4123)**C1                                       00014020
      A1(N1+4140)=(A1(N1+108)*A1(N1+108)+A1(N1+99)*A1(N1+99)+A1(N1+90)*A00014050
     C1(N1+90))                                                         00014080
      IF(A1(J1+4141))5,5,53                                             00014110
53    A1(N1+3213)=A1(J1+4141)**C1                                       00014140
```

```
      A1(N1+4158)=(A1(N1+135)*A1(N1+135)+A1(N1+126)*A1(N1+126)+A1(N1+11700014170
     C)*A1(N1+117))                                                     00014200
      IF(A1(J1+4159))5,5,54                                             00014230
54    A1(N1+3222)=A1(J1+4159)**C1                                       00014260
      A1(N1+4176)=(A1(N1+162)*A1(N1+162)+A1(N1+153)*A1(N1+153)+A1(N1+14400014290
     C)*A1(N1+144))                                                     00014320
      IF(A1(J1+4177))5,5,55                                             00014350
55    A1(N1+3231)=A1(J1+4177)**C1                                       00014380
      A1(N1+4194)=(A1(N1+189)*A1(N1+189)+A1(N1+180)*A1(N1+180)+A1(N1+17100014410
     C)*A1(N1+171))                                                     00014440
      IF(A1(J1+4195))5,5,56                                             00014470
56    A1(N1+3240)=A1(J1+4195)**C1                                       00014500
      A1(N1+4212)=(A1(N1+216)*A1(N1+216)+A1(N1+207)*A1(N1+207)+A1(N1+19800014530
     C)*A1(N1+198))                                                     00014560
      IF(A1(J1+4213))5,5,57                                             00014590
57    A1(N1+3249)=A1(J1+4213)**C1                                       00014620
      A1(N1+4230)=(A1(N1+243)*A1(N1+243)+A1(N1+234)*A1(N1+234)+A1(N1+22500014650
     C)*A1(N1+225))                                                     00014680
      IF(A1(J1+4231))5,5,58                                             00014710
58    A1(N1+3258)=A1(J1+4231)**C1                                       00014740
      A1(N1+4248)=(A1(N1+270)*A1(N1+270)+A1(N1+261)*A1(N1+261)+A1(N1+25200014770
     C)*A1(N1+252))                                                     00014800
      IF(A1(J1+4249))5,5,59                                             00014830
59    A1(N1+3267)=A1(J1+4249)**C1                                       00014860
      A1(N1+4275)=(C1/A1(N1+3276))                                      00014890
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A1(N1+4293)=(C1/A1(N1+3294))                                  00014920
A1(N1+4311)=(C1/A1(N1+3312))                                  00014950
A1(N1+4329)=(C1/A1(N1+3330))                                  00014980
A1(N1+4347)=(C1/A1(N1+3348))                                  00015010
A1(N1+4365)=(C1/A1(N1+3366))                                  00015040
A1(N1+4383)=(C1/A1(N1+3384))                                  00015070
A1(N1+4401)=(C1/A1(N1+3402))                                  00015100
A1(N1+4419)=(C1/A1(N1+3420))                                  00015130
A1(N1+4437)=(C1/A1(N1+3438))                                  00015160
A1(N1+4455)=(C1/A1(N1+3456))                                  00015190
A1(N1+4473)=(C1/A1(N1+3474))                                  00015220
A1(N1+4491)=(C1/A1(N1+3492))                                  00015250
A1(N1+4509)=(C1/A1(N1+3510))                                  00015280
A1(N1+4527)=(C1/A1(N1+3528))                                  00015310
A1(N1+4545)=(C1/A1(N1+3546))                                  00015340
A1(N1+4563)=(C1/A1(N1+3564))                                  00015370
A1(N1+4581)=(C1/A1(N1+3582))                                  00015400
A1(N1+4599)=(C1/A1(N1+3600))                                  00015430
A1(N1+4617)=(C1/A1(N1+3618))                                  00015460
A1(N1+4635)=(C1/A1(N1+3636))                                  00015490
A1(N1+4653)=(C1/A1(N1+3654))                                  00015520
A1(N1+4671)=(C1/A1(N1+3672))                                  00015550
A1(N1+4689)=(C1/A1(N1+3690))                                  00015580
A1(N1+4707)=(C1/A1(N1+3708))                                  00015610
A1(N1+4725)=(C1/A1(N1+3726))                                  00015640
A1(N1+4743)=(C1/A1(N1+3744))                                  00015670
A1(N1+4761)=(C1/A1(N1+3762))                                  00015700
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A1(N1+4779)=(C1/A1(N1+3780))                                    00015730
A1(N1+4797)=(C1/A1(N1+3798))                                    00015760
A1(N1+4815)=(C1/A1(N1+3816))                                    00015790
A1(N1+4833)=(C1/A1(N1+3834))                                    00015820
A1(N1+4851)=(C1/A1(N1+3852))                                    00015850
A1(N1+4869)=(C1/A1(N1+3870))                                    00015880
A1(N1+4887)=(C1/A1(N1+3888))                                    00015910
A1(N1+4905)=(C1/A1(N1+3906))                                    00015940
A1(N1+4923)=(C1/A1(N1+3924))                                    00015970
A1(N1+4941)=(C1/A1(N1+3942))                                    00016000
A1(N1+4959)=(C1/A1(N1+3960))                                    00016030
A1(N1+4977)=(C1/A1(N1+3978))                                    00016060
A1(N1+4995)=(C1/A1(N1+3996))                                    00016090
A1(N1+5013)=(C1/A1(N1+4014))                                    00016120
A1(N1+5031)=(C1/A1(N1+4032))                                    00016150
A1(N1+5049)=(C1/A1(N1+4050))                                    00016180
A1(N1+5067)=(C1/A1(N1+4068))                                    00016210
A1(N1+5085)=(C1/A1(N1+4086))                                    00016240
A1(N1+5103)=(C1/A1(N1+4104))                                    00016270
A1(N1+5121)=(C1/A1(N1+4122))                                    00016300
A1(N1+5139)=(C1/A1(N1+4140))                                    00016330
A1(N1+5157)=(C1/A1(N1+4158))                                    00016360
A1(N1+5175)=(C1/A1(N1+4176))                                    00016390
A1(N1+5193)=(C1/A1(N1+4194))                                    00016420
A1(N1+5211)=(C1/A1(N1+4212))                                    00016450
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      A1(N1+5229)=(C1/A1(N1+4230))                                      00016480
      A1(N1+5247)=(C1/A1(N1+4248))                                      00016510
      DO 60 N2=1,8                                                      00016540
      CALL X04(N1,N3,N4,K2,J1,N2)                                       00016541   *   INSERT
      CALL X03(N1,N3,N4,K2,J1,N2)                                       00016542   *   INSERT
60    N1=N1+1                                                           00016543   *   INSERT
      L1=.FALSE.                                                        00016544   *   INSERT
      RETURN                                                            00016545   *   INSERT
5     L1=.TRUE.                                                         00016546   *   INSERT
      RETURN                                                            00016547   *   INSERT
1     N1=8                                                              00016548   *   INSERT
      GOTO2                                                             00016549   *   INSERT
      END                                                               00016550   *   INSERT
      SUBROUTINE X04(N1,N3,N4,K2,J1,N2)                                 00016551   *   INSERT
      IMPLICIT REAL*8(A-H,O-Z)                                          00016552   *   INSERT
      LOGICAL L2                                                        00016553   *   INSERT
      COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM100016554   *   INSERT
     1,A,F1,C1,C2,A1(10512),L2                                          00016555   *   INSERT
      COMMON/F2ARRY/F2(10)                                              00016556   *   INSERT
      COMMON/F3ARRY/F3(10)                                              00016557   *   INSERT
      A1(N1+10)=(A1(N1+279)*F2(N2))                                     00016570
      A1(N1+19)=(A1(N1+288)*F2(N2))                                     00016600
      A1(N1+28)=(A1(N1+297)*F2(N2))                                     00016630
      A1(N1+549)=(GM1*A1(N1+3186))                                      00016660
      A1(N1+558)=(GM10*A1(N1+1566))                                     00016690
      A1(N1+567)=(GM9*A1(N1+1575))                                      00016720
      A1(N1+576)=(GM8*A1(N1+1593))                                      00016750
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A1(N1+585)=(GM7*A1(N1+1620))
A1(N1+594)=(GM6*A1(N1+1656))
A1(N1+603)=(GM5*A1(N1+1701))
A1(N1+612)=(GM4*A1(N1+1755))
A1(N1+621)=(GM3*A1(N1+1818))
A1(N1+630)=(GM2*A1(N1+1890))
A1(N1+37)=(A1(N1+306)*F2(N2))
A1(N1+46)=(A1(N1+315)*F2(N2))
A1(N1+55)=(A1(N1+324)*F2(N2))
A1(N1+639)=(GM1*A1(N1+3195))
A1(N1+648)=(GM11*A1(N1+1566))
A1(N1+657)=(GM9*A1(N1+1584))
A1(N1+666)=(GM8*A1(N1+1602))
A1(N1+675)=(GM7*A1(N1+1629))
A1(N1+684)=(GM6*A1(N1+1665))
A1(N1+693)=(GM5*A1(N1+1710))
A1(N1+702)=(GM4*A1(N1+1764))
A1(N1+711)=(GM3*A1(N1+1827))
A1(N1+720)=(GM2*A1(N1+1899))
A1(N1+64)=(A1(N1+333)*F2(N2))
A1(N1+73)=(A1(N1+342)*F2(N2))
A1(N1+82)=(A1(N1+351)*F2(N2))
A1(N1+729)=(GM1*A1(N1+3204))
A1(N1+738)=(GM11*A1(N1+1575))
A1(N1+747)=(GM10*A1(N1+1584))
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      A1(N1+756)=(GM8*A1(N1+1611))                                     00017530
      A1(N1+765)=(GM7*A1(N1+1638))                                     00017560
      A1(N1+774)=(GM6*A1(N1+1674))                                     00017590
      A1(N1+783)=(GM5*A1(N1+1719))                                     00017620
      A1(N1+792)=(GM4*A1(N1+1773))                                     00017650
      A1(N1+801)=(GM3*A1(N1+1836))                                     00017680
      A1(N1+810)=(GM2*A1(N1+1908))                                     00017710
      A1(N1+91)=(A1(N1+360)*F2(N2))                                    00017740
      A1(N1+100)=(A1(N1+369)*F2(N2))                                   00017770
      A1(N1+109)=(A1(N1+378)*F2(N2))                                   00017800
      A1(N1+819)=(GM1*A1(N1+3213))                                     00017830
      A1(N1+828)=(GM11*A1(N1+1593))                                    00017860
      A1(N1+837)=(GM10*A1(N1+1602))                                    00017890
      A1(N1+846)=(GM9*A1(N1+1611))                                     00017920
      A1(N1+855)=(GM7*A1(N1+1647))                                     00017950
      A1(N1+864)=(GM6*A1(N1+1683))                                     00017980
      A1(N1+873)=(GM5*A1(N1+1728))                                     00018010
      A1(N1+882)=(GM4*A1(N1+1782))                                     00018040
      A1(N1+891)=(GM3*A1(N1+1845))                                     00018070
      A1(N1+900)=(GM2*A1(N1+1917))                                     00018100
      A1(N1+118)=(A1(N1+387)*F2(N2))                                   00018130
      A1(N1+127)=(A1(N1+396)*F2(N2))                                   00018160
      A1(N1+136)=(A1(N1+405)*F2(N2))                                   00018190
      A1(N1+909)=(GM1*A1(N1+3222))                                     00018220
      A1(N1+918)=(GM11*A1(N1+1620))                                    00018250
      A1(N1+927)=(GM10*A1(N1+1629))                                    00018280
      A1(N1+936)=(GM9*A1(N1+1638))                                     00018310
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A1(N1+945)=(GM8*A1(N1+1647))
A1(N1+954)=(GM6*A1(N1+1692))
A1(N1+963)=(GM5*A1(N1+1737))
A1(N1+972)=(GM4*A1(N1+1791))
A1(N1+981)=(GM3*A1(N1+1854))
A1(N1+990)=(GM2*A1(N1+1926))
A1(N1+145)=(A1(N1+414)*F2(N2))
A1(N1+154)=(A1(N1+423)*F2(N2))
A1(N1+163)=(A1(N1+432)*F2(N2))
A1(N1+999)=(GM1*A1(N1+3231))
A1(N1+1008)=(GM11*A1(N1+1656))
A1(N1+1017)=(GM10*A1(N1+1665))
A1(N1+1026)=(GM9*A1(N1+1674))
A1(N1+1035)=(GM8*A1(N1+1683))
A1(N1+1044)=(GM7*A1(N1+1692))
A1(N1+1053)=(GM5*A1(N1+1746))
A1(N1+1062)=(GM4*A1(N1+1800))
A1(N1+1071)=(GM3*A1(N1+1863))
A1(N1+1080)=(GM2*A1(N1+1935))
A1(N1+172)=(A1(N1+441)*F2(N2))
A1(N1+181)=(A1(N1+450)*F2(N2))
A1(N1+190)=(A1(N1+459)*F2(N2))
A1(N1+1089)=(GM1*A1(N1+3240))
A1(N1+1098)=(GM11*A1(N1+1701))
A1(N1+1107)=(GM10*A1(N1+1710))
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A1(N1+1116)=(GM9*A1(N1+1719))                                    00019090
A1(N1+1125)=(GM8*A1(N1+1728))                                    00019120
A1(N1+1134)=(GM7*A1(N1+1737))                                    00019150
A1(N1+1143)=(GM6*A1(N1+1746))                                    00019180
A1(N1+1152)=(GM4*A1(N1+1809))                                    00019210
A1(N1+1161)=(GM3*A1(N1+1872))                                    00019240
A1(N1+1170)=(GM2*A1(N1+1944))                                    00019270
A1(N1+199)=(A1(N1+468)*F2(N2))                                   00019300
A1(N1+208)=(A1(N1+477)*F2(N2))                                   00019330
A1(N1+217)=(A1(N1+486)*F2(N2))                                   00019360
A1(N1+1179)=(GM1*A1(N1+3249))                                    00019390
A1(N1+1188)=(GM11*A1(N1+1755))                                   00019420
A1(N1+1197)=(GM10*A1(N1+1764))                                   00019450
A1(N1+1206)=(GM9*A1(N1+1773))                                    00019480
A1(N1+1215)=(GM8*A1(N1+1782))                                    00019510
A1(N1+1224)=(GM7*A1(N1+1791))                                    00019540
A1(N1+1233)=(GM6*A1(N1+1800))                                    00019570
A1(N1+1242)=(GM5*A1(N1+1809))                                    00019600
A1(N1+1251)=(GM3*A1(N1+1881))                                    00019630
A1(N1+1260)=(GM2*A1(N1+1953))                                    00019660
A1(N1+226)=(A1(N1+495)*F2(N2))                                   00019690
A1(N1+235)=(A1(N1+504)*F2(N2))                                   00019720
A1(N1+244)=(A1(N1+513)*F2(N2))                                   00019750
A1(N1+1269)=(GM1*A1(N1+3258))                                    00019780
A1(N1+1278)=(GM11*A1(N1+1818))                                   00019810
A1(N1+1287)=(GM10*A1(N1+1827))                                   00019840
A1(N1+1296)=(GM9*A1(N1+1836))                                    00019870
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      A1(N1+1305)=(GM8*A1(N1+1845))                                     00019900
      A1(N1+1314)=(GM7*A1(N1+1854))                                     00019930
      A1(N1+1323)=(GM6*A1(N1+1863))                                     00019960
      A1(N1+1332)=(GM5*A1(N1+1872))                                     00019990
      A1(N1+1341)=(GM4*A1(N1+1881))                                     00020020
      A1(N1+1350)=(GM2*A1(N1+1962))                                     00020050
      A1(N1+253)=(A1(N1+522)*F2(N2))                                    00020080
      A1(N1+262)=(A1(N1+531)*F2(N2))                                    00020110
      A1(N1+271)=(A1(N1+540)*F2(N2))                                    00020140
      A1(N1+1359)=(GM1*A1(N1+3267))                                     00020170
      A1(N1+1368)=(GM11*A1(N1+1890))                                    00020200
      A1(N1+1377)=(GM10*A1(N1+1899))                                    00020230
      A1(N1+1386)=(GM9*A1(N1+1908))                                     00020260
      A1(N1+1395)=(GM8*A1(N1+1917))                                     00020290
      A1(N1+1404)=(GM7*A1(N1+1926))                                     00020320
      A1(N1+1413)=(GM6*A1(N1+1935))                                     00020350
      A1(N1+1422)=(GM5*A1(N1+1944))                                     00020380
      A1(N1+1431)=(GM4*A1(N1+1953))                                     00020410
      A1(N1+1440)=(GM3*A1(N1+1962))                                     00020440
      A1(N1+1476)=(GM11*A1(N1+3186))                                    00020470
      A1(N1+1485)=(GM10*A1(N1+3195))                                    00020500
      A1(N1+1494)=(GM9*A1(N1+3204))                                     00020530
      A1(N1+1503)=(GM8*A1(N1+3213))                                     00020560
      A1(N1+1512)=(GM7*A1(N1+3222))                                     00020590
      A1(N1+1521)=(GM6*A1(N1+3231))                                     00020620
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A1(N1+1530)=(GM5*A1(N1+3240))                                     00020650
A1(N1+1539)=(GM4*A1(N1+3249))                                     00020680
A1(N1+1548)=(GM3*A1(N1+3258))                                     00020710
A1(N1+1557)=(GM2*A1(N1+3267))                                     00020740
A1(N1+1972)=(A1(N1+10)-A1(N1+37))                                 00020770
A1(N1+1981)=(A1(N1+19)-A1(N1+46))                                 00020800
A1(N1+1990)=(A1(N1+28)-A1(N1+55))                                 00020830
A1(N1+1999)=(A1(N1+10)-A1(N1+64))                                 00020860
A1(N1+2008)=(A1(N1+19)-A1(N1+73))                                 00020890
A1(N1+2017)=(A1(N1+28)-A1(N1+82))                                 00020920
A1(N1+2026)=(A1(N1+37)-A1(N1+64))                                 00020950
A1(N1+2035)=(A1(N1+46)-A1(N1+73))                                 00020980
A1(N1+2044)=(A1(N1+55)-A1(N1+82))                                 00021010
A1(N1+2053)=(A1(N1+10)-A1(N1+91))                                 00021040
A1(N1+2062)=(A1(N1+19)-A1(N1+100))                                00021070
A1(N1+2071)=(A1(N1+28)-A1(N1+109))                                00021100
A1(N1+2080)=(A1(N1+37)-A1(N1+91))                                 00021130
A1(N1+2089)=(A1(N1+46)-A1(N1+100))                                00021160
A1(N1+2098)=(A1(N1+55)-A1(N1+109))                                00021190
A1(N1+2107)=(A1(N1+64)-A1(N1+91))                                 00021220
A1(N1+2116)=(A1(N1+73)-A1(N1+100))                                00021250
A1(N1+2125)=(A1(N1+82)-A1(N1+109))                                00021280
A1(N1+2134)=(A1(N1+10)-A1(N1+118))                                00021310
A1(N1+2143)=(A1(N1+19)-A1(N1+127))                                00021340
A1(N1+2152)=(A1(N1+28)-A1(N1+136))                                00021370
A1(N1+2161)=(A1(N1+37)-A1(N1+118))                                00021400
A1(N1+2170)=(A1(N1+46)-A1(N1+127))                                00021430
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      A1(N1+2179)=(A1(N1+55)-A1(N1+136))                                00021460
      A1(N1+2188)=(A1(N1+64)-A1(N1+118))                                00021490
      A1(N1+2197)=(A1(N1+73)-A1(N1+127))                                00021520
      A1(N1+2206)=(A1(N1+82)-A1(N1+136))                                00021550
      A1(N1+2215)=(A1(N1+91)-A1(N1+118))                                00021580
      A1(N1+2224)=(A1(N1+100)-A1(N1+127))                               00021610
      A1(N1+2233)=(A1(N1+109)-A1(N1+136))                               00021640
      A1(N1+2242)=(A1(N1+10)-A1(N1+145))                                00021670
      A1(N1+2251)=(A1(N1+19)-A1(N1+154))                                00021700
      A1(N1+2260)=(A1(N1+28)-A1(N1+163))                                00021730
      A1(N1+2269)=(A1(N1+37)-A1(N1+145))                                00021760
      A1(N1+2278)=(A1(N1+46)-A1(N1+154))                                00021790
      A1(N1+2287)=(A1(N1+55)-A1(N1+163))                                00021820
      A1(N1+2296)=(A1(N1+64)-A1(N1+145))                                00021850
      A1(N1+2305)=(A1(N1+73)-A1(N1+154))                                00021880
      A1(N1+2314)=(A1(N1+82)-A1(N1+163))                                00021910
      A1(N1+2323)=(A1(N1+91)-A1(N1+145))                                00021940
      A1(N1+2332)=(A1(N1+100)-A1(N1+154))                               00021970
      A1(N1+2341)=(A1(N1+109)-A1(N1+163))                               00022000
      A1(N1+2350)=(A1(N1+118)-A1(N1+145))                               00022030
      A1(N1+2359)=(A1(N1+127)-A1(N1+154))                               00022060
      A1(N1+2368)=(A1(N1+136)-A1(N1+163))                               00022090
      A1(N1+2377)=(A1(N1+10)-A1(N1+172))                                00022120
      A1(N1+2386)=(A1(N1+19)-A1(N1+181))                                00022150
      A1(N1+2395)=(A1(N1+28)-A1(N1+190))                                00022180
```

```
A1(N1+2404)=(A1(N1+37)-A1(N1+172))
A1(N1+2413)=(A1(N1+46)-A1(N1+181))
A1(N1+2422)=(A1(N1+55)-A1(N1+190))
A1(N1+2431)=(A1(N1+64)-A1(N1+172))
A1(N1+2440)=(A1(N1+73)-A1(N1+181))
A1(N1+2449)=(A1(N1+82)-A1(N1+190))
A1(N1+2458)=(A1(N1+91)-A1(N1+172))
A1(N1+2467)=(A1(N1+100)-A1(N1+181))
A1(N1+2476)=(A1(N1+109)-A1(N1+190))
A1(N1+2485)=(A1(N1+118)-A1(N1+172))
A1(N1+2494)=(A1(N1+127)-A1(N1+181))
A1(N1+2503)=(A1(N1+136)-A1(N1+190))
A1(N1+2512)=(A1(N1+145)-A1(N1+172))
A1(N1+2521)=(A1(N1+154)-A1(N1+181))
A1(N1+2530)=(A1(N1+163)-A1(N1+190))
A1(N1+2539)=(A1(N1+10)-A1(N1+199))
A1(N1+2548)=(A1(N1+19)-A1(N1+208))
A1(N1+2557)=(A1(N1+28)-A1(N1+217))
A1(N1+2566)=(A1(N1+37)-A1(N1+199))
A1(N1+2575)=(A1(N1+46)-A1(N1+208))
A1(N1+2584)=(A1(N1+55)-A1(N1+217))
A1(N1+2593)=(A1(N1+64)-A1(N1+199))
A1(N1+2602)=(A1(N1+73)-A1(N1+208))
A1(N1+2611)=(A1(N1+82)-A1(N1+217))
A1(N1+2620)=(A1(N1+91)-A1(N1+199))
A1(N1+2629)=(A1(N1+100)-A1(N1+208))
A1(N1+2638)=(A1(N1+109)-A1(N1+217))
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A1(N1+2647)=(A1(N1+118)-A1(N1+199))
A1(N1+2656)=(A1(N1+127)-A1(N1+208))
A1(N1+2665)=(A1(N1+136)-A1(N1+217))
A1(N1+2674)=(A1(N1+145)-A1(N1+199))
A1(N1+2683)=(A1(N1+154)-A1(N1+208))
A1(N1+2692)=(A1(N1+163)-A1(N1+217))
A1(N1+2701)=(A1(N1+172)-A1(N1+199))
A1(N1+2710)=(A1(N1+181)-A1(N1+208))
A1(N1+2719)=(A1(N1+190)-A1(N1+217))
A1(N1+2728)=(A1(N1+10)-A1(N1+226))
A1(N1+2737)=(A1(N1+19)-A1(N1+235))
A1(N1+2746)=(A1(N1+28)-A1(N1+244))
A1(N1+2755)=(A1(N1+37)-A1(N1+226))
A1(N1+2764)=(A1(N1+46)-A1(N1+235))
A1(N1+2773)=(A1(N1+55)-A1(N1+244))
A1(N1+2782)=(A1(N1+64)-A1(N1+226))
A1(N1+2791)=(A1(N1+73)-A1(N1+235))
A1(N1+2800)=(A1(N1+82)-A1(N1+244))
A1(N1+2809)=(A1(N1+91)-A1(N1+226))
A1(N1+2818)=(A1(N1+100)-A1(N1+235))
A1(N1+2827)=(A1(N1+109)-A1(N1+244))
A1(N1+2836)=(A1(N1+118)-A1(N1+226))
A1(N1+2845)=(A1(N1+127)-A1(N1+235))
A1(N1+2854)=(A1(N1+136)-A1(N1+244))
A1(N1+2863)=(A1(N1+145)-A1(N1+226))
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A1(N1+2872)=(A1(N1+154)-A1(N1+235))                     00023770
A1(N1+2881)=(A1(N1+163)-A1(N1+244))                     00023800
A1(N1+2890)=(A1(N1+172)-A1(N1+226))                     00023830
A1(N1+2899)=(A1(N1+181)-A1(N1+235))                     00023860
A1(N1+2908)=(A1(N1+190)-A1(N1+244))                     00023890
A1(N1+2917)=(A1(N1+199)-A1(N1+226))                     00023920
A1(N1+2926)=(A1(N1+208)-A1(N1+235))                     00023950
A1(N1+2935)=(A1(N1+217)-A1(N1+244))                     00023980
A1(N1+2944)=(A1(N1+10)-A1(N1+253))                      00024010
A1(N1+2953)=(A1(N1+19)-A1(N1+262))                      00024040
A1(N1+2962)=(A1(N1+28)-A1(N1+271))                      00024070
A1(N1+2971)=(A1(N1+37)-A1(N1+253))                      00024100
A1(N1+2980)=(A1(N1+46)-A1(N1+262))                      00024130
A1(N1+2989)=(A1(N1+55)-A1(N1+271))                      00024160
A1(N1+2998)=(A1(N1+64)-A1(N1+253))                      00024190
A1(N1+3007)=(A1(N1+73)-A1(N1+262))                      00024220
A1(N1+3016)=(A1(N1+82)-A1(N1+271))                      00024250
A1(N1+3025)=(A1(N1+91)-A1(N1+253))                      00024280
A1(N1+3034)=(A1(N1+100)-A1(N1+262))                     00024310
A1(N1+3043)=(A1(N1+109)-A1(N1+271))                     00024340
A1(N1+3052)=(A1(N1+118)-A1(N1+253))                     00024370
A1(N1+3061)=(A1(N1+127)-A1(N1+262))                     00024400
A1(N1+3070)=(A1(N1+136)-A1(N1+271))                     00024430
A1(N1+3079)=(A1(N1+145)-A1(N1+253))                     00024460
A1(N1+3088)=(A1(N1+154)-A1(N1+262))                     00024490
A1(N1+3097)=(A1(N1+163)-A1(N1+271))                     00024520
A1(N1+3106)=(A1(N1+172)-A1(N1+253))                     00024550
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      A1(N1+3115)=(A1(N1+181)-A1(N1+262))                               00024580
      A1(N1+3124)=(A1(N1+190)-A1(N1+271))                               00024610
      A1(N1+3133)=(A1(N1+199)-A1(N1+253))                               00024640
      A1(N1+3142)=(A1(N1+208)-A1(N1+262))                               00024670
      A1(N1+3151)=(A1(N1+217)-A1(N1+271))                               00024700
      A1(N1+3160)=(A1(N1+226)-A1(N1+253))                               00024730
      A1(N1+3169)=(A1(N1+235)-A1(N1+262))                               00024760
      A1(N1+3178)=(A1(N1+244)-A1(N1+271))                               00024790
      A1(N1+1449)=0.D0                                                  00024820
      A1(N1+1458)=0.D0                                                  00024850
      A1(N1+1467)=0.D0                                                  00024880
      A1(N1+3277)=(A1(N1+1990)*A1(J1+1990)+A1(N1+1981)*A1(J1+1981)+A1(N100024910
     C+1972)*A1(J1+1972))                                               00024940
      A1(N1+3295)=(A1(N1+2017)*A1(J1+2017)+A1(N1+2008)*A1(J1+2008)+A1(N100024970
     C+1999)*A1(J1+1999))                                               00025000
      A1(N1+3313)=(A1(N1+2044)*A1(J1+2044)+A1(N1+2035)*A1(J1+2035)+A1(N100025030
     C+2026)*A1(J1+2026))                                               00025060
      A1(N1+3331)=(A1(N1+2071)*A1(J1+2071)+A1(N1+2062)*A1(J1+2062)+A1(N100025090
     C+2053)*A1(J1+2053))                                               00025120
      A1(N1+3349)=(A1(N1+2098)*A1(J1+2098)+A1(N1+2089)*A1(J1+2089)+A1(N100025150
     C+2080)*A1(J1+2080))                                               00025180
      A1(N1+3367)=(A1(N1+2125)*A1(J1+2125)+A1(N1+2116)*A1(J1+2116)+A1(N100025210
     C+2107)*A1(J1+2107))                                               00025240
      A1(N1+3385)=(A1(N1+2152)*A1(J1+2152)+A1(N1+2143)*A1(J1+2143)+A1(N100025270
     C+2134)*A1(J1+2134))                                               00025300
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 A1(N1+3403)=(A1(N1+2179)*A1(J1+2179)+A1(N1+2170)*A1(J1+2170)+A1(N100025330
C+2161)*A1(J1+2161))                                                    00025360
 A1(N1+3421)=(A1(N1+2206)*A1(J1+2206)+A1(N1+2197)*A1(J1+2197)+A1(N100025390
C+2188)*A1(J1+2188))                                                    00025420
 A1(N1+3439)=(A1(N1+2233)*A1(J1+2233)+A1(N1+2224)*A1(J1+2224)+A1(N100025450
C+2215)*A1(J1+2215))                                                    00025480
 A1(N1+3457)=(A1(N1+2260)*A1(J1+2260)+A1(N1+2251)*A1(J1+2251)+A1(N100025510
C+2242)*A1(J1+2242))                                                    00025540
 A1(N1+3475)=(A1(N1+2287)*A1(J1+2287)+A1(N1+2278)*A1(J1+2278)+A1(N100025570
C+2269)*A1(J1+2269))                                                    00025600
 A1(N1+3493)=(A1(N1+2314)*A1(J1+2314)+A1(N1+2305)*A1(J1+2305)+A1(N100025630
C+2296)*A1(J1+2296))                                                    00025660
 A1(N1+3511)=(A1(N1+2341)*A1(J1+2341)+A1(N1+2332)*A1(J1+2332)+A1(N100025690
C+2323)*A1(J1+2323))                                                    00025720
 A1(N1+3529)=(A1(N1+2368)*A1(J1+2368)+A1(N1+2359)*A1(J1+2359)+A1(N100025750
C+2350)*A1(J1+2350))                                                    00025780
 A1(N1+3547)=(A1(N1+2395)*A1(J1+2395)+A1(N1+2386)*A1(J1+2386)+A1(N100025810
C+2377)*A1(J1+2377))                                                    00025840
 A1(N1+3565)=(A1(N1+2422)*A1(J1+2422)+A1(N1+2413)*A1(J1+2413)+A1(N100025870
C+2404)*A1(J1+2404))                                                    00025900
 A1(N1+3583)=(A1(N1+2449)*A1(J1+2449)+A1(N1+2440)*A1(J1+2440)+A1(N100025930
C+2431)*A1(J1+2431))                                                    00025960
 A1(N1+3601)=(A1(N1+2476)*A1(J1+2476)+A1(N1+2467)*A1(J1+2467)+A1(N100025990
C+2458)*A1(J1+2458))                                                    00026020
 A1(N1+3619)=(A1(N1+2503)*A1(J1+2503)+A1(N1+2494)*A1(J1+2494)+A1(N100026050
C+2485)*A1(J1+2485))                                                    00026080
 A1(N1+3637)=(A1(N1+2530)*A1(J1+2530)+A1(N1+2521)*A1(J1+2521)+A1(N100026110
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C+2512)*A1(J1+2512))                                                    00026140
 A1(N1+3655)=(A1(N1+2557)*A1(J1+2557)+A1(N1+2548)*A1(J1+2548)+A1(N100026170
C+2539)*A1(J1+2539))                                                    00026200
 A1(N1+3673)=(A1(N1+2584)*A1(J1+2584)+A1(N1+2575)*A1(J1+2575)+A1(N100026230
C+2566)*A1(J1+2566))                                                    00026260
 A1(N1+3691)=(A1(N1+2611)*A1(J1+2611)+A1(N1+2602)*A1(J1+2602)+A1(N100026290
C+2593)*A1(J1+2593))                                                    00026320
 A1(N1+3709)=(A1(N1+2638)*A1(J1+2638)+A1(N1+2629)*A1(J1+2629)+A1(N100026350
C+2620)*A1(J1+2620))                                                    00026380
 A1(N1+3727)=(A1(N1+2665)*A1(J1+2665)+A1(N1+2656)*A1(J1+2656)+A1(N100026410
C+2647)*A1(J1+2647))                                                    00026440
 A1(N1+3745)=(A1(N1+2692)*A1(J1+2692)+A1(N1+2683)*A1(J1+2683)+A1(N100026470
C+2674)*A1(J1+2674))                                                    00026500
 A1(N1+3763)=(A1(N1+2719)*A1(J1+2719)+A1(N1+2710)*A1(J1+2710)+A1(N100026530
C+2701)*A1(J1+2701))                                                    00026560
 A1(N1+3781)=(A1(N1+2746)*A1(J1+2746)+A1(N1+2737)*A1(J1+2737)+A1(N100026590
C+2728)*A1(J1+2728))                                                    00026620
 A1(N1+3799)=(A1(N1+2773)*A1(J1+2773)+A1(N1+2764)*A1(J1+2764)+A1(N100026650
C+2755)*A1(J1+2755))                                                    00026680
 A1(N1+3817)=(A1(N1+2800)*A1(J1+2800)+A1(N1+2791)*A1(J1+2791)+A1(N100026710
C+2782)*A1(J1+2782))                                                    00026740
 A1(N1+3835)=(A1(N1+2827)*A1(J1+2827)+A1(N1+2818)*A1(J1+2818)+A1(N100026770
C+2809)*A1(J1+2809))                                                    00026800
 A1(N1+3853)=(A1(N1+2854)*A1(J1+2854)+A1(N1+2845)*A1(J1+2845)+A1(N100026830
C+2836)*A1(J1+2836))                                                    00026860
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      A1(N1+3871)=(A1(N1+2881)*A1(J1+2881)+A1(N1+2872)*A1(J1+2872)+A1(N100026890
     C+2863)*A1(J1+2863))                                              00026920
      A1(N1+3889)=(A1(N1+2908)*A1(J1+2908)+A1(N1+2899)*A1(J1+2899)+A1(N100026950
     C+2890)*A1(J1+2890))                                              00026980
      A1(N1+3907)=(A1(N1+2935)*A1(J1+2935)+A1(N1+2926)*A1(J1+2926)+A1(N100027010
     C+2917)*A1(J1+2917))                                              00027040
      A1(N1+3925)=(A1(N1+2962)*A1(J1+2962)+A1(N1+2953)*A1(J1+2953)+A1(N100027070
     C+2944)*A1(J1+2944))                                              00027100
      A1(N1+3943)=(A1(N1+2989)*A1(J1+2989)+A1(N1+2980)*A1(J1+2980)+A1(N100027130
     C+2971)*A1(J1+2971))                                              00027160
      A1(N1+3961)=(A1(N1+3016)*A1(J1+3016)+A1(N1+3007)*A1(J1+3007)+A1(N100027190
     C+2998)*A1(J1+2998))                                              00027220
      A1(N1+3979)=(A1(N1+3043)*A1(J1+3043)+A1(N1+3034)*A1(J1+3034)+A1(N100027250
     C+3025)*A1(J1+3025))                                              00027280
      A1(N1+3997)=(A1(N1+3070)*A1(J1+3070)+A1(N1+3061)*A1(J1+3061)+A1(N100027310
     C+3052)*A1(J1+3052))                                              00027340
      A1(N1+4015)=(A1(N1+3097)*A1(J1+3097)+A1(N1+3088)*A1(J1+3088)+A1(N100027370
     C+3079)*A1(J1+3079))                                              00027400
      A1(N1+4033)=(A1(N1+3124)*A1(J1+3124)+A1(N1+3115)*A1(J1+3115)+A1(N100027430
     C+3106)*A1(J1+3106))                                              00027460
      A1(N1+4051)=(A1(N1+3151)*A1(J1+3151)+A1(N1+3142)*A1(J1+3142)+A1(N100027490
     C+3133)*A1(J1+3133))                                              00027520
      A1(N1+4069)=(A1(N1+3178)*A1(J1+3178)+A1(N1+3169)*A1(J1+3169)+A1(N100027550
     C+3160)*A1(J1+3160))                                              00027580
      A1(N1+4087)=(A1(N1+28)*A1(J1+28)+A1(N1+19)*A1(J1+19)+A1(N1+10)*A1(00027610
     CJ1+10))                                                          00027640
      A1(N1+4105)=(A1(N1+55)*A1(J1+55)+A1(N1+46)*A1(J1+46)+A1(N1+37)*A1(00027670
```

```
      CJ1 +37))                                                           00027700
       A1(N1+4123)=(A1(N1+82)*A1(J1+82)+A1(N1+73)*A1(J1+73)+A1(N1+64)*A1(00027730
      CJ1+64))                                                            00027760
       A1(N1+4141)=(A1(N1+109)*A1(J1+109)+A1(N1+100)*A1(J1+100)+A1(N1+91)00027790
      C*A1(J1+91))                                                        00027820
       A1(N1+4159)=(A1(N1+136)*A1(J1+136)+A1(N1+127)*A1(J1+127)+A1(N1+11800027850
      C)*A1(J1+118))                                                      00027880
       A1(N1+4177)=(A1(N1+163)*A1(J1+163)+A1(N1+154)*A1(J1+154)+A1(N1+14500027910
      C)*A1(J1+145))                                                      00027940
       A1(N1+4195)=(A1(N1+190)*A1(J1+190)+A1(N1+181)*A1(J1+181)+A1(N1+17200027970
      C)*A1(J1+172))                                                      00028000
       A1(N1+4213)=(A1(N1+217)*A1(J1+217)+A1(N1+208)*A1(J1+208)+A1(N1+19900028030
      C)*A1(J1+199))                                                      00028060
       A1(N1+4231)=(A1(N1+244)*A1(J1+244)+A1(N1+235)*A1(J1+235)+A1(N1+22600028090
      C)*A1(J1+226))                                                      00028120
       A1(N1+4249)=(A1(N1+271)*A1(J1+271)+A1(N1+262)*A1(J1+262)+A1(N1+25300028150
      C)*A1(J1+253))                                                      00028180
       N3=N2                                                              00028210
       N4=J1                                                              00028240
       K2=J1+N2                                                           00028270
 61    A1(N1+1449)=A1(N1+1449)+(A1(N4+253)*A1(K2+1557)+A1(N4+226)*A1(K2+100028300
      C548)+A1(N4+199)*A1(K2+1539)+A1(N4+172)*A1(K2+1530)+A1(N4+145)*A1(K00028330
      C2+1521)+A1(N4+118)*A1(K2+1512)+A1(N4+91)*A1(K2+1503)+A1(N4+64)*A1(00028360
      CK2+1494)+A1(N4+37)*A1(K2+1485)+A1(N4+10)*A1(K2+1476))              00028390
       A1(N1+1458)=A1(N1+1458)+(A1(N4+262)*A1(K2+1557)+A1(N4+235)*A1(K2+100028420
```

```
C548)+A1(N4+208)*A1(K2+1539)+A1(N4+181)*A1(K2+1530)+A1(N4+154)*A1(K00028450
C2+1521)+A1(N4+127)*A1(K2+1512)+A1(N4+100)*A1(K2+1503)+A1(N4+73)*A100028480
C(K2+1494)+A1(N4+46)*A1(K2+1485)+A1(N4+19)*A1(K2+1476))              00028510
 A1(N1+1467)=A1(N1+1467)+(A1(N4+271)*A1(K2+1557)+A1(N4+244)*A1(K2+100028540
C548)+A1(N4+217)*A1(K2+1539)+A1(N4+190)*A1(K2+1530)+A1(N4+163)*A1(K00028570
C2+1521)+A1(N4+136)*A1(K2+1512)+A1(N4+109)*A1(K2+1503)+A1(N4+82)*A100028600
C(K2+1494)+A1(N4+55)*A1(K2+1485)+A1(N4+28)*A1(K2+1476))              00028630
 A1(N1+3277)=A1(N1+3277)+(A1(N4+1990)*A1(K2+1990)+A1(N4+1981)*A1(K200028660
C+1981)+A1(N4+1972)*A1(K2+1972))                                      00028690
 A1(N1+3295)=A1(N1+3295)+(A1(N4+2017)*A1(K2+2017)+A1(N4+2008)*A1(K200028720
C+2008)+A1(N4+1999)*A1(K2+1999))                                      00028750
 A1(N1+3313)=A1(N1+3313)+(A1(N4+2044)*A1(K2+2044)+A1(N4+2035)*A1(K200028780
C+2035)+A1(N4+2026)*A1(K2+2026))                                      00028810
 A1(N1+3331)=A1(N1+3331)+(A1(N4+2071)*A1(K2+2071)+A1(N4+2062)*A1(K200028840
C+2062)+A1(N4+2053)*A1(K2+2053))                                      00028870
 A1(N1+3349)=A1(N1+3349)+(A1(N4+2098)*A1(K2+2098)+A1(N4+2089)*A1(K200028900
C+2089)+A1(N4+2080)*A1(K2+2080))                                      00028930
 A1(N1+3367)=A1(N1+3367)+(A1(N4+2125)*A1(K2+2125)+A1(N4+2116)*A1(K200028960
C+2116)+A1(N4+2107)*A1(K2+2107))                                      00028990
 A1(N1+3385)=A1(N1+3385)+(A1(N4+2152)*A1(K2+2152)+A1(N4+2143)*A1(K200029020
C+2143)+A1(N4+2134)*A1(K2+2134))                                      00029050
 A1(N1+3403)=A1(N1+3403)+(A1(N4+2179)*A1(K2+2179)+A1(N4+2170)*A1(K200029080
C+2170)+A1(N4+2161)*A1(K2+2161))                                      00029110
 A1(N1+3421)=A1(N1+3421)+(A1(N4+2206)*A1(K2+2206)+A1(N4+2197)*A1(K200029140
C+2197)+A1(N4+2188)*A1(K2+2188))                                      00029170
 A1(N1+3439)=A1(N1+3439)+(A1(N4+2233)*A1(K2+2233)+A1(N4+2224)*A1(K200029200
C+2224)+A1(N4+2215)*A1(K2+2215))                                      00029230
```

```
 A1(N1+3457)=A1(N1+3457)+(A1(N4+2260)*A1(K2+2260)+A1(N4+2251)*A1(K200029260
C+2251)+A1(N4+2242)*A1(K2+2242))                                00029290
 A1(N1+3475)=A1(N1+3475)+(A1(N4+2287)*A1(K2+2287)+A1(N4+2278)*A1(K200029320
C+2278)+A1(N4+2269)*A1(K2+2269))                                00029350
 A1(N1+3493)=A1(N1+3493)+(A1(N4+2314)*A1(K2+2314)+A1(N4+2305)*A1(K200029380
C+2305)+A1(N4+2296)*A1(K2+2296))                                00029410
 A1(N1+3511)=A1(N1+3511)+(A1(N4+2341)*A1(K2+2341)+A1(N4+2332)*A1(K200029440
C+2332)+A1(N4+2323)*A1(K2+2323))                                00029470
 A1(N1+3529)=A1(N1+3529)+(A1(N4+2368)*A1(K2+2368)+A1(N4+2359)*A1(K200029500
C+2359)+A1(N4+2350)*A1(K2+2350))                                00029530
 A1(N1+3547)=A1(N1+3547)+(A1(N4+2395)*A1(K2+2395)+A1(N4+2386)*A1(K200029560
C+2386)+A1(N4+2377)*A1(K2+2377))                                00029590
 A1(N1+3565)=A1(N1+3565)+(A1(N4+2422)*A1(K2+2422)+A1(N4+2413)*A1(K200029620
C+2413)+A1(N4+2404)*A1(K2+2404))                                00029650
 A1(N1+3583)=A1(N1+3583)+(A1(N4+2449)*A1(K2+2449)+A1(N4+2440)*A1(K200029680
C+2440)+A1(N4+2431)*A1(K2+2431))                                00029710
 A1(N1+3601)=A1(N1+3601)+(A1(N4+2476)*A1(K2+2476)+A1(N4+2467)*A1(K200029740
C+2467)+A1(N4+2458)*A1(K2+2458))                                00029770
 A1(N1+3619)=A1(N1+3619)+(A1(N4+2503)*A1(K2+2503)+A1(N4+2494)*A1(K200029800
C+2494)+A1(N4+2485)*A1(K2+2485))                                00029830
 A1(N1+3637)=A1(N1+3637)+(A1(N4+2530)*A1(K2+2530)+A1(N4+2521)*A1(K200029860
C+2521)+A1(N4+2512)*A1(K2+2512))                                00029890
 A1(N1+3655)=A1(N1+3655)+(A1(N4+2557)*A1(K2+2557)+A1(N4+2548)*A1(K200029920
C+2548)+A1(N4+2539)*A1(K2+2539))                                00029950
 A1(N1+3673)=A1(N1+3673)+(A1(N4+2584)*A1(K2+2584)+A1(N4+2575)*A1(K200029980
```

```
C+2575)+A1(N4+2566)*A1(K2+2566))                                   00030010
 A1(N1+3691)=A1(N1+3691)+(A1(N4+2611)*A1(K2+2611)+A1(N4+2602)*A1(K200030040
C+2602)+A1(N4+2593)*A1(K2+2593))                                   00030070
 A1(N1+3709)=A1(N1+3709)+(A1(N4+2638)*A1(K2+2638)+A1(N4+2629)*A1(K200030100
C+2629)+A1(N4+2620)*A1(K2+2620))                                   00030130
 A1(N1+3727)=A1(N1+3727)+(A1(N4+2665)*A1(K2+2665)+A1(N4+2656)*A1(K200030160
C+2656)+A1(N4+2647)*A1(K2+2647))                                   00030190
 A1(N1+3745)=A1(N1+3745)+(A1(N4+2692)*A1(K2+2692)+A1(N4+2683)*A1(K200030220
C+2683)+A1(N4+2674)*A1(K2+2674))                                   00030250
 A1(N1+3763)=A1(N1+3763)+(A1(N4+2719)*A1(K2+2719)+A1(N4+2710)*A1(K200030280
C+2710)+A1(N4+2701)*A1(K2+2701))                                   00030310
 A1(N1+3781)=A1(N1+3781)+(A1(N4+2746)*A1(K2+2746)+A1(N4+2737)*A1(K200030340
C+2737)+A1(N4+2728)*A1(K2+2728))                                   00030370
 A1(N1+3799)=A1(N1+3799)+(A1(N4+2773)*A1(K2+2773)+A1(N4+2764)*A1(K200030400
C+2764)+A1(N4+2755)*A1(K2+2755))                                   00030430
 A1(N1+3817)=A1(N1+3817)+(A1(N4+2800)*A1(K2+2800)+A1(N4+2791)*A1(K200030460
C+2791)+A1(N4+2782)*A1(K2+2782))                                   00030490
 A1(N1+3835)=A1(N1+3835)+(A1(N4+2827)*A1(K2+2827)+A1(N4+2818)*A1(K200030520
C+2818)+A1(N4+2809)*A1(K2+2809))                                   00030550
 A1(N1+3853)=A1(N1+3853)+(A1(N4+2854)*A1(K2+2854)+A1(N4+2845)*A1(K200030580
C+2845)+A1(N4+2836)*A1(K2+2836))                                   00030610
 A1(N1+3871)=A1(N1+3871)+(A1(N4+2881)*A1(K2+2881)+A1(N4+2872)*A1(K200030640
C+2872)+A1(N4+2863)*A1(K2+2863))                                   00030670
 A1(N1+3889)=A1(N1+3889)+(A1(N4+2908)*A1(K2+2908)+A1(N4+2899)*A1(K200030700
C+2899)+A1(N4+2890)*A1(K2+2890))                                   00030730
 A1(N1+3907)=A1(N1+3907)+(A1(N4+2935)*A1(K2+2935)+A1(N4+2926)*A1(K200030760
C+2926)+A1(N4+2917)*A1(K2+2917))                                   00030790
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      A1(N1+3925)=A1(N1+3925)+(A1(N4+2962)*A1(K2+2962)+A1(N4+2953)*A1(K200030820
     C+2953)+A1(N4+2944)*A1(K2+2944))                                  00030850
      A1(N1+3943)=A1(N1+3943)+(A1(N4+2989)*A1(K2+2989)+A1(N4+2980)*A1(K200030880
     C+2980)+A1(N4+2971)*A1(K2+2971))                                  00030910
      A1(N1+3961)=A1(N1+3961)+(A1(N4+3016)*A1(K2+3016)+A1(N4+3007)*A1(K200030940
     C+3007)+A1(N4+2998)*A1(K2+2998))                                  00030970
      A1(N1+3979)=A1(N1+3979)+(A1(N4+3043)*A1(K2+3043)+A1(N4+3034)*A1(K200031000
     C+3034)+A1(N4+3025)*A1(K2+3025))                                  00031030
      A1(N1+3997)=A1(N1+3997)+(A1(N4+3070)*A1(K2+3070)+A1(N4+3061)*A1(K200031060
     C+3061)+A1(N4+3052)*A1(K2+3052))                                  00031090
      A1(N1+4015)=A1(N1+4015)+(A1(N4+3097)*A1(K2+3097)+A1(N4+3088)*A1(K200031120
     C+3088)+A1(N4+3079)*A1(K2+3079))                                  00031150
      A1(N1+4033)=A1(N1+4033)+(A1(N4+3124)*A1(K2+3124)+A1(N4+3115)*A1(K200031180
     C+3115)+A1(N4+3106)*A1(K2+3106))                                  00031210
      A1(N1+4051)=A1(N1+4051)+(A1(N4+3151)*A1(K2+3151)+A1(N4+3142)*A1(K200031240
     C+3142)+A1(N4+3133)*A1(K2+3133))                                  00031270
      A1(N1+4069)=A1(N1+4069)+(A1(N4+3178)*A1(K2+3178)+A1(N4+3169)*A1(K200031300
     C+3169)+A1(N4+3160)*A1(K2+3160))                                  00031330
      A1(N1+4087)=A1(N1+4087)+(A1(N4+28)*A1(K2+28)+A1(N4+19)*A1(K2+19)+A00031360
     C1(N4+10)*A1(K2+10))                                              00031390
      A1(N1+4105)=A1(N1+4105)+(A1(N4+55)*A1(K2+55)+A1(N4+46)*A1(K2+46)+A00031420
     C1(N4+37)*A1(K2+37))                                              00031450
      A1(N1+4123)=A1(N1+4123)+(A1(N4+82)*A1(K2+82)+A1(N4+73)*A1(K2+73)+A00031480
     C1(N4+64)*A1(K2+64))                                              00031510
      A1(N1+4141)=A1(N1+4141)+(A1(N4+109)*A1(K2+109)+A1(N4+100)*A1(K2+1000031540
```

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      C0)+A1(N4+91)*A1(K2+91))                                          00031570
       A1(N1+4159)=A1(N1+4159)+(A1(N4+136)*A1(K2+136)+A1(N4+127)*A1(K2+1200031600
      C7)+A1(N4+118)*A1(K2+118))                                        00031630
       A1(N1+4177)=A1(N1+4177)+(A1(N4+163)*A1(K2+163)+A1(N4+154)*A1(K2+1500031660
      C4)+A1(N4+145)*A1(K2+145))                                        00031690
       A1(N1+4195)=A1(N1+4195)+(A1(N4+190)*A1(K2+190)+A1(N4+181)*A1(K2+1800031720
      C1)+A1(N4+172)*A1(K2+172))                                        00031750
       A1(N1+4213)=A1(N1+4213)+(A1(N4+217)*A1(K2+217)+A1(N4+208)*A1(K2+2000031780
      C8)+A1(N4+199)*A1(K2+199))                                        00031810
       A1(N1+4231)=A1(N1+4231)+(A1(N4+244)*A1(K2+244)+A1(N4+235)*A1(K2+2300031840
      C5)+A1(N4+226)*A1(K2+226))                                        00031870
       A1(N1+4249)=A1(N1+4249)+(A1(N4+271)*A1(K2+271)+A1(N4+262)*A1(K2+2600031900
      C2)+A1(N4+253)*A1(K2+253))                                        00031930
       N4=N4+1                                                          00031960
       K2=K2-1                                                          00031990
       N3=N3-1                                                          00032020
       IF(N3)61,62,61                                                   00032050
62     A1(N1+4266)=(A1(N1+3277)*F3(N2))                                 00032080
       A1(N1+4284)=(A1(N1+3295)*F3(N2))                                 00032110
       A1(N1+4302)=(A1(N1+3313)*F3(N2))                                 00032140
       A1(N1+4320)=(A1(N1+3331)*F3(N2))                                 00032170
       A1(N1+4338)=(A1(N1+3349)*F3(N2))                                 00032200
       A1(N1+4356)=(A1(N1+3367)*F3(N2))                                 00032230
       A1(N1+4374)=(A1(N1+3385)*F3(N2))                                 00032260
       A1(N1+4392)=(A1(N1+3403)*F3(N2))                                 00032290
       A1(N1+4410)=(A1(N1+3421)*F3(N2))                                 00032320
       A1(N1+4428)=(A1(N1+3439)*F3(N2))                                 00032350
```

```
A1(N1+4446)=(A1(N1+3457)*F3(N2))                    00032380
A1(N1+4464)=(A1(N1+3475)*= 3(N2))                   00032410
A1(N1+4482)=(A1(N1+3493)*F3(N2))                    00032440
A1(N1+4500)=(A1(N1+3511)*F3(N2))                    00032470
A1(N1+4518)=(A1(N1+3529)*F3(N2))                    00032500
A1(N1+4536)=(A1(N1+3547)*F3(N2))                    00032530
A1(N1+4554)=(A1(N1+3565)*F3(N2))                    00032560
A1(N1+4572)=(A1(N1+3583)*F3(N2))                    00032590
A1(N1+4590)=(A1(N1+3601)*F3(N2))                    00032620
A1(N1+4608)=(A1(N1+3619)*F3(N2))                    00032650
A1(N1+4626)=(A1(N1+3637)*F3(N2))                    00032680
A1(N1+4644)=(A1(N1+3655)*F3(N2))                    00032710
A1(N1+4662)=(A1(N1+3673)*F3(N2))                    00032740
A1(N1+4680)=(A1(N1+3691)*F3(N2))                    00032770
A1(N1+4698)=(A1(N1+3709)*F3(N2))                    00032800
A1(N1+4716)=(A1(N1+3727)*F3(N2))                    00032830
A1(N1+4734)=(A1(N1+3745)*F3(N2))                    00032860
A1(N1+4752)=(A1(N1+3763)*F3(N2))                    00032890
A1(N1+4770)=(A1(N1+3781)*F3(N2))                    00032920
A1(N1+4788)=(A1(N1+3799)*F3(N2))                    00032950
A1(N1+4806)=(A1(N1+3817)*F3(N2))                    00032980
A1(N1+4824)=(A1(N1+3835)*F3(N2))                    00033010
A1(N1+4842)=(A1(N1+3853)*F3(N2))                    00033040
A1(N1+4860)=(A1(N1+3871)*F3(N2))                    00033070
A1(N1+4878)=(A1(N1+3889)*F3(N2))                    00033100
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A1(N1+4896)=(A1(N1+3907)*F3(N2))                                  00033130
A1(N1+4914)=(A1(N1+3925)*F3(N2))                                  00033160
A1(N1+4932)=(A1(N1+3943)*F3(N2))                                  00033190
A1(N1+4950)=(A1(N1+3961)*F3(N2))                                  00033220
A1(N1+4968)=(A1(N1+3979)*F3(N2))                                  00033250
A1(N1+4986)=(A1(N1+3997)*F3(N2))                                  00033280
A1(N1+5004)=(A1(N1+4015)*F3(N2))                                  00033310
A1(N1+5022)=(A1(N1+4033)*F3(N2))                                  00033340
A1(N1+5040)=(A1(N1+4051)*F3(N2))                                  00033370
A1(N1+5058)=(A1(N1+4069)*F3(N2))                                  00033400
A1(N1+5076)=(A1(N1+4087)*F3(N2))                                  00033430
A1(N1+5094)=(A1(N1+4105)*F3(N2))                                  00033460
A1(N1+5112)=(A1(N1+4123)*F3(N2))                                  00033490
A1(N1+5130)=(A1(N1+4141)*F3(N2))                                  00033520
A1(N1+5148)=(A1(N1+4159)*F3(N2))                                  00033550
A1(N1+5166)=(A1(N1+4177)*F3(N2))                                  00033580
A1(N1+5184)=(A1(N1+4195)*F3(N2))                                  00033610
A1(N1+5202)=(A1(N1+4213)*F3(N2))                                  00033640
A1(N1+5220)=(A1(N1+4231)*F3(N2))                                  00033670
A1(N1+5238)=(A1(N1+4249)*F3(N2))                                  00033700
A1(N1+280)=(-A1(N1+1449))                                         00033730
A1(N1+289)=(-A1(N1+1458))                                         00033760
A1(N1+298)=(-A1(N1+1467))                                         00033790
A1(N1+307)=(-A1(N1+1449))                                         00033820
A1(N1+316)=(-A1(N1+1458))                                         00033850
A1(N1+325)=(-A1(N1+1467))                                         00033880
A1(N1+334)=(-A1(N1+1449))                                         00033910
```

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      A1(N1+343)=(-A1(N1+1458))                                        00033940
      A1(N1+352)=(-A1(N1+1467))                                        00033970
      A1(N1+361)=(-A1(N1+1449))                                        00034000
      A1(N1+370)=(-A1(N1+1458))                                        00034030
      A1(N1+379)=(-A1(N1+1467))                                        00034060
      A1(N1+388)=(-A1(N1+1449))                                        00034090
      A1(N1+397)=(-A1(N1+1458))                                        00034120
      A1(N1+406)=(-A1(N1+1467))                                        00034150
      A1(N1+415)=(-A1(N1+1449))                                        00034180
      A1(N1+424)=(-A1(N1+1458))                                        00034210
      A1(N1+433)=(-A1(N1+1467))                                        00034240
      A1(N1+442)=(-A1(N1+1449))                                        00034270
      A1(N1+451)=(-A1(N1+1458))                                        00034300
      A1(N1+460)=(-A1(N1+1467))                                        00034330
      A1(N1+469)=(-A1(N1+1449))                                        00034360
      A1(N1+478)=(-A1(N1+1458))                                        00034390
      A1(N1+487)=(-A1(N1+1467))                                        00034420
      A1(N1+496)=(-A1(N1+1449))                                        00034450
      A1(N1+505)=(-A1(N1+1458))                                        00034480
      A1(N1+514)=(-A1(N1+1467))                                        00034510
      A1(N1+523)=(-A1(N1+1449))                                        00034540
      A1(N1+532)=(-A1(N1+1458))                                        00034570
      A1(N1+541)=(-A1(N1+1467))                                        00034600
      A1(N1+3285)=0.D0                                                 00034630
      A1(N1+3303)=0.D0                                                 00034660
```

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```
      A1(N1+3321)=0.D0                                                  00034690
      A1(N1+3339)=0.D0                                                  00034720
      A1(N1+3357)=0.D0                                                  00034750
      A1(N1+3375)=0.D0                                                  00034780
      A1(N1+3393)=0.D0                                                  00034810
      A1(N1+3411)=0.D0                                                  00034840
      A1(N1+3429)=0.D0                                                  00034870
      A1(N1+3447)=0.D0                                                  00034900
      A1(N1+3465)=0.D0                                                  00034930
      A1(N1+3483)=0.D0                                                  00034960
      A1(N1+3501)=0.D0                                                  00034990
      A1(N1+3519)=0.D0                                                  00035020
      A1(N1+3537)=0.D0                                                  00035050
      A1(N1+3555)=0.D0                                                  00035080
      A1(N1+3573)=0.D0                                                  00035110
      A1(N1+3591)=0.D0                                                  00035140
      A1(N1+3609)=0.D0                                                  00035170
      A1(N1+3627)=0.D0                                                  00035200
      A1(N1+3645)=0.D0                                                  00035230
      A1(N1+3663)=0.D0                                                  00035260
      A1(N1+3681)=0.D0                                                  00035290
      A1(N1+3699)=0.D0                                                  00035320
      A1(N1+3717)=0.D0                                                  00035350
      A1(N1+3735)=0.D0                                                  00035380
      A1(N1+3753)=0.D0                                                  00035410
      A1(N1+3771)=0.D0                                                  00035440
      A1(N1+3789)=0.D0                                                  00035470
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```
      A1(N1+3807)=0.D0                                                  00035500
      A1(N1+3825)=0.D0                                                  00035530
      A1(N1+3843)=0.D0                                                  00035560
      A1(N1+3861)=0.D0                                                  00035590
      A1(N1+3879)=0.D0                                                  00035620
      A1(N1+3897)=0.D0                                                  00035650
      A1(N1+3915)=0.D0                                                  00035680
      A1(N1+3933)=0.D0                                                  00035710
      A1(N1+3951)=0.D0                                                  00035740
      A1(N1+3969)=0.D0                                                  00035770
      A1(N1+3987)=0.D0                                                  00035800
      A1(N1+4005)=0.D0                                                  00035830
      A1(N1+4023)=0.D0                                                  00035860
      A1(N1+4041)=0.D0                                                  00035890
      A1(N1+4059)=0.D0                                                  00035920
      A1(N1+4077)=0.D0                                                  00035950
      A1(N1+4095)=0.D0                                                  00035980
      A1(N1+4113)=0.D0                                                  00036010
      A1(N1+4131)=0.D0                                                  00036040
      A1(N1+4149)=0.D0                                                  00036070
      A1(N1+4167)=0.D0                                                  00036100
      A1(N1+4185)=0.D0                                                  00036130
      A1(N1+4203)=0.D0                                                  00036160
      A1(N1+4221)=0.D0                                                  00036190
      A1(N1+4239)=0.D0                                                  00036220
```

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      A1(N1+4257)=0.D0                                                  00036250
      A1(N1+4276)=0.D0                                                  00036280
      A1(N1+4294)=0.D0                                                  00036310
      A1(N1+4312)=0.D0                                                  00036340
      A1(N1+4330)=0.D0                                                  00036370
      A1(N1+4348)=0.D0                                                  00036400
      A1(N1+4366)=0.D0                                                  00036430
      A1(N1+4384)=0.D0                                                  00036460
      A1(N1+4402)=0.D0                                                  00036490
      A1(N1+4420)=0.D0                                                  00036520
      A1(N1+4438)=0.D0                                                  00036550
      A1(N1+4456)=0.D0                                                  00036580
      A1(N1+4474)=0.D0                                                  00036610
      A1(N1+4492)=0.D0                                                  00036640
      A1(N1+4510)=0.D0                                                  00036670
      A1(N1+4528)=0.D0                                                  00036700
      A1(N1+4546)=0.D0                                                  00036730
      A1(N1+4564)=0.D0                                                  00036760
      A1(N1+4582)=0.D0                                                  00036790
      A1(N1+4600)=0.D0                                                  00036820
      A1(N1+4618)=0.D0                                                  00036850
      A1(N1+4636)=0.D0                                                  00036880
      A1(N1+4654)=0.D0                                                  00036910
      A1(N1+4672)=0.D0                                                  00036940
      A1(N1+4690)=0.D0                                                  00036970
      A1(N1+4708)=0.D0                                                  00037000
      A1(N1+4726)=0.D0                                                  00037030
```

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```
      A1(N1+4744)=0.D0                                                  00037060
      A1(N1+4762)=0.D0                                                  00037090
      A1(N1+4780)=0.D0                                                  00037120
      A1(N1+4798)=0.D0                                                  00037150
      A1(N1+4816)=0.D0                                                  00037180
      A1(N1+4834)=0.D0                                                  00037210
      A1(N1+4852)=0.D0                                                  00037240
      A1(N1+4870)=0.D0                                                  00037270
      A1(N1+4888)=0.D0                                                  00037300
      A1(N1+4906)=0.D0                                                  00037330
      A1(N1+4924)=0.D0                                                  00037360
      A1(N1+4942)=0.D0                                                  00037390
      A1(N1+4960)=0.D0                                                  00037420
      A1(N1+4978)=0.D0                                                  00037450
      A1(N1+4996)=0.D0                                                  00037480
      A1(N1+5014)=0.D0                                                  00037510
      A1(N1+5032)=0.D0                                                  00037540
      A1(N1+5050)=0.D0                                                  00037570
      A1(N1+5068)=0.D0                                                  00037600
      A1(N1+5086)=0.D0                                                  00037630
      A1(N1+5104)=0.D0                                                  00037660
      A1(N1+5122)=0.D0                                                  00037690
      A1(N1+5140)=0.D0                                                  00037720
      A1(N1+5158)=0.D0                                                  00037750
      A1(N1+5176)=0.D0                                                  00037780
```

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```
      A1(N1+5194)=0.D0                                                  00037810
      A1(N1+5212)=0.D0                                                  00037840
      A1(N1+5230)=0.D0                                                  00037870
      A1(N1+5248)=0.D0                                                  00037900
      N3=N2                                                             00037930
      N4=J1                                                             00037960
      K2=J1+N2                                                          00037990
      RETURN                                                            00038000   *   INSERT
      END                                                               00038001   *   INSERT
      SUBROUTINE X03(N1,N3,N4,K2,J1,N2)                                 00038002   *   INSERT
      IMPLICIT REAL*8(A-H,O-Z)                                          00038003   *   INSERT
      LOGICAL L2                                                        00038004   *   INSERT
      COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM100038005   *   INSERT
     1,A,F1,C1,C2,A1(10512),L2                                          00038006   *   INSERT
      COMMON/F2ARRY/F2(10)                                              00038007   *   INSERT
 63   A1(N1+280)=A1(N1+280)+(A1(N4+10)*A1(K2+549)-A1(N4+631)*A1(K2+2943)00038020
     C-A1(N4+622)*A1(K2+2727)-A1(N4+613)*A1(K2+2538)-A1(N4+604)*A1(K2+2300038050
     C76)-A1(N4+595)*A1(K2+2241)-A1(N4+586)*A1(K2+2133)-A1(N4+577)*A1(K200038080
     C+2052)-A1(N4+568)*A1(K2+1998)-A1(N4+559)*A1(K2+1971))             00038110
      A1(N1+289)=A1(N1+289)+(A1(N4+19)*A1(K2+549)-A1(N4+631)*A1(K2+2952)00038140
     C-A1(N4+622)*A1(K2+2736)-A1(N4+613)*A1(K2+2547)-A1(N4+604)*A1(K2+2300038170
     C85)-A1(N4+595)*A1(K2+2250)-A1(N4+586)*A1(K2+2142)-A1(N4+577)*A1(K200038200
     C+2061)-A1(N4+568)*A1(K2+2007)-A1(N4+559)*A1(K2+1980))             00038230
      A1(N1+298)=A1(N1+298)+(A1(N4+28)*A1(K2+549)-A1(N4+631)*A1(K2+2961)00038260
     C-A1(N4+622)*A1(K2+2745)-A1(N4+613)*A1(K2+2556)-A1(N4+604)*A1(K2+2300038290
     C94)-A1(N4+595)*A1(K2+2259)-A1(N4+586)*A1(K2+2151)-A1(N4+577)*A1(K200038320
     C+2070)-A1(N4+568)*A1(K2+2016)-A1(N4+559)*A1(K2+1989))             00038350
```

```
 A1(N1+307)=A1(N1+307)+(A1(N4+649)*A1(K2+1971)+A1(N4+37)*A1(K2+639)00038380
C-A1(N4+721)*A1(K2+2970)-A1(N4+712)*A1(K2+2754)-A1(N4+703)*A1(K2+250003841O
C65)-A1(N4+594)*A1(K2+2403)-A1(N4+685)*A1(K2+2268)-A1(N4+676)*A1(K200038440
C+2160)-A1(N4+667)*A1(K2+2079)-A1(N4+658)*A1(K2+2025))                 00038470
 A1(N1+316)=A1(N1+316)+(A1(N4+649)*A1(K2+1980)+A1(N4+46)*A1(K2+639)00038500
C-A1(N4+721)*A1(K2+2979)-A1(N4+712)*A1(K2+2763)-A1(N4+703)*A1(K2+2500038530
C74)-A1(N4+694)*A1(K2+2412)-A1(N4+685)*A1(K2+2277)-A1(N4+676)*A1(K200038560
C+2169)-A1(N4+667)*A1(K2+2088)-A1(N4+658)*A1(K2+2034))                 00038590
 A1(N1+325)=A1(N1+325)+(A1(N4+649)*A1(K2+1989)+A1(N4+55)*A1(K2+639)00038620
C-A1(N4+721)*A1(K2+2988)-A1(N4+712)*A1(K2+2772)-A1(N4+703)*A1(K2+2500038650
C83)-A1(N4+694)*A1(K2+2421)-A1(N4+685)*A1(K2+2286)-A1(N4+676)*A1(K200038680
C+2178)-A1(N4+667)*A1(K2+2097)-A1(N4+658)*A1(K2+2043))                 00038710
 A1(N1+334)=A1(N1+334)+(A1(N4+748)*A1(K2+2025)+A1(N4+739)*A1(K2+1990038740
C8)+A1(N4+64)*A1(K2+729)-A1(N4+811)*A1(K2+2997)-A1(N4+802)*A1(K2+2700038770
C81)-A1(N4+793)*A1(K2+2592)-A1(N4+784)*A1(K2+2430)-A1(N4+775)*A1(K200038800
C+2295)-A1(N4+765)*A1(K2+2187)-A1(N4+757)*A1(K2+2106))                 00038830
 A1(N1+343)=A1(N1+343)+(A1(N4+748)*A1(K2+2034)+A1(N4+739)*A1(K2+2000038860
C7)+A1(N4+73)*A1(K2+729)-A1(N4+811)*A1(K2+3006)-A1(N4+802)*A1(K2+2700038890
C90)-A1(N4+793)*A1(K2+2601)-A1(N4+784)*A1(K2+2439)-A1(N4+775)*A1(K200038920
C+2304)-A1(N4+766)*A1(K2+2196)-A1(N4+757)*A1(K2+2115))                 00038950
 A1(N1+352)=A1(N1+352)+(A1(N4+748)*A1(K2+2043)+A1(N4+739)*A1(K2+2010038980
C6)+A1(N4+82)*A1(K2+729)-A1(N4+811)*A1(K2+3015)-A1(N4+802)*A1(K2+2700039010
C99)-A1(N4+793)*A1(K2+2610)-A1(N4+784)*A1(K2+2448)-A1(N4+775)*A1(K200039040
C+2313)-A1(N4+765)*A1(K2+2205)-A1(N4+757)*A1(K2+2124))                 00039070
 A1(N1+361)=A1(N1+361)+(A1(N4+847)*A1(K2+2106)+A1(N4+838)*A1(K2+20700039100
```

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```
C9)+A1(N4+829)*A1(K2+2052)+A1(N4+91)*A1(K2+819)-A1(N4+901)*A1(K2+3000039130
C24)-A1(N4+892)*A1(K2+2808)-A1(N4+883)*A1(K2+2619)-A1(N4+874)*A1(K200039160
C+2457)-A1(N4+865)*A1(K2+2322)-A1(N4+856)*A1(K2+2214))                 00039190
 A1(N1+370)=A1(N1+370)+(A1(N4+847)*A1(K2+2115)+A1(N4+838)*A1(K2+20800039220
C8)+A1(N4+829)*A1(K2+2061)+A1(N4+100)*A1(K2+819)-A1(N4+901)*A1(K2+300039250
C033)-A1(N4+892)*A1(K2+2817)-A1(N4+883)*A1(K2+2628)-A1(N4+874)*A1(K00039280
C2+2466)-A1(N4+865)*A1(K2+2331)-A1(N4+856)*A1(K2+2223))                00039310
 A1(N1+379)=A1(N1+379)+(A1(N4+847)*A1(K2+2124)+A1(N4+838)*A1(K2+20900039340
C7)+A1(N4+829)*A1(K2+2070)+A1(N4+109)*A1(K2+819)-A1(N4+901)*A1(K2+300039370
C042)-A1(N4+892)*A1(K2+2826)-A1(N4+883)*A1(K2+2637)-A1(N4+874)*A1(K00039400
C2+2475)-A1(N4+855)*A1(K2+2340)-A1(N4+856)*A1(K2+2232))                00039430
 A1(N1+388)=A1(N1+388)+(A1(N4+946)*A1(K2+2214)+A1(N4+937)*A1(K2+21800039460
C7)+A1(N4+928)*A1(K2+2160)+A1(N4+919)*A1(K2+2133)+A1(N4+118)*A1(K2+00039490
C909)-A1(N4+991)*A1(K2+3051)-A1(N4+982)*A1(K2+2835)-A1(N4+973)*A1(K00039520
C2+2646)-A1(N4+964)*A1(K2+2484)-A1(N4+955)*A1(K2+2349))                00039550
 A1(N1+397)=A1(N1+397)+(A1(N4+946)*A1(K2+2223)+A1(N4+937)*A1(K2+21900039580
C6)+A1(N4+928)*A1(K2+2169)+A1(N4+919)*A1(K2+2142)+A1(N4+127)*A1(K2+00039610
C909)-A1(N4+991)*A1(K2+3060)-A1(N4+982)*A1(K2+2844)-A1(N4+973)*A1(K00039640
C2+2655)-A1(N4+964)*A1(K2+2493)-A1(N4+955)*A1(K2+2358))                00039670
 A1(N1+406)=A1(N1+406)+(A1(N4+946)*A1(K2+2232)+A1(N4+937)*A1(K2+22000039700
C5)+A1(N4+928)*A1(K2+2178)+A1(N4+919)*A1(K2+2151)+A1(N4+136)*A1(K2+00039730
C909)-A1(N4+991)*A1(K2+3069)-A1(N4+982)*A1(K2+2853)-A1(N4+973)*A1(K00039760
C2+2664)-A1(N4+964)*A1(K2+2502)-A1(N4+955)*A1(K2+2367))                00039790
 A1(N1+415)=A1(N1+415)+(A1(N4+1045)*A1(K2+2349)+A1(N4+1036)*A1(K2+200039820
C322)+A1(N4+1027)*A1(K2+2295)+A1(N4+1018)*A1(K2+2268)+A1(N4+1009)*A00039850
C1(K2+2241)+A1(N4+145)*A1(K2+999)-A1(N4+1081)*A1(K2+3078)-A1(N4+10700039880
C2)*A1(K2+2862)-A1(N4+1063)*A1(K2+2673)-A1(N4+1054)*A1(K2+2511))      00039910
```

```
      A1(N1+424)=A1(N1+424)+(A1(N4+1045)*A1(K2+2358)+A1(N4+1036)*A1(K2+200039940
     C331)+A1(N4+1027)*A1(K2+2304)+A1(N4+1018)*A1(K2+2277)+A1(N4+1009)*A00039970
     C1(K2+2250)+A1(N4+154)*A1(K2+999)-A1(N4+1081)*A1(K2+3087)-A1(N4+10700040000
     C2)*A1(K2+2871)-A1(N4+1063)*A1(K2+2682)-A1(N4+1054)*A1(K2+2520))    00040030
      A1(N1+433)=A1(N1+433)+(A1(N4+1045)*A1(K2+2367)+A1(N4+1036)*A1(K2+200040060
     C340)+A1(N4+1027)*A1(K2+2313)+A1(N4+1018)*A1(K2+2286)+A1(N4+1009)*A00040090
     C1(K2+2259)+A1(N4+163)*A1(K2+999)-A1(N4+1081)*A1(K2+3096)-A1(N4+10700040120
     C2)*A1(K2+2880)-A1(N4+1063)*A1(K2+2691)-A1(N4+1054)*A1(K2+2529))    00040150
      A1(N1+442)=A1(N1+442)+(A1(N4+1144)*A1(K2+2511)+A1(N4+1135)*A1(K2+200040180
     C484)+A1(N4+1126)*A1(K2+2457)+A1(N4+1117)*A1(K2+2430)+A1(N4+1108)*A00040210
     C1(K2+2403)+A1(N4+1099)*A1(K2+2376)+A1(N4+172)*A1(K2+1089)-A1(N4+1100040240
     C71)*A1(K2+3105)-A1(N4+1162)*A1(K2+2889)-A1(N4+1153)*A1(K2+2700))   00040270
      A1(N1+451)=A1(N1+451)+(A1(N4+1144)*A1(K2+2520)+A1(N4+1135)*A1(K2+200040300
     C493)+A1(N4+1126)*A1(K2+2466)+A1(N4+1117)*A1(K2+2439)+A1(N4+1108)*A00040330
     C1(K2+2412)+A1(N4+1099)*A1(K2+2385)+A1(N4+181)*A1(K2+1089)-A1(N4+1100040360
     C71)*A1(K2+3114)-A1(N4+1162)*A1(K2+2898)-A1(N4+1153)*A1(K2+2709))   00040390
      A1(N1+460)=A1(N1+460)+(A1(N4+1144)*A1(K2+2529)+A1(N4+1135)*A1(K2+200040420
     C502)+A1(N4+1126)*A1(K2+2475)+A1(N4+1117)*A1(K2+2448)+A1(N4+1108)*A00040450
     C1(K2+2421)+A1(N4+1099)*A1(K2+2394)+A1(N4+190)*A1(K2+1089)-A1(N4+1100040480
     C71)*A1(K2+3123)-A1(N4+1162)*A1(K2+2907)-A1(N4+1153)*A1(K2+2718))   00040510
      A1(N1+469)=A1(N1+469)+(A1(N4+1243)*A1(K2+2700)+A1(N4+1234)*A1(K2+200040540
     C673)+A1(N4+1225)*A1(K2+2646)+A1(N4+1216)*A1(K2+2619)+A1(N4+1207)*A00040570
     C1(K2+2592)+A1(N4+1198)*A1(K2+2565)+A1(N4+1189)*A1(K2+2538)+A1(N4+100040600
     C99)*A1(K2+1179)-A1(N4+1261)*A1(K2+3132)-A1(N4+1252)*A1(K2+2916))   00040630
      A1(N1+478)=A1(N1+478)+(A1(N4+1243)*A1(K2+2709)+A1(N4+1234)*A1(K2+200040660
```

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C682)+A1(N4+1225)*A1(K2+2655)+A1(N4+1216)*A1(K2+2628)+A1(N4+1207)*A00040690
C1(K2+2601)+A1(N4+1198)*A1(K2+2574)+A1(N4+1189)*A1(K2+2547)+A1(N4+200040720
C08)*A1(K2+1179)-A1(N4+1261)*A1(K2+3141)-A1(N4+1252)*A1(K2+2925))   00040750
 A1(N1+487)=A1(N1+487)+(A1(N4+1243)*A1(K2+2718)+A1(N4+1234)*A1(K2+200040780
C691)+A1(N4+1225)*A1(K2+2664)+A1(N4+1216)*A1(K2+2637)+A1(N4+1207)*A00040810
C1(K2+2610)+A1(N4+1198)*A1(K2+2583)+A1(N4+1189)*A1(K2+2556)+A1(N4+200040840
C17)*A1(K2+1179)-A1(N4+1261)*A1(K2+3150)-A1(N4+1252)*A1(K2+2934))   00040870
 A1(N1+496)=A1(N1+496)+(A1(N4+1342)*A1(K2+2916)+A1(N4+1333)*A1(K2+200040900
C889)+A1(N4+1324)*A1(K2+2862)+A1(N4+1315)*A1(K2+2835)+A1(N4+1306)*A00040930
C1(K2+2808)+A1(N4+1297)*A1(K2+2781)+A1(N4+1288)*A1(K2+2754)+A1(N4+100040960
C279)*A1(K2+2727)+A1(N4+226)*A1(K2+1269)-A1(N4+1351)*A1(K2+3159))   00040990
 A1(N1+505)=A1(N1+505)+(A1(N4+1342)*A1(K2+2925)+A1(N4+1333)*A1(K2+200041020
C898)+A1(N4+1324)*A1(K2+2871)+A1(N4+1315)*A1(K2+2844)+A1(N4+1306)*A00041050
C1(K2+2817)+A1(N4+1297)*A1(K2+2790)+A1(N4+1288)*A1(K2+2763)+A1(N4+100041080
C279)*A1(K2+2736)+A1(N4+235)*A1(K2+1269)-A1(N4+1351)*A1(K2+3168))   00041110
 A1(N1+514)=A1(N1+514)+(A1(N4+1342)*A1(K2+2934)+A1(N4+1333)*A1(K2+200041140
C907)+A1(N4+1324)*A1(K2+2880)+A1(N4+1315)*A1(K2+2853)+A1(N4+1306)*A00041170
C1(K2+2826)+A1(N4+1297)*A1(K2+2799)+A1(N4+1288)*A1(K2+2772)+A1(N4+100041200
C279)*A1(K2+2745)+A1(N4+244)*A1(K2+1269)-A1(N4+1351)*A1(K2+3177))   00041230
 A1(N1+523)=A1(N1+523)+(A1(N4+1441)*A1(K2+3159)+A1(N4+1432)*A1(K2+300041260
C132)+A1(N4+1423)*A1(K2+3105)+A1(N4+1414)*A1(K2+3078)+A1(N4+1405)*A00041290
C1(K2+3051)+A1(N4+1396)*A1(K2+3024)+A1(N4+1387)*A1(K2+2997)+A1(N4+100041320
C378)*A1(K2+2970)+A1(N4+1369)*A1(K2+2943)+A1(N4+253)*A1(K2+1359))   00041350
 A1(N1+532)=A1(N1+532)+(A1(N4+1441)*A1(K2+3168)+A1(N4+1432)*A1(K2+300041380
C141)+A1(N4+1423)*A1(K2+3114)+A1(N4+1414)*A1(K2+3087)+A1(N4+1405)*A00041410
C1(K2+3060)+A1(N4+1396)*A1(K2+3033)+A1(N4+1387)*A1(K2+3006)+A1(N4+100041440
C378)*A1(K2+2979)+A1(N4+1369)*A1(K2+2952)+A1(N4+262)*A1(K2+1359))   00041470
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      A1(N1+541)=A1(N1+541)+(A1(N4+1441)*A1(K2+3177)+A1(N4+1432)*A1(K2+300041500
     C150)+A1(N4+1423)*A1(K2+3123)+A1(N4+1414)*A1(K2+3096)+A1(N4+1405)*A00041530
     C1(K2+3069)+A1(N4+1396)*A1(K2+3042)+A1(N4+1387)*A1(K2+3015)+A1(N4+100041560
     C378)*A1(K2+2988)+A1(N4+1369)*A1(K2+2961)+A1(N4+271)*A1(K2+1359))  00041590
      A1(N1+3285)=A1(N1+3285)+(A1(N4+4267)*A1(K2+4275))                 00041620
      A1(N1+3303)=A1(N1+3303)+(A1(N4+4285)*A1(K2+4293))                 00041650
      A1(N1+3321)=A1(N1+3321)+(A1(N4+4303)*A1(K2+4311))                 00041680
      A1(N1+3339)=A1(N1+3339)+(A1(N4+4321)*A1(K2+4329))                 00041710
      A1(N1+3357)=A1(N1+3357)+(A1(N4+4339)*A1(K2+4347))                 00041740
      A1(N1+3375)=A1(N1+3375)+(A1(N4+4357)*A1(K2+4365))                 00041770
      A1(N1+3393)=A1(N1+3393)+(A1(N4+4375)*A1(K2+4383))                 00041800
      A1(N1+3411)=A1(N1+3411)+(A1(N4+4393)*A1(K2+4401))                 00041830
      A1(N1+3429)=A1(N1+3429)+(A1(N4+4411)*A1(K2+4419))                 00041860
      A1(N1+3447)=A1(N1+3447)+(A1(N4+4429)*A1(K2+4437))                 00041890
      A1(N1+3465)=A1(N1+3465)+(A1(N4+4447)*A1(K2+4455))                 00041920
      A1(N1+3483)=A1(N1+3483)+(A1(N4+4465)*A1(K2+4473))                 00041950
      A1(N1+3501)=A1(N1+3501)+(A1(N4+4483)*A1(K2+4491))                 00041980
      A1(N1+3519)=A1(N1+3519)+(A1(N4+4501)*A1(K2+4509))                 00042010
      A1(N1+3537)=A1(N1+3537)+(A1(N4+4519)*A1(K2+4527))                 00042040
      A1(N1+3555)=A1(N1+3555)+(A1(N4+4537)*A1(K2+4545))                 00042070
      A1(N1+3573)=A1(N1+3573)+(A1(N4+4555)*A1(K2+4563))                 00042100
      A1(N1+3591)=A1(N1+3591)+(A1(N4+4573)*A1(K2+4581))                 00042130
      A1(N1+3609)=A1(N1+3609)+(A1(N4+4591)*A1(K2+4599))                 00042160
      A1(N1+3627)=A1(N1+3627)+(A1(N4+4609)*A1(K2+4617))                 00042190
      A1(N1+3645)=A1(N1+3645)+(A1(N4+4627)*A1(K2+4635))                 00042220
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A1(N1+3663)=A1(N1+3663)+(A1(N4+4645)*A1(K2+4653))          00042250
A1(N1+3681)=A1(N1+3681)+(A1(N4+4663)*A1(K2+4671))          00042280
A1(N1+3699)=A1(N1+3699)+(A1(N4+4681)*A1(K2+4689))          00042310
A1(N1+3717)=A1(N1+3717)+(A1(N4+4699)*A1(K2+4707))          00042340
A1(N1+3735)=A1(N1+3735)+(A1(N4+4717)*A1(K2+4725))          00042370
A1(N1+3753)=A1(N1+3753)+(A1(N4+4735)*A1(K2+4743))          00042400
A1(N1+3771)=A1(N1+3771)+(A1(N4+4753)*A1(K2+4761))          00042430
A1(N1+3789)=A1(N1+3789)+(A1(N4+4771)*A1(K2+4779))          00042460
A1(N1+3807)=A1(N1+3807)+(A1(N4+4789)*A1(K2+4797))          00042490
A1(N1+3825)=A1(N1+3825)+(A1(N4+4807)*A1(K2+4815))          00042520
A1(N1+3843)=A1(N1+3843)+(A1(N4+4825)*A1(K2+4833))          00042550
A1(N1+3861)=A1(N1+3861)+(A1(N4+4843)*A1(K2+4851))          00042580
A1(N1+3879)=A1(N1+3879)+(A1(N4+4861)*A1(K2+4869))          00042610
A1(N1+3897)=A1(N1+3897)+(A1(N4+4879)*A1(K2+4887))          00042640
A1(N1+3915)=A1(N1+3915)+(A1(N4+4897)*A1(K2+4905))          00042670
A1(N1+3933)=A1(N1+3933)+(A1(N4+4915)*A1(K2+4923))          00042700
A1(N1+3951)=A1(N1+3951)+(A1(N4+4933)*A1(K2+4941))          00042730
A1(N1+3969)=A1(N1+3969)+(A1(N4+4951)*A1(K2+4959))          00042760
A1(N1+3987)=A1(N1+3987)+(A1(N4+4969)*A1(K2+4977))          00042790
A1(N1+4005)=A1(N1+4005)+(A1(N4+4987)*A1(K2+4995))          00042820
A1(N1+4023)=A1(N1+4023)+(A1(N4+5005)*A1(K2+5013))          00042850
A1(N1+4041)=A1(N1+4041)+(A1(N4+5023)*A1(K2+5031))          00042880
A1(N1+4059)=A1(N1+4059)+(A1(N4+5041)*A1(K2+5049))          00042910
A1(N1+4077)=A1(N1+4077)+(A1(N4+5059)*A1(K2+5067))          00042940
A1(N1+4095)=A1(N1+4095)+(A1(N4+5077)*A1(K2+5085))          00042970
A1(N1+4113)=A1(N1+4113)+(A1(N4+5095)*A1(K2+5103))          00043000
A1(N1+4131)=A1(N1+4131)+(A1(N4+5113)*A1(K2+5121))          00043030
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A1(N1+4149)=A1(N1+4149)+(A1(N4+5131)*A1(K2+5139))        00043060
A1(N1+4167)=A1(N1+4167)+(A1(N4+5149)*A1(K2+5157))        00043090
A1(N1+4185)=A1(N1+4185)+(A1(N4+5167)*A1(K2+5175))        00043120
A1(N1+4203)=A1(N1+4203)+(A1(N4+5185)*A1(K2+5193))        00043150
A1(N1+4221)=A1(N1+4221)+(A1(N4+5203)*A1(K2+5211))        00043180
A1(N1+4239)=A1(N1+4239)+(A1(N4+5221)*A1(K2+5229))        00043210
A1(N1+4257)=A1(N1+4257)+(A1(N4+5239)*A1(K2+5247))        00043240
A1(N1+4276)=A1(N1+4276)+(A1(K2+3277)*A1(N4+4276))        00043270
A1(N1+4294)=A1(N1+4294)+(A1(K2+3295)*A1(N4+4294))        00043300
A1(N1+4312)=A1(N1+4312)+(A1(K2+3313)*A1(N4+4312))        00043330
A1(N1+4330)=A1(N1+4330)+(A1(K2+3331)*A1(N4+4330))        00043360
A1(N1+4348)=A1(N1+4348)+(A1(K2+3349)*A1(N4+4348))        00043390
A1(N1+4366)=A1(N1+4366)+(A1(K2+3367)*A1(N4+4366))        00043420
A1(N1+4384)=A1(N1+4384)+(A1(K2+3385)*A1(N4+4384))        00043450
A1(N1+4402)=A1(N1+4402)+(A1(K2+3403)*A1(N4+4402))        00043480
A1(N1+4420)=A1(N1+4420)+(A1(K2+3421)*A1(N4+4420))        00043510
A1(N1+4438)=A1(N1+4438)+(A1(K2+3439)*A1(N4+4438))        00043540
A1(N1+4456)=A1(N1+4456)+(A1(K2+3457)*A1(N4+4456))        00043570
A1(N1+4474)=A1(N1+4474)+(A1(K2+3475)*A1(N4+4474))        00043600
A1(N1+4492)=A1(N1+4492)+(A1(K2+3493)*A1(N4+4492))        00043630
A1(N1+4510)=A1(N1+4510)+(A1(K2+3511)*A1(N4+4510))        00043660
A1(N1+4528)=A1(N1+4528)+(A1(K2+3529)*A1(N4+4528))        00043690
A1(N1+4546)=A1(N1+4546)+(A1(K2+3547)*A1(N4+4546))        00043720
A1(N1+4564)=A1(N1+4564)+(A1(K2+3565)*A1(N4+4564))        00043750
A1(N1+4582)=A1(N1+4582)+(A1(K2+3583)*A1(N4+4582))        00043780
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A1(N1+4600)=A1(N1+4600)+(A1(K2+3601)*A1(N4+4600))          00043810
A1(N1+4618)=A1(N1+4618)+(A1(K2+3619)*A1(N4+4618))          00043840
A1(N1+4636)=A1(N1+4636)+(A1(K2+3637)*A1(N4+4636))          00043870
A1(N1+4654)=A1(N1+4654)+(A1(K2+3655)*A1(N4+4654))          00043900
A1(N1+4672)=A1(N1+4672)+(A1(K2+3673)*A1(N4+4672))          00043930
A1(N1+4690)=A1(N1+4690)+(A1(K2+3691)*A1(N4+4690))          00043960
A1(N1+4708)=A1(N1+4708)+(A1(K2+3709)*A1(N4+4708))          00043990
A1(N1+4726)=A1(N1+4726)+(A1(K2+3727)*A1(N4+4726))          00044020
A1(N1+4744)=A1(N1+4744)+(A1(K2+3745)*A1(N4+4744))          00044050
A1(N1+4762)=A1(N1+4762)+(A1(K2+3763)*A1(N4+4762))          00044080
A1(N1+4780)=A1(N1+4780)+(A1(K2+3781)*A1(N4+4780))          00044110
A1(N1+4798)=A1(N1+4798)+(A1(K2+3799)*A1(N4+4798))          00044140
A1(N1+4816)=A1(N1+4816)+(A1(K2+3817)*A1(N4+4816))          00044170
A1(N1+4834)=A1(N1+4834)+(A1(K2+3835)*A1(N4+4834))          00044200
A1(N1+4852)=A1(N1+4852)+(A1(K2+3853)*A1(N4+4852))          00044230
A1(N1+4870)=A1(N1+4870)+(A1(K2+3871)*A1(N4+4870))          00044260
A1(N1+4888)=A1(N1+4888)+(A1(K2+3889)*A1(N4+4888))          00044290
A1(N1+4906)=A1(N1+4906)+(A1(K2+3907)*A1(N4+4906))          00044320
A1(N1+4924)=A1(N1+4924)+(A1(K2+3925)*A1(N4+4924))          00044350
A1(N1+4942)=A1(N1+4942)+(A1(K2+3943)*A1(N4+4942))          00044380
A1(N1+4960)=A1(N1+4960)+(A1(K2+3961)*A1(N4+4960))          00044410
A1(N1+4978)=A1(N1+4978)+(A1(K2+3979)*A1(N4+4978))          00044440
A1(N1+4996)=A1(N1+4996)+(A1(K2+3997)*A1(N4+4996))          00044470
A1(N1+5014)=A1(N1+5014)+(A1(K2+4015)*A1(N4+5014))          00044500
A1(N1+5032)=A1(N1+5032)+(A1(K2+4033)*A1(N4+5032))          00044530
A1(N1+5050)=A1(N1+5050)+(A1(K2+4051)*A1(N4+5050))          00044560
A1(N1+5068)=A1(N1+5068)+(A1(K2+4069)*A1(N4+5068))          00044590
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      A1(N1+5086)=A1(N1+5086)+(A1(K2+4087)*A1(N4+5086))                 00044620
      A1(N1+5104)=A1(N1+5104)+(A1(K2+4105)*A1(N4+5104))                 00044650
      A1(N1+5122)=A1(N1+5122)+(A1(K2+4123)*A1(N4+5122))                 00044680
      A1(N1+5140)=A1(N1+5140)+(A1(K2+4141)*A1(N4+5140))                 00044710
      A1(N1+5158)=A1(N1+5158)+(A1(K2+4159)*A1(N4+5158))                 00044740
      A1(N1+5176)=A1(N1+5176)+(A1(K2+4177)*A1(N4+5176))                 00044770
      A1(N1+5194)=A1(N1+5194)+(A1(K2+4195)*A1(N4+5194))                 00044800
      A1(N1+5212)=A1(N1+5212)+(A1(K2+4213)*A1(N4+5212))                 00044830
      A1(N1+5230)=A1(N1+5230)+(A1(K2+4231)*A1(N4+5230))                 00044860
      A1(N1+5248)=A1(N1+5248)+(A1(K2+4249)*A1(N4+5248))                 00044890
      N4=N4+1                                                           00044920
      K2=K2-1                                                           00044950
      N3=N3-1                                                           00044980
      IF(N3)63,64,63                                                    00045010
64    A1(N1+280)=(A1(N1+280)*F2(N2))                                    00045040
      A1(N1+289)=(A1(N1+289)*F2(N2))                                    00045070
      A1(N1+298)=(A1(N1+298)*F2(N2))                                    00045100
      A1(N1+307)=(A1(N1+307)*F2(N2))                                    00045130
      A1(N1+316)=(A1(N1+316)*F2(N2))                                    00045160
      A1(N1+325)=(A1(N1+325)*F2(N2))                                    00045190
      A1(N1+334)=(A1(N1+334)*F2(N2))                                    00045220
      A1(N1+343)=(A1(N1+343)*F2(N2))                                    00045250
      A1(N1+352)=(A1(N1+352)*F2(N2))                                    00045280
      A1(N1+361)=(A1(N1+361)*F2(N2))                                    00045310
      A1(N1+370)=(A1(N1+370)*F2(N2))                                    00045340
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```
A1(N1+379)=(A1(N1+379)*F2(N2))                                        00045370
A1(N1+388)=(A1(N1+388)*F2(N2))                                        00045400
A1(N1+397)=(A1(N1+397)*F2(N2))                                        00045430
A1(N1+406)=(A1(N1+406)*F2(N2))                                        00045460
A1(N1+415)=(A1(N1+415)*F2(N2))                                        00045490
A1(N1+424)=(A1(N1+424)*F2(N2))                                        00045520
A1(N1+433)=(A1(N1+433)*F2(N2))                                        00045550
A1(N1+442)=(A1(N1+442)*F2(N2))                                        00045580
A1(N1+451)=(A1(N1+451)*F2(N2))                                        00045610
A1(N1+460)=(A1(N1+460)*F2(N2))                                        00045640
A1(N1+469)=(A1(N1+469)*F2(N2))                                        00045670
A1(N1+478)=(A1(N1+478)*F2(N2))                                        00045700
A1(N1+487)=(A1(N1+487)*F2(N2))                                        00045730
A1(N1+496)=(A1(N1+496)*F2(N2))                                        00045760
A1(N1+505)=(A1(N1+505)*F2(N2))                                        00045790
A1(N1+514)=(A1(N1+514)*F2(N2))                                        00045820
A1(N1+523)=(A1(N1+523)*F2(N2))                                        00045850
A1(N1+532)=(A1(N1+532)*F2(N2))                                        00045880
A1(N1+541)=(A1(N1+541)*F2(N2))                                        00045910
A1(N1+4276)=(-A1(N1+4276)/A1(J1+3277))                                00045940
A1(N1+4294)=(-A1(N1+4294)/A1(J1+3295))                                00045970
A1(N1+4312)=(-A1(N1+4312)/A1(J1+3313))                                00046000
A1(N1+4330)=(-A1(N1+4330)/A1(J1+3331))                                00046030
A1(N1+4348)=(-A1(N1+4348)/A1(J1+3349))                                00046060
A1(N1+4366)=(-A1(N1+4366)/A1(J1+3367))                                00046090
A1(N1+4384)=(-A1(N1+4384)/A1(J1+3385))                                00046120
A1(N1+4402)=(-A1(N1+4402)/A1(J1+3403))                                00046150
```

```
A1(N1+4420)=(-A1(N1+4420)/A1(J1+3421))                          00046180
A1(N1+4438)=(-A1(N1+4438)/A1(J1+3439))                          00046210
A1(N1+4456)=(-A1(N1+4456)/A1(J1+3457))                          00046240
A1(N1+4474)=(-A1(N1+4474)/A1(J1+3475))                          00046270
A1(N1+4492)=(-A1(N1+4492)/A1(J1+3493))                          00046300
A1(N1+4510)=(-A1(N1+4510)/A1(J1+3511))                          00046330
A1(N1+4528)=(-A1(N1+4528)/A1(J1+3529))                          00046360
A1(N1+4546)=(-A1(N1+4546)/A1(J1+3547))                          00046390
A1(N1+4564)=(-A1(N1+4564)/A1(J1+3565))                          00046420
A1(N1+4582)=(-A1(N1+4582)/A1(J1+3583))                          00046450
A1(N1+4600)=(-A1(N1+4600)/A1(J1+3601))                          00046480
A1(N1+4618)=(-A1(N1+4618)/A1(J1+3619))                          00046510
A1(N1+4636)=(-A1(N1+4636)/A1(J1+3637))                          00046540
A1(N1+4654)=(-A1(N1+4654)/A1(J1+3655))                          00046570
A1(N1+4672)=(-A1(N1+4672)/A1(J1+3673))                          00046600
A1(N1+4690)=(-A1(N1+4690)/A1(J1+3691))                          00046630
A1(N1+4708)=(-A1(N1+4708)/A1(J1+3709))                          00046660
A1(N1+4726)=(-A1(N1+4726)/A1(J1+3727))                          00046690
A1(N1+4744)=(-A1(N1+4744)/A1(J1+3745))                          00046720
A1(N1+4762)=(-A1(N1+4762)/A1(J1+3763))                          00046750
A1(N1+4780)=(-A1(N1+4780)/A1(J1+3781))                          00046780
A1(N1+4798)=(-A1(N1+4798)/A1(J1+3799))                          00046810
A1(N1+4816)=(-A1(N1+4816)/A1(J1+3817))                          00046840
A1(N1+4834)=(-A1(N1+4834)/A1(J1+3835))                          00046870
A1(N1+4852)=(-A1(N1+4852)/A1(J1+3853))                          00046900
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```
      A1(N1+4870)=(-A1(N1+4870)/A1(J1+3871))                            00046930
      A1(N1+4888)=(-A1(N1+4888)/A1(J1+3889))                            00046960
      A1(N1+4906)=(-A1(N1+4906)/A1(J1+3907))                            00046990
      A1(N1+4924)=(-A1(N1+4924)/A1(J1+3925))                            00047020
      A1(N1+4942)=(-A1(N1+4942)/A1(J1+3943))                            00047050
      A1(N1+4960)=(-A1(N1+4960)/A1(J1+3961))                            00047080
      A1(N1+4978)=(-A1(N1+4978)/A1(J1+3979))                            00047110
      A1(N1+4996)=(-A1(N1+4996)/A1(J1+3997))                            00047140
      A1(N1+5014)=(-A1(N1+5014)/A1(J1+4015))                            00047170
      A1(N1+5032)=(-A1(N1+5032)/A1(J1+4033))                            00047200
      A1(N1+5050)=(-A1(N1+5050)/A1(J1+4051))                            00047230
      A1(N1+5068)=(-A1(N1+5068)/A1(J1+4069))                            00047260
      A1(N1+5086)=(-A1(N1+5086)/A1(J1+4087))                            00047290
      A1(N1+5104)=(-A1(N1+5104)/A1(J1+4105))                            00047320
      A1(N1+5122)=(-A1(N1+5122)/A1(J1+4123))                            00047350
      A1(N1+5140)=(-A1(N1+5140)/A1(J1+4141))                            00047380
      A1(N1+5158)=(-A1(N1+5158)/A1(J1+4159))                            00047410
      A1(N1+5176)=(-A1(N1+5176)/A1(J1+4177))                            00047440
      A1(N1+5194)=(-A1(N1+5194)/A1(J1+4195))                            00047470
      A1(N1+5212)=(-A1(N1+5212)/A1(J1+4213))                            00047500
      A1(N1+5230)=(-A1(N1+5230)/A1(J1+4231))                            00047530
      A1(N1+5248)=(-A1(N1+5248)/A1(J1+4249))                            00047560
      A1(N1+1567)=0.D0                                                  00047590
      A1(N1+1576)=0.D0                                                  00047620
      A1(N1+1585)=0.D0                                                  00047650
      A1(N1+1594)=0.D0                                                  00047680
      A1(N1+1603)=0.D0                                                  00047710
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      A1(N1+1612)=0.D0                                                  00047740
      A1(N1+1621)=0.D0                                                  00047770
      A1(N1+1630)=0.D0                                                  00047800
      A1(N1+1639)=0.D0                                                  00047830
      A1(N1+1648)=0.D0                                                  00047860
      A1(N1+1657)=0.D0                                                  00047890
      A1(N1+1666)=0.D0                                                  00047920
      A1(N1+1675)=0.D0                                                  00047950
      A1(N1+1684)=0.D0                                                  00047980
      A1(N1+1693)=0.D0                                                  00048010
      A1(N1+1702)=0.D0                                                  00048040
      A1(N1+1711)=0.D0                                                  00048070
      A1(N1+1720)=0.D0                                                  00048100
      A1(N1+1729)=0.D0                                                  00048130
      A1(N1+1738)=0.D0                                                  00048160
      A1(N1+1747)=0.D0                                                  00048190
      A1(N1+1756)=0.D0                                                  00048220
      A1(N1+1765)=0.D0                                                  00048250
      A1(N1+1774)=0.D0                                                  00048280
      A1(N1+1783)=0.D0                                                  00048310
      A1(N1+1792)=0.D0                                                  00048340
      A1(N1+1801)=0.D0                                                  00048370
      A1(N1+1810)=0.D0                                                  00048400
      A1(N1+1819)=0.D0                                                  00048430
      A1(N1+1828)=0.D0                                                  00048460
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A1(N1+1837)=0.D0                                                        00048490
A1(N1+1846)=0.D0                                                        00048520
A1(N1+1855)=0.D0                                                        00048550
A1(N1+1864)=0.D0                                                        00048580
A1(N1+1873)=0.D0                                                        00048610
A1(N1+1882)=0.D0                                                        00048640
A1(N1+1891)=0.D0                                                        00048670
A1(N1+1900)=0.D0                                                        00048700
A1(N1+1909)=0.D0                                                        00048730
A1(N1+1918)=0.D0                                                        00048760
A1(N1+1927)=0.D0                                                        00048790
A1(N1+1936)=0.D0                                                        00048820
A1(N1+1945)=0.D0                                                        00048850
A1(N1+1954)=0.D0                                                        00048880
A1(N1+1963)=0.D0                                                        00048910
A1(N1+3187)=0.D0                                                        00048940
A1(N1+3196)=0.D0                                                        00048970
A1(N1+3205)=0.D0                                                        00049000
A1(N1+3214)=0.D0                                                        00049030
A1(N1+3223)=0.D0                                                        00049060
A1(N1+3232)=0.D0                                                        00049090
A1(N1+3241)=0.D0                                                        00049120
A1(N1+3250)=0.D0                                                        00049150
A1(N1+3259)=0.D0                                                        00049180
A1(N1+3268)=0.D0                                                        00049210
N3=N2                                                                   00049240
N4=J1                                                                   00049270
```

```
      K2=J1+N2                                                           00049300
65    A1(N1+1567)=A1(N1+1567)+(A1(N4+1567)*A1(K2+3285))                  00049330
      A1(N1+1576)=A1(N1+1576)+(A1(N4+1576)*A1(K2+3303))                  00049360
      A1(N1+1585)=A1(N1+1585)+(A1(N4+1585)*A1(K2+3321))                  00049390
      A1(N1+1594)=A1(N1+1594)+(A1(N4+1594)*A1(K2+3339))                  00049420
      A1(N1+1603)=A1(N1+1603)+(A1(N4+1603)*A1(K2+3357))                  00049450
      A1(N1+1612)=A1(N1+1612)+(A1(N4+1612)*A1(K2+3375))                  00049480
      A1(N1+1621)=A1(N1+1621)+(A1(N4+1621)*A1(K2+3393))                  00049510
      A1(N1+1630)=A1(N1+1630)+(A1(N4+1630)*A1(K2+3411))                  00049540
      A1(N1+1639)=A1(N1+1639)+(A1(N4+1639)*A1(K2+3429))                  00049570
      A1(N1+1648)=A1(N1+1648)+(A1(N4+1648)*A1(K2+3447))                  00049600
      A1(N1+1657)=A1(N1+1657)+(A1(N4+1657)*A1(K2+3465))                  00049630
      A1(N1+1666)=A1(N1+1666)+(A1(N4+1666)*A1(K2+3483))                  00049660
      A1(N1+1675)=A1(N1+1675)+(A1(N4+1675)*A1(K2+3501))                  00049690
      A1(N1+1684)=A1(N1+1684)+(A1(N4+1684)*A1(K2+3519))                  00049720
      A1(N1+1693)=A1(N1+1693)+(A1(N4+1693)*A1(K2+3537))                  00049750
      A1(N1+1702)=A1(N1+1702)+(A1(N4+1702)*A1(K2+3555))                  00049780
      A1(N1+1711)=A1(N1+1711)+(A1(N4+1711)*A1(K2+3573))                  00049810
      A1(N1+1720)=A1(N1+1720)+(A1(N4+1720)*A1(K2+3591))                  00049840
      A1(N1+1729)=A1(N1+1729)+(A1(N4+1729)*A1(K2+3609))                  00049870
      A1(N1+1738)=A1(N1+1738)+(A1(N4+1738)*A1(K2+3627))                  00049900
      A1(N1+1747)=A1(N1+1747)+(A1(N4+1747)*A1(K2+3645))                  00049930
      A1(N1+1756)=A1(N1+1756)+(A1(N4+1756)*A1(K2+3663))                  00049960
      A1(N1+1765)=A1(N1+1765)+(A1(N4+1765)*A1(K2+3681))                  00049990
      A1(N1+1774)=A1(N1+1774)+(A1(N4+1774)*A1(K2+3699))                  00050020
```

```
A1(N1+1783)=A1(N1+1783)+(A1(N4+1783)*A1(K2+3717))             00050050
A1(N1+1792)=A1(N1+1792)+(A1(N4+1792)*A1(K2+3735))             00050080
A1(N1+1801)=A1(N1+1801)+(A1(N4+1801)*A1(K2+3753))             00050110
A1(N1+1810)=A1(N1+1810)+(A1(N4+1810)*A1(K2+3771))             00050140
A1(N1+1819)=A1(N1+1819)+(A1(N4+1819)*A1(K2+3789))             00050170
A1(N1+1828)=A1(N1+1828)+(A1(N4+1828)*A1(K2+3807))             00050200
A1(N1+1837)=A1(N1+1837)+(A1(N4+1837)*A1(K2+3825))             00050230
A1(N1+1846)=A1(N1+1846)+(A1(N4+1846)*A1(K2+3843))             00050260
A1(N1+1855)=A1(N1+1855)+(A1(N4+1855)*A1(K2+3861))             00050290
A1(N1+1864)=A1(N1+1864)+(A1(N4+1864)*A1(K2+3879))             00050320
A1(N1+1873)=A1(N1+1873)+(A1(N4+1873)*A1(K2+3897))             00050350
A1(N1+1882)=A1(N1+1882)+(A1(N4+1882)*A1(K2+3915))             00050380
A1(N1+1891)=A1(N1+1891)+(A1(N4+1891)*A1(K2+3933))             00050410
A1(N1+1900)=A1(N1+1900)+(A1(N4+1900)*A1(K2+3951))             00050440
A1(N1+1909)=A1(N1+1909)+(A1(N4+1909)*A1(K2+3969))             00050470
A1(N1+1918)=A1(N1+1918)+(A1(N4+1918)*A1(K2+3987))             00050500
A1(N1+1927)=A1(N1+1927)+(A1(N4+1927)*A1(K2+4005))             00050530
A1(N1+1936)=A1(N1+1936)+(A1(N4+1936)*A1(K2+4023))             00050560
A1(N1+1945)=A1(N1+1945)+(A1(N4+1945)*A1(K2+4041))             00050590
A1(N1+1954)=A1(N1+1954)+(A1(N4+1954)*A1(K2+4059))             00050620
A1(N1+1963)=A1(N1+1963)+(A1(N4+1963)*A1(K2+4077))             00050650
A1(N1+3187)=A1(N1+3187)+(A1(N4+3187)*A1(K2+4095))             00050680
A1(N1+3196)=A1(N1+3196)+(A1(N4+3196)*A1(K2+4113))             00050710
A1(N1+3205)=A1(N1+3205)+(A1(N4+3205)*A1(K2+4131))             00050740
A1(N1+3214)=A1(N1+3214)+(A1(N4+3214)*A1(K2+4149))             00050770
A1(N1+3223)=A1(N1+3223)+(A1(N4+3223)*A1(K2+4167))             00050800
A1(N1+3232)=A1(N1+3232)+(A1(N4+3232)*A1(K2+4185))             00050830
```

```
      A1(N1+3241)=A1(N1+3241)+(A1(N4+3241)*A1(K2+4203))
      A1(N1+3250)=A1(N1+3250)+(A1(N4+3250)*A1(K2+4221))
      A1(N1+3259)=A1(N1+3259)+(A1(N4+3259)*A1(K2+4239))
      A1(N1+3268)=A1(N1+3268)+(A1(N4+3268)*A1(K2+4257))
      N4=N4+1
      K2=K2-1
      N3=N3-1
      IF(N3)65,66,65
66    A1(N1+1567)=(A1(N1+1567)*F2(N2))
      A1(N1+1576)=(A1(N1+1576)*F2(N2))
      A1(N1+1585)=(A1(N1+1585)*F2(N2))
      A1(N1+1594)=(A1(N1+1594)*F2(N2))
      A1(N1+1603)=(A1(N1+1603)*F2(N2))
      A1(N1+1612)=(A1(N1+1612)*F2(N2))
      A1(N1+1621)=(A1(N1+1621)*F2(N2))
      A1(N1+1630)=(A1(N1+1630)*F2(N2))
      A1(N1+1639)=(A1(N1+1639)*F2(N2))
      A1(N1+1648)=(A1(N1+1648)*F2(N2))
      A1(N1+1657)=(A1(N1+1657)*F2(N2))
      A1(N1+1666)=(A1(N1+1666)*F2(N2))
      A1(N1+1675)=(A1(N1+1675)*F2(N2))
      A1(N1+1684)=(A1(N1+1684)*F2(N2))
      A1(N1+1693)=(A1(N1+1693)*F2(N2))
      A1(N1+1702)=(A1(N1+1702)*F2(N2))
      A1(N1+1711)=(A1(N1+1711)*F2(N2))
```

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```
A1(N1+1720)=(A1(N1+1720)*F2(N2))                    00051610
A1(N1+1729)=(A1(N1+1729)*F2(N2))                    00051640
A1(N1+1738)=(A1(N1+1738)*F2(N2))                    00051670
A1(N1+1747)=(A1(N1+1747)*F2(N2))                    00051700
A1(N1+1756)=(A1(N1+1756)*F2(N2))                    00051730
A1(N1+1765)=(A1(N1+1765)*F2(N2))                    00051760
A1(N1+1774)=(A1(N1+1774)*F2(N2))                    00051790
A1(N1+1783)=(A1(N1+1783)*F2(N2))                    00051820
A1(N1+1792)=(A1(N1+1792)*F2(N2))                    00051850
A1(N1+1801)=(A1(N1+1801)*F2(N2))                    00051880
A1(N1+1810)=(A1(N1+1810)*F2(N2))                    00051910
A1(N1+1819)=(A1(N1+1819)*F2(N2))                    00051940
A1(N1+1828)=(A1(N1+1828)*F2(N2))                    00051970
A1(N1+1837)=(A1(N1+1837)*F2(N2))                    00052000
A1(N1+1846)=(A1(N1+1846)*F2(N2))                    00052030
A1(N1+1855)=(A1(N1+1855)*F2(N2))                    00052060
A1(N1+1864)=(A1(N1+1864)*F2(N2))                    00052090
A1(N1+1873)=(A1(N1+1873)*F2(N2))                    00052120
A1(N1+1882)=(A1(N1+1882)*F2(N2))                    00052150
A1(N1+1891)=(A1(N1+1891)*F2(N2))                    00052180
A1(N1+1900)=(A1(N1+1900)*F2(N2))                    00052210
A1(N1+1909)=(A1(N1+1909)*F2(N2))                    00052240
A1(N1+1918)=(A1(N1+1918)*F2(N2))                    00052270
A1(N1+1927)=(A1(N1+1927)*F2(N2))                    00052300
A1(N1+1936)=(A1(N1+1936)*F2(N2))                    00052330
A1(N1+1945)=(A1(N1+1945)*F2(N2))                    00052360
A1(N1+1954)=(A1(N1+1954)*F2(N2))                    00052390
```

```
      A1(N1+1963)=(A1(N1+1963)*F2(N2))                                    00052420
      A1(N1+3187)=(A1(N1+3187)*F2(N2))                                    00052450
      A1(N1+3196)=(A1(N1+3196)*F2(N2))                                    00052480
      A1(N1+3205)=(A1(N1+3205)*F2(N2))                                    00052510
      A1(N1+3214)=(A1(N1+3214)*F2(N2))                                    00052540
      A1(N1+3223)=(A1(N1+3223)*F2(N2))                                    00052570
      A1(N1+3232)=(A1(N1+3232)*F2(N2))                                    00052600
      A1(N1+3241)=(A1(N1+3241)*F2(N2))                                    00052630
      A1(N1+3250)=(A1(N1+3250)*F2(N2))                                    00052660
      A1(N1+3259)=(A1(N1+3259)*F2(N2))                                    00052690
      A1(N1+3268)=(A1(N1+3268)*F2(N2))                                    00052720
      RETURN                                                              00052721     *      INSERT
      END                                                                 00052722     *      INSERT
DELETE SEQ1=00052750,SEQ2=00052960
   60 N1=N1+1                                                             00052750     *       DELET
      L1=.FALSE.                                                          00052780     *       DELET
      RETURN                                                              00052810     *       DELET
    5 L1=.TRUE.                                                           00052840     *       DELET
      RETURN                                                              00052870     *       DELET
    1 N1=8                                                                00052900     *       DELET
      GOTO 2                                                              00052930     *       DELET
      END                                                                 00052960     *       DELET
      SUBROUTINE VALUES(X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y1400052990
     C,Y15,Y16,Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,A00053020
     C2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A17,A18,A19,A2000053050
```

```
      C,A21,A22,A23,A24,A25,A26,A27,A28,A29,A30,A31)                    00053080
       DOUBLEPRECISION R1,R12,A1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM100053110
      C1,GM1,A,F1,C1,C2                                                 00053140
       LOGICAL L2                                                       00053170
       COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM100053200
      C,A,F1,C1,C2,A1(10512),L2                                         00053230
       DOUBLEPRECISION X1,X2,X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y1300053260
      C,Y14,Y15,Y16,Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y00053290
      C30,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A17,A18,A1900053320
      C,A20,A21,A22,A23,A24,A25,A26,A27,A28,A29,A30,A31                 00053350
10     IF(X-R1)1,2,2                                                    00053380
2      IF(R12-X)4,3,3                                                   00053410
4      IF(A1(1)-A1(5257))6,5,5                                          00053440
1      IF(X-R12)7,3,3                                                   00053470
7      IF(A1(1)-A1(5257))9,8,8                                          00053500
6      CALL XTAY01(5256,0,.FALSE.)                                      00053530
       L2=.TRUE.                                                        00053560
       GOTO10                                                           00053590
5      CALL XTAY01(0,5256,.FALSE.)                                      00053620
       L2=.FALSE.                                                       00053650
       GOTO10                                                           00053680
9      CALL XTAY01(0,5256,.TRUE.)                                       00053710
       L2=.FALSE.                                                       00053740
       GOTO10                                                           00053770
8      CALL XTAY01(5256,0,.TRUE.)                                       00053800
       L2=.TRUE.                                                        00053830
       GOTO10                                                           00053860
```

```
3     N5=0                                   00053890
      IF(L2)N5=5256                          00053920
      Y1=0.D0                                00053950
      Y2=0.D0                                00053980
      Y3=0.D0                                00054010
      Y4=0.D0                                00054040
      Y5=0.D0                                00054070
      Y6=0.D0                                00054100
      Y7=0.D0                                00054130
      Y8=0.D0                                00054160
      Y9=0.D0                                00054190
      Y10=0.D0                               00054220
      Y11=0.D0                               00054250
      Y12=0.D0                               00054280
      Y13=0.D0                               00054310
      Y14=0.D0                               00054340
      Y15=0.D0                               00054370
      Y16=0.D0                               00054400
      Y17=0.D0                               00054430
      Y18=0.D0                               00054460
      Y19=0.D0                               00054490
      Y20=0.D0                               00054520
      Y21=0.D0                               00054550
      Y22=0.D0                               00054580
      Y23=0.D0                               00054610
```

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```
      Y24=0.D0                                                          00054640
      Y25=0.D0                                                          00054670
      Y26=0.D0                                                          00054700
      Y27=0.D0                                                          00054730
      Y28=0.D0                                                          00054760
      Y29=0.D0                                                          00054790
      Y30=0.D0                                                          00054820
      A2=0.D0                                                           00054850
      A3=0.D0                                                           00054880
      A4=0.D0                                                           00054910
      A5=0.D0                                                           00054940
      A6=0.D0                                                           00054970
      A7=0.D0                                                           00055000
      A8=0.D0                                                           00055030
      A9=0.D0                                                           00055060
      A10=0.D0                                                          00055090
      A11=0.D0                                                          00055120
      A12=0.D0                                                          00055150
      A13=0.D0                                                          00055180
      A14=0.D0                                                          00055210
      A15=0.D0                                                          00055240
      A16=0.D0                                                          00055270
      A17=0.D0                                                          00055300
      A18=0.D0                                                          00055330
      A19=0.D0                                                          00055360
      A20=0.D0                                                          00055390
      A21=0.D0                                                          00055420
```

```
A22=0.D0
A23=0.D0
A24=0.D0
A25=0.D0
A26=0.D0
A27=0.D0
A28=0.D0
A29=0.D0
A30=0.D0
A31=0.D0
X2=( X-A1(N5+1))
N5=N5+8
DO 11 N4=1,8
Y1=Y1*X2+A1(N5+270)
Y2=Y2*X2+A1(N5+261)
Y3=Y3*X2+A1(N5+252)
Y4=Y4*X2+A1(N5+243)
Y5=Y5*X2+A1(N5+234)
Y6=Y6*X2+A1(N5+225)
Y7=Y7*X2+A1(N5+216)
Y8=Y8*X2+A1(N5+207)
Y9=Y9*X2+A1(N5+198)
Y10=Y10*X2+A1(N5+189)
Y11=Y11*X2+A1(N5+180)
Y12=Y12*X2+A1(N5+171)
```

```
      Y13=Y13*X2+A1(N5+162)                                           00056200
      Y14=Y14*X2+A1(N5+153)                                           00056230
      Y15=Y15*X2+A1(N5+144)                                           00056260
      Y16=Y16*X2+A1(N5+135)                                           00056290
      Y17=Y17*X2+A1(N5+126)                                           00056320
      Y18=Y18*X2+A1(N5+117)                                           00056350
      Y19=Y19*X2+A1(N5+108)                                           00056380
      Y20=Y20*X2+A1(N5+99)                                            00056410
      Y21=Y21*X2+A1(N5+90)                                            00056440
      Y22=Y22*X2+A1(N5+81)                                            00056470
      Y23=Y23*X2+A1(N5+72)                                            00056500
      Y24=Y24*X2+A1(N5+63)                                            00056530
      Y25=Y25*X2+A1(N5+54)                                            00056560
      Y26=Y26*X2+A1(N5+45)                                            00056590
      Y27=Y27*X2+A1(N5+36)                                            00056620
      Y28=Y28*X2+A1(N5+27)                                            00056650
      Y29=Y29*X2+A1(N5+18)                                            00056680
      Y30=Y30*X2+A1(N5+9)                                             00056710
      A2=A2*X2+A1(N5+540)                                             00056740
      A3=A3*X2+A1(N5+531)                                             00056770
      A4=A4*X2+A1(N5+522)                                             00056800
      A5=A5*X2+A1(N5+513)                                             00056830
      A6=A6*X2+A1(N5+504)                                             00056860
      A7=A7*X2+A1(N5+495)                                             00056890
      A8=A8*X2+A1(N5+486)                                             00056920
      A9=A9*X2+A1(N5+477)                                             00056950
      A10=A10*X2+A1(N5+468)                                           00056980
```

```
      A11=A11*X2+A1(N5+459)                                     00057010
      A12=A12*X2+A1(N5+450)                                     00057040
      A13=A13*X2+A1(N5+441)                                     00057070
      A14=A14*X2+A1(N5+432)                                     00057100
      A15=A15*X2+A1(N5+423)                                     00057130
      A16=A16*X2+A1(N5+414)                                     00057160
      A17=A17*X2+A1(N5+405)                                     00057190
      A18=A18*X2+A1(N5+396)                                     00057220
      A19=A19*X2+A1(N5+387)                                     00057250
      A20=A20*X2+A1(N5+378)                                     00057280
      A21=A21*X2+A1(N5+369)                                     00057310
      A22=A22*X2+A1(N5+360)                                     00057340
      A23=A23*X2+A1(N5+351)                                     00057370
      A24=A24*X2+A1(N5+342)                                     00057400
      A25=A25*X2+A1(N5+333)                                     00057430
      A26=A26*X2+A1(N5+324)                                     00057460
      A27=A27*X2+A1(N5+315)                                     00057490
      A28=A28*X2+A1(N5+306)                                     00057520
      A29=A29*X2+A1(N5+297)                                     00057550
      A30=A30*X2+A1(N5+288)                                     00057580
      A31=A31*X2+A1(N5+279)                                     00057610
11    N5=N5-1                                                   00057640
      RETURN                                                    00057670
      END                                                       00057700
      SUBROUTINE XTAY01(J1,J2,Z1)                               00057730
```

```
      DOUBLEPRECISION R1,R12,A1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM100057760
     C1,GM1,A,F1,C1,C2                                                   00057790
      LOGICAL L2                                                         00057820
      COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM100057850
     C,A,F1,C1,C2,A1(10512),L2                                           00057880
      DOUBLEPRECISION DABS,DMAX1,DEXP,DLOG,Z2,Z3,E1,E2,E3,Z4,Z5,T1,T2    00057910
      LOGICAL Z1,L1                                                      00057940
      DIMENSION T2(8)                                                    00057970
      DATA T2(1),T2(2),T2(3),T2(4),T2(5),T2(6),T2(7),T2(8)/1.D0,3.D0,7.D00058000
     C0.15.D0,31.D0,63.D0,127.D0,255.D0/                                 00058030
      Z2=1.D-4*1.D-6                                                     00058060     *        REPLAC
      Z2=1.D-4*1.D-14                                                    00058060     *     REPLACEME
      K2=J1+15                                                           00058090
      DO 6 N4=1,60                                                       00058120
      Z2=DMAX1(Z2,DABS(A1(K2)),DABS(A1(K2+1)),DABS(A1(K2+2)))            00058150
    6 K2=K2+9                                                            00058180
      Z3=DEXP(C2+0.111111D0*(DLOG(1.D-6)-DLOG(Z2)))                      00058210     *        REPLAC
      Z3=DEXP(C2+0.111111D0*(DLOG(1.D-14)-DLOG(Z2)))                     00058210     *     REPLACEME
      R1=0.5D0*(A1(J1+1)+A1(J2+1))                                       00058240
      IF(Z1) Z3=-Z3                                                      00058270
    3 A1(J2+1)=A1(J1+1)+Z3                                               00058300
      CALL XTAY02(J2,J1,L1)                                              00058330
      IF(L1)GOTO 5                                                       00058360
      E2=1.D-6*1.D-4                                                     00058390     *        REPLAC
      E2=1.D-14*1.D-4                                                    00058390     *     REPLACEME
      K2=J1+9                                                            00058420
      J3=J2+9                                                            00058450
```

```
      DO 7 N4=1,60                                              00058480
      E3=0.D0                                                   00058510
      N3=7                                                      00058540
      Z5=5.D-1*Z3                                               00058570
      Z4=-1.D0                                                  00058600
      N6=8+K2                                                   00058630
      N7=8+J3                                                   00058660
8     E1=E3                                                     00058690
      E3=Z5*((A1(N6)*T2(N3)+Z4*A1(N7))+E3)                      00058720
      Z4=-Z4                                                    00058750
      N3=N3-1                                                   00058780
      N6=N6-1                                                   00058810
      N7=N7-1                                                   00058840
      IF(N3)8,9,8                                               00058870
9     Z4=DABS(E3+E1*1.D-6*1.D-8)                                00058900    *       REPLACED*
9     Z4=DABS(E3+E1*1.D-14*1.D-8)                               00058900    *    REPLACEMENT*
      Z4=Z4/DMAX1(1.D0,Z4,DABS(A1(K2+1)),DABS(A1(J3+1)))        00058930
      IF(E2-Z4)10,11,11                                         00058960
10    E2=Z4                                                     00058990
11    K2=K2+9                                                   00059020
7     J3=J3+9                                                   00059050
      T1=0.111111D0*(DLOG(2.D-1)+DLOG(1.D-6)-DLOG(E2))          00059080    *       REPLACED*
      T1=0.111111D0*(DLOG(2.D-1)+DLOG(1.D-14)-DLOG(E2))         00059080    *    REPLACEMENT*
      IF(E2-1.D-6)4,4,2                                         00059110    *       REPLACED*
      IF(E2-1.D-14)4,4,2                                        00059110    *    REPLACEMENT*
```

```
2      Z3=Z3*DEXP(T1)                                                     00059140
       C2=C2+T1                                                           00059170
       GOTO3                                                              00059200
4      C2=C2+T1                                                           00059230
       R12=A1(J2+1)                                                       00059260
       RETURN                                                             00059290
5      Z3=0.5D0*Z3                                                        00059320
       C2=C2-1.D-1                                                        00059350
       GOTO 3                                                             00059380
       END                                                                00059410
       SUBROUTINE SETUP                                                   00059440
       DOUBLEPRECISION R1,R12,A1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM1 00059470
      C1,GM1,A,F1,C1,C2                                                   00059500
       LOGICAL L2                                                         00059530
       COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM1 00059560
      C,A,F1,C1,C2,A1(10512),L2                                           00059590
       LOGICAL L1                                                         00059620
       DO 1 N8=1,10512                                                    00059650
1      A1(N8)=0.D0                                                        00059680
       GM2=2.21816008725546139D13                                         00059710
       GM3=3.24860149564758458D14                                         00059740
       GM4=3.98601252568171984D14                                         00059770
       GM5=4.90278413018505173D12                                         00059800
       GM6=4.28284500017730839D13                                         00059830
       GM7=1.26707736997970820D17                                         00059860
       GM8=3.79265312129898992D16                                         00059890
       GM9=5.78772429221518774D15                                         00059920
```

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```
GM10=6.89057725963106205D15                                00059950
GM11=7.32409039848202291D13                                  00059980
GM1=(-1.32712518020494255D20)                                00060010
A=1.495979D11                                                00060040
F1=8.64D4                                                    00060070
C1=(-1.5D0)                                                  00060100
A1(5266)=1.22198026582411 2D12                               00060130
A1(5536)=(-1.982703626852726D3)                              00060160
A1(5275)=(-4.56128810497404D11)                              00060190
A1(5545)=(-5.427917845903 82D3)                              00060220
A1(5284)=(-4.507939432322619D12)                             00060250
A1(5554)=8.926015966071910 2                                 00060280
A1(5293)=(-1.472668423722840 12)                             00060310
A1(5563)=(-1.057960736616 7D3)                               00060340
A1(5302)=(-3.725701368492452D12)                             00060370
A1(5572)=(-2.289207067781211D3)                              00060400
A1(5311)=(-2.126978628716 74D12)                             00060430
A1(5581)=4.775409329230315D3                                 00060460
A1(5320)=(-2.206927181525619D11)                             00060490
A1(5590)=(-2.807044977324023D3)                              00060520
A1(5329)=(-5.898640709513289D11)                             00060550
A1(5599)=(-6.357453402539501D3)                              00060580
A1(5338)=(-2.672230824365125D12)                             00060610
A1(5608)=1.513962458729854D3                                 00060540
A1(5347)=4.233068852532208D11                                00060670
```

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```
A1(5617)=2.179686842881818D3                    00060700
A1(5356)=1.095367935972401D12                   00060730
A1(5626)=4.345055647136521D3                    00060760
A1(5365)=6.847437310989531D11                   00060790
A1(5635)=(-8.855730011568746D3)                 00060820
A1(5374)=(-2.890900272309138D11)                00060850
A1(5644)=(-1.807966511851175D3)                 00060880
A1(5383)=(-6.897326490306466D11)                00060910
A1(5653)=(-3.524614779252536D3)                 00060940
A1(5392)=(-2.784020406078878D11)                00060970
A1(5662)=1.210692858694180D4                    00061000
A1(5401)=(-4.245476575152248D10)                00061030
A1(5671)=9.651310060260457D3                    00061060
A1(5410)=(-8.167256627333656D10)                00061090
A1(5680)=2.171147564219973D4                    00061120
A1(5419)=1.850509895590312D11                   00061150
A1(5689)=1.172383746774455D4                    00061180
A1(5428)=(-1.808113967966595D10)                00061210
A1(5698)=1.175479478596660D4                    00061240
A1(5437)=(-4.174866036639673D10)                00061270
A1(5707)=2.691979250514838D4                    00061300
A1(5446)=1.441466039463378D11                   00061330
A1(5716)=8.592486761689603D3                    00061360
A1(5455)=(-1.808604345131865D10)                00061390
A1(5725)=1.125160968745281D4                    00061420
A1(5464)=(-4.170700270418870D10)                00061450
A1(5734)=2.595006237113201D4                    00061480
```

```
      A1(5473)=1.4379032863230030D11                                 00061510
      A1(5743)=8.490328251307925D3                                   00061540
      A1(5482)=1.435036217539261D10                                  00061570
      A1(5752)=(-1.378680683336160D4)                                00061600
      A1(5491)=1.708792654184785D10                                  00061630
      A1(5761)=(-3.159710456680229D4)                                00061660
      A1(5500)=(-1.052907434238580D11)                               00061690
      A1(5770)=(-7.155274593411677D3)                                00061720
      A1(5509)=4.392064122417938D9                                   00061750
      A1(5779)=2.490452986349714D4                                   00061780     *         REPLACED:
      A1(5779)=1.4383 5767 4930 7D0*A/F1/100D0                       00061780     *      REPLACEMENT:
      A1(5518)=1.712811609084371D10                                  00061810
      A1(5788)=4.141185322225982D4                                   00061840
      A1(5527)=4.653712465352382D10                                  00061870
      A1(5797)=(-2.654629433646562D4)                                00061900
      A1(1)=0.D0                                                     00061930
      A1(5257)=0.D0                                                  00061960
      A1(2)=1.D0                                                     00061990
      A1(5258)=1.D0                                                  00062020
      CALL XTAY02(0,5256,L1)                                         00062050
      IF(.NOT.L1)GOTO 3                                              00062080
      WRITE(6,4)                                                     00062110
4     FORMAT(36H1TAY003 - ILLEGAL INITIAL CONDITIONS)                00062140
      STOP 3                                                         00062170
3     DO 2 N8=1,5256                                                 00062200
```

```
  2     A1(N8+5256)=A1(N8)                                   00062230
        R12=A1(1)                                            00062260
        R1=R12                                               00062290
        L2=.TRUE.                                            00062320
        C2=0.D0                                              00062350
        RETURN                                               00062380
        END                                                  00062410
GHEST CONDITION CODE WAS 00000000
D OF JOB IEBUPDTE.
```

```
      IMPLICIT REAL*8(A-H,C-Z)
      CALL SETUP
      A=149597.9D6
      AR=1/A
      FB=86400
      FBC=FB*100
      FC=AR*FBC
      DC1 I=1,3
      X=(I-1)*FBC*400
      CALL
     1  VALUES(X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P)
      Y 1=Y 1*AR
      Y 2=Y 2*AR
      Y 3=Y 3*AR
      Y 4=Y 4*AR
      Y 5=Y 5*AR
      Y 6=Y 6*AR
      Y 7=Y 7*AR
      Y 8=Y 8*AR
      Y 9=Y 9*AR
      Y10=Y10*AR
      Y11=Y11*AR
      Y12=Y12*AR
      Y13=Y13*AR
      Y14=Y14*AR
      Y15=Y15*AR
      Y16=Y16*AR
      Y17=Y17*AR
      Y18=Y18*AR
      Y19=Y19*AR
      Y20=Y20*AR
      Y21=Y21*AR
      Y22=Y22*AR
      Y23=Y23*AR
      Y24=Y24*AR
      Y25=Y25*AR
      Y26=Y26*AR
      Y27=Y27*AR
      Y28=Y28*AR
      Y29=Y29*AR
      Y30=Y30*AR
      Y 1P=Y 1P*FC
      Y 2P=Y 2P*FC
      Y 3P=Y 3P*FC
      Y 4P=Y 4P*FC
      Y 5P=Y 5P*FC
      Y 6P=Y 6P*FC
      Y 7P=Y 7P*FC
      Y 8P=Y 8P*FC
      Y 9P=Y 9P*FC
      Y10P=Y10P*FC
      Y11P=Y11P*FC
      Y12P=Y12P*FC
```

```
      Y13P=Y13P*FC
      Y14P=Y14P*FC
      Y15P=Y15P*FC
      Y16P=Y16P*FC
      Y17P=Y17P*FC
      Y18P=Y18P*FC
      Y19P=Y19P*FC
      Y20P=Y20P*FC
      Y21P=Y21P*FC
      Y22P=Y22P*FC
      Y23P=Y23P*FC
      Y24P=Y24P*FC
      Y25P=Y25P*FC
      Y26P=Y26P*FC
      Y27P=Y27P*FC
      Y28P=Y28P*FC
      Y29P=Y29P*FC
      Y30P=Y30P*FC
      WRITE(6,2)
     1           X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P
      FORMAT (1H ,4X,1H*,5X,4(D25.16,5X)/(41X,3(D25.16,5X)))
      STOP
      END
```

SETUP 0002 D5BF2 000D4E90 FD000C00000000

MAIN CC790 010D5790 FD000C000F4FF8

T= 010D5790

APPENDIX 23 E 1

IXUP TAKEN , EXECUTION CONNG

0.0	0.3110814032384400D 00	0.1144943618248900D 00	0.2935912952265999D-01
	-0.7038250097351499D 00	0.1142257113358399D 00	0.9592622740955990D-01
	0.9611787908272796D 00	-0.2787940385806799D 00	-0.1208977094686399D 00
	0.9635603437370297D 00	-0.2790725027984800D 00	-0.1208649297862199D 00
	0.1236989219494600D 01	-0.5459472778249959D 00	-0.2837925248384000D 00
	-0.1861002330967799D 01	-0.4610577080498099D 01	-0.1932447094717999D 01
	0.4577228230469499D 01	0.7322080964855797D 01	0.2829631199724199D 01
	-0.1786275625770899D 02	-0.3942997000300999D 01	-0.1475239412803000D 01
	-0.1421797116615100D 02	-0.2490477051143399D 02	-0.9844178452523998D 01
	-0.3013370797532999D 02	-0.3049032175567999D 01	0.8168431948737996D 01
	-0.1533176488888300D 01	0.2391734187714699D 01	0.1438357674930700D 01
	-0.4132516063866998D 00	-0.1824885131791100D 01	-0.7962545666766994D 00
	0.4903573919907998D 00	0.1498741218202799D 01	0.6498347082384998D 00
	0.4962575385148999D 00	0.1554747808922999D 01	0.6788960737466997D 00
	0.6771081393609998D 00	0.1253942398580499D 01	0.5574096890440998D 00
	0.6992334985395995D 00	-0.2035634971663500D 00	-0.1044187830336799D 00
	-0.5114611054029098D 00	0.2509479129804599D 00	0.1258874243722599D 00
	0.8743863144753990D-01	-0.3671735859790898D 00	-0.1621203813962599D 00
	0.2758029130392199D 00	-0.1322127454037099D 00	-0.6110233341756994D-01
	0.5155204581538998D-01	-0.3134884258977499D 00	-0.1145106939068500D 00
0.3456000000000000D 08	-0.2164575662142005D 00	-0.3695222102114448D 00	-0.1756572182844437D 00
	0.2076299658016994D-01	0.6563621767939206D 00	0.2944686172890804D 00
	0.9575404454253367D 00	0.2596598222529057D 00	0.1125943368364757D 00
	0.9556608771044025D 00	0.2579656946577734D 00	0.1116253027701344D 00
	-0.1650919483943385D 01	0.1200050124837268D-01	0.4980539623029673D-01
	0.1077085121763583D 01	-0.4663516175829719D 01	-0.2026967979915227D 01
	0.2408520871036129D 01	0.8084533650031473D 01	0.3238716455811852D 01
	-0.1744499221457262D 02	-0.5394093895942719D 01	-0.2116976892331642D 01
	-0.1310287494649495D 02	-0.2541162818772385D 02	-0.1007986345552192D 02
	-0.2990417074196620D 02	-0.4299652085852840D 01	0.7704474832340395D 01
	0.1921645829759810D 01	-0.9677389367477973D 00	-0.7156562332972812D 00
	-0.2028855174958285D 01	-0.2945682249354034D-02	0.1268082361863876D 00
	-0.5162937965591847D 00	0.1508593953122030D 01	0.6541409423372126D 00
	-0.4765854796176339D 00	0.1471463724366933D 01	0.6401886827946261D 00
	0.2784378054620059D-01	-0.1163641888341583D 01	-0.5348782564248116D 00
	0.7302877110644601D 00	0.1828255831267725D 00	0.6058337022354025D-01
	-0.5673292132632596D 00	0.1279146961053590D 00	0.7743670157060100D-01
	0.1212386618795054D 00	-0.3579112232374425D 00	-0.1585417784022918D 00
	0.2816243722953726D 00	-0.1211715078790818D 00	-0.5671854470281436D-01

APPENDIX 23 E 2

	0.63194800766831500D-01	-0.31172817167333373D 00	-0.11744240558887023D 00
0.69120000000000000D 08	0.10718638471254250D 00	0.25887886916218560D 00	0.12762946945438150D 00
	0.71566047252224930D 00	0.12119671433603260D 00	0.94180737772616610D-02
	0.62072445969500720D 00	0.70675362844054460D 00	0.30646350867004050D 00
	0.62039737399290490D 00	0.70897783138713780D 00	0.30739027281216510D 00
	0.10712413511956290D 01	0.90989431929877140D 00	0.38892018605865490D 00
	0.36484424237172140D 01	-0.31885628560250450D 01	-0.14570594138002440D 01
	0.86081200821331600D-01	0.83323915034714110D 01	0.34416852468590190D 01
	-0.16894580321114670D 02	-0.68027902744600460D 01	-0.27420152025421330D 01
	-0.11965863980240500D 02	-0.25873934395508650D 02	-0.10297822028116510D 02
	-0.29628255336206860D 02	-0.55422379505677120D 01	0.72290409938785080D 01
	-0.31987803127782440D 01	0.85336075859325420D 00	0.78558079413089070D 00
	-0.32847843813887770D 00	0.18050337886403640D 01	0.83415954932432840D 00
	-0.13670537388903590D 01	0.98482153331657300D 00	0.42712306295959940D 00
	-0.14287314029811530D 01	0.98046078437690820D 00	0.41913208235876270D 00
	-0.89433781780381500D 00	0.10333945088951610D 01	0.49834155667697680D 00
	0.51458739173611990D 00	0.53770578569766570D 00	0.21809890337561480D 00
	-0.58771844013158320D 00	-0.48077953497939390D-02	0.23440036270264180D-01
	0.15371000246823810D 00	-0.34600609592142700D 00	-0.15378414591396080D 00
	0.28675086989381330D 00	-0.10995281783816610D 00	-0.52245552232546960D-01
	0.74728976763822300D-01	-0.30948199515773660D 00	-0.12025228562870170D 00

```
               SUBROUTINE XTAY01(J1,J2,Z1)
               DOUBLEPRECISION R1,R12,A1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM
              C1,GM1,A,F1,C1,C2
               LOGICAL L2
               COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM
              C,A,F1,C1,C2,A1(10512),L2
               DOUBLEPRECISION DABS,DMAX1,DEXP,DLOG,Z2,Z3,E1,E2,E3,Z4,Z5,T1,T2
               LOGICAL Z1,L1
               DIMENSION T2(8)
               DATA T2(1),T2(2),T2(3),T2(4),T2(5),T2(6),T2(7),T2(8)/1.D0,3.D0,7.
              C0,15.D0,31.D0,63.D0,127.D0,255.D0/
               Z2=1.D-4*1.D-15
               K2=J1+15
               DO 6 N4=1,60
               Z2=DMAX1(Z2,DABS(A1(K2)),DABS(A1(K2+1)),DABS(A1(K2+2)))
       6       K2=K2+9
               Z3=DEXP(C2+0.111111D0*(DLOG(1.D-15)-DLOG(Z2)))
               R1=0.5D0*(A1(J1+1)+A1(J2+1))
               IF(Z1) Z3=-Z3
       3       A1(J2+1)=A1(J1+1)+Z3
               CALL XTAY02(J2,J1,L1)
               IF(L1)GOTO 5
               E2=1.D-15*1.D-4
               K2=J1+9
               J3=J2+9
               DO 7 N4=1,60
               E3=0.D0
               N3=7
               Z5=5.D-1*Z3
               Z4=-1.D0
               N6=8+K2
               N7=8+J3
       8       E1=E3
               E3=Z5*((A1(N6)*T2(N3)+Z4*A1(N7))+E3)
               Z4=-Z4
               N3=N3-1
               N6=N6-1
               N7=N7-1
               IF(N3)8,9,8
       9       Z4=DABS(E3+E1*1.D-15*1.D-8)
               Z4=Z4/DMAX1(1.D0,Z4,DABS(A1(K2+1)),DABS(A1(J3+1)))
               IF(E2-Z4)10,11,11
      10       E2=Z4
      11       K2=K2+9
       7       J3=J3+9
               T1=0.111111D0*(DLOG(2.D-1)+DLOG(1.D-15)-DLOG(E2))
               IF(E2-1.D-15)4,4,2
               Z3=Z3*DEXP(T1)
               C2=C2+T1
               GOT 03
       4       C2=C2+T1
               R12=A1(J2+1)
               RETURN
               Z3=0.5D0*Z3
               C2=C2-1.D-1
               GOTO 3
               END
```

```
      IMPLICIT REAL*8(A-H,O-Z)
      CALL SETUP
      A=149597.9D6
      AR=1/A
      FB=86400
      FBC=FB*100
      FC=AR*FBC
      DO1 I=1,2
      X=(I-1)*FBC*4D0
      CALL
     1  VALUES(X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P)
      WRITE(7,3)
     1          X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P
    3 FORMAT((2D25.16))
      Y 1=Y 1*AR
      Y 2=Y 2*AR
      Y 3=Y 3*AR
      Y 4=Y 4*AR
      Y 5=Y 5*AR
      Y 6=Y 6*AR
      Y 7=Y 7*AR
      Y 8=Y 8*AR
      Y 9=Y 9*AR
      Y10=Y10*AR
      Y11=Y11*AR
      Y12=Y12*AR
      Y13=Y13*AR
      Y14=Y14*AR
      Y15=Y15*AR
      Y16=Y16*AR
      Y17=Y17*AR
      Y18=Y18*AR
      Y19=Y19*AR
      Y20=Y20*AR
      Y21=Y21*AR
      Y22=Y22*AR
      Y23=Y23*AR
      Y24=Y24*AR
      Y25=Y25*AR
      Y26=Y26*AR
      Y27=Y27*AR
      Y28=Y28*AR
      Y29=Y29*AR
      Y30=Y30*AR
      Y 1P=Y 1P*FC
      Y 2P=Y 2P*FC
      Y 3P=Y 3P*FC
      Y 4P=Y 4P*FC
```

```
      Y 5P=Y 5P*FC
      Y 6P=Y 6P*FC
      Y 7P=Y 7P*FC
      Y 8P=Y 8P*FC
      Y 9P=Y 9P*FC
      Y10P=Y10P*FC
      Y11P=Y11P*FC
      Y12P=Y12P*FC
      Y13P=Y13P*FC
      Y14P=Y14P*FC
      Y15P=Y15P*FC
      Y16P=Y16P*FC
      Y17P=Y17P*FC
      Y18P=Y18P*FC
      Y19P=Y19P*FC
      Y20P=Y20P*FC
      Y21P=Y21P*FC
      Y22P=Y22P*FC
      Y23P=Y23P*FC
      Y24P=Y24P*FC
      Y25P=Y25P*FC
      Y26P=Y26P*FC
      Y27P=Y27P*FC
      Y28P=Y28P*FC
      Y29P=Y29P*FC
      Y30P=Y30P*FC
 1    WRITE(6,2)
     1          X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P
 2    FORMAT (1H ,4X,1H*,5X,4(D25.16,5X)/(41X,3(D25.16,5X)))
      STOP
      END
```

SETUP 0002)D61FA 000D5490 FD000000000000

MAIN)0C790 010D5D90 FD0000000F4FF8 APPENDIX 24 B

T= 010D5D90

IXUP TAKEN , EXECUTICN COFNG

0.0	0.311081403238440D 00	0.114494361824890D 00	0.293591295226599D-01
	-0.703825009735149D 00	0.114225711335839D 00	0.959262274095599D-01
	0.961178790827279D 00	-0.278794038580679D 00	-0.120897709468639D 00
	0.963560343737029D 00	-0.279072502798480D 00	-0.120864929786219D 00
	0.123698921949460D 01	-0.545947277824999D 00	-0.283792524838400D 00
	-0.186100233096779D 01	-0.461057708049809D 01	-0.193244709471799D 01
	0.457722823046949D 01	0.732208096485579D 01	0.282963119972419D 01
	-0.178627562577089D 02	-0.394299700030099D 01	-0.147523941280300D 01
	-0.142179711661510D 02	-0.249047705114339D 02	-0.984417845252399D 01
	-0.301337079753299D 02	-0.304903217556799D 01	0.816843194873799D 01
	-0.153317648888830D 01	0.239173418771469D 01	0.143835767493070D 01
	-0.413251606386699D 00	-0.182488513179110D 01	-0.796254556676699D 00
	0.490357391990799D 00	0.149874121820279D 01	0.649834708238499D 00
	0.496257538514899D 00	0.155474780892299D 01	0.678896073746699D 00
	0.677108139360999D 00	0.125394239858049D 01	0.557409689044099D 00
	0.699233498539599D 00	-0.203563497166350D 00	-0.104418783033679D 00
	-0.511461105402909D 00	0.250947912980459D 00	0.125887424372259D 00
	0.874386314475399D-01	-0.367173585979089D 00	-0.162120381396259D 00
	0.275802913039219D 00	-0.132212745403709D 00	-0.611023334175699D-01
	0.515520458153899D-01	-0.313488425897749D 00	-0.114510693906850D 00
0.345600000000000D 08	-0.216457566213934D 00	-0.369522210211522D 00	-0.175657218284510D 00
	0.207629965785380D-01	0.656362176793702D 00	0.294468617289098D 00
	0.957540445424738D 00	0.259659822253892D 00	0.112594336836906D 00
	0.955660877106006D 00	0.257965569465670D 00	0.111625302769791D 00
	-0.165091948394296D 01	0.120005012477844D-01	0.498053962300088D-01
	0.107708512176350D 01	-0.466351617582960D 01	-0.202696797991513D 01
	0.240852087103612D 01	0.608453365002993D 01	0.323871645581173D 01
	-0.174449922145712D 02	-0.539409389594253D 01	-0.211697689233154D 01
	-0.131028749464936D 02	-0.254116231877223D 02	-0.100798634555203D 02
	-0.299041707419648D 02	-0.429965208585266D 01	0.770447483233903D 01
	0.192164582976073D 01	-0.967738936746452D 00	-0.715656233296636D 00
	-0.202885517495876D 01	-0.294568225358453D-02	0.126808236184511D 00
	-0.516293796561754D 00	0.150859395312113D 01	0.654140942336764D 00
	-0.476585479574277D 00	0.147146372440886D 01	0.640188682818579D 00
	0.278437805468674D-01	-0.116364188834173D 01	-0.534878256424876D 00
	0.730287711064414D 00	0.182825583126782D 00	0.605833702235434D-01
	-0.567329213263219D 00	0.127914696105337D 00	0.774367015705887D-01
	0.121238661879504D 00	-0.357911223237398D 00	-0.158541778402288D 00
	0.231624372295322D 00	-0.121171507879078D 00	-0.557185447028115D-01
	0.631948007668290D-01	-0.311728171673294D 00	-0.117442405588699D 00

```
      SUBROUTINE SETUP
      DOUBLEPRECISION R1,R12,A1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM1
     C1,GM1,A,F1,C1,C2
      LOGICAL L2
      COMMON/TAYLOR/R12,R1,GM2,GM3,GM4,GM5,GM6,GM7,GM8,GM9,GM10,GM11,GM1
     C,A,F1,C1,C2,A1(10512),L2
      LOGICAL L1
      DO 1 N8=1,10512
    1 A1(N8)=0.D0
      GM2=2.2181600872554613 9D13
      GM3=3.2486014956475845 8D14
      GM4=3.9860125256817198 4D14
      GM5=4.9027841301850517 3D12
      GM6=4.2828450001773083 9D13
      GM7=1.2670773699797082D17
      GM8=3.7926531212989899 2D16
      GM9=5.7877242922151877 4D15
      GM10=6.8905772596310620 5D15
      GM11=7.3240903984820229 1D13
      GM1=(-1.3271251802049425 5D20)
      A=1.495979D11
      F1=8.64D4
      C1=(-1.5D0)
      READ(5,5)
     1A1(5527),A1(5527),A1(5518),A1(5509),A1(5500),A1(5491),A1(5482),
     2          A1(5473),A1(5464),A1(5455),A1(5446),A1(5437),A1(5428),
     3          A1(5419),A1(5410),A1(5401),A1(5392),A1(5383),A1(5374),
     4          A1(5365),A1(5356),A1(5347),A1(5338),A1(5329),A1(5320),
     5          A1(5311),A1(5302),A1(5293),A1(5284),A1(5275),A1(5266),
     6          A1(5797),A1(5788),A1(5779),A1(5770),A1(5761),A1(5752),
     7          A1(5743),A1(5734),A1(5725),A1(5716),A1(5707),A1(5698),
     8          A1(5689),A1(5680),A1(5671),A1(5662),A1(5653),A1(5644),
     9          A1(5635),A1(5626),A1(5617),A1(5608),A1(5599),A1(5590),
     A          A1(5581),A1(5572),A1(5563),A1(5554),A1(5545),A1(5536)
    5 FORMAT((2D25.16))
      A1(1)=0.D0
      A1(5257)=0.D0
      A1(2)=1.D0
      A1(5258)=1.D0
      CALL XTAY02(0,5256,L1)
      IF(.NOT.L1)GOTO 3
      WRITE(6,4)
    4 FORMAT(36H1TAY003 - ILLEGAL INITIAL CONDITIONS)
      STOP 3
    3 DO 2 N8=1,5256
    2 A1(N8+5256)=A1(N8)
      R12=A1(1)
      R1=R12
      L2=.TRUE.
      C2=0.D0
      RETURN
      END
```

```
      IMPLICIT REAL*8(A-H,O-Z)
      CALL SETUP
      A=149597.9D6
      AR=1/A
      FB=86400
      FBC=FB*100
      FC=AR*FBC
      DO1I=1,2
      X=(I-1)*FBC*4D0
      CALL
     1  VALUES(X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P)
      Y 1=Y 1*AR
      Y 2=Y 2*AR
      Y 3=Y 3*AR
      Y 4=Y 4*AR
      Y 5=Y 5*AR
      Y 6=Y 6*AR
      Y 7=Y 7*AR
      Y 8=Y 8*AR
      Y 9=Y 9*AR
      Y10=Y10*AR
      Y11=Y11*AR
      Y12=Y12*AR
      Y13=Y13*AR
      Y14=Y14*AR
      Y15=Y15*AR
      Y16=Y16*AR
      Y17=Y17*AR
      Y18=Y18*AR
      Y19=Y19*AR
      Y20=Y20*AR
      Y21=Y21*AR
      Y22=Y22*AR
      Y23=Y23*AR
      Y24=Y24*AR
      Y25=Y25*AR
      Y26=Y26*AR
      Y27=Y27*AR
      Y28=Y28*AR
      Y29=Y29*AR
      Y30=Y30*AR
      Y 1P=Y 1P*FC
      Y 2P=Y 2P*FC
      Y 3P=Y 3P*FC
      Y 4P=Y 4P*FC
      Y 5P=Y 5P*FC
      Y 6P=Y 6P*FC
      Y 7P=Y 7P*FC
      Y 8P=Y 8P*FC
      Y 9P=Y 9P*FC
      Y10P=Y10P*FC
      Y11P=Y11P*FC
      Y12P=Y12P*FC
```

```
      Y13P=Y13P*FC
      Y14P=Y14P*FC
      Y15P=Y15P*FC
      Y16P=Y16P*FC
      Y17P=Y17P*FC
      Y18P=Y18P*FC
      Y19P=Y19P*FC
      Y20P=Y20P*FC
      Y21P=Y21P*FC
      Y22P=Y22P*FC
      Y23P=Y23P*FC
      Y24P=Y24P*FC
      Y25P=Y25P*FC
      Y26P=Y26P*FC
      Y27P=Y27P*FC
      Y28P=Y28P*FC
      Y29P=Y29P*FC
      Y30P=Y30P*FC
1     WRITE(6,2)
     1            X,Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11,Y12,Y13,Y14,Y15,Y16,
     2Y17,Y18,Y19,Y20,Y21,Y22,Y23,Y24,Y25,Y26,Y27,Y28,Y29,Y30,
     3Y1P,Y2P,Y3P,Y4P,Y5P,Y6P,Y7P,Y8P,Y9P,Y10P,Y11P,Y12P,Y13P,Y14P,Y15P,
     4Y16P,
     5Y17P,Y18P,Y19P,Y20P,Y21P,Y22P,Y23P,Y24P,Y25P,Y26P,Y27P,Y28P,Y29P,
     6Y30P
2     FORMAT (1H ,4X,1H*,5X,4(D25.16    )/(36X,3(D25.16    )))
      STOP
      END
```

```
MAIN        0000C790   010D5790   FD000008   000F4FF8

NT=  010D5790
```

APPENDIX 25 B

```
FIXUP TAKEN, EXECUTICN CONTINUING
 0.0                        -0.2164575662139348D 00  -0.3695222102115225D 00  -0.1756572182845100D 00
                             0.2076299657853809D-01   0.6563621767937025D 00   0.2944686172890980D 00
                             0.9575404454247385D 00   0.2596598222538927D 00   0.1125943368369063D 00
                             0.9556608771060067D 00   0.2579656946567061D 00   0.1116253027697911D 00
                            -0.1650919483942969D 01   0.1200050124778441D-01   0.4980539623000887D-01
                             0.1077085121763509D 01  -0.4663516175829607D 01  -0.2026967979915132D 01
                             0.2408520871036123D 01   0.8084533650299934D 01   0.3238716455811738D 01
                            -0.1744499221457123D 02  -0.5394093895942537D 01  -0.2116976892331542D 01
                            -0.1310287494649366D 02  -0.2541162818772232D 02  -0.1007986345552036D 02
                            -0.2990417074196486D 02  -0.4299652085852666D 01   0.7704474832339037D 01
                             0.1921645829760730D 01  -0.9677389367464525D 00  -0.7156562332966360D 00
                            -0.2028855174958768D 01  -0.2945682253584538D-02   0.1268082361845114D 00
                            -0.5162937965617542D 00   0.1508593953121131D 01   0.6541409423367643D 00
                            -0.4765854795742770D 00   0.1471463724408868D 01   0.6401886828185800D 00
                             0.2784378054686743D-01  -0.1163641888341736D 01  -0.5348782564248763D 00
                             0.7302877110644146D 00   0.1828255831267828D 00   0.6058337022354340D-01
                            -0.5673292132632199D 00   0.1279146961053375D 00   0.7743670157058870D-01
                             0.1212386618795045D 00  -0.3579112232373984D 00  -0.1555417784022888D 00
                             0.2816243722953220D 00  -0.1211715078790783D 00  -0.5671854470281157D-01
                             0.6319480076682890D-01  -0.3117281716732939D 00  -0.1174424055886992D 00
 0.3456000000000000D 08      0.1071863847084014D 00   0.2588788691632039D 00   0.1276294694553483D 00
                             0.7156604725206781D 00   0.1211967143422865D 00   0.9413073780178594D-02
                             0.6207244596906668D 00   0.7067536284432377D 00   0.3064635086712413D 00
                             0.6203973739757667D 00   0.7089778313887947D 00   0.3073902728116576D 00
                             0.1071241351192470D 01   0.9098943193013632D 00   0.3889201860599078D 00
                             0.3648442423716746D 01  -0.3188562856024813D 01  -0.1457059413800033D 01
                             0.8608120032148340D-01   0.8332391503468158D 01   0.3441685246858689D 01
                            -0.1689458032111191D 02  -0.6802790274459494D 01  -0.2742015202541919D 01
                            -0.1196586398023820D 02  -0.2587393439550559D 02  -0.1029782202811341D 02
                            -0.2962825533620421D 02  -0.5542237950567177D 01   0.7229040993876097D 01
                            -0.3198780312792718D 01   0.8533607585597261D 00   0.7855807941143840D 00
                            -0.3284784381584892D 00   0.1805033788637575D 01   0.8341595493243583D 00
                            -0.1367053738897015D 01   0.9848215333287156D 00   0.4271230629582824D 00
                            -0.1428731402945415D 01   0.9804607840855468D 00   0.4191320822371543D 00
                            -0.8943378178070410D 00   0.1033394508892886D 01   0.4933415566759743D 00
                             0.5145873917360088D 00   0.5377057856976814D 00   0.2180989033756309D 00
                            -0.5877184401315105D 00  -0.4807795349881209D-02   0.2344003627021058D-01
                             0.1537100024682414D 00  -0.3460060959213370D 00  -0.1537841459139539D 00
                             0.2867508698937138D 00  -0.1099528178381570D 00  -0.5224555223254106D-01
                             0.7472897676381870D-01  -0.3094819951576489D 00  -0.1202522856286956D 00
```

APPENDIX II C 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-11 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.311081403238440OD 00	0.114494361824890OD 00	0.293591295226599D-01
	-0.153317648888830OD 01	0.239173418771469D 01	0.143835767493069D 01
	-0.703825009735149D 00	0.114225711335840OD 00	0.959262274095600OD-01
	-0.413251663866699D 00	-0.182488513179109D 01	-0.796254566676699D 00
	0.961178790827279D 00	-0.278794038580680OD 00	-0.120897709468640OD 00
	0.490357391990799D 00	0.149874121820280OD 01	0.649834708238499D 00
	0.963560343737029D 00	-0.279072502798480OD 00	-0.120864929786220OD 00
	0.496257538514899D 00	0.155474780892299D 01	0.678896073746699D 00
	0.123698921949460OD 01	-0.545947277824999D 00	-0.283792524838400D 00
	0.677108139360999D 00	0.125394239858049D 01	0.557409689044099D 00
	-0.186100233096779D 01	-0.461057708049810OD 01	-0.193244709471800OD 01
	0.699233498539599D 00	-0.203563497166349D 00	-0.104418783033680OD 00
	0.457722823046950OD 01	0.732208096485580OD 01	0.282963119972420OD 01
	-0.511461105402909D 00	0.250947912980459D 00	0.125887424372260OD 00
	-0.178627562577089D 02	-0.394299700030100OD 01	-0.147523941280300OD 01
	0.874386314475400D-01	-0.367173585979089D 00	-0.162120381396259D 00
	-0.142179711661510OD 02	-0.249047705114339D 02	-0.984417845252400D 01
	0.275802913039219D 00	-0.132212745403710OD 00	-0.611023334175699D-01
	-0.301337079753299D 02	-0.304903217556800D 01	0.816843154873799D 01
	0.515520458153899D-01	-0.313488425897749D 00	-0.114510693906850OD 00

APPENDIX II C 2
(FORWARD INTEGRATION)

0.345600000000000D 08	-0.2164575662130261D 00	-0.3695222102119170D 00	-0.1756572182848127D 00
	0.1921645829763880D 01	-0.9677389367414244D 00	-0.7156562332942281D 00
	0.2076299658117966D-01	0.6563621767947567D 00	0.2944686172892042D 00
	-0.2028855174956765D 01	-0.2945682245700744D-02	0.1268082361876220D 00
	0.9575404454246404D 00	0.2596598222540813D 00	0.1125943368369819D 00
	-0.5162937965622018D 00	0.1508593953120979D 01	0.6541409423366817D 00
	0.9556608771062695D 00	0.2579656946565440D 00	0.1116253027697306D 00
	-0.4765854795672406D 00	0.1471463724416111D 01	0.6401886828225953D 00
	-0.1650919483943023D 01	0.1200050124778341D-01	0.4980539622998984D-01
	0.2784378054684580D-01	-0.1163641888341726D 01	-0.5348782564249056D 00
	0.1077085121763585D 01	-0.4663516175829318D 01	-0.2026967979915026D 01
	0.7302877110644235D 00	0.1828255831268119D 00	0.6058337022355771D-01
	0.2408520871035908D 01	0.8084533650030353D 01	0.3238716455811828D 01
	-0.5673292132632202D 00	0.1279146961053474D 00	0.7743670157058940D-01
	-0.1744499221457130D 02	-0.5394093895942373D 01	-0.2116976892331349D 01
	0.1212386618795079D 00	-0.3579112232373830D 00	-0.1585417784022855D 00
	-0.1310287494650797D 02	-0.2541162818772212D 02	-0.1007986345552210D 02
	0.2816243722953693D 00	-0.1211715078790831D 00	-0.5671854470281350D-01
	-0.2990417074196513D 02	-0.4299652085852626D 01	0.7704474832339773D 01
	0.6319480076682760D-01	-0.3117281716732395D 00	-0.1174424055887005D 00
0.691200000000000D 08	0.1071863847033992D 00	0.2588788691644700D 00	0.1276294694565397D 00
	-0.3198780312809992D 01	0.8533607585190308D 00	0.7855807940943204D 00
	0.7156604725246687D 00	0.1211967143244669D 00	0.9418073771930544D-02
	-0.3284784381027692D 00	0.1805033788646566D 01	0.8341595493246438D 00
	0.6207244596902459D 00	0.7067536284434995D 00	0.3064635086713453D 00
	-0.1367053738897797D 01	0.9848215333289814D 00	0.4271230629583776D 00
	0.6203973739721057D 00	0.7089778313887989D 00	0.3073902728113385D 00
	-0.1428731402935161D 01	0.9804607840121464D 00	0.4191320822067855D 00
	0.1071241351193261D 01	0.9098943193009693D 00	0.3889201860595466D 00
	-0.8943378178062505D 00	0.1033394508893351D 01	0.4983415566761101D 00
	0.3648442423716826D 01	-0.3188562856024265D 01	-0.1457059413799878D 01
	0.5145873917359681D 00	0.5377057856977590D 00	0.2180989033756610D 00
	0.8608120082137410D-01	0.8332391503469182D 01	0.3441685246858880D 01
	-0.5877184401314679D 00	-0.4807795349857341D-02	0.2344003627022172D-01
	-0.1689458032111245D 02	-0.6802790274459306D 01	-0.2742015202541743D 01
	0.1537100024682420D 00	-0.3460060959213858D 00	-0.1537841459139520D 00
	-0.1196586398024916D 02	-0.2587393439550515D 02	-0.1029782202811567D 02
	0.2867508698937584D 00	-0.1099528178381677D 00	-0.5224552232545370D-01
	-0.2962825533620474D 02	-0.5542237950566645D 01	0.7229040993877287D 01
	0.7472897676381620D-01	-0.3094819951574382D 00	-0.1202522856286949D 00

APPENDIX 11 C 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
ITH LOCAL ERROR TOLERANCE EP = 1.00000D-11 AND INITIAL STEP SIZE H =-0.86400D 05.
RINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
OR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.6912000000000000D 08	0.1071863847033992D 00	0.2568788691644700D 00	0.1276294694565397D 00
	-0.3198780312809992D 01	0.8533607585190308D 00	0.7855807940943204D 00
	0.7156604725246687D 00	0.1211967143244669D 00	0.9418073771930544D-02
	-0.3284784381027692D 00	0.1805033788646566D 01	0.8341595493246438D 00
	0.6207244596902459D 00	0.7067536284434995D 00	0.3064635086713453D 00
	-0.1367053738897797D 01	0.9848215333289814D 00	0.4271230629583776D 00
	0.6203973739721057D 00	0.7089778313887989D 00	0.3073902728113385D 00
	-0.1428731402935161D 01	0.9804607840121464D 00	0.4191320822067855D 00
	0.1071241351193261D 01	0.9098943193009693D 00	0.3889201860595466D 00
	-0.8943378178062505D 00	0.1033394508893351D 01	0.4983415566761101D 00
	0.3648442423716826D 01	-0.3188562856024265D 01	-0.1457059413799878D 01
	0.5145873917359681D 00	0.5377057856977590D 00	0.2180989033756610D 00
	0.8608120082137410D-01	0.8332391503469182D 01	0.3441685246858880D 01
	-0.5877184401314679D 00	-0.4807795349857341D-02	0.2344003627022172D-01
	-0.1689458032111245D 02	-0.6802790274459306D 01	-0.2742015202541743D 01
	0.1537100024682420D 00	-0.3460060959213858D 00	-0.1537841459139520D 00
	-0.1196586398024916D 02	-0.2567393439550515D 02	-0.1029782202811567D 02
	0.2867508698937584D 00	-0.1099528178381677D 00	-0.5224555223254537D-01
	-0.2962825533620474D 02	-0.5542237950566645D 01	0.7229040993877287D 01
	0.7472897676381620D-01	-0.3094819951574382D 00	-0.1202522856286949D 00

APPENDIX II C 4
(BACKWARD INTEGRATION)

	0.192164582975468 6D 01	-0.967738936757883 9D 00	-0.715656233302062 1D 00
	0.207629965869252 0D-01	0.656362176794063 2D 00	0.294466617288674 3D 00
	-0.202885517495741 9D 01	-0.294568223102195 3D-02	0.126808236194473 4D 00
	0.957540445425380 2D 00	0.259659822249468 6D 00	0.112594336834997 4D 00
	-0.516293796551871 9D 00	0.150859395312604 9D 01	0.654140942339229 2D 00
	0.955660877097460 8D 00	0.257965694661073 5D 00	0.111625302771181 4D 00
	-0.476585479759505 4D 00	0.147146372423240 5D 01	0.640186682717406 0D 00
	-0.165091948394164 4D 01	0.120005012500210 5D-01	0.498053962310534 5D-01
	0.278437805444426 5D-01	-0.116364188834233 3D 01	-0.534878256424927 9D 00
	0.107708512176348 1D 01	-0.466351617582856 4D 01	-0.202696797991483 3D 01
	0.730287711064279 7D 00	0.182825583126641 7D 00	0.605833702235243 2D-01
	0.240852087103541 7D 01	0.808453365002816 8D 01	0.323871645581155 4D 01
	-0.567329213263015 2D 00	0.127914696105381 8D 00	0.774367015706093 0D-01
	-0.174449922145667 2D 02	-0.539409389594260 6D 01	-0.211697689233116 9D 01
	0.121238661879438 0D 00	-0.357911223237201 6D 00	-0.158541778402277 2D 00
	-0.131028749464999 7D 02	-0.254116281877157 8D 02	-0.100798634555174 0D 02
	0.281624372295200 9D 00	-0.121171507879077 5D 00	-0.567185447028062 0D-01
	-0.299041707419607 9D 02	-0.429965208585266 0D 01	0.770447483233626 9D 01
	0.631948007668162 0D-01	-0.311728171672945 0D 00	-0.117442405588687 6D 00
0.0	0.311081403247313 3D 00	0.114494361810381 1D 00	0.293591295139775 8D-01
	-0.153317648873904 7D 01	0.239173418777150 2D 01	0.143835767494552 3D 01
	-0.703825009733629 0D 00	0.114225711342665 4D 00	0.959262274125277 0D-01
	-0.413251606407492 9D 00	-0.182488513178730 2D 01	-0.796254566673454 2D 00
	0.961178790820045 2D 00	-0.278794038596830 7D 00	-0.120897709475604 0D 00
	0.490357392012858 8D 00	0.149874121819601 5D 01	0.649834708235019 5D 00
	0.963560343726682 0D 00	-0.279072502844175 7D 00	-0.120864929808408 1D 00
	0.496257539349913 2D 00	0.155474780882726 4D 01	0.678896073754460 4D 00
	0.123698921948710 2D 01	-0.545947277835251 5D 00	-0.283792524842748 7D 00
	0.677108139373678 6D 00	0.125394239857584 4D 01	0.557409689041495 2D 00
	-0.186100233096646 5D 01	-0.461057708049578 2D 01	-0.193244709471743 7D 01
	0.699233498539077 5D 00	-0.203563497166734 8D 00	-0.104418783033812 5D 00
	0.457722823046721 8D 01	0.732208096484649 1D 01	0.282963119972346 1D 01
	-0.511461105402442 0D 00	0.250947912980617 6D 00	0.125887424372361 5D 00
	-0.178627562576992 7D 02	-0.394299700030172 0D 01	-0.147523941280238 6D 01
	0.874386314474904 0D-01	-0.367173585978755 2D 00	-0.162120381396240 5D 00
	-0.142179711661526 1D 02	-0.249047705114222 7D 02	-0.984417845251694 5D 01
	0.275802913038943 1D 00	-0.132212745403705 0D 00	-0.611023334175546 0D-01
	-0.301337079753240 1D 02	-0.304903217556936 8D 01	0.816843194873052 9D 01
	0.515520458153640 5D-01	-0.313488425897257 5D 00	-0.114510693906829 0D 00

:TAL NC CF FUNCTICN EVALUATICNS IS 164126

APPENDIX 13 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-12 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.31108140323844000D 00	0.11449436182489000D 00	0.29359129522659990D-01
	-0.15331764888883000D 01	0.23917341877146990D 01	0.14383576749306990D 01
	-0.70382500973514990D 00	0.11422571133584000D 00	0.95926227409560000D-01
	-0.41325160638669990D 00	-0.18248851317910990D 01	-0.79625456667669980D 00
	0.96117879082727990D 00	-0.27879403858068000D 00	-0.12089770946864000D 00
	0.49035739199079980D 00	0.14987412182028000D 01	0.64983470823849970D 00
	0.96356034373702990D 00	-0.27907250279848000D 00	-0.12086492978622000D 00
	0.49625753851489990D 00	0.15547478089229990D 01	0.67889607374669980D 00
	0.12369892194946000D 01	-0.54594727782499990D 00	-0.28379252483840000D 00
	0.67710813936099970D 00	0.12539423985804990D 01	0.55740968904409980D 00
	-0.18610023309677990D 01	-0.46105770804981000D 01	-0.19324470947180000D 01
	0.69923349853959970D 00	-0.20356349716634990D 00	-0.10441878303368000D 00
	0.45772282304695000D 01	0.73220809648558000D 01	0.28296311997242000D 01
	-0.51146110540290980D 00	0.25094791298045990D 00	0.12588742437226000D 00
	-0.17862756257708990D 02	-0.39429970003010000D 01	-0.14752394128030000D 01
	0.87438631447540000D-01	-0.36717358597908990D 00	-0.16212038139625990D 00
	-0.14217971166151000D 02	-0.24904770511433990D 02	-0.98441784525240000D 01
	0.27580291303921990D 00	-0.13221274540371000D 00	-0.61102333417569970D-01
	-0.30133707975329990D 02	-0.30490321755680000D 01	0.81684319487379990D 01
	0.51552045815389980D-01	-0.31348842589774990D 00	-0.11451069390685000D 00

APPENDIX 13 2

	0.1921645829762496D 01	-0.9677389367434614D 00	-0.7156562332951301D 00
	0.2076299657781490D-01	0.6563621767934984D 00	0.2944686172890416D 00
	-0.2028855174959226D 01	-0.2945682255585331D-02	0.1268082361836625D 00
	0.9575404454242832D 00	0.2596598222546835D 00	0.1125943368372436D 00
	-0.5162937965635200D 00	0.1508593953120699D 01	0.6541409423365461D 00
	0.9556608771061545D 00	0.2579656946568939D 00	0.1116253027699103D 00
	-0.4765854795635072D 00	0.1471463724420663D 01	0.6401886628253769D 00
	-0.1650919483942834D 01	0.1200050124764083D-01	0.4980539622995926D-01
	0.2784378054705053D-01	-0.1163641888341782D 01	-0.5348782564249268D 00
	0.1077085121763617D 01	-0.4663516175829269D 01	-0.2026967979915159D 01
	0.7302877110644130D 00	0.1828255831268021D 00	0.6058337022356177D-01
	0.2408520871035984D 01	0.8064533650026955D 01	0.3238716455811712D 01
	-0.5673292132632374D 00	0.1279146961053159D 00	0.7743670157057690D-01
	-0.1744499221457144D 02	-0.5394093895942436D 01	-0.2116976892331530D 01
	0.1212386618795056D 00	-0.3579112232373906D 00	-0.1585417784022842D 00
	-0.1310287494648196D 02	-0.2541162818772362D 02	-0.1007986345551656D 02
	0.2816243722953068D 00	-0.1211715078790746D 00	-0.5671854470281132D-01
	-0.2990417074196276D 02	-0.4299652085852598D 01	0.7704474832337997D 01
	0.6319480076682930D-01	-0.3117281716732851D 00	-0.1174424055886987D 00
0.6912000000000000D 03	0.1071863847059226D 00	0.2588788691638346D 00	0.1276294694559271D 00
	-0.3198780312801299D 01	0.8533607585393185D 00	0.7855807941045872D 00
	0.7156604725199683D 00	0.1211967143456120D 00	0.9418073781730362D-02
	-0.3284784381692720D 00	0.1805033788635835D 01	0.8341595493241903D 00
	0.6207244596879059D 00	0.7067536284448985D 00	0.3064635086719537D 00
	-0.1367053738900972D 01	0.9848215333254998D 00	0.4271230629568608D 00
	0.6203973739702310D 00	0.7089778313902178D 00	0.3073902728119898D 00
	-0.1428731402940536D 01	0.9804607840198589D 00	0.4191320822099250D 00
	0.1071241351191766D 01	0.9058943193020503D 00	0.3889201860602238D 00
	-0.8943378178077591D 00	0.1033394508892267D 01	0.4983[illegible]15566757270D 00
	0.3648442423716668D 01	-0.3188562856024214D 01	-0.1457059413799920D 01
	0.5145873917359475D 00	0.5377057856977439D 00	0.2180989033756775D 00
	0.8608120082124430D-01	0.8332391503465552D 01	0.3441685246858358D 01
	-0.5877184401315445D 00	-0.4807795349971860D-02	0.2344003627015438D-01
	-0.1689458032111129D 02	-0.6802790274459277D 01	-0.2742015202541828D 01
	0.1537100024682370D 00	-0.3460060959213495D 00	-0.1537841459139454D 00
	-0.1196586398022581D 02	-0.2587393439550725D 02	-0.1029782202810930D 02
	0.2867508698368000D 00	-0.1099528178381470D 00	-0.5224555223253498D-01
	-0.2962825533620181D 02	-0.5542237950566922D 01	0.7229040993873661D 01
	0.7472897676382010D-01	-0.3094819951576309D 00	-0.1202522856286918D 00

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APPENDIX 13 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
ITH LOCAL ERROR TOLERANCE EP = 1.00000D-12 AND INITIAL STEP SIZE H =-0.86400D 05.
RINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
OR K=0,1.... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),.... Y(N)

0.6912000000000000D 08	0.1071863847059226D 00	0.2588788691638346D 00	0.1276294694559271D 00
	-0.3196780312801299D 01	0.8533607585393185D 00	0.7855807941045872D 00
	0.7156604725199683D 00	0.1211967143456120D 00	0.9418073781730362D-02
	-0.3284784381692720D 00	0.1805033788635835D 01	0.8341595493241903D 00
	0.6207244596879059D 00	0.7067536284448985D 00	0.3064635086719537D 00
	-0.1367053738900972D 01	0.9848215333254598D 00	0.4271230629568608D 00
	0.6203973739702310D 00	0.7089778313902178D 00	0.3073902728119898D 00
	-0.1428731402940536D 01	0.9804607840198589D 00	0.4191320822099250D 00
	0.1071241351191766D 01	0.9098943193020503D 00	0.3889201860602238D 00
	-0.8943378178077591D 00	0.1033394508892267D 01	0.4983415566757270D 00
	0.3648442423716668D 01	-0.3188562856024214D 01	-0.1457059413799920D 01
	0.5145873917359475D 00	0.5377057856977439D 00	0.2180989033756775D 00
	0.8608120082124430D-01	0.8332391503465552D 01	0.3441685246858358D 01
	-0.5877184401315445D 00	-0.4807795349971860D-02	0.2344083627015438D-01
	-0.1689458032111129D 02	-0.6802790274459277D 01	-0.2742015202541828D 01
	0.1537100024682370D 00	-0.3460060959213495D 00	-0.1537841459139454D 00
	-0.1196586398022581D 02	-0.2587393439550725D 02	-0.1029782202810930D 02
	0.2867508698936800D 00	-0.1099528178381470D 00	-0.5224555223253498D-01
	-0.2962825533620181D 02	-0.5542237950566922D 01	0.7229040993873661D 01
	0.7472897676382010D-01	-0.3094819951576309D 00	-0.1202522856286918D 00

0.3456000000000000D 08	-0.2164575662164594D 00	-0.3695222102099010D 00	-0.1756572182835528D 00
	0.1921645829752551D 01	-0.9677389367620644D 00	-0.7156562333042653D 00
	0.2076299658310582D-01	0.6563621767926482D 00	0.2944686172883652D 00
	-0.2028855174960371D 01	-0.2945682241826817D-02	0.1268082361898328D 00
	0.9575404454256349D 00	0.2596598224742243D 00	0.1125943368341098D 00
	-0.5162937965500685D 00	0.1508593953125337D 01	0.6541409423387606D 00
	0.9556608771052766D 00	0.2579656946517746D 00	0.1116253027675730D 00
	-0.4765854795968278D 00	0.1471463724381955D 01	0.6401886828027825D 00
APPENDIX 13 4	-0.1650919483941172D 01	0.1200050125038187D-01	0.4980539623114998D-01
	0.2784378054409794D-01	-0.1163641888342531D 01	-0.5348782564250559D 00
	0.1077085121763528D 01	-0.4663516175828391D 01	-0.2026967979914773D 01
	0.7302877110642577D 00	0.1828255831266003D 00	0.6058337022352464D-01
	0.2408520871035143D 01	0.8084533650020413D 01	0.3238716455811163D 01
	-0.5673292132629852D 00	0.1279146961053997D 00	0.7743670157062220D-01
	-0.1744495221456618D 02	-0.5394093895942203D 01	-0.2116976892331229D 01
	0.1212386618794806D 00	-0.3579112232372590D 00	-0.1585417784022711D 00
	-0.1310287494647499D 02	-0.2541162818771927D 02	-0.1007986345551176D 02
	0.2816243722951127D 00	-0.1211715078790681D 00	-0.5671854470279748D-01
	-0.2990417074195889D 02	-0.4299652085852395D 01	0.7704474832332031D 01
	0.6319480076681560D-01	-0.3117281716731266D 00	-0.1174424055886829D 00
0.0	0.3110814032486045D 00	0.1144943618083626D 00	0.2935912951273796D-01
	-0.1533176488717525D 01	0.2391734187779309D 01	0.1438357674947716D 01
	-0.7038250097280770D 00	0.1142257113588716D 00	0.9592622741947930D-01
	-0.4132516064594510D 00	-0.1824885131781798D 01	-0.7962545666681092D 00
	0.9611787908171751D 00	-0.2787940386042680D 00	-0.1208977094788997D 00
	0.4903573920335305D 00	0.1498741218191401D 01	0.6498347082335118D 00
	0.9635603437259664D 00	-0.2790725028312110D 00	-0.1208649298012071D 00
	0.4962575388092541D 00	0.1554747808882494D 01	0.6788960737450972D 00
	0.1236989219485265D 01	-0.6459472778377826D 00	-0.2837925248439049D 00
	0.6771081393766984D 00	0.1253942398574748D 01	0.5574036890408260D 00
	-0.1861002330966789D 01	-0.4610577080495272D 01	-0.1932447094717026D 01
	0.6992334985392544D 00	-0.2035634971668252D 00	-0.1044187830338372D 00
	0.4577228230466619D 01	0.7322080964841160D 01	0.2829631199722869D 01
	-0.5114611054023319D 00	0.2509479129807539D 00	0.1258874243724479D 00
	-0.1786275625769841D 02	-0.3942997000301164D 01	-0.1475239412802463D 01
	0.8743863144747640D-01	-0.3671735859788028D 00	-0.1621203813962357D 00
	-0.1421797116612886D 02	-0.2490477051142626D 02	-0.9844178452507915D 01
	0.2758029130388489D 00	-0.1322127454037025D 00	-0.6110233341754644D-01
	-0.3013370797531913D 02	-0.3049032175568375D 01	0.8168431948724659D 01
	0.5155204581535712D-01	-0.3134884258973793D 00	-0.1145106939068248D 00

TAL NO OF FUNCTION EVALUATIONS IS 205686

APPENDIX 14 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TC XEND = 0.69120D 08
IITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
OF K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.311081403238440 0D 00	0.1144943618248900D 00	0.2935912952265999D-01
	-0.1533176488883000D 01	0.2391734187714699D 01	0.1438357674930699D 01
	-0.7038250097351499D 00	0.1142257113358400D 00	0.9592622740956000D-01
	-0.4132516063866999D 00	-0.1824885131791099D 01	-0.7962545666766998D 00
	0.9611787908272799D 00	-0.2787940385806800D 00	-0.1208977094686400D 00
	0.4903573919907998D 00	0.1498741218202800D 01	0.6498347082384997D 00
	0.9635603437370299D 00	-0.2790725027984800D 00	-0.1208649297862200D 00
	0.4962575385148999D 00	0.1554747808922999D 01	0.6788960737466998D 00
	0.1236989219494600D 01	-0.5459472778249999D 00	-0.2837925248384000D 00
	0.6771081393609997D 00	0.1253942398580499D 01	0.5574096890440998D 00
	-0.1861002330967799D 01	-0.4610577080498100D 01	-0.1932447094718000D 01
	0.6992334985395997D 00	-0.2035634971663499D 00	-0.1044187830336800D 00
	0.4577228230469500D 01	0.7322080964855800D 01	0.2829631199724200D 01
	-0.5114611054029098D 00	0.2509479129804599D 00	0.1258874243722600D 00
	-0.1786275625770899D 02	-0.3942997000301000D 01	-0.1475239412803000D 01
	0.8743863144754000D-01	-0.3671735859790899D 00	-0.1621203813962599D 00
	-0.1421797116615100D 02	-0.2490477051143399D 02	-0.9844178452524000D 01
	0.2758029130392199D 00	-0.1322127454037100D 00	-0.6110233341756997D-01
	-0.3013370797532999D 02	-0.3049032175568000D 01	0.8168431948737999D 01
	0.5155204581538998D-01	-0.3134884258977499D 00	-0.1145106939068500D 00

APPENDIX 14 2

0.6912000000000000D 08

0.1921645829760743D 01	-0.9677389367464828D 00	-0.7156562332967041D 00
0.2076299657905860D-01	0.6563621767937512D 00	0.2944686172890727D 00
-0.2028855174958721D 01	-0.2945682252313790D-02	0.1268082361851052D 00
0.9575404454247131D 00	0.2596598222539336D 00	0.1125943368369157D 00
-0.5162937965638474D 00	0.1508593953118992D 01	0.6541409423355327D 00
0.9556608771150984D 00	0.2579656946483746D 00	0.1116253027666283D 00
-0.4765854793855641D 00	0.1471463724584434D 01	0.6401886829191565D 00
-0.1650919483943335D 01	0.1200050124832476D-01	0.4980539623028157D-01
0.2764378054629025D-01	-0.1163641888341580D 01	-0.5348782564248036D 00
0.1077085121763646D 01	-0.4663516175829589D 01	-0.2026967979915169D 01
0.7302877110644570D 00	0.1828255831267706D 00	0.6058337022354771D-01
0.2408520871036282D 01	0.8084533650030387D 01	0.3238716455811825D 01
-0.5673292132632183D 00	0.1279146961053417D 00	0.7743670157058900D-01
-0.1744499221457150D 02	-0.5394093895942526D 01	-0.2116976892331633D 01
0.1212386618795022D 00	-0.3579112232374344D 00	-0.1585417784022926D 00
-0.1310287494649424D 02	-0.2541162818772238D 02	-0.1007986345552190D 02
0.2816243722953592D 00	-0.1211715078790752D 00	-0.5671854470281349D-01
-0.2990417074196545D 02	-0.4299652085852697D 01	0.7704474832337289D 01
0.6319480076683140D-01	-0.3117281716733125D 00	-0.1174424055887027D 00
0.1071863847076324D 00	0.2588788691633868D 00	0.1276294694555381D 00
-0.3198780312795425D 01	0.8533607585533371D 00	0.7855807941112823D 00
0.7156604725214943D 00	0.1211967143394187D 00	0.9418073778824160D-02
-0.3284784381495202D 00	0.1805033788638665D 01	0.8341595493242187D 00
0.6207244596928686D 00	0.7067536284426916D 00	0.3064635086710958D 00
-0.1367053738899143D 01	0.9848215333546908D 00	0.4271230629691368D 00
0.6203973738887392D 00	0.7089778313812867D 00	0.3073902727996567D 00
-0.1428731402644418D 01	0.9804607821031007D 00	0.4191320814127341D 00
0.1071241351194715D 01	0.9098943192994793D 00	0.3889201860589891D 00
-0.8943378178047018D 00	0.1033394508894656D 01	0.4983415566766946D 00
0.3648442423717173D 01	-0.3188562856024824D 01	-0.1457059413800090D 01
0.5145873917360564D 00	0.5377057856976610D 00	0.2180989033756276D 00
0.8608120082160630D-01	0.8332391503470678D 01	0.3441685246858872D 01
-0.5877184401315311D 00	-0.4807795349835673D-02	0.2344003627023598D-01
-0.1689458032111380D 02	-0.6802790274459683D 01	-0.2742015202542084D 01
0.1537100024682340D 00	-0.3460060959213934D 00	-0.1537841459139551D 00
-0.1196586398023899D 02	-0.2587393439550687D 02	-0.1029782202811748D 02
0.2867508698937790D 00	-0.1099528178381574D 00	-0.5224555223249745D-01
-0.2962825533620499D 02	-0.5542237950567332D 01	0.7229040993874146D 01
0.7472897676381930D-01	-0.3094819951576984D 00	-0.1202522856286983D 00

APPENDIX 14 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),..., Y(N)

0.69120000000000000D 08	0.1071863847076324D 00	0.2588788691633868D 00	0.1276294694555381D 00
	-0.3198780312795425D 01	0.8533607585533371D 00	0.7855807941112823D 00
	0.7156604725214943D 00	0.1211967143394187D 00	0.9418073778824160D-02
	-0.3284784381495202D 00	0.1805033788638665D 01	0.8341595493242187D 00
	0.6207244596928686D 00	0.7067536284426916D 00	0.3064635086710958D 00
	-0.1367053738899143D 01	0.9848215333546908D 00	0.4271230629691368D 00
	0.6203973738887392D 00	0.7089778313812867D 00	0.3073902727996567D 00
	-0.1428731402644418D 01	0.9804607821031007D 00	0.4191320814127341D 00
	0.1071241351194715D 01	0.9098943192994793D 00	0.3889201860589891D 00
	-0.8943378178047018D 00	0.1033394508894656D 01	0.4983415566766946D 00
	0.3648442423717173D 01	-0.3188562856024824D 01	-0.1457059413800090D 01
	0.5145873917360564D 00	0.5377057856976610D 00	0.2180989033756276D 00
	0.8608120082160630D-01	0.8332391503470678D 01	0.3441685246858872D 01
	-0.5877184401315311D 00	-0.4807795349835673D-02	0.2344003627023598D-01
	-0.1689458032111380D 02	-0.6802790274459683D 01	-0.2742015202542084D 01
	0.1537100024682340D 00	-0.3460060959213934D 00	-0.1537841459139551D 00
	-0.1196586398023899D 02	-0.2587393439550687D 02	-0.1029782202811748D 02
	0.2867508698937790D 00	-0.1099528178381574D 00	-0.5224552232497450D-01
	-0.2962825533620499D 02	-0.5542237950567332D 01	0.7229040993874146D 01
	0.7472897676381930D-01	-0.3094819951576984D 00	-0.1202522856286983D 00

0.3456000000000000D 08	-0.2164575662160196D 00	-0.3695222102102750D 00	-0.1756572182836377D 00
	0.1921645829753833D 01	-0.9677389367591237D 00	-0.7156562333027496D 00
	0.2076299658232295D-01	0.6563621767937036D 00	0.2944686172887605D 00
	-0.2028855174958491D 01	-0.2945682244413411D-02	0.1268082361888499D 00
	0.9575404454233378D 00	0.2596598222511878D 00	0.1125943368356666D 00
	-0.5162937966018293D 00	0.1508593953077860D 01	0.6541409423119499D 00
	0.9556608772950769D 00	0.2579656944703101D 00	0.1116253026991751D 00
	-0.4765854756043468D 00	0.1471463728117481D 01	0.6401886849394545D 00
	-0.1659919483942424D 01	0.1200050124972617D-01	0.4980539623080731D-01
	0.2784378054472515D-01	-0.1163641888341979D 01	-0.5348782564248210D 00
	0.1077085121763712D 01	-0.4663516175829006D 01	-0.2026967979914936D 01
	0.7302877110643405D 00	0.1828255831266327D 00	0.6058337022353552D-01
	0.2408520871035562D 01	0.8084533650028551D 01	0.3238716455811585D 01
	-0.5673292132631276D 00	0.1279146961053627D 00	0.7743670157059600D-01
	-0.1744499221456910D 02	-0.5394093895942461D 01	-0.2116976892331434D 01
	0.1212386618794869D 00	-0.3579112232373247D 00	-0.1585417784022782D 00
	-0.1310287494648556D 02	-0.2541162818771957D 02	-0.1007986345551841D 02
	0.2816243722952450D 00	-0.1211715078790697D 00	-0.5671854470275985D-01
	-0.2990417074195861D 02	-0.4299652085852600D 01	0.7704474832333922D 01
	0.6319480076681690D-01	-0.3117281716731952D 00	-0.1174424055886924D 00
0.0	0.3110814032450446D 00	0.1144943618141521D 00	0.2935912951623049D-01
	-0.1533176488777543D 01	0.2391734187756560D 01	0.1438357674941719D 01
	-0.7038250097322811D 00	0.1142257113444529D 00	0.9592622741333800D-01
	-0.4132516064137909D 00	-0.1824885131788302D 01	-0.7962545666734651D 00
	0.9611787908345940D 00	-0.2787940385635082D 00	-0.1208977094606108D 00
	0.4903573917925390D 00	0.1498741218221026D 01	0.6498347082341742D 00
	0.9635603436672378D 00	-0.2790725033059275D 00	-0.1208649300515515D 00
	0.4962575534249072D 00	0.1554747807530536D 01	0.6788960741694208D 00
	0.1236989219487105D 01	-0.5459472778345122D 00	-0.2837925248424181D 00
	0.6771081393730258D 00	0.1253942398576543D 01	0.5574096890417887D 00
	-0.1861002330966920D 01	-0.4610577080495737D 01	-0.1932447094717318D 01
	0.6992334985393290D 00	-0.2035634971666895D 00	-0.1044187830337789D 00
	0.4577228230467907D 01	0.7322080964849883D 01	0.2829631199723673D 01
	-0.5114611054026134D 00	0.2509479129805487D 00	0.1258874243723117D 00
	-0.1786275625770259D 02	-0.3942997000301208D 01	-0.1475239412802607D 01
	0.8743863144749950D-01	-0.3671735859788828D 00	-0.1621203813962408D 00
	-0.1421797116614291D 02	-0.2490477051142701D 02	-0.9844178452517989D 01
	0.2758029130389555D 00	-0.1322127454036963D 00	-0.6110233341751142D-01
	-0.3013370797531926D 02	-0.3049032175568310D 01	0.8168431948729586D 01
	0.5155204581539639D-01	-0.3134884258975163D 00	-0.1145106939067878D 00

APPENDIX 14 4

TAL NC CF FUNCTICN EVALUATICNS IS 137481

APPENDIX 15 1

THE SOLUTION FOR N = 3 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.69120D 08
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-09 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.3110814032384400D 00	0.1144943618248900D 00	0.2935912952265999D-01
	-0.1533176488888300D 01	0.2391734187714699D 01	0.1438357674930699D 01
	-0.7038250097351499D 00	0.1142257113358400D 00	0.9592622740956000D-01
	-0.4132516063866999D 00	-0.1824885131791099D 01	-0.7962545666766998D 00
	0.9611787908272799D 00	-0.2787940385806800D 00	-0.1208977094686400D 00
	0.4903573919907998D 00	0.1498741218202800D 01	0.6498347082384997D 00
	0.9635603437370299D 00	-0.2790725027984800D 00	-0.1208649297862200D 00
	0.4362575385148999D 00	0.1554747808922999D 01	0.6788960737466998D 00
	0.1236982219494600D 01	-0.5459472778249999D 00	-0.2837925248384000D 00
	0.6771081393609997D 00	0.1253942398580499D 01	0.5574096890440998D 00
	-0.1861002330967799D 01	-0.4610577080498100D 01	-0.1932447094718000D 01
	0.6992334985395997D 00	-0.2035634971663499D 00	-0.1044187830336800D 00
	0.4577228230469500D 01	0.7322080964855800D 01	0.2829631199724200D 01
	-0.5114611054029098D 00	0.2509479129804599D 00	0.1258874243722600D 00
	-0.1786275625770899D 02	-0.3942997000301000D 01	-0.1475239412803000D 01
	0.8743363144754000D-01	-0.3671735859790899D 00	-0.1621203813962599D 00
	-0.1421797116615100D 02	-0.2490477051143399D 02	-0.9844178452524000D 01
	0.2758029130392199D 00	-0.1322127454037100D 00	-0.6110233341756997D-01
	-0.3013370797532999D 02	-0.3049032175568000D 01	0.8168431948737999D 01
	0.5155204581538998D-01	-0.3134884258977499D 00	-0.1145106939068500D 00

APPENDIX 15 2

0.69120000000000000D 02

0.19216458297602450 01	-0.96773893674652430 00	-0.71565623329663750 00
0.30762996579139740-01	0.65636217679379860 00	0.29446861728908990 00
-0.20288551749585750 01	-0.29456822519887170-02	0.12680823618522630 00
0.95754044542672410 00	0.25965982224847210 00	0.11259433683429960 00
-0.51629379656529470 00	0.15085939531074330 01	0.65414094232789940 00
0.95560087717591900 00	0.25796569457948450 00	0.11162530273728540 00
-0.47658547833101570 00	0.14714637257783080 01	0.64018868363231520 00
-0.16509194839434320 01	0.12000501248426760-01	0.49805396230293240-01
0.27843780546162870-01	-0.11636418883415250 01	-0.53487825642485440 00
0.10770851217635930 01	-0.46635161758295470 01	-0.20269679799151840 01
0.73028771106445900 00	0.13282558312678810 00	0.60583370223550370-01
0.24085208710361300 01	0.80845336500312030 01	0.32387164558118480 01
-0.56732921326323710 00	0.12791469610534860 00	0.77436701548444400-01
-0.17444992214573330 02	-0.53940938959425600 01	-0.21169768923314830 01
0.12123866187950380 00	-0.35791122323744640 00	-0.15854177840229610 00
-0.13102874946496670 02	-0.25411628187721000 02	-0.10079863455522180 02
0.28162437229536460 00	-0.12117150787907650 00	-0.56718544702813990-01
-0.29904170741967060 02	-0.42996520858526860 01	0.77044748323397760 01
0.63194800766831600-01	-0.31172817167334180 00	-0.11744240558870170 00
0.10718638471175970 00	0.25587886916231700 00	0.12762946945453220 00
-0.31987803127815050 01	0.85336075858697260 00	0.78558079412785210 00
0.71566047252159640 00	0.12119671433867280 00	0.94180737778485513D-02
-0.32247843814723780 00	0.18050337886332480 01	0.83415954932425390 00
0.62072445972040690 00	0.70675302842623610 00	0.30646350866323120 00
-0.13670537388547400 01	0.98482153337054370 00	0.42712306297649300 00
0.62039737401313280 00	0.70897783136444950 00	0.30739027279910990 00
-0.14257314031362030 01	0.98046078397874790 00	0.41913208215555300 00
0.10712413511971160 01	0.96894319297860 70 00	0.38892018605822750 00
-0.89433781780239480 00	0.10333945088958960 01	0.49834155667717310 00
0.36484424237172500 01	-0.31835628560247060 01	-0.14570594138000890 01
0.51458739173611570 00	0.53770578569769670 00	0.21809890337563730 00
0.86051200821263400-01	0.83323915034711610 01	0.34416852468589990 01
-0.58771844013159410 00	-0.48077953498078580-02	0.23440036270259200-01
-0.16894580321116140 02	-0.68027902744597850 01	-0.27420152025420790 01
0.15371000246823110 00	-0.34600609592142370 00	-0.15378414591396090 00
-0.11965863980243760 02	-0.25573934395504960 02	-0.10297822028116860 02
0.28675086389381280 00	-0.10995281783816030 00	-0.52245552232545220-01
-0.29628255336208070 02	-0.55422379505676140 01	0.72290409938777320 01
0.74728976763620100-01	-0.30948199515773020 00	-0.12025228562869680 00

APPENDIX 15 3

OF SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-09 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OUTPUTS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.69120000000000000D 08	0.10718638471175970D 00	0.25887886916231700D 00	0.12762946945453220D 00
	-0.31987803127815050D 01	0.85336075858697260D 00	0.78558079412785210D 00
	0.71566047252159640D 00	0.12119671433867280D 00	0.94180737784855130D-02
	-0.32847843814723780D 00	0.18050337886392480D 01	0.83415954932425390D 00
	0.62072445972040690D 00	0.70675362842623610D 00	0.30646350866323120D 00
	-0.13670537388547400D 01	0.98482153337054370D 00	0.42712306297649300D 00
	0.62039737401313280D 00	0.70897783136444950D 00	0.30739027279910990D 00
	-0.14287314031362030D 01	0.98046078397874790D 00	0.41913208215555300D 00
	0.10712413511971160D 01	0.90989431929786070D 00	0.38892018605822750D 00
	-0.89433781780239480D 00	0.10333945088958960D 01	0.49834155667717310D 00
	0.36484424237172500D 01	-0.31885628560247060D 01	-0.14570594138000890D 01
	0.51458739173611570D 00	0.53770578569769670D 00	0.21809890337563730D 00
	0.86081200821263400D-01	0.83323915034711610D 01	0.34416852468589990D 01
	-0.58771844013159410D 00	-0.48077953498078580D-02	0.23440036270259200D-01
	-0.16894580321116140D 02	-0.68027902744597850D 01	-0.27420152025420790D 01
	0.15371000246825110D 00	-0.34600609592142370D 00	-0.15378414591396090D 00
	-0.11965863980243760D 02	-0.25873934395504960D 02	-0.10297822028116860D 02
	0.28675086989381280D 00	-0.10995281783816030D 00	-0.52245552232545220D-01
	-0.29628255336208070D 02	-0.55422379505676140D 01	0.72290409938777320D 01
	0.74728976763820100D-01	-0.30948199515773020D 00	-0.12025228562869680D 00

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0.1321645829755061D 01	-0.9677389367559836D 00	-0.7156562333011436D 00
0.2076299658305265D-01	0.6563621767933197D 00	0.2944661728861350D 00
-0.2028855174959037D 01	-0.2945082241790881D-02	0.1268082361898720D 00
0.9575404454484378D 00	0.2596598222436620D 00	0.1125943368323200D 00
-0.5162937901068198D 00	0.1508593953567241D 01	0.6541409425947563D 00
0.9556608753171325D 00	0.2579656964607258D 00	0.1116253034843033D 00
-0.4765855179427342D 00	0.1471463686869486D 01	0.6401886614885455D 00
-0.1650319483942477D 01	0.1200050125012925D-01	0.4980539623094858D-01
0.2784378054448127D-01	-0.1163641888342106D 01	-0.5348782564249052D 00
0.1077085121763495D 01	-0.4663516175828918D 01	-0.2026967979913199D 01
0.7302977110644503D 00	0.1828255831265942D 00	0.6058337022357657D-01
0.2408520371035766D 01	0.8084533650023597D 01	0.3238716455811686D 01
-0.5673292132631665D 00	0.1279146961053795D 00	0.7743670157061820D-01
-0.1744499221457150D 02	-0.5394093895942585D 01	-0.2116976892331433D 01
0.1212386618794912D 00	-0.3579112232372891D 00	-0.1585417784022849D 00
-0.1310287494649573D 02	-0.2541162818771744D 02	-0.1007986345551788D 02
0.2816243722952947D 00	-0.1211715078790750D 00	-0.5671854470280809D-01
-0.2990417074196497D 02	-0.4299652085852682D 01	0.7704474832337496D 01
0.6319480076681750D-01	-0.3117281716732453D 00	-0.1174424055886914D 00
0.3110614032423113D 00	0.1144943618185337D 00	0.2935912951885752D-01
-0.1533176488823272D 01	0.2391734187739495D 01	0.1438357674937192D 01
-0.7038250097305772D 00	0.1142257113510246D 00	0.9592622741613030D-01
-0.4132516064344336D 00	-0.1824885131784869D 01	-0.7962545666708684D 00
0.9611787908544116D 00	-0.2787940384642232D 00	-0.1208977094118111D 00
0.4903573893532225D 00	0.1498741218507575D 01	0.6498347082115210D 00
0.9635603429705523D 00	-0.2790725104696642D 00	-0.1208649337819113D 00
0.4962577492302464D 00	0.1554747784064009D 01	0.6788960759975048D 00
0.1236989219490865D 01	-0.5459472778305571D 00	-0.2837925248406791D 00
0.6771081393877069D 00	0.1253942398577755D 01	0.5574056890426141D 00
-0.1861002330968151D 01	-0.4610577080495745D 01	-0.1932447094715918D 01
0.6992334985394523D 00	-0.2035634971668693D 00	-0.1044187830336698D 00
0.4577228230468234D 01	0.7322080964850053D 01	0.2829631199723792D 01
-0.5114611054026061D 00	0.2509479129805847D 00	0.1258874243723439D 00
-0.1786275625770070D 02	-0.3942997000301497D 01	-0.1475239412802668D 01
0.5743863144750610D-01	-0.3671735859783374D 00	-0.1621203813962480D 00
-0.1401797118514702D 02	-0.2490477051142472D 02	-0.9844178452517126D 01
0.2758029130390472D 00	-0.1322127454036975D 00	-0.6110233341755988D-01
-0.3013370797539524D 02	-0.3049032175563348D 01	0.8168431948732178D 01
0.5155204581533039D-01	-0.3134884258975679D 00	-0.1145106939068307D 00

TAL NO OF FUNCTION EVALUATIONS IS 113542

APPENDIX 16 1

```
DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0          TO XEND = 0.69120D 08
ITH LOCAL ERROR TOLERANCE EP = 1.00000D-08 AND INITIAL STEP SIZE H = 0.86400D 05.
RINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
OR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

   THE OUTPUT COLUMNS ARE  X, Y(1), Y(2),...., Y(N)
```

0.0	0.311081403238440OD 00	0.114494361824890OD 00	0.293591295226599 9D-01
	-0.153317646888830OD 01	0.239173418771469 9D 01	0.143835767493069 9D 01
	-0.703825009735149 9D 00	0.114225711335840OD 00	0.959262274095600OD-01
	-0.413251606386699 9D 00	-0.182488513179109 9D 01	-0.796254566676699 8D 00
	0.961178790827279 9D 00	-0.278794038580680OD 00	-0.120897709468640OD 00
	0.490357391990799 8D 00	0.149874121820280OD 01	0.649834708238499 7D 00
	0.963560343737029 9D 00	-0.279072502798480OD 00	-0.120864929786220OD 00
	0.496257538514899 9D 00	0.155474780892299 9D 01	0.678896073746699 8D 00
	0.123698921949460OD 01	-0.545947277824999 9D 00	-0.283792524838400OD 00
	0.677108139360999 7D 00	0.125394239858049 9D 01	0.557409689044099 8D 00
	-0.186100233096779 9D 01	-0.461057708049810OD 01	-0.193244709471800OD 01
	0.599233498539599 7D 00	-0.203563497166349 9D 00	-0.104418783033680OD 00
	0.457722823046950OD 01	0.732208096485580OD 01	0.282963119972420OD 01
	-0.511461105402905 8D 00	0.250947912980459 9D 00	0.125887424372260OD 00
	-0.178627562577089 9D 02	-0.394299700030100OD 01	-0.147523941280300OD 01
	0.874386314475400OD-01	-0.367173585979089 9D 00	-0.162120381396259 9D 00
	-0.142179711661510OD 02	-0.249047705114339 9D 02	-0.984417845252400OD 01
	0.275802913039219 9D 00	-0.132212745403710OD 00	-0.611023334175699 7D-01
	-0.301337079753299 9D 02	-0.304903217556800OD 01	0.816843194873799 9D 01
	0.515520458153899 8D-01	-0.313488425897749 9D 00	-0.114510693906850OD 00

APPENDIX 16 2

	0.1921645829748961D 01	-0.9677389367651896D 00	-0.7156562333055083D 00
	0.2076299658033820D-01	0.6563621767939402D 00	0.294466172890766D 00
	-0.2023855174958254D 01	-0.2945682248920516D-02	0.1268082361865679D 00
	0.9575404454287843D 00	0.2596598222382838D 00	0.1125943368300320D 00
	-0.5162937966846498D 00	0.1508593952975738D 01	0.6541409422500718D 00
	0.9556608778342366D 00	0.2579656939900312D 00	0.1116253024863215D 00
	-0.4765854657459316D 00	0.1471463736962020D 01	0.6401886901179546D 00
	-0.1650919483943365D 01	0.1200050124829110D-01	0.4980539623025225D-01
	0.2784378054627139D-01	-0.1163641888341598D 01	-0.5348782564248107D 00
	0.1077085121763602D 01	-0.4663516175829667D 01	-0.2026967979915234D 01
	0.7302877110644640D 00	0.1828255831267785D 00	0.6058337022354291D-01
	0.2408520871036083D 01	0.8084533650031182D 01	0.3238716455811835D 01
	-0.5673292132632681D 00	0.1279146961053563D 00	0.7743670157059900D-01
	-0.1744499221455850D 02	-0.5394093895942553D 01	-0.2116976892331664D 01
	0.1212386618795422D 00	-0.3579112232374286D 00	-0.1585417784022837D 00
	-0.1310287494649518D 02	-0.2541162818772382D 02	-0.1007986345552204D 02
	0.2816243722953630D 00	-0.1211715078790748D 00	-0.5671854470281589D-01
	-0.2990417074196626D 02	-0.4299652085852822D 01	0.7704474832340192D 01
	0.6319480076682900D-01	-0.3117281716733359D 00	-0.1174424055887030D 00
0.6912000000000000D 08	0.1071863847063291D 00	0.2588788691636587D 00	0.1276294694558395D 00
	-0.3198780312799511D 01	0.8533607585441303D 00	0.7855807941068429D 00
	0.7156604725223390D 00	0.1211967143355803D 00	0.9418073777053460D-02
	-0.3284784381375262D 00	0.1805033788640688D 01	0.8341559493243303D 00
	0.6207244599073216D 00	0.7067536284163798D 00	0.3064635086755976D 00
	-0.1367053739329973D 01	0.9848215369680505D 00	0.4271230644914610D 00
	0.6203973613578820D 00	0.7089778302700729D 00	0.3073902710343829D 00
	-0.1428731361132629D 01	0.9804604960394697D 00	0.4191319614687406D 00
	0.1071241351195643D 01	0.9098943192938515D 00	0.3889201860586827D 00
	-0.8943378178038031D 00	0.1033394508895122D 01	0.4983415566769468D 00
	0.3648442423717226D 01	-0.3188562856024957D 01	-0.1457059413800210D 01
	0.5145873917361015D 00	0.5377057856976665D 00	0.2180989033756274D 00
	0.3608120082122390D-01	0.8332391503471554D 01	0.3441685246859118D 01
	-0.5877184401315981D 00	-0.4807795349799364D-02	0.2344003627026014D-01
	-0.1689458032110024D 02	-0.6802790274459741D 01	-0.2742015202542086D 01
	0.1537100024683174D 00	-0.3460060959213906D 00	-0.1537841459139420D 00
	-0.1196586398024989D 02	-0.2587393439550395D 02	-0.1029782202811684D 02
	0.2867508698938031D 00	-0.1099528178381568D 00	-0.5224552232546720D-01
	-0.2962825533620735D 02	-0.5542237950567598D 01	0.7229040993878018D 01
	0.7472897676382030D-01	-0.3094819951577379D 00	-0.1202522856287004D 00

APPENDIX 16 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-08 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.69120000000000000D 08	0.10718636470632291D 00	0.25887886916365870 00	0.12762946945583950 00
	-0.31987803127995110 01	0.85336075854413030 00	0.78558079410684290 00
	0.71566047252233900 00	0.12119671433558030 00	0.94180737770534600-02
	-0.32847843813752620 00	0.18050337886406880 01	0.83415549324330300 00
	0.52072445990732160 00	0.70675362841637980 00	0.30646350867559760 00
	-0.13670537393299730 01	0.58482153696805050 00	0.42712306449146100 00
	0.62039736135788200 00	0.70897783027007290 00	0.30739027103438290 00
	-0.14287313611326290 01	0.98046049603046970 00	0.41913196146874060 00
	0.10712413511956430 01	0.50989431929885150 00	0.38892018605868270 00
	-0.89433781780380810 00	0.10333945088951220 01	0.49834155667694680 00
	0.36484424237172260 01	-0.31885628560249570 01	-0.14570594138002100 01
	0.51458739173610150 00	0.53770578569766650 00	0.21809890337562740 00
	0.86081200821223900-01	0.83323915034715540 01	0.34416852468559118D 01
	-0.58771844013159810 00	-0.48077953497993640-02	0.23440036270260140-01
	-0.16894580321100240 02	-0.68027902744597410 01	-0.27420152025420860 01
	0.15371000246831740 00	-0.34600609592139060 00	-0.15378414591394200 00
	-0.11965863980240890 02	-0.25873934395503950 02	-0.10297822028116840 02
	0.28675086989380810 00	-0.10995281783815680 00	-0.52245552232546720-01
	-0.29628255336207350 02	-0.55422379505675980 01	0.72290409938780180 01
	0.74728976763820300-01	-0.30548199515773790 00	-0.12028228562870040 00

APPENDIX 16 4

0.0

0.2076299656296141D-01	0.6563621767935337D 00	0.2944686172887275D 00
-0.2022855174958720D 01	-0.2345632241869934D-02	0.1268082361897794D 00
0.9575404454597732D 00	0.2596598222794592D 00	0.1125943368485442D 00
-0.5162937956738630D 00	0.1508593954007148D 01	0.6541409428348423D 00
0.9556608733179881D 00	0.2579656982962523D 00	0.1116253041398056D 00
-0.4765855605600802D 00	0.1471463649051850D 01	0.6401886411833327D 00
-0.1659919483944551D 01	0.1290050124667918D-01	0.4980539622858167D-01
0.2784378054812741D-01	-0.1163641888340526D 01	-0.5348782564251279D 00
0.1077085121763728D 01	-0.4663516175829350D 01	-0.2026967959914948D 01
0.7302877110643754D 00	0.1828255831256823D 00	0.6058337022353811D-01
0.2408520871035818D 01	0.8084533650028900D 01	0.3238716455811778D 01
-0.5673292132631728D 00	0.1279146961053760D 00	0.7743670157060790D-01
-0.1744499221455602D 02	-0.5394093895942492D 01	-0.2116976892331515D 01
0.1212386618795299D 00	-0.3579112232373778D 00	-0.1585417784022781D 00
-0.1310237494649328D 02	-0.2541162818769034D 02	-0.1007986345558189D 02
0.2216243722952815D 00	-0.1211715078790691D 00	-0.5671854470282642D-01
-0.2990417074196445D 02	-0.4299652085852672D 01	0.7704474832337694D 01
0.6319480076682070D-01	-0.3117281716732548D 00	-0.1174424055886957D 00
0.3110814032511256D 00	0.1144943618043509D 00	0.2935912951035532D-01
-0.1533176488674933D 01	0.2391734187795389D 01	0.1438357674952155D 01
-0.7038250097319848D 00	0.1142257113467920D 00	0.9592622741429130D-01
-0.4132516064210529D 00	-0.1824885131786320D 01	-0.7962545666724001D 00
0.9611787909751840D 00	-0.2787940382888041D 00	-0.1208977093419957D 00
0.4903573935728720D 00	0.1498741218070166D 01	0.6498347083404815D 00
0.9635603446426234D 00	-0.2790724956656894D 00	-0.1208649260587883D 00
0.4962573562203512D 00	0.1554747833255374D 01	0.6788960714170567D 00
0.1236983219494513D 01	-0.5459472778228146D 00	-0.2837925248369975D 00
0.6771081393593086D 00	0.1253942398581891D 01	0.5574096890459514D 00
-0.1861002330967101D 01	-0.4610577080496957D 01	-0.1932447094717449D 01
0.6992334985394332D 00	-0.2035634971665663D 00	-0.1044187230337322D 00
0.4577228230469208D 01	0.7322080964850157D 01	0.2829631199723831D 01

-0.5114611054026681D 00	0.2509479129805609D 00	0.1258874243723188D 00
-0.1786275625769033D 02	-0.3942997000300918D 01	-0.1475239412802658D 01
0.8743863144734540D-01	-0.3671735859789617D 00	-0.1621203813962538D 00
-0.1421797116614550D 02	-0.2490477051139755D 02	-0.9844178452580995D 01
0.2758029130390530D 00	-0.1322127454036894D 00	-0.6110233341760492D-01
-0.3013370797532028D 02	-0.3049032175568151D 01	0.8158431948734626D 01
0.5155204581536658D-01	-0.3134884258975739D 00	-0.1145106939068373D 00

TAL NO OF FUNCTION EVALUATIONS IS 95391

HEAD UNIVERSITY COMPUTER CENTER

APPENDIX 17

```
 DE SOLUTICN FOR N =60 EQUATICNS FROM XSTART = 0.0          TO XEND = 0.69120D 08
ITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H = 0.86400D 05.
RINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
OR K=0,1,... AND SP = 0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

     THE OUTPUT COLUMNS ARE  X, Y(1), Y(2),..., Y(N)

 0.0                 0.3110814032384400D 00   0.1144943618248900D 00   0.2935912952265999D-01
                    -0.1533176488888300D 01   0.2391734187714699D 01   0.1438357674930699D 01
                    -0.7038250097351499D 00   0.1142257113358400D 00   0.9592622740956000D-01
                    -0.4132516063866999D 00  -0.1824885131791099D 01  -0.7962545566766998D 00
                     0.9611787908272799D 00  -0.2787940385806800D 00  -0.1208977094686400D 00
                     0.4903573919907998D 00   0.1498741218202800D 01   0.6498347082384997D 00
                     0.9635603437370299D 00  -0.2790725027984800D 00  -0.1208649297862200D 00
                     0.4962575385148999D 00   0.1554747808922999D 01   0.6788960737466998D 00
                     0.1236989219494600D 01  -0.5459472778249999D 00  -0.2837925248384000D 00
                     0.6771081393609997D 00   0.1253942398580499D 01   0.5574096890440998D 00
                    -0.1861002330967799D 01  -0.4610577080498100D 01  -0.1932447094718000D 01
                     0.6992334985395997D 00  -0.2035634971663499D 00  -0.1044187830336800D 00
                     0.4577228230469500D 01   0.7322080964855800D 01   0.2829631199724200D 01
                    -0.5114611054029098D 00   0.2509479129804599D 00   0.1258874243722600D 00
                    -0.1786275625770899D 02  -0.3942997000301000D 01  -0.1475239412803000D 01
                     0.8743863144754000D-01  -0.3671735859790899D 00  -0.1621203913962599D 00
                    -0.1421797116615100D 02  -0.2490477051143399D 02  -0.9844178452524000D 01
                     0.2758029130392199D 00  -0.1322127454037100D 00  -0.6110233341756997D-01
                    -0.3013370797532999D 02  -0.3049032175568000D 01   0.8168431948737999D 01
                     0.5155204581538998D-01  -0.3134884258977499D 00  -0.11451[illegible]69390685000D 00
```

APPENDIX 17 2

	0.20762996685156330-01	0.65636217683709710 00	0.29446861728791840 00
	-0.20288551748391240 01	-0.29456316419802450-02	0.12680823642906010 00
	0.95754044543800870 00	0.25965982221403660 00	0.11259433682090930 00
	-0.51629379646627710 00	0.15085939531562020 01	0.65414094235094790 00
	0.95566085771249843D 00	0.25796569461141650 00	0.11162530275174400 00
	-0.47658547935767590 00	0.14714637245606040 01	0.64018863289965620 00
	-0.16509194839531630 01	0.12000501214176390-01	0.49805396214781570-01
	0.27843780577558230-01	-0.11636418883365320 01	-0.53487825642356360 00
	0.10770851217203270 01	-0.46635161758282330 01	-0.20269679799145640 01
	0.73028771106785870 00	0.13282558312716190 00	0.60583370222619730-01
	0.24085208709914260 01	0.80845336500318970 01	0.32387164558123720 01
	-0.56732921326109530 00	0.12791469610529290 00	0.77436701569485900-01
	-0.17444992214617130 02	-0.53940938959411280 01	-0.21169768923309290 01
	0.12123866188139040 00	-0.35791122323723700 00	-0.15854177840329750 00
	-0.13102874946539240 02	-0.25411628187721650 02	-0.10079863455523510 02
	0.23162437229730100 00	-0.12117150787886750 00	-0.56718544703817980-01
	-0.29904170742011370 02	-0.42996520858512360 01	0.77044748323349010 01
	0.63194800768759100-01	-0.31172817167309760 00	-0.11744240558969720 00
0.69120000000000000D 08	0.10699257365969090 00	0.25887412946951020 00	0.12765578507779890 00
	-0.32004068041422150 01	0.85129942785714650 00	0.78466544423239580 00
	0.71566047235975880 00	0.12119671398632080 00	0.94180736328924410-02
	-0.32847843782160000 00	0.18050337885545910 01	0.83415954922298520 00
	0.62072445964592750 00	0.70675362845512370 00	0.30646350868032050 00
	-0.13670537391120900 01	0.98482153307435980 00	0.42712306284994640 00
	0.62039737386275600 00	0.70897783139500510 00	0.30739027281153970 00
	-0.14287314029368540 01	0.98046078229862430 00	0.41913209149002270 00
	0.10712413513283060 01	0.90989431926755920 00	0.38892018604462310 00
	-0.89433781786078060 00	0.10333945086255660 01	0.49834155655265720 00
	0.36484424237178010 01	-0.31885628560193870 01	-0.14570594137929700 01
	0.51458739153104830 00	0.53770578535509660 00	0.21809890322349710 00
	0.86081200813058400-01	0.83323915034666200 01	0.34416852468623810 01
	-0.58771844033865150 00	-0.48077956949282800-02	0.23440036117024150-01
	-0.16894580321124810 02	-0.68027902744613720 01	-0.27420152025377170 01
	0.15371000226051070 00	-0.34600609626617360 00	-0.15378414606696690 00
	-0.11965863980250300 02	-0.25873934395509340 02	-0.10297822028114450 02
	0.28675086968616400 00	-0.10995281818271190 00	-0.52245552385541310-01
	-0.29628255336217290 02	-0.55422379505692200 01	0.72290409938776550 01
	0.74728976556211600-01	-0.30948199550224580 00	-0.12025228578166940 00

APPENDIX 17 3

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.69120D 08 TO XEND = 0.0
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H =-0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1,... AND SP =-0.34560D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.6912000000000000D 08	0.1069025736596909D 00	0.2588741294695102D 00	0.1276557850777989D 00
	-0.3200406804142215D 01	0.8512994278571465D 00	0.7846654442323958D 00
	0.7156604723597588D 00	0.1211967139863208D 00	0.9418073632892441D-02
	-0.3284784378216000D 00	0.1805033788554591D 01	0.8341595492229852D 00
	0.6207244596459275D 00	0.7067536284551237D 00	0.3064635086803205D 00
	-0.1367053739112090D 01	0.9848215330743598D 00	0.4271230628499464D 00
	0.6203973738627560D 00	0.7089778313950051D 00	0.3073902728115397D 00
	-0.1428731402936854D 01	0.9804607822986243D 00	0.4191320814900227D 00
	0.1071241351328306D 01	0.9098943192675592D 00	0.3889201960446231D 00
	-0.8943378178607806D 00	0.1033394508625566D 01	0.4983415565526972D 00
	0.3648442423717801D 01	-0.3188562856019387D 01	-0.1457059413792970D 01
	0.5145873915310483D 00	0.5377057853550966D 00	0.2180989032234971D 00
	0.8608120081305840D-01	0.8332391503466620D 01	0.3441685246862381D 01
	-0.5877184403385515D 00	-0.4807795694928280D-02	0.2344003611702415D-01
	-0.1689458032112481D 02	-0.6802790274461372D 01	-0.2742015202537717D 01
	0.1537100022605107D 00	-0.3460060962661736D 00	-0.1537841460669669D 00
	-0.1196586398025030D 02	-0.2587393439550934D 02	-0.1029782202811445D 02
	0.2867508696861640D 00	-0.1099528181827119D 00	-0.5224555238554131D-01
	-0.2962825533621729D 02	-0.5542237950569220D 01	0.7229040993877655D 01
	0.7472897655621160D-01	-0.3094819955022458D 00	-0.1202522857816694D 00

APPENDIX 17 4

0.0

0.20762996886720220D-01	0.65636217683662540 00	0.29446861728761250 00
-0.20288551748399840 01	-0.29456816375784110-02	0.12680823643108650 00
0.95754044543661000 00	0.25965982221166700 00	0.11259433681984600 00
-0.51629379650397560 00	0.15085939531156990 01	0.65414094232773110 00
0.95566087730088490 00	0.25796569443734560 00	0.11162530268573130 00
-0.47658547565975380 00	0.14714637280233030 01	0.64018868487818510 00
-0.16509194839523940 01	0.12000501216285020-01	0.49805396215693100-01
0.27843780575717820-01	-0.11636418883368630 01	-0.53487825642365380 00
0.10770851217202060 01	-0.46635161758277410 01	-0.20269679799143320 01
0.73028771106781860 00	0.18282558312702590 00	0.60583370222600800-01
0.24085208709910810 01	0.80845336500279390 01	0.32387164558119240 01
-0.56732921326098090 00	0.12791469610533690 00	0.77436701569509700-01
-0.17444992214612130 02	-0.53940938959409280 01	-0.21169768923307230 01
0.12123866188137410 00	-0.35791122323729750 00	-0.15854177840328430 00
-0.13102874946334980 02	-0.25411628187718300 02	-0.10079863455519640 02
0.28162437229714960 00	-0.12117150787886590 00	-0.56718544703809130-01
-0.29904170742007760 02	-0.42996520858520150 01	0.77044748323332560 01
0.63194800768757800-01	-0.31172817167303510 00	-0.11744240558968370 00
0.31108140324459120 00	0.11449436181486150 00	0.29359129516652700-01
-0.15331764887849460 01	0.23917341877538110 01	0.14383576749410320 01
-0.70382500973049720 00	0.11422571134966770 00	0.95926227415506400-01
-0.41325160643042480 00	-0.18248851317858130 01	-0.79625456667199780 00
0.96117879083507340 00	-0.27879403856233530 00	-0.12089770946010030 00
0.49035739179358650 00	0.14987412182214990 01	0.64983470823470070 00
0.96356034366593900 00	-0.27907250329427970 00	-0.12086493004575590 00
0.49625755313425180 00	0.15547478075526960 01	0.67889607415299120 00
0.12369892194906300 01	-0.54594727783052300 00	-0.28379252484075690 00
0.67710813936789080 00	0.12539423985778980 01	0.55740968904265680 00
-0.18610023309674580 01	-0.46105770804963730 01	-0.19324470947172500 01
0.69923349853939750 00	-0.20356349716664200 00	-0.10441878303376100 00
0.45772282304612000 01	0.73220809648471840 01	0.28296311997233510 01
-0.51146110540260920 00	0.25094791298067510 00	0.12588742437238340 00
-0.17862756257699850 02	-0.35425970003004620 01	-0.14752394128026480 01
0.87438631447494400-01	-0.36717358597903880 00	-0.16212033139623670 00
-0.14217971166142710 02	-0.24904770511427000 02	-0.98441784525202010 01
0.27580291303894070 00	-0.13221274540370270 00	-0.61102333417554920-01
-0.30133707975324670 02	-0.30490321755690440 01	0.81684319487266670 01
0.51552045815372010-01	-0.31348842589756460 00	-0.11451069390682980 00

TAL NC OF FUNCTICN EVALUATICNS IS 138421

APPENDIX 18 . B 1

DE SOLUTION FOR N =60 EQUATIONS FROM XSTART = 0.0 TO XEND = 0.19699D 10
WITH LOCAL ERROR TOLERANCE EP = 1.00000D-10 AND INITIAL STEP SIZE H = 0.86400D 05.
PRINTING OCCURS AT EACH NATURAL STEP IN TIME AND AT SPECIFIED POINTS (XSTART+K*SP)
FOR K=0,1.... AND SP = 0.17280D 08 (SPECIFIED POINTS ARE IDENTIFIED WITH *).

THE OUTPUT COLUMNS ARE X, Y(1), Y(2),...., Y(N)

0.0	0.3014126682538900D 00	0.1265949471782200D 00	0.3784152564681999D-01
	-0.1681668076098099D 01	0.2333460037844399D 01	0.1422459237170899D 01
= 1913 AUGUST 21d.0UT	0.5359773796741900D 00	0.4544720093036000D 00	0.1708366717263000D 00
	0.1363414227993999D 01	0.1328526692131599D 01	0.6845979909916997D 00
	0.8561969833230699D 00	-0.4940630457237899D 00	-0.2143090507623300D 00
	0.8879834391806997D 00	0.1330002537802799D 01	0.5768781098963997D 00
	0.8588336752475199D 00	-0.4935399919452299D 00	-0.2139978024915200D 00
	0.8744280088090997D 00	0.1377761306977399D 01	0.6028704705911998D 00
	0.1205405982723599D 01	0.7272027017407000D 00	0.3012692776955000D 00
	-0.7092835268748998D 00	0.1165604376444299D 01	0.5541349661213998D 00
	0.1541370620191500D 01	-0.4524995863662500D 01	-0.1979172257169800D 01
	0.7124662329599998D 00	0.2456541072521799D 00	0.8796486314030000D-01
	0.2921471196571600D 01	0.7953605765225499D 01	0.3161587848402500D 01
	-0.5578190953901898D 00	0.1571326847358200D 00	0.8904565749596000D-01
	0.1174557044808400D 02	-0.1457166410026400D 02	-0.6551175794430000D 01
	0.3142105227680799D 01	0.1985913565926599D 00	0.8256797677439000D-01
	-0.1335274430240300D 02	0.2472563582378999D 02	0.1046458160766700D 02
	-0.2823271047024099D 00	-0.1298339633633900D 00	-0.4606982260126997D-01
	-0.1968083804770000D 00	0.4267739127085600D 02	0.1353916517083800D 02
	-0.2240184739979899D 00	-0.6860971572225000D-01	0.4640707700420958D-01
0.1831680000000000D 10	0.3110594086642583D 00	0.1145175302068891D 00	0.2937379539286403D-01
	-0.1533424327620864D 01	0.2391697865272904D 01	0.1438363682861081D 01
= 1971 SEPT. 6d.0 UT	-0.7038251212589963D 00	0.1142255420763392D 00	0.9592615813677220D-01
	-0.4132512698289209D 00	-0.1824884596908958D 01	-0.7962545272793743D 00
	0.9611785331930000D 00	-0.2787942448427997D 00	-0.1208977860803314D 00
	0.4903548853823926D 00	0.1498741685851408D 01	0.6498346154713371D 00
	0.9635590272749183D 00	-0.2790818541366114D 00	-0.1208701180933758D 00
	0.4965135466520003D 00	0.1554716762794207D 01	0.6789065752632285D 00
	0.1236990044086219D 01	-0.5459457259081769D 00	-0.2837918345997245D 00
	0.6771068775513574D 00	0.1253942969840599D 01	0.5574099851417444D 00
	-0.1861002346401783D 01	-0.4610577037628110D 01	-0.1932447075847635D 01
	0.6992335032837503D 00	-0.2035634994886706D 00	-0.1044187841180473D 00
	0.4577228160424188D 01	0.7322080989152762D 01	0.2829631212793234D 01
	-0.5114611077902946D 00	0.2509479103354469D 00	0.1258874233844928D 00
	-0.1786275625966163D 02	-0.3942997007829721D 01	-0.1475239416107365D 01
	0.8743863144564300D-01	-0.3671735859306097D 00	-0.1621203813716868D 00
	-0.1421797116650465D 02	-0.2490477051194110D 02	-0.9844178452665191D 01
	0.2758029129981776D 00	-0.1322127454194239D 00	-0.6110233342[illegible]8069D-01
	-0.3013370797744436D 02	-0.3049032180856080D 01	0.81684319[illegible]1324D 01
	0.5155204575554061D-01	-0.3134884259445574D 00	-0.1145106939137084D 00

APPENDIX 18 B 2

0.1866240000000000D 10 = 1972 OCT. $10^{d}.0$ UT

-0.2164618804953057D 00	-0.3695237574716468D 00	-0.1756576024042961D 00
0.1921653326333662D 01	-0.9676931172518284D 00	-0.7156324689847362D 00
0.2076280916520111D-01	0.6563621040024267D 00	0.2944685963623036D 00
-0.2028855407276674D 01	-0.2945933153870781D-02	0.1268081376538628D 00
0.9575404203638395D 00	0.2596595143096504D 00	0.1125942088438092D 00
-0.5162917656674539D 00	0.1508595865564750D 01	0.6541421180808676D 00
0.9556538700395069D 00	0.2579719333612767D 00	0.1116274566121395D 00
-0.4767276461590455D 00	0.1471338848702895D 01	0.6401063944678061D 00
-0.1650919236355247D 01	0.1200078642917819D-01	0.4980552046520972D-01
0.2784396423075109D-01	-0.1163642069606783D 01	-0.5348783445680665D 00
0.1077085129958320D 01	-0.4663516130617607D 01	-0.2026967960538504D 01
0.7302877168272827D 00	0.1828255870222619D 00	0.6058337176803060D-01
0.2408520793505999D 01	0.8084533662324767D 01	0.3238716464244146D 01
-0.5673292146028916D 00	0.1279146928110271D 00	0.7743670026827920D-01
-0.1744499221640387D 02	-0.5394093903231677D 01	-0.2116976895532594D 01
0.1212386619010958D 00	-0.3579112231613681D 00	-0.1585417783683963D 00
-0.1310287494684872D 02	-0.2541162818827669D 02	-0.1007986345567837D 02
0.2816243722960336D 00	-0.1211715078761352D 00	-0.5671854470073770D-01
-0.2990417074415883D 02	-0.4299652091296808D 01	0.7704474831004964D 01
0.6319480074717980D-01	-0.3117281716992093D 00	-0.1174424055890476D 00

0.1900800000000000D 10 = 1973 NOV. $14^{d}.0$ UT

0.1071463534453097D 00	0.258888284636441D 00	0.1276389141385161D 00
-0.3198899032205192D 01	0.8530954091575027D 00	0.7854508917970798D 00
0.7156603914275266D 00	0.1211965915272549D 00	0.9418023614309227D-02
-0.3284783310365525D 00	0.1805034067838477D 01	0.8341596684621304D 00
0.6207242618594275D 00	0.7067535180257447D 00	0.3064634423036578D 00
-0.1367053343272213D 01	0.9848190379761512D 00	0.4271220337716970D 00
0.6204071793781118D 00	0.7089781826592158D 00	0.3073918503686383D 00
-0.1428767792464231D 01	0.9806878372435912D 00	0.4192263706844409D 00
0.1071240949347834D 01	0.9098954647848427D 00	0.3889207226531664D 00
-0.8943382138071716D 00	0.1033393604706842D 01	0.4983411522493610D 00
0.3648442443265316D 01	-0.3188562784655061D 01	-0.1457059383458562D 01
0.5145873905158126D 00	0.5377057937604362D 00	0.2180989068572912D 00
0.8608112035858390D-01	0.8332391501892662D 01	0.3441685249687068D 01
-0.5877184402508003D 00	-0.4807798951854450D-02	0.2344003478276351D-01
-0.1689458032292184D 02	-0.6802790281453313D 01	-0.2742015205612211D 01
0.1537100024416679D 00	-0.3460060958873328D 00	-0.1537841459009487D 00
-0.1196586398061414D 02	-0.2587393439607030D 02	-0.1029782202827481D 02
0.2867508698664533D 00	-0.1099528178829799D 00	-0.5224555225420625D-01
-0.2962825533850399D 02	-0.5542237956131788D 01	0.7229040992532324D 01
0.7472897671426520D-01	-0.3094819952291349D 00	-0.1202522856512674D 00

= 1975 JULY 7d.OUT

APPENDIX 18 B 3

= 1976 JAN. 23d.OUT

```
0.1952640000000000D 10   0.3580636557467855D 00  -0.7629126381179080D-01  -0.7763554543234620D-01
                         0.2166342982079826D 00   0.2521568524587962D 01   0.1327951232581908D 01
                        -0.2278654377396116D 00  -0.6335686978831496D 00  -0.2711235214730905D 00
                         0.1906473291715786D 01  -0.5429467439854474D 00  -0.3650719766563802D 00
                         0.2447547326684251D 00  -0.9053889319202418D 00  -0.3925952995921230D 00
                         0.1642455597263842D 01   0.3742157907327996D 00   0.1623236138151982D 00
                         0.2453913011227849D 00  -0.9031157820249755D 00  -0.3916758467689299D 00
                         0.1583720644706904D 01   0.3868021932953772D 00   0.1622204139258748D 00
                         0.1364188845950968D 01  -0.2031373450927703D 00  -0.1298399615534209D 00
                         0.2958204754567344D 00   0.1363985844290502D 01   0.6181621504189882D 00
                         0.4872648170257767D 01   0.6536257936163610D 00   0.2471180024906894D 00
                        -0.1429960401271596D 00   0.7142644099244056D 00   0.3099140342657323D 00
                        -0.3363348015312384D 01   0.7706910608267444D 01   0.3332272861626394D 01

                        -0.5482586057273394D 00  -0.2009226465318519D 00  -0.5936819353664243D-01
                        -0.1583316807619868D 02  -0.8814643190022577D 01  -0.3638549126663989D 01
                         0.1994846307151182D 00  -0.3237801739180461D 00  -0.1446866113767260D 00
                        -0.1022525226586702D 02  -0.2648312010295147D 02  -0.1059109086304369D 02
                         0.2932426215245933D 00  -0.9312120637650020D-01  -0.4551195052081741D-01
                        -0.2912838716988476D 02  -0.7387448892885744D 01   0.6495194278181383D 01
                         0.9189015182622780D-01  -0.3054654461106500D 00  -0.1243395382116470D 00
0.1969920000000000D 10  -0.1636247847415748D 00   0.2381723765660813D 00   0.1443582739184913D 00
                        -0.2985140616230615D 01  -0.1274767300674314D 01  -0.3760770451265466D 00
                        -0.6104475376706533D 00  -0.3653888397962530D 00  -0.1261124962345273D 00
                         0.1065513887577085D 01  -0.1543574316934863D 01  -0.7628978870649721D 00
                        -0.5177463337941513D 00   0.7679422713259385D 00   0.3329967347608214D 00
                        -0.1491453316242526D 01  -0.8352878046865768D 00  -0.3622432647950139D 00
                        -0.5200800551496317D 00   0.7672512129390083D 00   0.3325799072069835D 00
                        -0.1473057956365821D 01  -0.8905413230856378D 00  -0.3811559605214446D 00
                        -0.3139024892080843D 00   0.1421118829959697D 01   0.6607423918975399D 00
                        -0.1317229118775075D 01  -0.1554275229545391D 00  -0.3600988475446260D-01
                         0.4355692459707933D 01   0.2217800315430902D 01   0.8449829823157661D 00
                        -0.3695814261794688D 00   0.6388676448231574D 00   0.2831063558110403D 00
                        -0.4403596543030850D 01   0.7244634533939224D 01   0.3187267359184316D 01
                        -0.5173624474427334D 00  -0.2606783425355638D 00  -0.8541870828773570D-01
                        -0.1541972810643659D 02  -0.9453818336765988D 01  -0.3924449417116025D 01
                         0.2138963219431845D 00  -0.3153234413572125D 00  -0.1411818281582600D 00
                        -0.9636865266051392D 01  -0.2666378162694996D 02  -0.1067987787465886D 02
                         0.2951389305340469D 00  -0.8755617503353390D-01  -0.4328221953400820D-01
                        -0.2893889584767776D 02  -0.7996900968311918D 01   0.6245178977655379D 01
                         0.9761368263537690D-01  -0.3039863408541074D 00  -0.1256793136486888D 00

TAL NO OF FUNCTION EVALUATIONS IS 535440
```

0.1952640000000000D 10	0.3580636557467855D 00	-0.7629126381179080D-01	-0.7763554543234620D-01
	0.2166342582079826D 00	0.2521568524587962D 01	0.1327951232581908D 01
	-0.2278654377396116D 00	-0.6335686978831496D 00	-0.2711235214730905D 00
	0.1906473291715786D 01	-0.5429467439854474D 00	-0.3650719766563802D 00
= 1975 JULY 7d.OUT	0.2447547326684251D 00	-0.9053889319202418D 00	-0.3925952995921230D 00
	0.1642455597263842D 01	0.3742157907327996D 00	0.1623236138151982D 00
	0.2453913011227849D 00	-0.9031157820249755D 00	-0.3916758467689299D 00
	0.1583720644706904D 01	0.3868021932953772D 00	0.1622204139258748D 00
	0.1364188845950968D 01	-0.2031373450927703D 00	-0.1298399615534209D 00
	0.2958204754967344D 00	0.1363985844290502D 01	0.6181621504189882D 00
	0.4872648170257767D 01	0.8536257936163610D 00	0.2471180024906894D 00
	-0.1429960401271596D 00	0.7142644099244056D 00	0.3099140342657323D 00
	-0.3363348015312384D 01	0.7706910608267444D 01	0.3332272861626394D 01
	-0.5482586057273394D 00	-0.2009226465318519D 00	-0.5936819353664243D-01
	-0.1583316807619868D 02	-0.8814643190022577D 01	-0.3638549126663989D 01
APPENDIX 18 B 3	0.1994846307151182D 00	-0.3237801739180461D 00	-0.1446866113767260D 00
	-0.1022525222686702D 02	-0.2648312010295147D 02	-0.1059109066304369D 02
	0.2932426215245933D 00	-0.9312120637650020D-01	-0.4551195052081741D-01
	-0.2912838716988476D 02	-0.7387448892885744D 01	0.6495194278181383D 01
	0.9189015182622780D-01	-0.3054654461106500D 00	-0.1243395382116470D 00
0.1969920000000000D 10	-0.1636247847415748D 00	0.2381723765660813D 00	0.1443582739184913D 00
	-0.2985140616230615D 01	-0.1274767300674314D 01	-0.3760770451265466D 00
	-0.6104475376706533D 00	-0.3653888397962530D 00	-0.1261124962345273D 00
	0.1065513887577085D 01	-0.1543574316934863D 01	-0.7628978870649721D 00
= 1976 JAN.23d.OUT	-0.5177463337941513D 00	0.7679422713259385D 00	0.3329967347608214D 00
	-0.1491453316242526D 01	-0.8352878046865768D 00	-0.3622432647950139D 00
	-0.5200800551496317D 00	0.7672512129390083D 00	0.3325799072069835D 00
	-0.1473057956365821D 01	-0.8905413230856378D 00	-0.3811559605214446D 00
	-0.3139024892080843D 00	0.1421118829959697D 01	0.6607423918975399D 00
	-0.1317229118775075D 01	-0.1554275229545391D 00	-0.3600988475446260D-01
	0.4355692459707933D 01	0.2217800315430902D 01	0.8449829823157661D 00
	-0.3695814261794688D 00	0.6388676448231574D 00	0.2831063558110403D 00
	-0.4430359654303085D 01	0.7244634533939224D 01	0.3187267359184316D 01
	-0.5173624474427334D 00	-0.2606783425355638D 00	-0.8541870828773570D-01
	-0.1541972810643659D 02	-0.9453818336765988D 01	-0.3924449417116025D 01
	0.2138963219431845D 00	-0.3153234413572125D 00	-0.1411818281582600D 00
	-0.9636865266051392D 01	-0.2666378162694996D 02	-0.1067987787465886D 02
	0.2951389305340469D 00	-0.8755617503353390D-01	-0.4328221953400820D-01
	-0.2893889584767776D 02	-0.7996900968311918D 01	0.6245178977655379D 01
	0.9761368263537690D-01	-0.3039863408541074D 00	-0.1256793136486888D 00

TAL NO OF FUNCTION EVALUATIONS IS 535440

APPENDIX 1 C

X	Y	$\dot{X}$	$\dot{Y}$
1.0000000000000000	0.0	0.0	1.0000000000000000
0.9999999999998341	0.0000000000011359	-0.0000000000011352	1.0000000000000830
0.9999999999996569	0.0000000000038470	-0.0000000000038467	1.0000000000001650
0.9999999999995010	0.0000000000081332	-0.0000000000081332	1.0000000000002480
0.9999999999993334	0.0000000000139943	-0.0000000000139941	1.0000000000003320
0.9999999999991655	0.0000000000214302	-0.0000000000214305	1.0000000000004160
0.9999999999989979	0.0000000000304513	-0.0000000000304514	1.0000000000005000
0.9999999999988304	0.0000000000410424	-0.0000000000410428	1.0000000000005840
0.9999999999986641	0.0000000000532126	-0.0000000000532122	1.0000000000006670
0.9999999999984981	0.0000000000669447	-0.0000000000559441	1.0000000000007510
0.9999999999983302	0.0000000000822442	-0.0000000000822435	1.0000000000008350

APPENDIX 4 C

X	Y	Ẋ	Ẏ
0.9999999999974046	0.0000000000222705	-0.0000000000222710	1.0000000000012980
0.9999999999948163	0.0000000000689717	-0.0000000000689723	1.0000000000025910
0.9999999999922203	0.0000000001401020	-0.0000000001401052	1.0000000000038900
0.9999999999896218	0.0000000002356920	-0.0000000002356957	1.0000000000051900
0.9999999999870256	0.0000000003557631	-0.0000000003557681	1.0000000000064870
0.9999999999844220	0.0000000005003560	-0.0000000005003590	1.0000000000077900
0.9999999999818192	0.0000000006694632	-0.0000000006694667	1.0000000000090920
0.9999999999792174	0.0000000008630632	-0.0000000008630685	1.00000000001[illegible]0
0.9999999999766136	0.0000000010811774	-0.0000000010811833	1.0000000000116970
0.9999999999740173	0.0000000013237853	-0.0000000013237924	1.0000000000129970

APPENDIX 5 A 1

```
//RMARNOO5 JCE '1610125,0010,3,,,1,,60','R. D. NORTH',TYPRUN=HOLD,
// CLASS=D,MSGLEVEL=(1,1)
// EXEC FORTHCLG,PARM.FORT='OPT=2,ID'
XXFORT    EXEC  PGM=IEKAA00,REGION=250K
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(2,5))
XXSYSPUNCH DD   SYSOUT=B,SPACE=(CYL,(0,5))
XXSYSUT1   DD   UNIT=2314,DCB=(RECFM=F,BLKSIZE=105),SPACE=(CYL,(1,5))
XXSYSUT2   DD   UNIT=2314,DCB=(RECFM=F,BLKSIZE=1024),SPACE=(CYL,(1,5))
XXSYSLIN   DD   DSN=&LOADSET,UNIT=2314,DISP=(MOD,PASS),SPACE=(CYL,(2,5))
//FORT.SYSIN DD *
IEF236I ALLOC. FOR RMARNOO5 FORT
IEF237I 365   ALLOCATED TO SYSPRINT
IEF237I 330   ALLOCATED TO SYSPUNCH
IEF237I 130   ALLOCATED TO SYSUT1
IEF237I 135   ALLOCATED TO SYSUT2
IEF237I 136   ALLOCATED TO SYSLIN
IEF237I 310   ALLOCATED TO SYSIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74066.T090324.RV000.RMARNOO5.R0001193      DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74066.T090324.RV000.RMARNOO5.R0001194      DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74066.T090324.RV000.RMARNOO5.LOADSET       PASSED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /FORT     / START 74066.2211
IEF374I STEP /FORT     / STOP  74066.2213 CPU   0MIN 33.45SEC MAIN 248K
CHARGE    $          2.09 CPU TIME 00.00.33   REGION REQUESTED 0250K   STA
                     DISK    READER   PRINTER   PUNCH
I/O COUNTS            42       78       85        0
NO. OF DD CARDS        3        1        1        1
XXLKED    EXEC  PGM=IEWL,REGION=96K,PARM=(MAP,LET,LIST),COND=(4,LT,FORT)
XXSYSLIB   DD   DSN=SYS1.FORTLIB,DISP=SHR
XX         DD   DSN=FORTSUB,DISP=SHR
XXSYSPRINT DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXSYSUT1   DD   SPACE=(CYL,(2,5)),UNIT=2314
XXSYSLMOD  DD   DSN=&GOSET(MAIN),DISP=(,PASS),UNIT=2314,
XX              SPACE=(CYL,(2,,1))
XXSYSLIN   DD   DSN=&LOADSET,DISP=(OLD,DELETE)
XX         DD   DDNAME=SYSIN
IEF236I ALLOC. FOR RMARNOO5 LKED
IEF237I 131   ALLOCATED TO SYSLIB
IEF237I 132   ALLOCATED TO
IEF237I 365   ALLOCATED TO SYSPRINT
IEF237I 130   ALLOCATED TO SYSUT1
IEF237I 135   ALLOCATED TO SYSLMOD
IEF237I 136   ALLOCATED TO SYSLIN
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS1.FORTLIB                                  KEPT
IEF285I   VOL SER NOS= MVT217.
IEF285I   FORTSUB                                       KEPT
IEF285I   VOL SER NOS= MVTRIF.
IEF285I   SYS74066.T090324.RV000.RMARNOO5.R0001197      DELETED
IEF285I   VOL SER NOS= SPLU06.
IEF285I   SYS74066.T090324.RV000.RMARNOO5.GOSET         PASSED
IEF285I   VOL SER NOS= ADMP03.
IEF285I   SYS74066.T090324.RV000.RMARNOO5.LOADSET       DELETED
IEF285I   VOL SER NOS= SPLU03.
IEF373I STEP /LKED     / START 74066.2213
IEF374I STEP /LKED     / STOP  74066.2214 CPU   0MIN 07.25SEC MAIN  68K I
CHARGE    $          0.67 CPU TIME 00.00.07   REGION REQUESTED 0096K   STA
```

APPENDIX 5 A 2

```
                      DISK    READER   PRINTER
I/O COUNTS             156       0        39
NC. CF DD CARDS          5       1         1
XXGC      EXEC  PGM=*.LKED.SYSLMOD,COND=((4,LT,FORT),(4,LT,LKED))
XXFTC5F001 DD   DDNAME=SYSIN
XXFTC6F001 DD   SYSOUT=A,SPACE=(CYL,(1,1))
XXFTC7F001 DD   SYSOUT=B,SPACE=(CYL,(0,5))
//
IEF236I ALLOC. FOR RMARN005 GO
IEF237I 135   ALLOCATED TO PGM=*.DD
IEF237I 365   ALLOCATED TO FT06F001
IEF237I 330   ALLOCATED TO FT07F001
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS74066.T090324.RV000.RMARN005.GOSET          PASSED
IEF285I   VOL SER NOS= ADMP03.
IEF373I STEP /GO       / START 74066.2214
IEF374I STEP /GO       / STOP  74066.2224 CPU    2MIN 14.90SEC MAIN  28K
CHARGE    $          4.36 CPU TIME 00.02.15   REGION REQUESTED 0062K   STA
                      DISK    READER   PRINTER   PUNCH
I/C COUNTS               0       0        11       0
NO. CF DD CARDS          1       1         1       1
IEF285I   SYS74066.T090324.RV000.RMARN005.GOSET          DELETED
IEF285I   VOL SER NOS= ADMP03.
IEF375I  JOB /RMARN005/ START 74066.2211
IEF376I  JOB /RMARN005/ STOP  74066.2224 CPU    2MIN 55.60SEC
RMARN005 JOB CHARGE $        7.89
```

APPENDIX 5 G 1

LEVEL 21.7 (JAN 73)   OS/360   FORTRAN H

```
                    COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                                          SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDI
  ISN 0002                  IMPLICIT REAL*8(A-H,O-Z)
  ISN 0003                  PI=3.14159265358979323846D0
  ISN 0004                  X1=1
  ISN 0005                  Y1=0
  ISN 0006                  DX1=0
  ISN 0007                  DY1=1
  ISN 0008                  WRITE(6,2)X1,Y1,DX1,DY1
  ISN 0009                  FORMAT(' '   ,4F30.16)
  ISN 0010                  H  =PI*32D-4
  ISN 0011                  NN=625
  ISN 0012                  H2=H*H
  ISN 0013                  A1=1D0/3
  ISN 0014                  A2=2D0/3
  ISN 0015                  A3=1
  ISN 0016                  G10=1D0/18
  ISN 0017                  G21=2D0/9
  ISN 0018                  G30=1D0/3
  ISN 0019                  G32=1D0/6
  ISN 0020                  G40=13D0/120
  ISN 0021                  G41=.3D0
  ISN 0022                  G42=3D0/40
  ISN 0023                  G43=1D0/60
  ISN 0024                  C0=13D0/120
  ISN 0025                  C1=.3D0
  ISN 0026                  C2=3D0/40
  ISN 0027                  C3=1D0/60
  ISN 0028                  CD0=1D0/8
  ISN 0029                  CD1=3D0/8
  ISN 0030                  CD2=3D0/8
  ISN 0031                  CD3=1D0/8
  ISN 0032                  H2G10=H2*G10
  ISN 0033                  H2G21=H2*G21
  ISN 0034                  H2G30=H2*G30
  ISN 0035                  H2G32=H2*G32
  ISN 0036                  A1H=A1*H
  ISN 0037                  A2H=A2*H
  ISN 0038                  DO3M=1,10
  ISN 0039                  DO1N=1,NN
  ISN 0040                  FXY=-(X1*X1+Y1*Y1)**(-1.5)
  ISN 0041                  F=X1*FXY
  ISN 0042                  G=Y1*FXY
  ISN 0043                  F0=F
  ISN 0044                  G0=G
  ISN 0045                  X1I=X1+DX1*A1 H+H2 G10*F0
  ISN 0046                  Y1I=Y1+DY1*A1 H+H2 G10*G0
  ISN 0047                  FXY=-(X1I*X1I+Y1I*Y1I)**(-1.5)
  ISN 0048                  F=X1I*FXY
  ISN 0049                  G=Y1I*FXY
  ISN 0050                  F1=F
  ISN 0051                  G1=G
  ISN 0052                  X1I=X1+DX1*A2 H+H2 G21*F1
  ISN 0053                  Y1I=Y1+DY1*A2 H+H2 G21*G1
  ISN 0054                  FXY=-(X1I*X1I+Y1I*Y1I)**(-1.5)
  ISN 0055                  F=X1I*FXY
  ISN 0056                  G=Y1I*FXY
  ISN 0057                  F2=F
```

APPENDIX 5 B 2

```
ISN 0058          G2=G
ISN 0059          X1I=X1+DX1*A3*H+H2  G30*F0+H2G32*F2
ISN 0060          Y1I=Y1+DY1*A3*H+H2  G30*G0+H2G32*G2
ISN 0061          FXY=-(X1I*X1I+Y1I*Y1I)**(-1.5)
ISN 0062          F=X1I*FXY
ISN 0063          G=Y1I*FXY
ISN 0064          F3=F
ISN 0065          G3=G
ISN 0066          X2=X1+DX1*H+H2*(C0*F0+C1*F1+C2*F2+C3*F3)
ISN 0067          Y2=Y1+DY1*H+H2*(C0*G0+C1*G1+C2*G2+C3*G3)
ISN 0068          DX2=DX1+H*(CD0*F0+CD1*F1+CD2*F2+CD3*F3)
ISN 0069          DY2=DY1+H*(CD0*G0+CD1*G1+CD2*G2+CD3*G3)
ISN 0070          X1=X2
ISN 0071          Y1=Y2
ISN 0072          DX1=DX2
ISN 0073          DY1=DY2
ISN 0074     1    CONTINUE
ISN 0075     3    WRITE(6,2)X2,Y2,DX2,DY2
ISN 0076          STOP
ISN 0077          END

*OPTIONS IN EFFECT*     NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,

*OPTIONS IN EFFECT*     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID

*STATISTICS*     SOURCE STATEMENTS =      76 ,PROGRAM SIZE =      2074

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******
```

APPENDIX 5 C

X	Y	$\dot{X}$	$\dot{Y}$
1.0000000000000000	0.0	0.0	1.0000000000000000
1.0000000000055450	-0.0000000007391609	0.0000000007391609	0.9999999999972273
1.0000000000110890	-0.0000000015305735	0.0000000015305741	0.9999999999944551
1.0000000000166320	-0.0000000023742360	0.0000000023742363	0.9999999999916835
1.0000000000221760	-0.0000000032701432	0.0000000032701434	0.9999999999889116
1.0000000000277190	-0.0000000042182969	0.0000000042182969	0.9999999999861400
1.0000000000332630	-0.0000000052186914	0.0000000052186920	0.9999999999833680
1.0000000000388060	-0.0000000062713312	0.0000000062713321	0.9999999999805964
1.0000000000443500	-0.0000000073762205	0.0000000073762213	0.9999999999778249
1.0000000000498940	-0.0000000085333592	0.0000000085333600	0.9999999999750524
1.0000000000554380	-0.0000000097427497	0.0000000097427509	0.9999999999722806

APPENDIX 6 C

TIME	$X, \dot{Y}$	Y	$\dot{X}$
0.0	0.1000000000000000D 01	0.0	0.0
	0.1000000000000000D 01		
0.6283185307179586D 01	0.9999999999999925D 00	0.3698262510531200D-13	-0.3831836588259104D-13
	0.1000000000000004D 01		
0.1256637061435917D 02	0.1000000000000213D 01	0.1424213162210415D-12	0.5988799415736928D-13
	0.9999999999998707D 00		
0.1884955592153875D 02	0.1000000000000198D 01	-0.1383171265656244D-11	0.1577031900149061D-11
	0.9999999999998750D 00		
0.2513274122871834D 02	0.1000000000000168D 01	-0.2553509584608089D-11	0.2797911438223304D-11
	0.9999999999998939D 00		
0.3141592653589793D 02	0.1000000000000120D 01	-0.3657249345319115D-11	0.3775342913949615D-11
	0.9999999999999457D 00		
0.3769911184307751D 02	0.1000000000000110D 01	-0.4275411516564499D-11	0.4474454948493093D-11
	0.9999999999999229D 00		
0.4398229715025710D 02	0.9999999999999411D 00	-0.4293681730754816D-11	0.4495374473170079D-11
	0.1000000000000039D 01		
0.5026548245743669D 02	0.9999999999999338D 00	-0.3863457580905437D-11	0.4064199100758438D-11
	0.1000000000000043D 01		
0.5654866776461627D 02	0.1000000000000031D 01	-0.3897768920871849D-11	0.4077032654032946D-11
	0.9999999999999798D 00		
0.6283185307179586D 02	0.1000000000000030D 01	-0.4045799064747678D-11	0.4223534998099373D-11
	0.9999999999999872D 00		

AL NO OF FUNCTION EVALUATIONS IS 9684

APPENDIX 7 B

TIME	X, Ẏ	Y	Ẋ
0.0	0.1000000000000000D 01	0.0	0.0
	0.1341640786498730D 01		
0.7024814731040722D 02	0.9999999999999125D 00	0.2358897459695163D-10	-0.1757516814789714D-10
	0.1341640786499914D 01		
0.1404962946208144D 03	0.9999999999998533D 00	0.9410138086020018D-10	-0.7012925982362985D-10
	0.1341640786499932D 01		
0.2107444419312217D 03	0.9999999999997826D 00	0.2097516103295411D-09	-0.1563239312610180D-09
	0.1341640786499965D 01		
0.2809925892416289D 03	0.9999999999996916D 00	0.3675031249230126D-09	-0.2738909227205067D-09
	0.1341640786500009D 01		
0.3512407365520361D 03	0.9999999999996230D 00	0.5725521985069476D-09	-0.4267847050335783D-09
	0.1341640786500039D 01		
0.4214888838624433D 03	0.9999999999995487D 00	0.8199136952381218D-09	-0.6110758420893921D-09
	0.1341640786500066D 01		
0.4917370311728506D 03	0.9999999999994714D 00	0.1117920726048350D-08	-0.8331907370699799D-09
	0.1341640786500100D 01		
0.5619851784832577D 03	0.9999999999993976D 00	0.1454753990020454D-08	-0.1084243974566097D-08
	0.1341640786500137D 01		
0.6322333257936650D 03	0.9999999999993099D 00	0.1837151735791054D-08	-0.1369259420563716D-08
	0.1341640786500176D 01		
0.7024814731040722D 03	0.9999999999992239D 00	0.2268880545647492D-08	-0.1691047644222103D-08
	0.1341640786500215D 01		

ITAL NO OF FUNCTION EVALUATIONS IS 23892

APPENDIX 8 D

X	Y	$\dot{X}$	$\dot{Y}$
1.0000007006495140	-0.0000007798774209	0.0000011293719927	0.9999995634532413
1.0000011253749640	-0.0000079127927949	0.0000082786836048	0.9999993632441671
1.0000015292111430	-0.0000189284056577	0.0000192406434419	0.9999992071302809
1.0000019118222590	-0.0000337755837665	0.0000341681280420	0.9999989841776513
1.0000023746678020	-0.0000526045161667	0.0000530032259860	0.9999987423946180
1.0000027829870290	-0.0000754385181373	0.0000757832470503	0.9999985032454313
1.0000032103150310	-0.0001021649485765	0.0001025310761945	0.9999983084986364
1.0000036126767880	-0.0001328320944064	0.0001331577786703	0.9999981452770696
1.0000039950884540	-0.0001673473248762	0.0001677368942049	0.9999979108310752
1.0000044329050420	-0.0002057680051635	0.0002061609719828	0.9999976788004703