TRANSCODE LIBRARY FUNCTIONS

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LIBRARY FUNCTIONS

This supplement has been prepared to supersede Chapter 5 of the Transcode Manual, and includes details of library tapes available to Transcode users.

They are described under the following headings:-

1. Title. The library tape will be labelled with this title.

2. "Tape Control - Standard"

This means that the tape for the function, which is to be used as FNTN oof, is to be reperforated into the program exactly as it comes from the library cabinet, immediately following

FFFF oof Spaces

If the Tape Control is not standard, alternative notes are given.

3. "Program Entry - Standard"

This means that the function oof is to be called into action as required by the program by means of the instruction

FNTN oof.0 aaa.A ddd.D

Where the argument is to be found in address aaa (modified by B-line A) and the function of this argument is to be placed in address ddd (modified by B-line D). Notation as on Summary Sheet, Appendix V.

If the Program Entry is not Standard, alternative notes are given.

Title TC:ARCTAN

Purpose To evaluate the principal value ($-\frac{\pi}{2} \leq \theta \leq \frac{\pi}{2}$) in radians of the inverse tangent.

Tape Control Standard

Program Entry Standard

Notes 1. A separate tape is available for ARCOT.

2. If both arctan and arcot are required in the same program, use TC:ARCTAN for arctan N and evaluate arcot N as ($\frac{\pi}{2}$ - arctan N) ($\frac{\pi}{2}$ = 1.570,796,326,795).

3. $\text{Sin}^{-1}\ N = \tan^{-1}\left(N/\sqrt{1-N^2}\right)$
   $\text{Cos}^{-1}\ N = \tan^{-1}\left(\sqrt{1-N^2}/N\right)$
   $\text{Sec}^{-1}\ N = \tan^{-1}\left(\sqrt{N^2-1}\right)$
   $\text{Cosec}^{-1}\ N = \frac{\pi}{2} - \tan^{-1}\left(\sqrt{N^2-1}\right)$.

Title TC:ARCOT

Purpose To evaluate the principal value ($0 \leq \theta \leq \pi$) in radians of the inverse cotangent.

Tape Control The Library tape is prepared for input as FNTN 005 and FNTN 006. These tape controls must not therefore be punched separately into the program tape. Also, these FNTN numbers cannot be used elsewhere in the program.

Program Entry FNTN 005,0 aaa.A ddd.D.

Error Between 1 in 10^{10} and 4 in 10^{7}.

Title TC:CARDIN

Purpose To read data from IBM punched cards.

Tape Control Standard - Requires a guide as described below.

Program Entry FNTN oof.0 000,0 Z14.0

Time

Notes 1. A guide should be added just before the EQS at the end of the library tape. This should be punched as follows:-

aaa,0 $n-d_1+d_2+\ldots,d_n+$"

where aaa,0 is the transcode address in which to place the first number from the card.

n is the number of numbers to be read per card. These are placed in sequential transcode addresses starting at aaa.0.

d_K is the number of digits in the k^{th} number.

The guide must be terminated by punching " which is then followed by EQS as on the library tape.

The following restrictions apply:-

$1 \leq n \leq 20 \quad 1 \leq d_K \leq 12 \quad \Sigma d \leq 63$

2. Each entry to TC:CARDIN in effect reads one card. In fact 11 cards are read on the first entry and each 11th entry thereafter. Drum positions 054 to 064 are used by TC:CARDIN and must therefore not be used by the program.

3. The special instruction J0TB 000.0 000,0 208,0 must be included in the transcode program so that it is obeyed at some time prior to the first use of TC:CARDIN and is not obeyed thereafter.

4. Numbers are interpreted as decimal fractions and must be multiplied by a suitable power of 10 after input.

5. An "X" or "Y" punching over any digit will cause the number to be treated as negative.

6. At least 14 blank cards should be placed on top of the cards in the input hopper.

Title TC:CARDOUT:I

Purpose To prepare and store one IBM card of data for subsequent punching by TC:CARDOUT:II.

Tape Control Standard - Requires a guide as described below.

Program Entry FNTN oof.0 000.0 Z14.0

Time 200 + 35n msec.

Notes 1. A guide should be added just before the EQS at the end of the library tape. This should be punched as follows:-

aaa.0 n-d_1+ d_2+ d_3+ . . . . d_n+"

where aaa.0 is the transcode address of the first number to appear on the card.

n is the number of numbers to be punched per card. These are taken from sequential transcode addresses starting at aaa.0.

d_K is the number of digits in the k^{th} number.

The guide must be terminated by punching " which is then followed by EQS as on the library tape.

If no guide is used, the routine will prepare 7 numbers each to 9 digits starting at Z01.

The following restrictions apply:-

$1 \leq n \leq 20$ $1 \leq d_K \leq 12$ $\leq d \leq 63$ $n+\Sigma d \leq 72$

2. Each entry to TC:CARDOUT:I prepares one card for output. The prepared data are stored in Drum locations 033 to 064 which must therefore not be used by the program. The number of cards prepared by TC:CARDOUT:I before using TC:CARDOUT:II to punch them must not be greater than 32 times the largest integer contained in 21/n (21 times if TC:CARDIN is used in the same program).

3. The special instruction JOTB 000.0 000.0 207.0 must be included in the transcode program so that it is obeyed at some time prior to the first use of TC:CARDOUT:I and is not obeyed thereafter.

4. Numbers will be punched in fixed decimal point notation assuming that their absolute value is less than unity. Numbers to be output must be multiplied by a suitable power of 10 to meet this condition before using TC:CARDOUT:I, otherwise only the fractional part will be punched.

5. Negative numbers are marked by an "X" punching in the most significant digit column.

Title TC:CARDOUT:II

Purpose To punch IBM cards with data prepared by TC:CARDOUT:I.

Tape Control Standard

Program Entry FNTN oof.0 000.0 Z14.0

Time 100 cards per minute.

Notes 1. One entry to TC:CARDOUT:II punches all the cards prepared by TC;CARDOUT:I since the last use of TC:CARDOUT:II.

2. Since the IBM punch must be allowed to coast to a stop before restarting, TC:CARDOUT:II must not be used at intervals closer than 3 seconds.

Title TC: COMPLEX ROOTS

Purpose Solves polynomial equations of degree less than 36 with complex coefficients.

Tape Preparation The coefficients are entered as NUMB (in order of decreasing power) with the real part preceding the imaginary one to DRUMS 017 to 020, each full drum containing 10 coefficients. At the end the sum of coeffs is entered.

Program Entry

Prepare short tape

INST	004		
BSET	000.6	00n.0	000.0
FNTN	001.0	000.0	Z14.0
HALT	000.0	000.0	000.0
QUIT	000.0	000.0	000.0
ENTR			

n = degree of polynomial

Roots are printed in complex form.

Title TC: CONVERSION/S
TC: CONVERSION/L

Purpose To convert Transcode floating numbers to fixed point binary numbers, enabling Transcode numbers to be printed in fixed point decimal form if desired.

These routines required some knowledge of machine code, and detailed information must be obtained from the librarian.

Title TC:COSINE

Purpose To evaluate the cosine of an angle expressed in radians.

Tape Control Standard

Program Entry Standard

Restrictions 1. Error is less than 5 in 10^9.

2. Routine reaches a dynamic stop DS/0 if the angle has modulus greater than about 5×10^7.

Title TC:EXP

Purpose To evaluate the exponential of a number N.

Tape Control Standard

Program Entry Standard

Error At most 1 in 10^{10}.

Restrictions If N is greater than 2^{44}, an IF/G stop occurs. A prepulse will cuase this to be replaced by a Transcode infinity.

TRANSCODE LIBRARY FUNCTION.

Title: TC:EIG/SYM

Purpose: To determine the eigenvalues and eigenvectors of a real symmetric matrix A of order $n \leq 21$.

Method: This routine is a modification to the Real code routine Eig: Jacobi: General, and fuller information is contained in the library sheets for the latter routine. The method used is due to Jacobi, and consists of repeated iterations, each iteration reducing to zero the off-diagonal element of greatest modulus. A group of 20 iterations forms a cycle, upon completion of which a residual R is printed, defined by

$$R = \sum R_\ell = \sum_\ell \sum_i \left| \sum_j a_{ij} \bar{U}_{j\ell} - \bar{\lambda}_\ell \bar{u}_{i\ell} \right|$$

where $\bar{\lambda}_\ell$ and $\bar{u}_{i\ell}$ are the intermediate states of the eigenvalues and eigenvectors respectively.

Tape Preparation and Program Entry: All elements of the matrix are to be scaled down by a factor 10^ℓ

where $10^\ell \geqslant 10n|a_{pq}| > 10^{\ell-1}$
and a_{pq} is the element of A of maximum modulus.

The matrix elements are read by columns, followed by a check column (whose elements are the sums of the several columns of A), to successive Drum locations beginning at Drum 001.

The program is entered by the instructions:

INST 007

BSET	000.6	00n.0	000.0
BSET	000.5	00(2n)0	000.0
BSET	000.4	00ℓ.0	000.0
BSET	000.3	00τ.0	000.0
FNTN	012.0	000.0	000.0
HALT	000.0	000.0	000.0
QUIT	000.0	000.0	000.0

ENTR

n = order of matrix
ℓ = index of 10 in the scaling factor 10^ℓ used to scale down the matrix elements.
τ = no. of decimal places required in the eigenvalues

The results are given with a correctly-positioned decimal point.

Console Procedure:

1. Read in the tape TC:EIG/SYM, no insertions are necessary to this tape.

2. Read in matrix elements, followed by instructions to initiate the program.

3. The matrix elements are first checked for correct read-in by computing check-sums for the various columns and comparing with the values already in the machine. If TALLY:OK is printed, a

prepulse should be given and actual matrix reduction begins. Otherwise the columns which are incorrect are given together with computed check sum.

4. Once the matrix reduction has begun the following /G stops require attention:-

a) /G stop preceded by the printing of an X. Normally occurs only after the first cycle, when the handswitches should be set to //// and a prepulse given. Otherwise set handswitches to ///½ (depress P18 only) and give a prepulse.

b) /G stop preceded by the printing of a residual R (This gives an indication of the accuracy of the eigenvalues available at this stage).

The following choices are then available:-

Set H = //// - Continue with another cycle (R decreasing and consistent with previous R).

H = ///½ (P18 depressed) - Repeat previous cycle (R questionable).

H = ///T (P19 depressed) - Print the results. ($R < 10^{-7}$ should give 6 correct significant figures in the results).

The results are automatically printed out if R is sufficiently small to give 8 or 9 figure accuracy.

5. Should control go astray in the middle of a cycle, operate K.E.C set handswitches to :/// (P2 depressed), and read in a tape punched - spaces -- @@K@/ - spaces ---.

Results:

The eigenvalues are printed in a two-column layout, the first column being the eigenvalues and the second column the associated residuals.

The eigenvectors are printed in a four-column layout.

Title TC:LINALG

Purpose A single routine which performs the following:-

(i) calculates the determinant D of the n x n matrix A.
(ii) calculates the inverse matrix of A.
(iii) solves m sets of n simultaneous linear equations with A as common matrix of coefficients but with m different sets of right hand sides. $(n + m \leq 20)$.

Tape Preparation and Console Procedure

Library tape is first read in followed by a short tape to set up the size of the matrix:-

```
INST    004
BSET    000.2      00n.0     000.0   }
BSET    000.3   00(n+m).0    000.0   }  Setting up size
FNTN    012.0      000.0     Z14.0   }  of matrix.
QUIT    000.0      000.0     000.0   }
ENTR
```

Data tape, prepared as below, is then read in:-

```
NUMB   A11, A12, A13, .... A1n, C11, C12, .... C1m, S1"   DRUM 022
       FNTN 000 RECHECK
NUMB   A21, A22, - - - - - - - - -
       FNTN 000 RECHECK
                - - - - - - - - -
NUMB   An1, An2, - - - Ann, Cn1, - - - Cnm, Sn"           DRUM 022
       FNTN 000 RECHECK
```

where the n x n matrix A has elements A_{ij} and the right hand sides form an m x n matrix C.
The check sums $S_1, S_2, \ldots, S_n$, are computed using
$S_1 = A_{11} + A_{12} + \ldots + A_{1n} + C_{11} + \ldots + C_{1m} + 1$, etc.

A hoot after read-in of any row indicates that the check has failed, when the read-in of the row in question should be repeated. Persistent failure indicates an incorrect check-sum or a punch error.

The matrix inversion is called in by the following:-

```
INST    008
FNTN    009.0     000.0     Z14.0
BSET    000.6     000.0     000.0   }
LOOP    00n.0     000.5     000.0   }
READ    001.0     000.6     X00.0   }  Output instructions
PRNT      ?         ?         ?     }
INCB    000.6     001.0     000.0   }
TRNS    004.0     000.5     000.0   }
QUIT    000.0     000.0     000.0   }
ENTR
```

The print instruction is set to give desired layout and accuracy.

$X_i^{(1)}$, $X_i^{(2)}$, . . . $X_i^{(m)}$, A_{i1}^{-1}, A_{i2}^{-1}, . . A_{in}^{-1}, S_i, $(i = 1, . , n)$ are in successive storage locations beginning at X01, where X's are solutions of the equations.

If the program proceeds satisfactorily, a sequence - - S : A @ E / will be printed. The console switch should initially be set to Print and when the character E is printed set machine to single prepulse and change output to Punch. The value of the determinant is automatically output.

Notes 1. The printing of an M or P indicates a probable machine fault. After operating KEC a short tape punched as follows should be read in:-

INST	002		
FNTN	011.0	000.0	Z14.0
QUIT	000.0	000.0	000.0
ENTR			

The same tape will normally rescue the program after a derail.

If the matrix is larger than 12 x 12 requiring over 15 minutes machine time, and difficulty is encountered please obtain additional information from the librarian as the matrix may be ill-conditioned.

2. If a sequence of numbers, e.g. 11.0, 8.0, 5.0, 0.0 is output before the value of the determinant, obtain information regarding interpretation of results.

3. The program TC:LINALG may be used as a sub-routine in a larger problem. It is assumed that the larger problem calculates the matrix elements and the right hand sides of any equations and writes these elements by rows to DRUMS 001 to 00n.

Provision must be made for presetting n and (n+m) as above, and for initiating the sub-routine TC:LINALG via FNTN 010 (FNTN 009 if check sums already calculated).

Output instructions must be arranged as previously from DRUMS 001 to 00n.

Title TC:LOG

Purpose To evaluate the natural log of a number N.

Tape Control Standard.

Program Entry Standard.

Stops An NL/G stop occurs for negative N. If followed by a prepulse, log (-N) is calculated.

Title TC:RESCUE

Purpose To re-enter a Transcode problem after a derail.

Tape Control Prepared for input as FNTN 064.

Program Entry FNTN 064.0 000.0 ddd.D.
The contents of the B-lines, the X,Y and Z pages and the link list are stored. ddd.D is made negative.

Entry after Derail

Set machine to single prepulses. Operate K.E.C. Set handswitches to T:@/. Switch on continuous prepulses.

This replaces the data stored by the last use of the FNTN entry, refreshes Perm and the Floaters and re-enters the calculation at the position in which FNTN 064 was last obeyed. This returns, as far as possible, to the position at the last FNTN entry. If drum positions have been altered they will not be reset, though it may be possible to use the sign of ddd.D to enter a sequence to look after changes in Drum positions.

Title TC:RUNGEKUTTA

Purpose To perform one step of a modified Rungekutta integration for a set of simultaneous first-order ordinary differential equations of the form

$$\frac{dy_i}{dx} = f_i(x, y_1, y_2, \ldots, y_n)$$

Detailed information sheets obtainable from the librarian.

Title: TC:MATRIX

Purpose: To form the product P = AB of two given matrices A and B where A is an rxn matrix and B an nxm matrix, $m \leq 20$, $n \leq 21$, $r \leq 31$.

Tape Control: The library tape is prepared for input as FNTNS 004, 005, 006 and 007. These FNTN numbers must not therefore be used elsewhere in the program.

Data Preparation: The matrix A is read by rows, preceded by a check row (whose elements are the sums of the several columns of A), to successive Drum locations beginning at DRUM 033.

The matrix B is read by columns, preceded by a check column (whose elements are the sums of the several rows of B) to successive Drum locations beginning at DRUM 001.

Program Entry: The following sequence of Transcode instructions will initiate the TC: MATRIX program.

BSET	000.2	00(m-1).0	000.0
BSET	000.3	00(n-1).0	000.0
BSET	000.4	00 r .0	000.0
FNTN	004.0	000 .0	Z14.0

The rows of AB, preceded by a check row (whose elements are the sums of the several columns of the matrix AB), are contained in successive drum locations 001-00(r+1), and may be printed from there as desired.

If it is desired to invert the product matrix (assumed square) using TC:LINALG, the following sequence of instructions will place the rows of AB and the required check sums for TC:LINALG in the correct drum locations:-

(S)	BSET	000.6	000.0	000.0
(S+1)	LOOP	00r.0	000.5	000.0
(S+2)	READ	002.0	000.6	X00.0
(S+3)	ADD	X0(m+1).0	*	X0(m+1) .0
(S+4)	WRITE	001.0	000.6	X00.0
(S+5)	INCB	000.6	001.0	000.0
(S+6)	TRNS	00(S+2).0	000.5	000.0

* storage location containing unity.

Stores Altered: (by TC:MATRIX)
Z01, Z02, B6.

Title TC:SIN

Purpose To evaluate the sine of an angle given in radians.

Tape Control Standard.

Program Entry Standard.

Error Less than 10^{-10}.

Title TC:SPECIAL

Purpose To perform any of 7 functions listed below.

Tape Control Standard.

1. Program Entry FNTN 00f.0 000.0 ddd.0.
Numbers are read from tape and placed in successive storage locations starting at ddd.0. The numbers are punched in the usual transcode notation and terminated by a " but without a NUMB tape control. ddd.0 may not be B-modified.

2. Program Entry FNTN 00f.0 00b.0 00c.0.
To check that data present in an X or Y page remains unaltered over a period of time.
To check X page, use 00b = X01.
To check Y page, use 00b = Y01.
When called in as a FNTN, one run through this routine forms a 4-character check sum out of the last 63 lines present on the X or Y page (X01 - X21, Y01 - Y21 respectively). If there is agreement (00c) is made negative. If there is not agreement, (00c) is made positive and the attached check-sum is replaced by the newly-formed one.
In each case control is then returned to the next instruction.

This routine should be used in two separate contexts in a given program.

(1) It should be used at the start of a calculation to form the "attached check-sum" for each page of data stored on the drum.
For example, to attach the correct check-sum to the data stored in drum position 00d, use:

```
READ   00d.0   000.0   X00.0
FNTN   00f.0   X01.0   Z14.0
WRTE   00d.0   000.0   X00.0
```

The (Z14) are of no consequence in this context.

(2) The routine should again be used to perform the check whenever data has been left on an X or Y page for any length of time. The sign of (00c) can now be used to indicate whether or not the check has been successful,

and a repeat procedure may be programmed to operate in case of failure.

For example, to check that data on Page Y has remained unchanged during a series of operations, use:

```
00m       READ   00d.0   000.0   Y00.0
 .          .       .       .       .
          (Series of operations)
 .          .       .       .       .
00n       FNTN   00f.0   Y01.0   Z01.0
00(n+1)   TRNS   00m.0   000.0   Z01.0
          (Next part of program)
```

Here it is assumed that a check-sum has already been attached to DRUM position 00d, that this data remains unchanged on the drum, and that Z01 is available as work space. The "series of operations" is repeated in the event of check-sum failure.

3. Program Entry FNTN 00f.0 00n.1 Z14.0
n line feeds are output. This is useful to divide output into blocks or pages.

4. Program Entry FNTN 00f.0 000.2 Z14.0
The printer is disabled so that future output is punched, provided:
a) Console switch set to 'Print and Punch'
b) P9 of the handswitches is not a 1.

5. Program Entry FNTN 00f.0 000.3 Z14.0
The effect of 4. above is cancelled.

6. Program Entry FNTN 00f.0 000.4 ddd.D
The contents of the handswitches (20 bits) are placed in the exponent line of ddd.D.

7. Program Entry FNTN 00f.0 00n.5 Z14.0
A hoot of about ¾ seconds will occur.
