SCELBAL

MATHEMATICAL FUNCTIONS SUPPLEMENT

(8008/8080)

SCELBI COMPUTER CONSULTING INC.

SCELBAL MATHEMATICAL FUNCTIONS SUPPLEMENT (8008/8080)

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IMPORTANT NOTICE

The information in this publication has been carefully reviewed and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies or for the success or failure of various applications to which the information herein might be applied.

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EXTENDED FUNCTIONS FOR SCELBAL

The extended functions for SCELBAL are SIN, COS, EXP, LOG, and ATN. The SIN and LOG functions are calculated using Chebyshev optimized Taylor series, and the EXP and ATN are calculated using continued fractions. The COS function is calculated using the SIN function. The argument of the function is reduced to an interval where the Taylor series or continued fraction is reasonably accurate. The range of the argument of the functions are:

SIN	$-4194303 < X < 4194303$
COS	$-4194303 < X < 4194303$
EXP	$-89 < X < 89$
LOG	$X > 0$
ATN	$-1E37 < X < 1E37$

FUNCTIONS CALCULATED USING TAYLOR SERIES

SIN and LOG, which are both calculated by series, call on a subroutine labeled TAYLOR which calculates the sum of the products of odd powers of X with constants stored on page 54, i.e.,

$$A*X+B*X^3+C*X^5.$$

THE SIN FUNCTION

The SIN function is calculated by first reducing the argument to the range $0 < R < 2*PI$, where R is the reduced argument, by finding the remainder when the argument is divided by 2*PI. R is then reduced to the range $-PI/2 < Y < PI/2$, so the SIN(X) can be calculated using SIN(PI/2*Y), since the Taylor series for the latter will converge faster than that of SIN(X). The TAYLOR subroutine can then be called.

THE LOG FUNCTION

The logarithm base e of the argument is calculated by separating the floating point exponent and the mantissa, and calculating the log base 2 of the mantissa. The mantissa is then used to calculate a new value which will be passed to the TAYLOR subroutine that is calculated by (Y-SQR(.5))/(Y+SQR(.5)); Y is the mantissa. The TAYLOR subroutine calculates part of the series, to which -1/2 must be added when the value is returned. The LOG function is then calculated by adding the fixed value of the original argument exponent to the value returned by TAYLOR, and then multiplied by the constant, LOG(2), to convert it to base e.

THE COS FUNCTION

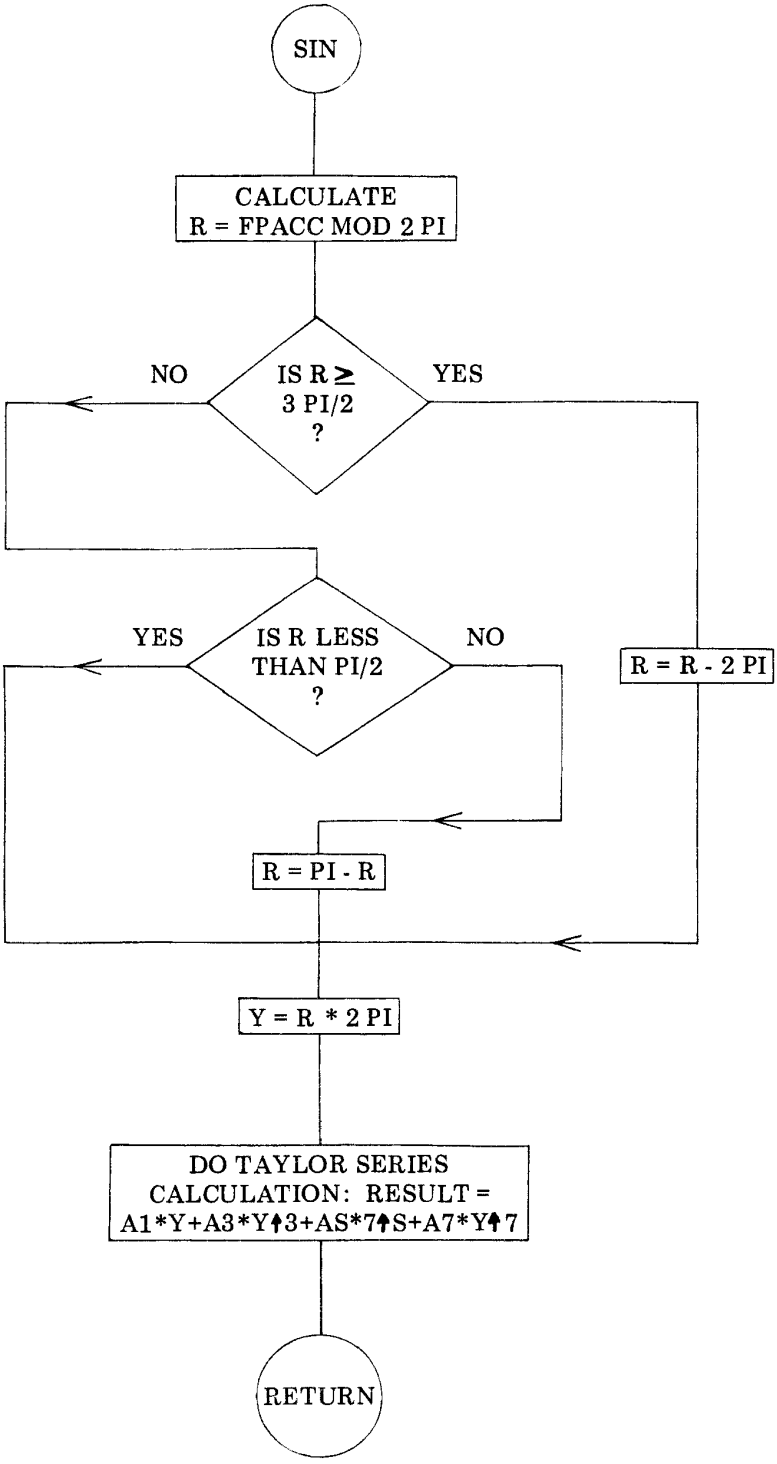
The COS function is calculated by adding PI/2 to the argument, and then calculating it as a SIN.

THE EXP FUNCTION

The EXP function is calculated by reducing the function using the laws of exponents. The argument is multiplied by log base 2 of e, so the EXP can be calculated by raising 2 to this product. The integral part of this product is saved, and the fractional part is used to calculate the two raised to this number, using a continued fraction.

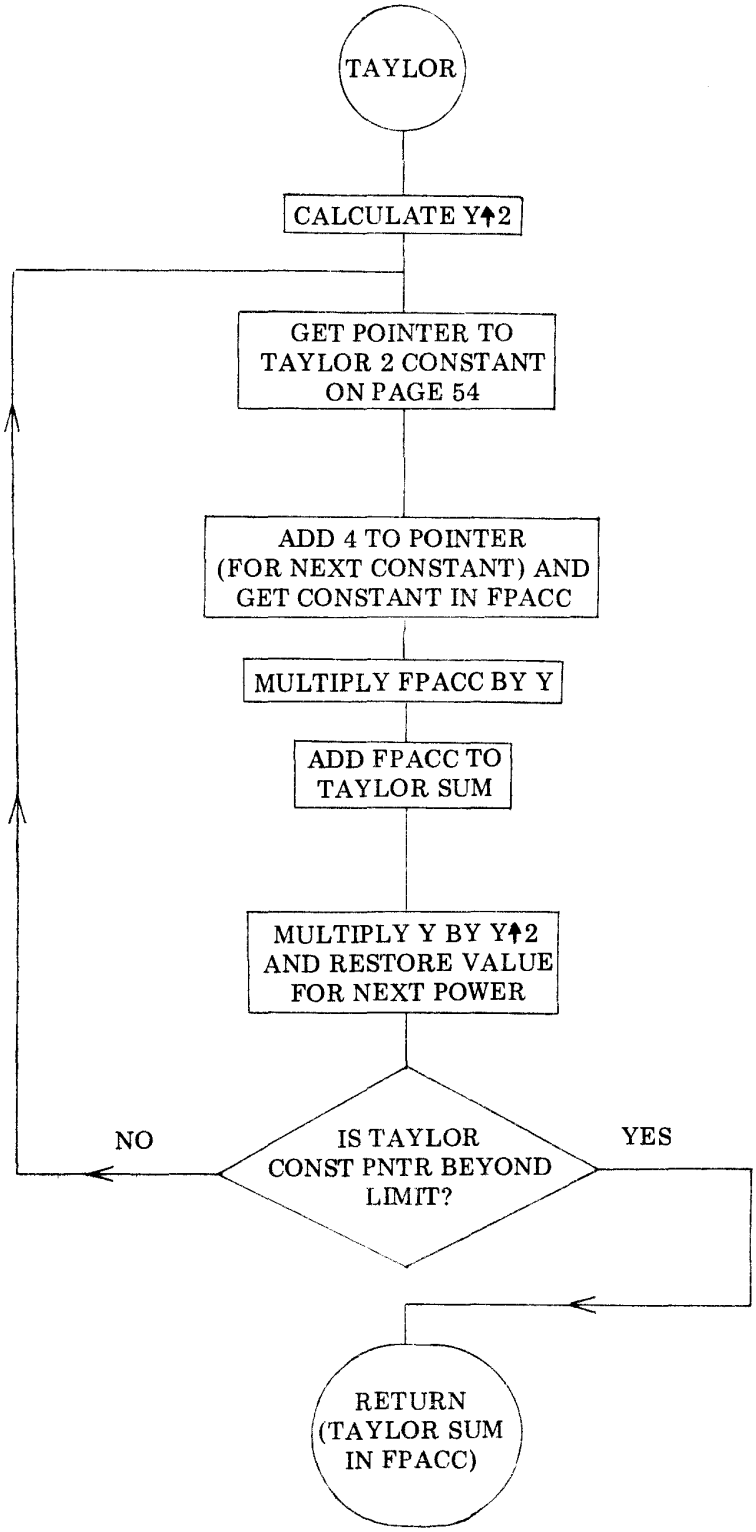
THE ATN FUNCTION

The ATN function is calculated by reducing the argument in the interval $0 < X < 1$. If the argument is negative, its absolute value is used to calculate the ATN, and then the value returned is negated. (A switch indicates this condition.) If the argument is greater than 1, the reciprocal is taken, the arctangent is calculated, and the value returned is subtracted from PI/2.


SIN
CALCULATE
R = FPACC MOD 2 PI
IS R ≥
3 PI/2
?
NO
YES
R = R - 2 PI
IS R LESS
THAN PI/2
?
YES
NO
R = PI - R
Y = R * 2 PI
DO TAYLOR SERIES
CALCULATION: RESULT =
A1*Y+A3*Y↑3+AS*7↑S+A7*Y↑7
RETURN

```
SINX,   LLI 034     Load L with address of TEMP FP storage
        LHI 001     **Load H with page of FP
        CAL FSTORE  Store FPACC in TEMP storage
        LLI 070     Load L with address of PI
        CAL FACXOP  Put FPACC in FPOP and PI in FPACC
        LLI 127     Load L with address of FPACC exponent
        LBM         Get FPACC exponent into B and add 1 to multiply
        INB         The FPACC by 2 to form 2*PI
        LMB         Store incremented value back into FPACC exponent
        CAL FPDIV   Divide the ARG by 2*PI
        CAL INTX    Integerize this value
        LLI 127     Load L with address of FPACC exponent and add
        LBM         One to it to multiply the FPACC, which contains
        INB         INT(X/(2*PI)), by two
        LMB         Store the incremented value back into FPACC exponent
        LLI 070     Load L with address of PI
        CAL OPLOAD  Load PI into the FPOP
        CAL FPMULT  Multiply by PI to form PI*2*INT(X/(PI*2))
        LLI 034     Load L with address of the ARG (X)
        CAL OPLOAD  Load the FPOP with the ARG from TEMP FP location
        CAL FPSUB   Subtract X to form:  X-PI*2*INT(X/(PI*2)),
        LLI 034     Which is X MOD 2*PI. Load L with address of X
        CAL FSTORE  Store X MOD 2*PI back in X, since this is
        LLI 074     In the primary interval ( 0<X< 2*PI). Load L
        CAL FACXOP  With addr of 3*PI/2, put X in FPOP, 3*PI/2 in FPACC
        CAL FPSUB   Subtract X from 3*PI/2 to compare them
        LLI 126     Load L with address of FPACC MSW
        LAM         Load accumulator with FPACC MSW and set flags
        NDA         To compare FPACC with zero
        JTS SIN1    If X less than 3*PI/2, go to SIN1
        LLI 070     Otherwise, load L with address of PI
        CAL FLOAD   Load FPACC with PI
        LLI 127     Load L with address of FPACC exponent
        LBM         Load B with FPACC exponent and add 1 to multiply
        INB         By 2 to form 2*PI in FPACC
        LMB         And store incremented value back into FPACC exp
        LLI 034     Load L with address of X
        CAL OPLOAD  Load FPOP with value of X
        CAL FPSUB   Subtract PI*2 from X
        LLI 034     Load L with address of X
        CAL FSTORE  Store X-PI*2 back into X
        JMP SIN2    Since X is in Q3, no need to reduce more

SIN1,   LLI 070     Load L with address of PI
        CAL FLOAD   Load the FPACC with PI
        LLI 127     Load L with address of FPACC exponent
        LBM         Load B with value of FPACC exponent
        DCB         Subtract 1 to divide FPACC by 2
        LMB         Store back decremented value to form PI/2
        LLI 034     Load L with address of X
        CAL OPLOAD  Load FPOP with value of X
```

```
        CAL FPSUB     Subtract PI/2 from X to compare them
        LLI 126       Load L with address of FPACC MSW
        LAM           Load FPACC MSW into accumulator and set flags
        NDA           To compare FPACC with zero
        JTS SIN2      If X is less than PI/2, go on to calculate SIN
        LLI 034       Load L with address of X
        CAL FLOAD     Load FPACC with X
        LLI 070       Load L with address of PI
        CAL OPLOAD    Load FPOP with value of PI
        CAL FPSUB     Subtract X from PI
        LLI 034       Load L with address of X
        CAL FSTORE    Store reduced value of X back (X is in Q4)

SIN2,   LLI 034       Load L with address of reduced X (-PI/2< X< PI/2)
        CAL OPLOAD    Load FPOP with value of reduced X
        LLI 070       Load L with address of PI
        CAL FLOAD     Load FPACC with value of PI
        CAL FPDIV     Divide X by PI
        LLI 127       Load L with address of FPACC exponent & add 1 to
        LBM           FPACC exponent to mltply by 2 in order to make value
        INB           In FPACC equal 2/PI * X, so -1  FPACC  1
        LMB           This is because the TAYLOR series is for SIN(PI/2*X)
        LLI 000       Load L with address of TAYLOR CONSTANT pntr loc
        LMI 074       Load TAYLOR CONSTANT pntr with start of SIN
        INL           Constants-4 (SIN constants go from 100-123, pg 54)
        LMI 120       Load TAYLOR FINISH pntr w/ addr of last SIN const

TAYLOR, LLI 014       Load L with address of TEMP FP storage loc (Y)
        CAL FSTORE    Store FPACC in Y
        LLI 014       Load L with address of Y
        CAL OPLOAD    Load FPOP with value of Y
        CAL FPMULT    Form Y  2 in FPACC
        LLI 034       Load L with address of TEMP FP location
        CAL FSTORE    Store Y  2 in TEMP FP location
        CAL CFALSE    Put zero in FPACC
        LLI 044       Load L with address of TEMP FP loc (SUM)
        CAL FSTORE    Initialize SUM to zero

TAYLOP, LLI 000       Load L with address of CONSTANT pointer
        LAM           Load the accumulator with the CONSTANT pointer
        ADI 004       Add 4 to CONSTANT pointer (no. of bytes per FP no.)
        LMA           Store CONSTANT pointer back
        LLA           Load L with value of CONSTANT pointer
        LHI 054       **Load H with extended function CONSTANT page
        CAL FLOAD     Load TAYLOR CONSTANT into FPACC
        LHI 001       **Restore H to point to FP page
        LLI 014       Load L with address of Y
        CAL OPLOAD    Load FPOP with value of Y
        CAL FPMULT    Multiply CONSTANT by Y
        LLI 044       Load L with address of SUM
        CAL OPLOAD    Load FPOP with value of SUM
```


TAYLOR
CALCULATE Y↑2
GET POINTER TO TAYLOR 2 CONSTANT ON PAGE 54
ADD 4 TO POINTER (FOR NEXT CONSTANT) AND GET CONSTANT IN FPACC
MULTIPLY FPACC BY Y
ADD FPACC TO TAYLOR SUM
MULTIPLY Y BY Y↑2 AND RESTORE VALUE FOR NEXT POWER
IS TAYLOR CONST PNTR BEYOND LIMIT?
NO
YES
RETURN (TAYLOR SUM IN FPACC)

```
CAL FPADD     Add SUM to product of CONSTANT and Y
LLI 044       Load L with address of SUM
CAL FSTORE    Store SUM back into SUM
LLI 014       Load L with address of Z  2
CAL OPLOAD    Load FPOP with value of Z  2
LLI 034       Load L with address of Y
CAL FLOAD     Load FPACC with value of Y
CAL FPMULT    Multiply Y by Z  2 to form next odd power of Z
LLI 014       Load L with address of Y
CAL FSTORE    Store this power back into Y for next time
LLI 000       Load L with address of CONSTANT pointer
LAM           Get CONSTANT pointer into accumulator
INL           Point to pntr of last TAYLOR CONST for this function
CPM           Compare pointers to see if finished with function
JFZ TAYLOP    If not, continue loop
LLI 044       Otherwise, load L with address of SUM
JMP FLOAD     Exit with value of function in FPACC
```

MATHEMATICAL SUPPLEMENT MEMORY ALLOCATION FOR CONSTANTS, TABLES, AND TEMPORARY DATA

The MATHEMATICAL FUNCTIONS SUPPLEMENT utilizes various locations in memory for the storage of a table, temporary data (pointer information) and constants. The following list shows the areas used for these purposes in the assembled version of the MATHEMATICAL SUPPLEMENT routines presented herein.

Page 1:

```
Locations
000           Start Address of TAYLOR
              constants (on page 54)
001           Finish Addr of TAYLOR cons.
 .
 .
 .
070           PI (3.14159)
074           3*PI/2
 .
 .
 .
114           Log base e 2
 .
 .
 .
170           Log base 2 e
 .
 .
 .
```

```
204         SQR (.5)

Page 54:

000         New Function Names Table
 .
 .
 .          SIN constants
100         A1
104         A3
110         A5
114         A7
120         A9
            EXP constants
134         B1
140         A1
144         A0
            ATN constants
150         B3
154         A3
160         B2
164         A2
170         B1
174         A1
200         B0
            LOG constants
204         C1
210         C3
214         C5
```

ASSEMBLED LISTINGS OF MATHEMATICAL FUNCTIONS SUPPLEMENT

The following pages contain assembled listings of the MATHEMATICAL FUNCTIONS SUPPLEMENT routines just described in source form. Two sets of listings are provided side-by-side. One for the 8008, the other for the 8080. The listings starts with the constant values that must be placed on page 01 of the original SCELBAL program. It then presents the several patches that must be installed in the main portion of the original SCELBAL interpreter. It then continues with the routines described herein as they would appear when assembled to reside in pages 50 (last quarter of the page) through page 53 of memory. Page 54 in the assembled version is reserved for table use and additional constant values used by the mathematical routines. The listing concludes with the values to be placed on that page.

As in the original SCELBAL publication, the use of a double asterisk (**) in the listing indicates that a page pointer would have to be altered if the program is relocated.

8008					8080				
01 070	354			354	01 070	354			354 /PI
01 071	207			207	01 071	207			207
01 072	144			144	01 072	144			144
01 073	002			002	01 073	002			002
01 074	362			362	01 074	362			362 /3*PI/2
01 075	145			145	01 075	145			145
01 076	113			113	01 076	113			113
01 077	003			003	01 077	003			003
01 114	015			015	01 114	015			015 /Log Base
01 115	271			271	01 115	271			271 /Exp 2
01 116	130			130	01 116	130			130
01 117	000			000	01 117	000			000
01 170	041			041	01 170	041			041 /Log Base
01 171	125			125	01 171	125			125 /Exp 2
01 172	134			134	01 172	134			134
01 173	001			001	01 173	001			001
01 204	172			172	01 204	172			172 /SQR(2)/2
01 205	202			202	01 205	202			202
01 206	132			132	01 206	132			132
01 207	000			000	01 207	000			000
07 074	104 320 052			JMP NEWFNS	07 074	303 320 052			JMP NEWFNS
07 126	066 374			LLI 374	07 126	056 374			LLI 374
07 130	056 053	**		LHI 053	07 130	046 053	**		LHI 053
07 154	074 020			CPI 020	07 154	376 020			CPI 020
50 330	066 001		ATNX,	LLI 001	50 330	056 001		ATNX,	LLI 001
50 332	056 001	**		LHI 001	50 332	046 001	**		LHI 001
50 334	076 000			LMI 000	50 334	066 000			LMI 000
50 336	066 126			LLI 126	50 336	056 126			LLI 126
50 340	307			LAM	50 340	176			LAM
50 341	066 013			LLI 013	50 341	056 013			LLI 013
50 343	370			LMA	50 343	167			LMA
50 344	106 346 007			CAL ABS	50 344	315 346 007			CAL ABS
50 347	066 014			LLI 014	50 347	056 014			LLI 014
50 351	106 255 022			CAL FSTORE	50 351	315 255 022			CAL FSTORE
50 354	066 024			LLI 024	50 354	056 024			LLI 024
50 356	106 266 022			CAL OPLOAD	50 356	315 266 022			CAL OPLOAD
50 361	106 211 020			CAL FPADD	50 361	315 211 020			CAL FPADD
50 364	066 126			LLI 126	50 364	056 126			LLI 126
50 366	307			LAM	50 366	176			LAM
50 367	240			NDA	50 367	247			NDA
50 370	150 024 051			JTZ ATN1	50 370	312 024 051			JTZ ATN1
50 373	160 024 051			JTS ATN1	50 373	372 024 051			JTS ATN1
50 376	066 014			LLI 014	50 376	056 014			LLI 014
51 000	106 244 022			CAL FLOAD	51 000	315 244 022			CAL FLOAD
51 003	066 004			LLI 004	51 003	056 004			LLI 004
51 005	106 266 022			CAL OPLOAD	51 005	315 266 022			CAL OPLOAD
51 010	106 322 021			CAL FPDIV	51 010	315 322 021			CAL FPDIV
51 013	066 014			LLI 014	51 013	056 014			LLI 014
51 015	106 255 022			CAL FSTORE	51 015	315 255 022			CAL FSTORE
51 020	066 001			LLI 001	51 020	056 001			LLI 001
51 022	076 001			LMI 001	51 022	066 001			LMI 001

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```
51 024  066 014          ATN1,  LLI 014
51 026  106 244 022             CAL FLOAD
51 031  066 014                 LLI 014
51 033  106 266 022             CAL OPLOAD
51 036  106 046 021             CAL FPMULT
51 041  066 034                 LLI 034
51 043  106 255 022             CAL FSTORE
51 046  066 150                 LLI 150
51 050  056 054      **         LHI 054
51 052  106 266 022             CAL OPLOAD
51 055  106 211 020             CAL FPADD
51 060  066 154                 LLI 154
51 062  056 054      **         LHI 054
51 064  106 266 022             CAL OPLOAD
51 067  106 322 021             CAL FPDIV
51 072  066 160                 LLI 160
51 074  056 054      **         LHI 054
51 076  106 266 022             CAL OPLOAD
51 101  106 211 020             CAL FPADD
51 104  066 034                 LLI 034
51 106  106 266 022             CAL OPLOAD
51 111  106 211 020             CAL FPADD
51 114  066 164                 LLI 164
51 116  056 054      **         LHI 054
51 120  106 266 022             CAL OPLOAD
51 123  106 322 021             CAL FPDIV
51 126  066 170                 LLI 170
51 130  056 054      **         LHI 054
51 132  106 266 022             CAL OPLOAD
51 135  106 211 020             CAL FPADD
51 140  066 034                 LLI 034
51 142  106 266 022             CAL OPLOAD
51 145  106 211 020             CAL FPADD
51 150  066 174                 LLI 174
51 152  056 054      **         LHI 054
51 154  106 266 022             CAL OPLOAD
51 157  106 322 021             CAL FPDIV
51 162  066 200                 LLI 200
51 164  056 054      **         LHI 054
51 166  106 266 022             CAL OPLOAD
51 171  106 211 020             CAL FPADD
51 174  066 014                 LLI 014
51 176  106 266 022             CAL OPLOAD
51 201  106 046 021             CAL FPMULT
51 204  066 001                 LLI 001
51 206  307                     LAM
51 207  240                     NDA
51 210  150 230 051             JTZ ATN2
51 213  066 070                 LLI 070
51 215  106 266 022             CAL OPLOAD
51 220  066 137                 LLI 137
51 222  317                     LBM
51 223  011                     DCB
51 224  371                     LMB
51 225  106 032 021             CAL FPSUB

51 230  066 013          ATN2,  LLI 013
51 232  307                     LAM
51 233  240                     NDA
```

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```
51 024  056 014          ATN1,  LLI 014
51 026  315 244 022             CAL FLOAD
51 031  056 014                 LLI 014
51 033  315 266 022             CAL OPLOAD
51 036  315 046 021             CAL FPMULT
51 041  056 034                 LLI 034
51 043  315 255 022             CAL FSTORE
51 046  056 150                 LLI 150
51 050  046 054      **         LHI 054
51 052  315 266 022             CAL OPLOAD
51 055  315 211 020             CAL FPADD
51 060  056 154                 LLI 154
51 062  046 054      **         LHI 054
51 064  315 266 022             CAL OPLOAD
51 067  315 322 021             CAL FPDIV
51 072  056 160                 LLI 160
51 074  046 054      **         LHI 054
51 076  315 266 022             CAL OPLOAD
51 101  315 211 020             CAL FPADD
51 104  056 034                 LLI 034
51 106  315 266 022             CAL OPLOAD
51 111  315 211 020             CAL FPADD
51 114  056 164                 LLI 164
51 116  046 054      **         LHI 054
51 120  315 266 022             CAL OPLOAD
51 123  315 322 021             CAL FPDIV
51 126  056 170                 LLI 170
51 130  046 054      **         LHI 054
51 132  315 266 022             CAL OPLOAD
51 135  315 211 020             CAL FPADD
51 140  056 034                 LLI 034
51 142  315 266 022             CAL OPLOAD
51 145  315 211 020             CAL FPADD
51 150  056 174                 LLI 174
51 152  046 054      **         LHI 054
51 154  315 266 022             CAL OPLOAD
51 157  315 322 021             CAL FPDIV
51 162  056 200                 LLI 200
51 164  046 054      **         LHI 054
51 166  315 266 022             CAL OPLOAD
51 171  315 211 020             CAL FPADD
51 174  056 014                 LLI 014
51 176  315 266 022             CAL OPLOAD
51 201  315 046 021             CAL FPMULT
51 204  056 001                 LLI 001
51 206  176                     LAM
51 207  247                     NDA
51 210  312 230 051             JTZ ATN2
51 213  056 070                 LLI 070
51 215  315 266 022             CAL OPLOAD
51 220  056 137                 LLI 137
51 222  106                     LBM
51 223  005                     DCB
51 224  160                     LMB
51 225  315 032 021             CAL FPSUB

51 230  056 013          ATN2,  LLI 013
51 232  176                     LAM
51 233  247                     NDA
```

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```
51 234  160 202 020          JTS FPCOMP
51 237  007                  RET

51 240  066 170        EXPX, LLI 170
51 242  056 001     **       LHI 001
51 244  106 266 022          CAL OPLOAD
51 247  106 046 021          CAL FPMULT
51 252  066 034              LLI 034
51 254  106 255 022          CAL FSTORE
51 257  106 000 020          CAL FPFIX
51 262  066 124              LLI 124
51 264  307                  LAM
51 265  066 123              LLI 123
51 267  076 000              LMI 000
51 271  066 013              LLI 013
51 273  370                  LMA
51 274  106 064 020          CAL FPFLT
51 277  066 034              LLI 034
51 301  106 266 022          CAL OPLOAD
51 304  106 032 021          CAL FPSUB
51 307  066 114              LLI 114
51 311  106 266 022          CAL OPLOAD
51 314  066 137              LLI 137
51 316  317                  LBM
51 317  011                  DCB
51 320  371                  LMB
51 321  106 046 021          CAL FPMULT
51 324  066 034              LLI 034
51 326  106 255 022          CAL FSTORE
51 331  066 034              LLI 034
51 333  106 266 022          CAL OPLOAD
51 336  106 046 021          CAL FPMULT
51 341  066 144              LLI 144
51 343  056 054     **       LHI 054
51 345  106 266 022          CAL OPLOAD
51 350  106 211 020          CAL FPADD
51 353  066 140              LLI 140
51 355  056 054     **       LHI 054
51 357  106 266 022          CAL OPLOAD
51 362  106 322 021          CAL FPDIV
51 365  066 034              LLI 034
51 367  106 277 022          CAL FACXOP
51 372  106 032 021          CAL FPSUB
51 375  066 134              LLI 134
51 377  056 054     **       LHI 054
52 001  106 266 022          CAL OPLOAD
52 004  106 211 020          CAL FPADD
52 007  066 034              LLI 034
52 011  106 266 022          CAL OPLOAD
52 014  106 322 021          CAL FPDIV
52 017  066 127              LLI 127
52 021  317                  LBM
52 022  010                  INB
52 023  371                  LMB
52 024  066 004              LLI 004
52 026  106 266 022          CAL OPLOAD
52 031  106 211 020          CAL FPADD
52 034  066 124              LLI 124
52 036  106 266 022          CAL OPLOAD
```

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```
51 234  372 202 020          JTS FPCOMP
51 237  311                  RET

51 240  056 170        EXPX, LLI 170
51 242  046 001     **       LHI 001
51 244  315 266 022          CAL OPLOAD
51 247  315 046 021          CAL FPMULT
51 252  056 034              LLI 034
51 254  315 255 022          CAL FSTORE
51 257  315 000 020          CAL FPFIX
51 262  056 124              LLI 124
51 264  176                  LAM
51 265  056 123              LLI 123
51 267  066 000              LMI 000
51 271  056 013              LLI 013
51 273  167                  LMA
51 274  315 064 020          CAL FPFLT
51 277  056 034              LLI 034
51 301  315 266 022          CAL OPLOAD
51 304  315 032 021          CAL FPSUB
51 307  056 114              LLI 114
51 311  315 266 022          CAL OPLOAD
51 314  056 137              LLI 137
51 316  106                  LBM
51 317  005                  DCB
51 320  160                  LMB
51 321  315 046 021          CAL FPMULT
51 324  056 034              LLI 034
51 326  315 255 022          CAL FSTORE
51 331  056 034              LLI 034
51 333  315 266 022          CAL OPLOAD
51 336  315 046 021          CAL FPMULT
51 341  056 144              LLI 144
51 343  046 054     **       LHI 054
51 345  315 266 022          CAL OPLOAD
51 350  315 211 020          CAL FPADD
51 353  056 140              LLI 140
51 355  046 054     **       LHI 054
51 357  315 266 022          CAL OPLOAD
51 362  315 322 021          CAL FPDIV
51 365  056 034              LLI 034
51 367  315 277 022          CAL FACXOP
51 372  315 032 021          CAL FPSUB
51 375  056 134              LLI 134
51 377  046 054     **       LHI 054
52 001  315 266 022          CAL OPLOAD
52 004  315 211 020          CAL FPADD
52 007  056 034              LLI 034
52 011  315 266 022          CAL OPLOAD
52 014  315 322 021          CAL FPDIV
52 017  056 127              LLI 127
52 021  106                  LBM
52 022  004                  INB
52 023  160                  LMB
52 024  056 004              LLI 004
52 026  315 266 022          CAL OPLOAD
52 031  315 211 020          CAL FPADD
52 034  056 124              LLI 124
52 036  315 266 022          CAL OPLOAD
```

8008					8080				
52 041	106 046 021			CAL FPMULT	52 041	315 046 021			CAL FPMULT
52 044	066 013			LLI 013	52 044	056 013			LLI 013
52 046	307			LAM	52 046	176			LAM
52 047	066 127			LLI 127	52 047	056 127			LLI 127
52 051	207			ADM	52 051	206			ADM
52 052	370			LMA	52 052	167			LMA
52 053	007			RET	52 053	311			RET
52 060	066 126		LOGX,	LLI 126	52 060	056 126		LOGX,	LLI 126
52 062	056 001	**		LHI 001	52 062	046 001	**		LHI 001
52 064	307			LAM	52 064	176			LAM
52 065	240			NDA	52 065	247			NDA
52 066	150 074 052			JTZ LOGERR	52 066	312 074 052			JTZ LOGERR
52 071	120 103 052			JFS LOG1	52 071	362 103 052			JFS LOG1
52 074	006 314		LOGERR,	LAI 314	52 074	076 314		LOGERR,	LAI 314
52 076	026 307			LCI 307	52 076	016 307			LCI 307
52 100	104 226 002			JMP ERROR	52 100	303 226 002			JMP ERROR
52 103	060		LOG1,	INL	52 103	054		LOG1,	INL
52 104	307			LAM	52 104	176			LAM
52 105	076 000			LMI 000	52 105	066 000			LMI 000
52 107	066 013			LLI 013	52 107	056 013			LLI 013
52 111	370			LMA	52 111	167			LMA
52 112	060			INL	52 112	054			INL
52 113	106 255 022			CAL FSTORE	52 113	315 255 022			CAL FSTORE
52 116	066 204			LLI 204	52 116	056 204			LLI 204
52 120	106 277 022			CAL FACXOP	52 120	315 277 022			CAL FACXOP
52 123	106 032 021			CAL FPSUB	52 123	315 032 021			CAL FPSUB
52 126	066 034			LLI 034	52 126	056 034			LLI 034
52 130	106 255 022			CAL FSTORE	52 130	315 255 022			CAL FSTORE
52 133	066 014			LLI 014	52 133	056 014			LLI 014
52 135	106 244 022			CAL FLOAD	52 135	315 244 022			CAL FLOAD
52 140	066 204			LLI 204	52 140	056 204			LLI 204
52 142	106 266 022			CAL OPLOAD	52 142	315 266 022			CAL OPLOAD
52 145	106 211 020			CAL FPADD	52 145	315 211 020			CAL FPADD
52 150	066 034			LLI 034	52 150	056 034			LLI 034
52 152	106 266 022			CAL OPLOAD	52 152	315 266 022			CAL OPLOAD
52 155	106 322 021			CAL FPDIV	52 155	315 322 021			CAL FPDIV
52 160	066 014			LLI 014	52 160	056 014			LLI 014
52 162	106 255 022			CAL FSTORE	52 162	315 255 022			CAL FSTORE
52 165	066 000			LLI 000	52 165	056 000			LLI 000
52 167	076 200			LMI 200	52 167	066 200			LMI 200
52 171	060			INL	52 171	054			INL
52 172	076 214			LMI 214	52 172	066 214			LMI 214
52 174	106 236 053			CAL TAYLOR	52 174	315 236 053			CAL TAYLOR
52 177	066 024			LLI 024	52 177	056 024			LLI 024
52 201	106 266 022			CAL OPLOAD	52 201	315 266 022			CAL OPLOAD
52 204	066 137			LLI 137	52 204	056 137			LLI 137
52 206	317			LBM	52 206	106			LBM
52 207	011			DCB	52 207	005			DCB
52 210	371			LMB	52 210	160			LMB
52 211	106 211 020			CAL FPADD	52 211	315 211 020			CAL FPADD
52 214	066 044			LLI 044	52 214	056 044			LLI 044
52 216	106 255 022			CAL FSTORE	52 216	315 255 022			CAL FSTORE
52 221	106 247 006			CAL CFALSE	52 221	315 247 006			CAL CFALSE
52 224	066 013			LLI 013	52 224	056 013			LLI 013
52 226	307			LAM	52 226	176			LAM
52 227	066 124			LLI 124	52 227	056 124			LLI 124

NEW FUNCTION TOKENS

Since these new functions require additional tokens beyond those originally provided for in SCELBAL, a patch to the existing FUNARR and PRIGHT routines was needed. The new NEWFNS routine also provides facilities for several user defined functions if the user desires to create unique additions.

SOURCE LISTINGS AND FLOW CHARTS

The following source listings and flow charts show the detailed operation of the extended mathematical function routines.

```
ATNX,   LLI 001     Load L with address of ARG > 1 flag
        LHI 001     **Load H with page
        LMI 000     Initialize flag to false condition
        LLI 126     Load L with address of FPACC MSW
        LAM         Load accumulator with MSW of FPACC
        LLI 013     Load L with address of TEMP byte storage location
        LMA         Save ARG MSW to save sign of ARG
        CAL ABS     Find the absolute value of ARG
        LLI 014     Load L with address of TEMP FP location
        CAL FSTORE  Store absolute value of ARG there (X)
        LLI 024     Load L with address of -1.0
        CAL OPLOAD  Load FPOP with -1.0 to compare FPACC
        CAL FPADD   With one by adding -1.0 to it
        LLI 126     Load L with address of FPACC MSW
        LAM         Load accumulator with FPACC MSW
        NDA         Set flags to see if FPACC greater than 1
        JTZ ATN1    If FPACC =1, don't find reciprocal
        JTS ATN1    Or if FPACC is less than 1, don't find reciprocal
        LLI 014     Load L with address of X
        CAL FLOAD   Load FPACC with value of X
        LLI 004     Load L with address of FP +1.0
        CAL OPLOAD  Load FPOP with +1.0
        CAL FPDIV   Find reciprocal of X
        LLI 014     Load L with address of X
        CAL FSTORE  Store reciprocal of X back in X
        LLI 001     Load L with address of ARG > 1 flag
        LMI 001     Set the ARG > 1 flag to 1

ATN1,   LLI 014     Load L with address of X
        CAL FLOAD   Load FPACC with value of X
        LLI 014     Load L with address of X
        CAL OPLOAD  Load FPOP with value of X
        CAL FPMULT  Form X↑2 in FPACC
        LLI 034     Load L with address of TEMP FP location
        CAL FSTORE  Store X↑2 there
        LLI 150     Load L with address of ATN constant B3
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of B3
        CAL FPADD   Form B3+X↑2 in the FPACC
```

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```
52 231  370                        LMA
52 232  240                        NDA
52 233  120 246 052                JFS LOG2
52 236  054 377                    XRI 377
52 240  004 001                    ADI 001
52 242  370                        LMA
52 243  106 202 020                CAL FPCOMP

52 246  106 064 020          LOG2, CAL FPFLT
52 251  066 044                    LLI 044
52 253  106 266 022                CAL OPLOAD
52 256  106 211 020                CAL FPADD
52 261  066 114                    LLI 114
52 263  106 266 022                CAL OPLOAD
52 266  104 046 021                JMP FPMULT

52 271  066 070              COSX, LLI 070
52 273  056 001        **          LHI 001
52 275  106 266 022                CAL OPLOAD
52 300  066 137                    LLI 137
52 302  317                        LBM
52 303  011                        DCB
52 304  371                        LMB
52 305  106 211 020                CAL FPADD
52 310  104 000 053                JMP SINX
--------
52 320  074 010           NEWFNS, CPI 010
52 322  150 000 053                JTZ SINX
52 325  074 011                    CPI 011
52 327  150 271 052                JTZ COSX
52 332  074 012                    CPI 012
52 334  150 060 052                JTZ LOGX
52 337  074 013                    CPI 013
52 341  150 240 051                JTZ EXPX
52 344  074 014                    CPI 014
52 346  150 330 050                JTZ ATNX
52 351  074 015                    CPI 015
52 353  150 000 000  ††            JTZ UDF1
52 356  074 016                    CPI 016
52 360  150 000 000  ††            JTZ UDF2
52 363  074 017                    CPI 017
52 365  150 000 000  ††            JTZ UDF3
52 370  074 020                    CPI 020
52 372  150 000 000  ††            JTZ UDF4
52 375  104 172 007                JMP FAERR

53 000  066 034              SINX, LLI 034
53 002  056 001        **          LHI 001
53 004  106 255 022                CAL FSTORE
53 007  066 070                    LLI 070
53 011  106 277 022                CAL FACXOP
53 014  066 127                    LLI 127
53 016  317                        LBM
53 017  010                        INB
53 020  371                        LMB
53 021  106 322 021                CAL FPDIV
53 024  106 243 007                CAL INTX
53 027  066 127                    LLI 127
53 031  317                        LBM
```

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```
52 231  167                        LMA
52 232  247                        NDA
52 233  362 246 052                JFS LOG2
52 236  356 377                    XRI 377
52 240  306 001                    ADI 001
52 242  167                        LMA
52 243  315 202 020                CAL FPCOMP

52 246  315 064 020          LOG2, CAL FPFLT
52 251  056 044                    LLI 044
52 253  315 266 022                CAL OPLOAD
52 256  315 211 020                CAL FPADD
52 261  056 114                    LLI 114
52 263  315 266 022                CAL OPLOAD
52 266  303 046 021                JMP FPMULT

52 271  056 070              COSX, LLI 070
52 273  046 001        **          LHI 001
52 275  315 266 022                CAL OPLOAD
52 300  056 137                    LLI 137
52 302  106                        LBM
52 303  005                        DCB
52 304  160                        LMB
52 305  315 211 020                CAL FPADD
52 310  303 000 053                JMP SINX
--------
52 320  376 010           NEWFNS, CPI 010
52 322  312 000 053                JTZ SINX
52 325  376 011                    CPI 011
52 327  312 271 052                JTZ COSX
52 332  376 012                    CPI 012
52 334  312 060 052                JTZ LOGX
52 337  376 013                    CPI 013
52 341  312 240 051                JTZ EXPX
52 344  376 014                    CPI 014
52 346  312 330 050                JTZ ATNX
52 351  376 015                    CPI 015
52 353  312 000 000  ††            JTZ UDF1
52 356  376 016                    CPI 016
52 360  312 000 000  ††            JTZ UDF2
52 363  376 017                    CPI 017
52 365  312 000 000  ††            JTZ UDF3
52 370  376 020                    CPI 020
52 372  312 000 000  ††            JTZ UDF4
52 375  303 172 007                JMP FAERR

53 000  056 034              SINX, LLI 034
53 002  046 001        **          LHI 001
53 004  315 255 022                CAL FSTORE
53 007  056 070                    LLI 070
53 011  315 277 022                CAL FACXOP
53 014  056 127                    LLI 127
53 016  106                        LBM
53 017  004                        INB
53 020  160                        LMB
53 021  315 322 021                CAL FPDIV
53 024  315 243 007                CAL INTX
53 027  056 127                    LLI 127
53 031  106                        LBM
```

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```
53 032  010              INB
53 033  371              LMB
53 034  066 070          LLI 070
53 036  106 266 022      CAL OPLOAD
53 041  106 046 021      CAL FPMULT
53 044  066 034          LLI 034
53 046  106 266 022      CAL OPLOAD
53 051  106 032 021      CAL FPSUB
53 054  066 034          LLI 034
53 056  106 255 022      CAL FSTORE
53 061  066 074          LLI 074
53 063  106 277 022      CAL FACXOP
53 066  106 032 021      CAL FPSUB
53 071  066 126          LLI 126
53 073  307              LAM
53 074  240              NDA
53 075  160 132 053      JTS SIN1
53 100  066 070          LLI 070
53 102  106 244 022      CAL FLOAD
53 105  066 127          LLI 127
53 107  317              LBM
53 110  010              INB
53 111  371              LMB
53 112  066 034          LLI 034
53 114  106 266 022      CAL OPLOAD
53 117  106 032 021      CAL FPSUB
53 122  066 034          LLI 034
53 124  106 255 022      CAL FSTORE
53 127  104 205 053      JMP SIN2

53 132  066 070      SIN1, LLI 070
53 134  106 244 022      CAL FLOAD
53 137  066 127          LLI 127
53 141  317              LBM
53 142  011              DCB
53 143  371              LMB
53 144  066 034          LLI 034
53 146  106 266 022      CAL OPLOAD
53 151  106 032 021      CAL FPSUB
53 154  066 126          LLI 126
53 156  307              LAM
53 157  240              NDA
53 160  160 205 053      JTS SIN2
53 163  066 034          LLI 034
53 165  106 244 022      CAL FLOAD
53 170  066 070          LLI 070
53 172  106 266 022      CAL OPLOAD
53 175  106 032 021      CAL FPSUB
53 200  066 034          LLI 034
53 202  106 255 022      CAL FSTORE

53 205  066 034      SIN2, LLI 034
53 207  106 266 022      CAL OPLOAD
53 212  066 070          LLI 070
53 214  106 244 022      CAL FLOAD
53 217  106 322 021      CAL FPDIV
53 222  066 127          LLI 127
53 224  317              LBM
53 225  010              INB
```

8080

```
53 032  004              INB
53 033  160              LMB
53 034  056 070          LLI 070
53 036  315 266 022      CAL OPLOAD
53 041  315 046 021      CAL FPMULT
53 044  056 034          LLI 034
53 046  315 266 022      CAL OPLOAD
53 051  315 032 021      CAL FPSUB
53 054  056 034          LLI 034
53 056  315 255 022      CAL FSTORE
53 061  056 074          LLI 074
53 063  315 277 022      CAL FACXOP
53 066  315 032 021      CAL FPSUB
53 071  056 126          LLI 126
53 073  176              LAM
53 074  247              NDA
53 075  372 132 053      JTS SIN1
53 100  056 070          LLI 070
53 102  315 244 022      CAL FLOAD
53 105  056 127          LLI 127
53 107  106              LBM
53 110  004              INB
53 111  160              LMB
53 112  056 034          LLI 034
53 114  315 266 022      CAL OPLOAD
53 117  315 032 021      CAL FPSUB
53 122  056 034          LLI 034
53 124  315 255 022      CAL FSTORE
53 127  303 205 053      JMP SIN2

53 132  056 070      SIN1, LLI 070
53 134  315 244 022      CAL FLOAD
53 137  056 127          LLI 127
53 141  106              LBM
53 142  005              DCB
53 143  160              LMB
53 144  056 034          LLI 034
53 146  315 266 022      CAL OPLOAD
53 151  315 032 021      CAL FPSUB
53 154  056 126          LLI 126
53 156  176              LAM
53 157  247              NDA
53 160  372 205 053      JTS SIN2
53 163  056 034          LLI 034
53 165  315 244 022      CAL FLOAD
53 170  056 070          LLI 070
53 172  315 266 022      CAL OPLOAD
53 175  315 032 021      CAL FPSUB
53 200  056 034          LLI 034
53 202  315 255 022      CAL FSTORE

53 205  056 034      SIN2, LLI 034
53 207  315 266 022      CAL OPLOAD
53 212  056 070          LLI 070
53 214  315 244 022      CAL FLOAD
53 217  315 322 021      CAL FPDIV
53 222  056 127          LLI 127
53 224  106              LBM
53 225  004              INB
```

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```
53 226  371                    LMB
53 227  066 000                LLI 000
53 231  076 074                LMI 074
53 233  060                    INL
53 234  076 120                LMI 120

52 236  066 014        TAYLOR, LLI 014
53 240  106 255 022            CAL FSTORE
53 243  066 014                LLI 014
53 245  106 266 022            CAL OPLOAD
53 250  106 046 021            CAL FPMULT
53 253  066 034                LLI 034
53 255  106 255 022            CAL FSTORE
53 260  106 247 006            CAL CFALSE
53 263  066 044                LLI 044
53 265  106 255 022            CAL FSTORE

53 270  066 000        TAYLOP, LLI 000
53 272  307                    LAM
53 273  004 004                ADI 004
53 275  370                    LMA
53 276  360                    LLA
53 277  056 054     **         LHI 054
53 301  106 244 022            CAL FLOAD
53 304  056 001     **         LHI 001
53 306  066 014                LLI 014
53 310  106 266 022            CAL OPLOAD
53 313  106 046 021            CAL FPMULT
53 316  066 044                LLI 044
53 320  106 266 022            CAL OPLOAD
53 323  106 211 020            CAL FPADD
53 326  066 044                LLI 044
53 330  106 255 022            CAL FSTORE
53 333  066 014                LLI 014
53 335  106 266 022            CAL OPLOAD
53 340  066 034                LLI 034
53 342  106 244 022            CAL FLOAD
53 345  106 046 021            CAL FPMULT
53 350  066 014                LLI 014
53 352  106 255 022            CAL FSTORE
53 355  066 000                LLI 000
53 357  307                    LAM
53 360  060                    INL
53 361  277                    CPM
53 362  110 270 053            JFZ TAYLOP
53 365  066 044                LLI 044
53 367  104 244 022            JMP FLOAD
--------

54 000  003                    003  /INT
54 001  311                    311
54 002  316                    316
54 003  324                    324
54 004  003                    003  /SGN
54 005  323                    323
54 006  307                    307
54 007  316                    316
54 010  003                    003  /ABS
54 011  301                    301
54 012  302                    302
```

8080

```
53 226  160                    LMB
53 227  056 000                LLI 000
53 231  066 074                LMI 074
53 233  054                    INL
53 234  066 120                LMI 120

53 236  056 014        TAYLOR, LLI 014
53 240  315 255 022            CAL FSTORE
53 243  056 014                LLI 014
53 245  315 266 022            CAL OPLOAD
53 250  315 046 021            CAL FPMULT
53 253  056 034                LLI 034
53 255  315 255 022            CAL FSTORE
53 260  315 247 006            CAL CFALSE
53 263  056 044                LLI 044
53 265  315 255 022            CAL FSTORE

53 270  056 000        TAYLOP, LLI 000
53 272  176                    LAM
53 273  306 004                ADI 004
53 275  167                    LMA
53 276  157                    LLA
53 277  046 054     **         LHI 054
53 301  315 244 022            CAL FLOAD
53 304  046 001     **         LHI 001
53 306  056 014                LLI 014
53 310  315 266 022            CAL OPLOAD
53 313  315 046 021            CAL FPMULT
53 316  056 044                LLI 044
53 320  315 266 022            CAL OPLOAD
53 323  315 211 020            CAL FPADD
53 326  056 044                LLI 044
53 330  315 255 022            CAL FSTORE
53 333  056 014                LLI 014
53 335  315 266 022            CAL OPLOAD
53 340  056 034                LLI 034
53 342  315 244 022            CAL FLOAD
53 345  315 046 021            CAL FPMULT
53 350  056 014                LLI 014
53 352  315 255 022            CAL FSTORE
53 355  056 000                LLI 000
53 357  176                    LAM
53 360  054                    INL
53 361  276                    CPM
53 362  302 270 053            JFZ TAYLOP
53 365  056 044                LLI 044
53 367  303 244 022            JMP FLOAD
--------

54 000  003                    003  /INT
54 001  311                    311
54 002  316                    316
54 003  324                    324
54 004  003                    003  /SGN
54 005  323                    323
54 006  307                    307
54 007  316                    316
54 010  003                    003  /ABS
54 011  301                    301
54 012  302                    302
```

8008

```
54 013  323
54 014  003
54 015  323
54 016  321
54 017  322
54 020  003
54 021  324
54 022  301
54 023  302
54 024  003
54 025  322
54 026  316
54 027  304
54 030  003
54 031  303
54 032  310
54 033  322
54 034  003
54 035  323
54 036  311
54 037  316
54 040  003
54 041  303
54 042  317
54 043  323
54 044  003
54 045  314
54 046  317
54 047  307
54 050  003
54 051  305
54 052  330
54 053  320
54 054  003
54 055  301
54 056  324
54 057  316
-------------
54 100  361
54 101  207
54 102  144
54 103  001
54 104  023
54 105  121
54 106  255
54 107  000
54 110  052
54 111  232
54 112  121
54 113  375
54 114  314
54 115  154
54 116  263
54 117  371
54 120  340
54 121  153
54 122  117
54 123  364
```

```
323
003  /SQR
323
321
322
003  /TAB
324
301
302
003  /RND
322
316
304
003  /CHR
303
310
322
003  /SIN
323
311
316
003  /COS
303
317
323
003  /LOG
314
317
307
003  /EXP
305
330
320
003  /ATN
301
324
316

361  /A1
207
144
001
023  /A2
121
255
000
052  /A5
232
121
375
314  /A7
154
263
371
340  /A9
153
117
364
```

8080

```
54 013  323
54 014  003
54 015  323
54 016  321
54 017  322
54 020  003
54 021  324
54 022  301
54 023  302
54 024  003
54 025  322
54 026  316
54 027  304
54 030  003
54 031  303
54 032  310
54 033  322
54 034  003
54 035  323
54 036  311
54 037  316
54 040  003
54 041  303
54 042  317
54 043  323
54 044  003
54 045  314
54 046  317
54 047  307
54 050  003
54 051  305
54 052  330
54 053  320
54 054  003
54 055  301
54 056  324
54 057  316
-------------
54 100  361
54 101  207
54 102  144
54 103  001
54 104  023
54 105  121
54 106  255
54 107  000
54 110  052
54 111  232
54 112  121
54 113  375
54 114  314
54 115  154
54 116  263
54 117  371
54 120  340
54 121  153
54 122  117
54 123  364
```

```
323
003  /SQR
323
321
322
003  /TAB
324
301
302
003  /RND
322
316
304
003  /CHR
303
310
322
003  /SIN
323
311
316
003  /COS
303
317
323
003  /LOG
314
317
307
003  /EXP
305
330
320
003  /ATN
301
324
316

361  /A1
207
144
001
023  /A2
121
255
000
052  /A5
232
121
375
314  /A7
154
263
371
340  /A9
153
117
364
```

8008

```
54 134  301      301  /A0
54 135  036      036
54 136  140      140
54 137  004      004

54 140  104      104  /A1
54 141  306      306
54 142  264      264
54 143  012      012

54 144  046      046  /B1
54 145  056      056
54 146  170      170
54 147  006      006
54 150  142      142  /B3
54 151  266      266
54 152  134      134
54 153  001      001

54 154  034      034  /A3
54 155  070      070
54 156  274      274
54 157  377      377

54 160  156      156  /B2
54 161  037      037
54 162  152      152
54 163  002      002

54 164  262      262  /A2
54 165  112      112
54 166  216      216
54 167  003      003

54 170  264      264  /B1
54 171  061      061
54 172  154      154
54 173  003      003

54 174  076      076  /A1
54 175  262      262
54 176  166      166
54 177  002      002

54 200  164      164  /B0
54 201  154      154
54 202  131      131
54 203  376      376

54 204  042      042  /C1
54 205  125      125
54 206  134      134
54 207  002      002

54 210  170      170  /C3
54 211  021      021
54 212  173      173
54 213  000      000
```

8080

```
54 134  301      301  /A0
54 135  036      036
54 136  140      140
54 137  004      004

54 140  104      104  /A1
54 141  306      306
54 142  264      264
54 143  012      012

54 144  046      046  /B1
54 145  056      056
54 146  170      170
54 147  006      006
54 150  142      142  /B3
54 151  266      266
54 152  134      134
54 153  001      001

54 154  034      034  /A3
54 155  070      070
54 156  274      274
54 157  377      377

54 160  156      156  /B2
54 161  037      037
54 162  152      152
54 163  002      002

54 164  262      262  /A2
54 165  112      112
54 166  216      216
54 167  003      003

54 170  264      264  /B1
54 171  061      061
54 172  154      154
54 173  003      003

54 174  076      076  /A1
54 175  262      262
54 176  166      166
54 177  002      002

54 200  164      164  /B0
54 201  154      154
54 202  131      131
54 203  376      376

54 204  042      042  /C1
54 205  125      125
54 206  134      134
54 207  002      002

54 210  170      170  /C3
54 211  021      021
54 212  173      173
54 213  000      000
```

8008

```
54 214  123        123  /C5
54 215  253        253
54 216  114        114
54 217  000        000
```

8080

```
54 214  123        123  /C5
54 215  253        253
54 216  114        114
54 217  000        000
```

ADDING USER DEFINED FUNCTIONS

The user may add several user defined names to the function name table which occupies locations 000 - 077 on page 54 in the assembled listing just presented. Remember, the table format is for the first byte in an entry to contain the character count (cc) for the name followed by the characters contained in the name.

User defined functions may be located wherever there is sufficient room in memory (providing they do not interfere with regular or supplemental SCELBAL routines). A good place for short user defined routines might be unused locations on page 54 when the MATHEMATICAL SUPPLEMENT routines are installed, or on page zero if space is available. The starting addresses of user defined routines whose names are installed in the function name table should be placed in the appropriate bytes of the JUMP instructions in the NEWFNS routine (which starts on page 52 location 320 in the assembled listing provided herein).

EXAMPLES

Two examples are given of usage of the extended functions in SCELBAL programs. The first is a simple program to calculate the value of one number raised to another number. Note that this is different from raising a number to another using the up arrow operator, since it can only raise numbers to integral powers. In this program, a number can be raised to .5, or .333333, which is the same as taking a square or cube root respectively.

The second example shows the use of the SIN, COS, and ATN functions. This program will solve for all sides and angles of a right triangle, given two of them (but not just two angles, since this is an ambiguous case). For the sides which you wish to solve for, enter a -1.

Sometimes the programmer wishes to use functions other than SIN, COS, and ATN, so here are some formulas for building other trigonometric functions using the three available:

```
TAN(X) = SIN(X)/COS(X)
SEC(X) = 1/COS(X)
ARCCOS(X) = ATN(SQR(1-X*X)/X)
COTAN(X) = COS(X)/SIN(X)
COSEC(X) = 1/SIN(X)
ARCSIN(X) = (X/SQR(1=X*X))
```

Remember, SIN and COS expect arguments in radians, and ATN returns the angle in radians.

```
10 REM LOG & EXP EXAMPLE
20 PRINT 'BASE';
30 INPUT B
40 PRINT 'POWER';
50 INPUT P
60 PRINT B;'        ';P;'  =';EXP(P*LOG(B))
70 GOTO 10
```

```
BASE?2
POWER?3
 2.0    3.0  =  8.0
BASE?4
POWER?5
 4.0    5.0  =  1024.005

BASE?3
POWER?.5
 3.0    0.5000000  =  1.732055

BASE?2
POWER?.333333
 2.0    0.3333332  =  1.259922
BASE?8
POWER?1.5
 8.0    1.5  =  22.62751


100 PRINT 'RIGHT TRIANGLE SOLVER'
110 PRINT
130 R=ATN(1)/45
140 PRINT 'INPUT ANG A+B; SIDES A+B+C'
150 INPUT A,B,S1,S2,S3
155 IF S1 < 0 THEN 180
160 IF S2 > =0 THEN 300
170 IF S3 > =0 THEN 340
180 IF S2<0 THEN 200
190 IF S3 > =0 THEN 400
200 IF A <0 THEN 250
210 IF B > =0 THEN 290
220 IF S1 > =0 THEN 480
230 IF S2 > =0 THEN 540
240 IF S3 > =0 THEN 600
250 IF B <0 THEN 290
260 IF S1 > =0 THEN 660
270 IF S2 > =0 THEN 720
280 IF S3 > =0 THEN 780
290 PRINT 'ILLEGAL INPUTS'
295 GOTO 140
300 A=ATN(S1/S2)/R
310 B=90-A
320 S3=SQR(S1 ↑ 2+S2 ↑ 2)
330 GOTO 830
340 S2=SQR(S3 ↑ 2-S1 ↑ 2)
350 A=ATN(S1/S2)/R
360 B=90-A
370 GOTO 830
400 S1=SQR(S3 ↑ 2-S2 ↑ 2)
410 GOTO 350
480 B=90-A
```

```
490  S2=S1*COS(A*R)/SIN(A*R)
500  S3=SQR(S1 ↑ 2+S2 ↑ 2)
510  GOTO 830
540  B=90-A
550  S1=S2*SIN(A*R)/COS(A*R)
560  GOTO 500
600  B=90-A
610  S1=S3*SIN(A*R)
620  S2=S3*COS(A*R)
630  GOTO 830
660  A=90-B
670  S2=SIN(B*R)+COS(B*R)*S1
680  GOTO 500
720  A=90-B
750  S1 = SIN(A*R)/COS(A*R)*S2
760  GOTO 500
780  A=90-B
790  S1=S3*SIN(A*R)
800  S2=S3*COS(A*R)
830  PRINT 'ANGLES:','A =';A,'B =';B
840  PRINT 'SIDES:','A =';S1, 'B =';S2, 'C =';S3
850  PRINT
860  GOTO 140
```

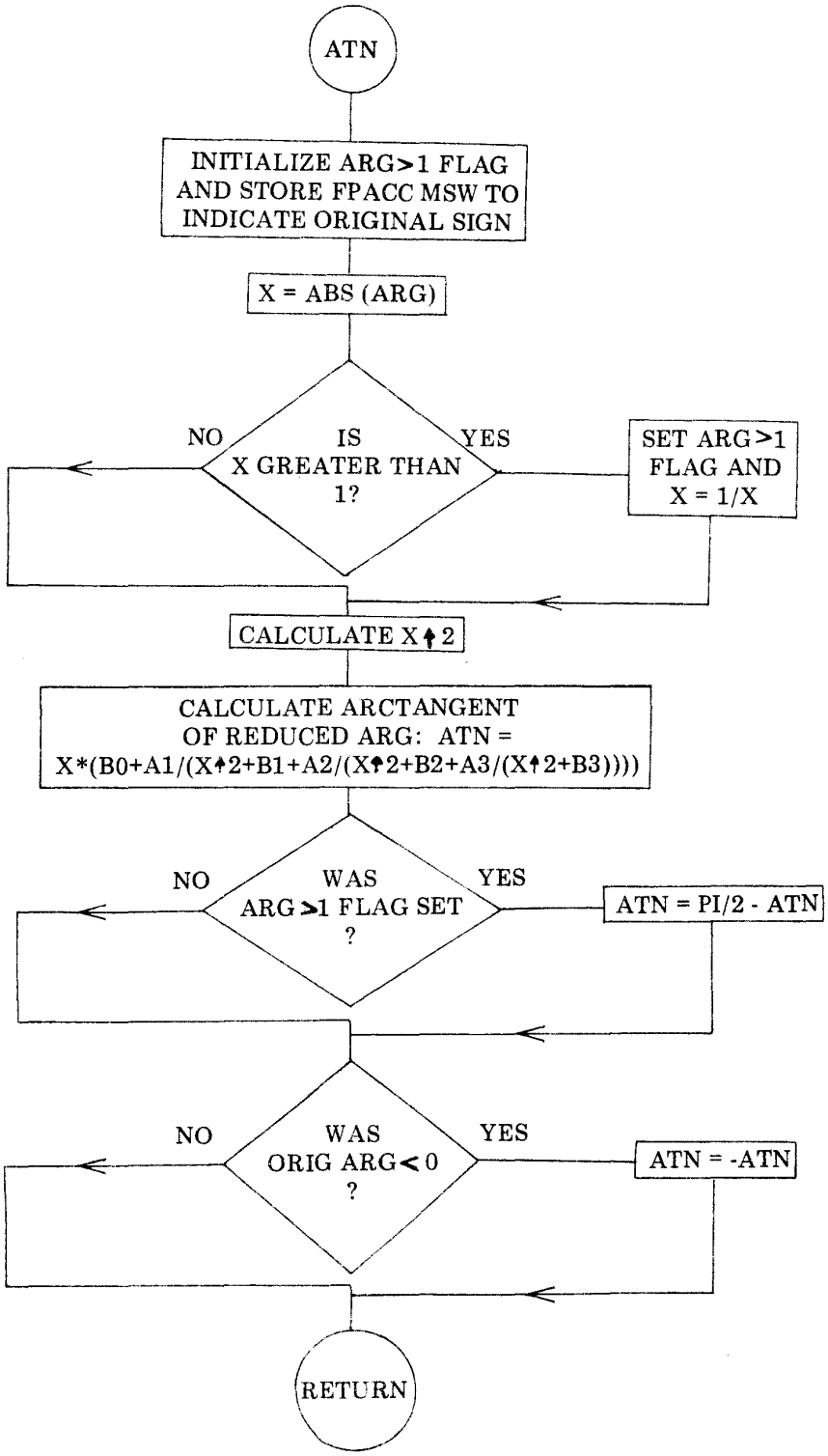
```
RIGHT TRIANGLE SOLVER

INPUT ANG A+B; SIDES A+B+C
?-1
?+1
?3
?4
?5
ANGLES:     A = 36.86988    B = 53.13
SIDES:      A = 3.0         B = 4.0         C = 5.0


INPUT ANG A+B; SIDES A+B+C
?90
?0
?-1
?-1
?-1
ILLEGAL INPUTS
```

The following is a list of the labels referred to by the MATHEMATICAL FUNCTIONS SUPPLEMENT that are in the original SCELBAL publication. The list is arranged alphabetically. The second column shows the address of the label in the original assembled version of SCELBAL. The third column indicates the chapter and page where the label appeared in the source listing section of the book.

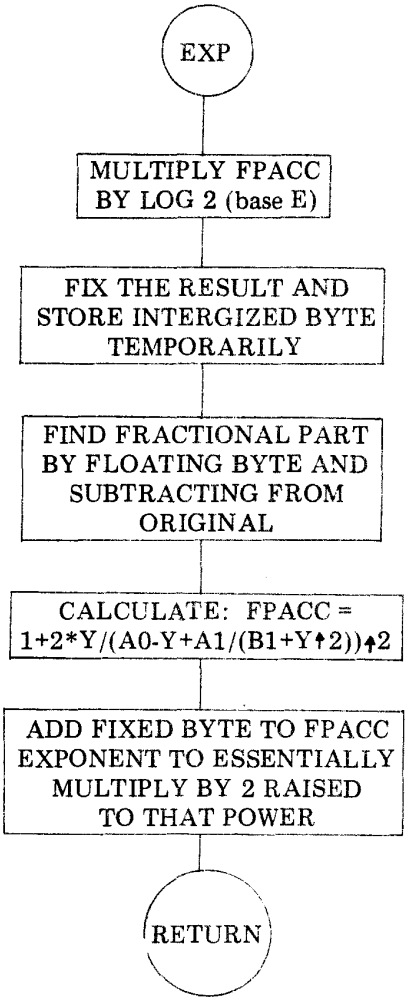
ABSX	07 346	9-8
CFALSE	06 247	8-14
ERROR	02 226	5-6
FACXOP	22 277	10-16
FAERR	07 172	9-3
FLOAD	22 244	10-16
FPADD	20 211	10-5
FPCOMP	20 202	10-5
FPDIV	21 322	10-11
FPFIX	20 000	10-3
FPFLT	20 064	10-4
FPMULT	21 046	10-8
FSTORE	22 255	10-16
FSUB	21 032	10-7
INTX	07 243	9-8
OPLOAD	22 266	10-16

The following is a list of the labels defined for the MATHEMATICAL FUNCTIONS SUPPLEMENT routines. This list is ordered alphabetically. The second column shows the address of the label in the assembled version of the program presented in this publication. The third column presents the page number where the label occurs in the source listing presented in this publication.

ATN1	51 024	2
ATN2	51 230	4
ATNX	50 330	2
COSX	52 271	9
EXPX	51 240	5
LOG1	52 103	8
LOG2	52 246	9
LOGERR	52 074	8
LOGX	52 060	8
NEWFNS	52 320	9
SIN1	53 132	11
SIN2	53 205	12
SINX	53 000	11
TAYLOP	53 270	12
TAYLOR	53 236	12

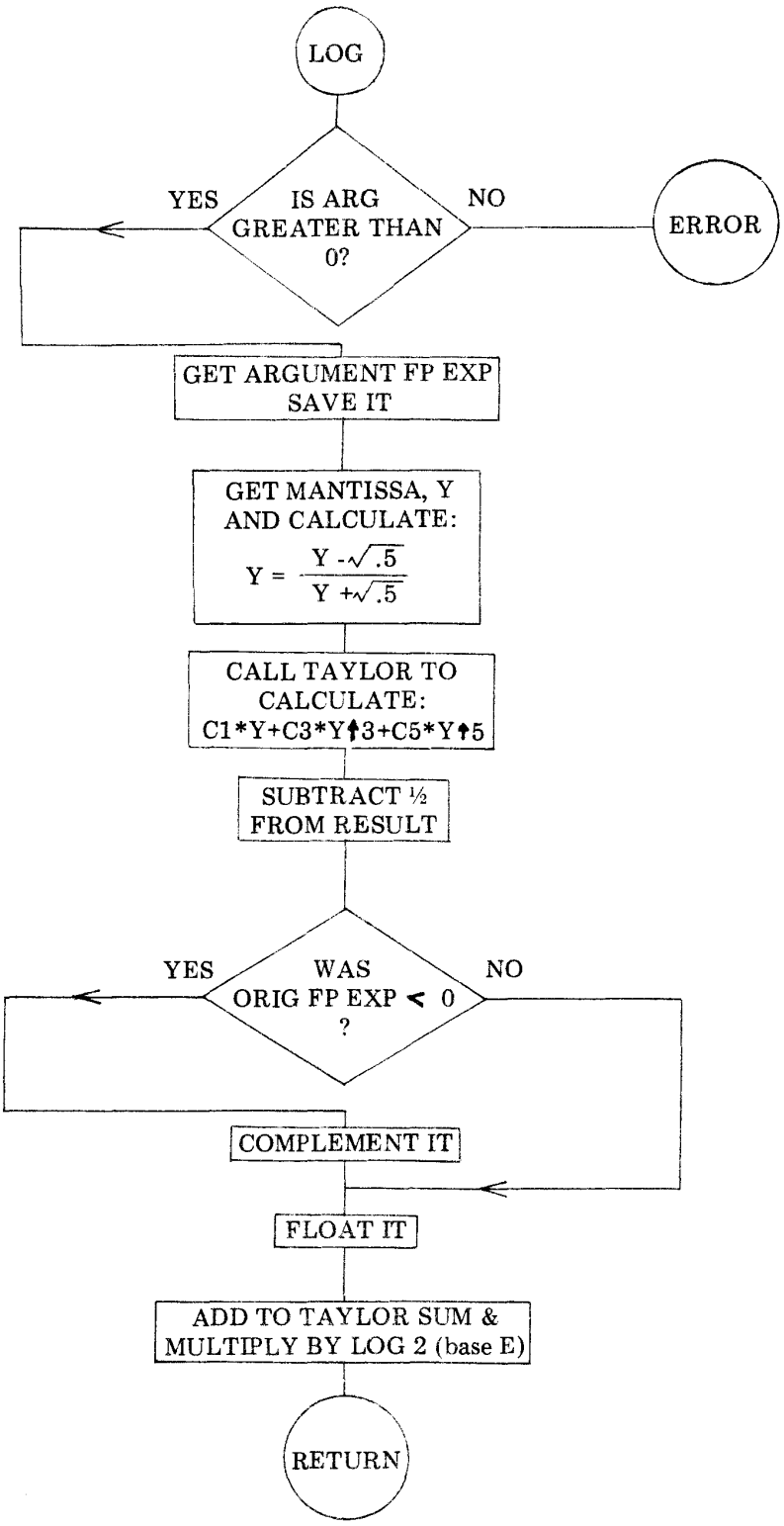

ATN
INITIALIZE ARG>1 FLAG AND STORE FPACC MSW TO INDICATE ORIGINAL SIGN
X = ABS (ARG)
IS X GREATER THAN 1?
NO
YES
SET ARG>1 FLAG AND X = 1/X
CALCULATE X↑2
CALCULATE ARCTANGENT OF REDUCED ARG: ATN = X*(B0+A1/(X↑2+B1+A2/(X↑2+B2+A3/(X↑2+B3))))
WAS ARG>1 FLAG SET ?
NO
YES
ATN = PI/2 - ATN
WAS ORIG ARG<0 ?
NO
YES
ATN = -ATN
RETURN

```
        LLI 154     Load L with address of ATN constant A3
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of A3
        CAL FPDIV   Form A3/(B3+X↑2) in FPACC
        LLI 160     Load L with address of ATN constant B2
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of B2
        CAL FPADD   Form B2+A3/(B3+X↑2) in FPACC
        LLI 034     Load L with address of X↑2
        CAL OPLOAD  Load FPOP with value of X↑2
        CAL FPADD   Form X↑2+B2+A3/(B3+X↑2) in FPACC
        LLI 164     Load L with address of ATN constant A2
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of A2
        CAL FPDIV   Form A2/(X↑2+B2+A3/(B3+X↑2)) in FPACC
        LLI 170     Load L with address of ATN constant B1
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of B1
        CAL FPADD   Form B1+A2/(X↑2+B2+A3/(B3+X↑2))
        LLI 034     Load L with address of X↑2
        CAL OPLOAD  Load FPOP with value of X 2
        CAL FPADD   Form X↑2+B1+A2/(X↑2+B2+A3/(B3+X↑2))
        LLI 174     Load L with address of ATN constant A1
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of A1
        CAL FPDIV   Form A1/(X↑2+B1+A2/(X↑2+B2+A3/(B3+X↑2)))
        LLI 200     Load L with address of ATN constant B0
        LHI 054     **Load H with page of external function constants
        CAL OPLOAD  Load FPOP with value of B0. Form
        CAL FPADD   B0+A1/(X↑2+B1+A2/(X↑2+B2+A3/(B3+X↑2)))
        LLI 014     Load L with address of X
        CAL OPLOAD  Load FPOP with value of X. Form
        CAL FPMULT  X*(B0+A1/(X↑2+B1+A2/(X↑2+B2+A3/(B3+X↑2))))
        LLI 001     Load L with address of ARG > 1 flag
        LAM         Load accumulator with ARG > 1 flag
        NDA         Set flags to see if ARG greater than 1
        JTZ ATN2    If not, no need to adjust function
        LLI 070     Otherwise, load L with address of PI
        CAL OPLOAD  Load FPOP with value of PI
        LLI 137     Load L with address of FPOP exponent
        LBM         Load B with FPOP exponent
        DCB         Subtract 1 to divide FPOP by two
        LMB         FPOP now contains PI/2
        CAL FPSUB   Subtract FPACC from PI/2 as result

ATN2,   LLI 013     Load L with address of original ARG MSW
        LAM         Bring original ARG MSW into accumulator
        NDA         Set flags to see if original ARG is less than 0
        JTS FPCOMP  If so, negate function and return
        RET         Otherwise, return with function value in FPACC
```




```
EXPX,   LLI 170      Load L with address of LOG base 2 E
        LHI 001      **Load H with page of FP
        CAL OPLOAD   Load FPOP with LOG base 2 E
        CAL FPMULT   Multiply ARG by LOG base 2 E
        LLI 034      Load L with address of TEMP FP location
        CAL FSTORE   Store LOG base 2 E times ARG there
        CAL FPFIX    Convert product to byte
        LLI 124      Load L with address of LSW of FPACC
        LAM          Get fixed byte
        LLI 123      Load L with address of FPACC extension
        LMI 000      Clear FPACC extension
        LLI 013      Load L with address of TEMP byte storage
        LMA          Put value of ARG there
        CAL FPFLT    Convert fixed value back to FP
```

```
LLI 034       Load L with address of TEMP FP location
CAL OPLOAD    Load FPOP with LOG base 2 E * ARG
CAL FPSUB     Find initial part of LOG base 2 E * ARG
LLI 114       Load L with address of LOG base E 2
CAL OPLOAD    Load FPOP with LOG base E 2
LLI 137       Load L with address of FPOP exponent
LBM           Bring FPOP exponent into B
DCB           Subtract 1 to divide by two to form
LMB           LOG base E 2 / 2
CAL FPMULT    Multiply fractional part by LN 2/2
LLI 034       Load L with address of TEMP FP location
CAL FSTORE    Store FPACC there (Y)
LLI 034       Load L with address of Y
CAL OPLOAD    Load FPOP with value of Y
CAL FPMULT    Form Y↑2 in FPACC
LLI 144       Load L with address of exponent constant B1
LHI 054       **Load H with address of external function constant pg
CAL OPLOAD    Load FPOP with value of B1
CAL FPADD     Form B1+Y↑2 in FPACC
LLI 140       Load L with address of exponent constant A1
LHI 054       **Load H with page of external function constants
CAL OPLOAD    Load FPOP with value of A1
CAL FPDIV     Form A1/(B1+Y↑2) in FPACC
LLI 034       Load L with address of Y
CAL FACXOP    Put FPACC in FPOP, Y in FPACC
CAL FPSUB     Form Y-A1/(B1+Y↑2) in FPACC
LLI 134       Load L with address of exponent constant A0
LHI 054       **Load H with page of external function constant
CAL OPLOAD    Load the value of A0 in FPOP
CAL FPADD     Form A0+Y-A1/(B1+Y↑2) in FPACC
LLI 034       Load L with address of Y
CAL OPLOAD    Load FPOP with value of Y
CAL FPDIV     Form Y/(A0+Y-A1/(B1+Y↑2)) in FPACC
LLI 127       Load L with address of FPACC exponent
LBM           Load B with FPACC exponent
INB           Add 1 to multiply by 2
LMB           To form 2*Y/(A0+Y-A1/(B1+Y↑2)) in FPACC
LLI 004       Load L with address of +1.0
CAL OPLOAD    Load FPOP with FP +1.0
CAL FPADD     Form 1+2*Y/(A0+Y-A1/(B1+Y↑2))
LLI 124       Load L with address of FPACC
CAL OPLOAD    Load FPOP with FPACC
CAL FPMULT    Form (1+2*Y/(A0+Y-A1/(B1+Y↑2))) 2
LLI 013       Load L with address of TEMP byte storage
LAM           Get initial part of LOG base 2 E * ARG
LLI 127       Load L with address of FPACC exponent
ADM           Add initial part of LOG base 2 E * ARG to FPACC exp
LMA           To multiply FPACC times 2 INT(LOG base 2 E)
RET           And return to caller
```


LOG
IS ARG GREATER THAN 0?
YES
NO
ERROR
GET ARGUMENT FP EXP SAVE IT
GET MANTISSA, Y AND CALCULATE:
Y = (Y - √.5) / (Y + √.5)
CALL TAYLOR TO CALCULATE:
C1*Y+C3*Y↑3+C5*Y↑5
SUBTRACT ½ FROM RESULT
WAS ORIG FP EXP < 0 ?
YES
NO
COMPLEMENT IT
FLOAT IT
ADD TO TAYLOR SUM & MULTIPLY BY LOG 2 (base E)
RETURN

```
LOGX,   LLI 126     Load L with address of FPACC MSW
        LHI 001     **Load H with page of FP
        LAM         Load accumulator with MSW of FPACC
        NDA         Set flags to see if FPACC less than or equal to 0
        JTZ LOGERR  If ARG is zero, then LOG error
        JFS LOG1    If ARG greater than 0, value is O.K.

LOGERR, LAI 314     Print out "L"
        LCI 307     "G" error message when
        JMP ERROR   ARG is less than or equal to 0

LOG1,   INL         L points to FPACC exponent
        LAM         Load accumulator with FPACC exponent
        LMI 000     Put zero in FPACC exponent so .5< FPACC<1
        LLI 013     Load L with address of TEMP byte storage
        LMA         Store old exponent of ARG there
        INL         Increment L to point to TEMP FP storage
        CAL FSTORE  Store FPACC there (Y)
        LLI 204     Load L with address of SQR(2)/2
        CAL FACXOP  Put Y into FPOP, SQR(2)/2 into FPACC
        CAL FPSUB   Subtract SQR(2)/2 from Y
        LLI 034     Load L with address of TEMP FP location
        CAL FSTORE  Store Y-SQR(2)/2 there
        LLI 014     Load L with address of Y
        CAL FLOAD   Load FPACC with value of Y
        LLI 204     Load L with address of SQR(2)/2
        CAL OPLOAD  Load FPOP with SQR(2)/2
        CAL FPADD   Add SQR(2)/2 to Y
        LLI 034     Load L with address of TEMP FP location
        CAL OPLOAD  Load FPOP with Y-SQR(2)/2
        CAL FPDIV   Form (Y-SQR(2)/2)/(Y+SQR(2)/2) in FPACC
        LLI 014     Load L with address of Y
        CAL FSTORE  Store ((Y-SQR(2)/2)/(Y+SQR(2)/2) back in Y
        LLI 000     Load L with address of TAYLOR CONSTANT pointer
        LMI 200     Load TAYLOR pointer with start of LOG constants-4
        INL         Increment to point to TAYLOR FINISH pointer
        LMI 214     Load TAYLOR FINISH pointer with location of last
        CAL TAYLOR  Constant. Call TAYLOR subroutine to
        LLI 024     Calculate LOG base 2. L points to -1.0
        CAL OPLOAD  Load FPOP with -1.0
        LLI 137     Load L with address of FPOP exponent
        LBM         Load FPOP exponent into B and subtract 1 to divide
        DCB         By two in order to form
        LMB         -1/2 in the FPOP after new exponent is stored
        CAL FPADD   Add -1/2 to TAYLOR value
        LLI 044     Load L with address of TAYLOR sum
        CAL FSTORE  Store new value back into TAYLOR sum
        CAL CFALSE  Load 0.0 into FPACC
        LLI 013     Load L with address of TEMP byte storage
        LAM         Get old ARG exponent into accumulator
        LLI 124     Load L with address of FPACC LSW
```

```
        LMA         Store old ARG exponent in FPACC LSW
        NDA         Set flags to see if exponent less than 0
        JFS LOG2    If not, don't complement FPACC
        XRI 377     Otherwise, form two's complement of
        ADI 001     Old ARG exponent so will be ready for 23 bit
        LMA         Store complemented value in LSW of FPACC
        CAL FPCOMP  Do 23 bit complement of FPACC mantissa

LOG2,   CAL FPFLT   Convert ARG exponent to FP
        LLI 044     Load L with address of TAYLOR sum
        CAL OPLOAD  Load FPOP with TAYLOR sum
        CAL FPADD   Add TAYLOR sum to floated ARG exponent
        LLI 114     Load L with address of LOG base E 2
        CAL OPLOAD  Load FPOP with LOG base E 2 to convert to
        JMP FPMULT  Base E LOG. Multiply and exit


COSX,   LLI 070     Load L with address of PI
        LHI 001     **Load H with page of FP
        CAL OPLOAD  Load FPOP with value of PI
        LLI 137     Load L with address of FPOP exponent
        LBM         Load B with FPOP exponent
        DCB         Subtract 1 to divide FPOP by 2
        LMB         To form PI/2 in FPOP
        CAL FPADD   Add PI/2 to ARG in FPACC
        JMP SINX    And exit using SIN function


NEWFNS, CPI 010     Compare token value for Sine function
        JTZ SINX    To Sine routine if match
        CPI 011     Check for Cosine function
        JTZ COSX    To Cosine routine if appropriate
        CPI 012     Check for Log token
        JTZ LOGX    Do Log routine if match
        CPI 013     Test for Exponent token value
        JTZ EXPX    Perform Exponent routine if required
        CPI 014     Check for Arctangent
        JTZ ATNX    To Archtangent routine on match
        CPI 015     Else check for user defined
        JTZ UDF1    Routine token values
        CPI 016     To appropriate user defined
        JTZ UDF2    Address on token match
        CPI 017
        JTZ UDF3
        CPI 020
        JTZ UDF4
        JMP FAERR   If none of the above, have error
```