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IMPLEMENTATION GUIDE FOR MINPACK-1

by

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Applied Mathematics Division

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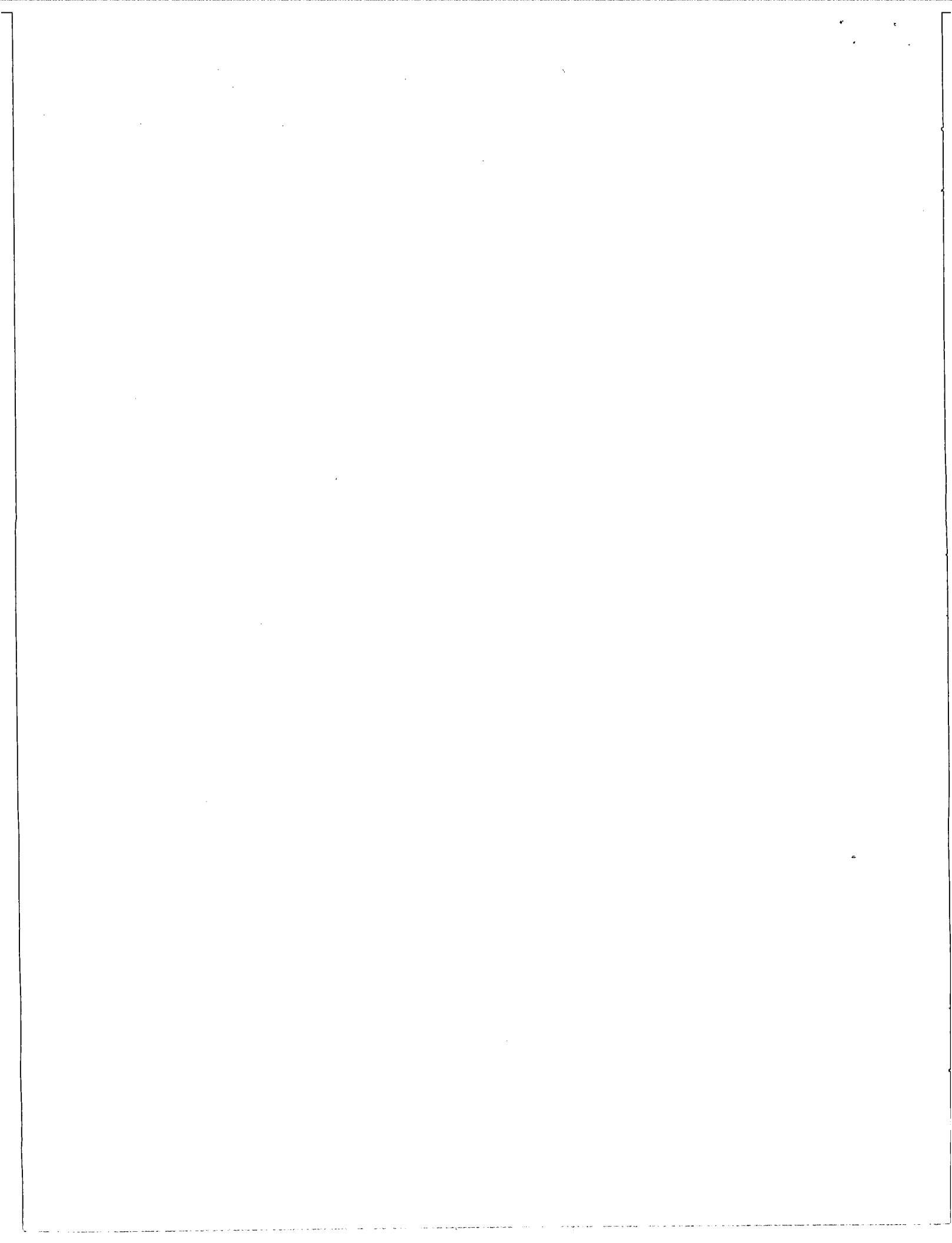
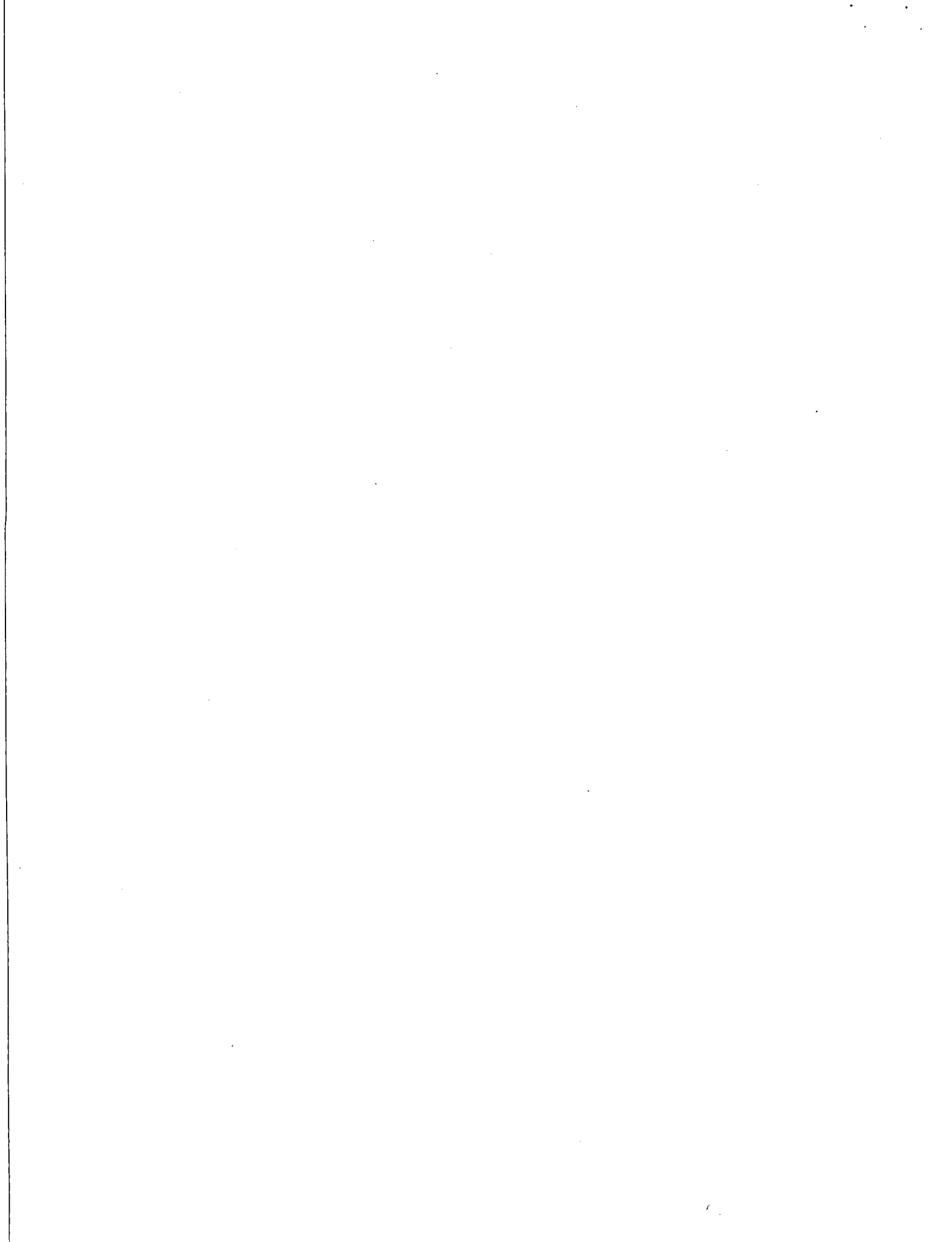


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ABSTRACT

MINPACK-1 is a package of Fortran subprograms for the numerical solution of systems of nonlinear equations and nonlinear least squares problems. This report describes how to implement the package from the tape on which it is transmitted.

1. Introduction

This report describes the tape containing MINPACK-1, a package of Fortran subprograms for the numerical solution of systems of nonlinear equations and nonlinear least squares problems. Future editions of the MINPACK package will address unconstrained minimization and constrained optimization problems. For each problem area MINPACK-1 contains algorithms that proceed either from an analytic specification of the Jacobian matrix of the problem functions or directly from the problem functions themselves. Since the specification of the Jacobian matrix can be an error-prone task, MINPACK-1 also contains an algorithm to check that the Jacobian matrix is consistent with the functions. Also included on the tape are machine-readable documentation and a complete set of testing aids.

MINPACK-1 may be obtained from either:

National Energy Software Center
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439
Phone: (312) 972-7250

or

IMSL
Sixth Floor-NBC Building
7500 Bellaire Blvd.
Houston, TX 77036
Phone: (713) 772-1927

2. The Tape Organization

The tape contains 23 files. The card counts for the respective files are given in Table 1.

TABLE 1

File	Count
1	139
2	4,771
3	3,526
4	186
5	4,778
6	3,528
7	283
8	551
9	879
10	1,022
11	1,033
12	673
13	858
14	284
15	552
16	881
17	1,025
18	1,036
19	675
20	860
21	23
22	29
23	15

3. Overview of Tape Contents

The tape contains both single and double precision versions of the routines in MINPACK-1. For each precision there is a function that provides machine-dependent constants (when an appropriate set of DATA statements is activated); all other MINPACK-1 subprograms are written in a portable subset of ANSI standard Fortran. For those subprograms normally called by the user, machine-readable documentation is provided for both the single and the double precision forms.

The first six files on the tape are:

1. Function SPMPAR, single precision machine-dependent constants.
2. MINPACK-1, single precision, 22 subprograms.

3. MINPACK-1 documentation, single precision, 11 documents.
4. Function DPMPAR, double precision machine-dependent constants.
5. MINPACK-1, double precision, 22 subprograms.
6. MINPACK-1 documentation, double precision, 11 documents.

The remaining 17 files contain test material; their contents are described in Section 6.

4. Machine-Dependent Constants

There are three machine-dependent constants that have to be set before the single or double precision version of MINPACK-1 can be used; for most machines the correct values of these constants are encoded into DATA statements in functions SPMPAR (single precision) and DPMPAR (double precision). As transmitted on the tape, the constants for the IBM 360,370 series are "activated"; that is, the DATA statements encoding all other constants are rendered comments by the presence of 'C' in column 1. If the activated constants are appropriate for the target machine (various non-IBM machines share these constants), then no changes are required to SPMPAR or DPMPAR. Otherwise, a different set of constants will have to be "activated" and the IBM constants "deactivated". The listings of SPMPAR and DPMPAR are included as Appendix A of this report.

We are also including (files 7 and 14) single and double precision versions (named SMCHAR and DMCHAR, respectively) of the environmental inquiry program of W. J. Cody, with which we confirmed many of the constants in SPMPAR and DPMPAR (most of which were obtained from the corresponding Bell Laboratories PORT Library function). These programs should be useful in determining the appropriate constants for machines not already covered in SPMPAR and DPMPAR.

5. Files 1-6: The MINPACK-1 Package and Its Documentation

As described in Section 3, files 1-3 of the tape contain the single precision version of MINPACK-1 and its associated documentation and files 4-6 contain the double precision equivalents. File 2 contains 22 Fortran subprograms: CHKDER, DOGLEG, ENORM, FDJAC1, FDJAC2, HYBRD, HYBRD1, HYBRJ, HYBRJ1, LMDER, LMDER1, LMDIF, LMDIF1, LMPAR, LMSTR, LMSTR1, QFORM, QRFAC, QRSOLV, RWUPDT, RIMPYQ, and RIUPDT. ENORM is of FUNCTION type; the others are all SUBROUTINE's. File 5 contains 22 subprograms with the same names and in the

same order. There are no separator cards between members, but the last card of each subprogram has 'END' in columns 7-9.

File 1 contains SPMPAR and file 4 contains DPMPAR. As described in Section 4, these programs may have to be changed, after which the programs in files 1 and 2, or 4 and 5, can be compiled into a library. We might suggest that you choose the precision that corresponds to your normal operating environment.

Machine-readable documentation is provided in files 3 and 6 for the 11 MINPACK-1 members normally called by the user: HYBRD1, HYBRD, HYBRJ1, HYBRJ, LMDER1, LMDER, LMSTR1, LMSTR, LMDIF1, LMDIF, and CHKDER. HYBRD, HYBRJ, LMDER, LMSTR, and LMDIF are the core subroutines in the five general algorithmic paths in MINPACK-1. HYBRD1, HYBRJ1, LMDER1, LMSTR1, and LMDIF1 are "easy-to-use" drivers with simplified calling sequences made possible by assuming default settings for certain parameters and by returning a limited amount of information; many applications do not require full flexibility and in these cases "easy-to-use" drivers can be invoked. Finally, CHKDER should be helpful to users who wish to check the coding of their Jacobian evaluation subroutine.

The documents are recorded with both upper and lower case characters (realizable if the TN print chain is available). They include carriage control characters '1', '0', and ' ' that enable their printing in paged format under program control; one blank page is inserted between successive documents. The printed material can be trimmed to fit onto 8 1/2 x 11 sheets of paper.

6. Files 7-23: The Testing Aids

Files 7-13 on the tape contain testing aids for running the environmental inquiry program (see Section 4 above), the five available algorithmic paths (HYBRD, HYBRJ, LMDER, LMSTR, and LMDIF), and CHKDER, respectively, in single precision. Files 14-20 contain testing aids for the corresponding double precision versions. The testing aids include drivers, initial point specifying subroutines, and subroutines (named FCN) that evaluate the functions and Jacobians. Files 21-23 comprise the input data -- file 21 is used by HYBRD and HYBRJ, file 22 by LMDER, LMSTR, and LMDIF, and file 23 by CHKDER.

In summary, the contents of files 7-23 are as follows:

7. SMCHAR test
8. HYBRD test (single precision)
9. HYBRJ test (single precision)

10. LMDER test (single precision)
11. LMSTR test (single precision)
12. LMDIF test (single precision)
13. CHKDER test (single precision)
14. DMCHAR test
15. HYBRD test (double precision)
16. HYBRJ test (double precision)
17. LMDER test (double precision)
18. LMSTR test (double precision)
19. LMDIF test (double precision)
20. CHKDER test (double precision)
21. HYBRD and HYBRJ data
22. LMDER, LMSTR, and LMDIF data
23. CHKDER data

Small changes may be required to the drivers, for example to renumber the logical input and output units (from 5 and 6) or to include a program card. To facilitate these changes we have placed the drivers at the beginning of the respective test files and, in addition, are including listings of the drivers (double precision versions) as Appendix B of this report.

For each test run, pair one of the program files with the corresponding data file, and make available the library where the MINPACK-1 package has been stored. For example, to run the double precision LMDER test you would point to files 17 and 22.

A special note applies to the drivers for LMSTR in files 11 and 18. Instead of calculating one row of the Jacobian per call, the test FCN subroutine calculates the entire Jacobian at the first call and moves one row at each subsequent call. This strategy depends, therefore, on retention by the system of quantities stored at an earlier call of FCN toward accessing at later calls. Although this feature is nonstandard, we hope that your system enables it.

The test runs for HYBRD, HYBRJ, LMDER, LMSTR, and LMDIF each produce about 1200 lines of output. The test run for CHKDER produces about 300 lines of output, and the SMCHAR (or DMCHAR) test produces only a single page after possibly triggering several underflow messages. The last page of the output for each run contains a summary of the results. We are including listings of the summaries that we produced from our double precision IBM runs (IBM 3033, Fortran H Extended) as Appendix C of this report. Section 7 contains further details toward the evaluation of the test results.

Towards estimating timing, we offer the following two tables: Table 2 records the CPU time in seconds on Argonne's IBM 3033 (including compilation)

and Table 3 gives the approximate ratio of the speed of the 3033 to various other machines.

TABLE 2

HYBRD	17
HYBRJ	17
LMDER	21
LMSTR	26
LMDIF	21
CHKDER	4

TABLE 3

CDC 7600	1
CDC 6600	5
Univac 1110	11
Amdahl 470V/6	3
IBM 370/168	3
IBM 360/75	15
Honeywell 6070	10-20
DEC PDP-10	100-150
Burroughs 6700	100

7. Evaluation of the Test Results

The test runs for the machine constants (files 7 and 14) compare the results obtained by the environmental inquiry programs SMCHAR and DMCHAR with the constants specified in SPMPAR and DPMPAR, respectively. The test programs print

$$\begin{aligned} \text{RERR}(1) &= (\text{EPSMCH} - \text{EPS}) / \text{EPSMCH} \\ \text{RERR}(2) &= (\text{DWARF} - \text{XMIN}) / \text{DWARF} \\ \text{RERR}(3) &= (\text{XMAX} - \text{GIANT}) / \text{GIANT} \end{aligned}$$

where EPSMCH, DWARF, and GIANT are the constants specified in the MINPACK-1 functions, and EPS, XMIN, and XMAX are the values returned from the environmental inquiry programs.

The constants specified in the MINPACK-1 functions are conservative and do not take into account special features of the system. Therefore, components of RERR are not necessarily zero. For example, rounded arithmetic is reflected by EPS being half as large as EPSMCH, thereby producing a value of 0.5 in RERR(1). Values with magnitude as large as unity should usually be considered suspicious, but we have encountered the following exceptions:

- a) In CDC systems, the treatment of small double precision numbers requires a value of DWARF that is large relative to XMIN, and so the value of RERR(2) is close to unity.
- b) In Honeywell and Prime systems, the use of extra length registers results in an overly small value of EPS, and so the value of RERR(1) is close to unity; this only occurs in single precision on the Prime but in both precisions on the Honeywell. In addition, these systems do not allow a proper determination of XMAX in double precision and produce a value of RERR(3) close to minus unity.

The interpretation of the test results for the other MINPACK-1 programs depends on the machine precision and on the sensitivity of the problems to the precision of the computations. For those problems sensitive to the precision of the computations we have underlined the (IBM) results in Appendix C. The performances of the MINPACK-1 programs on these problems vary from machine to machine, but in general we expect about the same number of successes and failures as in the IBM runs if the working precision provides at least 10 decimal digits. If this is not the case, there is a deterioration in performance commensurate to the lack of digits. For problems not sensitive to the precision of the computations we expect about the same number of successes and failures as in the IBM runs regardless of the machine precision.

The criteria for the designation "successful" that we have adopted are as follows. For the nonlinear equation solvers success is obtained if the final L2-norm is less than the square root of the machine precision. For the IBM double precision runs (machine precision approximately $10^{**}(-16)$) there are 51 successes and four failures. For the nonlinear least squares solvers success is obtained if either the absolute or the relative error in the final L2-norm of the residuals is less than the square root of the machine precision. For the IBM double precision runs there are 53 successes and one failure.

8. Referral for Questions and Comments

We hope that no difficulty will be encountered in installing MINPACK-1, but if a problem occurs we will try to help. We are especially interested in comments about the performance of the codes. Questions and comments may be directed to:

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Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439
Phone: (312) 972-7184

A P P E N D I X A

SPMPAR and DPMPAR Listings


```
REAL FUNCTION SPMPAR(I)
INTEGER I
*****
C
C
C FUNCTION SPMPAR
C
C THIS FUNCTION PROVIDES SINGLE PRECISION MACHINE PARAMETERS
C WHEN THE APPROPRIATE SET OF DATA STATEMENTS IS ACTIVATED (BY
C REMOVING THE C FROM COLUMN 1) AND ALL OTHER DATA STATEMENTS ARE
C RENDERED INACTIVE. MOST OF THE PARAMETER VALUES WERE OBTAINED
C FROM THE CORRESPONDING BELL LABORATORIES PORT LIBRARY FUNCTION.
C
C THE FUNCTION STATEMENT IS
C
C REAL FUNCTION SPMPAR(I)
C
C WHERE
C
C I IS AN INTEGER INPUT VARIABLE SET TO 1, 2, OR 3 WHICH
C SELECTS THE DESIRED MACHINE PARAMETER. IF THE MACHINE HAS
C T BASE B DIGITS AND ITS SMALLEST AND LARGEST EXPONENTS ARE
C EMIN AND EMAX, RESPECTIVELY, THEN THESE PARAMETERS ARE
C
C SPMPAR(1) = B**(1 - T), THE MACHINE PRECISION,
C
C SPMPAR(2) = B**(EMIN - 1), THE SMALLEST MAGNITUDE,
C
C SPMPAR(3) = B**EMAX*(1 - B**(-T)), THE LARGEST MAGNITUDE.
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER MCHEPS(2)
C INTEGER MINMAG(2)
C INTEGER MAXMAG(2)
C REAL RMACH(3)
C EQUIVALENCE (RMACH(1),MCHEPS(1))
C EQUIVALENCE (RMACH(2),MINMAG(1))
C EQUIVALENCE (RMACH(3),MAXMAG(1))
C
C MACHINE CONSTANTS FOR THE IBM 360/370 SERIES,
C THE AMDAHL 470/V6, THE ICL 2900, THE ITEL AS/6,
C THE XEROX SIGMA 5/7/9 AND THE SEL SYSTEMS 85/86.
C
C DATA RMACH(1) / Z3C100000 /
C DATA RMACH(2) / Z00100000 /
C DATA RMACH(3) / Z7FFFFFFF /
C
C MACHINE CONSTANTS FOR THE HONEYWELL 600/6000 SERIES.
C
C DATA RMACH(1) / 0716400000000 /
C DATA RMACH(2) / 0402400000000 /
C DATA RMACH(3) / 037677777777 /
C
C MACHINE CONSTANTS FOR THE CDC 6000/7000 SERIES.
C
C DATA RMACH(1) / 1641400000000000000B /
C DATA RMACH(2) / 0001400000000000000B /
C DATA RMACH(3) / 3776777777777777777B /
```

SPPR0010
SPPR0020
SPPR0030
SPPR0040
SPPR0050
SPPR0060
SPPR0070
SPPR0080
SPPR0090
SPPR0100
SPPR0110
SPPR0120
SPPR0130
SPPR0140
SPPR0150
SPPR0160
SPPR0170
SPPR0180
SPPR0190
SPPR0200
SPPR0210
SPPR0220
SPPR0230
SPPR0240
SPPR0250
SPPR0260
SPPR0270
SPPR0280
SPPR0290
SPPR0300
SPPR0310
SPPR0320
SPPR0330
SPPR0340
SPPR0350
SPPR0360
SPPR0370
SPPR0380
SPPR0390
SPPR0400
SPPR0410
SPPR0420
SPPR0430
SPPR0440
SPPR0450
SPPR0460
SPPR0470
SPPR0480
SPPR0490
SPPR0500
SPPR0510
SPPR0520
SPPR0530
SPPR0540
SPPR0550
SPPR0560
SPPR0570
SPPR0580
SPPR0590
SPPR0600

C		SPPR0610
C	MACHINE CONSTANTS FOR THE PDP-10 (KA OR KI PROCESSOR).	SPPR0620
C		SPPR0630
C	DATA RMACH(1) / "147400000000 /	SPPR0640
C	DATA RMACH(2) / "000400000000 /	SPPR0650
C	DATA RMACH(3) / "377777777777 /	SPPR0660
C		SPPR0670
C	MACHINE CONSTANTS FOR THE PDP-11 FORTRAN SUPPORTING	SPPR0680
C	32-BIT INTEGERS (EXPRESSED IN INTEGER AND OCTAL).	SPPR0690
C		SPPR0700
C	DATA MCHEPS(1) / 889192448 /	SPPR0710
C	DATA MINMAG(1) / 8388608 /	SPPR0720
C	DATA MAXMAG(1) / 2147483647 /	SPPR0730
C		SPPR0740
C	DATA RMACH(1) / 006500000000 /	SPPR0750
C	DATA RMACH(2) / 000040000000 /	SPPR0760
C	DATA RMACH(3) / 017777777777 /	SPPR0770
C		SPPR0780
C	MACHINE CONSTANTS FOR THE PDP-11 FORTRAN SUPPORTING	SPPR0790
C	16-BIT INTEGERS (EXPRESSED IN INTEGER AND OCTAL).	SPPR0800
C		SPPR0810
C	DATA MCHEPS(1),MCHEPS(2) / 13568, 0 /	SPPR0820
C	DATA MINMAG(1),MINMAG(2) / 128, 0 /	SPPR0830
C	DATA MAXMAG(1),MAXMAG(2) / 32767, -1 /	SPPR0840
C		SPPR0850
C	DATA MCHEPS(1),MCHEPS(2) / 0032400, 0000000 /	SPPR0860
C	DATA MINMAG(1),MINMAG(2) / 0000200, 0000000 /	SPPR0870
C	DATA MAXMAG(1),MAXMAG(2) / 0077777, 0177777 /	SPPR0880
C		SPPR0890
C	MACHINE CONSTANTS FOR THE BURROUGHS 5700/6700/7700 SYSTEMS.	SPPR0900
C		SPPR0910
C	DATA RMACH(1) / 01301000000000000 /	SPPR0920
C	DATA RMACH(2) / 01771000000000000 /	SPPR0930
C	DATA RMACH(3) / 0077777777777777 /	SPPR0940
C		SPPR0950
C	MACHINE CONSTANTS FOR THE BURROUGHS 1700 SYSTEM.	SPPR0960
C		SPPR0970
C	DATA RMACH(1) / Z4EA800000 /	SPPR0980
C	DATA RMACH(2) / Z400800000 /	SPPR0990
C	DATA RMACH(3) / Z5FFFFFFFF /	SPPR1000
C		SPPR1010
C	MACHINE CONSTANTS FOR THE UNIVAC 1100 SERIES.	SPPR1020
C		SPPR1030
C	DATA RMACH(1) / 0147400000000 /	SPPR1040
C	DATA RMACH(2) / 0000400000000 /	SPPR1050
C	DATA RMACH(3) / 0377777777777 /	SPPR1060
C		SPPR1070
C	MACHINE CONSTANTS FOR THE DATA GENERAL ECLIPSE S/200.	SPPR1080
C		SPPR1090
C	NOTE - IT MAY BE APPROPRIATE TO INCLUDE THE FOLLOWING CARD -	SPPR1100
C	STATIC RMACH(3)	SPPR1110
C		SPPR1120
C	DATA MINMAG/20K,0/,MAXMAG/77777K,177777K/	SPPR1130
C	DATA MCHEPS/36020K,0/	SPPR1140
C		SPPR1150
C	MACHINE CONSTANTS FOR THE HARRIS 220.	SPPR1160
C		SPPR1170
C	DATA MCHEPS(1) / '20000000, '00000353 /	SPPR1180
C	DATA MINMAG(1) / '20000000, '00000201 /	SPPR1190
C	DATA MAXMAG(1) / '37777777, '00000177 /	SPPR1200

C		SPPR1210
C	MACHINE CONSTANTS FOR THE CRAY-1.	SPPR1220
C		SPPR1230
C	DATA RMACH(1) / 037722400000000000000000B /	SPPR1240
C	DATA RMACH(2) / 020003400000000000000000B /	SPPR1250
C	DATA RMACH(3) / 05777777777777777777776B /	SPPR1260
C		SPPR1270
C	MACHINE CONSTANTS FOR THE PRIME 400.	SPPR1280
C		SPPR1290
C	DATA MCHEPS(1) / :10000000153 /	SPPR1300
C	DATA MINMAG(1) / :10000000000 /	SPPR1310
C	DATA MAXMAG(1) / :1777777777 /	SPPR1320
C		SPPR1330
	SPMPAR = RMACH(I)	SPPR1340
	RETURN	SPPR1350
C		SPPR1360
C	LAST CARD OF FUNCTION SPMPAR.	SPPR1370
C		SPPR1380
	END	SPPR1390


```

DOUBLE PRECISION FUNCTION DPMPAR(I)
INTEGER I
*****
C
C
C FUNCTION DPMPAR
C
C THIS FUNCTION PROVIDES DOUBLE PRECISION MACHINE PARAMETERS
C WHEN THE APPROPRIATE SET OF DATA STATEMENTS IS ACTIVATED (BY
C REMOVING THE C FROM COLUMN 1) AND ALL OTHER DATA STATEMENTS ARE
C RENDERED INACTIVE. MOST OF THE PARAMETER VALUES WERE OBTAINED
C FROM THE CORRESPONDING BELL LABORATORIES PORT LIBRARY FUNCTION.
C
C THE FUNCTION STATEMENT IS
C
C DOUBLE PRECISION FUNCTION DPMPAR(I)
C
C WHERE
C
C I IS AN INTEGER INPUT VARIABLE SET TO 1, 2, OR 3 WHICH
C SELECTS THE DESIRED MACHINE PARAMETER. IF THE MACHINE HAS
C T BASE B DIGITS AND ITS SMALLEST AND LARGEST EXPONENTS ARE
C EMIN AND EMAX, RESPECTIVELY, THEN THESE PARAMETERS ARE
C
C DPMPAR(1) = B**(1 - T), THE MACHINE PRECISION,
C
C DPMPAR(2) = B**(EMIN - 1), THE SMALLEST MAGNITUDE,
C
C DPMPAR(3) = B**EMAX*(1 - B**(-T)), THE LARGEST MAGNITUDE.
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C
C INTEGER MCHEPS(4)
C INTEGER MINMAG(4)
C INTEGER MAXMAG(4)
C DOUBLE PRECISION DMACH(3)
C EQUIVALENCE (DMACH(1),MCHEPS(1))
C EQUIVALENCE (DMACH(2),MINMAG(1))
C EQUIVALENCE (DMACH(3),MAXMAG(1))
C
C MACHINE CONSTANTS FOR THE IBM 360/370 SERIES,
C THE AMDAHL 470/V6, THE ICL 2900, THE ITEL AS/6,
C THE XEROX SIGMA 5/7/9 AND THE SEL SYSTEMS 85/86.
C
C DATA MCHEPS(1),MCHEPS(2) / Z34100000, Z00000000 /
C DATA MINMAG(1),MINMAG(2) / Z00100000, Z00000000 /
C DATA MAXMAG(1),MAXMAG(2) / Z7FFFFFFF, ZFFFFFFF /
C
C MACHINE CONSTANTS FOR THE HONEYWELL 600/6000 SERIES.
C
C DATA MCHEPS(1),MCHEPS(2) / 0606400000000, 0000000000000 /
C DATA MINMAG(1),MINMAG(2) / 0402400000000, 0000000000000 /
C DATA MAXMAG(1),MAXMAG(2) / 0376777777777, 0777777777777 /
C
C MACHINE CONSTANTS FOR THE CDC 6000/7000 SERIES.
C
C DATA MCHEPS(1) / 15614000000000000000B /
C DATA MCHEPS(2) / 15010000000000000000B /

```

```

DPPR0010
DPPR0020
DPPR0030
DPPR0040
DPPR0050
DPPR0060
DPPR0070
DPPR0080
DPPR0090
DPPR0100
DPPR0110
DPPR0120
DPPR0130
DPPR0140
DPPR0150
DPPR0160
DPPR0170
DPPR0180
DPPR0190
DPPR0200
DPPR0210
DPPR0220
DPPR0230
DPPR0240
DPPR0250
DPPR0260
DPPR0270
DPPR0280
DPPR0290
DPPR0300
DPPR0310
DPPR0320
DPPR0330
DPPR0340
DPPR0350
DPPR0360
DPPR0370
DPPR0380
DPPR0390
DPPR0400
DPPR0410
DPPR0420
DPPR0430
DPPR0440
DPPR0450
DPPR0460
DPPR0470
DPPR0480
DPPR0490
DPPR0500
DPPR0510
DPPR0520
DPPR0530
DPPR0540
DPPR0550
DPPR0560
DPPR0570
DPPR0580
DPPR0590
DPPR0600

```

C	DATA MINMAG(1) / 00604000000000000000B /	DPPR0610
C	DATA MINMAG(2) / 00000000000000000000B /	DPPR0620
C		DPPR0630
C	DATA MAXMAG(1) / 3776777777777777777B /	DPPR0640
C	DATA MAXMAG(2) / 3716777777777777777B /	DPPR0650
C		DPPR0660
C	MACHINE CONSTANTS FOR THE PDP-10 (KA PROCESSOR).	DPPR0670
C		DPPR0680
C	DATA MCHEPS(1),MCHEPS(2) / "114400000000, "000000000000 /	DPPR0690
C	DATA MINMAG(1),MINMAG(2) / "033400000000, "000000000000 /	DPPR0700
C	DATA MAXMAG(1),MAXMAG(2) / "377777777777, "344777777777 /	DPPR0710
C		DPPR0720
C	MACHINE CONSTANTS FOR THE PDP-10 (KI PROCESSOR).	DPPR0730
C		DPPR0740
C	DATA MCHEPS(1),MCHEPS(2) / "104400000000, "000000000000 /	DPPR0750
C	DATA MINMAG(1),MINMAG(2) / "000400000000, "000000000000 /	DPPR0760
C	DATA MAXMAG(1),MAXMAG(2) / "377777777777, "377777777777 /	DPPR0770
C		DPPR0780
C	MACHINE CONSTANTS FOR THE PDP-11 FORTRAN SUPPORTING	DPPR0790
C	32-BIT INTEGERS (EXPRESSED IN INTEGER AND OCTAL).	DPPR0800
C		DPPR0810
C	DATA MCHEPS(1),MCHEPS(2) / 620756992, 0 /	DPPR0820
C	DATA MINMAG(1),MINMAG(2) / 8388608, 0 /	DPPR0830
C	DATA MAXMAG(1),MAXMAG(2) / 2147483647, -1 /	DPPR0840
C		DPPR0850
C	DATA MCHEPS(1),MCHEPS(2) / 004500000000, 000000000000 /	DPPR0860
C	DATA MINMAG(1),MINMAG(2) / 000040000000, 000000000000 /	DPPR0870
C	DATA MAXMAG(1),MAXMAG(2) / 017777777777, 037777777777 /	DPPR0880
C		DPPR0890
C	MACHINE CONSTANTS FOR THE PDP-11 FORTRAN SUPPORTING	DPPR0900
C	16-BIT INTEGERS (EXPRESSED IN INTEGER AND OCTAL).	DPPR0910
C		DPPR0920
C	DATA MCHEPS(1),MCHEPS(2) / 9472, 0 /	DPPR0930
C	DATA MCHEPS(3),MCHEPS(4) / 0, 0 /	DPPR0940
C		DPPR0950
C	DATA MINMAG(1),MINMAG(2) / 128, 0 /	DPPR0960
C	DATA MINMAG(3),MINMAG(4) / 0, 0 /	DPPR0970
C		DPPR0980
C	DATA MAXMAG(1),MAXMAG(2) / 32767, -1 /	DPPR0990
C	DATA MAXMAG(3),MAXMAG(4) / -1, -1 /	DPPR1000
C		DPPR1010
C	DATA MCHEPS(1),MCHEPS(2) / 0022400, 0000000 /	DPPR1020
C	DATA MCHEPS(3),MCHEPS(4) / 0000000, 0000000 /	DPPR1030
C		DPPR1040
C	DATA MINMAG(1),MINMAG(2) / 0000200, 0000000 /	DPPR1050
C	DATA MINMAG(3),MINMAG(4) / 0000000, 0000000 /	DPPR1060
C		DPPR1070
C	DATA MAXMAG(1),MAXMAG(2) / 0077777, 0177777 /	DPPR1080
C	DATA MAXMAG(3),MAXMAG(4) / 0177777, 0177777 /	DPPR1090
C		DPPR1100
C	MACHINE CONSTANTS FOR THE BURROUGHS 6700/7700 SYSTEMS.	DPPR1110
C		DPPR1120
C	DATA MCHEPS(1) / 014510000000000000 /	DPPR1130
C	DATA MCHEPS(2) / 000000000000000000 /	DPPR1140
C		DPPR1150
C	DATA MINMAG(1) / 017710000000000000 /	DPPR1160
C	DATA MINMAG(2) / 077700000000000000 /	DPPR1170
C		DPPR1180
C	DATA MAXMAG(1) / 007777777777777777 /	DPPR1190
C	DATA MAXMAG(2) / 077777777777777777 /	DPPR1200

C		DPPR1210
C	MACHINE CONSTANTS FOR THE BURROUGHS 5700 SYSTEM.	DPPR1220
C		DPPR1230
C	DATA MCHEPS(1) / 014510000000000000 /	DPPR1240
C	DATA MCHEPS(2) / 000000000000000000 /	DPPR1250
C		DPPR1260
C	DATA MINMAG(1) / 017710000000000000 /	DPPR1270
C	DATA MINMAG(2) / 000000000000000000 /	DPPR1280
C		DPPR1290
C	DATA MAXMAG(1) / 007777777777777777 /	DPPR1300
C	DATA MAXMAG(2) / 000077777777777777 /	DPPR1310
C		DPPR1320
C	MACHINE CONSTANTS FOR THE BURROUGHS 1700 SYSTEM.	DPPR1330
C		DPPR1340
C	DATA MCHEPS(1) / ZCC6800000 /	DPPR1350
C	DATA MCHEPS(2) / Z000000000 /	DPPR1360
C		DPPR1370
C	DATA MINMAG(1) / ZC00800000 /	DPPR1380
C	DATA MINMAG(2) / Z000000000 /	DPPR1390
C		DPPR1400
C	DATA MAXMAG(1) / ZDFFFFFFF /	DPPR1410
C	DATA MAXMAG(2) / ZFFFFFFF /	DPPR1420
C		DPPR1430
C	MACHINE CONSTANTS FOR THE UNIVAC 1100 SERIES.	DPPR1440
C		DPPR1450
C	DATA MCHEPS(1),MCHEPS(2) / 0170640000000, 0000000000000 /	DPPR1460
C	DATA MINMAG(1),MINMAG(2) / 0000040000000, 0000000000000 /	DPPR1470
C	DATA MAXMAG(1),MAXMAG(2) / 0377777777777, 0777777777777 /	DPPR1480
C		DPPR1490
C	MACHINE CONSTANTS FOR THE DATA GENERAL ECLIPSE S/200.	DPPR1500
C		DPPR1510
C	NOTE - IT MAY BE APPROPRIATE TO INCLUDE THE FOLLOWING CARD -	DPPR1520
C	STATIC DMACH(3)	DPPR1530
C		DPPR1540
C	DATA MINMAG/20K,3*0/,MAXMAG/77777K,3*177777K/	DPPR1550
C	DATA MCHEPS/32020K,3*0/	DPPR1560
C		DPPR1570
C	MACHINE CONSTANTS FOR THE HARRIS 220.	DPPR1580
C		DPPR1590
C	DATA MCHEPS(1),MCHEPS(2) / '20000000, '00000334 /	DPPR1600
C	DATA MINMAG(1),MINMAG(2) / '20000000, '00000201 /	DPPR1610
C	DATA MAXMAG(1),MAXMAG(2) / '37777777, '37777577 /	DPPR1620
C		DPPR1630
C	MACHINE CONSTANTS FOR THE CRAY-1.	DPPR1640
C		DPPR1650
C	DATA MCHEPS(1) / 03764240000000000000000B /	DPPR1660
C	DATA MCHEPS(2) / 00000000000000000000000B /	DPPR1670
C		DPPR1680
C	DATA MINMAG(1) / 02000340000000000000000B /	DPPR1690
C	DATA MINMAG(2) / 00000000000000000000000B /	DPPR1700
C		DPPR1710
C	DATA MAXMAG(1) / 0577777777777777777777B /	DPPR1720
C	DATA MAXMAG(2) / 00000077777777777777776B /	DPPR1730
C		DPPR1740
C	MACHINE CONSTANTS FOR THE PRIME 400.	DPPR1750
C		DPPR1760
C	DATA MCHEPS(1),MCHEPS(2) / :10000000000, :00000000123 /	DPPR1770
C	DATA MINMAG(1),MINMAG(2) / :10000000000, :00000100000 /	DPPR1780
C	DATA MAXMAG(1),MAXMAG(2) / :17777777777, :37777677776 /	DPPR1790
C		DPPR1800

```
DPMPAR = DMACH(I)  
RETURN  
C  
C  
C  
LAST CARD OF FUNCTION DPMPAR.  
END
```

```
DPPR1810  
DPPR1820  
DPPR1830  
DPPR1840  
DPPR1850  
DPPR1860
```


A P P E N D I X B

Test Driver Listings


```

C *****
C
C THIS PROGRAM CHECKS THE CONSTANTS OF MACHINE PRECISION AND
C SMALLEST AND LARGEST MACHINE REPRESENTABLE NUMBERS SPECIFIED IN
C FUNCTION DPMPAR, AGAINST THE CORRESPONDING HARDWARE-DETERMINED
C MACHINE CONSTANTS OBTAINED BY DMCHAR, A SUBROUTINE DUE TO
C W. J. CODY.
C
C DATA STATEMENTS IN DPMPAR CORRESPONDING TO THE MACHINE USED MUST
C BE ACTIVATED BY REMOVING C IN COLUMN 1.
C
C THE PRINTED OUTPUT CONSISTS OF THE MACHINE CONSTANTS OBTAINED BY
C DMCHAR AND COMPARISONS OF THE DPMPAR CONSTANTS WITH THEIR
C DMCHAR COUNTERPARTS. DESCRIPTIONS OF THE MACHINE CONSTANTS ARE
C GIVEN IN THE PROLOGUE COMMENTS OF DMCHAR.
C
C SUBPROGRAMS CALLED
C
C   MINPACK-SUPPLIED ... DMCHAR,DPMPAR
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER IBETA, IEXP, IRND, IT, MACHEP, MAXEXP, MINEXP, NEGEP, NGRD,
*   NWRITE
C DOUBLE PRECISION DWARF, EPS, EPSMCH, EPSNEG, GIANT, XMAX, XMIN
C DOUBLE PRECISION RERR(3)
C DOUBLE PRECISION DPMPAR
C
C LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C DATA NWRITE /6/
C
C DETERMINE THE MACHINE CONSTANTS DYNAMICALLY FROM DMCHAR.
C
C CALL DMCHAR(IBETA, IT, IRND, NGRD, MACHEP, NEGEP, IEXP, MINEXP, MAXEXP,
*   EPS, EPSNEG, XMIN, XMAX)
C
C COMPARE THE DPMPAR CONSTANTS WITH THEIR DMCHAR COUNTERPARTS AND
C STORE THE RELATIVE DIFFERENCES IN RERR.
C
C   EPSMCH = DPMPAR(1)
C   DWARF = DPMPAR(2)
C   GIANT = DPMPAR(3)
C   RERR(1) = (EPSMCH - EPS)/EPSMCH
C   RERR(2) = (DWARF - XMIN)/DWARF
C   RERR(3) = (XMAX - GIANT)/GIANT
C
C WRITE THE DMCHAR CONSTANTS.
C
C   WRITE (NWRITE, 10)
*   IBETA, IT, IRND, NGRD, MACHEP, NEGEP, IEXP, MINEXP, MAXEXP, EPS,
*   EPSNEG, XMIN, XMAX
C
C WRITE THE DPMPAR CONSTANTS AND THE RELATIVE DIFFERENCES.
C
C   WRITE (NWRITE, 20) EPSMCH, RERR(1), DWARF, RERR(2), GIANT, RERR(3)
C   STOP
10 FORMAT (17H1DMCHAR CONSTANTS /// 8H IBETA =, I6 // 8H IT =,
*   I6 // 8H IRND =, I6 // 8H NGRD =, I6 // 9H MACHEP =,
DPPD0010
DPPD0020
DPPD0030
DPPD0040
DPPD0050
DPPD0060
DPPD0070
DPPD0080
DPPD0090
DPPD0100
DPPD0110
DPPD0120
DPPD0130
DPPD0140
DPPD0150
DPPD0160
DPPD0170
DPPD0180
DPPD0190
DPPD0200
DPPD0210
DPPD0220
DPPD0230
DPPD0240
DPPD0250
DPPD0260
DPPD0270
DPPD0280
DPPD0290
DPPD0300
DPPD0310
DPPD0320
DPPD0330
DPPD0340
DPPD0350
DPPD0360
DPPD0370
DPPD0380
DPPD0390
DPPD0400
DPPD0410
DPPD0420
DPPD0430
DPPD0440
DPPD0450
DPPD0460
DPPD0470
DPPD0480
DPPD0490
DPPD0500
DPPD0510
DPPD0520
DPPD0530
DPPD0540
DPPD0550
DPPD0560
DPPD0570
DPPD0580
DPPD0590
DPPD0600
DPPD0610

```



```

C *****
C
C THIS PROGRAM TESTS CODES FOR THE SOLUTION OF N NONLINEAR
C EQUATIONS IN N VARIABLES. IT CONSISTS OF A DRIVER AND AN
C INTERFACE SUBROUTINE FCN. THE DRIVER READS IN DATA, CALLS THE
C NONLINEAR EQUATION SOLVER, AND FINALLY PRINTS OUT INFORMATION
C ON THE PERFORMANCE OF THE SOLVER. THIS IS ONLY A SAMPLE DRIVER,
C MANY OTHER DRIVERS ARE POSSIBLE. THE INTERFACE SUBROUTINE FCN
C IS NECESSARY TO TAKE INTO ACCOUNT THE FORMS OF CALLING
C SEQUENCES USED BY THE FUNCTION SUBROUTINES IN THE VARIOUS
C NONLINEAR EQUATION SOLVERS.
C
C SUBPROGRAMS CALLED
C
C USER-SUPPLIED ..... FCN
C
C MINPACK-SUPPLIED ... DPMPAR,ENORM,HYBRD1,INITPT,VECFCN
C
C FORTRAN-SUPPLIED ... DSQRT
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER I,IC,INFO,K,LWA,N,NFEV,NPROB,NREAD,NTRIES,NWRITE
C INTEGER NA(60),NF(60),NP(60),NX(60)
C DOUBLE PRECISION FACTOR, FNORM1, FNORM2, ONE, TEN, TOL
C DOUBLE PRECISION FNM(60),FVEC(40),WA(2660),X(40)
C DOUBLE PRECISION DPMPAR,ENORM
C EXTERNAL FCN
C COMMON /REFNUM/ NPROB,NFEV
C
C LOGICAL INPUT UNIT IS ASSUMED TO BE NUMBER 5.
C LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C DATA NREAD,NWRITE /5,6/
C
C DATA ONE,TEN /1.0D0,1.0D1/
C TOL = DSQRT(DPMPAR(1))
C LWA = 2660
C IC = 0
10 CONTINUE
   READ (NREAD,50) NPROB,N,NTRIES
   IF (NPROB .LE. 0) GO TO 30
   FACTOR = ONE
   DO 20 K = 1, NTRIES
     IC = IC + 1
     CALL INITPT(N,X,NPROB,FACTOR)
     CALL VECFCN(N,X,FVEC,NPROB)
     FNORM1 = ENORM(N,FVEC)
     WRITE (NWRITE,60) NPROB,N
     NFEV = 0
     CALL HYBRD1(FCN,N,X,FVEC,TOL,INFO,WA,LWA)
     FNORM2 = ENORM(N,FVEC)
     NP(IC) = NPROB
     NA(IC) = N
     NF(IC) = NFEV
     NX(IC) = INFO
     FNM(IC) = FNORM2
     WRITE (NWRITE,70) FNORM1,FNORM2,NFEV,INFO,(X(I), I = 1, N)
     FACTOR = TEN*FACTOR
HYBD0010
HYBD0020
HYBD0030
HYBD0040
HYBD0050
HYBD0060
HYBD0070
HYBD0080
HYBD0090
HYBD0100
HYBD0110
HYBD0120
HYBD0130
HYBD0140
HYBD0150
HYBD0160
HYBD0170
HYBD0180
HYBD0190
HYBD0200
HYBD0210
HYBD0220
HYBD0230
HYBD0240
HYBD0250
HYBD0260
HYBD0270
HYBD0280
HYBD0290
HYBD0300
HYBD0310
HYBD0320
HYBD0330
HYBD0340
HYBD0350
HYBD0360
HYBD0370
HYBD0380
HYBD0390
HYBD0400
HYBD0410
HYBD0420
HYBD0430
HYBD0440
HYBD0450
HYBD0460
HYBD0470
HYBD0480
HYBD0490
HYBD0500
HYBD0510
HYBD0520
HYBD0530
HYBD0540
HYBD0550
HYBD0560
HYBD0570
HYBD0580
HYBD0590
HYBD0600
HYBD0610

```

20	CONTINUE	HYBD0620
	GO TO 10	HYBD0630
30	CONTINUE	HYBD0640
	WRITE (NWRITE,80) IC	HYBD0650
	WRITE (NWRITE,90)	HYBD0660
	DO 40 I = 1, IC	HYBD0670
	WRITE (NWRITE,100) NP(I),NA(I),NF(I),NX(I),FNM(I)	HYBD0680
40	CONTINUE	HYBD0690
	STOP	HYBD0700
50	FORMAT (3I5)	HYBD0710
60	FORMAT (//// 5X, 8H PROBLEM, I5, 5X, 10H DIMENSION, I5, 5X //)	HYBD0720
70	FORMAT (5X, 33H INITIAL L2 NORM OF THE RESIDUALS, D15.7 // 5X,	HYBD0730
	* 33H FINAL L2 NORM OF THE RESIDUALS , D15.7 // 5X,	HYBD0740
	* 33H NUMBER OF FUNCTION EVALUATIONS , I10 // 5X,	HYBD0750
	* 15H EXIT PARAMETER, 18X, I10 // 5X,	HYBD0760
	* 27H FINAL APPROXIMATE SOLUTION // (5X, 5D15.7))	HYBD0770
80	FORMAT (12H1SUMMARY OF , I3, 16H CALLS TO HYBRD1 /)	HYBD0780
90	FORMAT (39H NPROB N NFEV INFO FINAL L2 NORM /)	HYBD0790
100	FORMAT (I4, I6, I7, I6, 1X, D15.7)	HYBD0800
C		HYBD0810
C	LAST CARD OF DRIVER.	HYBD0820
C		HYBD0830
	END	HYBD0840
	SUBROUTINE FCN(N,X,FVEC,IFLAG)	HYBD0850
	INTEGER N,IFLAG	HYBD0860
	DOUBLE PRECISION X(N),FVEC(N)	HYBD0870
C	*****	HYBD0880
C		HYBD0890
C	THE CALLING SEQUENCE OF FCN SHOULD BE IDENTICAL TO THE	HYBD0900
C	CALLING SEQUENCE OF THE FUNCTION SUBROUTINE IN THE NONLINEAR	HYBD0910
C	EQUATION SOLVER. FCN SHOULD ONLY CALL THE TESTING FUNCTION	HYBD0920
C	SUBROUTINE VECFCN WITH THE APPROPRIATE VALUE OF PROBLEM	HYBD0930
C	NUMBER (NPROB).	HYBD0940
C		HYBD0950
C	SUBPROGRAMS CALLED	HYBD0960
C		HYBD0970
C	MINPACK-SUPPLIED ... VECFCN	HYBD0980
C		HYBD0990
C	ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.	HYBD1000
C	BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE	HYBD1010
C		HYBD1020
C	*****	HYBD1030
	INTEGER NPROB,NFEV	HYBD1040
	COMMON /REFNUM/ NPROB,NFEV	HYBD1050
	CALL VECFCN(N,X,FVEC,NPROB)	HYBD1060
	NFEV = NFEV + 1	HYBD1070
	RETURN	HYBD1080
C		HYBD1090
C	LAST CARD OF INTERFACE SUBROUTINE FCN.	HYBD1100
C		HYBD1110
	END	HYBD1120

```

C *****
C
C THIS PROGRAM TESTS CODES FOR THE SOLUTION OF N NONLINEAR
C EQUATIONS IN N VARIABLES. IT CONSISTS OF A DRIVER AND AN
C INTERFACE SUBROUTINE FCN. THE DRIVER READS IN DATA, CALLS THE
C NONLINEAR EQUATION SOLVER, AND FINALLY PRINTS OUT INFORMATION
C ON THE PERFORMANCE OF THE SOLVER. THIS IS ONLY A SAMPLE DRIVER,
C MANY OTHER DRIVERS ARE POSSIBLE. THE INTERFACE SUBROUTINE FCN
C IS NECESSARY TO TAKE INTO ACCOUNT THE FORMS OF CALLING
C SEQUENCES USED BY THE FUNCTION AND JACOBIAN SUBROUTINES IN
C THE VARIOUS NONLINEAR EQUATION SOLVERS.
C
C SUBPROGRAMS CALLED
C
C USER-SUPPLIED ..... FCN
C
C MINPACK-SUPPLIED ... DPMPAR,ENORM,HYBRJ1,INITPT,VECFCN
C
C FORTRAN-SUPPLIED ... DSQRT
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER I,IC,INFO,K,LDFJAC,LWA,N,NFEV,NJEV,NPROB,NREAD,NTRIES,
1 NWRITE
C INTEGER NA(60),NF(60),NJ(60),NP(60),NX(60)
C DOUBLE PRECISION FACTOR, FNORM1, FNORM2, ONE, TEN, TOL
C DOUBLE PRECISION FNM(60), FJAC(40,40), FVEC(40), WA(1060), X(40)
C DOUBLE PRECISION DPMPAR, ENORM
C EXTERNAL FCN
C COMMON /REFNUM/ NPROB, NFEV, NJEV
C
C LOGICAL INPUT UNIT IS ASSUMED TO BE NUMBER 5.
C LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C DATA NREAD, NWRITE /5,6/
C
C DATA ONE, TEN /1.0D0,1.0D1/
C TOL = DSQRT(DPMPAR(1))
C LDFJAC = 40
C LWA = 1060
C IC = 0
10 CONTINUE
C READ (NREAD,50) NPROB,N,NTRIES
C IF (NPROB .LE. 0) GO TO 30
C FACTOR = ONE
C DO 20 K = 1, NTRIES
C IC = IC + 1
C CALL INITPT(N,X,NPROB,FACTOR)
C CALL VECFCN(N,X,FVEC,NPROB)
C FNORM1 = ENORM(N,FVEC)
C WRITE (NWRITE,60) NPROB,N
C NFEV = 0
C NJEV = 0
C CALL HYBRJ1(FCN,N,X,FVEC,FJAC,LDFJAC,TOL,INFO,WA,LWA)
C FNORM2 = ENORM(N,FVEC)
C NP(IC) = NPROB
C NA(IC) = N
C NF(IC) = NFEV
C NJ(IC) = NJEV
C
C HYJD0010
C HYJD0020
C HYJD0030
C HYJD0040
C HYJD0050
C HYJD0060
C HYJD0070
C HYJD0080
C HYJD0090
C HYJD0100
C HYJD0110
C HYJD0120
C HYJD0130
C HYJD0140
C HYJD0150
C HYJD0160
C HYJD0170
C HYJD0180
C HYJD0190
C HYJD0200
C HYJD0210
C HYJD0220
C HYJD0230
C HYJD0240
C HYJD0250
C HYJD0260
C HYJD0270
C HYJD0280
C HYJD0290
C HYJD0300
C HYJD0310
C HYJD0320
C HYJD0330
C HYJD0340
C HYJD0350
C HYJD0360
C HYJD0370
C HYJD0380
C HYJD0390
C HYJD0400
C HYJD0410
C HYJD0420
C HYJD0430
C HYJD0440
C HYJD0450
C HYJD0460
C HYJD0470
C HYJD0480
C HYJD0490
C HYJD0500
C HYJD0510
C HYJD0520
C HYJD0530
C HYJD0540
C HYJD0550
C HYJD0560
C HYJD0570
C HYJD0580
C HYJD0590
C HYJD0600
C HYJD0610

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	NX(IC) = INFO	HYJD0620
	FNM(IC) = FNORM2	HYJD0630
	WRITE (NWRITE,70)	HYJD0640
1	FNORM1,FNORM2,NFEV,NJEV,INFO,(X(I), I = 1, N)	HYJD0650
	FACTOR = TEN*FACTOR	HYJD0660
20	CONTINUE	HYJD0670
	GO TO 10	HYJD0680
30	CONTINUE	HYJD0690
	WRITE (NWRITE,80) IC	HYJD0700
	WRITE (NWRITE,90)	HYJD0710
	DO 40 I = 1, IC	HYJD0720
	WRITE (NWRITE,100) NP(I),NA(I),NF(I),NJ(I),NX(I),FNM(I)	HYJD0730
40	CONTINUE	HYJD0740
	STOP	HYJD0750
50	FORMAT (3I5)	HYJD0760
60	FORMAT (//// 5X, 8H PROBLEM, I5, 5X, 10H DIMENSION, I5, 5X //)	HYJD0770
70	FORMAT (5X, 33H INITIAL L2 NORM OF THE RESIDUALS, D15.7 // 5X,	HYJD0780
1	33H FINAL L2 NORM OF THE RESIDUALS , D15.7 // 5X,	HYJD0790
2	33H NUMBER OF FUNCTION EVALUATIONS , I10 // 5X,	HYJD0800
3	33H NUMBER OF JACOBIAN EVALUATIONS , I10 // 5X,	HYJD0810
4	15H EXIT PARAMETER, 18X, I10 // 5X,	HYJD0820
5	27H FINAL APPROXIMATE SOLUTION // (5X, 5D15.7))	HYJD0830
80	FORMAT (12H1SUMMARY OF , I3, 16H CALLS TO HYBRJ1 /)	HYJD0840
90	FORMAT (46H NPROB N NFEV NJEV INFO FINAL L2 NORM /)	HYJD0850
100	FORMAT (I4, I6, 2I7, I6, 1X, D15.7)	HYJD0860
C		HYJD0870
C	LAST CARD OF DRIVER.	HYJD0880
C		HYJD0890
	END	HYJD0900
	SUBROUTINE FCN(N,X,FVEC,FJAC,LDFJAC,IFLAG)	HYJD0910
	INTEGER N,LDFJAC,IFLAG	HYJD0920
	DOUBLE PRECISION X(N),FVEC(N),FJAC(LDFJAC,N)	HYJD0930
C	*****	HYJD0940
C		HYJD0950
C	THE CALLING SEQUENCE OF FCN SHOULD BE IDENTICAL TO THE	HYJD0960
C	CALLING SEQUENCE OF THE FUNCTION SUBROUTINE IN THE NONLINEAR	HYJD0970
C	EQUATION SOLVER. FCN SHOULD ONLY CALL THE TESTING FUNCTION	HYJD0980
C	AND JACOBIAN SUBROUTINES VECFCN AND VECJAC WITH THE	HYJD0990
C	APPROPRIATE VALUE OF PROBLEM NUMBER (NPROB).	HYJD1000
C		HYJD1010
C	SUBPROGRAMS CALLED	HYJD1020
C		HYJD1030
C	MINPACK-SUPPLIED ... VECFCN,VECJAC	HYJD1040
C		HYJD1050
C	ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.	HYJD1060
C	BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE	HYJD1070
C		HYJD1080
C	*****	HYJD1090
	INTEGER NPROB,NFEV,NJEV	HYJD1100
	COMMON /REFNUM/ NPROB,NFEV,NJEV	HYJD1110
	IF (IFLAG .EQ. 1) CALL VECFCN(N,X,FVEC,NPROB)	HYJD1120
	IF (IFLAG .EQ. 2) CALL VECJAC(N,X,FJAC,LDFJAC,NPROB)	HYJD1130
	IF (IFLAG .EQ. 1) NFEV = NFEV + 1	HYJD1140
	IF (IFLAG .EQ. 2) NJEV = NJEV + 1	HYJD1150
	RETURN	HYJD1160
C		HYJD1170
C	LAST CARD OF INTERFACE SUBROUTINE FCN.	HYJD1180
C		HYJD1190
	END	HYJD1200


```

C *****
C
C THIS PROGRAM TESTS CODES FOR THE LEAST-SQUARES SOLUTION OF
C M NONLINEAR EQUATIONS IN N VARIABLES. IT CONSISTS OF A DRIVER
C AND AN INTERFACE SUBROUTINE FCN. THE DRIVER READS IN DATA,
C CALLS THE NONLINEAR LEAST-SQUARES SOLVER, AND FINALLY PRINTS
C OUT INFORMATION ON THE PERFORMANCE OF THE SOLVER. THIS IS
C ONLY A SAMPLE DRIVER, MANY OTHER DRIVERS ARE POSSIBLE. THE
C INTERFACE SUBROUTINE FCN IS NECESSARY TO TAKE INTO ACCOUNT THE
C FORMS OF CALLING SEQUENCES USED BY THE FUNCTION AND JACOBIAN
C SUBROUTINES IN THE VARIOUS NONLINEAR LEAST-SQUARES SOLVERS.
C
C SUBPROGRAMS CALLED
C
C USER-SUPPLIED ..... FCN
C
C MINPACK-SUPPLIED ... DPMPAR,ENORM,INITPT,LMDER1,SSQFCN
C
C FORTRAN-SUPPLIED ... DSQRT
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER I,IC,INFO,K,LDFJAC,LWA,M,N,NFEV,NJEV,NPROB,NREAD,NTRIES,
* NWRITE
C INTEGER IWA(40),MA(60),NA(60),NF(60),NJ(60),NP(60),NX(60)
C DOUBLE PRECISION FACTOR, FNORM1, FNORM2, ONE, TEN, TOL
C DOUBLE PRECISION FJAC(65,40), FNM(60), FVEC(65), WA(265), X(40)
C DOUBLE PRECISION DPMPAR, ENORM
C EXTERNAL FCN
C COMMON /REFNUM/ NPROB, NFEV, NJEV
C
C LOGICAL INPUT UNIT IS ASSUMED TO BE NUMBER 5.
C LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C DATA NREAD, NWRITE /5,6/
C
C DATA ONE, TEN /1.0D0,1.0D1/
C TOL = DSQRT(DPMPAR(1))
C LDFJAC = 65
C LWA = 265
C IC = 0
10 CONTINUE
C READ (NREAD,50) NPROB,N,M,NTRIES
C IF (NPROB .LE. 0) GO TO 30
C FACTOR = ONE
C DO 20 K = 1, NTRIES
C IC = IC + 1
C CALL INITPT(N,X,NPROB,FACTOR)
C CALL SSQFCN(M,N,X,FVEC,NPROB)
C FNORM1 = ENORM(M,FVEC)
C WRITE (NWRITE,60) NPROB,N,M
C NFEV = 0
C NJEV = 0
C CALL LMDER1(FCN,M,N,X,FVEC,FJAC,LDFJAC,TOL,INFO,IWA,WA,
* LWA)
C CALL SSQFCN(M,N,X,FVEC,NPROB)
C FNORM2 = ENORM(M,FVEC)
C NP(IC) = NPROB
C NA(IC) = N

```

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LMDD0010
LMDD0020
LMDD0030
LMDD0040
LMDD0050
LMDD0060
LMDD0070
LMDD0080
LMDD0090
LMDD0100
LMDD0110
LMDD0120
LMDD0130
LMDD0140
LMDD0150
LMDD0160
LMDD0170
LMDD0180
LMDD0190
LMDD0200
LMDD0210
LMDD0220
LMDD0230
LMDD0240
LMDD0250
LMDD0260
LMDD0270
LMDD0280
LMDD0290
LMDD0300
LMDD0310
LMDD0320
LMDD0330
LMDD0340
LMDD0350
LMDD0360
LMDD0370
LMDD0380
LMDD0390
LMDD0400
LMDD0410
LMDD0420
LMDD0430
LMDD0440
LMDD0450
LMDD0460
LMDD0470
LMDD0480
LMDD0490
LMDD0500
LMDD0510
LMDD0520
LMDD0530
LMDD0540
LMDD0550
LMDD0560
LMDD0570
LMDD0580
LMDD0590
LMDD0600
LMDD0610

```

	MA(IC) = M	LMDD0620
	NF(IC) = NFEV	LMDD0630
	NJ(IC) = NJEV	LMDD0640
	NX(IC) = INFO	LMDD0650
	FNМ(IC) = FNORM2	LMDD0660
	WRITE (NWRITE,70)	LMDD0670
*	FNORM1,FNORM2,NFEV,NJEV,INFO,(X(I), I = 1, N)	LMDD0680
	FACTOR = TEN*FACTOR	LMDD0690
20	CONTINUE	LMDD0700
	GO TO 10	LMDD0710
30	CONTINUE	LMDD0720
	WRITE (NWRITE,80) IC	LMDD0730
	WRITE (NWRITE,90)	LMDD0740
	DO 40 I = 1, IC	LMDD0750
	WRITE (NWRITE,100) NP(I),NA(I),MA(I),NF(I),NJ(I),NX(I),FNМ(I)	LMDD0760
40	CONTINUE	LMDD0770
	STOP	LMDD0780
50	FORMAT (4I5)	LMDD0790
60	FORMAT (/// 5X, 8H PROBLEM, I5, 5X, 11H DIMENSIONS, 2I5, 5X //	LMDD0800
	*)	LMDD0810
70	FORMAT (5X, 33H INITIAL L2 NORM OF THE RESIDUALS, D15.7 // 5X,	LMDD0820
*	33H FINAL L2 NORM OF THE RESIDUALS , D15.7 // 5X,	LMDD0830
*	33H NUMBER OF FUNCTION EVALUATIONS , I10 // 5X,	LMDD0840
*	33H NUMBER OF JACOBIAN EVALUATIONS , I10 // 5X,	LMDD0850
*	15H EXIT PARAMETER, 18X, I10 // 5X,	LMDD0860
*	27H FINAL APPROXIMATE SOLUTION // (5X, 5D15.7))	LMDD0870
80	FORMAT (12H1SUMMARY OF , I3, 16H CALLS TO LMDER1 /)	LMDD0880
90	FORMAT (49H NPROB N M NFEV NJEV INFO FINAL L2 NORM /)	LMDD0890
100	FORMAT (3I5, 3I6, 1X, D15.7)	LMDD0900
C		LMDD0910
C	LAST CARD OF DRIVER.	LMDD0920
C		LMDD0930
	END	LMDD0940
	SUBROUTINE FCN(M,N,X,FVEC,FJAC,LDFJAC,IFLAG)	LMDD0950
	INTEGER M,N,LDFJAC,IFLAG	LMDD0960
	DOUBLE PRECISION X(N),FVEC(M),FJAC(LDFJAC,N)	LMDD0970
	*****	LMDD0980
C		LMDD0990
C		LMDD1000
C	THE CALLING SEQUENCE OF FCN SHOULD BE IDENTICAL TO THE	LMDD1010
C	CALLING SEQUENCE OF THE FUNCTION SUBROUTINE IN THE NONLINEAR	LMDD1020
C	LEAST-SQUARES SOLVER. FCN SHOULD ONLY CALL THE TESTING	LMDD1030
C	FUNCTION AND JACOBIAN SUBROUTINES SSQFCN AND SSQJAC WITH	LMDD1040
C	THE APPROPRIATE VALUE OF PROBLEM NUMBER (NPROB).	LMDD1050
C		LMDD1060
C	SUBPROGRAMS CALLED	LMDD1070
C		LMDD1080
C	MINPACK-SUPPLIED ... SSQFCN,SSQJAC	LMDD1090
C		LMDD1100
C	ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.	LMDD1110
C	BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE	LMDD1120
C		LMDD1130
C	*****	LMDD1140
	INTEGER NPROB,NFEV,NJEV	LMDD1150
	COMMON /REFNUM/ NPROB,NFEV,NJEV	LMDD1160
	IF (IFLAG .EQ. 1) CALL SSQFCN(M,N,X,FVEC,NPROB)	LMDD1170
	IF (IFLAG .EQ. 2) CALL SSQJAC(M,N,X,FJAC,LDFJAC,NPROB)	LMDD1180
	IF (IFLAG .EQ. 1) NFEV = NFEV + 1	LMDD1190
	IF (IFLAG .EQ. 2) NJEV = NJEV + 1	LMDD1200
	RETURN	LMDD1210
C		LMDD1220
C	LAST CARD OF INTERFACE SUBROUTINE FCN.	LMDD1220

C

END

LMDD1230
LMDD1240

```

C      *****
C
C      THIS PROGRAM TESTS CODES FOR THE LEAST-SQUARES SOLUTION OF
C      M NONLINEAR EQUATIONS IN N VARIABLES. IT CONSISTS OF A DRIVER
C      AND AN INTERFACE SUBROUTINE FCN. THE DRIVER READS IN DATA,
C      CALLS THE NONLINEAR LEAST-SQUARES SOLVER, AND FINALLY PRINTS
C      OUT INFORMATION ON THE PERFORMANCE OF THE SOLVER. THIS IS
C      ONLY A SAMPLE DRIVER, MANY OTHER DRIVERS ARE POSSIBLE. THE
C      INTERFACE SUBROUTINE FCN IS NECESSARY TO TAKE INTO ACCOUNT THE
C      FORMS OF CALLING SEQUENCES USED BY THE FUNCTION AND JACOBIAN
C      SUBROUTINES IN THE VARIOUS NONLINEAR LEAST-SQUARES SOLVERS.
C
C      SUBPROGRAMS CALLED
C
C      USER-SUPPLIED ..... FCN
C
C      MINPACK-SUPPLIED ... DPMPAR,ENORM,INITPT,LMSTR1,SSQFCN
C
C      FORTRAN-SUPPLIED ... DSQRT
C
C      ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C      BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C      *****
C      INTEGER I,IC,INFO,K,LDFJAC,LWA,M,N,NFEV,NJEV,NPROB,NREAD,NTRIES,
*      NWRITE
C      INTEGER IWA(40),MA(60),NA(60),NF(60),NJ(60),NP(60),NX(60)
C      DOUBLE PRECISION FACTOR, FNORM1, FNORM2, ONE, TEN, TOL
C      DOUBLE PRECISION FJAC(40,40), FNM(60), FVEC(65), WA(265), X(40)
C      DOUBLE PRECISION DPMPAR, ENORM
C      EXTERNAL FCN
C      COMMON /REFNUM/ NPROB, NFEV, NJEV
C
C      LOGICAL INPUT UNIT IS ASSUMED TO BE NUMBER 5.
C      LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C      DATA NREAD, NWRITE /5,6/
C
C      DATA ONE, TEN /1.0D0,1.0D1/
C      TOL = DSQRT(DPMPAR(1))
C      LDFJAC = 40
C      LWA = 265
C      IC = 0
10 CONTINUE
      READ (NREAD,50) NPROB,N,M,NTRIES
      IF (NPROB .LE. 0) GO TO 30
      FACTOR = ONE
      DO 20 K = 1, NTRIES
        IC = IC + 1
        CALL INITPT(N,X,NPROB,FACTOR)
        CALL SSQFCN(M,N,X,FVEC,NPROB)
        FNORM1 = ENORM(M,FVEC)
        WRITE (NWRITE,60) NPROB,N,M
        NFEV = 0
        NJEV = 0
        CALL LMSTR1(FCN,M,N,X,FVEC,FJAC,LDFJAC,TOL,INFO,IWA,WA,
*          LWA)
        CALL SSQFCN(M,N,X,FVEC,NPROB)
        FNORM2 = ENORM(M,FVEC)
        NP(IC) = NPROB
        NA(IC) = N

```

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LMSD0010
LMSD0020
LMSD0030
LMSD0040
LMSD0050
LMSD0060
LMSD0070
LMSD0080
LMSD0090
LMSD0100
LMSD0110
LMSD0120
LMSD0130
LMSD0140
LMSD0150
LMSD0160
LMSD0170
LMSD0180
LMSD0190
LMSD0200
LMSD0210
LMSD0220
LMSD0230
LMSD0240
LMSD0250
LMSD0260
LMSD0270
LMSD0280
LMSD0290
LMSD0300
LMSD0310
LMSD0320
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LMSD0350
LMSD0360
LMSD0370
LMSD0380
LMSD0390
LMSD0400
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LMSD0550
LMSD0560
LMSD0570
LMSD0580
LMSD0590
LMSD0600
LMSD0610

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```

MA(IC) = M                                LMSD0620
NF(IC) = NFEV                              LMSD0630
NJ(IC) = NJEV                              LMSD0640
NX(IC) = INFO                              LMSD0650
FNM(IC) = FNORM2                           LMSD0660
WRITE (NWRITE,70)                          LMSD0670
*      FNORM1,FNORM2,NFEV,NJEV,INFO,(X(I), I = 1, N) LMSD0680
      FACTOR = TEN*FACTOR                   LMSD0690
20    CONTINUE                              LMSD0700
      GO TO 10                              LMSD0710
30    CONTINUE                              LMSD0720
      WRITE (NWRITE,80) IC                  LMSD0730
      WRITE (NWRITE,90)                    LMSD0740
      DO 40 I = 1, IC                       LMSD0750
        WRITE (NWRITE,100) NP(I),NA(I),MA(I),NF(I),NJ(I),NX(I),FNM(I) LMSD0760
40    CONTINUE                              LMSD0770
      STOP                                  LMSD0780
50    FORMAT (4I5)                          LMSD0790
60    FORMAT ( /// 5X, 8H PROBLEM, I5, 5X, 11H DIMENSIONS, 2I5, 5X // LMSD0800
*      )                                     LMSD0810
70    FORMAT (5X, 33H INITIAL L2 NORM OF THE RESIDUALS, D15.7 // 5X, LMSD0820
*      33H FINAL L2 NORM OF THE RESIDUALS , D15.7 // 5X, LMSD0830
*      33H NUMBER OF FUNCTION EVALUATIONS , I10 // 5X, LMSD0840
*      33H NUMBER OF JACOBIAN EVALUATIONS , I10 // 5X, LMSD0850
*      15H EXIT PARAMETER, 18X, I10 // 5X, LMSD0860
*      27H FINAL APPROXIMATE SOLUTION // (5X, 5D15.7)) LMSD0870
80    FORMAT (12H1SUMMARY OF , I3, 16H CALLS TO LMSTR1 /) LMSD0880
90    FORMAT (49H NPROB N M NFEV NJEV INFO FINAL L2 NORM /) LMSD0890
100   FORMAT (3I5, 3I6, 1X, D15.7)         LMSD0900
C                                           LMSD0910
C      LAST CARD OF DRIVER.                 LMSD0920
C                                           LMSD0930
      END                                   LMSD0940
      SUBROUTINE FCN(M,N,X,FVEC,FJROW,IFLAG) LMSD0950
      INTEGER M,N,IFLAG                    LMSD0960
      DOUBLE PRECISION X(N),FVEC(M),FJROW(N) LMSD0970
C      *****                               LMSD0980
C                                           LMSD0990
C      THE CALLING SEQUENCE OF FCN SHOULD BE IDENTICAL TO THE LMSD1000
C      CALLING SEQUENCE OF THE FUNCTION SUBROUTINE IN THE NONLINEAR LMSD1010
C      LEAST SQUARES SOLVER. IF IFLAG = 1, FCN SHOULD ONLY CALL THE LMSD1020
C      TESTING FUNCTION SUBROUTINE SSQFCN. IF IFLAG = I, I .GE. 2, LMSD1030
C      FCN SHOULD ONLY CALL SUBROUTINE SSQJAC TO CALCULATE THE LMSD1040
C      (I-1)-ST ROW OF THE JACOBIAN. (THE SSQJAC SUBROUTINE PROVIDED LMSD1050
C      HERE FOR TESTING PURPOSES CALCULATES THE ENTIRE JACOBIAN LMSD1060
C      MATRIX AND IS THEREFORE CALLED ONLY WHEN IFLAG = 2.) EACH LMSD1070
C      CALL TO SSQFCN OR SSQJAC SHOULD SPECIFY THE APPROPRIATE LMSD1080
C      VALUE OF PROBLEM NUMBER (NPROB). LMSD1090
C                                           LMSD1100
C      SUBPROGRAMS CALLED                    LMSD1110
C                                           LMSD1120
C      MINPACK-SUPPLIED ... SSQFCN,SSQJAC LMSD1130
C                                           LMSD1140
C      ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980. LMSD1150
C      BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE LMSD1160
C                                           LMSD1170
C      *****                               LMSD1180
C      INTEGER NPROB,NFEV,NJEV,J           LMSD1190
C      DOUBLE PRECISION TEMP(65,40)        LMSD1200
C      COMMON /REFNUM/ NPROB,NFEV,NJEV LMSD1210
C      IF (IFLAG .EQ. 1) CALL SSQFCN(M,N,X,FVEC,NPROB) LMSD1220

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```
IF (IFLAG .EQ. 2) CALL SSQJAC(M,N,X,TEMP,65,NPROB)
IF (IFLAG .EQ. 1) NFEV = NFEV + 1
IF (IFLAG .EQ. 2) NJEV = NJEV + 1
IF (IFLAG .EQ. 1) GO TO 120
DO 110 J = 1, N
    FJROW(J) = TEMP(IFLAG-1,J)
110    CONTINUE
120 CONTINUE
    RETURN
C
C    LAST CARD OF INTERFACE SUBROUTINE FCN.
C
    END
```

```
LMSD1230
LMSD1240
LMSD1250
LMSD1260
LMSD1270
LMSD1280
LMSD1290
LMSD1300
LMSD1310
LMSD1320
LMSD1330
LMSD1340
LMSD1350
```

```

C *****
C
C THIS PROGRAM TESTS CODES FOR THE LEAST-SQUARES SOLUTION OF
C M NONLINEAR EQUATIONS IN N VARIABLES. IT CONSISTS OF A DRIVER
C AND AN INTERFACE SUBROUTINE FCN. THE DRIVER READS IN DATA,
C CALLS THE NONLINEAR LEAST-SQUARES SOLVER, AND FINALLY PRINTS
C OUT INFORMATION ON THE PERFORMANCE OF THE SOLVER. THIS IS
C ONLY A SAMPLE DRIVER, MANY OTHER DRIVERS ARE POSSIBLE. THE
C INTERFACE SUBROUTINE FCN IS NECESSARY TO TAKE INTO ACCOUNT THE
C FORMS OF CALLING SEQUENCES USED BY THE FUNCTION AND JACOBIAN
C SUBROUTINES IN THE VARIOUS NONLINEAR LEAST-SQUARES SOLVERS.
C
C SUBPROGRAMS CALLED
C
C USER-SUPPLIED ..... FCN
C
C MINPACK-SUPPLIED ... DPMPAR,ENORM,INITPT,LMDIF1,SSQFCN
C
C FORTRAN-SUPPLIED ... DSQRT
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER I,IC,INFO,K,LWA,M,N,NFEV,NJEV,NPROB,NREAD,NTRIES,NWRITE
C INTEGER IWA(40),MA(60),NA(60),NF(60),NJ(60),NP(60),NX(60)
C DOUBLE PRECISION FACTOR, FNORM1, FNORM2, ONE, TEN, TOL
C DOUBLE PRECISION FNM(60), FVEC(65), WA(2865), X(40)
C DOUBLE PRECISION DPMPAR, ENORM
C EXTERNAL FCN
C COMMON /REFNUM/ NPROB, NFEV, NJEV
C
C LOGICAL INPUT UNIT IS ASSUMED TO BE NUMBER 5.
C LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C DATA NREAD,NWRITE /5,6/
C
C DATA ONE,TEN /1.0D0,1.0D1/
C TOL = DSQRT(DPMPAR(1))
C LWA = 2865
C IC = 0
10 CONTINUE
    READ (NREAD,50) NPROB,N,M,NTRIES
    IF (NPROB .LE. 0) GO TO 30
    FACTOR = ONE
    DO 20 K = 1, NTRIES
        IC = IC + 1
        CALL INITPT(N,X,NPROB,FACTOR)
        CALL SSQFCN(M,N,X,FVEC,NPROB)
        FNORM1 = ENORM(M,FVEC)
        WRITE (NWRITE,60) NPROB,N,M
        NFEV = 0
        NJEV = 0
        CALL LMDIF1(FCN,M,N,X,FVEC,TOL,INFO,IWA,WA,LWA)
        CALL SSQFCN(M,N,X,FVEC,NPROB)
        FNORM2 = ENORM(M,FVEC)
        NP(IC) = NPROB
        NA(IC) = N
        MA(IC) = M
        NF(IC) = NFEV
        NJEV = NJEV/N

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LMFD0010
LMFD0020
LMFD0030
LMFD0040
LMFD0050
LMFD0060
LMFD0070
LMFD0080
LMFD0090
LMFD0100
LMFD0110
LMFD0120
LMFD0130
LMFD0140
LMFD0150
LMFD0160
LMFD0170
LMFD0180
LMFD0190
LMFD0200
LMFD0210
LMFD0220
LMFD0230
LMFD0240
LMFD0250
LMFD0260
LMFD0270
LMFD0280
LMFD0290
LMFD0300
LMFD0310
LMFD0320
LMFD0330
LMFD0340
LMFD0350
LMFD0360
LMFD0370
LMFD0380
LMFD0390
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LMFD0450
LMFD0460
LMFD0470
LMFD0480
LMFD0490
LMFD0500
LMFD0510
LMFD0520
LMFD0530
LMFD0540
LMFD0550
LMFD0560
LMFD0570
LMFD0580
LMFD0590
LMFD0600
LMFD0610

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NJ(IC) = NJEV
NX(IC) = INFO
FNM(IC) = FNORM2
WRITE (NWRITE,70)
*          FNORM1,FNORM2,NFEV,NJEV,INFO,(X(I), I = 1, N)
          FACTOR = TEN*FACTOR
20      CONTINUE
      GO TO 10
30 CONTINUE
WRITE (NWRITE,80) IC
WRITE (NWRITE,90)
DO 40 I = 1, IC
      WRITE (NWRITE,100) NP(I),NA(I),MA(I),NF(I),NJ(I),NX(I),FNM(I)
40 CONTINUE
STOP
50 FORMAT (4I5)
60 FORMAT ( /// 5X, 8H PROBLEM, I5, 5X, 11H DIMENSIONS, 2I5, 5X //
* )
70 FORMAT (5X, 33H INITIAL L2 NORM OF THE RESIDUALS, D15.7 // 5X,
* 33H FINAL L2 NORM OF THE RESIDUALS , D15.7 // 5X,
* 33H NUMBER OF FUNCTION EVALUATIONS , I10 // 5X,
* 33H NUMBER OF JACOBIAN EVALUATIONS , I10 // 5X,
* 15H EXIT PARAMETER, 18X, I10 // 5X,
* 27H FINAL APPROXIMATE SOLUTION // (5X, 5D15.7))
80 FORMAT (12H1SUMMARY OF , I3, 16H CALLS TO LMDIF1 /)
90 FORMAT (49H NPROB N M NFEV NJEV INFO FINAL L2 NORM /)
100 FORMAT (3I5, 3I6, 1X, D15.7)
C
C LAST CARD OF DRIVER.
C
END
SUBROUTINE FCN(M,N,X,FVEC,IFLAG)
INTEGER M,N,IFLAG
DOUBLE PRECISION X(N),FVEC(M)
*****
C
C THE CALLING SEQUENCE OF FCN SHOULD BE IDENTICAL TO THE
C CALLING SEQUENCE OF THE FUNCTION SUBROUTINE IN THE NONLINEAR
C LEAST-SQUARES SOLVER. FCN SHOULD ONLY CALL THE TESTING
C FUNCTION SUBROUTINE SSQFCN WITH THE APPROPRIATE VALUE OF
C PROBLEM NUMBER (NPROB).
C
C SUBPROGRAMS CALLED
C
C MINPACK-SUPPLIED ... SSQFCN
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER NPROB,NFEV,NJEV
C COMMON /REFNUM/ NPROB,NFEV,NJEV
C CALL SSQFCN(M,N,X,FVEC,NPROB)
C IF (IFLAG .EQ. 1) NFEV = NFEV + 1
C IF (IFLAG .EQ. 2) NJEV = NJEV + 1
C RETURN
C
C LAST CARD OF INTERFACE SUBROUTINE FCN.
C
END

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LMFD0620
LMFD0630
LMFD0640
LMFD0650
LMFD0660
LMFD0670
LMFD0680
LMFD0690
LMFD0700
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LMFD1120
LMFD1130
LMFD1140
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LMFD1160
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LMFD1190
LMFD1200
LMFD1210


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C *****
C
C THIS PROGRAM TESTS THE ABILITY OF CHKDER TO DETECT
C INCONSISTENCIES BETWEEN FUNCTIONS AND THEIR FIRST DERIVATIVES.
C FOURTEEN TEST FUNCTION VECTORS AND JACOBIANS ARE USED. ELEVEN OF
C THE TESTS ARE FALSE(F), I.E. THERE ARE INCONSISTENCIES BETWEEN
C THE FUNCTION VECTORS AND THE CORRESPONDING JACOBIANS. THREE OF
C THE TESTS ARE TRUE(T), I.E. THERE ARE NO INCONSISTENCIES. THE
C DRIVER READS IN DATA, CALLS CHKDER AND PRINTS OUT INFORMATION
C REQUIRED BY AND RECEIVED FROM CHKDER.
C
C SUBPROGRAMS CALLED
C
C MINPACK SUPPLIED ... CHKDER,ERRJAC,INITPT,VECFCN
C
C ARGONNE NATIONAL LABORATORY. MINPACK PROJECT. MARCH 1980.
C BURTON S. GARBOW, KENNETH E. HILLSTROM, JORGE J. MORE
C
C *****
C INTEGER I, LDFJAC, LNP, MODE, N, NPROB, NREAD, NWRITE
C INTEGER NA(14), NP(14)
C LOGICAL A(14)
C DOUBLE PRECISION CP, ONE
C DOUBLE PRECISION DIFF(10), ERR(10), ERRMAX(14), ERRMIN(14),
*          FJAC(10,10), FVEC1(10), FVEC2(10), X1(10), X2(10)
C
C LOGICAL INPUT UNIT IS ASSUMED TO BE NUMBER 5.
C LOGICAL OUTPUT UNIT IS ASSUMED TO BE NUMBER 6.
C
C DATA NREAD, NWRITE /5,6/
C
C DATA A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8),A(9),A(10),A(11),
*      A(12),A(13),A(14)
*      /.FALSE.,.FALSE.,.FALSE.,.TRUE.,.FALSE.,.FALSE.,.FALSE.,
*      .TRUE.,.FALSE.,.FALSE.,.FALSE.,.FALSE.,.TRUE.,.FALSE./
C DATA CP, ONE /1.23D-1,1.0D0/
C LDFJAC = 10
10 CONTINUE
   READ (NREAD,60) NPROB,N
   IF (NPROB .LE. 0) GO TO 40
   CALL INITPT(N,X1,NPROB,ONE)
   DO 20 I = 1, N
     X1(I) = X1(I) + CP
     CP = -CP
20   CONTINUE
   WRITE (NWRITE,70) NPROB,N,A(NPROB)
   MODE = 1
   CALL CHKDER(N,N,X1,FVEC1,FJAC,LDFJAC,X2,FVEC2,MODE,ERR)
   MODE = 2
   CALL VECFCN(N,X1,FVEC1,NPROB)
   CALL ERRJAC(N,X1,FJAC,LDFJAC,NPROB)
   CALL VECFCN(N,X2,FVEC2,NPROB)
   CALL CHKDER(N,N,X1,FVEC1,FJAC,LDFJAC,X2,FVEC2,MODE,ERR)
   ERRMIN(NPROB) = ERR(1)
   ERRMAX(NPROB) = ERR(1)
   DO 30 I = 1, N
     DIFF(I) = FVEC2(I) - FVEC1(I)
     IF (ERRMIN(NPROB) .GT. ERR(I)) ERRMIN(NPROB) = ERR(I)
     IF (ERRMAX(NPROB) .LT. ERR(I)) ERRMAX(NPROB) = ERR(I)
30   CONTINUE
   NP(NPROB) = NPROB
CHKD0010
CHKD0020
CHKD0030
CHKD0040
CHKD0050
CHKD0060
CHKD0070
CHKD0080
CHKD0090
CHKD0100
CHKD0110
CHKD0120
CHKD0130
CHKD0140
CHKD0150
CHKD0160
CHKD0170
CHKD0180
CHKD0190
CHKD0200
CHKD0210
CHKD0220
CHKD0230
CHKD0240
CHKD0250
CHKD0260
CHKD0270
CHKD0280
CHKD0290
CHKD0300
CHKD0310
CHKD0320
CHKD0330
CHKD0340
CHKD0350
CHKD0360
CHKD0370
CHKD0380
CHKD0390
CHKD0400
CHKD0410
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CHKD0550
CHKD0560
CHKD0570
CHKD0580
CHKD0590
CHKD0600
CHKD0610

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LNP = NPROB	CHKD0620
NA(NPROB) = N	CHKD0630
WRITE (NWRITE,80) (FVEC1(I), I = 1, N)	CHKD0640
WRITE (NWRITE,90) (DIFF(I), I = 1, N)	CHKD0650
WRITE (NWRITE,100) (ERR(I), I = 1, N)	CHKD0660
GO TO 10	CHKD0670
40 CONTINUE	CHKD0680
WRITE (NWRITE,110) LNP	CHKD0690
WRITE (NWRITE,120)	CHKD0700
DO 50 I = 1, LNP	CHKD0710
WRITE (NWRITE,130) NP(I),NA(I),A(I),ERRMIN(I),ERRMAX(I)	CHKD0720
50 CONTINUE	CHKD0730
STOP	CHKD0740
60 FORMAT (2I5)	CHKD0750
70 FORMAT (/// 5X, 8H PROBLEM, I5, 5X, 15H WITH DIMENSION, I5, 2X,	CHKD0760
* 5H IS , L1)	CHKD0770
80 FORMAT (// 5X, 25H FIRST FUNCTION VECTOR // (5X, 5D15.7))	CHKD0780
90 FORMAT (// 5X, 27H FUNCTION DIFFERENCE VECTOR // (5X, 5D15.7))	CHKD0790
100 FORMAT (// 5X, 13H ERROR VECTOR // (5X, 5D15.7))	CHKD0800
110 FORMAT (12H1SUMMARY OF , I3, 16H TESTS OF CHKDER /)	CHKD0810
120 FORMAT (46H NPROB N STATUS ERRMIN ERRMAX /)	CHKD0820
130 FORMAT (I4, I6, 6X, L1, 3X, 2D15.7)	CHKD0830
C	CHKD0840
C LAST CARD OF DERIVATIVE CHECK TEST DRIVER.	CHKD0850
C	CHKD0860
END	CHKD0870

A P P E N D I X C

Test Output Summaries

DMCHAR CONSTANTS

IBETA = 16
IT = 14
IRND = 0
NGRD = 1
MACHEP = -13
NEGEP = -14
IEXP = 7
MINEXP = -65
MAXEXP = 63
EPS = 0.2220446D-15
EPSNEG = 0.1387779D-16
XHIN = 0.5397605D-78
XMAX = 0.7237006D+76

DPMPAR CONSTANTS AND RELATIVE DIFFERENCES

EI'SMCH = 0.2220446D-15
RERR(1) = 0.0
DHARF = 0.5397605D-78
RERR(2) = 0.0
GIANT = 0.7237006D+76
RERR(3) = 0.0

SUMMARY OF 55 CALLS TO HYBRD1

NPROB	N	NFEV	INFO	FINAL L2 NORM
1	2	24	1	0.0
1	2	9	1	0.3469447D-14
1	2	9	1	0.0
2	4	107	4	0.1680600D-32
2	4	114	4	0.2602497D-33
2	4	125	4	0.1103789D-32
3	2	181	1	0.1712493D-08
3	2	11	1	0.3744485D-07
4	4	94	1	0.3993906D-10
4	4	233	1	0.3341714D-08
4	4	505	1	0.1731553D-09
5	3	27	1	0.2753435D-12
5	3	32	1	0.2250875D-09
5	3	40	1	0.1623431D-12
6	6	96	1	0.3316730D-12
6	6	171	1	0.1615190D-11
6	9	124	1	0.1580959D-12
6	9	476	4	0.3079344D-01
7	5	17	1	0.3252653D-11
7	5	238	1	0.1533203D-09
7	5	482	1	0.4930352D-10
7	6	25	1	0.3757052D-09
7	6	172	1	0.1029402D-09
7	6	253	1	0.1824689D-11
7	7	20	1	0.2742537D-08
7	7	616	1	0.1809471D-09
7	7	139	4	0.1006304D+14
7	8	120	4	0.6440508D-01
7	9	41	1	0.1881985D-08
8	10	31	1	0.6195651D-14
8	10	31	1	0.2954633D-14
8	10	77	1	0.3316379D-13
8	30	112	1	0.7826137D-14
8	40	92	1	0.4549521D-12
9	10	16	1	0.2516594D-14
9	10	19	1	0.1725957D-12
9	10	52	1	0.4174341D-09
10	1	7	1	0.2775558D-16
10	1	9	1	0.5551115D-16
10	1	16	1	0.0
10	10	16	1	0.5013184D-14
10	10	19	1	0.2188251D-12
10	10	39	1	0.3045701D-14
11	10	130	4	0.5296388D-02
11	10	84	1	0.5915050D-10
11	10	83	1	0.3427482D-08
12	10	60	1	0.0
12	10	46	1	0.3767526D-13
12	10	61	1	0.4598020D-10
13	10	21	1	0.1493879D-07
13	10	59	1	0.5104291D-08
13	10	42	1	0.9878354D-10
14	10	30	1	0.2057898D-08
14	10	45	1	0.7953612D-08
14	10	58	1	0.4526428D-09

SUMMARY OF 55 CALLS TO HYBRJ1

NPROB	N	NFEV	NJEV	INFO	FINAL L2 NORM
1	2	17	3	1	0.0
1	2	7	1	1	0.0
1	2	7	1	1	0.0
2	4	163	10	4	0.46346650-33
2	4	122	8	4	0.36781470-35
2	4	128	6	4	0.36793060-33
3	2	169	6	1	0.17126670-08
3	2	9	1	1	0.37440620-07
4	4	86	2	1	0.39855280-10
4	4	202	8	1	0.37713350-09
4	4	386	35	1	0.34764590-10
5	3	18	3	1	0.27534430-12
5	3	20	4	1	0.22509960-09
5	3	37	8	1	0.72027770-09
6	6	60	6	1	0.35125520-12
6	6	140	6	1	0.26629960-13
6	9	92	4	1	0.51934970-11
6	9	274	12	4	0.38884320-01
7	5	10	1	1	0.60463890-12
7	5	134	24	1	0.19366490-09
7	5	222	47	1	0.10468330-09
7	6	13	2	1	0.14343440-10
7	6	91	13	1	0.72196360-10
7	6	129	21	1	0.15009950-10
7	7	11	1	1	0.19358160-09
7	7	270	43	1	0.17180970-08
7	7	64	11	4	0.67575990+12
7	8	56	8	4	0.64405120-01
7	9	23	2	1	0.42088290-09
8	10	11	2	1	0.61956510-14
8	10	11	2	1	0.29486630-14
8	10	27	5	1	0.32620820-13
8	30	22	3	1	0.54712980-13
8	40	12	2	1	0.43146980-12
9	10	6	1	1	0.25250500-14
9	10	9	1	1	0.17258220-12
9	10	42	1	1	0.41741720-09
10	1	6	1	1	0.27755580-16
10	1	8	1	1	0.55511150-16
10	1	15	1	1	0.13877790-16
10	10	6	1	1	0.50058600-14
10	10	9	1	1	0.21882280-12
10	10	19	2	1	0.30397060-14
11	10	60	7	4	0.52963920-02
11	10	34	5	1	0.59165910-10
11	10	44	4	1	0.15116970-08
12	10	21	1	1	0.53531630-11
12	10	25	1	1	0.15063120-09
12	10	39	2	1	0.0
13	10	11	1	1	0.14938790-07
13	10	49	1	1	0.50819910-08
13	10	22	2	1	0.98788390-10
14	10	20	1	1	0.20579000-08
14	10	25	2	1	0.79536130-08
14	10	38	2	1	0.45264300-09

SUMMARY OF 53 CALLS TO LMDER1

NPROB	N	M	NFEV	NJEV	INFO	FINAL L2 NORM
1	5	10	3	2	3	0.2236068D+01
1	5	50	3	2	3	0.6708204D+01
2	5	10	3	2	1	0.1463850D+01
2	5	50	3	2	1	0.3482630D+01
3	5	10	3	2	1	0.1909727D+01
3	5	50	3	2	1	0.3691729D+01
4	2	2	22	16	2	0.1394700D-15
4	2	2	8	5	2	0.1387779D-15
4	2	2	6	4	2	0.1387779D-15
5	3	3	11	8	2	0.9936519D-16
5	3	3	20	15	2	0.1044677D-18
5	3	3	19	16	2	0.1883267D-28
6	4	4	62	59	4	0.4508313D-33
6	4	4	68	64	4	0.1894894D-34
6	4	4	75	68	4	0.4699954D-33
7	2	2	14	8	1	0.6998875D+01
7	2	2	19	12	1	0.6998875D+01
7	2	2	24	17	1	0.6998875D+01
8	3	15	6	5	1	0.9063596D-01
8	3	15	37	36	1	0.4174769D+01
8	3	15	14	13	1	0.4174769D+01
9	4	11	18	16	1	0.1753584D-01
9	4	11	78	70	1	0.3205219D-01
9	4	11	500	380	1	0.1753584D-01
10	3	16	126	116	2	0.9377945D+01
10	3	16	400	348	5	0.8006049D+03
11	6	31	8	7	1	0.4782959D-01
11	6	31	14	13	1	0.4782959D-01
11	6	31	15	14	1	0.4782959D-01
11	9	31	8	7	2	0.1183115D-02
11	9	31	19	15	1	0.1183115D-02
11	9	31	18	15	1	0.1183115D-02
11	12	31	10	9	3	0.2173104D-04
11	12	31	13	12	3	0.2173104D-04
11	12	31	34	28	3	0.2173104D-04
12	3	10	7	6	2	0.1331111D-15
13	2	10	21	12	1	0.1115178D+02
14	4	20	255	237	1	0.2929543D+03
14	4	20	53	42	1	0.2929543D+03
14	4	20	237	221	1	0.2929543D+03
15	1	8	1	1	4	0.1886238D+01
15	1	8	29	28	1	0.1884248D+01
15	1	8	47	46	1	0.1884248D+01
15	8	8	39	20	1	0.5930324D-01
15	9	9	12	9	2	0.2373103D-15
15	10	10	25	12	1	0.8064710D-01
16	10	10	14	12	2	0.2831409D-14
16	10	10	13	8	2	0.5998352D-14
16	10	10	44	42	2	0.4081981D-14
16	30	30	19	14	2	0.9132593D-13
16	40	40	19	14	2	0.4212873D-12
17	5	33	18	15	1	0.7392493D-02
18	11	65	16	12	1	0.2003440D+00

SUMMARY OF 53 CALLS TO LMSTR1

NPROB	N	M	NFEV	NJEV	INFO	FINAL L2 NORM
1	5	10	3	2	2	0.2236068D+01
1	5	50	3	2	2	0.6708204D+01
2	5	10	3	2	1	0.1463350D+01
2	5	50	3	2	1	0.3482630D+01
3	5	10	3	2	1	0.1909727D+01
3	5	50	3	2	1	0.3691729D+01
4	2	2	21	16	4	0.0
4	2	2	8	5	2	0.1387779D-15
4	2	2	6	4	2	0.0
5	3	3	11	8	2	0.9936521D-16
5	3	3	20	15	2	0.1044678D-18
5	3	3	19	16	2	0.2354083D-28
6	4	4	65	60	4	0.4433152D-33
6	4	4	67	64	4	0.7945177D-35
6	4	4	77	73	4	0.6418465D-37
7	2	2	14	8	1	0.6998875D+01
7	2	2	19	12	1	0.6998875D+01
7	2	2	24	17	1	0.6998875D+01
8	3	15	6	5	1	0.9063596D-01
8	3	15	37	36	1	0.4174769D+01
8	3	15	14	13	1	0.4174769D+01
9	4	11	18	16	1	0.1753584D-01
9	4	11	78	70	1	0.3205219D-01
9	4	11	488	377	1	0.1753584D-01
10	3	16	126	116	3	0.9377945D+01
10	3	16	400	344	5	0.7997702D+03
11	6	31	8	7	1	0.4782959D-01
11	6	31	14	13	1	0.4782959D-01
11	6	31	15	14	1	0.4782959D-01
11	9	31	8	7	2	0.1183115D-02
11	9	31	19	15	1	0.1183115D-02
11	9	31	19	16	2	0.1183115D-02
11	12	31	10	9	3	0.2173104D-04
11	12	31	13	12	2	0.2173104D-04
11	12	31	34	28	2	0.2173104D-04
12	3	10	7	6	2	0.1331111D-15
13	2	10	21	12	1	0.1115178D+02
14	4	20	254	236	1	0.2929543D+03
14	4	20	53	42	1	0.2929543D+03
14	4	20	237	221	1	0.2929543D+03
15	1	8	1	1	4	0.1886238D+01
15	1	8	29	28	1	0.1884248D+01
15	1	8	47	46	1	0.1884248D+01
15	8	8	39	20	1	0.5930324D-01
15	9	9	12	9	2	0.4204808D-15
15	10	10	25	12	1	0.8064710D-01
16	10	10	14	12	2	0.4147068D-14
16	10	10	13	8	2	0.1426985D-14
16	10	10	29	26	2	0.1426985D-14
16	30	30	19	14	2	0.1157636D-12
16	40	40	19	14	2	0.1745470D-12
17	5	33	18	15	1	0.7392493D-02
18	11	65	16	12	1	0.2003440D+00

SUMMARY OF 53 CALLS TO LMDIF1

NPROB	N	M	NFEV	NJEV	INFO	FINAL L2 NORM
1	5	10	3	2	1	0.2236068D+01
1	5	50	3	2	1	0.6708204D+01
2	5	10	4	2	1	0.1463850D+01
2	5	50	4	2	1	0.3482630D+01
3	5	10	3	2	1	0.1909727D+01
3	5	50	4	2	1	0.3691729D+01
4	2	2	22	16	2	0.0
4	2	2	8	5	2	0.6938894D-15
4	2	2	7	5	2	0.0
5	3	3	12	9	2	0.5165626D-24
5	3	3	20	15	2	0.4447791D-17
5	3	3	19	16	2	0.1045223D-21
6	4	4	234	192	5	0.9887847D-21
6	4	4	232	192	5	0.7654726D-19
6	4	4	230	193	5	0.8369304D-19
7	2	2	14	8	1	0.6998875D+01
7	2	2	19	12	1	0.6998875D+01
7	2	2	24	17	1	0.6998875D+01
8	3	15	6	5	1	0.9063596D-01
8	3	15	36	35	1	0.4174769D+01
8	3	15	14	13	1	0.4174769D+01
9	4	11	18	16	1	0.1753584D-01
9	4	11	77	69	1	0.3205219D-01
9	4	11	232	193	5	0.3070894D-01
10	3	16	126	116	3	0.9377945D+01
10	3	16	4	3	4	0.6237599D+05
11	6	31	9	8	1	0.5104662D-01
11	6	31	14	13	1	0.4782959D-01
11	6	31	15	14	1	0.4782959D-01
11	9	31	9	8	1	0.1183214D-02
11	9	31	31	16	2	0.1183115D-02
11	9	31	28	16	2	0.1183115D-02
11	12	31	23	9	2	0.2173105D-04
11	12	31	23	12	2	0.2173207D-04
11	12	31	52	32	2	0.2173204D-04
12	3	10	7	6	2	0.1422050D-15
13	2	10	21	12	1	0.1115178D+02
14	4	20	212	197	5	0.2929563D+03
14	4	20	55	43	1	0.2929543D+03
14	4	20	212	197	5	0.2929544D+03
15	1	8	2	1	1	0.1886238D+01
15	1	8	29	28	1	0.1884248D+01
15	1	8	47	46	1	0.1884248D+01
15	8	8	39	20	1	0.5930324D-01
15	9	9	12	9	2	0.1989012D-15
15	10	10	25	12	1	0.8064710D-01
16	10	10	7	5	1	0.1000000D+01
16	10	10	13	8	2	0.1461391D-14
16	10	10	28	26	3	0.1000000D+01
16	30	30	4	2	3	0.1000000D+01
16	40	40	11	10	2	0.2805404D-12
17	5	33	18	15	1	0.7392493D-02
18	11	65	16	12	1	0.2003440D+00

SUMMARY OF 14 TESTS OF CHKDER

HPROB	N	STATUS	ERRMIN	ERRMAX
1	2	F	0.3644165D-01	0.1000000D+01
2	4	F	0.5678432D-01	0.1000000D+01
3	2	F	0.0	0.0
4	4	T	0.9801855D+00	0.1000000D+01
5	3	F	0.0	0.1000000D+01
6	9	F	0.0	0.1062543D+00
7	7	F	0.0	0.0
8	10	T	0.1000000D+01	0.1000000D+01
9	10	F	0.1652737D-01	0.1620568D+00
10	10	F	0.0	0.5761877D-01
11	10	F	0.0	0.0
12	10	F	0.2027908D-01	0.2027917D-01
13	10	T	0.8344429D+00	0.1000000D+01
14	10	F	0.0	0.0

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