DOCUMENT RESUME

ED 064 960 24 EM 010 210

TITLE	EIN Software Catalog; Entries, Volume III.
INSTITUTION	Interuniversity Communications Council (EDUCOM), Boston, Mass.
SPONS AGENCY	National Science Foundation, Washington, D.C.; Office of Education (DHEW), Washington, D.C.
BUREAU NO	BR-8-0697/Attachment No. 1
PUB DATE	[72]
GRANT	OEG-0-8-080697-4468(007)
NOTE	563p.; See also EM 010 206, EM 010 207, EM 010 208, EM 010 209, EM 010 211, EM 010 212
EDRS PRICE	MF-$0.65 HC-$19.74
DESCRIPTORS	Behavioral Sciences; Biological Sciences; *Catalogs; Computer Oriented Programs; *Computer Programs; Earth Science; Educational Administration; Engineering; *Information Networks; Information Science; *Interinstitutional Cooperation; Library Science; Mathematics; Operations Research; Physical Sciences; *Program Descriptions; Statistics; Technology; Tests
IDENTIFIERS	*Educational Information Network; EIN

ABSTRACT

The EIN (Educational Information Network) is a non-profit operation which coordinates the sharing of educational computing resources. It is administered by EDUCOM and funded jointly by the U. S. Office of Education and the National Science Foundation. EIN maintains a group of contact personnel at member institutions to serve as a liaison between the institution and EIN. Through these persons items of software are offered for distribution. EIN also publishes a catalog of the software which is available through the network. The four- volume catalog contains an alphabetical listing of the participating EIN members that are represented in the catalog by program descriptions; descriptions of each computer facility listed and its general pricing algorithm; abstracts of available programs, subdivided into 13 areas of application; three indexes--by EIN number, by descriptive title, and by keyword; and complete descriptions of programs, including user instructions, samples of input and output, and cost estimates. Volume one contains a description of the EIN, facilities descriptions, abstracts, and indexes. This volume is one of three which contain the complete program descriptions. (JY)

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EIN Software Catalog; Entries, Volume III.

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DESCRIPTIVE TITLE	Static Leontief Input–Output Analysis
CALLING NAME	INOUT
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	M.C. Hallberg M. Swope Department of Agricultural Economics, The Pennsylvania State University
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Daniel Bernitt, 105 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

INOUT will solve the static Leontief input–output problem for a model with as many as 175 sectors. From data consisting of a square input matrix, an output vector, and a set of final demand vectors, a great variety of results may be selectively opted, calculated, and printed. Among these are matrices of technical and interdependency coefficients, matrices of interdependency values and net effects, and some other useful vectors.

REFERENCE

Leontief, W., *et al.*, *Studies in the Structure of the American Economy*, Harvard Economic Research Proj. (Oxford University Press, New York, 1953); theoretical and empirical explorations in input–output analysis.

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USER INSTRUCTIONS

The data deck consists of the following cards in the order specified.

```
--------JOB CARD--------
// EXEC LIBRARY.PARM=INOUT
// DATA.INPUT DD *
Master control card for Problem 1
Total output or receipts vector
Input matrix cards
Final demand vector
Master control card for Problem 2
.
.
.
.
```

Master Control Card

Columns	*Contents*
1– 3	number of sectors (must not exceed 175)
10	1 if technical coefficients are to be printed (else =0)
15	1 if interdependency coefficients are to be printed (else = 0)
16–20	number of final demand vectors to be read
25	1 if sector multipliers are to be printed (else = 0)
30	1 if matrix of interdependency values is to be printed (else = 0)
35	1 if matrix of net effects is to be printed (else = 0)
40	1 if column sums of technical coefficients are to be printed (else = 0)
45	1 if interdependency coefficients are to be punched (else = 0)
50	1 if matrix of technical coefficients is to be punched in 8F10.5 format (else = 0)
55	1 if matrix of interdependency coefficients is to be punched in 4F20.8 format (else = 0)

Total Output or Receipts Vector Cards

This vector is punched eight elements per card in 10-column fields. If the decimal point is not punched, it will automatically be

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placed between the sixth and seventh columns in each 10-column field. These cards are to follow the master control card.

Input-Matrix Cards

The input matrix is punched by rows, eight elements per card in 10-column fields. The first element in each row will occupy the first 10-column field on a new card—each subsequent element in that row will follow in consecutive order. If the decimal point is not punched, it will automatically be placed between the sixth and seventh columns in each 10-column field. These cards are to follow the total output vector cards.

Final Demand Vector(s) Cards

If a nonzero number appears in Cols. 16–20 of the master control card, the final demand vectors desired will be punched in the same fashion as the total output or receipts vector. Each demand vector will require a separate set of cards. These cards will follow the input-matrix cards. To obtain solutions for more than one final demand vector, insert a set of cards for each final demand vector and make the appropriate entry in Cols. 16–20 of the master control card.

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SAMPLE INPUT

```
//                 (54002,T=200,X=20001,TBERNIII)
// EXEC LIBRARY,PARM=INDIII
//DATA.INPUT DD *
   29    1    1    1    1    1    1    1    1    1
1790.     852.      999.      2274.     123.      137.      355.      805.
778.      1692.     1076.     1121.     751.      351.      204.      140.
95.       1147.     219.      142.      829.      166.      196.      452.
104.      5545.     311.      1122.     1612.
58.       312.                17.
          1.

          2.

                    30.                 2.        2.
                                        10.
          26.       1.        5.        8.



10.                         107.
16.
1.                                                          1.
          2.
          21.       4.
          1.        5.        5.        5.        2.
          6.
          29.       2.        5.        8.
          11.                 7.                  5.

                                                                      4.
          24.       1.        6.        7.
60.                 1.        16.                                     1.
                    6.        2.        7.        5.                  1.

                    :         :         :         :
                    :         :         :         :

15.       376.      618.      445.      32.       10.       81.       45.
166.      101.      52.       55.       61.       29.       18.       10.
17.       57.       53.       72.       435.      48.       79.       368.
98.
14.                 16.                 13.                           141.
1.        8.        4.        4.        1.                  2.
          9.        10.       1.        2.        1.                1.
6.        40.       2.        8.        12.

                                                  11.               62.

177.      25.                 559.      3.        17.       8.        28.
165.      97.       25.       27.       96.       38.       76.       79.
7.        185.

1400.     768.      999.      2142.     29.       72.       156.      111.
233.      788.      321.      426.      385.      345.      71.       10.
86.       435.      71.       119.      613.      52.       13.       254.
64.       2154.     16.       1044.
```

SAMPLE OUTPUT

29 SECTOR INPUT-OUTPUT MODEL

A=MATRIX OF TECHNICAL COEFFICIENTS
(I-A) INVERSE=MATRIX OF INTERDEPENDENCE COEFFICIENTS

TECHNICAL COEFFICIENTS

SECTOR	1	0.03240223	0.36619718	0.0	0.00745941	0.0	0.0	0.0
		0.0	0.0	0.00059102	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.00036069	0.0	0.0
		0.0						
SECTOR	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.02788104	0.0	0.00266312	0.00569801
		0.0	0.0	0.0	0.0	0.0	0.0	0.01206273
		0.0	0.0	0.0	0.0	0.00468891	0.00321543	0.00445633
		0.00496278						
SECTOR	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0						
SECTOR	4	0.00558659	0.0	0.0	0.04695042	0.0	0.0	0.0
		0.0	0.02056555	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.01052632	0.0	0.0	0.0	0.0
		0.0	0.00510204	0.0	0.0	0.00036069	0.0	0.0
		0.0						
			:		:		:	
SECTOR	26	0.00637989	0.44131455	0.61861862	0.21720053	0.26016260	0.07295270	0.22816901
		0.05590062	0.21336761	0.05969267	0.04832714	0.04906334	0.08122503	0.08262108
		0.08866995	0.07142857	0.17894737	0.05013193	0.24200913	0.37500000	0.52472859
		0.28915663	0.40306122	0.81415929	0.94230769	0.0	0.0	0.0
		0.0						
SECTOR	27	0.00782123	0.0	0.01601602	0.0	0.10569106	0.0	0.0
		0.17515528	0.00128535	0.00472813	0.00371747	0.00267618	0.00133156	0.0
		0.00985222	0.0	0.0	0.00791557	0.04566210	0.00520833	0.00241255
		0.00602410	0.0	0.00221239	0.05769231	0.00721371	0.00643087	0.00713012
		0.00744417						
SECTOR	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.06626506	0.0	0.13716814	0.0	0.0	0.0	0.0
		0.0						
SECTOR	29	0.09888268	0.02934272	0.0	0.24528302	0.02439024	0.12408759	0.02253521
		0.03479261	0.21209226	0.05732861	0.02323420	0.02408564	0.12782956	0.10826211
		0.37438424	0.56428571	0.07368421	0.16270888	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0						

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COLUMN SUMS

SECTOR	1	C.48044453
SECTOR	2	C.90375587
SECTOR	3	C.76176175
SECTOR	4	C.67485739
SECTOR	5	C.58536585
SECTOR	6	C.50364564
SECTOR	7	C.28452724
SECTOR	8	C.27701863
SECTOR	9	C.55526592
SECTOR	10	C.15337329
SECTOR	11	C.17657993
SECTOR	12	C.34875572
SECTOR	13	C.53335473
SECTOR	14	C.37606838
SECTOR	15	C.64035409
SECTOR	16	C.72857143
SECTOR	17	C.68421053
SECTOR	18	C.29139648
SECTOR	19	C.55251142
SECTOR	20	C.61575167
SECTOR	21	C.66586244
SECTOR	22	C.61445783
SECTOR	23	C.47559184
SECTOR	24	C.97345133
SECTOR	25	1.00000000
SECTOR	26	C.46438233
SECTOR	27	C.47500568
SECTOR	28	C.46078431
SECTOR	29	C.46464020

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INTERDEPENDENCE COEFFICIENTS

SECTOR	1	1.03438373	0.38063829	0.00256198	0.01011666	0.00155642	0.00096610	0.00098055
		0.00083736	0.00192827	0.00108026	0.01096968	0.00057936	0.00239391	0.00333841
		0.00184831	0.00230108	0.00172055	0.00085061	0.00146243	0.00180913	0.00689721
		0.00231460	0.00171884	0.00348265	0.00364993	0.00370152	0.00280732	0.00322592
		0.00343522						
SECTOR	2	0.00190529	1.00502373	0.00593744	0.00494629	0.00368833	0.00215870	0.00230411
		0.00209732	0.00404009	0.00114223	0.02881572	0.00102574	0.00581613	0.00858199
		0.00462414	0.00582894	0.00391589	0.00210231	0.00349484	0.00416493	0.01751222
		0.00560123	0.00390490	0.00820051	0.00851602	0.00859609	0.00720826	0.00833566
		0.00888482						
SECTOR	3	0.0	0.0	1.00000000	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0						
SECTOR	4	0.00653338	0.00322249	0.00317652	1.05036082	0.00050291	0.00025657	0.00031860
		0.00033586	0.02226208	0.00015749	0.00019625	0.00019527	0.00066165	0.00115349
		0.00166579	0.00104729	0.01331421	0.00028879	0.00053072	0.00467103	0.00262050
		0.00125454	0.00610881	0.00114669	0.00118505	0.00120521	0.00085580	0.00080132
		0.00082736						
			.		.	.		
			.		.	.		
			.		.	.		
SECTOR	26	0.06990238	0.52883257	0.70792589	0.32367989	0.32475914	0.12159109	0.25738333
		0.08457522	0.27036824	0.07602065	0.07898364	0.08029718	0.19399118	0.15516542
		0.15871866	0.13890592	0.25357831	0.07969418	0.30429585	0.46677207	0.60635056
		0.43585040	0.46643836	0.85812006	1.02885815	1.08566967	0.10093665	0.08181874
		0.08613992						
SECTOR	27	0.01803351	0.02340881	0.03568461	0.01615946	0.12145349	0.00555856	0.00790292
		0.18317116	0.01500019	0.00914030	0.00823690	0.00874772	0.01499922	0.01030009
		0.02793395	0.01980566	0.01419491	0.01765220	0.05832627	0.01942185	0.01890783
		0.02359292	0.01225883	0.02830878	0.08489824	0.02717748	1.02767074	0.02693400
		0.02743623						
SECTOR	28	0.00123875	0.00300773	0.00257525	0.00267795	0.00326833	0.00199000	0.00151194
		0.00103145	0.00203759	0.00075724	0.00049592	0.00068338	0.01128754	0.00251738
		0.00259602	0.00237497	0.00362450	0.00105664	0.00133712	0.00215185	0.00212765
		0.00805823	0.00291856	0.14055858	0.00356711	0.00354560	0.00351837	1.00338339
		0.00356517						
SECTOR	29	0.14259887	0.10555007	0.05783848	0.30905483	0.05522211	0.15369011	0.03883072
		0.04966159	0.25047870	0.06627746	0.03629419	0.04657904	0.16168981	0.13774265
		0.42344573	0.60582200	0.15387606	0.18001291	0.04669637	0.07315905	0.05036813
		0.04243869	0.02546786	0.04740762	0.04702945	0.04696867	0.04802220	0.04675191
		1.04674054						

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SECTOR MULTIPLIERS

SECTOR	1	1.75849171
SECTOR	2	2.61751947
SECTOR	3	2.37829803
SECTOR	4	2.24202846
SECTOR	5	2.01196011
SECTOR	6	1.80469549
SECTOR	7	1.50609016
SECTOR	8	1.50199679
SECTOR	9	1.97599651
SECTOR	10	1.26972594
SECTOR	11	1.31425545
SECTOR	12	1.49337767
SECTOR	13	1.92883132
SECTOR	14	1.68236403
SECTOR	15	2.13144021
SECTOR	16	2.27832987
SECTOR	17	2.20212481
SECTOR	18	1.50498571
SECTOR	19	1.92131127
SECTOR	20	2.14093116
SECTOR	21	2.19541974
SECTOR	22	2.16939559
SECTOR	23	1.87105213
SECTOR	24	2.72894405
SECTOR	25	2.78221157
SECTOR	26	1.77989373
SECTOR	27	1.82006961
SECTOR	28	1.76923921
SECTOR	29	1.78057197

continued

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OUTPUT LEVELS REQUIRED TO MEET SPECIFIED FINAL DEMAND

		FINAL DEMAND	REQUIRED OUTPUT
SECTOR	1	1400.00000000	1790.00000000
SECTOR	2	768.00000000	852.00000000
SECTOR	3	999.00000000	999.00000000
SECTOR	4	2142.00000000	2279.00000000
SECTOR	5	29.00000000	123.00000000
SECTOR	6	72.00000000	137.00000000
SECTOR	7	156.00000000	355.00000000
SECTOR	8	111.00000000	805.00000000
SECTOR	9	233.00000000	778.00000000
SECTOR	10	788.00000000	1692.00000000
SECTOR	11	321.00000000	1076.00000000
SECTOR	12	326.00000000	1121.00000000
SECTOR	13	385.00000000	751.00000000
SECTOR	14	345.00000000	351.00000000
SECTOR	15	71.00000000	203.00000000
SECTOR	16	10.00000000	140.00000000
SECTOR	17	86.00000000	95.00000000
SECTOR	18	435.00000000	1137.00000000
SECTOR	19	71.00000000	219.00000000
SECTOR	20	119.00000000	192.00000000
SECTOR	21	613.00000000	829.00000000
SECTOR	22	52.00000000	166.00000000
SECTOR	23	13.00000000	196.00000000
SECTOR	24	254.00000000	452.00000000
SECTOR	25	64.00000000	104.00000000
SECTOR	26	2154.00000000	5545.00000000
SECTOR	27	16.00000000	311.00000000
SECTOR	28	1049.00000000	1122.00000000
SECTOR	29	0.0	1612.00000000
TOTAL		13082.00000000	25432.00000000

continued

MATRIX OF INTERDEPENDENCY VALUES

1448.13722798	292.33020774	2.55942063	21.66988022	0.04513629	0.06955907
0.15296646	0.09294674	0.42598658	0.85124246	3.52094700	0.18886975
0.92165539	1.15175105	0.13123013	0.02301079	0.14796768	0.37001354
0.10383272	0.21528658	4.22799155	0.12035930	0.02234496	0.88459254
0.23359558	7.97307300	0.04491710	3.38398716	0.0	
1790.00000000					
2.67301224	771.55522805	5.03150415	10.59494334	0.10696143	0.15542670
0.35944161	0.23280305	0.94134157	0.90007714	9.24984614	0.33439202
2.23920941	2.96078739	0.32831377	0.05828943	0.33676693	0.91450623
0.24813388	0.49562697	10.73499386	0.29126399	0.05076368	2.08292847
0.54502527	18.51597119	0.11533211	8.74410998	0.0	
852.00000000					
0.0	0.0	999.00000000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	
999.00000000					
9.70673741	2.47487068	3.17334403	2249.97286799	0.01458451	0.01847320
0.04970153	0.03728079	5.18706435	0.12410067	0.06299490	0.06365908
0.25473516	0.39795271	0.11855513	0.01047294	1.14502169	0.12562253
0.03768103	0.55585200	1.60636589	0.06523597	0.07941447	0.29125941
0.07584339	2.59602511	0.01369282	0.84058858	0.0	
	.	.	.		
	.	.	.		
	.	.	.		
97.86333820	406.14341685	707.21796273	693.32232107	9.41801513	8.75455842
40.15179984	9.38784968	62.99579946	59.90426875	25.35374751	26.17687947
74.68660409	53.53213953	11.26902456	1.38905919	25.24773469	34.66696995
21.60500505	55.54587652	371.69289081	22.66630072	6.06369866	228.12249473
65.34692173	2338.53247509	1.61498634	85.82786122	0.0	
5545.00000000					
25.24691192	17.97756320	35.64892335	34.61356654	3.52215123	0.68821608
1.23285539	20.33159914	3.49504474	7.20255419	2.64404493	2.85175724
5.77470140	3.55353175	1.98331080	0.19805656	1.22076200	7.67870776
4.14116493	2.31239028	11.59049766	1.07082673	0.15936476	7.19042937
5.43348737	58.54028138	16.44273177	28.25376754	0.0	
311.00000000					
1.73425192	2.30993838	2.57267498	5.73617676	0.09478167	0.14328011
0.23586189	0.11449050	0.47475918	0.59670257	0.15919130	0.22278306
4.34570168	0.86849764	0.18431769	0.02374967	0.31170717	0.45963727
0.09493541	0.25607026	1.30424916	3.53902815	0.03794128	35.70187861
0.22829488	7.63722585	0.06269394	1052.54917900	0.0	
1122.00000000					
195.62442329	84.13445488	57.78063767	659.85343817	1.60144125	11.06568793
6.05759169	5.51243611	58.40813631	52.22663690	11.65043367	15.18476676
62.25057587	47.52121515	30.06464674	6.05822001	13.23334104	78.30561557
3.31544192	8.70592654	30.87566074	2.20525192	0.33108222	12.04153541
3.00988482	101.17051496	0.76835516	49.04264730	0.0	
1612.00000000					

continued

MATRIX OF NET EFFECTS--(I-A) INVERSE MINUS A

1.00158150	0.01444111	0.00256198	0.00265725	0.00155642	0.00096610
0.00098055	0.00093736	0.00182827	0.00048924	0.01096868	0.00057936
0.00239391	0.00333841	0.00184831	0.00230108	0.00172055	0.00085061
0.00146243	0.00180913	0.00683721	0.00231460	0.00171884	0.00348265
0.00364993	0.00234083	0.00280732	0.00322592	0.00343522	
0.00190929	1.00532373	0.00593744	0.00494629	0.00368833	0.00215870
0.00230411	0.00209732	0.00404009	0.00114223	0.00093468	0.00102574
0.00315301	0.00289399	0.00462414	0.00582894	0.00391589	0.00210231
0.00349494	0.00416493	0.00544950	0.00560123	0.00390490	0.00820051
0.00951602	0.00390718	0.00399282	0.00387933	0.00392204	
0.0	0.0	1.00000000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	
0.00134679	0.00322249	0.00317652	1.00341040	0.00050291	0.00025657
0.00031860	0.00033586	0.00149453	0.00015749	0.00019625	0.00019527
0.00066165	0.00115349	0.00166979	0.00104729	0.00278789	0.00028879
0.00053072	0.00467103	0.00262050	0.00125454	0.00100676	0.00114669
0.00118505	0.00084453	0.00085580	0.00080132	0.00082736	
	.	.	.		
	.	.	.		
	.	.	.		
0.06152250	0.08751802	0.08930727	0.10647936	0.06459654	0.04859839
0.02921432	0.02867460	0.05700063	0.01632797	0.03065650	0.03123384
0.11276615	0.07254454	0.07004870	0.06747735	0.11463094	0.02956226
0.06228671	0.09177207	0.08162197	0.14673377	0.06337713	0.08396077
0.08655046	1.08566967	0.10093665	0.08181874	0.08613992	
0.01021228	0.02340881	0.01966859	0.01615946	0.01576243	0.00955856
0.00790292	0.00801588	0.01371484	0.00441216	0.00451943	0.00607154
0.01366767	0.01330009	0.01808174	0.01980566	0.01419491	0.00973663
0.01266417	0.01422352	0.01649528	0.01456873	0.01225883	0.02609639
0.02720593	0.01996377	1.02123987	0.01980388	0.01999206	
0.00123875	0.00300773	0.00257525	0.00267795	0.00326833	0.00199000
0.00151194	0.00103145	0.00203759	0.00075724	0.00049592	0.00068338
0.01128754	0.00251738	0.00259602	0.00237497	0.00362450	0.00105464
0.00133712	0.00215185	0.00212765	0.00179317	0.00291856	0.00339044
0.00356711	0.00354560	0.00391837	1.00338339	0.00356517	
0.04370619	0.08020735	0.05783848	0.06277181	0.03083187	0.02960252
0.01629550	0.01487898	0.03859643	0.00894885	0.01305999	0.02249340
0.03386025	0.02948054	0.04906149	0.04153629	0.08019185	0.01730403
0.04669637	0.07315905	0.05036813	0.04240869	0.02546786	0.04740762
0.04702945	0.04696867	0.04802220	0.04675181	1.04674094	

END OF RUN

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COST ESTIMATE

For the job listed on the Sample Input, the total running time was 11 seconds. At the current rate for computer time ($0.11/sec.) at The Pennsylvania State University, the chargeable time amounts to $1.21.

Charge to user = computer time + network overhead
= $1.21 + network overhead

CONTENTS—INOUT

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DESCRIPTIVE TITLE	Synagraphic Mapping
CALLING NAME	SYMAP
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Laboratory for Computer Graphics Harvard University Graduate School of Design Adapted by Larry Rich Jeffrey Simon Larry Sinkey Department of Architectural Engineering, The Pennsylvania State University
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks, listings, and documentation presently available
CONTACT	Dr. Daniel Bernitt, EIN Technical Representative, 105 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

The Synagraphic Mapping program (SYMAP) produces maps that depict spatially disposed quantitative and qualitative information. Raw data of every kind (physical, social, economic, etc.) may be related, weighted, and aggregated in a graphic format by assigning values to the coordinate locations of data points or data zones. According to the application and desired representation of data, three basic types of mapping procedure may be specified: contour, conformant, or proximal.

CONTOUR
—based on the use of *contour* lines, each of which represents a value remaining constant throughout its length. The map consists of closed curves that connect all points having the same numerical value. The value at each of the different levels of contour

continued

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(where a single contour level will represent a particular data value) is determined by the program, according to the scale of the map and the range of the data. Between any two contour lines, a continuous variation is assumed. Therefore, the use of contour mapping should be restricted to the representation of continuously varying information, such as topography, rainfall, or population density.

CONFORMANT
—based on the *conformance* to the boundaries of a data zone. This type of mapping is best suited to data for which the representation as a continuously varying surface is inappropriate owing to the significance of areal limits or boundaries. Each predefined data zone is assigned one data value and, depending on its numeric class (range), one representative character on the map itself. Local variation within the zone boundaries will not be apparent, but will, on the average, be correct.

PROXIMAL
—based on *proximity* to a data point. In appearance, this type of map is similar to the conformant map. However, point information is used here to define the data zones. Each character location on the output map is assigned the value of the *nearest* data point, using nearest-neighbor techniques. Boundaries are then assumed along the lines where these values change. Then, the mapping is carried out as in the conformant type.

While the contour type of map is mose often used and the easiest to produce, the conformant and proximal maps are often more helpful in the "soft" disciplines. Output is in the form of printed pages that, if the total map size exceeds the width of the computer printed page (13 in.), may easily be glued or pasted together to form a continuous map. Also included in the output is a histogram showing frequencies for given data levels, plus several optional features.

REFERENCES

Robertson, J.C., "The SYMAP Programme for Computer Mapping," Cartographic 108–113 (Dec. 1967); taken from a report of the Select Committee on the Ordinance Survey of Scotland.

Fisher, M., "The Laboratory for Computer Graphics," Harvard Univ. Grad. School Design Suppl. (summer 1967).

continued

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Shepard, D., "A Two-Dimensional Interpolation Function for Irregularly Spaced Data," Harvard Univ. Grad. School Design Lab. Computer Graphics (Feb. 1968); available from the EIN Office for the cost of duplication and mailing. Deals with the subject of analyzing irregularly spaced data derived from a continuous surface. A method is developed for reconstructing the surface from the sampled data. This method is the main device used to generate the maps produced by SYMAP.

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USER INSTRUCTIONS

The user must establish the geographic area that he wishes to map, called the *study area*; it may be of any desired shape. He must then establish the relative locations of any controlling points to which his data relate. For these two purposes, it is best to construct a *source map*, with borders from which measurements may be taken. This source map may be identical in size to the maps that are to be produced—or it may be of any size, because there are automatic scaling and proportioning electives built into the program.

Owing to the availability of the digitizer at The Pennsylvania State University (PSU), it is recommended that users of the PSU modification of SYMAP consider using this device for these proportional adjustments. The purpose of the digitizer is to transfer automatically to punched cards, the X and Y coordinates from a map or drawing. The drawing or map itself is limited to 30X30 in., but it may be drawn to almost any scale. The digitizer is in *no way* connected to a computer but only provides the cards (via an IBM 029 card-punch machine) that can be used as computer input. Interested persons are directed to contact the EIN technical representative at PSU.

Input to the computer in the form of a deck of punched cards must be prepared. This deck will consist of certain introductory cards and a number of packages, each composed of additional cards covering a specific category of information about the map to be produced.

Job Card

Will be prepared by Computation Center personnel.

Introductory Cards

See Ref. 1.

Types of Packages

The titles of all available packages, with a brief explanation of their general purpose, are listed below in the sequency of their position in the deck. For more-complete and -definitive instructions in the preparation of these packages, see Ref. 1.

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A-OUTLINE

—describes the outline of the study area if nonrectangular by specifying the coordinate locations of the outline vertices. Used for contour and proximal maps only.

A-CONFORMOLINES

—used to give the positions of the data zones to which your data are to be related, by specifying the coordinate locations of vertices on the zonal outlines. This package is required for a conformant map.

B-DATA POINTS

—used to give the positions of the data points to which your data are to be related, by specifying their coordinate locations. Data points may be either the points for which data are available or the centers of areas, called *data zones*, for which data are available. (When warranted by the nature of your study, and under exceptional circumstances, other "centers" may be used, such as centers of population.) This package is required for contour and proximal maps.

C-OTOLEGENDS

—used to specify the relative position of legends that are to be adjusted automaticlly if the size and/or scale of the map are altered.

D-BARRIERS

—used to give the coordinate location and strength of impediments to interpolation at specified vertices.

E-VALUES

—used to assign numerical data to the data points and/or data zones by specifying the values involved. All such data must, of course, be measured on a consistent uniform basis. While normally required, this package may be omitted if you wish to procure a preliminary base map for checking locations before applying values.

E1-VALUES INDEX

—used to adjust the reference order of data values in the E-VALUES package.

F-MAP

—used to specify below the map an appropriate title for the identification of each separate map that you wish to run. In addition, it instructs the computer to make each specific map pursuant to

continued

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certain electives. These electives provide a variety of options for obtaining maps suited to your particular needs. An F-MAP package is required for each map desired.

REFERENCES

1. *Introductory Manual for Synagraphic Computer Mapping*—"SYMAP," Pa. State Univ. Dept. Arch. Eng. & Grad. Interdisciplinary Program in Regional Planning. Rept. No. 69-4, Version 5, PSU Modification 3. Available from the EIN office for the cost of duplication and mailing.

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SAMPLE INPUT—Population-Density Contour Map of Pennsylvania

```
                'C5993,T=200,R=600,SYMAP','HULL E J',MSGLEVEL=1
// EXEC LIBRARY,PARM=SYMAP
//DATA.INPUT DD *
VERSION 5
A-OUTLINES      0008      0052                                    01
                0027      0051                                    02
                0027      0059                                    03
                0028      0095                                    04
                0028      0131                                    05
                0028      0161                                    06
                0028      0197                                    07
                0028      0237                                    08
                0028      0278                                    50
                0031      0281                                    51
                  :         :                                      :
                0082      0304                                    68
                0087      0301                                    69

99999
B-DATA
                0018      0036                                    01
                0039      0082                                    02
                0042      0119                                    03
                0044      0140                                    04
                0046      0177                                    05
                  :         :                                      :
                0086      0085                                    24
                0096      0119                                    25
99999
C-OTOLEGENDS
   12    P      0165      0297
PHILADELPHIA
   10    P      0135      0034       -5.       -4.
PITTSBURGH
   15    P      0111      0149                                    10
*   PENN STATE
        TL      0099      0008                                    01
                0126      0046                                    02
                0138      0053                                    03
                0147      0054                                    04
                0157      0069                                    05
                  :         :                                      :
                0152      0295                                    19
                0155      0316                                    20
        IL      0082      0009                                    01
                0081      0043                                    02
                0084      0061                                    03
                0082      0068                                    04
                0084      0083                                    05
                  :         :                                      :
                0096      0283                                    21
                0096      0293                                    22
        SL      0087      0141                                    01
                0078      0148                                    02
                0074      0159                                    03
                0088      0167                                    04
                0081      0186                                    05
                  :         :                                      :
                0176      0227                                    29
                0190      0238                                    30
99999
```

continued

000 0047

```
E-VALUES
                309.0
                 50.0
                 55.0
                 15.0
                 32.0
                 48.0
                 40.0
                 38.0
                 17.0
                517.0
                 42.0
                 13.0
                 90.0
                 42.0
                 19.0
                 46.0
                 11.0
                117.0
                 77.0
                187.0
                308.0
                144.0
                 63.0
                 72.0
                 71.0
99999
F-MAP
C   PENNSYLVANIA POPULATION DENSITY
C   PERSONS PER SQUARE MILE

    1            24.       36.
    3            10.
    6            25.       25.       50.      100.      100.      100.
                100.      100.      400.    14584.
   10
1965 DATA
C. F. GERLACH
9999
   13            .11
   14            1.5       1.5       2.0       1.5
99999
/*
```

000 0047

SAMPLE INPUT—Population-Density Conformant Map of Pennsylvania

```
//              'C5993,T=200,R=6000,SYMAP','HULL E J',MSGLEVEL=1
// EXEC LIBRARY,PARM=SYMAP
//DATA.INPUT DD *
VARSION 5
A-CONFORMOLINES
         A      0008      0052                                    01
                0027      0051                                    02
                0027      0059                                    03
                0037      0059                                    04
                0036      0012                                    05
                0027      0012                                    06
                0023      0023                                    07
                0008      0052                                    08
         A      0027      0059                                    01
                0028      0095                                    02
                0040      0095                                    03
                0040      0093                                    04
                0054      0093                                    05
99999
B-DATA
                0018      0036                                    01
                0039      0082                                    02
                  :         :                                      :
                0069      0219                                    12
                0081      0192                                    13
99999
C-OTOLEGENDS
   12    P      0165      0297
PHILADELPHIA
-  10    P      0135      0034       -5.       -4.
PITTSBURGH
   15    P      0111      0149                                    10
*   PENN STATE
        TL      0099      0008                                    01

                0143      0199                                    21
                0147      0198                                    22
                  :         :                                      :
                0176      0227                                    29
                0190      0238                                    30
```

continued

000 0047

```
E-VALUES
                309.0
                 50.0
                 55.0
                 15.0
                 32.0
                 48.0
                 40.0
                 38.0
                 17.0
                517.0
                 42.0
                 13.0
                 90.0
                 42.0
                 19.0
                 46.0
                 11.0
                137.0
                 77.0
                187.0
                308.0
                144.0
                 63.0
                 72.0
                 71.0
99999
F-MAP
C   PENNSYLVANIA POPULATION DENSITY
C   PERSONS PER SQUARE MILE

    1            24.       36.
    3            10.
    4            25.
    5          3000.
    6            25.       25.       50.      100.      100.      100.
                100.      100.      400.     2000.
   10
1965 DATA
C. F. GERLACH
9999
   13           .11
   14           1.5       1.5       2.0       1.5
   15            6.       10.
99999
/*
```

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000 0047

SAMPLE OUTPUT—Showing Contours of Population Density

A-OUTLINE

VERTEX	DOWN	ACROSS
	ISLAND	1
(1)	27.00	31.00
(2)	8.00	52.00
(3)	27.00	59.00
(4)	28.00	95.00
(5)	28.00	131.00
(6)	28.00	141.00
(7)	28.00	197.00
(8)	28.00	237.00
(9)	28.00	278.00
.		
.		
.		
(50)	177.00	268.00
(51)	179.00	263.00
(52)	182.00	260.00
(53)	185.00	259.00
(54)	186.00	194.00
(55)	185.00	98.00
(56)	183.00	7.00
(57)	27.00	12.00
(58)	23.00	23.00
(59)	8.00	52.00

AREA= 45299.00 CENTER =(105.65, 151.50)

B-DATA POINTS

POINT	DOWN	ACROSS
(1)	19.00	36.00
(2)	39.00	82.00
(3)	42.00	119.00
(4)	44.00	140.00
(5)	46.00	177.00
(6)	45.00	222.00
(7)	40.00	251.00
(8)	57.00	283.00
(9)	73.00	306.00
(10)	70.00	263.00
.		
.		
.		
(60)	144.00	231.00
(61)	143.00	250.00
(62)	124.00	273.00
(63)	144.00	292.00
(64)	157.00	281.00
(65)	168.00	268.00
(66)	171.00	279.00
(67)	169.00	291.00

continued

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C-OTCLEGENDS

```
VERTEX          DOWN     ACROSS     +ROWS     +COLS

(   1) 'PHILADELPHIA' ACROSS FROM

             165.00     297.00        0.        0.

(   2) 'PITTSBURGH' DOWN FROM

             135.00      34.00       -5.       -4.

(   3) '*   PENN STATE ' ACROSS FROM

             111.00     149.00        0.        0.

(   4) 'T' ON LINE

(   1)        99.00       8.00
(   2)       126.00      46.00
(   3)       138.00      53.00
(   4)       147.00      54.00
(   5)       157.00      69.00
            :
            :
            :
(  16)       153.00     154.00
(  17)       148.00     238.00
(  18)       161.00     267.00
(  19)       152.00     295.00
(  20)       155.00     316.00
LENGTH=     351.82

(   5) 'I' ON LINE

(   1)        82.00       9.00
(   2)        81.00      43.00
(   3)        84.00      61.00
(   4)        82.00      68.00
(   5)        84.00      83.00
            :
            :
            :
(  16)        98.00     209.00
(  17)        94.00     228.00
(  18)        97.00     233.00
(  19)        93.00     265.00
(  20)        92.00     280.00
(  21)        96.00     283.00
(  22)        96.00     293.00
LENGTH=     297.99

(   6) 'S' ON LINE

(   1)        87.00     141.00
(   2)        78.00     148.00
(   3)        74.00     159.00
(   4)        88.00     167.00
(   5)        81.00     186.00
            :
            :
            :
            .
```

continued

000 0047

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F-VALUES

DATUM	VALUE	
(1)	309.00	
(2)	50.00	
(3)	55.00	
(4)	15.00	
(5)	32.00	
(6)	48.00	
(7)	40.00	
(8)	38.00	
(9)	17.00	
(10)	517.00	
.		
.		
.		
(25)	161.00	212.00
(26)	163.00	218.00
(27)	169.00	223.00
(28)	172.00	227.00
(29)	176.00	227.00
(30)	190.00	239.00
LENGTH=	219.26	
.		
.		
.		
(60)	294.00	
(61)	320.00	
(62)	654.00	
(63)	503.00	
(64)	1042.00	
(65)	277.00	
(66)	3005.00	
(67)	15584.00	

continued

000 0047

```
F-MAP
-----

C   PENNSYLVANIA POPULATION DENSITY

C   PERSONS PER SQUARE MILE


ELECTIVE

    1 MAP SIZE IS          24.00 INCHES LONG BY          36.00 INCHES WIDE
    3 NUMBER OF LEVELS IS 10
    6 LEVEL SIZES ARE PROPORTIONED TO   1)     25.00   2)     25.00   3)     50.00   4)    100.00   5)    100.00
                                        6)    100.00   7)    100.00   8)    100.00   9)    400.00  10)  14584.00
   10 MAP TEXT
                              1965 DATA
                              C. F. GERLACH
   13 MAP SCALE IS       0.11
   14 MARGIN SHIFTS ARE      1.50  T TOP,      1.50 AT LEFT,      2.00 AT BOTTOM, AND      1.50 AT RIGHT
   15 NEW NUMBER OF LINES PER INCH IS   6.00

TIME = 19:13:13.12

ELAPSE TIME =     3.37 SECONDS FOR INPUT
```

continued

000 0047

MAP 1

C PENNSYLVANIA POPULATION DENSITY
C PERSONS PER SQUARE MILE

MAP SCALE = 0.1100 INCHES ON OUTPUT MAP/UNITS ON SOURCE MAP

MAP SHOULD BE PRINTED AT 6.0 ROWS PER INCH AND 10.0 COLUMNS PER INCH

ROW = (DOWN COORDINATE - -9.82) * 0.6600
COLUMN = (ACROSS COORDINATE - -3.14) * 1.1000

DATA POINTS FOR MAP

POINT	ROW	COLUMN	DATUM	VALUE	LEVEL
1)	18	43	1	309.00	5
2)	32	94	2	50.00	2
3)	34	134	3	55.00	2
4)	36	157	4	15.00	1
5)	37	198	5	32.00	1
6)	36	248	6	48.00	2
7)	33	280	7	40.00	2
8)	44	315	8	38.00	2
9)	55	340	9	17.00	1
10)	53	293	10	517.00	8
		.			
		.			
		.			
61)	101	278	61	320.00	6
62)	88	304	62	654.00	9
63)	102	325	63	503.00	7
64)	110	313	64	1042.00	10
65)	117	298	65	277.00	5
66)	119	310	66	3005.00	10
67)	118	324	67	15584.00	10

STANDARD SEARCH RADIUS IS 42.9321

TIME = 18:13:13.59

ELAPSE TIME = 0.47 SECONDS FOR INITIAL CALCULATIONS

continued

000 0047

continued

000 0047

TIME = 19:15:50.71

ELAPSE TIME = 157.12 SECONDS FOR MAP

C PENNSYLVANIA POPULATION DENSITY

C PERSONS PER SQUARE MILE

1965 DATA
C. F. GERLACH

DATA VALUE EXTREMES ARE 11.00 15584.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	11.00	35.98	60.96	110.93	210.86	310.79	410.72	510.65	610.58	1010.29
MAXIMUM	35.98	60.96	110.93	210.86	310.79	410.72	510.65	610.58	1010.29	15584.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	0.16	0.16	0.32	0.64	0.64	0.64	0.64	0.64	2.57	93.58

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
 LEVEL        1         2         3         4         5         6         7         8         9        10

              ========================================================================================================
              .........  !!!!!!!!!  ---------  =========  +++++++++  XXXXXXXXX  000000000  ©©©©©©©©©  ©©©©©©©©©  ■■■■■■■■■
              .........  !!!!!!!!!  ---------  =========  +++++++++  XXXXXXXXX  000000000  ©©©©©©©©©  ©©©©©©©©©  ■■■■■■■■■
 SYMBOLS      ....1....  !!!!2!!!!  ----3----  ====4====  ++++5++++  XXXX6XXXX  000070000  ©©©©©©©©©  ©©©©©©©©©  ■■■■*■■■■
              .........  !!!!!!!!!  ---------  =========  +++++++++  XXXXXXXXX  000000000  ©©©©©©©©©  ©©©©©©©©©  ■■■■■■■■■
              .........  !!!!!!!!!  ---------  =========  +++++++++  XXXXXXXXX  000000000  ©©©©©©©©©  ©©©©©©©©©  ■■■■■■■■■
              ========================================================================================================
 FREQ.          7         12        14         8         13        3         3         2         1         4
       1   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I   IXX6XXI   I007001I   I98889I   I00900I   I■■*■■I
       2   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I   IXX6XXI   I007001I   I98889I             I■■*■■I
       3   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I   IXX6XXI   I007001I                       I■■*■■I
       4   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I                                            I■■*■■I
       5   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I
       6   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I
       7   I..1..I   I!!2!!I   I--3--I   I==4==I   I++5++I
       8             I!!2!!I   I--3--I   I==4==I   I++5++I
       9             I!!2!!I   I--3--I             I++5++I
      10             I!!2!!I   I--3--I             I++5++I
      11             I!!2!!I   I--3--I             I++5++I
      12             I!!2!!I   I--3--I             I++5++I
      13                       I--3--I             I++5++I
      14                       I--3--I
```

TIME = 18:15:52.66

ELAPSE TIME = 1.95 SECONDS FOR HISTOGRAM

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SAMPLE OUTPUT—Showing Population Density by Counties

000 0047

A-CONFORMCLINES

```
VERTEX            DOWN     ACROSS

    1     AREA

(    1)           8.00      52.00
(    2)          27.00      51.00
(    3)          27.00      59.00
(    4)          37.00      59.00
(    5)          36.00      12.00
(    6)          27.00      12.00
(    7)          23.00      23.00
(    8)           8.00      52.00
LENGTH=     137.39
AREA=     792.50
CENTER=(      26.95,      37.26)
          .
          .
          .
   67     AREA

(    1)         156.00     298.00
(    2)         158.00     301.00
(    3)         161.00     301.00
(    4)         168.00     293.00
(    5)         172.00     293.00
(    6)         175.00     286.00
(    7)         170.00     285.00
(    8)         167.00     285.00
(    9)         165.00     289.00
(   10)         161.00     285.00
(   11)         159.00     287.00
(   12)         160.00     289.00
(   13)         160.00     290.00
(   14)         162.00     294.00
(   15)         156.00     298.00
LENGTH=      64.89
AREA=     137.00
CENTER=(     165.09,     291.93)
```

B-DATA POINTS

```
POINT             DOWN     ACROSS

(    1)          18.00      46.00
(    2)          39.00      82.00
(    3)          42.00     119.00
(    4)          44.00     140.00
(    5)          46.00     177.00
(    6)          45.00     222.00
(    7)          40.00     251.00
(    8)          57.00     293.00
(    9)          73.00     306.00
(   10)          70.00     263.00
          .
          .
          .
(   60)         164.00     231.00
(   61)         143.00     250.00
(   62)         124.00     273.00
(   63)         144.00     292.00
(   64)         157.00     281.00
(   65)         159.00     268.00
(   66)         171.00     279.00
(   67)         169.00     291.00
```

continued

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C-ITC LEGENDS

VERTEX	DOWN	ACROSS	+ROWS	+COLS
(1) 'PHILADELPHIA' ACROSS FROM				
	165.00	297.00	0.	0.
(2) 'PITTSBURGH' DOWN FROM				
	135.00	34.00	-5.	-4.
(3) 'A PENN STATE' ACROSS FROM				
	111.00	149.00	0.	0.
(4) 'T' ON LINE				
(1)	99.00	8.00		
(2)	126.00	46.00		
(3)	138.00	53.00		
(4)	147.00	54.00		
(5)	157.00	57.00		
.				
.				
.				
(16)	153.00	194.00		
(17)	148.00	238.00		
(18)	161.00	267.00		
(19)	152.00	295.00		
(20)	155.00	316.00		
LENGTH=	351.82			
(5) 'I' ON LINE				
(1)	82.00	9.00		
(2)	81.00	43.00		
(3)	84.00	61.00		
(4)	82.00	68.00		
(5)	84.00	83.00		
.				
.				
.				
(20)	92.00	280.00		
(21)	96.00	283.00		
(22)	96.00	293.00		
LENGTH=	297.99			
(6) 'S' ON LINE				
(1)	87.00	141.00		
(2)	78.00	148.00		
(3)	74.00	159.00		
(4)	88.00	167.00		
(5)	81.00	186.00		
.				
.				
.				
(26)	163.00	213.00		
(27)	169.00	223.00		
(28)	172.00	227.00		
(29)	176.00	227.00		
(30)	190.00	238.00		
LENGTH=	219.26			

continued

000 0047

E-VALUES

DATUM	VALUE
(1)	309.00
(2)	50.00
(3)	55.00
(4)	15.00
(5)	32.00
(6)	48.00
(7)	40.00
(8)	39.00
(9)	17.00
(10)	517.00
:	
(60)	294.00
(61)	320.00
(62)	554.00
(63)	503.00
(64)	1042.00
(65)	277.00
(66)	3005.00
(67)	15584.00

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continued

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```
E-MAP
-----

C   PENNSYLVANIA POPULATION DENSITY

C   PERSONS PER SQUARE MILE


ELECTIVE

    1 MAP SIZE IS            24.00 INCHES LONG BY          36.00 INCHES WIDE
    3 NUMBER OF LEVELS IS 10
    4 LEVEL SIZES ARE PROPORTIONED TO   1)     25.00   2)     25.00   3)     50.00   4)    100.00   5)    100.00
                                        6)    100.00   7)    100.00   8)    100.00   9)    400.00  10)  14584.00
   10 MAP TEXT
                              1965 DATA
                              C. E. GERLACH
   13 MAP SCALE IS       0.11
   14 MARGIN SHEETS ARE       1.50 AT TOP,       1.50 AT LEFT,       2.00 AT BOTTOM, AND       1.50 AT RIGHT
   15 NEW NUMBER OF LINES PER INCH IS   6.00

TIME = 18:16:28.95

ELAPSE TIME =   11.56 SECONDS FOR INPUT
```

continued

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MAP 1

C PENNSYLVANIA POPULATION DENSITY
C PERSONS PER SQUARE MILE

MAP SCALE = 0.1100 INCHES ON OUTPUT MAP/UNITS ON SOURCE MAP

MAP SHOULD BE PRINTED AT 5.0 ROWS PER INCH AND 10.0 COLUMNS PER INC

ROW = (DOWN COORDINATE - -5.82) * 0.6600
COLUMN = (ACROSS COORDINATE - -3.14) * 1.1000

CONFORMOLINES FOR MAP

ZONE	TYPE	ROW	COLUMN	DATUM	VALUE	LEVEL
1)	A	21	42	1	309.00	5
2)	A	33	88	2	50.00	2
3)	A	34	127	3	55.00	2
4)	A	27	165	4	15.00	1
5)	A	36	202	5	32.00	1
6)	A	26	243	6	48.00	2
7)	A	33	284	7	40.00	2
8)	A	42	315	8	38.00	2
9)	A	54	329	9	17.00	1
10)	A	52	294	10	517.00	8
		.				
		.				
		.				
60)	A	115	257	60	224.00	5
61)	A	98	275	61	320.00	6
62)	A	88	296	62	654.00	9
63)	A	100	324	63	503.00	7
64)	A	106	312	64	1042.00	10
65)	A	117	288	65	277.00	5
66)	A	119	308	66	3005.00	10
67)	A	116	326	67	15584.00	10

TIME = 18:16:30.20

ELAPSE TIME = 1.25 SECONDS FOR INITIAL CALCULATIONS

continued

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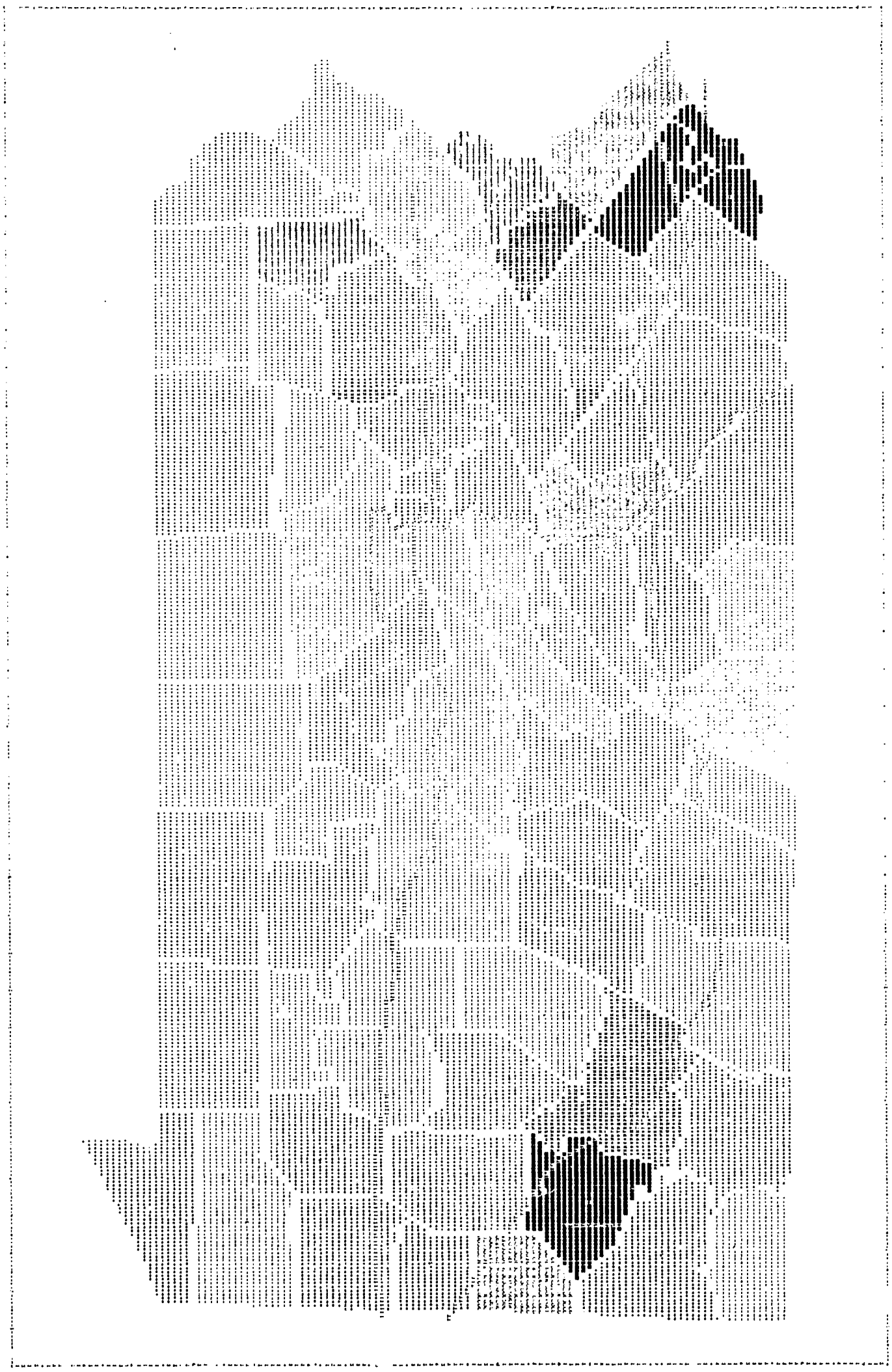


continued

000 0047

TIME = 18:19:42.08

ELAPSE TIME = 191.88 SECONDS FOR MAP

C PENNSYLVANIA POPULATION DENSITY

C PERSONS PER SQUARE MILE

1965 DATA
C. E. GERLACH

DATA VALUE EXTREMES ARE 11.00 15594.00

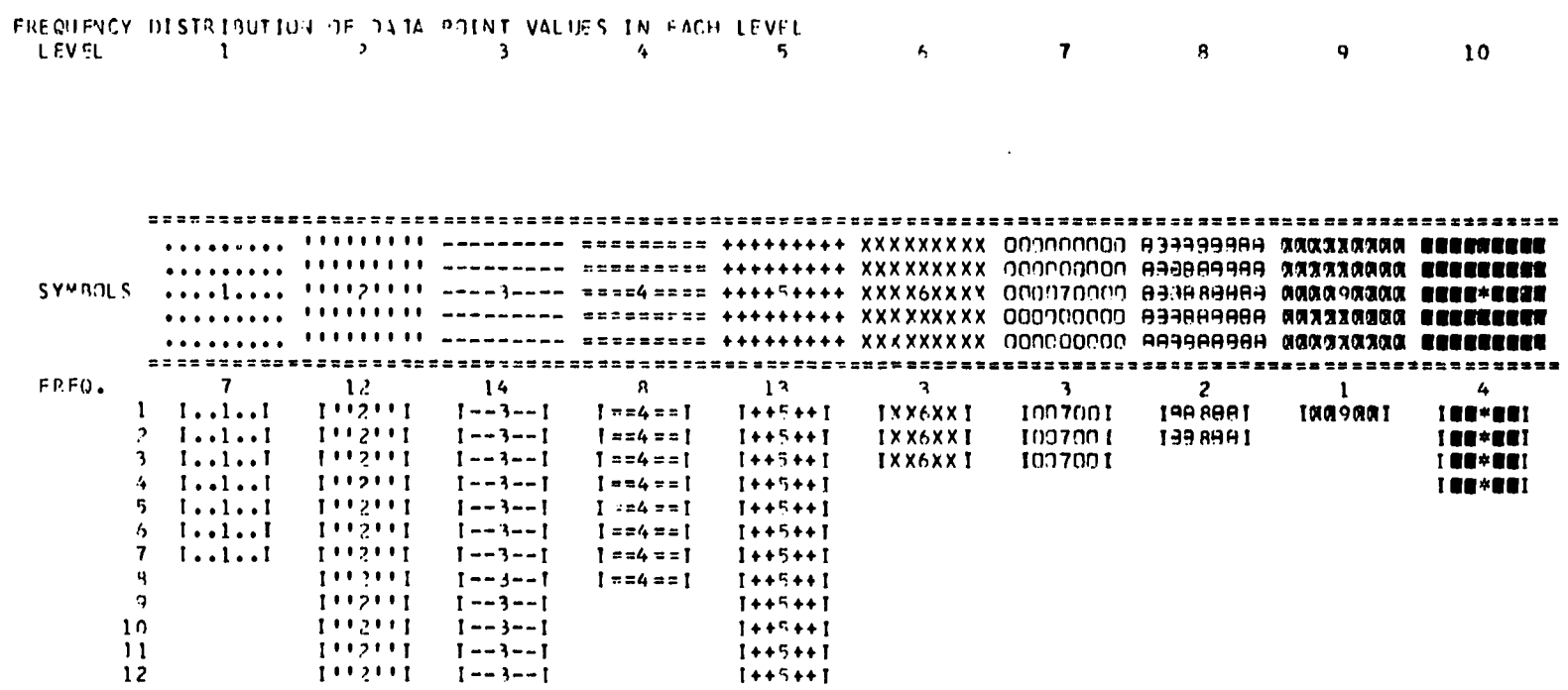
ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM* INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	11.00	35.98	60.96	110.93	210.86	310.79	410.72	510.65	610.58	1010.29
MAXIMUM	36.98	60.96	110.93	210.86	310.79	410.72	510.65	610.58	1010.29	15584.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

0.16	0.16	0.32	0.64	0.64	0.64	0.64	0.64	2.57	93.59

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL



TIME = 18:19:42.84

ELAPSE TIME = 0.76 SECONDS FOR HISTOGRAM

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COST ESTIMATE

For the jobs listed on the Sample Input, the total running time was 118 seconds for the *contour* map and 168 seconds for the *conformant* map. At the current rate for computer time ($0.11/sec.) at The Pennsylvania State University, the chargeable time amounts are the following.

Charge to user = computer time + network overhead

= $12.98 + network over ad—*for the contour map*

= $18.48 + network overhead—*for the conformant map*

CONTENTS—SYMAP

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DESCRIPTIVE TITLE	Quick-Draw Graphics System
CALLING NAME	QDGS
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Jeff Raskin, The Pennsylvania State Univ. Computation Center; extended and revised by Graham Donaldson, The Pennsylvania State Univ. Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Daniel L. Bernitt, 105 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

QDGS is a set of FORTRAN subroutines that can be used to draw charts, graphs, diagrams, maps, or any other form of pictorial output. The graphic material is produced on the CalComp plotter and other graphic devices as they become available.

To use QDGS, a program is written in FORTRAN IV for the IBM System/360 computer. This program calls the QDGS subroutines; the subroutines produce output (in the form of cards or tape) that is later put into a special system to produce the actual graphical output. When the cards (or tape) are received from the dispatcher and the user has verified that the run was successful, he usually submits the cards to the dispatcher along with a plot request form.

The three concepts underlying the design of QDGS are (1) the description of an elementary picture in terms of coordinates, (2) the geometric transformation of pictures (into various positions and orientations), and (3) the building of complex pictures from elementary ones. There will be subroutines to do each of the three basic processes. In addition, there are special routines to draw axes for graphs and charts, to do lettering and numbering, and automatically to do the necessary task of punching the cards or

continued

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writing the tape used in plotting (physically drawing on the plotting device). QDGS is intended as a nucleus about which the user's graphic routines, tailored to his own unique application, can be written.

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USER INSTRUCTIONS

Initialization

Before any portion of the QDGS may be used by a program, four arrays must be specified. These arrays are used by the system as a working area and may not be used or altered in any way by the user's program. It is difficult to estimate the size of the arrays as space requirements vary widely with different program; however, the following declarations will do for many jobs. If the message LAVS EXHAUSTED appears, the 1000 may be increased.

```
REAL D(6,1000)
INTEGER * 2 A(1000), B(1000), C(1000)
```

Any FORTRAN variable names may be used for the A, B, C, and D. The first subscript of the D array must be 6. Once the arrays have been initialized, and before any other QDGS subroutines are called, the following statement must be used

```
CALL INITQ(A,B,C,D,1000)
```

Defining Elementary Pictures

Pictures are defined in Cartesian coordinates; however, with each point (x,y), we now associate a third coordinate z, which has a code for the condition of the plotter pen in *arriving* at the point (x,y). The convention used is to code z=0 to indicate "without drawing" and z=1 to indicate "drawing." The desired picture is achieved, therefore, by storing these ordered triples. This is the purpose of the ADPTQ subroutine (see Summary of Subroutines).

Building Pictures from Pictures

In the QDGS, pictures are formed out of line segments defined with ADPTQ and by transformed versions of pictures previously defined. A geometric transformation is applied to the previously defined picture before being placed into another picture. There are six basic transformations (and compounds of these) allowed by the QDGS:

(1) translation in X (TX)—motion of a figure horizontally

(2) translation in Y (TY)—motion of a figure vertically

(3) scaling in S (SX)—horizontal expansion or contraction

(4) scaling in Y (SY)—vertical expansion or contraction

(5) rotation (TH)—the TH is for theta, traditonally used to denote an angle—here measured *counterclockwise* in radians

continued

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(6) skew (or shear) (SK)—a tilting that leaves height unchanged, measure in radians clockwise from the positive Y direction

Transformations are represented by variables and must, therefore, be dimensioned (using 6 as the dimension); their values, however, are set by calling the subroutine XFSTQ. Compound and inverse transformations may be performed by using subroutines XFXFQ and XFINQ, respectively. Adding pictures (building more complex ones) can be achieved by using ADELQ, which also allows a picture to be transformed before being added to another picture.

Displaying a Completed Picture

Once a picture has been created and given a name, the card or tape output representing it may be obtained. Up to now, pictures have been described in terms of abstract coordinates, but the *physical* size is determined by a physical scale factor in the call to the outputting routine, subroutine DISPQ. The scale factor itself, however, is determined by the desired units of the user and the plotter's raster unit. (A raster unit is the smallest distance over which a line can be drawn by a particular device.)

Axes

A single subroutine, AXISQ, provides a logarithmic or linear axis with appropriate labeling of the tic marks as an option.

Drawing Labels and Titles

A legend on a graph or chart, the text that accompanies a drawing, sizes, tolerance, and the like are produced by subroutine LABLQ (for alphamerics) and NMBRQ (for numbers). A label is itself a picture and differs from other pictures only in that a subroutine sets up the picture automatically. The user transforms it to the desired size and position by using the same transformations as for any other picture.

REFERENCES

Primer on the Quick-Draw Graphics System (QDGS), Pa. State Univ. Computation Ctr. (July 1967).

Summary of Subroutines

Name	Form of Call	Meaning of Parameters		Purpose and/or Abilities
INITQ	CALL INITQ (A,B,C,D, 1000)	any FORTRAN variables names for A,B, C,D		initialization (required after declaring A,B,C,D)
ADPTQ	CALL ADPTQ (X,Y,Z, NAME)	X,Y: Z: NAME:	Cartesian coordinates; plotter per code name for picture	adds (stores) points to an elementary picture
XFSTQ	CALL XFSTQ (TX,TY,SX, SY,TH,SK,Q)	Q:	first six already described; transformation to be given the value	transforming routine (transformations performed in order SK,TH,SY,SX,TY,TX)
XFXFQ	CALL XFXFQ (S,Q,T)	Q,S: T:	two predfined transformations the new compound transformation of Q and S	allows compounding of transformations (Q performed first, then S)
XFINQ	CALL XFINQ (Q,QI)	Q: QI:	predefined transformation new, inverse transformations	creates inverse transformations
ADELQ	CALL ADELQ (N,Q,M)	N: Q: M:	picture to be added transformation to be applied to N new picture or picture to be built up	allows pictures of any structure depth to be created
DISPQ	CALL DISPQ (N,SCLF)	N: SCLF:	name of picture to be output scale factor for plotting	actual displaying routine; for various plotting devices

continued

Summary of Subroutines *(cont.)*

Name	Form of Call	Meaning of Parameters		Purpose and/or Abilities
AXISQ	CALL AXISQ (SIZE, K, TMIN, TINC,HITE,N, Q,M)	SIZE: K: TMIN: TINC: HITE: N: Q: M:	overall axis length number of segments value placed at first mark increment for each succeeding mark size of axis marks and numbers appearing with the axis number of digits to right of decimal point in numbers transformation to be applied to axis name of axis pictured	Sp,e options may be indicated by using each parameter. Minus signs before the values of SIZE,K, and HITE indicate axis suppression, logarithmic (rather than linear) scaling, and placement of numbers on the *other* side of an axis. If K is negative, TINC represents the constant ratio between marks rather than the linear increment; if N=-2, numbering is suppressed for the axis (TMIN and TINC are ignored)
LABLQ	CALL LABLQ (LABEL, LGTH,Q,M)	LABEL: LGTH: Q: M:	label (in quotes) number of characters transformation to be applied picture to which label is to be added	LABEL may be replaced by a variable representing alphanumeric data; a minus sign before LGTH indicates centering rather than left-justification
NMBRQ	CALL NMBRQ (R,N,IC, Q,M)	R: N: IC: Q,M:	real number desired number of digits behind decimal point position code same as above	N=-1 suppresses decimal IC=0 for centering, 1 for left-justification; R may have no more than 8 digits to the left and 7 digits to the right of the decimal point

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SAMPLE INPUT WITH CORRESPONDING OUTPUT

EXAMPLE OF A COMPLETE PROGRAM WITH OUTPUT

```
C       PROGRAM TO PRODUCE FIGURE 8 FOR THE QDGS PRIMER
C
C       INITIALIZATION
        INTEGER*2 A(1000),B(1000),C(1000)
        INTEGER M/0/
        REAL D(6,1000),Q(6),PI/3.141593/
        CALL INITQ(A,B,C,D,1000)
C
C       CREATE TRANSFORM FOR Y-AXIS
        CALL XFSTQ(0.0,-1.5,1.00,1.00,PI/2.0,0.0,Q)
C       PUT THE AXIS ONTO PICTURE M
        CALL AXISQ(3.0,6,-0.3,0.1,-0.08,1,Q,M)
C
C       CREATE TRANSFORM FOR THE X-AXIS AND ADD AXIS TO M
        CALL XFSTQ(0.0,0.0,1.00,1.00,0.0,0.0,Q)
        CALL AXISQ(3.0,-3,1.0,10.0,0.08,-1,Q,M)
C
C       PREPARE A TRANSFORM FOR THE LABEL
        CALL XFSTQ(1.5,-.75,.12,.13,0.,.3,Q)
C       ADD THE LABEL TO M
        CALL LABLQ('FIGURE 8',-8,Q,M)
C
C       DISPLAY THE COMPLETED FIGURE 8, SCALED FOR THE CALCOMP
        CALL DISPQ(M,200.0)
C
C       NOTE:  ALL OF THE ILLUSTRATIONS FOR THE QDGS PRIMER WERE
C       DRAWN ON THE CALCOMP PLOTTER.  ONLY THOSE GRAPHIC
C       SUBROUTINES MENTIONED IN THIS PRIMER WERE USED.
        STOP
        END
```

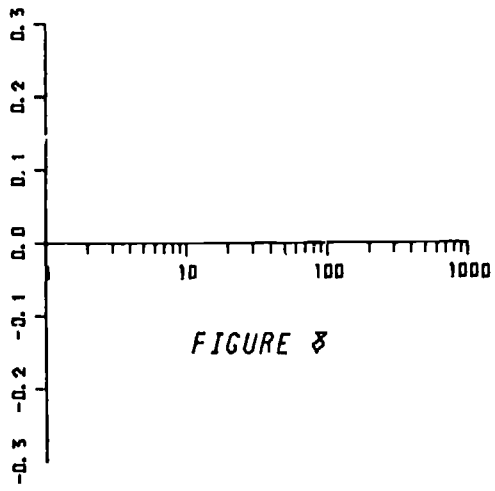

FIGURE 8

continued

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```
C         PROGRAM TO READ POINTS AND PLOT A GRAPH
C
C         ASSUME THE RANGES OF X AND Y ARE KNOWN
C         X: -5 TO +5      Y: -2 TO +2
C         AND THE (X,Y) PAIRS HAVE BEEN SORTED IN ORDER OF INCREASING X.
C         CALL THE GRAPH "GRAPH"
      INTEGER GRAPH/0/,PLUS/0/,INPUT/5/
C         INITIALIZE
      INTEGER*2 AA(1000),BB(1000),CC(1000)
      REAL DD(6,1000),PI/3.141593/,Q(6)
      CALL INITQ(AA,BB,CC,DD,1000)
C
C         PUT X-AXIS ON GRAPH
C         MAKE AXIS RUN FROM -5 TO +5 WITH 10 SEGMENTS, THUS 'SIZE' IS
C         10. AND 'K' IS 10. AXISO PROVIDES AN AXIS STARTING AT 0 AND
C         STRETCHING IN THE POSITIVE X-DIRECTION. THEREFORE, SET TX=-5.
C         IN ORDER TO START THIS AXIS AT -5. NUMBER EACH TIC MARK
C         STARTING WITH -5 AT THE LEFT END AND INCREMENTING BY 1.
C         SUPPRESS THE DECIMAL POINT('N'=-1) AND MAKE THE DIGITS .1 UNIT
C         HIGH('HITE'=.1).
      CALL XFSTQ(-5.,0.,1.,1.,0.,0.,Q)
      CALL AXISQ(10.,10 , -5.,1.,.1,-1,Q,GRAPH)
C         LABEL X-AXIS
C         MAKE LETTERS .1 HIGH TO MATCH NUMBERS. USE N=-10 TO CENTRE
C         LABEL AT (4.,-.5)
      CALL XFSTQ(4 ,-.5,.1,.1,0.,0.,Q)
      CALL LABLQ('X-VARIABLE',-10,Q,GRAPH)
C         PUT Y-AXIS ON GRAPH
C         USE 'SIZE'=4. THIS GIVES AN AXIS FROM 0 TO 4 IN X-DIRECTION.
C         ROTATE BY PI/2 FOR AXIS FROM 0 TO 4  IN Y-DIRECTION. TRANSLATE
C         BY -2. FOR AXIS FROM -2 TO +2 IN Y-DIRECTION. NUMBER TIC MARKS
C         AS BEFORE BUT USE 'HITE'=-.1 TO PUT TIC MARKS AND NUMBERS
C         ON THE OTHER SIDE.
      CALL XFSTQ(0.,-2.,1.,1.,PI/2.,0.,Q)
      CALL AXISQ(4.,4,-2.,1.,-.1,-1,Q,GRAPH)
C         LABEL Y-AXIS
C         MAKE LETTERS .1 HIGH TO MATCH NUMBERS. USE N=-10 TO CENTRE
C         LABEL AT (-.4,1.)
      CALL XFSTQ(-.4,1.,.1,.1,PI/2.,0.,Q)
      CALL LABLQ('Y-VARIABLE',-10,Q,GRAPH)
C         IF DATA POINTS ARE TO BE DENOTED BY A SPECIAL SYMBOL,
C         CREATE IT NOW,E.G.,A PLUS SIGN CALLED "PLUS"
C         MAKE IT SO THAT THE PEN IS BACK AT THE STARTING POINT AFTER
C         DRAWING IT. ALSO MAKE IT A STANDARD SIZE(1 BY 1).
      CALL ADPTQ(-.5,0.,0,PLUS)
      CALL ADPTQ(.5,0.,1,PLUS)
      CALL ADPTQ(0.,-.5,0,PLUS)
      CALL ADPTQ(0.,.5,1,PLUS)
      CALL ADPTQ(0.,0.,0,PLUS)
C
C         MOVE PEN TO FIRST DATA POINT WITHOUT DRAWING A LINE.
      READ(INPUT,2,END=4) X,Y
    2 FORMAT(2F10.2)
      CALL ADPTQ(X,Y,0,GRAPH)
C         OMIT NEXT SET OF STATEMENTS IF NO SPECIAL SYMBOL IS TO BE
C         PLACED AT THIS POINT.
C         MAKE PLUS SIGN .1 UNIT SQUARE ON GRAPH,PLACED AT (X,Y)
      CALL XFSTQ(X,Y,.1,.1,0.,0.,Q)
      CALL ADELQ(PLUS,Q,GRAPH)
C         READ DATA POINTS AND PUT ON GRAPH
    3 READ(INPUT,2,END=4) X,Y
C         OMIT NEXT STATEMENT IF POINTS ARE NOT TO BE JOINED BY A LINE
      CALL ADPTQ(X,Y,1,GRAPH)
C         OMIT NEXT SET OF STATEMENTS IF NO SPECIAL SYMBOL IS TO BE
C         PLACED AT EACH POINT.
      CALL XFSTQ(X,Y,.1,.1,0.,0.,Q)
      CALL ADELQ(PLUS,Q,GRAPH)
C         (X,Y) HAS NOW BEEN ADDED TO GRAPH
      GO TO 3
C
    4 CONTINUE
C         GRAPH IS COMPLETED. CHOOSE SCALEFACTOR AND DISPLAY IT.
      CALL DISPQ(GRAPH,200.)
      STOP
      END
```

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COST ESTIMATE

For the jobs listed as the Sample Input, no exact timing figures were available. However, none of the included examples would require more than 15 seconds of computer time to run. At the current rate of charge at The Pennsylvania State University ($0.11/sec.), this amounts to a maximum of $1.65 per example.

Approximate charge to user = $1.65 (maximum) X number of examples
+ network overhead

CONTENTS—QDGS

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DESCRIPTIVE TITLE	Key Grapheme in Context
CALLING NAME	KGIC
INSTALLATION NAME	Washington University Computing Facilities
AUTHOR(S) AND AFFILIATION(S)	Joel Achtenberg Computing Facilities Washington University
LANGUAGE	PL/I
COMPUTER	S/360 under OS
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	J. Philip Miller, Computing Facilities, Washington University, St. Louis, Mo. 63130 Tel.: (314) 863-0100 ext. 4041

FUNCTIONAL ABSTRACT

The KGIC program was written to facilitate the analysis of the environmental distribution of graphic characters. It produces a KWIC-like listing of all occurrences of a given grapheme along with the graphic environment in which each instance appeared. The listing may be sorted either forward or backward from the key grapheme to facilitate inspection. Provision is made for specification by the user of special alphabets for foreign languages or for phonemic transcriptions.

If any word appears more than once in the data to be processed, only one set or records will be produced for that word. A counter will be increased and the frequency of occurrence printed in both the alphabetical listing and in the KGIC listing. The alpha listing thus will contain a complete frequency count of the corpus under consideration.

It should be noted that whenever the user can attribute phonetic or phonemic status to individual graphemes, the KGIC listing provides correspondingly significant information about phonetic and/or phonemic environments.

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The program produces the items listed below as output.

1. an alphabetical listing of all words processed by the KGIC program, along with their absolute and relative frequencies of occurrence,

2. the KGIC listing itself grouped by alphabetical character, with the absolute frequency of occurrence given for each unique occurrence, and the total number of occurrences and the total number of unique occurrences given for each character,

3. a summary table containing the absolute and relative frequencies of occurrence for both the total number of occurrences and for the total of unique occurences,

4. optionally, a horizontal bar graph of the relative frequencies of all occurrences of each grapheme,

5. a number of summary statistics, i.e.,

   a) total number of words processed, i.e., tokens
   b) average length of word
   c) total number of unique words, i.e., types
   d) the type/token ratio
   e) total number of characters processed
   f) total number of unique occurrences of all characters

6. a statement of all program options used in a particular run, and a complete listing of the EMICTT, defining the alphabet in use for that run.

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USER INSTRUCTIONS

A number of the run-time options are available. One or more options may be selected by including the appropriate information in the data set OPTIN. For each available option, except TITLE, a default is indicated which will apply if the given option is not specified. Two or more options are separated by commas, and the final option is followed by a semicolon.

1. TITLE

   The user must specify a project title to be used in the headings of certain parts of the program output. The title must be no longer than 80 characters, including blanks, and must be enclosed within single quote marks, as follows,

   TITLE = 'users project title'

2. SORT

   As indicated previously, the KGIC listing can be sorted either forward or backward from the key character. Merely code BACKWARD or FORWARD, as follows,

   SORT = 'BACKWARD'
   'FORWARD'

   If SORT is not specified, the list is alphabetized forward by default.

3. GRAPHX

   A horizontal bar graph displaying graphically the frequency of occurrence of each grapheme which appeared in the data may be produced. Code,

   GRAPHX ='YES'
   'NO'

   The default option bypasses graphing.

4. SPACING

   To indicate desired spacing of the alpha and KGIC listings, merely code

   SPACING = n

   where n is the number of lines skipped after printing. Default is 1 (i.e., single spacing).

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5. EMICTT

Because the program is designed for graphic analysis of foreign languages as well as English, provision has been made for the specification of special alphabets designed by the user for foreign languages or for phonetic transcription. Such specification is done through the Expanded Master Input Character Translate Table (EMICTT), which consists of two major parts. The first, MICTT, specifies the use to be made of each of the 256 characters recognized by the 360. The codes employed are as follows.

1 = Ignore, not used as print.

2 = Delimiter for ID fields, comments, titles, and other information to be ignored in processing.

3 = Space.

4 = Character to be considered part of the alphabet in use.

If any character other than 1 to 4 is coded, the improper code will be replaced by code 4, and an error message produced.

The second part of EMICTT specifies the character(s) to be produced on output for each character designated as part of the alphabet (i.e., those coded '4'). There are two possibilities. First, each character can be represented by a single character from the S/360 TN train, or other available print train. Second, for additional flexibility, two characters may be overprinted to yield a composite character. For example, the break character (_') might be used to distinguish low toned vowels from other vowels. In either case, printing is determined by specification of the appropriate character in either PRT(1), for base characters, or PRT(2), for overprinted characters.

For both MICTT and PRT(1) and PRT(2), default values specified are for the standard English (ROMAN) alphabet, as given in Appendix A. Changes are made in MICTT by coding as follows,

MICTT (xxx) = n

continued

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where xxx is the decimal number from 1 to 255 specifying the internal character under consideration, and n is the usage code (1–4). Changes are made in the print routine by coding

PRT(i, xxx) = 'c'

where xxx is the decimal number from 1 to 255, i designates the portion of PRT involved (i.e., 1 = base character, 2 = overprint), and c is the punched code for the desired print character.

Note that hex zero is a reserved character used in the production of the alpha listing. Attempts to change MICTT (0) or PRT(i,0) will be ignored and an error message produced.

Multiple changes in PRT and MICTT can be made by separating them by commas.

For example, to treat the hyphen (-) and the apostrophe (') as characters to be ignored rather than part of the alphabet, code as follows,

```
MICTT(96)  = 1, PRT(1,96) = '',
MICTT(125) = 1, PRT(1,125) = '',
```

A modification of EMICTT for use with a phonemic transcription of the Mayan Language is shown in Appendix B. Upper-case consonants are used for glottalized sounds. High-, mid-, and low-toned vowels are represented by upper-case, lower-case and underlined lower-case vowels respectively.

Description of Input

Input consists of two files, one carrying the run-time program options (OPTIN), and the other carrying the data itself (SYSIN).

File OPTIN consists of one or more cards containing the user-specified project title and one or more program options, or none at all. The title and each of the program options are separated from each other by commas, and the final option is followed by a semicolon. If no program options are specified the title must be followed by a semicolon.

continued

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A typical example might be as follows,

```
//GO.OPTIN DD *
TITLE = 'MAYAN PROJECT', SPACING = 2
GRAPHX = 'YES';
/*
```

File SYSIN carries the data to be analyzed. The input stream may contain any acceptable 8-bit code except 0000000 (hex 00) which is reserved for internal use. For example,

```
//GO.SYSIN DD *
THIS IS A SAMPLE OF INPUT DATA.  DEFAULT VALUES OF
MICTT WILL IGNORE PUNCTUATION AND BYPASS ALL CHARAC-
TERS BETWEEN PARENTHESES.  FOR EXAMPLE (TITLE IS
"SAMPLE DATA") WILL BE IGNORED.
/*
```

Running Instructions

The KGIC load module is contained in a partitioned data set DS09810.JALIB, stored in disk, and can thus be executed directly without compilation. In addition to the data input file, SYSIN, and the program options file, OPTIN, the program requires three work files for the SORT routine and the file SYSPRINT which contains the program output.

The JCL for a typical run is illustrated below. This is only an illustration, however, and must be adapted to the user's specifications.

```
---current OS JOB card---
//JOBLIB DD DSNAME=DS09810.JALIB,DISP=SHR
//  EXEC  PGM=KGIC
//SORTWK01 DD UNIT=SYSDA,SPACE=(TRK,500,,CONTIG)
//SORTWK02 DD UNIT=(SYSDA,SEP=SORTWK01),SPACE=(TRK,500,,CONTIG)
//SORTWK03 DD UNIT=(SYSDA,SEP=(SORTWK02,SORTWK01)),
//                SPACE=(TRK,500,,CONTIG)
//SYSOUT DD SYSOUT=A
//SORTLIB DD DSNAME=SYS1.SORTLIB,DISP=SHR
//SYSLIN DD UNIT=SYSDA,SPACE=(TRK,(10,10))
//SYSUTI DD UNIT=SYSDA,SPACE=(TRK,(10,10))
//SYSPRINT DD SYSOUT=A   CONTAINS THE PROGRAM OUTPUT
//SYSIN    DD UNIT=TAPE9,DISP=(OLD,KEEP) CONTAINS INPUT DATA
//OPTIN    DD *
---One of more cards with program options and project title---
/*
```

continued

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Appendix A: Default values for EMICTT

EXPANDED MASTER INPUT CHARACTER TRANSLATE TABLE

DEC	CODE	PRT(1)	PRT(2)	DEC	CODE	PRT(1)	PRT(2)
0	1			41	1		
1	1			42	1		
2	1			43	1		
3	1			44	1		
4	1			45	1		
5	1			46	1		
6	1			47	1		
7	1			48	1		
8	1			49	1		
9	1			50	1		
10	1			51	1		
11	1			52	1		
12	1			53	1		
13	1			54	1		
14	1			55	1		
15	1			56	1		
16	1			57	1		
17	1			58	1		
18	1			59	1		
19	1			60	1		
20	1			61	1		
21	1			62	1		
22	1			63	1		
23	1			64	3		
24	1			65	1		
25	1			66	1		
26	1			67	1		
27	1			68	1		
28	1			69	1		
29	1			70	1		
30	1			71	1		
31	1			72	1		
32	1			73	1		
33	1			74	1		
34	1			75	1		
35	1			76	2		
36	1			77	1		
37	1			78	1		
38	1			79	1		
39	1			80	1		
40	1						

continued

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DEC	CODE	PRT(1)	PRT(2)
81	1		
82	1		
83	1		
84	1		
85	1		
86	1		
87	1		
88	1		
89	1		
90	1		
91	2		
92	1		
93	1		
94	1		
95	1		
96	4	-	
97	1		
98	1		
99	1		
100	1		
101	1		
102	1		
103	1		
104	1		
105	1		
106	1		
107	1		
108	1		
109	4	—	
110	2		
111	1		
112	1		
113	1		
114	1		
115	1		
116	1		
117	1		
118	1		
119	1		
120	1		
121	1		
122	1		
123	1		
124	1		
125	4	'	

DEC	CODE	PRT(1)	PRT(2)
126	1		
127	1		
128	1		
129	4	a	
130	4	b	
131	4	c	
132	4	d	
133	4	e	
134	4	f	
135	4	g	
136	4	h	
137	4	i	
138	1		
139	2		
140	1		
141	1		
142	1		
143	1		
144	1		
145	4	j	
146	4	k	
147	4	l	
148	4	m	
149	4	n	
150	4	o	
151	4	p	
152	4	q	
153	4	r	
154	1		
155	2		
156	1		
157	1		
158	1		
159	1		
160	1		
161	1		
162	4	s	
163	4	t	
164	4	u	
165	4	v	
166	4	w	
167	4	x	
168	4	y	
169	4	z	
170	1		

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continued

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DEC	CODE	PRT(1)	PRT(2)
171	1		
172	1		
173	1		
174	1		
175	1		
176	1		
177	1		
178	1		
179	1		
180	1		
181	1		
182	1		
183	1		
184	1		
185	1		
186	1		
187	1		
188	1		
189	1		
190	1		
191	1		
192	1		
193	4	A	
194	4	B	
195	4	C	
196	4	D	
197	4	E	
198	4	F	
199	4	G	
200	4	H	
201	4	I	
202	1		
203	1		
204	1		
205	1		
206	1		
207	1		
208	1		
209	4	J	
210	4	K	
211	4	L	
212	4	M	
213	4	N	
214	4	O	
215	4	P	

DEC	CODE	PRT(1)	PRT(2)
216	4	Q	
217	4	R	
218	1		
219	1		
220	1		
221	1		
222	1		
223	1		
224	1		
225	1		
226	4	S	
227	4	T	
228	4	U	
229	4	V	
230	4	W	
231	4	X	
232	4	Y	
233	4	Z	
234	1		
235	1		
236	1		
237	1		
238	1		
239	1		
240	4	0	
241	4	1	
242	4	2	
243	4	3	
244	4	4	
245	4	5	
246	4	6	
247	4	7	
248	4	8	
249	4	9	
250	1		
251	1		
252	1		
253	1		
254	1		
255	1		

continued

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Appendix B: EMICTT for a Mayan Language Project

EXPANDED MASTER INPUT CHARACTER TRANSLATE TABLE

DEC	CODE	PRT(1)	PRT(2)
0	1		
1	4	'	
2	4	b	
3	4	z	
4	4	Z	
5	4	c	
6	4	C	
7	4	h	
8	4	k	
9	4	K	
10	4	l	
11	4	m	
12	4	n	
13	4	p	
14	4	P	
15	4	s	
16	4	x	
17	4	t	
18	4	T	
19	4	w	
20	4	y	
21	4	A	
22	4	a	
23	4	a	
24	4	E	–
25	4	e	
26	4	e	–
27	4	I	
28	4	i	
29	4	i	–
30	4	O	
31	4	o	
32	4	o	–
33	4	U	
34	4	u	
35	4	u	–

Characters 36-255 are not used and are coded 1, with PRT(1) and PRT(2) null.

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SAMPLE INPUT

Input for the sample program consists of a data stream that is not keypunchable. However, it is similar in content to the sample given in the Description of Input section of the User Instructions.

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SAMPLE OUTPUT

ALPHA LISTING OF INPUT ITEMS

```
A
ALL
AND
BE
BETWEEN
CAUSE
CHARACTERS
DATA
DEFAULT
DELIMITERS
EXAMPLE
FOR
IGNORED
INPUT
IS
KGIC
MARKS
MICTT
OF
PARAGRAPH
PROGRAM
PROVIDED
PUNCTUATION
SAMPLE
TABLE
THE
THIS
TITLE
TO
VALUES
WILL
```

TYPES= 31

TOKENS= 43

KGIC: KEY GRAPHEME IN CONTEXT LISTING

A TYPICAL KGIC RUN WITH ENGLISH DATA

```
>>>>>>>>>>>>>>>>>>>>>>>A<<<<<<<<<<<<<<<<<<<<<<<
                      A                          1
                   DATA                          2
                  TABLE                          1
             CHARACTERS                          1
              PARAGRAPH                          1
                    ALL                          2
                 VALUES                          1
              PROGRAM                            1
                 SAMPLE                          2
                EXAMPLE                          1
                    AND                          1
            PARAGRAPH                            1
            CHARACTERS                           1
             PARAGRAPH                           1
                 MARKS                           1
                  DATA                           2
            PUNCTUATION                          1
               DEFAULT                           1
                 CAUSE                           1
THERE ARE A TOTAL OF     23 OCCURRANCES OF GRAPHEME A
THERE ARE     19 UNIQUE OCCURRANCES OF GRAPHEME A
```

continued

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```
>>>>>>>>>>>>>>>>>>>>>>>>B<<<<<<<<<<<<<<<<<<<<<<<<
                        BE                                  2
                        BETWEEN                             1
                      TABLE                                 1
0
1   THERE ARE A TOTAL OF      4 OCCURRANCES OF GRAPHEME b
2   THERE ARE      3 UNIQUE OCCURRANCES OF GRAPHEME B
1
2
1   >>>>>>>>>>>>>>>>>>>>>>>>C<<<<<<<<<<<<<<<<<<<<<<<<
1                       KGIC                                1
1                          CAUSE                            1
2                          CHARACTERS                       1
1                    CHARACTERS                             1
1                       MICTT                               1
1                      PUNCTUATION                          1
2
2   THERE ARE A TOTAL OF      6 OCCURRANCES OF GRAPHEME C
1   THERE ARE      6 UNIQUE OCCURRANCES OF GRAPHEME C
2
1   >>>>>>>>>>>>>>>>>>>>>>>>D<<<<<<<<<<<<<<<<<<<<<<<<
1                        AND                                1
2                    IGNORED                                2
1                   PROVIDED                                1
1                         DATA                              2
1                     PROVIDED                              1
1                         DEFAULT                           1
2                         DELIMITERS                        1
1
2   THERE ARE A TOTAL OF      9 OCCURRANCES OF GRAPHEME D
2   THERE ARE      7 UNIQUE OCCURRANCES OF GRAPHEME D
1
2   >>>>>>>>>>>>>>>>>>>>>>>>E<<<<<<<<<<<<<<<<<<<<<<<<
1
2
1
2                        BE                                 2
                        THE                                 2
                      CAUSE                                 1
                      TABLE                                 1
                      TITLE                                 1
                     SAMPLE                                 2
                    EXAMPLE                                 1
                     IGNORED                                2
                    PROVIDED                                1
                       BETWEEN                              1
                          DEFAULT                           1
                          DELIMITERS                        1
                     BETWEEN                                1
                   CHARACTERS                               1
                   DELIMITERS                               1
                      VALUES                                1
                          BETWEEN                           1
                           EXAMPLE                          1
THERE ARE A TOTAL OF      22 OCCURRANCES OF GRAPHEME E
THERE ARE      18 UNIQUE OCCURRANCES OF GRAPHEME E

>>>>>>>>>>>>>>>>>>>>>>>>F<<<<<<<<<<<<<<<<<<<<<<<<
                        OF                                  2
                       DEFAULT                              1
                         FOR                                2
THERE ARE A TOTAL OF      5 OCCURRANCES OF GRAPHEME F
THERE ARE      3 UNIQUE OCCURRANCES OF GRAPHEME F

>>>>>>>>>>>>>>>>>>>>>>>>G<<<<<<<<<<<<<<<<<<<<<<<<
                        KGIC                                1
                        IGNORED                             2
                      PROGRAM                               1
                     PARAGRAPH                              1
THERE ARE A TOTAL OF      5 OCCURRANCES OF GRAPHEME G
THERE ARE      4 UNIQUE OCCURRANCES OF GRAPHEME G
```

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continued

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```
>>>>>>>>>>>>>>>>>>>>>>>H<<<<<<<<<<<<<<<<<<<<<<<<
                    PARAGRAPH                          1
                          CHARACTERS                   1
                          THE                          2
                          THIS                         2
THERE ARE A TOTAL OF      6 OCCURRANCES OF GRAPHEME H
THERE ARE      4 UNIQUE OCCURRANCES OF GRAPHEME H
```

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A FEW STATISTICS

TOTAL NUMBER OF WORDS PROCESSED(TOKENS) IS 43

NUMBER OF DIFFERENT WORDS(TYPES) IS 31

TYPE/TOKEN RATIO IS 0.721

TOTAL NUMBER OF CHARACTERS PROCESSED IS 204

TOTAL NUMBER OF UNIQUE OCCURRENCES OF ALL CHARACTERS IS 162

AVERAGE LENGTH OF WORD IS 4.744

FREQUENCIES OF OCCURRANCE OF EACH GRAPHEME

	ALL OCCURRENCES		UNIQUE OCCURRENCES	
GRAPHEME	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE
-	0	0.000	0	0.000
_	0	0.000	0	0.000
'	0	0.000	0	0.000
a	0	0.000	0	0.000
b	0	0.000	0	0.000
c	0	0.000	0	0.000
d	0	0.000	0	0.000
e	0	0.000	0	0.000
f	0	0.000	0	0.000
g	0	0.000	0	0.000
h	0	0.000	0	0.000
i	0	0.000	0	0.000
j	0	0.000	0	0.000
k	0	0.000	0	0.000
l	0	0.000	0	0.000
m	0	0.000	0	0.000
n	0	0.000	0	0.000
o	0	0.000	0	0.000
p	0	0.000	0	0.000
q	0	0.000	0	0.000
r	0	0.000	0	0.000
s	0	0.000	0	0.000
t	0	0.000	0	0.000
u	0	0.000	0	0.000
v	0	0.000	0	0.000
w	0	0.000	0	0.000
x	0	0.000	0	0.000
y	0	0.000	0	0.000
z	0	0.000	0	0.000
A	23	0.113	19	0.117
B	4	0.020	3	0.019
C	6	0.029	6	0.037
D	9	0.044	7	0.043
E	22	0.108	18	0.111
F	5	0.025	3	0.019
G	5	0.025	4	0.025
H	6	0.029	4	0.025
I	16	0.078	12	0.074
J	0	0.000	0	0.000
K	2	0.010	2	0.012

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continued

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L	16	0.078	11	0.068
M	7	0.034	6	0.037
N	7	0.034	6	0.037
O	11	0.054	7	0.043
P	9	0.044	8	0.049
Q	0	0.000	0	0.000
R	13	0.064	11	0.068
S	11	0.054	8	0.049
T	20	0.098	16	0.099
U	6	0.029	6	0.037
V	2	0.010	2	0.012
W	3	0.015	2	0.012
X	1	0.005	1	0.006
Y	0	0.000	0	0.000
Z	0	0.000	0	0.000
0	0	0.000	0	0.000
1	0	0.000	0	0.000
2	0	0.000	0	0.000
3	0	0.000	0	0.000
4	0	0.000	0	0.000
5	0	0.000	0	0.000
6	0	0.000	0	0.000
7	0	0.000	0	0.000
8	0	0.000	0	0.000
9	0	0.000	0	0.000

continued

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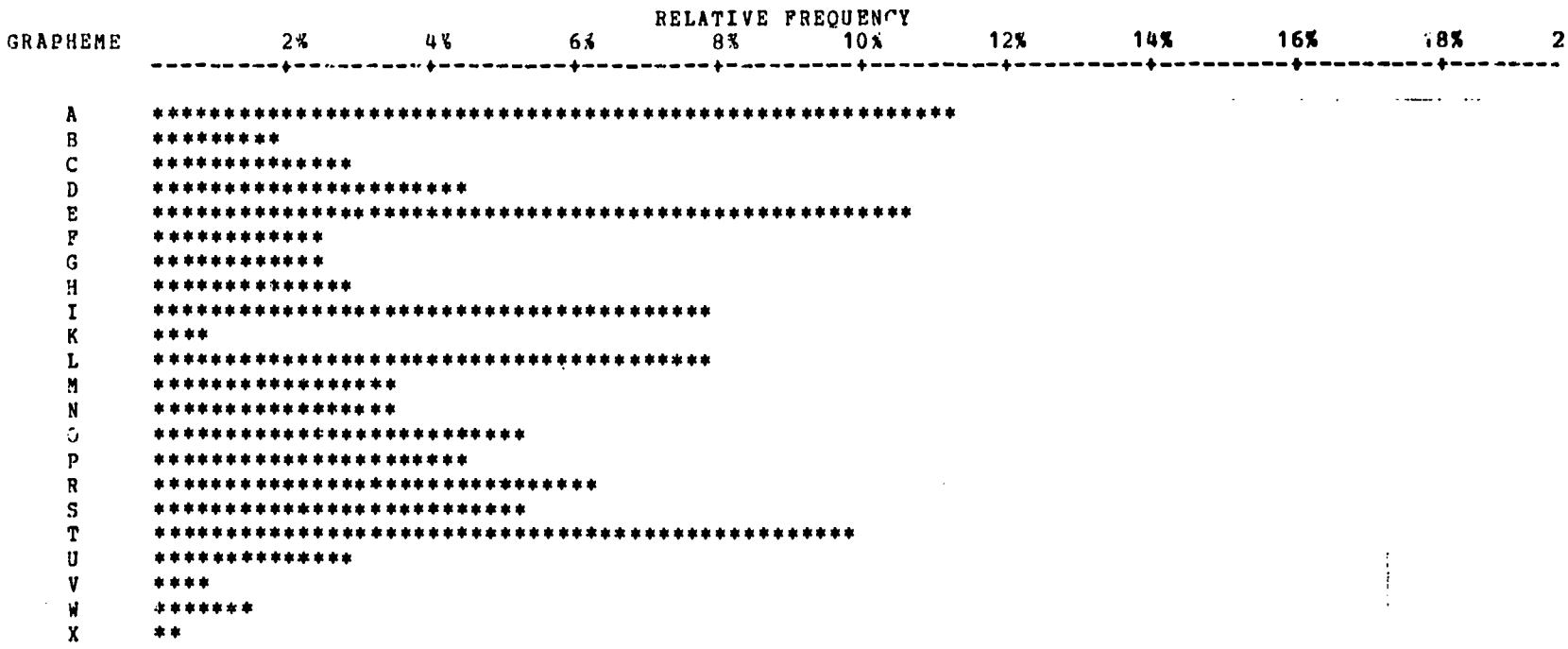
A TYPICAL KGIC RUN WITH ENGLISH DATA

FREQUENCY OF OCCURRANCE OF EACH GRAPHEME



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COST ESTIMATE

The computer costs for running the problem listed on the Sample Input were $3.30.

Charge to user = computer costs + network overhead
= $3.30 + network overhead

CONTENTS—KGIC

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DESCRIPTIVE TITLE	PL/I–FORMAC Interpreter
CALLING NAME	FORMAC
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	R. Tobey J. Baker R. Crews P. Marks K. Victor International Business Machines Corporation
LANGUAGE	PL/I–FORMAC
COMPUTER	IBM 360/67
PROGRAM AVAILABILITY	Source code available on tape
CONTACT	Dr. Daniel Bernitt, EIN Technical Representative, Computation Center, 105 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

FORMAC is a system for carrying out formal manipulations on mathematical expressions. This allows for the use of analytic as well as numeric techniques. The most important capability of FORMAC is its accommodation of mathematical expressions as symbolic entities at execution time. For example, the execution of the FORMAC program segment

```
LET( A = X + Y ** 2;
     B = 2;
     C = A/B + 2.8);
```

may be interpreted as assigning the alphanumeric value $(X+Y^2)/2 + 2.8$ to the FORMAC variable C.

FORMAC enables the user to analyze expressions by identifying coefficients, common denominators, lead operators, and some characteristics of the operands. Constants can be factored, left in a rational form, or converted to real notation. New expressions can be synthesized by the simplification, expansion and substitution of

continued

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terms, as well as finding the derivatives of functions. The user can specify functions completely or partially in addition to making use of the PL/I functions. Procedures are available for transfering arguments between PL/I and FORMAC program segments.

REFERENCES

Tobey, R., Baker, J., Crews, R., Marks, P., Victor, K., "PL/I-FORMAC Interpreter User's Reference Manual," IBM Publ. 360D 03.3.004 (1967). Copies of the User's Manual will be available through The Pennsylvania State University Computation Center to any user with a PSU account number.

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USER INSTRUCTIONS

The user should consult the reference listed.

FORMAC constants can be integer, floating-point, rational, or systems constants such as e, π, and i. Note that this latter constant enables FORMAC to handle imaginary expressions. FORMAC variables take on expressions as values that are retained as symbolic entities. Variables are either assigned or atomic—i.e., specified or unspecified. Expressions in FORMAC are written in essentially the same way as PL/I expressions but, whereas the latter evaluate to numbers, FORMAC expressions generally evaluate to new FORMAC expressions. There are four types of FORMAC functions: PL/I-like functions (such as SIN and COS), integer-valued functions (such as factorials and combinational expressions), user-defined functions, and function variables (unspecified functions). Functions with arguments that evaluate to constants can be either evaluated or retained as symbolic entities, at the user's option.

Program Deck

JOB-Control Language Statements and End-of-File Cards must begin in Col. 1; for FORMAC-PL/I statements, only Cols. 2–72 are used.

JOB Card will be punched by The Pennsylvania State University Computation Center personnel.

EXEC Card

Columns	*Contents*
1– 2	//
4– 7	EXEC
9–21	LIBRARY,PROG=
22–27	FORMAC

Data Card

Columns	*Contents*
1–17	//DATA.INPUT DD *

Program Deck

```
JOB Card
EXEC Card
Data Card
    ⋮
Program Deck
    ⋮
/*
```

continued

000 0050

REFERENCES

Tobey, R., Baker, J., Crews, R., Marks, P., Victor, K., "PL/I-FORMAC Interpreter User's Reference Manual," IBM Publ. 360D 03.3.004 (1967). Copies of the User's Manual will be available through The Pennsylvania State University Computation Center to any user with a PSU account number.

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SAMPLE INPUT

```
//AA112345 JOB 'S4002,R=600,T=60,EMAC','KNUBLE H'
// EXEC LIBRARY,PROG=EMACUT
//DATA.INPUT DD *
'OPTSET(LINELENGTH=SHORT)'
'COMMENT        IN THE FOLLOWING EXAMPLES "STRING=" INDICATES THE INPUT. '
'COMMENTSTRING:  THE UNDERLINED TWO-DIMENSIONAL EDITED OUTPUT IS THE'
'COMMENTRESULT OF PROCESSING BY THE INTERPRETATIVE FORMAC SYSTEM.'
'PAGE'
'COMMENT        GENERAL EXAMPLE.'
      'A = (X**2 + 7/3)**P'
      'B = 3*SIN(A+1) + .3E-4*LOG(COS(Y))'
'COMMENT   UNSPECIFIED FUNCTIONS AND DERIVATIVES.'
      'A = F.(3*X**2) + LOG(X)'
      'B = DERIV(A,X,2)'
      'C = DERIV(ATANH(X**2) + X.X)'
      'D = DRV(H.(U,V,W).*(1),3, *(2),2, *(3),2)'
'COMMENT   TRANS OPTION FOR TRANCENDENTAL FUNCTION EVALUATION.
'OPTSET(NOTRANS)'
      'A = 1/3'
      'B = SIN(X**4) + LOG(2*A) + SIN(PI//)'
'OPTSET(TRANS)'
      'C = B'
'COMMENT   INT OPTION FOR COMBINATIONS, FACTORIAL, AND EVAL CAPABILITY.'
'OPTSET(NOINT)'
      'Y = COMB(N,K-1) + COMB(N,K)'
      'A = EVAL(Y,N,5,K,3)'
'OPTSET(INT)'
      'B = EVAL(Y,N,5,K,3)'
'COMMENT   FUNCTION DEFINITION AND EXPANSION APPLYING MULT. AND DIST. LAWS'
      'FNC(G) = *(1) + 2*SIN(*(2))'
      'P = G(X**2+1,7)'
      'A = (X+4)**2 + 3*(2*X+7) * (7-3)'
      'B = EXPAND(A)'
'COMMENT   COMMON DENOM., NUM, DENOM, LOW AND HIGH POWER, AND COEFF'
      'A = X/7 + 7 + X/W'
      'B = CODEM(A)'
      'Y = (7*X**5 + 7/3*X**3)/(SIN(X) + COS(X))'
      'A=NUM(Y)'  'B = DENOM(Y)'  'C = HIGHPOW(A,X)'  'D = LOWPOW(A,X)'
      'E = COEFF(A,X**5)'
'COMMENT   EDIT FEATURE.'
      'A = C1 + C2*X + C3*X**2'
'OPTSET(NOEDIT)'
      'C = A'
'COMMENT   INTEGER AND RATIONAL CONSTANTS MAY BE DEVELOPED OR SPECIFIED'
'COMMENTWITH AS MANY AS 2295 SIGNIFICANT DIGITS.'
      'Y = 1167271348795/5 * X**174'
      'A = DERIV(Y,X,5)'
      'B = EVAL(A,X,2+11/12)'
'COMMENT   Y=0: X<-1, X>1:  Y=1: -1.=X<0: Y=COS(X): 0<=X<1.'
      'Y = STEP(-1,X,0) + STEP(0,X,1) * COS(X)'
/*
```

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SAMPLE OUTPUT

```
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1917....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JCB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JGB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA
HASP-II***HASP-II***HASP-II***..........START JOB 1817....AA112345......KNOBLE H.......................***HASP-II***HASP-II***  OR=AA

TIMF: 14:35:34  CATE: 01/21/70             H A S P   S Y S T E M   L O G


//AA112345 JOB 'S4002,R=6CC,T=60,FMAC','KNOBLE H'


STRING='OPTSET(LINELENGTH=SHORT)';
LINELENGTH=  64
          IN THE FOLLOWING EXAMPLES "STRING=" INDICATES THE INPUT
STRING;  THE UNDERLINED TWO-DIMENSIONAL EDITED OUTPUT IS THE
RESULT OF PROCESSING BY THE INTERPRETATIVE FORMAC SYSTEM.
```

continued

GENERAL EXAMPLE.

```
STRING='A = (X**2 + 7/3)*#P';
A = #P ( X^2 + 7/3 )
--------------------

STRING='B = 3*SIN(A+1) + .3E-4*LOG(COS(Y))';
B = .3E-04 LN ( COS ( Y ) ) + 3 SIN ( #P ( X^2 + 7/3 ) + 1 )
------------------------------------------------------------
```

UNSPECIFIED FUNCTIONS AND DERIVATIVES.

← abstract functions F(x) is represented as F.(x)

```
STRING='A = F.(3*X**2) + LOG(X)';
A = F.( 3 X^2 ) + LN ( X )
--------------------------

STRING='B = DERIV(A,X,2)';
B = 36 F^(2).( 3 X^2 ) X^2 - 1 / X^2 + 6 F^(1).( 3 X^2 )
--------------------------------------------------------

STRING='C = DERIV(ATANH(X**2) + X,X)';
C = 2 X / ( - X^4 + 1 ) + 1
---------------------------

STRING='D = DRV(H.(U,V,W),$(1),3, $(2),2, $(3),2)';
D = H^(1 3 2 2 3 ).( U, V, W )
------------------------------
```

TRANS OPTION FOR TRANCENDENTAL FUNCTION EVALUATION.

```
STRING='OPTSET(NOTRANS)';
OPTSET(NOTRANS)

STRING='A = 1/3';
A = 1/3
-------

STRING='B = SIN(X**4) + LOG(2*A) + SIN(#P/6)';
B = LN ( 2/3 ) + SIN ( 1/6 #P ) + SIN ( X^4 )
---------------------------------------------

STRING='OPTSET(TRANS)';
OPTSET(TRANS)

STRING='C = B';

C = SIN ( X^4 ) + .09453489
---------------------------
```

INT OPTION FOR COMBINATIONS, FACTORIAL, AND EVAL CAPABILITY.

```
STRING='OPTSET(NOINT)';
OPTSET(NOINT)

STRING='Y = COMB(N,K-1) + COMB(N,K)';
Y = ( N; K ) + ( N; K - 1 )
---------------------------
```

continued

```
STRING='A = EVAL(Y,N,5,K,3)';
A = ( 5; 2 ) + ( 5; 3 )
-----------------------

STRING='OPTSET(INT)';
OPTSET(INT)

STRING='B = EVAL(Y,N,5,K,3)';
B = 20
------
```

FUNCTION DEFINITION AND EXPANSION APPLYING MULT. AND DIST. LAWS

```
STRING='FNC(G) = $(1) + 2*SIN($(2))';
G = 2 SIN ( $(2) ) + $(1)
-------------------------

STRING='P = G(X**2+1,Z)';
      2
P = X   + 2 SIN ( Z ) + 1
------------------------

STRING='A = (X+4)**2 + 3*(2*X+Z) * (Z-3)';
                                        2
A = 3 ( Z - 3 ) ( Z + 2 X ) + ( X + 4 )
---------------------------------------

STRING='B = EXPAND(A)';
                                  2     2
B =  - 9 Z - 10 X + 6 X Z + 3 Z   + X   + 16
--------------------------------------------
```

COMMON DENOM., NUM, DENOM, LOW AND HIGH POWER AND COEFF

```
STRING='A = X/Z + Z + X/W';
A = Z + X /  W + X /  Z
-----------------------

STRING='B = CODEM(A)';
B = ( X W + ( X + Z W ) Z ) / (  Z W )
--------------------------------------

STRING='Y = (Z*X**5 + 7/3*X**3)/(SIN(X) + COS(X))';
        5                 3
Y =  ( X   Z + 7/3 X   ) / ( SIN ( X ) + COS ( X ) )
----------------------------------------------------

STRING='A=NUM(Y)';
     5          3
A = X   Z + 7/3 X
-----------------

STRING='B = DENOM(Y)';
B = SIN ( X ) + COS ( X )
-------------------------

STRING='C = HIGHPOW(A,X)';
C = 5
-----

STRING='D = LOWPOW(A,X)';
D = 3
-----
```

continued

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```
STRING='E = COEFF(A,X**5)';
E = 7
-----

   EDIT FEATURE.

STRING='A = C1 + C2*X + C3*X**2';
                        2
A = C1 + X C2 + X   C3
----------------------


STRING='OPTSET(NOEDIT)';
OPTSET(NOEDIT)

STRING='C = A';
C = C1 + C2*X + C3*X**2
-----------------------

   INTEGER AND RATIONAL CONSTANTS MAY BE DEVELOPED OR SPECIFIED
WITH AS MANY AS 2295 SIGNIFICANT DIGITS.

STRING='Y = 116727134687955/5 * X**174';
Y = X**174*2334542693759
------------------------


STRING='A = DERIV(Y,X,5)';
A = X**169*351374831813933791336720
-----------------------------------


STRING='B = EVAL(A,X,2+11/12)';
B = (720752901967543751748036225257161223598876421196893817372
-------------------------------------------------------------------
953841030055920105250382345793678832323239245958570433346085570
-------------------------------------------------------------------
507465119842170842320609136976317025501920713908186546167420740
-------------------------------------------------------------------
738669199626461274731368501587171417203988725358408990611693012
-------------------------------------------------------------------
429128657458932138979434967041015625/557374165629320277805245157
-------------------------------------------------------------------
200742152038930601140921715150883641.702510452310306937607988039
-------------------------------------------------------------------
272580484172401592984257880242341124.261344303532708441130245 4
-------------------------------------------------------------------
109408161641176161725710336 )
-----------------------------

   Y=0: X<-1, X>1;  Y=1: -1.=X<0. Y=COS(X): 0<=X<1.

STRING='Y = STEP(-1,X,0) + STEP(0,X,1) * COS(X)';
Y = COS(X)*STEP(0,X,1) + STEP(-1,X,0)
-------------------------------------


**NORMAL STOP WITH INPUT TO FMACUT EXHAUSTED**


HASP VERSION 2.M20    51 CARDS READ    179 LINES PRINTED    0 CARDS PUNCHED    5 SECS NET CPU TIME
```

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COST ESTIMATE

For the job listed on the Sample Output, the total running time on the central-processor unit was 10 seconds, at $0.11 per second. The chargeable computer time was $1.10.

Charge to user = computer time + network overhead
= $1.10 + network overhead

CONTENTS—FORMAC

000 0050

DESCRIPTIVE TITLE	FORMAC Utility Program
CALLING NAME	FMACUT
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Robert Duquet Meteorology Department The Pennsylvania State University H.D. Knoble (assistance) The Pennsylvania State University Computation Center
LANGUAGE	PL/1–FORMAC
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Dr. Daniel L. Bernitt, EIN Technical Representative, Computation Center, 105 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

The FORMAC version available at The Pennsylvania State University is an interpretative system; i.e., FORMAC expressions are treated as character strings that are evaluated and executed at run time only. These character strings may be specified by reference to a PL/1 character-string variable. The PL/1 variable, in turn, may be constructed by execution of the PL/1 program in which the FORMAC statements are embedded. FMACUT merely capitalizes on the last-named feature. FORMAC statements are read by the preprocessed, precompiled, and prelink-edited program and are passed to the FORMAC package as character-string arguments. Note that this is made possible also because FORMAC variables need not (in fact *cannot*) be declared in the PL/1 program. Reference 1 should be consulted concerning more-detailed PL/1 FORMAC information.

FMACUT will execute FORMAC statements that are supplied as *input data*. It effectively divorces FORMAC from PL/1 insofar as the user is concerned. This has two advantages: (1) the user need have no knowledge of PL/1 to use FORMAC and (2) FORMAC is available without preprocessing, compilation, or link-editing (which

continued

saves approximately 50 seconds of run time for a null job on the IBM 360/67). The corresponding disadvantage is that PL/1 facilities and those (few) FORMAC statements involving a PL/1 direct interface are not available to the user.

REFERENCES

Tobey, R., Baker, J., Crews, R., Marks, P., and Victor, K., "PL/1 FORMAC Interpreter," IBM Publ. 360D 03.3.004 (1967).

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USER INSTRUCTIONS

FMACUT may be executed via the catalogued procedure LIBRARY. The input is freeform; i.e., card boundaries are ignored. FORMAC statements are written within single quotes (') rather than within balanced parentheses following the word LET. For example, instead of using LET(X=A+B*COS(PL/2)), use 'X=A+B*COS(PL/2)'. Only one FORMAC statement may be enclosed within a given pair of single quotes. For example, instead of using LET(X+A**2+C*A-D; Y=COEFF (x,A**2)), use 'S=A**2+c*a-D' 'Y=COEFF(X,A**2)'. *NOTE:* The single quote terminating one FORMAC statement by one or more blanks and/or one comma. An individual FORMAC statement, exclusive of its enclosing quotes may be no longer than 800 characters in length, including blanks.

To facilitate setting FORMAC options, the OPTSET command may be used. OPTSET followed by the desired options (optionally enclosed within parentheses) must be enclosed within single quotes. For example, 'OPTSET INT EXPAND' and 'OPTSET(PROPER)' are acceptable. All options, including PRINT and NOPRINT, may be used and may be set, changed, and reset as often as desired. The default options are LINELENGTH=LONG (i.e., 120), PRINT, TRANS, INT, NOEXPND, EDIT, and IMPROPER. OPTSET is a reserved keyword.

To provide the capability of adding comments to the output, the command 'COMMENT-any comment' may be used. For example, 'COMMENT-PROOF BY INDUCTION' would result in this comment being printed. COMMENT is a reserved keyword and, like OPTSET, may not be used as a variable name.

To adjust the number of characters that will be printed out per line, two options are available: 'OPTSET(LINELENGTH=LONG)' will use a full page (120 characters per line) and 'OPTSET(LINELENGTH=SHORT)' will print out in a form suitable for 8½ X 11 in. paper (72 characters per line). When using the latter option, comments should be limited to 72 characters, including COMMENT.

Capabilities and Limitations

The commands SAVE and ATOMIZE are not available. In general, only those FORMAC statements that would normally be enclosed within parentheses following LET may be used. In particular, the features ARITH, INTEGER, IDENT, EXCH, and double quotes (") involving a direct PL/1 to FORMAC interface are not available. OPTSET and COMMENT are available as explained above. If a FORMAC expression is incorrectly structured with respect to syntax or logic, as described in the FORMAC manual,[1] the statement is bypassed, an error message is issued, and processing continues. One special character used by FORMAC—namely, the exclamation point (!)—is

continued

000 0050(a)

not available on the QN (normal) print train. Therefore, this character, used as a factorial sign when the INT option is *off*, will print as a blank. This limitation, however, is not probelm when using a terminal via RJE.

The transcendental-function names that are available are the following: SIN, COS, SINH, COSH, ATAN, ATANH, ATAN(x,y), LOG, LOG10, LOG2, ERF, EXP, SQRT, SIND, COSD, TAN, TAND, TANH, ATAND, ATAND(x,y), and ERFC. In addition, as part of the functional expression, the constants #P=Pi, #E=e (base of natural logs), and #i=$\sqrt{-1}$ will be recognized. [E.g., FORMAC will transform SIN(#P/6) before computation to 1/2.] The functions FAC(n) = n! and COMB($n,n_1,n_2,\cdots,n_k$) = $[n(n-1)\cdots(n-n_1-\cdots-n_k+1)]/[n!n_1!\cdots n_k!]$ also are available for n and k non-negative integers. The absolute-value function ABS(X) is *not* available; however, this operation may be effected by SQRT(X**2).

The number of significant digits in any floating-point constants may not exceed eight. The number of variables and degree of expansion are limited only by storage. Most of these limitations can be eliminated for a particular case by modifying FMACUT.

Program deck and Control Cards are the same for FMACUT and FORMAC, except that Cols. 22–27 of the EXEC Card contain FMACUT.

REFERENCES

1. Tobey, R., Baker, J., Crews, R., Marks, P., and Victor, K., "PL/1 FORMAC Interpreter," IBM Publ. 360D 03.3.004 (1967).

000 0050(a)

000 0050(a)

000 0050(a)

SAMPLE INPUT

```
// EXEC LIBRARY,PROG=FMACUT
//DATA.INPUT DD *
'OPTSET(LINELENGTH=SHORT)'
'COMMENT       IN THE FOLLOWING EXAMPLES "STRING=" INDICATES THE INPUT  '
'COMMENTSTRING;  THE UNDERLINED TWO-DIMENSIONAL EDITED OUTPUT IS THE'
'COMMENTRESULT OF PROCESSING BY THE INTERPRETATIVE FORMAC SYSTEM.'
'PAGE'
'COMMENT      GENERAL EXAMPLE.'
      'A = (X**2 + 7/3)*#P'
      'B = 3*SIN(A+1) + .3E-4*LOG(COS(Y))'
'COMMENT   UNSPECIFIED FUNCTIONS AND DERIVATIVES.'
      'A = F.(3*X**2) + LOG(X)'
      'B = DERIV(A,X,2)'
      'C = DERIV(ATANH(X**2) + X,X)'
      'D = DRV(H.(U,V,W),$(1),3, $(2),2, $(3),2)'
'COMMENT   TRANS OPTION FOR TRANCENDENTAL FUNCTION EVALUATION.'
'OPTSET(NOTRANS)'
      'A = 1/3'
      'B = SIN(X**4) + LOG(2*A) + SIN(#P/6)'
'OPTSET(TRANS)'
      'C = B'
'COMMENT   INT OPTION FOR COMBINATIONS, FACTORIAL, AND EVAL CAPABILITY.'
'OPTSET(NOINT)'
      'Y = COMB(N,K-1) + COMB(N,K)'
      'A = EVAL(Y,N,5,K,3)'
'OPTSET(INT)'
      'B = EVAL(Y,N,5,K,3)'
'COMMENT   FUNCTION DEFINITION AND EXPANSION APPLYING MULT. AND DIST. LAWS'
      'FNC(G) = $(1) + 2*SIN($(2))'
      'P = G(X**2+1,Z)'
      'A = (X+4)**2 + 3*(2*X+Z) * (Z-3)'
      'B = EXPAND(A)'
'COMMENT   COMMON DENOM., NUM, DENOM, LOW AND HIGH POWER, AND COEFF'
      'A = X/Z + Z + X/W'
      'B = CODEM(A)'
      'Y = (Z*X**5 + 7/3*X**3)/(SIN(X) + COS(X))'
      'A=NUM(Y)'  'B = DENOM(Y)'  'C = HIGHPOW(A,X)'  'D = LOWPOW(A,X)'
      'E = COEFF(A,X**5)'
'COMMENT   EDIT FEATURE.'
      'A = C1 + C2*X + C3*X**2'
'OPTSET(NOEDIT)'
      'C = A'
'COMMENT   INTEGER AND RATIONAL CONSTANTS MAY BE DEVELOPED OR SPECIFIED'
'COMMENTWITH AS MANY AS 2295 SIGNIFICANT DIGITS.'
      'Y = 116727134687 95/5 * X**174'
      'A = DERIV(Y,X,5)'
      'B = EVAL(A,X,2+11/12)'
'COMMENT   Y=0: X<-1, X>1;  Y=1: -1.=X<0; Y=COS(X): 0<=X<1.'
      'Y = STEP(-1,X,0) + STEP(0,X,1) * COS(X)'
/*
```


000 0050(a)

000 0050(a)

SAMPLE OUTPUT

```
STRING='OPTSET(LINELENGTH=SHORT)';
LINELENGTH=  64
      IN THE FOLLOWING EXAMPLES "STRING=" INDICATES THE INPUT
STRING; THE UNDERLINED TWO-DIMENSIONAL EDITED OUTPUT IS THE
RESULT OF PROCESSING BY THE INTERPRETATIVE FORMAC SYSTEM.

      GENERAL EXAMPLE.

STRING='A = (X**2 + 7/3)**#P';
                 2
A = #P ( X    + 7/3 )
-------------------

STRING='B = 3*SIN(A+1) + .3E-4*LOG(COS(Y))';
                                          2
B = .3E-04 LN ( COS ( Y ) ) + 3 SIN ( #P ( X    + 7/3 ) + 1 )
-------------------------------------------------------------

   UNSPECIFIED FUNCTIONS AND DERIVATIVES.

STRING='A = F.(3*X**2) + LOG(X)';
                 2
A = F.( 3 X    ) + LN ( X )
-------------------------

STRING='B = DERIV(A,X,2)';
        (2)        2     2          2        (1)        2
B = 36 F    .( 3 X    ) X    - 1 / X    + 6 F    .( 3 X    )
-----------------------------------------------------------

STRING='C = DERIV(ATANH(X**2) + X,X)';
                                 4
C = 2 X / (  - X    + 1 ) + 1
-----------------------------

STRING='D = DRV(H.(U,V,W),$(1),3, $(2),2, $(3),2)';
        3  2  2
      (1  2  3  )
D = H             .( U, V, W )
-----------------------------

   TRANS OPTION FOR TRANCENDENTAL FUNCTION EVALUATION.

STRING='OPTSET(NOTRANS)';
OPTSET(NOTRANS)

STRING='A = 1/3';
A = 1/3
-------

STRING='B = SIN(X**4) + LOG(2*A) + SIN(#P/6) ;
                                          4
B = LN ( 2/3 ) + SIN ( 1/6 #P ) + SIN ( X    )
---------------------------------------------

STRING='OPTSET(TRANS)';
OPTSET(TRANS)

STRING='C = B';
```

continued

000 0050(a)

000 0050(a)

```
C = SIN ( X^4 ) + .09453489
---------------------------

   INT OPTION FOR COMBINATIONS, FACTORIAL, AND EVAL CAPABILITY.

STRING='OPTSET(NOINT)';
OPTSET(NOINT)

STRING='Y = COMB(N,K-1) + COMB(N,K)';
Y = ( N; K ) + ( N; K - 1 )
---------------------------


STRING='A = EVAL(Y,N,5,K,3)';
A = ( 5; 2 ) + ( 5; 3 )
-----------------------


STRING='OPTSET(INT)';
OPTSET(INT)

STRING='B = EVAL(Y,N,5,K,3)';
B = 20
------

   FUNCTION DEFINITION AND EXPANSION APPLYING MULT. AND DIST. LAWS

STRING='FNC(G) = $(1) + 2*SIN($(2))';
G = 2 SIN ( $(2) ) + $(1)
-------------------------


STRING='P = G(X**2+1,Z)';
P = X^2 + 2 SIN ( Z ) + 1
-------------------------


STRING='A = (X+4)**2 + 3*(2*X+7) * (Z-3)';
A = 3 ( Z - 3 ) ( Z + 2 X ) + ( X + 4 )^2
-----------------------------------------


STRING='B = EXPAND(A)';
B =  - 9 Z - 10 X + 6 X Z + 3 Z^2 + X^2 + 16
--------------------------------------------

   COMMON DENOM., NUM, DENOM, LOW AND HIGH POWER, AND COEFF

STRING='A = X/Z + Z + X/W';
A = Z + X / W + X / Z
---------------------


STRING='B = CODEM(A)';
B = ( X W + ( X + Z W ) Z ) / ( Z W )
-------------------------------------
```

continued

000 0050(a)

```
STRING='Y = (Z*X**5 + 7/3*X**3)/(SIN(X) + COS(X))';
                5            3
Y =  ( X   Z + 7/3 X   ) / ( SIN ( X ) + COS ( X ) )
-----------------------------------------------------

STRING='A=NUM(Y)';
     5            3
A = X   Z + 7/3 X
-------------------

STRING='B = DENOM(Y)';
B = SIN ( X ) + COS ( X )
-------------------------

STRING='C = HIGHPOW(A,X)';
C = 5
-----

STRING='D = LOWPOW(A,X)';
D = 3
-----

STRING='E = COEFF(A,X**5)';
E = Z
-----

   EDIT FEATURE.

STRING='A = C1 + C2*X + C3*X**2';
                         2
A = C1 + X C2 + X   C3
----------------------

STRING='OPTSET(NOEDIT)';
OPTSET(NOEDIT)

STRING='C = A';
C = C1 + C2*X + C3*X**2
-----------------------

   INTEGER AND RATIONAL CONSTANTS MAY BE DEVELOPED OR SPECIFIED
WITH AS MANY AS 2295 SIGNIFICANT DIGITS.

STRING='Y = 11672713468795/5 * X**174';
Y = X**174*2334542693759
------------------------

STRING='A = DERIV(Y,X,5)';
A = X**169*3513748318138337913367 20
------------------------------------
```

continued

```
STRING='B = EVAL(A,X,2+11/12)';
B = (720752901067543751748096225257161223588876421196893817372
-----------------------------------------------------------------
953841030055920105250382345753678832323239245958570433346085570
-----------------------------------------------------------------
507465119842170842320609136976317025501920713908186546157420740
-----------------------------------------------------------------
738669198626461274731368501587171417203988725358408990611693012
-----------------------------------------------------------------
429128657458932138979434967041015625/557374165629320277805245157
-----------------------------------------------------------------
200742152038930601140921715158836197025104523103069376079880 39
-----------------------------------------------------------------
272580484172401592984257880024234112442613443035327084411302454
-----------------------------------------------------------------
109408161641176161725710336 )
-----------------------------

   Y=0: X<-1, X>1;  Y=1: -1.=X<0; Y=COS(X): 0<=X<1.

STRING='Y = STEP(-1,X,0) + STEP(0,X,1) * COS(X)';
Y = COS(X)*STEP(0,X,1) + STEP(-1,X,0)
-------------------------------------

**NORMAL STOP WITH INPUT TO FMACUT EXHAUSTED**

HASP VERSION 2.M2B   52 CARDS READ   236 LINES PRINTED   0 CARDS PUNCHED   5 SECS NET CPU TIME
```

000 0050(a)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central-processor unit was 10 seconds, at $0.11 per second. The chargeable computer time was $1.10.

Charge to user = computer time + network overhead
= $1.10 + network overhead

CONTENTS—FMACUT

000 0050(a)

000 0051

DESCRIPTIVE TITLE	Collection of Statistical Routines
CALLING NAME	STPAC
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	William H. Verity Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

STPAC consists logically of two sections: a monitor and a collection of statistical routines. The monitor is a program that will read all Control Cards, save the original data if required or requested, save any intermediate results that may be needed later on, and then transfer control to the first routine requested. When this routine is finished, it returns control to the monitor, which then looks to see if there is more work to be done. This work can be of several different types, as follows.

1. Using the same data deck (but possibly different columns of it), execute the same routine again.

2. Using the same data deck, execute another routine. Thus, one deck can be subjected to several types of analyses during one run.

3. Execute another program, possibly the same one as before, on a new set of data.

4. Using the results of a previous routine, continue to another program that takes these results as input; e.g., output from correlation can be the input to regression or factor analysis.

The statistical routines available include a variety for summary

continued

000 0051

of data, frequency analysis, tests of significance, analyses of variance, and rank and product-moment correlation coefficients. See individual abstracts for EIN Nos. 000 0051(a)-(s) for the details of the individual statistical routines.

REFERENCES

See individual abstracts for EIN numbers 000 0051 (a)-(s).

STPAC ROUTINES

EIN No.	*Calling Name*
000 0051(a)	FAWCS
(b)	STSUM
(c)	TTEST
(d)	PPMCR
(e)	SIGPP
(f)	PARCOR
(g)	CANON
(h)	UPREG/DNREG
(i)	FANAL
(j)	VARMX
(k)	PHICO
(l)	KETAU
(m)	SPRHO
(n)	MNWHT
(o)	KRWAL
(p)	ANOVUM
(q)	ANOVES
(r)	AOVRM
(s)	BARTL

USER INSTRUCTIONS

To use any of the programs of the statistical package, *STPAC MUST BE SPECIFIED AS THE LIBRARY NAME*. Programs available as part of this package are identified and described in separate writeups [EIN Nos. 000 0051(a)–(s)].

Control Cards and Their Functions

Problem information is given through the use of Control Cards. Each Control Card transmits one type of information and conveys to the user its function. The information on a Control Card is contained in one or more fields, where a field is defined to be one or more contiguous nonblank characters. Fields are separated from one another by one or more blank spaces or commas, thus allowing the user to punch the Control Cards without regard to specific columns, although the fields must be in the specified order. The only restriction is that the first field must begin in Col. 1. If any field contains special characters or blanks, it must be enclosed in single quotation marks.

To execute any given analysis, two types of Control Cards will be needed: those applicable to all of the programs in the package and those specific to the program at hand. The Control Cards that can apply to *all* programs are described next. The Control Cards that are peculiar to *an individual* program are described in the appropriate program writeup. Information printed in capital letters must appear on the Control Card letter for letter as it is typed and all fields must be in the order indicated.

Execute Card (required for each problem)

Columns	*Contents*
1– 7	EXECUTE
9–13	Name of program to be executed

NOTE: This must be the first card for *each* problem under STPAC.

Comments Card(s) (optional)

Columns	*Contents*
1	*
2–80	Information to be printed on a page immediately preceding output (for documentation)

Any number (or none) of these cards may be used.

continued

000 0051

Title Card (optional)

Columns	*Contents*
1– 5	TITLE
6–80	Heading to be printed on each section of output

Variable Card (may or may not be required)

Columns	*Contents*
1– 9	VARIABLES
11–12	Number of variables for the problem
14–22	SEQUENCED
24–25	Number of variables on each Data Card (≤ number in Cols. 11–12)
27–32	PERCARD

NOTE: If Cols. 14–32 of this card are specified, then it is inferred that case and sequence numbers (strictly increasing only) are on each Data Card, each case number being identified in the first card field and the sequence number within the case being given in the second card field. If the case and sequence numbers are missing (or it is not desired that they be checked), entries in these columns *must* be omitted. In this instance, either all variables fit on one card or the Format Card (see below) controls the reading of more than one card.

Name Card(s) (optional; first form)

Columns	*Contents*
1–80	VARIABLE NAMES i=xxx,j=yyy, etc.
	or
	TREATMENT NAMES i=xxx,j=yyy, etc.

One or more of these cards may be used to assign alphanumeric names to each variable and/or treatment. Variable (treatment) i will be called xxx, j will be called yyy, etc., where xxx and yyy represent some combinations of eight or fewer characters, *at least one of which must be nonnumeral.* If the card is omitted, variables (treatments) will be numbered sequentially. It is also possible to name *some* variables (treatments) and to allow the remaining ones to be numbered. In addition, xxx, yyy, etc., may be labelled with a two-word term if it totals no more than eight characters and has single quotation marks around it.

continued

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Examples (starting in Col. 1)

```
 VARIABLE NAMES 1=AGE,2=PARTY
TREATMENT NAMES 1=HEIGHT,2='HAIR COL'
```

Name Card(s) (optional; second form)

Columns	*Contents*
1–80	VARIABLE NAMES TRANSFER or TREATMENT NAMES TRANSFER

This card indicates that the names from the immediately preceding problem are to be used in the present problem (especially useful when results from one problem are data for another).

Format Card(s) (may or may not be required)

Columns	*Contents*
1– 6	FORMAT
8	Number of cards used in format specification (≤ 3)
10–80	Beginning of format specification (any valid FORTRAN FORMAT)

NOTE: If the number of cards required is one, the format specification may begin in Col. 8 (and the 1 need not be specified). If more than one card is required, the word FORMAT need not be repunched, thus making all 80 columns of the second (and third) card available for use.

Begin-Data Card (required if Data Cards are to be used; must be omitted if data from previous problem are to be used)

Columns	*Contents*
1–10	BEGIN DATA

This card must immediately precede the data deck. Previous data are no longer available after this card has been read.

End-Data Card (required if Data Cards are being used)

Columns	*Contents*
1– 8	END DATA

This card must immediately follow the data deck.

continued

000 0051

Same-Data Card (optional)

Columns	*Contents*
1– 9	SAME DATA

This card indicates that the *last* set of raw data is to be used, allowing a data deck to be used over and over again. When this card is used, there *cannot* be either a Begin- or End-Data Card.

Input Card (optional)

Columns	*Contents*
1–10	INPUT FROM
12–16	Name of program already run (during the *present* run) from which the input to this program is coming (used when the results of one program are the input to another). There may be cases in which the input may be from *both* another program and card input. Then, both the INPUT FROM *and* BEGIN DATA–END DATA sequence would be used.

Stop Card (required once for each submission to the package)

Columns	*Contents*
1– 4	STOP (indicating the end of input to STPAC)

Execution of all programs will terminate after this card is read.

Job Deck Structure

EXECUTE xxxxx (required)
Comments Card(s)
Title Card
Variable Card
Name Card(s)
Format Card(s)
Other cards (required or optional for program xxxxx)
Same-Data Card
Input Card
Begin-Data Card
Data Card(s)
End-Data Card
Stop Card (required at end of STPAC input)

May be in any order

Not used if Same-Data Card is used or Input Card specifies *all* required input

Repeat for as many problems (programs) as necessary

NOTE: For each problem, there *must* be either a Same-Data Card, an Input Card, or a deck of Data Cards (beginning with the Begin-Data Card and ending with the End-Data Card).

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SAMPLE INPUT/OUTPUT

Sample Input and Output are specific to the various routines. See items 000 0051(a)–(s).

000 0051

000 0051

COST ESTIMATE

Inappropriate for STPAC alone; see individual routines EIN Nos. 000 0051 (a)-(s)

CONTENTS—STPAC

pages

000 0051

000 0051(a)

DESCRIPTIVE TITLE	Frequency Analysis with Chi Square
CALLING NAME	(STPAC) FAWCS
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	C.B. Broderick Department of Family Relations, The Pennsylvania State University William H. Verity The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

FAWCS computes (1) discrete, two-dimensional frequency-distribution tables (often called *contingency tables*) whose cells contain an actual frequency and, optionally, (2) expected frequencies and/or percentages. There is no missing-data code inherent to the program, but the user may specify that certain categories of his variables be ignored or combined with one another. If the user has any 2X2 tables, he may request that the Yates correction factor be used in computing his chi-square value.

FAWCS will crosstabulate one variable, the *row* variable, with variables called *column* variables. It can work with up to 50 total variables for any one problem, separately crosstabulating the row variable with each of the column variables. The row variable can have up to 31 categories where 0 is a valid category. Thus, the row variable can be coded 0 through 30. Each column variable can have a maximum of 13 categories where, again, 0 is a valid code. Therefore, column variables can be coded 0 through 12. *Any data outside of these ranges will be ignored.*

continued

REFERENCES

Edwards, A.L., *Experimental Design in Psychological Research* (Holt Rinehart and Winston, New York, 1962).

Snedecor, G.W., *Statistical Methods* (Iowa State University Press, Ames, Ia., 1961).

Wert, J.E., Neidt, C.O., and Ahmann, J.S., *Statistical Methods in Educational and Psychological Research* (Appleton-Century-Crofts, New York, 1954).

000 0051(a)

000 0051(a)

000 0051(a)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

In addition to the Control Cards applicable to all programs in STPAC, FAWCS uses the Control Cards that are described in the following. There is no standard format for raw data, but if totals data are used they must be punched as described under the PUNCH option. *A Variables Card is required for FAWCS.*

Row-Variable Card (required)

Columns	*Contents*
1–12	ROW VARIABLE
14–80	Variable to be used as *row* variable. All others will become column variables. It may be specified by either the name or the number assigned to it. (If Name Cards were not used. the reference to the variable *by name* would be permitted.)

Percentages Card (optional)

Columns	*Contents*	
1–11	PERCENTAGES	
13–15	ROW	one of these
	or	
13–18	COLUMN	

This card indicates that percentages are to be computed on the basis of row (column) totals. Only one choice may be made for any one problem.

Chi-Square Card (optional)

Columns	*Contents*
1–10	CHI-SQUARE

This card indicates that a chi-square value is to be printed for each table, as well as the probability of exceeding this value by chance.

continued

000 0051(a)

Yates-Correction-Factor Card (optional)

Columns	*Contents*
1– 5	YATES

This card indicates that the Yates correction factor should be used in any 2X2 tables that are developed. It will be used *only* in computing the chi square.

Expected-Frequency Card (optional)

Columns	*Contents*
1– 8	EXPECTED

This card causes the expected cell frequencies to be printed.

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card causes the raw cell frequencies to be punched onto cards so that it is possible to go back and either combine or ignore different or new combinations of row and column categories without rereading the raw data. In order that a minimum number of cards have to be repunched by hand, the following cards are punched.

```
EXECUTE FAWCS
VARIABLES 2
VARIABLE NAMES 1=xxxxx,2=wwwww
ROW VARIABLE xxxxx
TOTALS (see below)
BEGIN DATA
   :          actual totals from the raw table
   :
END DATA
```

Thus, all that must be added is a Title Card. After adding or ignoring any other cards (including optional Control Cards), the deck is ready for resubmission. Totals are punched according to a format of 20I4, as follows.

Columns	*Contents*
1– 4	Row number
6– 9	Column number
13	1
14–17	Total for this row–column combination

continued

000 0051(a)

NOTE: The PUNCH option is recommended only for exceptionally large amounts of data. Otherwise, it is easier simply to resubmit the raw data.

Totals Card (optional)

Columns	*Contents*
1– 6	TOTALS

This card indicates that totals punched in a previous run of FAWCS (or otherwise) are to be used. Totals must be punched in the 20I4 format described above.

Ignore-Categories Card (optional; one or more as required—first form)

Columns	*Contents*
1–80	IGNORE xxxxx CATEGORIES i j k ···

This card causes categories i,j,k,··· of the variable xxxxx to be ignored, where xxxxx is either the name or the number of a variable. A preliminary table with *all* categories will be printed, followed by a final table in which the specified categories will not appear. All chi squares, percentages, and expected frequencies will be based on the final table.

Ignore-Categories Card (optional; second form)

Columns	*Contents*
1–80	IGNORE $COLUMN$ CATEGORIES i j k ···

This card indicates that categories i,j,k,··· of *all column variables* are to be ignored. To ignore row-variable categories, the *first form* of this card must be used.

Combine-Categories Card (optional; one or more as required—first form)

Columns	*Contents*
1–80	COMBINE xxxxx CATEGORIES i j k ···

This card causes categories i,j,k,··· of variable xxxxx to be combined to form a new category, where xxxxx is xxxxx is either the name or the number of a variable. The new category will carry a number that is the smallest of those combined.

continued

000 0051(a)

Combine-Categories Card (optional; second form)

Columns	*Contents*
1–80	COMBINE $COLUMN$ CATEGORIES i j k ···

This form indicates that, for each column variable, categories i,j,k,··· are to be combined to form a new category. Again, to combine row-variable categories, the *first form* of this card must be used.

NOTE: If there is an inconsistency in the Combine- and Ignore-Categories Cards, only the preliminary table will be printed and cards will be punched.

Format Card (required for raw data; not permitted for totals)

The form of this card is as described in the general discussion of Control Cards for STPAC. For FAWCS, the format can specify only integer data (I notation). If case and sequence numbers are required, the format must allow for them.

Description of Output

The printed output for a FAWCS problem is a series of two-dimensional tables, one table for each column variable. Each table is headed by the title that the user has supplied. The categories of each column variable are listed across the top of the table, along with the name of the column variable. The categories of the row variable are listed down the lefthand margin of the table, along with the name of the row variable. The body of the table contains the observed frequencies for each cell and percentages and expected frequencies if requested. Below each table, if requested, the chi-square value is printed, along with its degrees of freedom and the probability of exceeding this value by chance.

If any Combine- or Ignore-Categories Cards were present, a preliminary table is printed. It contains the same title and headings, but only the observed frequencies appear in the body of the table. At the bottom of this table are listed the categories that are to be ignored and combined. Then, a final table in which the combining and ignoring has taken place is printed on a new page. All calculations are based on this final table.

Card output is produced where applicable, as described under the Punch Card.

000 0051(a)

SAMPLE INPUT

```
EXECUTE FAMCS
VARIABLES 2
FORMAT(4X,2I4)
VARIABLE VALUES 1=COLLEGE,2=NON-COLLEGE
TITLE SAMPLE DATA DEFINED FOR SPSS PROGRAM FAMCS
JOB VARIABLE COLLEGE
CHISQUARE
BEGIN DATA
   1   4   1 13117.
   2   4   2 16220.
   3   4   1  5647.
   4   2   1  7748.
   5   2   2 11975.
   6   1   0  4137.
   7   4   1 12175.
   8   2   2  5550.
   9   4   1 16331.
  10   1   0  7475.
  11   5   1  8310.
  12   3   1  7429.
  13   1   2 14664.
  14   1   1 16701.
  15   2   1  4629.
  16   3   1  5656.
  17   1   1 11275.
  18   4   2  5336.
  19   1   2  8629.
  20   3   2  5447.
  21   5   1  8824.
  22   2   2 13139.
  23   5   1  7056.
  24   4   1 14917.
  25   5   2 10570.
  26   1   2  5419.
  27   1   1 11191.
  28   3   1  4560.
  29   5   1  9265.
  30   1   2  9863.
  31   2   1  9599.
  32   1   2  7051.
  33   3   0 13634.
  34   5   2  6190.
  35   1   2 10644.
  36   1   1  9692.
  37   0   0 13194.
  38   3   1 12469.
  39   1   2 14916.
  40   1   1  4662.
  41   3   1 11969.
  42   2   1 16822.
  43   2   2  4737.
  44   5   1  6468.
  45   2   1 13314.
  46   4   2 10080.
  47   5   1  5437.
  48   1   1 11110.
  49   2   0  6678.
  50   1   1 11625.
END DATA
EXECUTE FAMCS


SAME DATA
FORMAT(4X,2I4)
TITLE ILLUSTRATE SAME DATA OPTION
CHISQUARE
PERCENTAGES ROW
TENDER COLLEGE CATEGORIES 0
TENDER NON-COLLEGE CATEGORIES 0
VARIABLES 2
COMPARE COLLEGE CATEGORIES 1 2
COMPARE 1 CATEGORIES 3 4 5
YATES
STOP
```

SAMPLE OUTPUT

FREQUENCY DISTRIBUTION TABLE

WITH CHI-SQUARE

SAMPLE PROBLEM FOR STPAC PROGRAM FAWCS

EACH CELL OF THE TABLE CONTAINS AN ACTUAL FREQUENCY ON THE FIRST LINE

CATEGORIES OF ROW VARIABLE 1 COLLEGE	CATEGORIES OF COLUMN VARIABLE RESIDENC 2	0	1	2	ROW TOTAL
0		1	0	0	1
1		2	7	7	16
2		1	5	4	10
3		1	5	1	7
4		0	5	3	8
5		0	6	2	8
COLUMN TOTAL		5	28	17	50

THE VALUE OF CHI-SQUARE FOR 10 DEGREES OF FREEDOM IS EQUAL TO 13.768

THE PROBABILITY OF EXCEEDING THIS VALUE OF CHI-SQUARE BY CHANCE IS 0.184

continued

000 0051(a)

FREQUENCY DISTRIBUTION TABLE

ILLUSTRATE SAME DATA OPTION

PRELIMINARY TABLE

CATEGORIES OF ROW VARIABLE 1 COLLEGE	CATEGORIES OF COLUMN VARIABLE RESIDENC 2 0	1	2	ROW TOTAL
0	1	0	0	1
1	2	7	7	16
2	1	5	4	10
3	1	5	1	7
4	0	5	3	8
5	0	6	2	8
COLUMN TOTAL	5	28	17	50

THE FOLLOWING ROW CATEGORIES WERE IGNORED - C,

THE FOLLOWING COLUMN CATEGORIES WERE IGNORED - C,

THE FOLLOWING ROW CATEGORIES WERE COMBINED TO FORM CATEGORY 1 - 1, 2,

THE FOLLOWING ROW CATEGORIES WERE COMBINED TO FORM CATEGORY 3 - 3, 4, 5,

continued

000 0051(a)

PERCENT-FREQUENCY DISTRIBUTION TABLE

WITH CHI-SQUARE

ILLUSTRATE SAME DATA OPTION

EACH CELL OF THE TABLE CONTAINS A PERCENTAGE FREQUENCY ON THE FIRST LINE AND AN ACTUAL FREQUENCY ON THE SECOND LINE
PERCENTAGES ARE BASED ON ROW TOTALS.

CATEGORIES OF ROW VARIABLE 1 COLLEGE	CATEGORIES OF COLUMN VARIABLE RESIDENC 2 1	2	ROW TOTAL
1	52.2 12	47.8 11	51.1 23
3	72.7 16	27.3 6	48.9 22
COLUMN TOTAL	62.2 28	37.8 17	45

THE VALUE OF CHI-SQUARE FOR 1 DEGREES OF FREEDOM IS EQUAL TO 1.241

YATES CORRECTION FACTOR WAS USED IN OBTAINING THIS VALUE OF CHI SQUARE

THE PROBABILITY OF EXCEEDING THIS VALUE OF CHI-SQUARE BY CHANCE IS 0.265

000 0051(a)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 5 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.55 + network overhead

CONTENTS—(STPAC) FAWCS

000 0051(a)

000 0051(b)

DESCRIPTIVE TITLE	Statistical Summary
CALLING NAME	(STPAC) STSUM
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

STSUM computes, in double-precision arithmetic, the sample size, total, mean, standard deviation, population-variance estimate, standard error, sum of squares, coefficient of variation, third and fourth moments about the origin, third and fourth central moments, alpha (square root of beta 1), alpha 4 (beta 2), momental skewness, and kurtosis. Missing data will be permitted.

Equations

$$\left.\begin{aligned} V_1 &= \Sigma X/N \\ V_2 &= \Sigma X^2/N \\ V_3 &= \Sigma X^3/N \\ V_4 &= \Sigma X^4/N \end{aligned}\right]$$

moments about origin
$V_1 = \bar{X}$ mean
ΣX total

$$\left.\begin{aligned} \mu_2 &= V_2 - V_1^2 \\ \mu_3 &= V_3 - 3V_1V_2 + 2V_1^3 \\ \mu_4 &= V_4 - 4V_1V_3 + 6V_1^2V_2 - 3V_1^4 \\ \alpha_3 &= \sqrt{\beta_1} = (\mu_3^2/\mu_2^3)^{1/2} \\ \alpha_4 &= \beta_2 = \mu_4/\mu_2 \end{aligned}\right]$$

moments about mean

$\alpha_3/2$ momental skewness
$(\alpha_4 - 3)/2$ kurtosis
$\Sigma X^2 - (\Sigma X)^2/N$ sum of squares

continued

000 0051(b)

REFERENCES

Beyer, W.H., Ed., *Handbook of Tables for Probability and Statistics* (Chemical Rubber Co., Cleveland, 1966), p.3.

000 0051(b)

000 0051(b)

000 0051(b)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards are essential to STSUM. Begin- and End-Data Cards also are necessary if the data have not already been read for a previous STPAC program. All other STPAC Control Cards are optional.

Missing-Data Card (optional)

Columns	*Contents*
1–12	MISSING DATA
14–21	x, any number, up to eight digits including a decimal point, that will be read as a code for missing data.

Include this card only if some data are missing. If this card is omitted, it will be assumed that all fields contain data (blanks will be read as zero). If this card is included and Cols. 14–21 are blank, zeros and blanks in the Data Cards will be treated as missing data. If Cols. 14–21 are punched, the number x in a data field will be treated as a case of missing data.

Example (starting in Col. 1)

MISSING DATA 99.9

This would provide for a case where Data Cards can contain instances of zero observations and instances of missing data. All data fields previously blank would then be coded 99.9 on the Data Cards.

Description of Input Data

Data must be punched according to the format given on the Format Card. A case and sequence number should be punched on each card (but only if required, as described in the STPAC writeup), as well as the data points in F or E format. The number of a variable is determined by the order in which it is read, which is determined by the format supplied.

continued

000 0051(b)

Description of Output

Statistics are printed in two tables. All variables are numbered and also are named according to the Variable-Name(s) Card, if it is included.

REFERENCES

Beyer, W.H., Ed., *Handbook of Tables for Probability and Statistics* (Chemical Rubber Co., Cleveland, 1966), p.3.

000 0051(b)

000 0051(b)

000 0051(b)

SAMPLE INPUT

```
EXECUTE STSDA
TITLE TEST DOF
VARIABLES & SEPARATED 2 PERCAPI
FORMAT (2I1,2F1.0)
BEGIN DATA
4256
6637
1138
1656
END DATA
```


000 0051(b)

000 0051(b)

SAMPLE OUTPUT

TEST ONE

VARIABLE	NUMBER	TOTAL	MEAN	ST.DEV.	VARIANCE ESTIMATE	ST.ERROR	SUM OF SQUARES	CV. PCT.
1	2	0.300000 01	0.450000 01	0.141420 01	0.200000 01	0.100000 01	0.200000 01	35.4
2	2	0.140000 02	0.700000 01	0.141420 01	0.200000 01	0.100000 01	0.200000 01	20.2
3	2	0.300000 01	0.400000 01	0.141420 01	0.200000 01	0.100000 01	0.200000 01	35.4
4	2	0.110000 02	0.550000 01	0.212130 01	0.450000 01	0.150000 01	0.450000 01	38.6

TEST ONE

VARIABLE	MOMENTS ABOUT ORIGIN THIRD	MOMENTS ABOUT ORIGIN FOURTH	ADDITIONAL MOMENTS MOMENTS ABOUT MEAN THIRD	ADDITIONAL MOMENTS MOMENTS ABOUT MEAN FOURTH	ALPHA 3	ALPHA 4	SKEWNESS	KURTOSIS
1	0.760000 02	0.353000 03	0.0	0.100000 01	0.0	0.100000 01	0.0	-0.100000 01
2	0.364000 02	0.264960 04	0.0	0.100000 01	0.0	0.100000 01	0.0	-0.100000 01
3	0.760000 02	0.353000 03	0.0	0.100000 01	0.0	0.100000 01	0.0	-0.100000 01
4	0.203350 03	0.132650 04	0.0	0.566250 01	0.0	0.100000 01	0.0	-0.100000 01

000 0051(b)

(b)1500 000

000 0051(b)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) STSUM

000 0051(b)

000 0051(c)

DESCRIPTIVE TITLE	T Test on Difference between Means
CALLING NAME	(STPAC) TTEST
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

TTEST variables (samples) may be correlated or noncorrelated. Missing observations are permitted. Data may be submitted in the form of a single deck or multiple decks. Output can consist of values of t, frequencies, probabilities, and levels of significance. TTEST will perform a t test on each of all possible pairs of variables, each t being computed independently of all others.

For a t test on the difference between means of correlated samples, the formula used is

$$t = \frac{\Sigma D/N}{\left\{[\Sigma D^2 - \frac{(\Sigma D)^2}{N}]/[N(N-1)]\right\}^{1/2}},$$

where N is the number of pairs and D is the difference between the scores for each pair. The number of degrees of freedom is expressed by N - 1.

For a t test on the difference between means of noncorrelated samples, with separate variances, the formula used is

$$t = (\bar{X}_1 - \bar{X}_2)/(S_{\bar{X}_1}{}^2 + S_{\bar{X}_2}{}^2)^{1/2},$$

continued

000 0051(c)

where the X's are the means and the $S_{\overline{X}_1}{}^2$ and $S_{\overline{X}_2}{}^2$ are the squares of the standard errors of the means.

If the frequencies of the two samples are equal, the number of degrees of freedom are equal to the frequency minus 1. If the frequencies are unequal, the program uses the lowest frequency minus 1 as the number of degrees of freedom.

A t test on the difference between means of noncorrelated samples, with pooled variances, involves the formula

$$t = (\overline{X}_1 - \overline{X}_2)/[S^2(\frac{1}{K_1} + \frac{1}{K_2})]^{1/2},$$

where S^2 is the variance—i.e., the sum of squares has been calcalculated by summing the squared deviations for each individual case from the mean of the group in which that case is found—and the K's are the individual group frequencies. The number of degrees of freedom is equal to $K_1 + K_2 - 2$.

REFERENCES

Wert, J.E., Neidt, C.O., and Ahmann, J.S., *Statistical Methods in Educational and Psychological Research* (Appleton—Century—Crofts, New York, 1954), pp.128—142.

000 0051(c)

000 0051(c)

000 0051(c)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards are essential to TTEST. Begin- and End-Data Cards also are necessary if the data have already been read for a previous STPAC program. All other STPAC Control Cards are optional. There are in addition some required and optional Control Cards specific to TTEST; these are described below.

Correlated or Noncorrelated Card (one required)

Columns	*Contents*	
1–10	CORRELATED	one of these
	or	
1–13	NONCORRELATED	
	or	
1–20	NONCORRELATED POOLED	

This card informs the program as to whether the variables are correlated or uncorrelated (noncorrelated), and, if the latter, whether pooled variance or unpooled variance is to be used.

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card should be included only if the values of t are to be punched on cards in addition to being printed.

Decks Card (optional)

Columns	*Contents*	
1– 7	DECKS M	one of these
	or	
1– 5	DECKS	

continued

000 0051(c)

This card should be included if the data should be submitted in multiple decks rather than in a single deck. DECKS M is used if all decks have equal numbers of variables punched on them and M represents that number of variables. DECKS is used when decks have different numbers of variables punched on them; in this case, the number of variables per card is included in the data. See Description of Input Data, below.

000 0051(c)

Probabilities Card (optional)

Columns	*Contents*
1–13	PROBABILITIES

This card causes a table of probabilities for each t to be printed.

Significance-Levels Card (optional)

Columns	*Contents*
1–19	SIGNIFICANCE LEVELS

Include this card to print out a table containing entries that describe significance at the 0.05, 0.025, 0.01, and 0.001 levels.

Missing-Data Card (optional)

Columns	*Contents*
1–12	MISSING DATA
14–21	Any number up to eight digits, including a decimal point, that will be read as a code for missing data.

Include this card only if some data are missing. If this card is omitted, it will be assumed that all fields contain data (blanks will be read as zero). If this card is included and Cols. 14–21 are blank, zeros and blanks in the Data Cards will be treated as missing data. If Cols. 14–21 are punched, the number x in a data field will be treated as a case of missing data.

Example (starting in Col. 1)

MISSING DATA 99.9

This would provide for a case where Data Cards can contain instances of zero observations and instances of missing data. All data fields previously blank would then be coded 99.9 on the Data Cards.

Description of Input Data

Data must be punched according to the format given on the Format

continued

000 0051(c)

000 0051(c)

Card. In standard form, each card should contain case and sequence numbers in I format (but only if required for multiple cards per case, as described in the STPAC writeup), followed by data points for each variable in F or E format.

If the DECKS M option (1st form) is used, each card should contain a deck-identification number in I format and a data point in F, E, or D format for each variable in that deck.

If the DECKS option (2nd form) is used, each card should contain not only a deck-identification number but also the number of variables on that card (i.e., that deck), both in I format, in addition to a data point in F, E, or D format for each variable in that deck. All cards for one deck—containing the same deck-identification number and the same number of variables on every card—must be together. Correlated variables (samples) will not be handled with the DECKS option.

The number of a variable is determined by the order in which it is read, which is determined by the format supplied (and the order of the decks if multiple decks are used). In the case of decks, where the first deck contains three variables and the second contains four, the variables will be renumbered from 1 through 7.

Description of Output

Values of t will be printed and also punched at the user's option. In the case of correlated samples, a table of frequencies also will be printed. Tables of probabilities of significance levels will be printed at the user's option.

All tables are printed as triangular matrices. Every variable is numbered and named according to the Variable-Name(s) Card if it is included.

REFERENCES

Wert, J.E., Neidt, C.O., and Ahmann, J.S., *Statistical Methods in Education and Psychological Research* (Appleton-Century-Crofts, New York, 1954), pp.128-142.

000 0051(c)

000 0051(c)

SAMPLE INPUT

```
EXECUTE TTEST
VARIABLES 2 SEPARATED 1 BY
FORMAT(2I4,F4.1)
TITLE TEST OF SECOND TIMES DATA
FORMAT(2I4,F4.1)
NORMALIZED
BEGIN DATA
   1   1 175
   1   2 142
   2   1 142
   2   2 411
   3   1 218
   3   2 337
   4   1 151
   4   2 2[illegible]2
   5   1 200
   5   2 402
   6   1 219
   6   2 195
   7   1 234
   7   2 253
   8   1 149
   8   2 199
   9   1 187
   9   2 236
  10   1 123
  10   2 216
  11   1 245
  11   2 211
  12   1 266
  12   2 175
  13   1 179
  13   2 269
  14   1 [illegible]
  14   2 214
END DATA
[illegible]
```

000 0051(c)

SAMPLE OUTPUT

TEST OF SECOND TTNSE DECK

VARIABLE	NO.OBS.	MEAN	STANDARD ERROR SQUARED
1	14	0.18764D 03	0.10363D 03
2	14	0.23593D 03	0.21059D 03

TEST OF SECOND TTNSE DECK

T TEST

UNCORRELATED SAMPLES

	1
NO.OBS.	14
2 NO.OBS. 14	2.724

000 0051(c)

000 0051(c)

000 0051(c)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) TTEST

000 0051(c)

000 0051(d)

DESCRIPTIVE TITLE	Pearson Product-Moment Correlation Coefficient
CALLING NAME	(STPAC) PPMCR
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	William H. Verity Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

PPMCR computes not only a Pearson product-moment correlation coefficient for each possible pair of input variables, but also the mean and standard deviation of each input variable.

000 0051(d)

000 0051(d)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

PPMCR can have an unlimited number of observations per variable. The output can be punched and then submitted at a later date as input to another program, such as regression analysis, or it can be passed directly to another program in STPAC. All computations use double-precision arithmetic.

Control Cards and Their Functions

PPMCR has one optional Control Card in addition to those applicable to all STPAC programs. There is *no standard format* for this program, so a Format Card must be supplied. Also, a *Variables Card is required.*

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card will cause PPMCR to punch a deck that can be used later as input to another STPAC program [for example, DNREG, EIN No. 000 0051(h)]. Since intermediate results can be passed directly to another STPAC program, the use of punched-card output is recommended only where it is desirable to break up the run.

Description of Input Data

Data Cards must be supplied to PPMCR, along with the proper format. If, as discussed in the STPAC writeup, case and sequence numbers are used (only when all the variables do not fit on one card), the format must allow for them. Data are read by using an F- or E-format code (both for single-precision floating-point numbers). Case and sequence numbers, if used, are read with an I-format code.

Description of Output

The first page of PPMCR output is a table of means and standard deviations for each of the input variables. Then, starting on a new page, the correlation coefficients are printed in the form of a triangular matrix, with the rows and columns identified by variable

continued

000 0051(d)

number and name if a Variable-Name(s) Card was used.

If punched output was requested, the punched deck contains

(1) Title Card

(2) A set of Variable-Name(s) Cards, if the variables were named

(3) A Begin-Data Card

(4) Cards containing the means, standard deviations, and correlation coefficients and a card with the number of variables and number of observations

(5) An End-Data Card

000 0051(d)

000 0051(d)

000 0051(d)

SAMPLE INPUT

```
EXECUTE PPMCR
TITLE SNEDECOR EXAMPLE ON PAGE 414
VARIABLES 3
VARIABLE NAMES 1=X1,2=X2,3=Y
FORMAT(F3.1,F2.0,F4.2)
BEGIN DATA
0045364
0042360
0311971
0063461
0472454
0176577
0944481
1013193
1162993
1265851
1093776
2314696
2315077
2164493
2315695
0193654
2685816R
2995199
END DATA
EXECUTE SIGPP
INPUT FROM PPMCR
LEVEL .1 TEN
EXECUTE ONREG
INPUT FROM PPMCR
DEPENDENT Y
PARSIMONY
EXECUTE UPREG
INPUT FROM PPMCR
DEPENDENT Y
EXECUTE CANON
INPUT FROM PPMCR
LEFT Y
RIGHT X1,X2
EXECUTE FANAL
INPUT FROM PPMCR
FACTORS 3
EXECUTE VARMX
INPUT FROM FANAL
STOP
```

0051(d)

0051(e)

0051(h)

0051(g)

0051(i)

0051(j)

000 0051(d)

000 0051(d)

SAMPLE OUTPUT

000 0051(d)

SNEDECOR EXAMPLE ON PAGE 414

MEANS AND STANDARD DEVIATIONS

		MEANS	STD. DEV
1	X1	11.94	1[illegible].15
2	X2	42.11	1[illegible].62
3	Y	81.28	27.[illegible]0

CORRELATION COEFFICIENTS

		1 X1	2 X2
2	X2	0.4616	
3	Y	0.6934	0.3545

TOTAL NUMBER OF DATA CARDS PROCESSED: 18 NUMBER OF OBSERVATIONS: 19

NUMBER OF VARIABLES EXAMINED: 3

000 0051(d)

000 0051(d)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central processor unit was 6 seconds, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.66 + network overhead

CONTENTS—(STPAC) PPMCR

000 0051(d)

000 0051(e)

DESCRIPTIVE TITLE	Significance of Pearson Product-Moment Correlation Coefficient
CALLING NAME	(STPAC) SIGPP
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	W.M. Stiteler, III Mathematics Department, The Pennsylvania State University F. Yates Borden Forestry Department, The Pennsylvania State University H.D. Knoble, The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

SIGPP is to be used optionally in conjunction with the correlation programs to determine the significance of correlation coefficients at any desired probability levels. That is, the null hypothesis $r = 0$ (alternate: $r \neq 0$) is tested for each correlation coefficient.

REFERENCES

U.S. Department of Commerce, *Handbook of Mathematical Functions* (U.S. Government Printing Office, Washington, D.C., 1964), p.949, formula 26.7.8.

Snedecor, G.W., *Statistical Methods* (Iowa State University Press, Ames, Ia., 1961), p. 190.

000 0051(e)

000 0051(e)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

In addition to Control Cards specified for STPAC, the following Control Card may be used for this program.

Level Card(s) (optional)

Columns	*Contents*		
1–80	LEVEL	RRRRRRRR	CCCC

There may be from zero to five of these cards for a problem. LEVEL is a key word. RRRRRRRR is a two- to eight-character floating-point field, including a decimal point (e.g., .001 or .05), indicating the probability of making a type I error (rejecting the null hypothesis when it is true). 0 < RRRRRRRR < 1. CCCC is a one- to four-character symbol to be associated with RRRRRRRR (e.g., * or .05).

Description of Input Data

Punched-card output from a correlation program may be used as data. That is,

BEGIN DATA
⋮
Output from a correlation program
⋮
END DATA

By using the Input-From Card as described in the STPAC writeup, SIGPP may be executed during the same run as a correlation program.

To repeat a problem using the same data but different Level-Card options, the Same-Data Card may be used according to the STPAC rules.

NOTES:

1. Of the above three options (Punch Card, Input-From Card, Same-Data Card), one must be chosen for a problem.

continued

000 0051(e)

2. Although means and standard-deviations cards are not necessary for SIGPP, these may be left intact on punched-card input as they will automatically be ignored by this program.

3. Level Card(s), if used, may be placed anywhere after the Execute Card and before the Begin-Data Card if the latter card is present.

The approximations in the program begin to lose accuracy as the number of observations becomes less than 10. According to Ref. 1, the approximations in SIGPP are valid also for Spearman rank coefficients for cases where there are more than eight ranks.

Description of Output

A probability of making a type I error is computed for each correlation coefficient, using a two-tailed test based on a transformation and approximation of the Z (standard normal) probability density function.

If Level Card(s) have been used, the null hypothesis $H_0: r = 0$ is tested versus the alternate $H_0: r \neq 0$ at the specified level(s) of significance and a triangular matrix of results is printed, using corresponding symbols. The sign of the correlation coefficient also is printed with each respective symbol. Thus, each position of the triangular matrix of correlations will have a sign and a symbol that designate the sign and significance of the correlation coefficient of that corresponding position. All probabilities greater than the greatest probability on all of the Level Card(s) appear in the output as #NS#, meaning that the null hypothesis is to be accepted at the level of significance greater than or equal to the largest probability specified.

If no Level Card(s) have been used for a problem, each position of the triangular matrix will have a sign and the actual probability (of making a type I error or rejecting the null hypothesis when it is true) associated with the correlation coefficient of that corresponding position.

REFERENCES

1. Snedecor, G.W., *Statistical Methods* (Iowa State University Press, Ames, Ia., 1961), p. 190.

000 0051(e)

SAMPLE INPUT

```
EXECUTE PPMCR
TITLE SNEDECOR EXAMPLE ON PAGE 414
VARIABLES 3
VARIABLE NAMES 1=X1,2=X2,3=Y
FORMAT(F3.1,F2.0,F4.2)
BEGIN DATA
0045364
0042360
0311971
0063461
0472454
0176577
0944481
1013193
1162993
1265851
1093776
2314496
2315077
2164493
2315695
0193654
26858168.
2995199
END DATA
EXECUTE SIGPP
INPUT FROM PPMCR
LEVEL  .1 TEN
EXECUTE DNREG
INPUT FROM PPMCR
DEPENDENT Y
PARSIMONY
EXECUTE UPREG
INPUT FROM PPMCR
DEPENDENT Y
EXECUTE CANON
INPUT FROM PPMCR
LEFT Y
RIGHT X1,X2
EXECUTE FANAL
INPUT FROM PPMCR
FACTORS 3
EXECUTE VARMX
INPUT FROM FANAL
STOP
```

0051(d)

0051(e)

0051(h)

0051(g)

0051(i)

0051(j)

000 0051(e)

SIGNIFICANCE OF CORRELATION COEFFICIENTS OS/360 VERSION, OCTOBER, 1967.

SNEDECOR EXAMPLE ON PAGE 414

THE NULL HYPOTHESIS: R .EQ. 0 .VS. THE ALTERNATE: R .NE. 0 IS TESTED FOR EACH CORRELATION COEFFICIENT, R.

PROBABILITIES LESS THAN OR EQUAL TO 0.10000 ARE DESIGNATED BY TEN INDICATES REJECTION OF THE NULL HYPOTHESIS AT THIS LEVEL.

PROBABILITIES GREATER THAN 0.10000 ARE DESIGNATED BY #NS# INDICATES ACCEPTANCE OF THE NULL HYPOTHESIS AT THIS LEVEL.

NOTE: THE SIGN ACCOMPANYING A PROBABILITY OR SYMBOL IS THE SIGN OF THE RESPECTIVE CORRELATION COEFFICIENT.

NUMBER OF OBSERVATIONS = 18 DEGREES OF FREEDOM = 16

		1 X1	2 X2
X2	2	+ TEN	
Y	3	+ TEN	#NS#

000 0051(e)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central processor unit was 6 seconds, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.66 + network overhead

CONTENTS—(STPAC) SIGPP

000 0051(e)

000 0051(f)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

PARCOR can have an unlimited number of observations per variable. Up to 27 variables may be specified on the Include and Delete Cards for the calculation of partial correlations and multiple correlations. All computations are done in double-precision arithmetic.

Control Cards and Their Functions

There is *no standard format* for this program, so a Format Card must be supplied. A Variable Card is also required, and a Variable-Names Card may be included.

PARCOR has four types of optional Control Cards in addition to those applicable to all programs in STPAC.

Print Card (optional)

Columns	*Contents*
1– 5	PRINT

This card instructs the program to print the variance–covariance matrix for the total number of variables.

All Card (optional)

Columns	*Contents*
1– 3	ALL

This card specifies that partial correlations and multiple correlations of all the variables are to be computed, using the entire variance–covariance matrix.

Include Cards (optional)

Columns	*Contents*
1– 7	INCLUDE
9–80	i j k ···

This card instructs the program to compute partial correlation and multiple correlations for variables i, j, k, ···, only. The variable list specified for a single calculation must fit on

continued

000 0051(f)

one card. The variables may be specified by their number or, if a Variable-Names Card was supplied, by their names. They must be separated by at least one blank, and hence at most 27 variables could be specified for a single calculation.

Delete Card(s) (optional)

Columns	*Contents*
1– 6	DELETE
8–80	i j k ···

This card instructs the program to delete variables i, j, k, ···, from the calculation of partial correlations and multiple correlations. All variables specified for a single calculation must fit on one card. They may be specified by number or by name (if a Variable-Names Card was supplied), and they must be separated by one or more blanks. Up to 27 variables may be specified on each Delete Card.

Example: DELETE AGE SEX WEIGHT HEIGHT

This card specifies that all the variables *except* age, sex, weight, and height should be included in the calculation of partial and multiple correlations. In this example, the variables are specified by name, and it is assumed that a Variable-Names Card was supplied.

NOTE: PARCOR Control Cards may be inserted anywhere among the STPAC Control Cards and they may appear in any order. A given set of Control Cards may consist of any number of Include or Delete Cards and, at most, one Print Card and one All Card for any given set of data.

Description of Input Data

Data Cards must be supplied to PARCOR along with the appropriate Format Card. If, as described in the STPAC writeup, the case and sequence numbers are used (i.e., if all the variables do *not* fit on one card), the format must allow for them. Data are read using F- or E-format code, and the case and sequence numbers, if used, with an I–format code.

Description of Output

If a Print Control Card was supplied, the variance–covariance ance matrix for all the variables is printed in the form of a triangular matrix, together with the means of all the variables. The rows and columns are identified by variable numbers and, if a Variable-Names Card was supplied, by their names.

continued

000 0051(f)

000 0051(f)

000 0051(f)

For each Include, Delete, and All Card, a triangular matrix of partial correlations of the specified variables is printed. The rows and columns are identified by the variable numbers and, if a Variable-Names Card was included, by their names. The heading gives the total number of variables as well as the number of variables included in the calculation of partial correlations and multliple correlations. The multiple correlations of these variables are printed below the matrix.

000 0051(f)

000 0051(f)

SAMPLE INPUT

```
EXECUTE PARCOR
VARIABLES 30
VARIABLE NAMES 1=VAR1,2=VAR2,3=VAR3,4=VAR4,5=VAR5,6=VAR6,7=VAR7,8=VAR8,
VARIABLE NAMES 9=VAR9,10=VAR10,11=VAR11,12=VAR12,13=VAR13,14=VAR14,15=VAR15,
VARIABLE NAMES 16=VAR16,17=VAR17,18=VAR18,19=VAR19,20=VAR20
TITLE TEST OF PARTIAL CORRELATIONS PROGRAM
FORMAT  (2X,78-1,0)
PRINT
INCLUDE  19 20 21 22 23 24 25 26 27 28 29 30
DELETE VAR1 VAR2 VAR3 VAR4 VAR5 VAR6 VAR7 VAR8 VAR9 VAR10 VAR11 VAR12 VAR13
INCLUDE VAR5 VAR10 VAR15
ALL
DELETE VAR1 VAR3 VAR5 VAR7 VAR29 VAR30
DELET 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
BEGIN DATA
0167656646566667767547656576767566556666564477565655565666666577046576526666036[illegible]
0244507157757705704447605556405655266657502232266546655507503254407755756556465[illegible]
0305405305706604304407407507405506355706406407507565505507506404507607560750465[illegible]
0404753405606325453556405546403456447655467447267555604407336465406705604454[illegible]
0504566657657557664565656766744770765775545574770760760607654577465065077575055[illegible]
0655544642143447447575444445545543653643266643574462455266456464754543335575552[illegible]
0702504505504504405504704404504604365340465045036034044044053055045024033555053044
0803403404402403343443404403203430323024025032024053024043063432043723403503402403[illegible]
0953502344304403303743304454202251404602203203203403424452041032042064303250333042
1003603304304503303403305405402452444403305302305402405645523404406444302403403[illegible]
1104654556554564464455704545403405575545776443654455355655476546406556607546[illegible]
1255403465454554552505405454304755375465154542466605472654405544506576305305455[illegible]
                    .          .          .          .
                    .          .          .          .
                    .          .          .          .
4654404444404534765744034446433446033733535034034654646564355664013555755055544
4734565304505405604305454504405374046545355406374604554504704455673564553403[illegible]
4806352303405305563342534054433044443043045053045035544034525543403403303403[illegible]
4906443303304502203342403255403204404303101405464403346443403403403443303403[illegible]
5004453304475404403205404405343354465302305304204403364403403403435755033045[illegible]
5154553464405405033544043452543443443043044062045545034555544555345405503303[illegible]
5206556444405455544354503440540444534454444550545555545044035145454056055453[illegible]
5305545364655406504454652305503405444404403404305504643404404405305545444453543[illegible]
5403304344403301404344503440340430335440340330430554540350440530550430430250440[illegible]
5505606404605404024043454552054044054054046064056055047035055044067056055056635[illegible]
5676364575573375444454164271164262355373452464463256263352454663303326456336560[illegible]
5756354644354454305454402203144165357303544404554346252303454452304204443355453[illegible]
5804303405606604305445424430340440424204544340430446642052034054011204444404206[illegible]
5904102102104101203415110410210220420333235230110210130120114437510410320210130[illegible]
6045503555554405455404306430450434463453653545044455553562055745025635455523054[illegible]
6156553404766465546455555055403054653566044054554545546667044735535054044445555
6205704554607556545556456757304054055565567076047067057077567055655555577475044576
6355303345606205344506546546304407344255404605655454466565540564154554430445145[illegible]
6405553344464405403402305404344355455304446505304504503555453504405504034046063
6501202302301204403742202252553203430240140434130225230210220436335420224235440[illegible]
6601205353301201202101502302502203201102302305202201302102361302204202203302202[illegible]
6702104263353242201202602152403354144144301455403203153352352442103301541642522
6802251252101272163272361251472241162142201171101102151110127310120415114125110[illegible]
6905142301402202101203201302201102203201303255101202203303301202204201201202301[illegible]
7001201202302202101101101201101101201302102401101101301201102104101101172301[illegible]
7104402406505706705506305705506407405304505605456405704024036057037074564044066
END DATA
```

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000 0051(f)

SAMPLE OUTPUT

TEST OF PARTIAL CORRELATIONS PROGRAM

*** VARIANCE-COVARIANCE MATRIX ***

		1 VAR1	2 VAR2	3 VAR3	4 VAR4	5 VAR5	6 VAR6	7 VAR7	8 VAR8	9 VAR9	10 VAR10	11 VAR11	12 VAR12
1	VAR1	7.21E 00											
2	VAR2	5.86E-01	2.00E 00										
3	VAR3	2.00E-01	6.43E-01	2.00E 00									
4	VAR4	2.32D 00	1.17E 00	6.25D-01	7.70E 00								
5	VAR5	1.11D 00	6.00E-01	7.71D-01	7.43E-01	2.00D 00							
6	VAR6	1.66D 00	3.43D-01	4.71D-01	1.19E 00	5.29D-01	2.00E 00						
7	VAR7	3.82D 00	4.00D-01	1.43D-01	2.50D 00	1.17D 00	8.00E-01	6.77D 00					
8	VAR8	7.29E-01	3.86E-01	8.86D-01	3.86D-01	8.14D-01	5.86E-01	8.57E-01	2.00D 00				
9	VAR9	-3.71E-01	7.14E-01	8.43D-01	-7.14D-02	5.14D-01	-1.71E-01	4.29E-02	1.20D 00	2.00D 00			
10	VAR10	2.20D 00	5.43E-01	5.00D-01	2.58E 00	7.57D-01	1.16E 00	2.71D 00	1.33D 00	7.00E-01	7.18D 00		
11	VAR11	2.00D-01	8.00E-01	1.00D 00	7.00D-01	4.43D-01	2.00E-01	-1.43E-01	1.11D 00	1.27E 00	8.71D-01	2.00D 00	
12	VAR12	0.0	5.57D-01	5.86D-01	-3.14D-01	4.86D-01	1.43E-01	-2.29E-01	1.13D 00	1.43E 00	5.29D-01	1.40D 00	2.00D 00
13	VAR13	2.55D 00	5.43E-01	5.57D-01	3.39D 00	9.00D-01	1.01E 00	2.47D 00	3.00D-01	1.43E-02	2.43D 00	2.43D-01	2.57D-01
14	VAR14	7.43D-01	7.43E-01	8.86D-01	1.41D 00	4.86D-01	9.86E-01	4.29E-01	8.86D-01	5.86E-01	1.11D 00	1.11D 00	5.57D-01
15	VAR15	8.71D-01	8.00E-01	8.86D-01	8.29E-01	9.43D-01	7.43D-01	5.00E-01	1.17D 00	8.57D-01	1.29D 00	9.43D-01	8.57D-01
16	VAR16	2.51D 00	2.71E-01	6.86D-01	2.69D 00	5.71D-01	1.47E 00	2.27D 00	4.43D-01	-1.14E-01	1.83D 00	4.57D-01	2.86D-02
17	VAR17	1.06D 00	6.29E-01	6.57D-01	7.71D-01	6.43D-01	1.03E 00	4.00E-01	7.43D-01	3.14D-01	8.29D-01	4.71D-01	6.29D-01
18	VAR18	1.06D 00	-1.57E-01	4.57D-01	8.57D-02	8.57D-02	2.14E-01	2.00E-01	3.57D-01	2.71D-01	2.57D-01	3.29D-01	3.71D-01
19	VAR19	1.50D 00	3.86E-01	3.71D-01	2.77E 00	2.29D-01	5.86E-01	1.69D 00	-3.57D-01	-2.86E-01	8.67D-01	2.86D-01	-6.71D-01
20	VAR20	6.57D-01	5.57E-01	5.86D-01	8.29D-01	7.29D-01	6.29E-01	2.29D-01	1.30D 00	1.31D 00	6.71D-01	1.40D 00	1.03D 00
21		5.86D-01	0.0	6.86D-01	8.00D-01	8.86D-01	6.86E-01	1.03D 00	6.71D-01	3.43E-01	1.03D 00	5.14D-01	3.86D-01
22		2.53D 00	2.14E-01	2.71D-01	2.80D 00	5.14D-01	1.13E 00	2.02D 00	-1.57D-01	-1.00E-01	1.88D 00	2.00D-01	-5.29D-01
23		1.29D-01	7.00E-01	5.43D-01	2.00D-01	6.29D-01	3.86E-01	-2.57D-01	1.10E 00	9.43D-01	5.71D-01	1.13D 00	9.14D-01
24		1.27D-01	6.86E-01	1.04D 00	4.23E-01	6.86D-01	4.29E-01	2.76E-01	1.01D 00	9.71E-01	2.74D-01	7.86D-01	1.13D 00
25		3.22D 00	-2.57E-01	1.71D-01	2.12D 00	7.14D-02	1.03E 00	3.35D 00	6.57D-01	-1.57E-01	2.97D 00	4.71D-01	4.00D-01
26		2.14D-01	8.57E-01	1.20D 00	7.14D-01	7.57D-01	5.29E-01	2.86E-02	5.86D-01	9.86E-01	5.57D-01	1.53D 00	9.43D-01
27		6.43D-01	-1.14E-01	2.57D-01	8.57D-02	4.86D-01	4.71D-01	-2.71E-01	1.57D-01	1.43E-02	2.86D-01	1.71D-01	3.57D-01
28		3.09D 00	4.57E-01	-5.71D-02	3.55D 00	1.71D-01	1.01E 00	2.69D 00	-1.86D-01	-7.43E-01	2.31D 00	-4.00D-01	-6.00D-01
29		1.11D 00	5.71E-01	8.00D-01	1.06E 00	1.17D 00	1.09E 00	7.71E-01	1.10D 00	5.71E-01	1.14D 00	9.00D-01	7.43D-01
30		7.57D-01	2.86E-01	7.57D-01	2.57E-01	1.04D 00	6.86E-01	6.00E-01	1.03D 00	5.43E-01	8.14D-01	6.57D-01	8.71D-01
MEANS		2.23D 00	4.00D 00	4.00D 00	2.39E 00	4.00D 00	4.00E 00	2.83E 00	4.00D 00	4.00E 00	2.64D 00	4.00D 00	4.00D 00

continued

*** PARTIAL CORRELATION COEFFICIENTS MATRIX ***

TOTAL NUMBER OF VARIABLES= 30
NUMBER OF VARIABLES IN CORRELATION = 12

		19 VAR19	20 VAR20	21	22	23	24	25	26	27	28	29	30
19	VAR19	1.0000											
20	VAR20	0.1128	1.0000										
21		-0.0903	0.0308	1.0000									
22		0.2069	-0.0282	-0.1084	1.0000								
23		-0.1580	0.1176	-0.4298	-0.1023	1.0000							
24		-0.0654	0.2735	-0.0791	-0.0657	0.0935	1.0000						
25		0.2103	-0.0288	0.2759	0.2955	0.2212	-0.0075	1.0000					
26		0.1642	0.3904	0.3189	0.0246	0.4237	0.1164	-0.0762	1.0000				
27		0.1327	-0.0018	0.1536	0.0121	-0.0945	0.0584	-0.0725	-0.0143	1.0000			
28		0.0778	0.0167	-0.0360	0.3163	-0.0438	-0.0963	0.1972	-0.0392	0.0203	1.0000		
29		-0.0226	0.2430	0.2244	0.1581	0.1645	0.1695	-0.0849	-0.0813	0.0788	0.0908	1.0000	
30		-0.0800	-0.0135	0.2667	0.1517	0.3432	0.1439	-0.0179	-0.0589	0.2429	-0.0053	0.2324	1.0000

*** MULTIPLE CORRELATION COEFFICIENTS ***

19	0.5104	20	0.8037	21	0.6571	22	0.6413	23	0.8048	24	0.7266
25	0.5983	26	0.8045	27	0.4939	28	0.5492	29	0.7576	30	0.7618

continued

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*** PARTIAL CORRELATION COEFFICIENTS MATRIX ***

TOTAL NUMBER OF VARIABLES= 30
NUMBER OF VARIABLES IN CORRELATION = 17

		14 VAR14	15 VAR15	16 VAR16	17 VAR17	18 VAR18	19 VAR19	20 VAR20	21	22	23	24	25
14	VAR14	1.0000											
15	VAR15	0.2419	1.0000										
16	VAR16	0.0950	-0.1087	1.0000									
17	VAR17	0.0126	0.2085	0.0955	1.0000								
18	VAR18	0.1739	-0.1374	0.0372	0.1526	1.0000							
19	VAR19	-0.0216	-0.0609	0.2316	0.1186	0.0026	1.0000						
20	VAR20	0.2717	0.0304	-0.0381	0.0722	-0.0168	0.1070	1.0000					
21		0.0316	-0.2348	-0.0291	0.2704	-0.2352	-0.1155	0.0258	1.0000				
22		0.0289	0.0267	0.1951	0.1137	-0.1063	0.1335	-0.0443	-0.1341	1.0000			
23		0.0200	-0.1912	-0.0772	0.1776	-0.0262	-0.1632	0.1072	-0.4610	-0.0963	1.0000		
24		-0.0772	0.2285	0.2123	0.0547	0.1373	-0.1106	0.2312	-0.0169	-0.1083	0.1215	1.0000	
25		-0.0296	0.1327	0.3199	-0.1868	0.2315	0.1263	-0.0170	0.3358	0.2303	0.2539	-0.1079	1.0000
26		0.0884	0.1613	0.0404	-0.2664	0.1082	0.1819	0.3297	0.3871	0.0450	0.4555	0.0801	-0.1458
27		0.0687	0.0990	0.1055	0.0251	0.2056	0.0876	-0.0384	0.1828	-0.0042	-0.0788	-0.0156	-0.1473
28		0.0512	0.0466	0.0615	0.0647	0.0405	0.0513	-0.0134	-0.0283	0.2793	-0.0401	-0.1286	0.1496
29		0.2257	0.2183	-0.0681	0.2379	-0.1162	-0.0133	0.0842	0.1596	0.0837	0.1446	0.0324	-0.0176
30		-0.2198	0.2740	0.1013	-0.1589	0.1427	-0.0647	0.0347	0.3305	0.1449	0.3778	0.0522	-0.1012

PARTIAL CORRELATION COEFFICIENTS MATRIX (CONT.)

	26	27	28	29	30
26	1.0000				
27	-0.0425	1.0000			
28	-0.0400	-0.0139	1.0000		
29	-0.0623	0.0377	0.0326	1.0000	
30	-0.1084	0.1994	-0.0062	0.2194	1.0000

*** MULTIPLE CORRELATION COEFFICIENTS ***

14	0.7459	15	0.7895	16	0.6874	17	0.6828	18	0.5425	19	0.5646
20	0.8244	21	0.7149	22	0.6710	23	0.8177	24	0.7647	25	0.6883
26	0.9266	27	0.5503	28	0.5626	29	0.8205	30	0.7945		

*** INPUT ERROR ***
THE VARIABLE - VAR29 SPECIFIED ON THE INCLUDE OR DELETE CARD WAS NOT DEFINED ON THE VARIABLE-NAMES CARD

PROGRAM PROCEEDED TO THE NEXT PROBLEM

****** INCORRECT CONTROL CARDS ******
THE KEYWORD DELET CANNOT BE RECOGNIZED
PROGRAM PROCEEDED TO NEXT CARD

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COST ESTIMATE

For the job listed on the Sample Input, the total running time was 7 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.77 + network overhead

CONTENTS—(STPAC) PARCOR

000 0051(f)

000 0051(g)

DESCRIPTIVE TITLE	Canonical Correlation
CALLING NAME	(STPAC) CANON
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	William H. Verity Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

CANON solves successively for the most significant canonical correlation coefficients. At the same time, two sets of weights associated with each pair of canonical variates are computed.

All matrix computations are done in double-precision floating-point arithmetic. The set of criteria and predictor variables is divided into two groups: l (lefthand) and r (righthand) variables, the smaller set automatically becoming the righthand variables. The program then uses a variation of the jacobian method to extract r eigenvalues and r eigenvectors (righthand weights). These are then used through further calculations to compute r canonical correlation coefficients and r sets of lefthand weights. For each canonical correlation coefficient, chi square is computed with the aid of the eigenvalues and the parameters N (the number of observations), r, and l.

Original variables are brought into the canonical-correlation problem by means of Right- and Left-Variables Cards. Computationally, it is irrelevant whether the variables on the left or on the right are considered as criteria or predictor variables. However, to save computer time, the set with the smallest number of variables (always put into the righthand category by the pro-

continued

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gram) should be designated as *right*. Any or all of the variables brought into the problem may be named by using Name Cards according to STPAC rules.

The maximum output records for a problem may be estimated as follows. Let R be the number of righthand variables, L be the number of lefthand variables, and $R < L$. Then, the number of records equals $R(16 + L) + 10$.

Given two sets of variables—not necessarily random variables—[X_i (where $i = 1, 2, \cdots, p$, the number of predictor variables, and Y_i (where $i = 1, 2, \cdots, q$, the number of criterion variables] the problem that CANON solves is essentially that of maximizing the correlation between certain members of the two sets, simultaneously reducing the others to zero. Canonical correlation, then, may be defined in one sense as a process by which the relationship between two sets of variables is reduced to its simplest form. In canonical correlation, *both multiple criteria and multiple predictors* can be involved. (Note that, when $q = 1$ and $p > 1$, the problem is equivalent to that of multiple regression.)

For a hypothetical example, let $p = 3$ and $q = 2$. Here, it is possible to extract two canonical correlation coefficients—say R_1 and R_2. There is a total of $p + q = 5$ variables—say X_1, X_2, X_3 (predictors) and X_4, X_5 (criteria). There will be two pairs of canonical variates—say U_1V_1 and U_2V_2. Suppose for R_1 that the weights for the predictor variables are P_{11}, P_{12}, P_{13} and for the criteria variables that the weights are C_{11}, C_{12}. Then, the pair of new variates, the canonical variates, which are multiples of a linear function of the original variables, are

$$U_1 = K_{11}(P_{11}X_1 + P_{12}X_2 + P_{13}X_3),$$

$$V_1 = K_{12}(C_{11}X_4 + C_{12}X_5),$$

where the K's are arbitrary constants of proportionality and U_1 and V_1 are correlated as described by R_1. A similar situation exists for U_2 and V_2, which are correlated as described by R_2. Furthermore, in general all of the U's and V's have zero mean and unit variance; any U is independent of any other U and likewise for the V's; the correlation between any U and V is zero, except for r correlations $R_1, R_2, \cdots, R_r$, which are the correlations between U_1 and V_1, U_2 and V_2, $\cdots$, U_r and V_r.

As far as interpretation is concerned, the same difficulty arises as in factor analysis: that of knowing whether or not the linear functions correspond to anything real or whether they are merely mathematical figments.

continued

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REFERENCES

Cooley, W.W., and Lohnes, P.R., *Multivariate Procedures for the Behavioral Sciences* (John Wiley & Sons, Inc., New York, 1964), pp. 35–59.

Borko, H., *Computer Applications in the Behavioral Sciences* (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1962), pp. 267–279.

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USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

In addition to Control Cards specified in the STPAC writeup, the following Control Cards may be used for this program. At least one of each is necessary unless specified as optional. The key word and parameters for each card may be punched anywhere on that card, separated by one or more blanks, with the stipulation that the *order* of each field be adhered to as follows.

Right-Variables Card(s)

Columns	*Contents*
1–80	RIGHT III III III ··· III

RIGHT is a key word. III is either (1) a field of one- to three-digit variable numbers of those variables to be used as right variables or (2) a field of one- to eight-character variable names of those variables to be used as right variables. In the first case, III must be a number between one and the number of variables that are brought into a problem. In the second case, III must be a variable name as defined on the STPAC Name Card(s). In both cases, there may be as many of these fields per Right-Variables Card(s) as will fit on the card or as are necessary to define the problem. However, a maximum of 50 right variables is allowed. Numbered and named fields may be mixed on one card and between cards.

Examples:

```
RIGHT    7    11    2    1                    4
RIGHT    OAT    WHEAT    CORN
RIGHT    DBH      VOLUME      PINEHT    HRDWDHT    14    17
```

Left-Variables Card(s)

Columns	*Contents*
1–80	LEFT III III III ··· III

LEFT is a key word. III is defined the same as above, except that its application is to left variables.

continued

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Examples:

```
LEFT   6   3   5   8   9   10   12   21
LEFT   RELATIVE   ABSOLUTE   'NO. SPOR'
LEFT   13    PROBEL    9     STRESS     STRAIN    10
```

Tolerance Card (optional)

Columns	*Contents*	
1–80	TOL	RRRRRRRR

This card reassigns or overrides the default tolerance to be used when pivoting through the correlation matrix during inversions. The user is cautioned when changing the tolerance, which is set to 0.01 as a default. The tolerance may not be changed to any value outside the range 10^{-1}–10^{-7} and will be reset to 10^{-2} if an attempt is made to do so.

TOL is a key word. RRRRRRRR is a two- to eight-character floating-point field, including a decimal point, designating the tolerance to be used for the current problem.

Description of Input Data

Punched-card output from a Pearson product–moment correlation program may be used as data. That is,

```
BEGIN DATA
   :
Output from a Pearson product–moment correlation program
   :
END DATA
```

By use of the Input-From Card as described in the STPAC writeup, CANON may be executed during the same run as a correlation program.

To repeat a problem using the same data but different Right-Variables and/or Left-Variables options, the Same-Data Card may be used according to the STPAC rules.

NOTES:

1. Of the three above options (Punch Card, Input-From Card, Same-Data Card), one must be chosen for a problem.

2. Although means and standard-deviations cards are not necessary

continued

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for CANON, these may be left intact on punched-card input, as they will be ignored by this program.

3. The cards described above may be placed in any order after the Execute Card and before the Begin-Data Card, if one is used.

Description of Output

The normalized and unnormalized vectors of weights associated with the set of criteria variables and the corresponding vectors associated with the set of predictor variables are printed out with each canonical correlation coefficient. The value of chi square, Wilk's lambda, and the probability of obtaining a greater value of chi square associated with the hypothesis that the predictor variate is unrelated to the criteria variate also is printed with each coefficient.

Other pertinent information such as title, variable names, number of observations, degrees of freedom for chi square, and eigenvalues used in calculation of the weights also will be printed.

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SAMPLE INPUT

```
EXECUTE PPMCR
TITLE SNEDECOR EXAMPLE ON PAGE 414
VARIABLES 3
VARIABLE NAMES 1=X1,2=X2,3=Y
FORMAT(F3.1,F2.0,F4.2)
BEGIN DATA
0045364
0042360
0311971
0063461
0472454
0176577
0944481
1013193
1162993
1265851
1093776
2314696
2315077
2164493
2315695
0193654
26858168.
2995199
END DATA
EXECUTE SIGPP
INPUT FROM PPMCR
LEVEL  .1 TEN
EXECUTE ONREG
INPUT FROM PPMCR
DEPENDENT Y
PARSIMONY
EXECUTE UPREG
INPUT FROM PPMCR
DEPENDENT Y
EXECUTE CANON
INPUT FROM PPMCR
LEFT Y
RIGHT X1,X2
EXECUTE FANAL
INPUT FROM PPMCR
FACTORS 3
EXECUTE VARMX
INPUT FROM FANAL
STOP
```

000 0051(d)

000 0051(e)

000 0051(h)

000 0051(g)

000 0051(i)

000 0051(j)

000 0051(g)

CANONICAL CORRELATION PSU OS/360 STATISTICAL PACKAGE VERSION - MARCH, 1968.

SNEDECOR EXAMPLE ON PAGE 414

EIGENVALUE 1 0.48231278

SUM OF EIGENVALUES = 0.48231278

NO. VARIABLES IN CORRELATION ARRAY = 3
WILKS LAMBDA = 0.518
SQUARED CANONICAL CORRELATION COEFFICIENT = 0.482

NO. OF OBSERVATIONS = 16
CHI-SQUARE = 10.5 WITH 2 DEGREES OF FREEDOM
CANONICAL CORRELATION COEFFICIENT = 0.694

VARIABLE NAME	VARIABLE NUMBER	NORMALIZED LEFT-HAND WEIGHTS	UNNORMALIZED LEFT-HAND WEIGHTS
X1	1	0.998	0.673
X2	2	0.065	0.044

VARIABLE NAME	VARIABLE NUMBER	NORMALIZED RIGHT-HAND WEIGHTS	UNNORMALIZED RIGHT-HAND WEIGHTS
Y	3	1.000	1.000

PROBABILITY OF A GREATER VALUE OF CHI-SQUARE = 0.005

000 0051(g)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central processor unit was 6 seconds, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.66 + network overhead

CONTENTS—(STPAC) CANON

000 0051(g)

000 0051(h)

DESCRIPTIVE TITLE	Step-Up and Step-Down Multiple Linear Regression
CALLING NAME	(STPAC) UPREG/DNREG
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Dennis Deaven (programming) The Pennsylvania State University Computation Center M.A. Efroymson (flow charts)
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

UPREG/DNREG computes stepwise multiple-regression equations, adding or deleting one variable at a time until no variables remain to add significantly to the equations or until no significant variables remain in the equation. At each step, the following are printed for those variables currently in the equation.

(1) Regression coefficients

(2) Standard deviation of the regression coefficients

(3) Standard regression coefficients

(4) Partial correlation coefficients

(5) Fraction of explained variance

(6) Multiple correlation coefficient

(7) Regression-equation intercept

(8) Standard deviation of the dependent variable (UPREG only)

(9) F value for the variable entering or leaving the equation (UPREG only)

continued

000 0051(h)

UPREG

In the step-up procedure, intermediate results are used to give statistical information at each step in the calculation. These intermediate answers are also used to control the method of calculation. A number of intermediate-regression equations are obtained, as well as the final multiple-regression equation. These equations are obtained by adding or deleting one variable at a time, giving the following equations.

$$Y = b\ (0) + b\ (1)x(1),$$

$$Y = b'(0) + b'(1)x(1) + b'(2)x(2),$$

$$Y = b''(0) + b''(1)x(1) + b''(2)x(2) + b''(3)x(3)$$

$$\vdots$$

The variable added is the one that makes the greatest improvement in goodness of fit. The coefficients represent the best values when the equation is fitted by using the specific variables included in the equation. An important property of this procedure is that a variable may be indicated to be significant in any early stage and thus enter the regression equation. In addition, after several other variables are added to the equation, the initial variable may be indicated to be insignificant. The insignificant variable will be removed from the regression equation before adding an additional variable. Therefore, only significant variables are included in the final multiple-regression equation.

DNREG

The step-down procedure of DNREG is simpler than the step-up procedure of UPREG. If the parsimony option has been chosen, DNREG eliminates one variable at a time, printing the intermediate results at each step. The variable eliminated is the one that contributes least to the overall significance. Note that, once a variable has been eliminated with the procedure, it is never brought back into the equation.

REFERENCES

Efroymson, M.A., "Multiple Regression Analysis," in *Mathematical Methods for Digital Computers*, A. Ralston and H.S. Wilf, Eds. (John Wiley & Sons, Inc., New York, 1965).

000 0051(h)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program

---

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute Card is essential. If PPMCR [EIN No. 000 0051(d)] is executed during the same run and Name(s) Card(s) were used, then the Variable-Name(s)-Transfer Card should be used. Note that a Variables Card is not required since PPMCR either passes the number of variables or punches it onto a card to be read by UPREG later on. Some additional required and optional Control Cards are specific to UPREG and DNREG. These are described below.

Dependent-Variable Card (one required)

Columns	*Contents*
1– 9	DEPENDENT
11–14	xxx

This card designates the variable to be used as the dependent variable. xxx is either the name or the number of one of the variables.

IN Variables Card (optional; one or more)

Columns	*Contents*
1– 2	IN
4– .	xxx yyy zzz ··· .
⋮	

This card selects variables to be forced into the equation no matter what their significance. xxx, yyy, and zzz are either the numbers or names of some of the variables.

OUT Variables Card (optional; one or more)

Columns	*Contents*
1– 3	OUT
5– .	xxx yyy zzz ··· .
⋮	

continued

000 0051(h)

This card selects variables that are *never* wanted in the equation, no matter how significant any might be. xxx, yyy, and zzz are either the numbers or names of some of the variables.

Tolerance Card (optional)

Columns	*Contents*
1– 9	TOLERANCE
11–13	xxx

This card changes the tolerance used in pivoting through the matrix. The default tolerance is 0.01. The correlation matrix is inverted by using a Gauss–Jordan technique and selecting the largest diagonal element at any given stage on which to pivot. If this pivot should become small, it often indicates a degeneracy in the correlation matrix, which indicates that one of the "independent" variables is, in fact, approximately a linear combination of other independent variables. If the tolerance is set too low, the program may develop erroneous results owing to inverting a singular correlation matrix. In any case, the *tolerance must be greater than zero.*

F-Value Card (optional; UPREG only)

Columns	*Contents*
1– 6	FVALUE
8–10	xxx

This card selects the critical F value that the program uses to determine whether to add or delete a variable from the equation. The default F value is 2.5.

Parsimony Card (optional; DNREG only)

Columns	*Contents*
1– 9	PARSIMONY

This card indicates to DNREG that the step-down procedure should be used, eliminating one variable at a time from the equation. If the parsimony option is not selected, only one set of results will be printed for each problem—that is, one equation with all variables present except those declared OUT.

Description of Input Data

Data for UPREG and DNREG are a set of means, standard deviations, and correlation coefficients, along with the number of variables

continued

000 0051(h)

and number of observations. Normally, the input comes from PPMCR (from a previous problem during the same run using the Input-From PPMCR Card *or* by using a deck that was punched by PPMCR during some previous job). If the input is supplied by cards, they must be identical in format to those punched by PPMCR.

Description of Output

The output from UPREG and DNREG consists of a series of tables, one table being produced each time a variable is added to or deleted from the equation. Each table contains all the information specified in the Functional Abstract.

000 0051(h)

000 0051(h)

SAMPLE INPUT

```
EXECUTE PPMCR
TITLE SNEDECOR EXAMPLE ON PAGE 414
VARIABLES 3
VARIABLE NAMES 1=X1,2=X2,3=Y
FORMAT(F3.1,F2.0,F4.2)
BEGIN DATA
0045364
0042360
0311971
0063461
0472454
0176577
0944481
1013193
1162993
1265851
1093776
2314696
2315077
2164493
2315695
0193654
2685816B.
2995199
END DATA
EXECUTE SIGPP
INPUT FROM PPMCR
LEVEL  .1 TEN
EXECUTE ONREG
INPUT FROM PPMCR
DEPENDENT Y
PARSIMONY
EXECUTE UPREG
INPUT FROM PPMCR
DEPENDENT Y
EXECUTE CANON
INPUT FROM PPMCR
LEFT Y
RIGHT X1,X2
EXECUTE FANAL
INPUT FROM PPMCR
FACTORS 3
EXECUTE VARMX
INPUT FROM FANAL
STOP
```

000 0051(d)

000 0051(e)

000 0051(h)

000 0051(g)

000 0051(i)

000 0051(j)

000 0051(h)

SAMPLE OUTPUT—UPREG

```
MULTIPLE REGRESSION ANALYSIS FOR: SNEDECOR EXAMPLE ON PAGE 414

TOLERANCE=.010

TOTAL NUMBER OF VARIABLES =    3
NUMBER OF OBSERVATIONS =      18

FVALUE =     2.50000

DEPENDENT VARIABLE :   3(        Y)

START REGRESSION, STANDARD DEVIATION OF THE DEPENDENT VARIABLE:     3(        Y) =       26.996
```

continued

STEP NUMBER 1

VARIABLE ENTERING:	1(X1)
STANDARD ERROR OF ESTIMATE:	0.20051D 02
F VALUE:	0.14817D 02
INTERCEPT:	0.59259D 02
MULTIPLE CORRELATION COEFFICIENT:	0.69340
FRACTION OF EXPLAINED VARIANCE:	0.48081

INDEP. VARIABLE NUMBER	AND NAME	REGRESSION COEFFICIENT	STAND.DEVIATION FOR COEFFICIENT	STAND.REGRESSION COEFFICIENT	PARTIAL CORRELATION COEFFICIENT
1	X1	0.184344E 01	0.478902E 00	0.6934031	0.6934

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
DUE TO REG	1	5.95702D 03	5.95702D 03	1.48171D 01
ABOUT REG	16	6.43259D 03	4.02037D 02	
TOTAL	17	1.23896D 04		

DIAGONAL ELEMENTS

VARIABLE IDENTIFICATION		VALUE	VARIABLE IDENTIFICATION		VALUE	VARIABLE IDENTIFICATION		VALUE
1	X1	1.000 ENTR	2	X2	0.787	3	Y	0.519 DEP

000 0051(h)

000 0051(h)

000 0051(h)

SAMPLE OUTPUT—DNREG

```
MULTIPLE REGRESSION ANALYSIS FOR: SNEDECOR EXAMPLE ON PAGE 414

PARSIMONY OPTION SELECTED

TOLERANCE=.010

TOTAL NUMBER OF VARIABLES =    3
NUMBER OF OBSERVATIONS =      18


NUMBER OF VARIABLES ELEGIBLE FOR ELIMINATION BY PARSIMONY:    2
THE NUMBER ASSOCIATED WITH THESE VARIABLES AND THEIR NAMES, IF SPECIFIED, ARE LISTED BELOW.
  1(       X1),  2(       X2)

DEPENDANT VARIABLE(NAME,IF SPECIFIED, AND ASSOCIATED NUMBER):    3(       Y)
```

000 0051(h)

continued

000 0051(h)

INDEP. VARIABLE NUMBER	AND NAME	REGRESSION COEFFICIENT	STAND.DEVIATION FOR COEFFICIENT	STAND.REGRESSION COEFFICIENT	PARTIAL CORRELATION COEFFICIENT
1	X1	0.178977D 01	0.556743D 00	0.6732183	0.6387
2	X2	0.866492D-01	0.414943D 00	0.0437310	0.0538

NUMBER OF VARIABLES PRESENTLY ELIMINATED: 0

CANDIDATE FOR THE NEXT ELIMINATION-VARIABLE: 2(X2)
F-RATIO OF VARIANCE OF AGGREGATE ELIMINATED AND CANDIDATE VARIABLES
TO UNEXPLAINED VARIANCE WITH NONE ELIMINATED: 0.4361D-01
FRACTION OF EXPLAINED VARIANCE: 0.482
MULTIPLE CORRELATION COEFFICIENT: 0.6945
INTERCEPT B(0): 0.562510D 02

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
DUE TO REG	2	5.975670 03	2.98783D 03	6.98751D 00
ABOUT REG	15	6.41394D 03	4.27596D 02	
TOTAL	17	1.23896D 04		

continued

000 0051(h)

INDEP. VARIABLE NUMBER	AND NAME	REGRESSION COEFFICIENT	STAND.DEVIATION FOR COEFFICIENT	STAND.REGRESSION COEFFICIENT	PARTIAL CORRELATION COEFFICIENT
1	X1	0.184344D 01	0.478902D 00	0.6934031	0.6934

NUMBER OF VARIABLES PRESENTLY ELIMINATED: 1
THE NUMBER ASSOCIATED WITH THE ELIMINATED VARIABLES AND THEIR NAMES, IF SPECIFIED, ARE LISTED BELOW.
2(X2)

CANDIDATE FOR THE NEXT ELIMINATION-VARIABLE: 1(X1)
F-RATIO OF VARIANCE OF AGGREGATE ELIMINATED AND CANDIDATE VARIABLES
TO UNEXPLAINED VARIANCE WITH NONE ELIMINATED: 0.6988D 01
FRACTION OF EXPLAINED VARIANCE: 0.481
MULTIPLE CORRELATION COEFFICIENT: 0.6934
INTERCEPT B(0): 0.592590D 02

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
DUE TO REG	1	5.95702D 03	5.95702D 03	1.481710 01
ABOUT REG	16	6.43259D 03	4.02037D 02	
TOTAL	17	1.23896D 04		

VALUE OF DETERMINANT = 0.7870D 00
AVERAGE ABSOLUTE DEVIATION FROM ORIGINAL ELEMENTS OF INVERSE-INVERSE MATRIX ELEMENTS = 0.20046D-16

000 0051(h)

000 0051(h)

000 0051(h)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central processor unit was 6 seconds, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.66 + network overhead

CONTENTS—(STPAC) UPREG/DNREG

000 0051(h)

000 0051(i)

DESCRIPTIVE TITLE	Factor Analysis (or Principal-Components Analysis)
CALLING NAME	(STPAC) FANAL
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	J. Cooley D. Laird L. Pryor J. McConnochie The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

FANAL solves successively for the most dominant factors represented in a (symmetric) correlation matrix. Factors are ranked according to the variance accounted for. The number of factors to be extracted is specified in advance. The program may also be used to find the dominant eigenvalues and eigenvectors of other (symmetric) positive definite matrices.

All computations are done in double-precision floating-point arithmetic. The method used is an iterative one in which a vector converges to the eigenvector. The largest eigenvalue is found first and then a deflation process is used to find the successively smaller eigenvalues. An extrapolation procedure is used to accelerate convergence of the basic iterative method.

000 0051(i)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Description of Input

The input to FANAL consists of the Control Cards described below and the lower half of the symmetric matrix plus optional diagonal elements. Normally, the symmetric matrix is the output from PPMCR [EIN No. 000 0051(d)], another STPAC program, which computes the Pearson product-moment correlation coefficients for a set of variables. The output from PPMCR may be in the form of punched cards received from some previous job or it may be passed directly to FANAL by the Input-From PPMCR option.

The symmetric matrix may also come from another program in STPAC or from a user's program. At present, PHICO [EIN No. 000 0051(k)], SPRHO [EIN No. 000 0051(m)], and PPMCR can pass their results to FANAL. In the case of a user's program, the data must be punched in *exactly* the same format that PPMCR punches its output.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute Card is required. If the data were punched by the user, a Variables Card is required also.

Factors Card (one or none)

Columns	*Contents*
1– 7	FACTORS
9–80	n, the number of factors to be extracted from the matrix

If this card is omitted, the program will attempt to extract as many factors as there are variables so long as the variance accounted for is greater than or equal to the minimum variance.

Minimum-Variance Card (one or none)

Columns	*Contents*
1–16	MINIMUM VARIANCE
18–80	x, any floating-point number, with the decimal point punched

continued

x indicates the eigenvalue at which factor extraction will be terminated. If this card is not supplied, the default minimum variance will be zero.

Correlation Card (one or none)

Columns	*Contents*
1–18	CORRELATION MATRIX

This card is a request that the input matrix be printed out.

Residual Card (one or none)

Columns	*Contents*
1–15	RESIDUAL MATRIX

This card is a request that the residual matrix be printed out prior to termination of the program.

Diagonal Card (one or none)

Columns	*Contents*
1– 8	DIAGONAL
10–80	d, a floating-point number, with the decimal point punched, followed by an optional E or D field

d is the value to be placed into each diagonal element of the matrix. An alternative version permits the entry of unique diagonal elements.

Columns	*Contents*
1–14	DIAGONAL CARDS

This card indicates that the diagonal elements will be read from Data Cards following the Begin-Data Card. They must be punched according to a specific format.

Columns	*Contents*
1	Blank
2	D
3	Blank
4– 6	Card sequence number
7–18	1st diagonal element on this card
⋮	⋮
67–78	6th diagonal element on this card

continued

000 0051(i)

Thus, card 1 would contain the diagonal elements (1,1) through (6,6) and card 5, for example, would contain the diagonal elements (25,25) through (30,30). Note that this format is identical to that used by PPMCR to punch its means and standard deviations, except for the letter D, which designates these cards as diagonal cards.

Description of Output

For each factor, the output includes the variance accounted for (the eigenvalue λ_i), the eigenvector U_i, and the vector of factor loadings f_i, where $f_i = U_i\sqrt{\lambda_i}$.

At the user's option, the input matrix can be printed out and, at the completion of the factor extraction, the residual matrix can be printed out. Also, a punched deck can be requested to be entered at a later time to VARMX [EIN No. 000 0051(j)].

000 0051(i)

000 0051(i)

SAMPLE INPUT

```
EXECUTE PPMCR
TITLE SNEDECOR EXAMPLE ON PAGE 414
VARIABLES 3
VARIABLE NAMES 1=X1,2=X2,3=Y
FORMAT(F3.1,F2.0,F4.2)
BEGIN DATA
0045364
0042360
0311971
0063461
0472454
0176577
0944481
1013193
1162993
1265851
1093776
2314696
2315077
2164493
2315695
0193654
2685816B,
2995199
END DATA
EXECUTE SIGPP
INPUT FROM PPMCR
LEVEL .1 TEN
EXECUTE DNREG
INPUT FROM PPMCR
DEPENDENT Y
PARSIMONY
EXECUTE UPREG
INPUT FROM PPMCR
DEPENDENT Y
EXECUTE CANON
INPUT FROM PPMCR
LEFT Y
RIGHT X1,X2
EXECUTE FANAL
INPUT FROM PPMCR
FACTORS 3
EXECUTE VARMX
INPUT FROM FANAL
STOP
```

0051(d)

0051(e)

0051(h)

0051(g)

0051(i)

0051(j)

000 0051(i)

SAMPLE OUTPUT

PRINCIPAL COMPONENTS ANALYSIS - SEPTEMBER 1968 VERSION - THE PENNSYLVANIA STATE UNIVERSITY COMPUTATION CENTER.

PROBLEM NAME: SNEDECOR EXAMPLE ON PAGE 414

THIS PROBLEM HAS 3 VARIABLE(S) AND 3 FACTOR(S).

FACTOR NUMBER		TEST NUMBER	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED
1	X1	1	0.89601	2.02068	0.63032	10
	X2	2	0.70114		0.49324	
	Y	3	0.85220		0.59951	

FACTOR NUMBER		TEST NUMBER	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED
2	X1	1	0.18620	0.69498	0.22498	10
	X2	2	-0.70775		-0.85515	
	Y	3	0.38653		0.46702	

FACTOR NUMBER		TEST NUMBER	FACTOR LOADING	VARIANCE (EIGENVALUE)	EIGENVECTOR	ITERATIONS REQUIRED
3	X1	1	0.40311	0.29433	0.74302	3
	X2	2	-0.08653		-0.15950	
	Y	3	-0.35263		-0.64999	

000 0051(i)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central processor unit was 6 seconds, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.66 + network overhead

CONTENTS—(STPAC) FANAL

000 0051(i)

000 0051(j)

DESCRIPTIVE TITLE	Varimax Rotation
CALLING NAME	(STPAC) VARMX
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	J. Cooley D. Thompson John McConnochie The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

VARMX can perform a number of orthogonal rotations on an arbitrary matrix of factor loadings, using the normal varimax criterion. The result is a unique (within tolerance limits) matrix of factor loadings.

All computations are done in double-precision floating-point arithmetic. First, the original factor loadings as produced by FANAL [EIN No. 000 0051(i)] are normalized by dividing the loadings in each row by the square root of the communality (sum of squares) for that row. The rotation is performed with a criterion of .005 and the resulting loadings are denormalized to give the rotated matrix.

REFERENCES

Kaiser, H.F., "Computer Program for Varimax Rotation in Factor Analysis," Educ. Psychol. Meas. *19*, 413–420 (1959).

000 0051(j)

000 0051(j)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Description of Input

The input to VARMX consists of the Control Cards described below and the matrix of factor loadings to be rotated. The factor matrix is the output from FANAL [EIN No. 000 0051(i)], either passed directly to VARMX by using the Input-From FANAL option or in the form of a card deck punched by FANAL during some previous job.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute Card is required and either an Input-From FANAL Card or a Begin-Data/End-Data sequence with a deck punched by FANAL. There are some additional Control Cards specific to VARMX. They are discussed below.

Rotate Card(s) (none, one, or more)

Columns	*Contents*
1– 6	ROTATE
8–80	$n_1 \cdots n_k$

This general form of the Rotate Card requests that k distinct rotations be performed, first rotating the first n_1 factors, then the first n_2 factors, and finally the first n_k factors. If this card is omitted, the entire matrix of factor loadings will be rotated.

NOTE: When VARMX is completed, the output from FANAL is no longer available. It is destroyed after the last rotation request is completed.

Print Card(s) (one or more)

Columns	*Contents*
1– 5	PRINT

This card requests a printout of the input matrix.

continued

000 0051(j)

Punch Card(s) (one or more)

Columns	*Contents*
1– 5	PUNCH

This card requests a punched deck of the matrix of rotated factor loadings. For each rotation, a set of cards will be punched for each variable, with each set of cards containing the corresponding rotated factor loadings for that variable. The format of the punched cards is ('VAR',I3,'CD',I2,7F10.5). The first integer field is the variable number, the second is a card sequence number for this variable, and the seven floating-point fields are for the rotated loadings. This deck can then be submitted to PPMCR [EIN No. 000 0051(d)] to correlate the rotated factors. Actually, a Format Card is punched along with some other Control Cards so that about all that the deck needs to submit it to PPMCR is an Execute PPMCR Card.

Description of Output

For each rotation, the output includes the communalities and the rotated matrix of factor loadings. At the user's option, the original input matrix can be printed out and a deck of cards containing the rotated matrix can be obtained for possible submission to PPMCR at a later date.

000 0051(j)

000 0051(j)

000 0051(j)

SAMPLE INPUT

```
EXECUTE PPMCR
TITLE SNEDECOR EXAMPLE ON PAGE 414
VARIABLES 3
VARIABLE NAMES 1=X1,2=X2,3=Y
FORMAT(F3.1,F2.0,F4.2)
BEGIN DATA
0045364
0042360
0311071
0063461
0472454
0176577
0944481
1013193
1162993
1265851
1093776
2314696
2315077
2164493
2315695
0193654
2685816B.
2995199
END DATA
EXECUTE SIGPP
INPUT FROM PPMCR
LEVEL  .1 TEN
EXECUTE DNREG
INPUT FROM PPMCR
DEPENDENT Y
PARSIMONY
EXECUTE UPREG
INPUT FROM PPMCR
DEPENDENT Y
EXECUTE CANON
INPUT FROM PPMCR
LEFT Y
RIGHT X1,X2
EXECUTE FANAL
INPUT FROM PPMCR
FACTORS 3
EXECUTE VARMX
INPUT FROM FANAL
STOP
```

0051(d)

0051(e)

0051(h)

0051(g)

0051(i)

0051(j)

000 0051(j)

SAMPLE OUTPUT

VARIMAX ROTATION

SNEDECOR EXAMPLE ON PAGE 414

THE INPUT MATRIX FROM FACTOR ANALYSIS CONTAINS 3 VARIABLES AND 3 FACTORS.

ROTATION OF FIRST 3 FACTORS

COMMUNALITIES

X1	1	1.00000
X2	2	1.00000
Y	3	1.00000

THE ROTATED MATRIX OF FACTOR LOADINGS

		F 1	F 2	F 3
X1	1	0.37412	-0.23774	0.89639
X2	2	0.14472	-0.96959	0.19737
Y	3	0.92506	-0.15712	0.34580

000 0051(j)

000 0051(j)

000 0051(j)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on central processor unit was 6 seconds, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.66 + network overhead

CONTENTS—(STPAC) VARMX

000 0051(j)

000 0051(k)

DESCRIPTIVE TITLE	Phi Coefficient
CALLING NAME	(STPAC) PHICO
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

PHICO processes a maximum of 105 variables and computes phi coefficients for all possible pairs of variables.

Data are dichotomous and are coded 0 and 1 or 1 and 2. The equation used is

$$\text{phi} = (ad-bc)/[(a+b)(c+d)(a+c)(b+d)]^{1/2}.$$

REFERENCES

Wert, J.E., Neidt, C.O., and Ahmann, J.S., *Statistical Methods in Educational and Psychological Research* (Appleton-Century-Crofts, New York, 1954).

000 0051(k)

000 0051(k)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program

Control Cards and Their Functions

Of the various STPAC Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards *are essential* for PHICO. Begin- and End-Data Cards are also necessary if the data have not already been read for a previous STPAC program. All other STPAC Control Cards are optional. There are some additional required and optional Control Cards specific to PHICO. These are described below.

Code Card (one required)

Columns	*Contents*
1– 4	CODE
6	A: data punched 0 and 1 B: data punched 1 and 2

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

If this card is included, phi coefficients will be punched on cards in addition to being printed.

Description of Input Data

Data must be punched according to the format given on the Format Card. On each card should be punched a case and sequence number (only if required, as described in the STPAC writeup) and the data points in I format. The "number" of a variable is determined by the order in which it is read, which is determined by the format supplied.

Description of Output

Phi coefficients are printed in a triangular matrix. All variables are numbered. Rows and columns will also be named according to the Variable-Names Card, if included. Card ouput is also produced when requested.

000 0051(k)

000 0051(k)

SAMPLE INPUT

```
EXECUTE PHICO
TITLE TEST OF 1S AND 2S
VARIABLES 15
FORMAT(15I1)
CODE B
BEGIN DATA
121111112222111 1
212112111122211
121222211121221
121111122211111 2
121212122211111 2
121211111222211 1
121211112211111222
121212111111222 1
END DATA
STOP
```

000 0051(k)

TEST OF 1S AND 2S

PHI COEFFICIENT SYMMETRIC MATRIX

NUMBER OF CASES 8

	1	2	3	4	5	6	7	8	9	10	11	12
- 2	-1.000											
- 3	1.000	-1.000										
- 4	-0.488	0.488	-0.488									
- 5	-0.143	0.143	-0.143	0.293								
- 6	0.378	-0.378	0.378	0.258	0.378							
- 7	-0.143	0.143	-0.143	0.293	1.000	0.378						
- 8	-0.218	0.218	-0.218	-0.149	-0.218	0.0	-0.218					
- 9	-0.378	0.378	-0.378	-0.258	-0.378	-0.500	-0.378	0.577				
- 10	-0.488	0.488	-0.488	-0.067	-0.488	-0.775	-0.488	0.447	0.775			
- 11	0.378	-0.378	0.378	-0.258	0.378	0.0	0.378	-0.577	-0.500	-0.258		
- 12	0.488	-0.488	0.488	-0.467	-0.293	-0.258	-0.293	-0.447	-0.258	0.067	0.775	
- 13	0.378	-0.378	0.378	0.258	0.378	0.500	0.378	-0.577	-1.000	-0.775	0.500	0.258
- 14	-0.293	0.293	-0.293	0.600	0.488	0.258	0.488	-0.447	-0.775	-0.467	0.258	-0.067
- 15	-0.143	0.143	-0.143	0.293	-0.143	0.378	-0.143	-0.218	-0.378	-0.488	-0.378	-0.293

	13	14
- 14	0.775	
- 15	0.378	0.488

000 0051(k)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—STPAC

000 0051(k)

000 0051(1)

DESCRIPTIVE TITLE	Kendall Rand Correlation Coefficients (tau)
CALLING NAME	(STPAC) KETAU
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

KETAU computes Kendall rank-correlation coefficients (tau), the values of z scores corresponding to them, and the probabilities and levels of significance of the z scores, for all possible pairs of variables. A correction is made for ties. The correlation coefficients will also be punched on cards, at the option of the user.

REFERENCES

Siegel, S., *Nonparametric Statistics for the Behavioral Sciences* (McGraw-Hill Book Co., Inc., New York, 1956), pp.213-222.

000 0051(1)

000 0051(1)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program

---

Control Cards and Their Functions

Of the various STPAC Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards are essential for KETAU. Begin- and End-Data Cards are also necessary if the data have not been already read for a previous STPAC program. All other STPAC Control Cards are optional. There is one additional optional Control Card specific to KETAU. This is described below.

Punch Card (optional)

Columns	*Contents*
1– 5	Punch

This card should be included if the user wishes to have the values of tau punched, in addition to being printed.

Description of Input Data

Data for all variables should be punched together. The number of a variable is determined by the order in which it is read, which is determined by the format supplied. Thus, the first variable read will be variable 1, the second will be variable 2, and so on. There is no standard format for raw or ranked data, but the data must be in F or E format. Sequence or case numbers, if needed, must be in I format.

Description of Output

The printed output for a KETAU problem consists of four triangular matrices. All are headed by the title that the user supplies. All variables are numbered and both rows and columns will be named according to the Variable-Names Card, if it is included. The first matrix consists of the values of tau for each possible pair of variables. The second is a table of z scores associated with the corresponding coefficients. The third give the probabilities of the z scores and the fourth gives their level of significance. If the total number of observations is less than 10, z scores should be interpreted with caution. However, special tables of the critical values of tau in this range are available.

000 0051(1)

000 0051(1)

SAMPLE INPUT

```
EXECUTE KETAU
FORMAT(2F2.0,F3.1)
TITLE KENDALLS RANK CORRELATION SIEGEL  PAGE 227
VARIABLE NAMES 1 = STRIVING, 2 = AUTHORIT 3 = CONFORMITY
VARIABLES 3
BEGIN DATA
 3 2 15
 4 6 15
 2 5 35
 1 1 35
 8 10 50
 11 9 60
 10 8 70
 6 3 80
 7 4 90
 12 12 105
 5 7 105
 9 11 120
END DATA
STOP
```

000 0051(1)

SAMPLE OUTPUT

KENDALLS RANK CORRELATION SIEGEL PAGE 227

KENDALL RANK CORRELATION COEFFICIENT

NUMBER OF OBSERVATIONS IS 12

		1 STRIVING	2 AUTHORIT
AUTHORIT-	2	0.6667	
CONFORMI-	3	0.3722	0.3412

CORRESPONDING Z SCORES

		1 STRIVING	2 AUTHORIT
AUTHORIT-	2	3.0172	
CONFORMI-	3	1.6845	1.5441

CORRESPONDING PROBABILITIES OF Z SCORES(PROB (X GREATER THAN OR EQUAL TO Z))

		1 STRIVING	2 AUTHORIT
AUTHORIT-	2	0.0013	
CONFORMI-	3	0.0460	0.0613

LEVELS OF SIGNIFICANCE

BLANK	IF	0.050 < P
*	IF	0.025 < P < 0.050
**	IF	0.010 < P < 0.025
***	IF	0.001 < P < 0.010
****	IF	P < 0.001

		1 STRIVING	2 AUTHORIT
AUTHORIT-	2	***	
CONFORMI-	3	*	

000 0051(1)

000 0051(1)

000 0051(1)

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the central processor unit was 4 seconds at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) KETAU

000 0051(1)

000 0051(m)

DESCRIPTIVE TITLE	Spearman Rank Correlation Coefficients (rho)
CALLING NAME	(STPAC) SPRHO
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

SPRHO computes Spearman rank-order correlation coefficients (rho) and the values of t corresponding to them for all possible pairs of variables. A correction is made for ties. The correlation coefficients will also be punched on cards at the option of the user.

REFERENCES

Siegel, S., *Nonparametric Statistics for the Behavioral Sciences* (McGraw-Hill Book Co., Inc., New York, 1956), pp. 202-213.

000 0051(m)

000 0051(m)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various STPAC Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards are essential for SPRHO. Begin- and End-Data Cards are also necessary if the data have not been already read for a previous STPAC program. All other STPAC Control Cards are optional. There is one additional optional Control Card specific to SPRHO. It is described below.

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card should be included if the user wishes to have the correlation coefficients punched in addition to being printed.

Description of Input Data

Data for all variables within one observation should be punched together. The number of a variable is determined by the order in which it is read, which is determined by the format supplied. Thus, the first variable read will be variable 1, the second will be variable 2, etc. There is no standard format, but the data must be in F or E format. Sequence and case numbers, if needed, must be in I format.

Description of Output

The printed output for a SPRHO problem consists of two triangular matrices. Both are headed by the title that the user supplies. All variables are numbered and both rows and columns will also be named according to the Variable-Name(s) Card, if it is included. The first matrix consists of the Spearman rank-order correlation coefficients for all possible pairs of variables. The second is a table of the values of t associated with the corresponding values of rho. Degrees of freedom are given as part of the heading. If the number of observations is less than 10, these values should be interpreted with caution. However, special tables of critical values of rho in this range are available.

000 0051(m)

000 0051(m)

SAMPLE INPUT

```
EXECUTE SPRHI
VARIABLES 21 SEQUENCED 17 PERCARD
VARIABLE NAMES 1=ONE,2=TWO,3=THREE,4=FOUR
TITLE    DEMONSTRATION OF SPRHI
FORMAT(2I2,19F4.2)
BEGIN DATA
 1 1 1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1 230  30  10  18
 2 1 3   5   6   8   9   4   2   1   3  28   9   8   6   4   5   2   1   9  10
 2 2235 29   8  85
 3 1 5  21  22  23  24  25  26  27  28  29  30  21  12  13  14  15  16  17  18
 3 2155 19  10 165
 4 1 20  200023  25  26  21  22  20  26  25  24  12  13  15  14  17  22  30  24
 4 226  26  13 205
 5 1 1   2   3   4   5   6   7   8   9   9   8   7   6   5   4   3   2   1   2
 5 2 1   3  26  25
 6 1 9   8   7   6   5   4   3   2   1   1   2   3   4   5   6   7   8   9   5
 6 2 65  1  175 145
 7 1 9   8   7   6   5   4   3   2   1   1   2   3   4   5   6   7   8   9   5
 7 221  205 13  11
 8 1 2  10  23  24  25  40  26  27  28  29  12  11  10  14  15  16  17  18  19
 8 226  10   2   2
 9 1 2  10  23  24  25  40  26  27  28  29  12  11  10  14  15  16  17  18  19
 9 213   4  21  22
10 111  22  31  22  24  25  26  12  13  14  15  16  17  18  19  29  28  27  26
10 2 35 13   5   5
11 111  22  31  22  24  25  26  12  13  14  15  16  17  18  19  29  28  27  26
11 2 65  7  21  23
12 1 2  19  18  17  16  15  14  13  12  11  12  13  14  15  16  17  18  19  11
12 228  28 175 165
13 1 2  19  18  17  16  15  14  13  12  11  12  13  14  15  16  17  18  19  11
13 2235 24 155 12
14 115  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  11  12  13
14 219 145 10  85
15 115  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  11  12  13
15 229  27  35   6
16 122  33  21  22  24  25  26  27  28  29  30  11  10  12  13  14  15  16  17
16 2 35  6  29  27
17 122  33  21  22  24  25  26  27  28  29  30  11  10  12  13  14  15  16  17
17 210  85 19  145
18 111  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29
18 2155 12  235 24
19 111  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29
19 2175 165 28  28
20 1 9   8   7   6   5   4   3   2   1   1   2   3  13  12   5   5  25  25  35
20 221  23  65   7
21 1 9   8   7   6   5   4   3   2   1   1   2   3  13  12   5   5  25  25  35
21 2 5   5  35 13
22 130  30  30  30  30  40  40  30  30  30  29  29  29  28  28  28  28  27  27
22 221  22  13   4
23 130  30  30  30  30  40  40  30  30  30  29  29  29  28  28  28  28  27  27
23 2 2   2  26  10
24 1 1   1   1   1   1   2   2   2   2   3   3   3   3   4   5   6   5   4  55
24 213  11  21 205
25 1232323232323232323232323232323232323232454545454545454665656565656565656532323232323232323
25 2175 145  65   1
26 1232323232323212121212121212121211232356565565656565665698989898965654545434545544 5
26 226  25   1   3
27 1999999999996666666666665555555555222533232323232312121212222121222121212121212121212
27 213  205 26  26

28 1353535353535453535353535353535565565656562626262626262989898989898984644646646564644646
28 210  165 155 19
29 1353535353535353535353535353535565565656562626262626262989898989898984644646646664644646
29 2 8   85 235 29
30 1 1   1   1   1   1   2   2   2   2   3   3   3   3   4   5   6   5   4  55
30 210  18  30  30
END DATA
STOP
```


000 0051(m)

SAMPLE OUTPUT

DEMONSTRATION OF SPRHO

SPEARMAN RANK CORRELATION COEFFICIENT

NUMBER OF OBSERVATIONS IS 30

	1 ONE	2 TWO	3 THREE	4 FOUR	5	6	7	8	9	10	11	12
TWO- 2	0.865											
THREE- 3	0.752	0.906										
FOUR- 4	0.734	0.878	0.952									
- 5	0.720	0.880	0.950	0.991								
- 6	0.739	0.868	0.943	0.982	0.971							
- 7	0.782	0.906	0.950	0.967	0.958	0.989						
- 8	0.708	0.859	0.816	0.909	0.889	0.930	0.934					
- 9	0.689	0.797	0.789	0.861	0.845	0.881	0.871	0.900				
- 10	0.712	0.794	0.787	0.865	0.847	0.871	0.844	0.849	0.955			
- 11	0.774	0.864	0.757	0.787	0.776	0.809	0.830	0.846	0.939	0.910		
- 12	0.790	0.805	0.794	0.783	0.759	0.797	0.808	0.802	0.858	0.842	0.893	
- 13	0.742	0.766	0.760	0.727	0.708	0.746	0.758	0.748	0.832	0.785	0.861	0.979
- 14	0.690	0.717	0.741	0.708	0.688	0.732	0.740	0.739	0.825	0.750	0.825	0.953
- 15	0.675	0.699	0.712	0.684	0.661	0.700	0.706	0.714	0.816	0.737	0.822	0.933
- 16	0.701	0.727	0.767	0.697	0.675	0.726	0.739	0.694	0.780	0.728	0.804	0.931
- 17	0.633	0.765	0.829	0.738	0.735	0.741	0.763	0.692	0.756	0.678	0.746	0.822
- 18	-0.229	-0.243	-0.239	-0.191	-0.232	-0.255	-0.303	-0.189	-0.101	-0.074	-0.156	-0.058
- 19	-0.127	-0.136	-0.201	-0.215	-0.241	-0.291	-0.302	-0.249	-0.170	-0.081	-0.104	-0.023
- 20	0.023	0.107	-0.007	0.020	0.065	0.067	0.098	0.192	0.030	0.033	0.078	-0.008
- 21	-0.150	-0.071	-0.150	-0.148	-0.099	-0.099	-0.077	0.006	-0.130	-0.120	-0.060	-0.172

	13	14	15	16	17	18	19	20
- 14	0.988							
- 15	0.976	0.992						
- 16	0.961	0.972	0.972					
- 17	0.864	0.873	0.864	0.851				
- 18	-0.048	-0.023	0.023	-0.014	-0.171			
- 19	-0.041	-0.077	-0.041	-0.038	-0.182	0.837		
- 20	0.007	-0.018	-0.040	-0.056	0.091	-0.523	-0.404	
- 21	-0.183	-0.198	-0.207	-0.209	-0.077	0.404	-0.255	0.837

continued

DEMONSTRATION OF SPRHO

CORRESPONDING VALUES OF STUDENT'S

28 DEGREES OF FREEDOM

NUMBER OF OBSERVATIONS IS 30

	1 ONE	2 TWO	3 THREE	4 FOUR	5	6	7	8	9	10	11	
TWO- 2	9.136											
THREE- 3	6.044	11.316										
FOUR- 4	5.718	9.696	16.396									
- 5	5.484	9.826	16.059	39.226								
- 6	5.812	9.246	14.947	27.278	21.433							
- 7	6.648	11.349	16.095	20.095	17.661	34.924						
- 8	5.305	8.164	7.470	11.515	10.262	13.385	13.819					
- 9	5.028	6.992	6.794	8.976	8.351	9.852	9.402	10.897				
- 10	5.365	6.923	6.753	9.123	8.445	9.364	8.340	8.510	16.95			
- 11	6.467	9.096	6.126	6.750	6.519	7.271	7.880	8.389	14.487	11.624		
- 12	6.807	7.184	6.906	6.657	6.167	6.981	7.262	7.098	8.851	8.247	10.488	
13	5.849	6.307	6.187	5.604	5.310	5.923	6.149	5.955	7.974	6.705	8.954	25.644
- 14	5.041	5.438	5.834	5.308	5.011	5.693	5.829	5.813	7.727	5.995	7.732	16.581
- 15	4.845	5.173	5.370	4.960	4.664	5.182	5.275	5.390	7.457	5.773	7.645	13.706
- 16	5.208	5.598	6.325	5.144	4.845	5.581	5.812	5.095	6.589	5.622	7.163	13.498
- 17	4.327	6.291	7.831	5.780	5.732	5.843	6.249	5.070	5.108	4.881	5.993	7.645
- 18	-1.246	-1.323	-1.303	-1.027	-1.265	-1.397	-1.680	-1.019	-0.536	-0.393	-0.837	-0.305
- 19	-0.679	-0.729	-1.087	-1.163	-1.316	-1.612	-1.676	-1.363	-0.913	-0.428	-0.554	-0.123
- 20	0.122	0.570	-0.038	0.107	0.346	0.353	0.521	1.036	0.161	0.173	0.416	-0.040
21	-0.801	-0.375	-0.804	-0.790	-0.525	-0.528	-0.408	0.033	-0.693	-0.641	-0.320	-0.923

	13	14	15	16	17	18	19	20
- 14	34.060							
- 15	23.595	41.763						
- 16	18.424	21.740	21.889					
- 17	9.065	9.477	9.062	8.558				
- 18	-0.255	-0.120	0.124	-0.075	-0.916			
- 19	-0.219	-0.408	-0.213	-0.201	-0.980	8.081		
- 20	0.035	-0.093	-0.215	-0.296	0.483	-3.249	-2.335	
- 21	-0.987	-1.067	-1.121	-1.129	-0.406	-2.335	-1.397	8.081

000 0051(m)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 5 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.55 + network overhead

CONTENTS—(STPAC) SPRHO

000 0051(m)

000 0051(n)

DESCRIPTIVE TITLE	Mann–Whitney U Test
CALLING NAME	(STPAC) MNWHT
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

MNWHT computes results for the Mann–Whitney U test and gives corresponding z scores, probabilities of the z scores, and levels of significance. U's are calculated for all possible pairs of variables. Observations per variable may be unequal. A correction is made for ties. U's will be punched on cards at the option of the user.

REFERENCES

Siegre, S., *Nonparametric Statistics for the Behavioral Sciences* (McGraw–Hill Book Co., Inc., New York, 1956), pp. 116–127.

000 0051(n)

000 0051(n)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program

---

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards are essential for MNWHT. Begin- and End-Data Cards also are necessary if the data have not been already read for a previous STPAC program. All other STPAC Control Cards are optional. One additional optional Control Card is specific to MNWHT and is described below.

Punch Card (optional)

Columns	*Contents*
1–5	PUNCH

This card should be included only if the user wishes to have the values of U punched on cards in addition to being printed.

Description of Input Data

Each Data Card should have a variable-identification number (in integer format), followed by a data point (in E or F format). Variable-identification numbers need not be successive, but the program's number of a variable is determined by the order in which it is read. All Data Cards for one variable should be together.

Description of Output

The printed output for a MNWHT problem consists of four triangular matrices. All tables are headed by a user-supplied title. All variables are numbered, and both rows and columns will be named according to the Variable-Names Card, if it is included. Variable identification in each table also includes the number of observations for each variable.

The first table consists of the Mann–Whitney U's for all sets of observations. The second table gives corresponding z scores. A z score in this case should be interpreted cautiously if the number of observations for both of the variables involved is less than 20. Special tables are available to determine the associated

continued

000 0051(n)

probability in that range. The third table gives the probability associated with each z score.

The fourth table gives the level of significance associated with each of the probabilities.

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SAMPLE INPUT

```
EXECUTE MNWHT
TITLE MANN-WHITNEY TEST TIME
VARIABLES 6
FORMAT(I1,2F2.0)
BEGIN DATA
1 9.
111
115
2 6
217
2 8
216
2 8
215
210
215
210
215
210
214
211
214
211
214
212
213
212
213
212
213
212
378
 .
 .
 .
513
699
670
653
651
 .
END DATA
STOP
```

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SAMPLE OUTPUT

MANN-WHITNEY TEST ONE

MANN - WHITNEY U TEST

		1	2	3	4	5
N		3	23	5	16	4
- 2 N=	23	29.500				
- 3 N=	5	0.0	0.0			
- 4 N=	16	10.500	64.000	0.0		
- 5 N=	4	3.000	20.500	0.0	30.000	
- 6 N=	4	0.0	0.0	9.000	0.0	0.0

MANN-WHITNEY TEST ONE

CORRESPONDING Z SCORES

		1	2	3	4	5
N		3	23	5	16	4
- 2 N=	23	-0.404				
- 3 N=	5	-2.236	-3.462			
- 4 N=	16	-1.532	-3.451	-3.338		
- 5 N=	4	-1.061	-1.752	-2.449	-0.192	
- 6 N=	4	-2.121	-3.153	-0.245	-3.061	-2.309

MANN-WHITNEY TEST ONE

CORRESPONDING PROBABILITIES OF Z SCORES(PROB(X GREATER THAN OR EQUAL TO Z))

		1	2	3	4	5
N		3	23	5	16	4
- 2 N=	23	0.343				
- 3 N=	5	0.013	0.000			
- 4 N=	16	0.063	0.000	0.000		
- 5 N=	4	0.144	0.040	0.007	0.424	
- 6 N=	4	0.017	0.001	0.403	0.001	0.010

MANN-WHITNEY TEST ONE

LEVELS OF SIGNIFICANCE

BLANK IF 0.050 < P
* IF 0.025 < P < 0.050
** IF 0.010 < P < 0.025
*** IF 0.001 < P < 0.010
**** IF P < 0.001

		1	2	3	4	5
N		3	23	5	16	4
- 2 N=	23					
- 3 N=	5	**	****			
- 4 N=	16		****	****		
- 5 N=	4		*	***		
- 6 N=	4	**	****		***	**

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COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) MNWHT

000 0051(n)

000 0051(o)

DESCRIPTIVE TITLE	Kruskal–Wallis One-Way Analysis of Variance
CALLING NAME	(STPAC) KRWAL
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

KRWAL does a Kruskal–Wallis one-way analysis of variance. The levels need not have equal numbers of observations in each. A correction is made for ties.

REFERENCES

Siegel, *Nonparametric Statistics for the Behavioral Sciences*, (McGraw–Hill Book Co., Inc., New York, 1956).

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000 0051(o)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed by using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various STPAC Control Cards discussed in the STPAC writeup, the Execute and Format cards are essential for KRWAL. Begin-Data and End-Data Cards also are necessary if the data have not been already read for a previous STPAC program. All other STPAC Control Cards are optional. No additional Control Cards are necessary for KRWAL.

Description of Input Data

Each Data Card must contain a level (sample) number in integer format and a data value in E or F format. Level numbers may be any integer values. They need not be consecutive but must be distinct. All Data Cards for a single level (sample) must be together. There is no standard format for this program.

Description of Output

Output consists of degrees of freedom, the value of H, and the chi-square probability of H. If there are ties in the data, the number of groups of ties, the total number of ties, and the correction factor also will be printed. If the number of observations per level (sample) is less than five, caution should be exercised in the interpretation of the chi-square probability. Tables are available for probabilities of H in this lower range.

000 0051(o)

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SAMPLE INPUT

```
EXECUTE KRWAL
TITLE SECOND TEST OF KRUSKAL WALLIS ANOVA-FIRST DATA RANKED
VARIABLES 8
FORMAT(I1,F3.1)
BEGIN DATA
1 85
1275
1475
141
156
1545
1 6
1475
1275
1 1
2525
2275
241
2525
214
2155
2 85
2 5
3475
 .
 .
 .
6185
723
7125
7125
7185
7 25
7 25
8185
8155
835

8 4
END DATA
STOP
```

000 0051(o)

SAMPLE OUTPUT

```
KRUSKALL-WALLIS ONE WAY ANALYSIS OF VARIANCE BY RANKS
SECOND TEST OF KRUSKAL WALLIS ANOVA-FIRST DATA RANKED
                    7   DEGREES OF FREEDOM
                    H =    18.565
13 GROUPS OF TIES.    56 TOTAL TIES.   CORRECTION FACTOR IS 0.9945318
              CHI SQUARE PROBABILITY =  0.009664
```

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COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) KRWAL

000 0051(o)

000 0051(p)

DESCRIPTIVE TITLE	Analysis-of-Variance Method of Unweighted Means
CALLING NAME	(STPAC) ANOVUM
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

ANOVUM is designed to handle a factorial analysis of variance with either equal or unequal numbers of observations in subclasses. The method of unweighted means is based on the assumption that the population from which the sample is drawn has proportional or equal subclass numbers. It can be relied upon only if the subclass numbers are approximately equal and presumably represent a population with equal numbers. The analysis is performed upon the means for each cell, and each sum of squares is multiplied by the harmonic mean of the number of observations per cell. Up to 150 variables (separate analyses) will be permitted with data code = 1. Only 1 variable is acceptable with data code = 0.

A Bartlett's test for homogeneity of variance is performed on the raw data. If the chi square computed in this test is significant at the 0.05 level, the conclusions of the analysis of variance should be interpreted cautiously. If cell frequencies are greater than 1, and if they are equal, a Scheffe's test will be performed on main effects.

REFERENCES

Winer, B.J., *Statistical Principles in Experimental Design* (McGraw-Hill Book Co., Inc., New York, 1962), pp. 95–96, 222–224.

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USER INSTRUCTIONS

This Program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute and Format Cards are essential for ANOVUM. Begin- and End-Data Cards are also necessary if the data have not already been read for a previous STPAC program. All other STPAC Control Cards are optional. Some additional Control Cards are required and some optional Control Cards are specific to ANOVUM (see below).

Treatments Card (required)

Columns	*Contents*
1–10	TREATMENTS
12	N, the number of treatments
14–19	LEVELS
21–80	$L_1, L_2, \cdots, L_N$; L_i is the number of levels for the ith treatment

Data-Code Card (required)

Columns	*Contents*
1– 9	DATA CODE
11	1: there is one data point per variable per card, preceded by cell identification
	0: all data for a single cell are punched on a single card or card sequence. If more than one Data Card per cell is required (i.e., if cell identification and data use more than 80 columns), a sequence number must be included on each card, following the cell identification. See Data Cards, below.

Equal or Unequal Card (required only if data code is 0)

Columns	*Contents*
1–80	EQUAL n SEQUENCED m PERCARD
	or

continued

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Columns	*Contents*
	UNEQUAL n SEQUENCED m PERCARD

This card indicates whether the cell frequencies are equal or unequal. n must be the number of observations per cell if cells are equal or the maximum number of observations per cell if cells are unequal.

The next three fields may be omitted if only one Data Card per cell is necessary. If, however, more than one Data Card per cell is necessary, the last three fields of this card must be included. m, in this case, is the number of data points per card.

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card should be included only if the user desires punched-card output of means.

Cell Summary Card (optional)

Columns	*Contents*
1–12	CELL SUMMARY

This card calls for a summary table of cell frequencies, means, variance, and degrees of freedom to be printed.

Treatment Summary Card (optional)

Columns	*Contents*
1–17	TREATMENT SUMMARY

This card calls for a summary table of totals, number of observations, means, and sums of squares for each treatment group and combination to be printed.

Missing-Data Card (optional)

Columns	*Contents*
1–12	MISSING DATA
14–21	x, any number up to eight digits, including a decimal, which will be read as a code for missing data

Include this card only if some data are missing. If this card is omitted, it will be assumed that all fields contain data (blanks

continued

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will be read as zero). If this card is included with Cols. 14–21 blank, zeros and blanks in the Data Cards will be treated as missing data. If Cols. 14–21 are punched, the number x in a data field will be treated as a case of missing data.

Scheffe Card (optional)

Columns	*Contents*
1– 7	SCHEFFE
9–80	Desired level of alpha for the Scheffe test. (The default level of alpha is 0.05.)

No standard format is provided for this program; format must be supplied by the user as specified in the requirements for STPAC.

Data Cards

Data Cards are punched with code numbers signifying level for each treatment, starting at the lefthand side of the card (cell identification). These must be in integer format. The first (I_1) indicates level for treatment 1; the second (I_2) indicates level for treatment 2; etc. If any of the $I_1,\cdots,I_N$ are blank or zero, the card will be ignored by the program. If any of the $I_1,\cdots,I_N$ are greater than the maximum number of levels specified on the Treatments Card, the analysis will not be performed.

If the data code is 1, a single data point for each of the variables specified (in F, D, or E format) follows the cell identification. Data Cards with this data code may be in any order.

If the data code is 0, and cell frequencies are unequal, the number of data points in that particular cell (in I format) must immediately follow the cell identification. If a sequence number is also required, it (also in I format) follows the number of data points. In the case where more than one card per cell is needed under data code = 0, cell identification, number of data points, and sequence number must be the first items of information on *every* card. Data fields follow the preceding fields. All cards for a single cell must be together.

Data Code = 1 FORM: $I_1,\cdots,I_N\ X_1,\cdots,X_K$

where $I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; $X_1,\cdots,X_K$ are data points, one for each of K specified variables.

continued

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Data Code = 0 FORM 1: $I_1,\cdots,I_N\ X_1,\cdots,X_n$

WHEN: cell frequencies are equal

all data for a cell on single card

$I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; $X_1,\cdots,X_n$ are the n data points as specified on the Equal Card.

FORM 2: $I_1,\cdots,I_N\ M\ X_1,\cdots,X_M$

WHEN: cell frequencies are *un*equal

data for a cell on single card

$I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; M (an integer) is the number of data points in that particular cell; $X_1,\cdots X_M$ are the M data points.

FORM 3: $I_1,\cdots,I_N\ J\ X_1,\cdots,X_m$

WHEN: cell frequencies are equal

more than 1 card necessary for all data points in each cell

$I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; J (integer) is the card sequence number; $X_1,\cdots,X_m$ are the m data points per sequenced card, as specified on the Equal Card.

FORM 4: $I_1,\cdots,I_N\ M\ J\ X_1,\cdots X_m$

WHEN: cell frequencies are *un*equal

more than 1 card necessary for all data points in each cell

$I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; M (integer) is the number of data points in that particular cell and must be repeated for every card in that cell; J (integer) is the card sequence number; $X_1,\cdots,X_m$ are the m data points per sequenced card, as specified on the Unequal Card.

Description of Output

For each cell, mean, number, variance, degrees of freedom, and cell identification are printed at the option of the user. Chi square, correction factor, degrees of freedom, and probability are printed for the Bartlett's test for homogeneity of variance. For each treatment group and combination, total, number of observations, mean, and sum of squares are given at the option of the user. An analysis-of-

continued

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variance summary table, including treatment names (according to Treatment—Names Card), sums of squares, degrees of freedom, mean squares, and F ratios, and their probabilities will be given, along with the output from the Scheffe's test if applicable.

REFERENCES

Winer, B.J., *Statistical Principles in Experimental Design* (McGraw—Hill Book Co., Inc., New York, 1962), pp. 95—96, 222—224.

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SAMPLE INPUT

```
EXECUTE ANOVUM
TITLE DEMONSTRATION OF ANOVUM WITH EQUAL OBSERVATIONS PER CELL
TREATMENTS 3 LEVELS 2 2 2
TREATMENT SUMMARY
VARIABLES 1
CELL SUMMARY
TREATMENT NAMES 1=SEX,2=INCOME,3=DUR
FORMAT(3I1,2F2.0)
DATA CODE 0
EQUAL 2
BEGIN DATA
1112536
1122943
1211513
1221012
211 9 8
21211 7
221 5 4
222 6 8
END DATA
STOP.
```

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SAMPLE OUTPUT

DEMONSTRATION OF ANOVUM WITH EQUAL OBSERVATIONS PER CELL

VARIABLE NUMBER 1

MEAN	N	VARIANCE	DEGREES OF FREEDOM	CELL		
30.500	2	60.5000	1	1	1	1
36.000	2	98.0000	1	1	1	2
14.000	2	2.0000	1	1	2	1
11.000	2	2.0000	1	1	2	2
8.500	2	0.5000	1	2	1	1
9.000	2	8.0000	1	2	1	2
4.500	2	0.5000	1	2	2	1
7.000	2	2.0000	1	2	2	2

CORRECTION FACTOR IS 1.37500

BARTLETT'S TEST OF HOMOGENEITY OF VARIANCE:
CHI SQUARE = 9.5680 PROBABILITY = 0.214402
7 DEGREES OF FREEDOM
USE CAUTION IN INTERPRETATION IF ANY CELL FREQUENCIES ARE LESS THAN 3

continued

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DEMONSTRATION OF ANOVUM WITH EQUAL OBSERVATIONS PER CELL

CELL FREQUENCIES ARE EQUAL - STANDARD ANALYSIS FOLLOWS

VARIABLE NUMBER 1

TREATMENT LEVEL			TOTAL	N	MEAN	SUM OF SQUARES
1			[illegible].0000	8	22.8750	0.418613D 04
	2		58.0000	8	7.2500	0.420500D 03
2						
	1		168.0000	8	21.0000	0.352800D 04
	2		73.0000	8	9.1250	0.666125D 03
3						
	1		115.0000	8	14.3750	0.1653130 0
	2		126.0000	8	15.7500	0.198450D 0
12						
	1	1	133.0000	4	33.2500	0.442225D 04
	2	1	35.0000	4	8.7500	0.306250D 03
	1	2	50.0000	4	12.5000	0.6250000 03
	2	2	23.0000	4	5.7500	0.132250D 03
13						
	1	1	89.0000	4	22.2500	0.1980250 04
	2	1	26.0000	4	6.5000	0.169000D 03
	1	2	94.0000	4	23.5000	0.220900D 04
	2	2	32.0000	4	8.0000	0.2560000 03
23						
	1	1	78.0000	4	19.5000	0.1521000 04
	2	1	37.0000	4	9.2500	0.342250D 03
	1	2	90.0000	4	22.5000	0.202500D 04
	2	2	36.0000	4	9.0000	0.324000D 03
123						
	1	1	61.0000	2	30.5000	0.186050D 04
	2	1	17.0000	2	8.5000	0.144500D 03
	1	2	28.0000	2	14.0000	0.392000D 03
	2	2	9.0000	2	4.5000	0.405000D 02
	1	1	72.0000	2	36.0000	0.259200D 04
	2	1	18.0000	2	9.0000	0.162000D 03
	1	2	22.0000	2	11.0000	0.242000D 03
	2	2	14.0000	2	7.0000	0.980000D 02

continued

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DEMONSTRATION OF ANOVUM WITH EQUAL OBSERVATIONS PER CELL

VARIABLE NUMBER 1

ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE		SUMS OF SQUARES	DF	MEAN SQUARES	F RATIO	PROBABILITY
1	SEX	0.976563D 03	1	0.976563D 03	45.029	0.0000
2	INCOME	0.564063D 03	1	0.564063D 03	26.009	0.0000
3	JOB	0.756250D 01	1	0.756250D 01	0.349	0.5711
12		0.315063D 03	1	0.315063D 03	14.527	0.0052
13		0.625000D-01	1	0.625000D-01	0.003	0.9585
23		0.105625D 02	1	0.105625D 02	0.487	0.5050
123		0.275625D 02	1	0.275625D 02	1.271	0.2923
ERROR		0.173500D 03	8	0.216875D 02		

CORRECTED TOTAL SUM OF SQUARES = 0.207494D 04

UNCORRECTED TOTAL SUM OF SQUARES = 0.570500D 04

TREATMENT	LEVEL	DIFFERS FROM	LEVEL	WITH ALPHA = 0.0500.	DIFFERENCE BETWEEN MEANS	SCHEFFE'S CONSTANT	ESTIMATE OF VARIANCE OF DIFFERENCES
1	1		2		0.1563D 02	2.316	0.2328D 01
2	1		2		0.1188D 02	2.316	0.2328D 01

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COST ESTIMATE

For the job listed on the Sample Input, the total running time was 8 seconds on the central-processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.88 + network overhead

CONTENTS—(STPAC) ANOVUM

000 0051(p)

000 0051(q)

DESCRIPTIVE TITLE	Analysis of Variance with Unequal Subclass Numbers (Method of Expected Subclass Numbers)
CALLING NAME	(STPAC) ANOVES
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

ANOVES is designed to handle a factorial analysis of variance with unequal numbers of observations in subclasses (cells). A problem with equal subclass numbers is acceptable, although it is not advisable to use ANOVES for a balanced design with equal subclass numbers owing to its relatively long computing time as compared to that of ANOVUM. Up to 150 variables (separate analyses) will be permitted with data code = 1. Only one variable is acceptable with data code = 0.

This method of analyzing data of multiple classifications with unequal subclass numbers is based on the assumption that the population from which the sample is drawn has proportional or equal subclass numbers. Under its fundamental hypotheses, this method affords an estimate of both the main effects and the interactions. However, every subclass must contain at least one observed value.

If the computed chi-square value for disproportionality is significant, a reduction factor will be calculated and all the sums of squares (except the with-in subclasses, which is calculated from the original data) will be reduced accordingly. This is an attempt to remove part of the disproportionality of the data.

continued

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The probability associated with the chi-square value computed by using subclass numbers is calculated and the 0.05 probability point is considered critical in determining whether a reduction factor will be computed or not.

The reduction factor is

$$\frac{N}{\sum_{1}^{K} E^2/A}$$

where N is the total number of observations, K is the number of cell subclasses, E is the expected number of observations in a cell, and A is the actual number of observations in the same cell.

A Bartlett's test for homogeneity of variance is performed on the raw data. If the chi square computed in this test is significant, the conclusions of the analysis of variance should be interpreted cautiously.

REFERENCES

Snedecor, G.W., and Cox, G.M., "Disproportionate Subclass Numbers in Tables of Multiple Classification," Ia. Agriculture Sta. Res. Bul. *180*, 233–272 (1935).

Bennett, K.R. (personal correspondence to J. Streeter).

Winer, B.J., *Statistical Principles in Experimental Design* (McGraw--Hill Book Co., Inc., New York, 1962).

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000 0051(q)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute and Format Cards are essential for ANOVES. Begin- and End-Data Cards are also necessary if the data have not already been read for a previous STPAC program. All other STPAC Control Cards are optional. Some additional Control Cards are required and some optional Control Cards are specific to ANOVES (see below).

Treatments Card (required)

Columns	*Contents*
1–10	TREATMENTS
12	N, the number of treatments
14–19	LEVELS
21–80	$L_1, L_2, \cdots, L_N$; L_i is the number of levels for the ith treatment

Data-Code Card (required)

Columns	*Contents*
1– 9	DATA CODE
11	1: there is one data point per variable per card, preceded by cell identification
	0: all data for a single cell are punched on a single card or card sequence. If more than one Data Card per cell is required (i.e., if cell identification and data use more than 80 columns), a sequence number must be included on each card, following the cell identification. See Data Cards, below.

Equal or Unequal Card (required only if data code is 0)

Columns	*Contents*
1–80	EQUAL n SEQUENCED m PERCARD
	or

continued

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Columns	*Contents*
	UNEQUAL n SEQUENCED m PERCARD

This card indicates whether the cell frequencies are equal or unequal. n must be the number of observations per cell if cells are equal or the maximum number of observations per cell if cells are unequal.

The next three fields may be omitted if only one Data Card per cell is necessary. If, however, more than one Data Card per cell is necessary, the last three fields of this card must be included. m, in this case, is the number of data points per card.

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card should be included only if the user desires punched-card output of means.

Cell Summary Card (optional)

Columns	*Contents*
1–12	CELL SUMMARY

This card calls for a summary table of cell frequencies, means, variance, and degrees of freedom to be printed.

Treatment Summary Card (optional)

Columns	*Contents*
1–17	TREATMENT SUMMARY

This card calls for a summary table of totals, number of observations, means, and sums of squares for each treatment group and combination to be printed.

Missing-Data Card (optional)

Columns	*Contents*
1–12	MISSING DATA
14–21	x, any number up to eight digits, including a decimal, which will be read as a code for missing data

Include this card only if some data are missing. If this card is omitted, it will be assumed that all fields contain data (blanks

continued

will be read as zero). If this card is included with Cols. 14–21 blank, zeros and blanks in the Data Cards will be treated as missing data. If Cols. 14–21 are punched, the number x in a data field will be treated as a case of missing data.

No standard format is provided for this program; format must be supplied by the user as specified in the requirements for STPAC.

Data Cards

Data Cards are punched with code numbers signifying level for each treatment, starting at the lefthand side of the card (cell identification). These must be in integer format. The first (I_1) indicates level for treatment 1; the second (I_2) indicates level for treatment 2; etc. If any of the $I_1,\cdots,I_N$ are blank or zero, the card will be ignored by the program. If any of the $I_1,\cdots,I_N$ are greater than the maximum number of levels specified on the Treatments Card, the analysis will not be performed.

If the data code is 1, a single data point for each of the variables specified (in F, D, or E format) follows the cell identification. Data Cards with this data code may be in any order.

If the data code is 0, and cell frequencies are unequal, the number of data points in that particular cell (in I format) must immediately follow the cell identification. If a sequence number is also required, it (also in I format) follows the number of data points. In the case where more than one card per cell is needed under data code = 0, cell identification, number of data points, and sequence number must be the first items of information on *every* card. Data fields follow the preceding fields. All cards for a single cell must be together.

Data Code = 1 FORM: $I_1,\cdots,I_N\ X_1,\cdots,X_K$

where $I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; $X_1,\cdots,X_K$ are data points, one for each of K specified variables.

Data Code = 0 FORM 1: $I_1,\cdots,I_N\ X_1,\cdots,X_n$

WHEN: cell frequencies are equal

all data for a cell on single card

$I_1,\cdots,I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; $X_1,\cdots,X_n$ are the n data points as specified on the Equal Card.

continued

000 0051(q)

FORM 2: $I_1, \cdots, I_N$ M $X_1, \cdots, X_M$
WHEN: cell frequencies are *un*equal
data for a cell on single card

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; M (an integer) is the number of data points in that particular cell; $X_1, \cdots, X_M$ are the M data points.

FORM 3: $I_1, \cdots, I_N$ J $X_1, \cdots, X_m$
WHEN: cell frequencies are equal
more than 1 card necessary for all data points in each cell

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; J (integer) is the card sequence number; $X_1, \cdots, X_m$ are the m data points per sequenced card, as specified on the Equal Card.

FORM 4: $I_1, \cdots, I_N$ M J $X_1, \cdots, X_m$
WHEN: cell frequencies are *un*equal
more than 1 card necessary for all data points in each cell

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; M (integer) is the number of data points in that particular cell and must be repeated for every card in that cell; J (integer) is the card sequence number; $X_1, \cdots, X_m$ are the m data points per sequenced card, as specified on the Unequal Card.

Description of Output

The chi-square value of the Bartlett's test for homogeneity of variance is printed out, along with its associated probability. For each cell, the total, number of observations, mean, expected total, and expected mean are printed also. The chi-square value for disproportionality is printed along with its associated probability. If this chi square is significant at the 0.05 level, the reduction factor is also printed. For each treatment group and combination, expected total, expected number of observations, and sum of squares are given. An analysis-of-variance summary table, including treatment names (according to Treatment-Names Card), sums of squares, degrees of freedom, mean squares, and F ratios, is printed last. Card output of means is provided at the option of the user.

000 0051(q)

SAMPLE INPUT

```
EXEC ANOVES
TREATMENTS 3 LEVELS 2 2 2
DATA CODE 1
TREATMENT NAMES TRANSFER
FORMAT(3I1,F2.0)
TREATMENT SUMMARY
VARIABLES 1
BEGIN DATA
11125
11229
12115
12210
211 9
21211
221 5
222 6
11131
11226
22115
22213
END DATA
STOP
```

000 0051(q)

SAMPLE OUTPUT

BARTLETT'S TEST FOR HOMOGENEITY OF VARIANCE

VARIABLE NUMBER 1

BARTLETT'S TEST CANNOT BE COMPUTED BECAUSE ONE OR MORE CELL FREQUENCIES EQUAL 1;
OR BECAUSE ONE OR MORE VARIANCES EQUAL 0.

VARIABLE NUMBER 1

CHI SQUARE OF DISPROPORTIONALITY OF SUBCLASS FREQUENCIES = 1.3333 P = 0.248213

VARIABLE NUMBER 1

TREATMENT SUMMARY - MARGINAL VALUES

FACTOR	LEVEL			EXPECTED TOTAL	EXPECTED NO.	EXPECTED MEAN	SUM OF SQUARES
1							
	1			120.7500	6.000	20.1250	0.243009D 04
	2			59.2500	6.000	9.8750	0.585094D 03
2							
	1			113.2500	6.000	18.8750	0.213759D 04
	2			66.7500	6.000	11.1250	0.742594D 03
3							
	1			93.0000	6.000	15.5000	0.144150D 04
	2			87.0000	6.000	14.5000	0.126150D 04
12							
	1	1		83.2500	3.000	27.7500	0.231019D 04
	2	1		30.0000	3.000	10.0000	0.300000D 03
	1	2		37.5000	3.000	12.5000	0.468750D 03
	2	2		29.2500	3.000	9.7500	0.285188D 03
13							
	1	1		64.5000	3.000	21.5000	0.138675D 04
	2	1		28.5000	3.000	9.5000	0.270750D 03
	1	2		56.2500	3.000	18.7500	0.105469D 04
	2	2		30.7500	3.000	10.2500	0.315188D 03
23							
	1	1		55.5000	3.000	18.5000	0.102675D 04
	2	1		37.5000	3.000	12.5000	0.468750D 03
	1	2		57.7500	3.000	19.2500	0.111169D 04
	2	2		29.2500	3.000	9.7500	0.285188D 03
123							
	1	1	1	42.0000	1.500	28.0000	0.117600D 04
	2	1	1	13.5000	1.500	9.0000	0.121500D 03
	1	2	1	22.5000	1.500	15.0000	0.337500D 03
	2	2	1	15.0000	1.500	10.0000	0.150000D 03
	1	1	2	41.2500	1.500	27.5000	0.113438D 04
	2	1	2	16.5000	1.500	11.0000	0.181500D 03
	1	2	2	15.0000	1.500	10.0000	0.150000D 03
	2	2	2	14.2500	1.500	9.5000	0.135375D 03

VARIABLE NUMBER 1

ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	DF	MEAN SQUARES	F RATIO
1	0.315188D 03	1	0.315188D 03	12.997
2	0.180188D 03	1	0.180188D 03	7.430
3	0.300000D 01	1	0.300000D 01	0.124
12	0.168750D 03	1	0.168750D 03	6.959
13	0.918750D 01	1	0.918750D 01	0.379
23	0.918750D 01	1	0.918750D 01	0.379
123	0.750000D 00	1	0.750000D 00	0.031
ERROR	0.970000D 02	4	0.242500D 02	

UNCORRECTED TOTAL SUM OF SQUARES = 0.408500D 04

000 0051(q)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) ANOVES

pages

000 0051(q)

000 0051(r)

DESCRIPTIVE TITLE	Analysis of Variance with Repeated Measures (Proportionality Assumed)
CALLING NAME	(STPAC) AOVRM
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

AOVRM is designed to handle a factorial analysis of variance with repeated measures and either equal or unequal numbers of observations in subclasses (cells). A problem with no repeated measures is acceptable, although it is not advisable to use AVORM for such a design owing to the relatively long computing time as compared with that of ANOVM or ANOVES.

This method of analyzing data of multiple classifications with unequal subclass numbers is based on the assumption that the population from which the sample is drawn has proportional or equal subclass numbers. This method allows calculation of all main effects and interactions. However, every subclass must contain at least one subject and the data for every subject included must be complete.

REFERENCES

Winer, B.J., *Statistical Principles in Experimental Design* (McGraw-Hill Book Co., Inc., New York, 1962).

000 0051(r)

000 0051(r)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute, Variables, and Format Cards are essential for AVORM. Begin- and End-Data Cards are also necessary if the data have not already been read for a previous STPAC program. All other STPAC Control Cards are optional. Some additional Control Cards are required and some optional Control Cards are specific to AOVRM (see below).

Treatments Card (required)

Columns	*Contents*
1–10	TREATMENTS
12	N, the number of treatments
14–19	LEVELS
21–80	$L_1, L_2, \cdots, L_N$; L_i is the number of levels for the ith treatment

This card form is used *only* if *no* repeated measures are involved in the design. For repeated treatments, use the following form.

Columns	*Contents*
1–10	TREATMENTS
12	N, the total number of treatments
14–21	REPEATED
23	M, the number of repeated treatments
25–30	LEVELS
32–80	$L_1, L_2, \cdots, L_n$, as above. The repeated-measure treatments must be the last M of the N treatments

Data-Code Card (required)

Columns	*Contents*
1– 9	DATA CODE

continued

000 0051(r)

Data-Code Card

Columns	*Contents*
11	1: there is one data point per card, preceded by cell identification for all treatements, and the subject number
	0: all data for a single subject are punched on a single card or card sequence. If more than one Data Card per subject is required (i.e., if cell identification and data use more than 80 columns), the format supplied by the user must take this into account. The program will not. Cell identification in this case is only for the nonrepeated measures and the subject number

Observations Card (required)

Columns	*Contents*
1–12	OBSERVATIONS
14–80	N, an integer, the number of observations per cell (in the case of equal cell frequencies) or the maximum number of subjects per cell (in the case of unequal cell frequencies)

Punch Card (optional)

Columns	*Contents*
1– 5	PUNCH

This card should be included only if the user desires punched-card output of means.

Cell Summary Card (optional)

Columns	*Contents*
1–12	CELL SUMMARY

This card calls for a summary table of cell frequencies, means, variance, and degrees of freedom to be printed.

Treatment Summary Card (optional)

Columns	*Contents*
1–17	TREATMENT SUMMARY

This card calls for a summary table of totals, number of observations, means, and sums of squares for each treatment group and combination to be printed.

continued

Missing-Data Card (required if there are unequal number of subjects in subclasses)

Columns	*Contents*
1–12	MISSING DATA
14–21	x, any number up to eight digits, including a decimal, which will be read as a code for missing data

If this card is omitted, it will be assumed that all fields contain data (blanks will be read as zero). If this card is included with Cols. 14–21 blank, zeros and blanks in the Data Cards will be treated as missing data. If Cols. 14–21 are punched, the number x in a data field will be treated as a case of missing data.

Data Cards

If data code = 1, Data Cards are punched with code numbers signifying level for each treatment, the code for the subject (all in integer format), followed by a single data point (in F, E, or D format).

If data code = 0, Data Cards are punched with code numbers signifying level for each nonrepeated treatment, the code for the subject (all in integer format), followed by *all* the data for that subject (in F, E, or D format).

The order in which the data are punched if data code = 0 is critical, since order is the only way in which the program can identify the data. The first treatment level to be changed should be the last repeated-measure treatment. The last to be changed should be the first repeated-measure treatment; i.e., data for the levels of the innermost treatment in the nest of treatments should be punched first, and so on, to the outermost.

Subject codes must be consecutive, beginning with 1, for each individual cell, whether data code = 0 or 1.

Description of Output

For each cell, the mean, number, variance, degrees of freedom, and cell identification are printed at the option of the user. For each treatment group and combination, the total, number of observations, mean, and sum of squares are given, also at the user's option.

An analysis-of-variance summary table—including treatment names (according to the Treatment-Names Card, if provided), sums of squares, degrees of freedom, mean squares, and F ratios for all treatments, interactions, and error terms—is printed last.

Punched-card output of cell means is provided optionally.

SAMPLE INPUT

```
EXECUTE ANVRM
TREATMENTS 4 REPEATED 2 LEVELS 2 2 3 2
DATA CODE 0
OBSERVATIONS 2
TREATMENT SUMMARY
VARIABLES 1
FORMAT(3I1,6F2.0)
TREATMENT NAMES 1=SEX,2=OCCUPATION,3=PERIOD,4=TEST
BEGIN DATA
111415239463847
112365341493645
121425043503548
122435445534049
211354938473747
212335039463248
221385134503147
222415240463545
END DATA
STOP
```

SAMPLE OUTPUT

TREATMENT	LEVEL				TOTAL	N	MEAN	SUM OF SQUARES
1								
	1				1075.0000	24	44.7917	0.481510D 05
	2				1011.0000	24	42.1250	0.425884D 05
2								
	1				1024.0000	24	42.6667	0.436907D 05
	2				1062.0000	24	44.2500	0.469935D 05
3								
	1				720.0000	16	45.0000	0.324000D 05
	2				706.0000	16	44.1250	0.311523D 05
	3				660.0000	16	41.2500	0.272250D 05
4								
	1				912.0000	24	38.0000	0.346560D 05
	2				1174.0000	24	48.9167	0.574282D 05
12								
	1	1			523.0000	12	43.5833	0.227941D 05
	2	1			501.0000	12	41.7500	0.209148D 05
	1	2			552.0000	12	46.0000	0.253920D 05
	2	2			510.0000	12	42.5000	0.216750D 05
					⋮			⋮
134								
	1	1	1		162.0000	4	40.5000	0.656100D 04
	2	1	1		147.0000	4	36.7500	0.540225D 04
	1	2	1		168.0000	4	42.0000	0.705600D 04
	2	2	1		151.0000	4	37.7500	0.570025D 04
	1	3	1		149.0000	4	37.2500	0.555025D 04
	2	3	1		135.0000	4	33.7500	0.455625D 04
	1	1	2		209.0000	4	52.2500	0.109203D 05
	2	1	2		202.0000	4	50.5000	0.102010D 05
	1	2	2		198.0000	4	49.5000	0.980100D 04
	2	2	2		189.0000	4	47.2500	0.893025D 04
	1	3	2		189.0000	4	47.2500	0.893025D 04
	2	3	2		187.0000	4	46.7500	0.874225D 04
234								
	1	1	1		145.0000	4	36.2500	0.525625D 04
	2	1	1		164.0000	4	41.0000	0.672400D 04
	1	2	1		157.0000	4	39.2500	0.616225D 04
	2	2	1		162.0000	4	40.5000	0.656100D 04
	1	3	1		143.0000	4	35.7500	0.511225D 04
	2	3	1		141.0000	4	35.2500	0.497025D 04
	1	1	2		204.0000	4	51.0000	0.104040D 05
	2	1	2		207.0000	4	51.7500	0.107123D 05
	1	2	2		188.0000	4	47.0000	0.883600D 04
	2	2	2		199.0000	4	49.7500	0.990025D 04
	1	3	2		187.0000	4	46.7500	0.874225D 04
	2	3	2		189.0000	4	47.2500	0.893025D 04
1234								
	1	1	1	1	77.0000	2	38.5000	0.296450D 04
	2	1	1	1	68.0000	2	34.0000	0.231200D 04
	1	2	1	1	85.0000	2	42.5000	0.361250D 04

continued

2	2	1	1	79.0000	2	39.5000	0.312050D 04
1	1	2	1	80.0000	2	40.0000	0.320000D 04
2	1	2	1	77.0000	2	38.5000	0.296450D 04
1	2	2	1	88.0000	2	44.0000	0.387200D 04
2	2	2	1	74.0000	2	37.0000	0.273800D 04
1	1	3	1	74.0000	2	37.0000	0.273800D 04
2	1	3	1	69.0000	2	34.5000	0.238050D 04
1	2	3	1	75.0000	2	37.5000	0.281250D 04
2	2	3	1	66.0000	2	33.0000	0.217800D 04
1	1	1	2	105.0000	2	52.5000	0.551250D 04
2	1	1	2	99.0000	2	49.5000	0.490050D 04
1	2	1	2	104.0000	2	52.0000	0.540800D 04
2	2	1	2	103.0000	2	51.5000	0.530450D 04
1	1	2	2	95.0000	2	47.5000	0.451250D 04
2	1	2	2	93.0000	2	46.5000	0.432450D 04
1	2	2	2	103.0000	2	51.5000	0.530450D 04
2	2	2	2	96.0000	2	48.0000	0.460800D 04
1	1	3	2	92.0000	2	46.0000	0.423200D 04
2	1	3	2	95.0000	2	47.5000	0.451250D 04
1	2	3	2	97.0000	2	48.5000	0.470450D 04
2	2	3	2	92.0000	2	46.0000	0.423200D 04

ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE		SUMS OF SQUARES	DF	MEAN SQUARES	F RATIO
BETWEEN SUBJECTS					
1	SEX	0.853333D 02	1	0.853333D 02	11.571
2	OCCUPATI	0.300833D 02	1	0.300833D 02	4.079
12		0.833333D 01	1	0.833333D 01	1.130
ERROR		0.295000D 02	4	0.737500D 01	
WITHIN SUBJECTS					
3	PERIOD	0.123167D 03	2	0.615833D 02	29.859
13		0.316667D 01	2	0.1[illegible]333D 01	0.768
23		0.161667D 02	2	0.808333D 01	3.919
123		0.206667D 02	2	0.103333D 02	5.010
ERROR		0.165000D 02	8	0.206250D 01	
4	TEST	0.143008D 04	1	0.143008D 04	162.664
14		0.163333D 02	1	0.163333D 02	1.858
24		0.750000D 00	1	0.750000D 00	0.085
124		0.333333D 00	1	0.333333D 00	0.038
ERROR		0.351667D 02	4	0.879167D 01	
34		0.381667D 02	2	0.190833D 02	5.485
134		0.666667D 00	2	0.333333D 00	0.096
234		0.185000D 02	2	0.925000D 01	2.659
1234		0.316667D 01	2	0.158333D 01	0.455
ERROR		0.278333D 02	8	0.347917D 01	

GRAND TOTAL = 0.208600D 04
NUMBER OF DATA POINTS = 48
CORRECTION FACTOR = 0.906541D 05
UNCORRECTED SUM OF SQUARES = 0.925580D 05

continued

ACCOUNT NUMBER	DATE PROCESSED	NAME OF PERSON REQUESTING RUN	USER IDENT.	MAXIMUM TIME	ACTUAL TIME	MAXIMUM RECORDS	ACTUAL RECORDS	COST	JOB NAME SITE	CAT.	SERIAL
S4002	12/08/69	DAUBERT N C	AOVRM	100	9	2000	342	$.00	AA	3	38050

000 0051(r)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 5 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.55 + network overhead

CONTENTS—(STPAC) AOVRM

000 0051(r)

000 0051(s)

DESCRIPTIVE TITLE	Bartlett's Test for Homogeneity of Variance
CALLING NAME	(STPAC) BARTL
INSTALLATION NAME	The Pennsylvania State University Computation Center
AUTHOR(S) AND AFFILIATION(S)	Nancy C. Daubert The Pennsylvania State University Computation Center
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/67
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	William H. Verity, 104 Computer Building, The Pennsylvania State University, University Park, Pa. 16802 Tel.: (814) 865-9527

FUNCTIONAL ABSTRACT

BARTL performs a Bartlett's test for homogeneity of variance on up to 6000 subgroups (or cells). Subgroups may be equal or unequal.

REFERENCES

Winer, B.J. *Statistical Principles in Experimental Design* (McGraw-Hill Book Co., Inc., New York, 1962), pp. 95–96.

000 0051(s)

000 0051(s)

USER INSTRUCTIONS

This program is one of a collection of programs that are all executed using the library program STPAC. The writeup for STPAC must be consulted for the description of additional Control Cards and procedures for running this program.

Control Cards and Their Functions

Of the various Control Cards discussed in the STPAC writeup, the Execute and Format Cards are essential for BARTL. Begin- and End-Data Cards are also necessary if the data have not already been read for a previous STPAC program. All other STPAC Control Cards are optional. Some additional Control Cards are required and some optional Control Cards are specific to BARTL (see below).

Treatments Card (required only if data code = 0 or 1—i.e., data are punched as for analysis of variance)

Columns	*Contents*
1–10	TREATMENTS
12	N, the number of treatments
14–19	LEVELS
21–80	$L_1, L_2, \cdots, L_N$; L_i is the number of levels for the ith treatment

Data-Code Card (required)

Columns	*Contents*
1– 9	DATA CODE
11	1 or 2: there is one data point per card, preceded by subgroup identification. Further differentiation between these two codes will be included in the section on Data Cards. 0: all data for a single subgroup are punched on a single card or card sequence. If more than one Data Card per subgroup is required (i.e., if subgroup identification and data use more than 80 columns), a sequence number must be included on each card, following the subgroup identification. See Data Cards, below.

continued

000 0051(s)

Equal or Unequal Card (required only if data code is 0)

Columns	*Contents*
1–80	EQUAL n SEQUENCED m PERCARD or UNEQUAL n SEQUENCED m PERCARD

This card indicates whether the cell frequencies are equal or unequal. n must be the number of observations per cell if cells are equal or the maximum number of observations per cell if cells are unequal.

The next three fields may be omitted if only one Data Card per cell is necessary. If, however, more than one Data Card per cell is necessary, the last three fields of this card must be included. m, in this case, is the number of data points per card.

No standard format is provided for this program; format must be supplied by the user as specified in the requirements for STPAC.

Data Cards

Data Cards are punched with code numbers that are the subgroup- or cell-identification numbers. These must be in integer format.

For data code = 2, the subgroup identification must be a single-integer number, and a single data point (in F, E, or D format) follows the identification number. Identification numbers in this data code need not be sequential (i.e., an analysis could be performed on subgroups identified as 1, 22, 1000, 50), but all cards for a single subgroup must be together.

For data codes = 0 and 1, Data Cards are punched with code numbers signifying level for each treatment, starting at the lefthand side of the card (cell identification). These must be in integer format. The first (I_1) indicates level for treatment 1; the second (I_2) indicates level for treatment 2; etc.

If the data code is 1, a single data point (in F, D, or E format) follows the cell identification (cell identification as in the analysis of variance). Data Cards with this data code may be in any order.

Data Code = 2 FORM: I X

where I is an integer subgroup-identification number and X is a single data point in F, E, or D format. This is the proper form whether cell frequencies are equal or unequal.

continued

000 0051(s)

Data Code = 1 FORM: $I_1, \cdots, I_N$ X

where $I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; X is a single data point.

Data Code = 0 FORM 1: $I_1, \cdots, I_N$ $X_1, \cdots, X_n$

WHEN: cell frequencies are equal

all data for a cell on single card

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; $X_1, \cdots, X_n$ are the n data points as specified on the Equal Card.

FORM 2: $I_1, \cdots, I_N$ M $X_1, \cdots, X_M$

WHEN: cell frequencies are *un*equal

data for a cell on single card

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; M (an integer) is the number of data points in that particular cell; $X_1, \cdots, X_M$ are the M data points.

FORM 3: $I_1, \cdots, I_N$ J $X_1, \cdots, X_m$

WHEN: cell frequencies are equal

more than 1 card necessary for all data points in each cell

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; J (integer) is the card sequence number; $X_1, \cdots, X_m$ are the m data points per sequenced card, as specified on the Equal Card.

FORM 4: $I_1, \cdots, I_N$ M J $X_1, \cdots, X_m$

WHEN: cell frequencies are *un*equal

more than 1 card necessary for all data points in each cell

$I_1, \cdots, I_N$ are integer cell-identification numbers, identifying one level for each of the N treatments; M (integer) is the number of data points in that particular cell and must be repeated for every card in that cell; J (integer) is the card sequence number; $X_1, \cdots, X_m$ are the m data points per sequenced card, as specified on the Unequal Card.

continued

000 0051(s)

Description of Output

For each subgroup (or cell), its variance, degrees of freedom, and identification are printed.

The chi-square value of the Bartlett's test, along with its correction factor, degrees of freedom, and associated probability are printed.

NOTE: A Bartlett's test cannot and will not be calculated if any of the subgroups have only one observation or a variance equal to 0.

000 0051(s)

000 0051(s)

000 0051(s)

SAMPLE INPUT

```
EXECUTE BARTL
CELL SUMMARY
TITLE POLAND CHINA PIGS
FORMAT(I1,9X,F3.0)
DATA CODE 1
TREATMENTS 1 LEVELS 8
BEGIN DATA
1     1     2.0
1     1     2.8
1     1     3.3
1     1     3.2
1     1     4.4
1     1     3.6
1     1     1.9
1     1     3.3
1     1     2.9
1     1     1.1
2     1     3.5
2     1     2.8
2     1     3.2
2     1     3.5
2     1     2.3
2     1     2.4
2     1     2.0
2     1     1.6
3     1     3.3
3     1     3.6
          .
          .
          .
8     1     2.4
8     1     3.0
8     1     1.5
END DATA
STOP
```

000 0051(s)

BARTLETT'S TEST FOR HOMOGENEITY OF VARIANCE

POLAND CHINA PIGS

VARIANCE	DEGREES OF FREEDOM	TREATMENT
0.90933	9	1
0.49696	7	2
0.08889	9	3
0.10214	7	4
0.14667	5	5
0.08000	3	6
0.39367	5	7
0.35000	3	8

CORRECTION FACTOR IS 1.07399

BARTLETTS'S TEST OF HOMOGENEITY OF VARIANCE:
CHI SQUARE = 17.8350 PROBABILITY = 0.012737
7 DEGREES OF FREEDOM
USE CAUTION IN INTERPRETATION IF ANY CELL FREQUENCIES ARE LESS THAN 3

CHI SQUARE IS SIGNIFICANT AT THE .05 LEVEL
DATA DO NOT SUPPORT THE HYPOTHESIS OF HOMOGENEITY OF VARIANCE

000 0051(s)

COST ESTIMATE

For the job listed on the Sample Input, the total running time was 4 seconds on the central processor unit, at $0.11 per second.

Charge to user = computer time + network overhead
= $0.44 + network overhead

CONTENTS—(STPAC) BARTL

000 0051(s)

000 0052

DESCRIPTIVE TITLE	CalComp Plotter Subroutines
CALLING NAME	See specific subroutine
INSTALLATION NAME	The University of Iowa University Computer Center
AUTHOR(S) AND AFFILIATION(S)	CalComp Modified by the University of Iowa
LANGUAGE	FORTRAN IV
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Available for use at the University of Iowa, but not for distribution
CONTACT	Mrs. Louise R. Levine, Program Librarian, Applications Programming, University Computer Center, The University of Iowa, Iowa City, Iowa 52240 Tel.: (319) 353-5580

FUNCTIONAL ABSTRACT

The CalComp plot routines are a series of subroutines used to obtain graphic output. They are designed for the following purposes:

1) providing values to scale data to fit the plotting area,
2) drawing identification symbols at plotted data points,
3) drawing connected lines between data points (when desired),
4) drawing and labeling axes at any desired orientation, and
5) selecting from a large number of characters, numbers, and special symbols, any of which can be drawn in any size and at any angular orientation anywhere on the plotting surface.

These routines have been written by CalComp and modified by the University of Iowa to run under OS on the IBM 360/65. Plotting is done off line. The user's plotter program will create a plot tape containing various commands used to drive a drum plotter (see fig. 1). Each of eight possible commands moves the pen 1/100 of an inch in one of the eight designated directions (see fig. 2). In addition there are commands to move

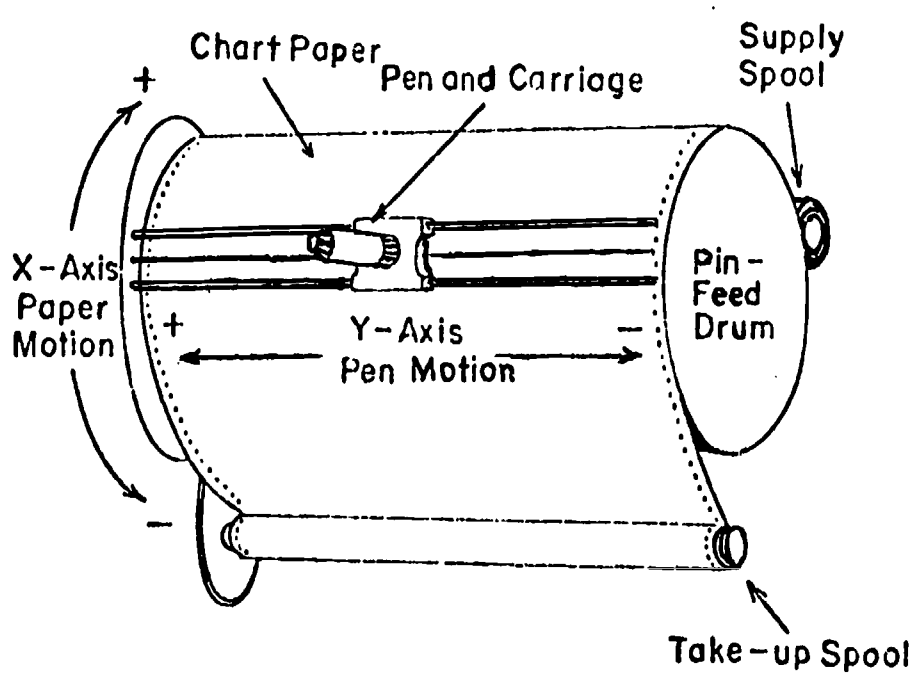
continued

000 0052

the pen up and down. The plot tape is then taken to a smaller computer which drives the CalComp plotter (see fig. 3).

Access to the plot routines is by the FORTRAN "CALL" statement. Integer and floating point conventions must be followed (i.e. integer arguments must be used where the dummy argument specifies integer, likewise for floating point). All x and y coordinates used as arguments, must be expressed as floating point inches within actual page dimensions and in deflection from the (0.,0.) origin or the established reference point which is an established (0.,0.) origin. If the y coordinates are not within actual page dimensions in deflection from the reference point, that reference point will be destroyed and anything plotted after that will be erroneous. For orientation of the paper see fig. 1. All angles must be expressed in floating point degrees, with the positive sense counterclockwise. Character heights are specified as floating point inches. These heights should be greater than 0.07 but less than page size. Page size is 11 inches high and any reasonable length, since paper is continuous to a maximum length of 120 ft.

Figure 1



continued

000 0052

Figure 2

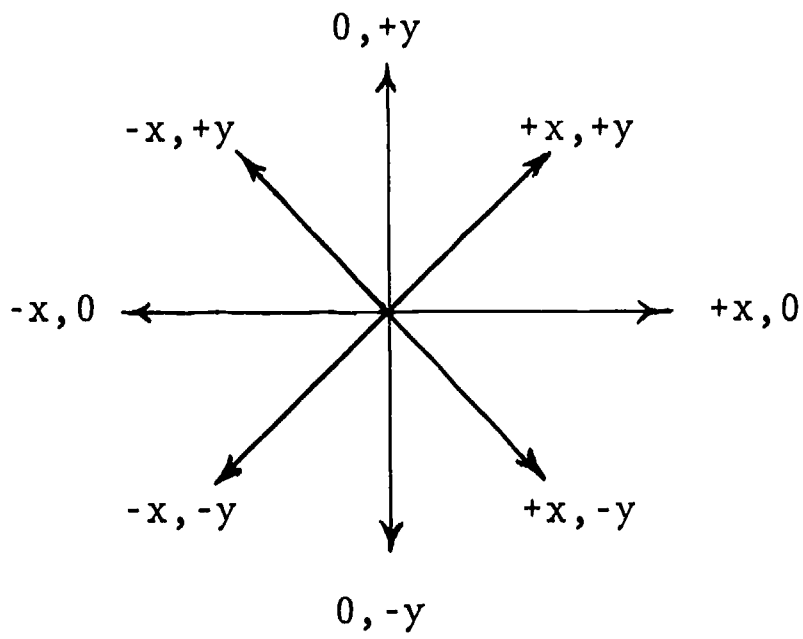
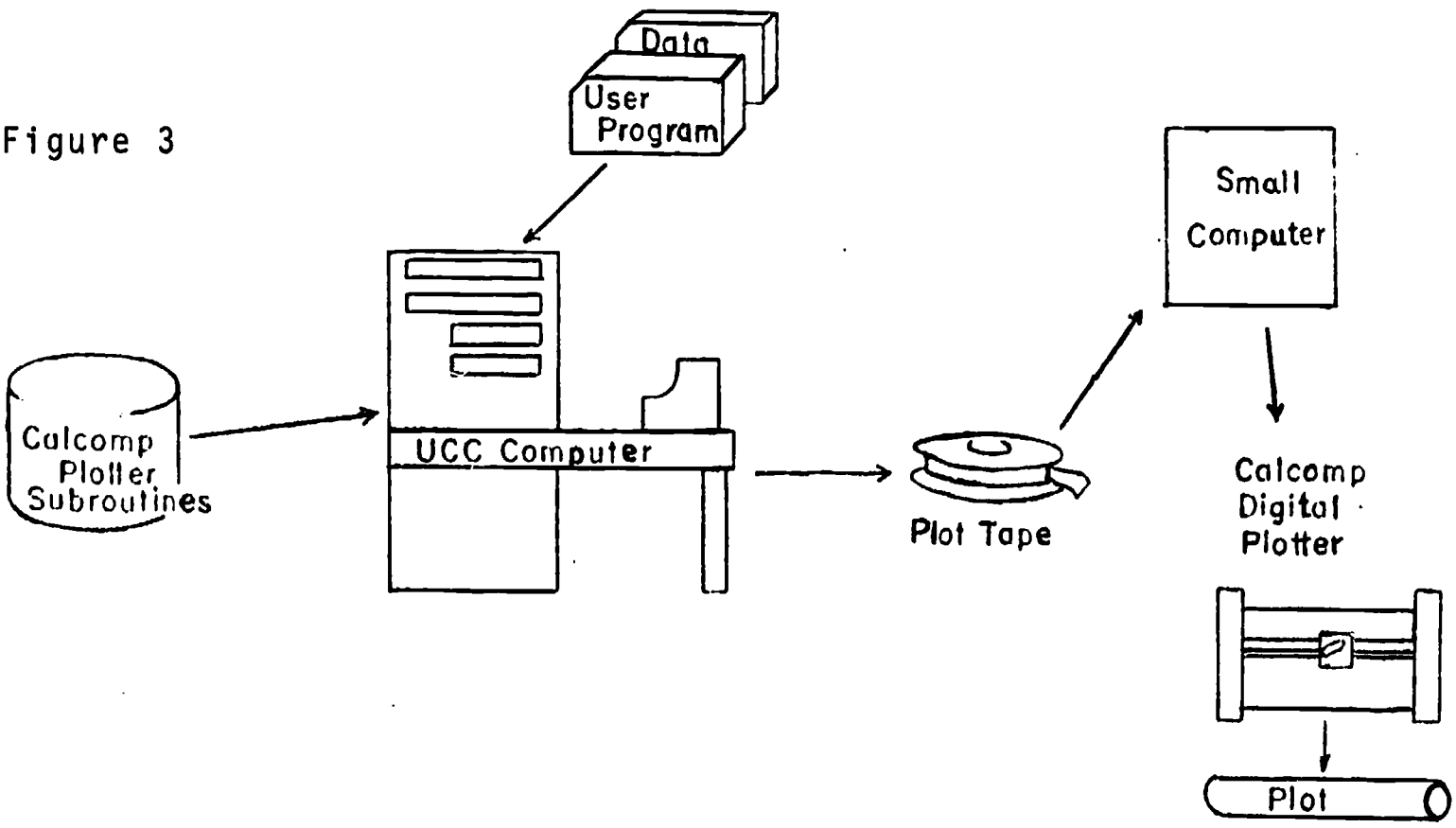


Figure 3



REFERENCES

Plotter Subroutines for CalComp Digital Incremental Plotter (Iowa City, Ia.: Univ. Comp. Ctr., Univ. of Ia., 1970), Revised. Available from the EIN Office at the cost of reproduction and mailing.

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USER INSTRUCTIONS

The user is referred to the reference below for instructions regarding use of the subroutines.

REFERENCES

Plotter Subroutines for CalComp Digital Incremental Plotter (Iowa City, Ia.: Univ. Comp. Ctr., Univ. of Ia., 1970), Revised. Available from the EIN Office at the cost of reproduction and mailing.

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SAMPLE INPUT

```
// EXEC FORTPLOT
//FORT.SYSIN DD *
      DIMENSION BUFFER(600),IDENT(9)
      DATA IDENT/'     LOUISE LEVINE  UCC PLOT COURSE '/
C SET REFERENCE POINT PENUP
      CALL PLOT(0.,-12.,-3)
C MOVE ORIGIN PEN UP
      CALL PLOT(0.,2.,-3)
C DRAW BOX 8X3.5 PEN DOWN
      CALL PLOT(8.,0.,2)
      CALL PLOT(8.,3.5,2)
      CALL PLOT(0.,3.5,2)
      CALL PLOT(0.,0.0,2)
C PRINT NAME IN BOX
      CALL SYMBOL(1.,2.,1.,'LOUISE',0.,6)
      CALL SYMBOL(1.,.5,1.,'LEVINE',0.,6)
C TERMINATE PLOTTING
      CALL WRAPUP
      CALL EXIT
      END
//GO.SYSIN DD *
/*
```

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SAMPLE OUTPUT

REDUCED TO 60% OF ORIGINAL SIZE.

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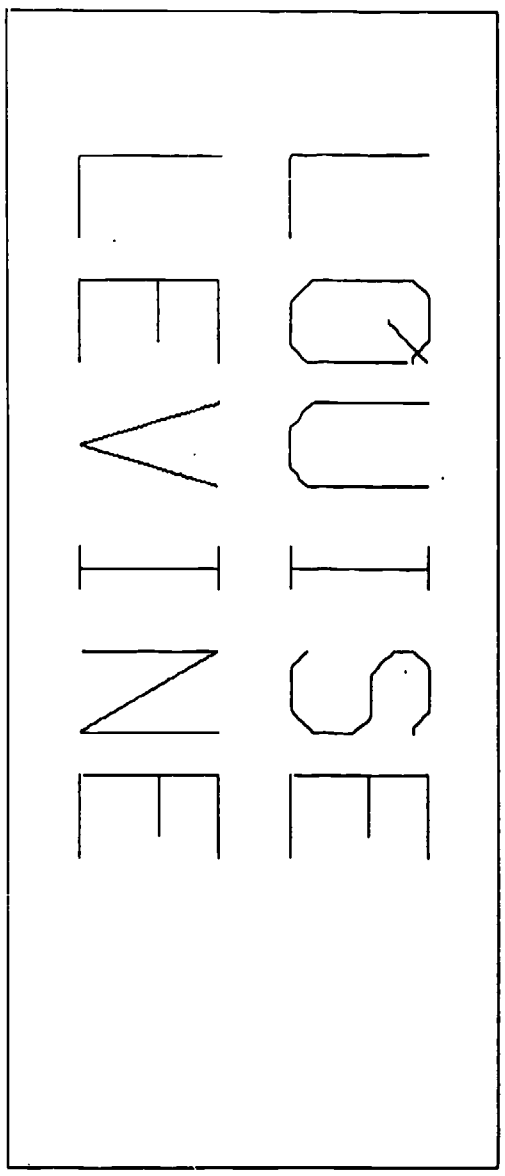
LOUISE LEVINE UCC PLOT COURSE



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COST ESTIMATE

The costing algorithm is based on the amount of computing time, I/O accesses, core storage, cards in and out, and lines and pages printed. The total cost for the Sample Output above was $0.71.

Charge to user = computer costs + postage + network overhead
= $0.71 + postage + network overhead

CONTENTS—CALCOMP PLOTTER SUBROUTINES

000 0053

DESCRIPTIVE TITLE	BEEF Data Processing Subroutines
CALLING NAME	BEEFDP
INSTALLATION NAME	The University of Notre Dame Computing Center
AUTHOR(S) AND AFFILIATION(S)	Westinghouse Electric Corporation UNIVAC Division of Sperry Rand Corporation
LANGUAGE	SLEUTH II/FORTRAN IV
COMPUTER	UNIVAC 1107
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Elizabeth Hutcheson, EIN Technical Representative, Computing Center, University of Notre Dame, Notre Dame, Ind. 46556 Tel.: (219) 283-7784

FUNCTIONAL ABSTRACT

The BEEF Data Processing library is a set of subroutines supplied by UNIVAC to "enhance FORTRAN's abilities as a commercial processor." This enrichment is in the form of subroutines for whole word data movement, character and field movement, supplementary formatting, decision-making with FORTRAN arrays, data conversion, report generation and control, I/O control, sorting, and compatability with EAM/EDP (Electronic Accounting Machine/Electronic Data Processing) equipment.

REFERENCE

UNIVAC 1107 BEEF Data Processing Manual, (UP-3985), (UNIVAC Division of Sperry Rand Corp., N.Y.). Copies of this manual are available through the local UNIVAC representative or through the EIN Office at the cost of reproduction and mailing.

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USER INSTRUCTIONS

Full details of the description and use of the BEEFDP library are given in the reference cited below. A brief description of the library subroutines is presented as an aid for the interested person. The user should specify the subprogram name to obtain all the subroutines listed under that name, for a run.

Subprogram Name	*Subroutine Name*	*Description*
WWDM		Whole Word Data Movement
	MOVEKA	Moves the contents of a word into an array
	MOVEKL	Moves the contents of a word into a list specified in the calling sequence
	MOVEAA	Moves whole words from one array to another
	MOVEAL	Moves whole words from an array to a list specified in the calling sequence
	MOVELA	Moves whole words from a list specified in the calling sequence to an array
	MOVELL	Moves one list of words to another
CAFM		Character and Field Movement
	IXTRAC	Selects a character from an array and creates a variable FORTRAN integer
	INSERT	Replaces a character with the low order bits of a FORTRAN integer variable
	MOVECH	Transfers a field of characters from one array to another
	EXTRAC	Selects a character from an array and creates a Hollerith variable
	ENSERT	Places a single Hollerith character into an array

continued

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Subprogram Name	*Subroutine Name*	*Description*
FORMAT		Formatting
	MOVMCH	Transfers several fields of characters from one array to another
	MOVECC	Packs or unpacks several fields of characters from one array to another
	MOVEHA	Defines Hollerith constants which may be used as FORTRAN variables
	HEDSET	Sets up to allow automatic writing of headings on reports
	HEDING	Allows the automatic writing of headings on reports
	CLKNDT	Transfers the date and/or time as FORTRAN integers
	DATBCD	Transfers the date as Hollerith characters
DECM		Decision Making with FORTRAN Arrays
	CMPAA	Compares logically or arithmetically a number of words of two arrays
	CMPAL	Compares logically or arithmetically a number of words of an array and a list
	CMPLL	Compares logically or arithmetically a number of words of two lists
	CMPKA	Determines if a word exists in a number of words of an array
	CMPKL	Determines if a word exists in a list
	FINDKA	Searches an array for a one word match
	FINDKL	Searches a list for a one word match
DATAC		Data Conversion
	BCD21	Converts a Hollerith number into a FORTRAN integer

continued

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Subprogram Name	*Subroutine Name*	*Description*
	DECIN	Creates a FORTRAN integer from a Hollerith number (two word)
	DECN	Creates a FORTRAN integer from a Hollerith number (one word)
	AAADEC	Creates a signed Hollerith field from a FORTRAN integer
	AADEC	Creates a signed, edited Hollerith field from a FORTRAN integer
	LEDZER	Converts leading of a word to blanks
RPTGC		Report Generation and Control
	RPTFLT	Real variable report generator control
	RPTFIX	Integer variable report generator control
IOC		Input/Output Control
	BSFILE	Backspace a file
	UNLOAD	Rewind FORTRAN unit with interlock
	EOFBIN	End-of-file, binary
	EOFILE	End-of-file, Hollerith
	IOPACK	Blocking and buffering routine for fixed and variable tape records
	COPY	Copy a print file to the printer
SORTS		Sorting Routines
	BCDSR, MLSRT	Internal commercial and arithmetic sort
COMPAT		Compatibility of EAM/EDP Equipment
	EAM	Creates a word containing the positional representation of the commercial sequence of the characters of a word

continued

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Subprogram Name	*Subroutine Name*	*Description*
	EDP	Restores the word of the EAM routine
	CMPEAM	Compares two arrays for commercial sequence
	KMPWL	Compares word fields in two arrays for Field Data sequence
	KMPWA	Compares word fields in two arrays for Algebraic sequence
	KMPCL	Compares character fields in two arrays for Field Data sequence
	KMPCA	Compares character fields in two arrays for Algebraic sequence
	KMPWC	Compares word fields in two arrays for commercial sequence
	KMPWS	Compares word fields in two arrays for scientific sequence
	KMPCC	Compares character fields in two arrays for commercial sequence
	KMPCS	Compares character fields in two arrays for scientific sequence
	LOGSET	Compares (EAM) two strings of Hollerith characters
	JC	Defines a FORTRAN constant
	JD	Divides one FORTRAN constant by another
	JM	Multiplies one FORTRAN constant by another
	ENDFIL	Mark end-of-file on FORTRAN unit
	REWIND	Rewinds FORTRAN unit

REFERENCE

UNIVAC 1107 BEEF Data Processing Manual, (UP-3985), (UNIVAC Division of Sperry Rand Corp., N.Y.). Copies of this manual are available through the local UNIVAC representative or through the EIN Office at the cost of reproduction and mailing.

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SAMPLE INPUT and SAMPLE OUTPUT

Sample Input and Output are included in the reference listed under the USER INSTRUCTIONS. Interested persons are directed to this source.

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COST ESTIMATE

See reference listed in USER INSTRUCTIONS.

Charge to user = computer time + postage and handling + network overhead

= computer time + $10.00 + network overhead

CONTENTS—BEFFDP

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000 0054

DESCRIPTIVE TITLE	BEEF Mathematical Subroutine
CALLING NAME	BEEFM
INSTALLATION NAME	University of Notre Dame Computation Center
AUTHOR(S) AND AFFILIATION(S)	UNIVAC Division of Sperry Rand Corporation Westinghouse Electric Corporation Baltimore Defense and Space Center Boeing Corporation
LANGUAGE	FORTRAN IV and SLEUTH II
COMPUTER	UNIVAC 1107
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mrs. Elizabeth Hutcheson, Computer Center, University of Notre Dame, Notre Dame, Ind. 46556 Tel.: (219) 283-7784

FUNCTIONAL ABSTRACT

The BEEF mathematical library is a set of subroutines supplied by UNIVAC to "enhance FORTRAN's abilities as a scientific processor." This enrichment is in the form of subroutines for the evaluation of mathematical functions, matrix arithmetic, and other standard engineering requirements.

See the User Instructions for further information on BEEFM.

REFERENCE

UNIVAC 1107 BEEF Math Routines Manual (UP-3984), UNIVAC Division of Sperry Rand Corporation, (New York, N.Y., March 1965). Available through the UNIVAC 1107 Librarian, Systems Prog. Library Services, UNIVAC Div. of Sperry Rand, Sperry Rand Bldg., New York, N.Y. 10019.

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USER INSTRUCTIONS

Program Description

The following subroutines comprise the BEEF Math library.

Name	*Description*
DED	SOLUTION OF A SET OF FIRST ORDER DIFFERENTIAL EQUATIONS The subroutines DED, DEI, DES and DEDIS solve a system of N first-order ordinary differential equations having the form $Y_i^1 = f_i(t, y_1, y_2, \cdots y_n)$ The user may select one of the following options. (a) a fourth order Runge-Kutta method with fixed step size (b) Adams-Moulton method with fixed step size (c) Adams-Moulton method with variable step size
LAGIT	LAGRANGIAN INTERPOLATION This subroutine computes y = f(x) given a discrete set of values of x and y, using variable degree Lagrangian interpolation by the following formula. $P_n(x) = \sum_{s=1}^{n} L_s(x) f(x_s)$ where $L_s(x) = \prod_{\substack{t=1 \\ t \neq s}}^{n} \frac{(x-x_t)}{(x_s-x_t)}$ for $s = 1, 2, \cdots, n$ and $Y_s = f(x_s)$ are known for x_s.
RANDM	UNIFORM OR NORMAL NUMBER GENERATOR This subroutine computes either a uniform or normally distributed random number.
RKVS	RUNGE-KUTTA VARIABLE STEP This subroutine solves numerically a set of N first-order differential equations (linear or non-linear) using a fifth-order Runge-Kutta

continued

000 0054

Name	*Description*
	technique. Speed and accuracy are attained by using a step size control. However, because of the necessity to make at least twelve evaluations of each functional expression, complicated functions or large sets of functions may consume a large amount of time particularly if the values of the dependent variables are desired at a number of points and/or the interval of integration is large.
SPLIN	SPLINE INTERPOLATION This set of subroutines fits a set of points with an interpolating function made up of piecewise curves which act somewhat as an ideal spline. First and second derivatives of the fitted curve are continuous from interval to interval. The user must specify either the first or the second derivatives (but not both) at the end points. The condition that the second derivative be zero at an end means that the end is not held in a bent position.
SETU	GAUSS QUADRATURE This subroutine provides the abscissa and weight coefficients used in the evaluation of a definite integral by Gauss's mechanical quadrature formula. This formula differs from Simpson's Rule and Weddle's Rule in that the subdivisions are not equidistant but are symmetrically placed with respect to the midpoint of the interval of integration.
COMBES	COMPLEX BESSEL FUNCTION (COMPLEX ARGUMENT AND ORDER) This subroutine computes the Bessel Functions, $$J_{a\pm n+ib}(x+iy) \text{ and } Y_{a\pm n+ib}(x+iy)$$ of complex order and argument. The method used is that of Goldstein and Thaler.[2]
NSIMEQ	SIMULTANEOUS LINEAR EQUATION The subroutine NSIMEQ solves the matrix equation $A \cdot X=B$ for the unknown matrix X. The subroutine NDETRM computes a scaled value of the determinant of the A matrix.
ORTHLS	ORTHOGONAL POLYNOMIAL LEAST SQUARES CURVE FITTING This subroutine finds the polynomial $P_k(x)$ of degree

continued

000 0054

Name	*Description*
	$\leq$K which best approximates, in the least squares sense, a weighted set of data points using orthogonal polynomials. The fitted values for a given set of arguments and the fitted value and derivative for a single argument may also be obtained. The user must provide input and output in source program.
GAMMA	GAMMA FUNCTION This subroutine calculates the value of $\Gamma(1 + X)$.
TABF	SINGLE INTERPOLATION This subroutine performs a K-th order interpolation (K<6) on a table of X_iY_i values giving, for a given value of X, the corresponding value of Y. The method of interpolation used by this subroutine is Aitken's method as described in Ref. 3. Independent variables must be monotonic but need not be equally spaced.
BES	BESSEL FUNCTION (REAL ARGUMENT AND ORDER) This subroutine computes the Bessel functions for real argument and order. The method used is that of Goldstein and Thaler.[2]
MATAB	MATRIX ABSTRACTION This subroutine performs addition, subtraction, multiplication, postmultiplication and transposition of real and complex matrices.
MATRTA	MATRIX ROTATION This subroutine will rotate a 3 X 3 matrix about any one of the three orthogonal axes through any given angle.
CINV1	MATRIX INVERSION AND DETERMINANT EVALUATION OF COMPLEX MATRICES This subroutine provides for inversion and determinant evaluation of general complex matrices or real matrices compatible with existing real matrix subroutine. The matrix is inverted by a variation of the Gauss elimination method.
INV	MATRIX INVERSION AND DETERMINANT EVALUATION (REAL) This subroutine inverts an N X N real matrix or

continued

000 0054

Names	*Description*
	evaluates its determinant. The mathematical technique employed for matrix is a variation of the Gauss elimination method.
DETIGN	DETERMINANT AND NORMALIZED EIGENVECTORS OF A COMPLEX MATRIX This subroutine calculates the determinant and (if desired) normalized eigenvectors of a complex matrix.
TBLP	SINGLE LINEAR INTERPOLATION LOOK-UP This subroutine performs a single linear interpolation. The interpolation tables must have previously read into the computer. The set of values for the independent variable must be monotonically increasing.
GDT	SIMULTANEOUS LINEAR EQUATIONS (SINGLE OR DOUBLE PRECISION) This subroutine solves a set of N single or double precision simultaneous linear equations.
INV1	MATRIX INVERSION AND DETERMINANT EVALUATION (SINGLE OR DOUBLE PRECISION) This subroutine inverts an N X N real matrix and evaluates its determinant.
CMPXMD	MULTIPLICATION AND DIVISION OF COMPLEX NUMBER OF LARGE MAGNITUDE The subroutines COMMPY and COMDIV perform a complex multiplication and division respectively of large magnitude numbers.
UDRNRT	UNIFORMLY DISTRIBUTED PSEUDO RANDOM NUMBER GENERATOR This subroutine produces a set of uniformly distributed numbers on the unit interval.
TBLF	PARABOLIC INTERPOLATION Given paired values of X and Y, this subprogram calculates the Y value for any particular value of X,XBAR within the range of the given X values.
PMTR	POLYNOMIAL MATRIX TRIANGULARIZATION ROUTINE This subroutine reduces a given polynomial matrix to triangular form. The subroutine saves computer time over the usual method of determinants by treating polynomial elements individually.

continued

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Name	*Description*
ICEM	INTEGRATION WITH CONTROLLED ERROR This subroutine provides the numerical solution of an N—th order system of linear or non-linear differential equations expressed as a system of N first-order equations.
ARTN	FOUR QUADRANT ARCTANGENT SUBROUTINE This subroutine computes the arctangent of the ratio of two floating point numbers.
DEFI	DEFINITE INTEGRAL EVALUATION This subroutine computes the definite integral of functions which are not well behaved. Two estimates of the value of the integral are made, a parabolic approximation, and one using Simpson's Rule. The program will vary the step size to keep the error estimated within specified bounds. In specifying the minimum step size allowed, the user can greatly determine the capabilities of the program in handling oscillating or discontinuous functions.
ERF3	ERROR AND NORMAL FREQUENCY FUNCTION ERF3 consists of two subroutines, the error function and the normal frequency function.[4] For a given value, Y, the functions are evaluated using approximations for the following integrals

$$\mathrm{erf}(Y) = \frac{2}{\sqrt{\pi}} \int_0^Y e^{-t^2}\, dt \cong 1-\left(\sum_{i=0}^{6} A_i Y^i\right)^{-16}$$

$$F(Y) = \frac{2}{\sqrt{2\pi}} \int_{-00}^{Y} e^{-t^2/2}\, dt \cong \frac{1}{2}[1 + \mathrm{ERF}(Y/\sqrt{2})].$$

WEGSTN	WEGSTEIN ITERATION SUBROUTINE Given an implicit equation of the form X = f(X), the subroutine finds the value for X which provides a specified accuracy in either a relative or absolute sense. The method used is a modification of iteration which determines the root of the explicit function g(X)=0 by the iteration process

$$X_{n+1} = X_n - g(X)/g'(X).$$

$$X_{n+1} = \frac{f(X_n) - X_{nF'}}{1 - F'}$$

continued

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Name	*Description*
BESMMM	BESSEL FUNCTION EVALUATION This subroutine will evaluate the Bessel functions for a given floating point argument. Calculation is terminated either when the nth computed value is equal to the n-1 value or when the nth computed value is less than the absolute value of a pre-assigned test number.
RANNUM	NORMALLY DISTRIBUTED PSEUDO-RANDOM NUMBER GENERATOR This program will produce a normally-distributed random number with a given mean and standard deviation.
XLAGIN	LAGRANGE INTERPOLATION SUBROUTINE Given a table of paired values of X, Y, this program computes a value of Y corresponding to a specific XX value within the range of the table. The Lagrange interpolation formula is used.

$$Y = \sum_{k=1}^{n+1} \left[Y_k \prod_{\substack{j \\ j \neq k}} \frac{XX - X_j}{X_k - X_j} \right]$$

The user must provide input and output routines in a source program. Data for the table need not be in descending order nor equally spaced.

SIM2	DEFINITE INTEGRAL EVALUATION This subroutine will compute the definite integral of a function using the maximum step size which will provide accuracy within a given bound. The program makes use of Simpson's Rule, computing and comparing two successive terms. Discontinuous functions or functions that oscillate rapidly may result in incorrect results.
DITTO	SPECIALIZED DOUBLE INTEGRAL EVALUATION This subroutine will evaluate the special definite integral

$$\int_{yL}^{yu} g(Y)\, dy \int_{xL=y}^{xu} f(X,Y)\, dx$$

where g(Y) and f(X,Y) are defined by function subprograms; yu, yL and xu are fixed limits, and xL is a variable limit equal to y. The user may specify

continued

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Name	*Description*
	the accuracy desired. The basic method of integration used is a variable-interval Simpson's Rule, modified to yield results two orders higher in accuracy than the basic Simpson's Rule.
FRENEL	FRESNEL INTEGRATION ROUTINE This subroutine evaluates the integral $(2\pi)^{-1} \int_0^x \frac{e^{-it}}{\sqrt{t}} dt$ for any value X>0. The output of the subroutine consists of the real and imaginary results of the integration.
FSERIE	FRACTION SERIES SOLUTION COMPLEX This subroutine calculates the N complex eigenvalues of a complex or real matrix, given N+1 distinct guesses, $\lambda_1, \lambda_2, \cdots, \lambda_n$, of the roots and the corresponding N+1 determinants, $D(\lambda_1), D(\lambda_2), \cdots, D(\lambda_{n+1})$. This subroutine may also be used to solve for the roots of the polynomial F(x). In this case, the guesses X_i of the roots replace the λ_i and $F(X_i)$ replaces $D(\lambda_i)$ for $i=1,2,\cdots,n+1$.
INTEG	SINGLE OR DOUBLE INTEGRAL EVALUATION This subroutine will evaluate the double definite integral $\int dy \int f(X,Y) dx$ where f(X,Y) and the limits of integration are defined by the user. The accuracy is also user-specified. The basic method of integration used is a variable-interval Simpson's Rule, modified to yield results two orders higher in accuracy than the basic Simpson's Rule. This program was designed primarily for functions which can be expressed mathematically, rather than tabulated data.
PLOTXX	PLOT ORDERING SUBROUTINE This subroutine will provide a graphical representation of data stored in computer memory for listing on a standard printer. A maximum of 20 curves may be depicted. Scaling is automatic and all titles and plotting symbols may be specified by the user.

continued

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000 0054

Name	*Description*
ROOTS	ROOTS OF A POLYNOMIAL This subroutine obtains approximations to the N complex roots of a polynomial with complex coefficients by the Newton-Raphson method. The polynomial must be of degree $\leq$ 50.

Description of Input

For a complete description of the options available and the usage conventions the user should consult the reference cited below.

Control Cards

Run Card

The Run Card will be provided by University of Notre Dame personnel.

ASG Card

Columns	*Contents*
1	Multipunch 7 and 8
2–12	ASG A=BEEFM

PLT Card

Columns	*Contents*
1	Multipunch 7 and 8
2– 6	PLT, A
8–72	The user should list the names of the subprograms he desires, separated by commas.

Note: The subprogram name appearing in the left column of the description given in the Functional Abstract should be specified. In this way, all the subroutines comprising a subprogram will be available.

FOR Card

Columns	*Contents*
1	Multipunch 7 and 8
2– 4	FOR

continued

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Columns	*Contents*
5	Blank
6–10	User-supplied job name

XQT Card

Columns	*Contents*
1	Multipunch 7 and 8
2– 4	XQT
5	Blank
6–10	Job name specified on FOR Card

FIN Card

Columns	*Contents*
1	Multipunch 7 and 8
2– 4	FIN

Input Deck

Run Card
ASG Card
PLT Card
FOR Card
    [Program Deck]
XQT Card
    [Data Cards, if any]
FIN Card

REFERENCES

1. UNIVAC 1107 BEEF Math Routines Manual (UP–3984), UNIVAC Division of Sperry Rand Corporation, (New York, N.Y., March 1965). Available through the UNIVAC 1107 Librarian, Systems Prog. Library Services, UNIVAC Div. of Sperry Rand, Sperry Rand Bldg., New York, N.Y. 10019.

2. Goldstein, M., and Thaler, M.R., "Recurrence Techniques for the Calculation of Bessel Functions," MATC *XIII*, 1959, p. 102.

3. Milne, W.E., *Numerical Calculus*, (Princeton University Press, Princeton, N.J., 1949).

4. Hildebrand, F.B., *Introduction to Numerical Analysis*, (McGraw-Hill Book, Co., Inc., New York, N.Y., 1956) p. 3.

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SAMPLE INPUT (FOR GAMMA)

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=BEEFM
- PLT,A GAMMA
- FOR TEST
C     MAIN PROGRAM TO TEST GAMMA FUNCTION ROUTINE
C
      DIMENSION X(50)
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,101) N
      READ (5,102) (X(I),I=1,N)
C
C     CALCULATE GAMMA FUNCTION.
C
      DO 2 I=1,N
      Y=GAMMA(X(I))
C
C     OUTPUT.
C
    2 WRITE (6,103) X(I),Y
      GO TO 1
C
C     FORMAT STATEMENTS.
C
  100 FORMAT (45H1MAIN PROGRAM TO TEST GAMMA FUNCTION ROUTINE.////)
  101 FORMAT (I10)
  102 FORMAT (F10.0)
  103 FORMAT (8H FOR X = F15.7,10X,17HGAMMA FUNCTION = F15.7//)
      END
- XQT TEST
         9
       2.3
       2.0
       1.3
       1.0
       0.0
       0.7
       1.7
       2.7
       2.0
- FIN
```

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SAMPLE OUTPUT (FROM GAMMA)

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```
MAIN PROGRAM TO TEST GAMMA FUNCTION ROUTINE.

FOR Y =      2.300000E0        GAMMA FUNCTION =      2.6834374

FOR Y =      2.000000E0        GAMMA FUNCTION =      2.0000000

FOR Y =      1.300000E0        GAMMA FUNCTION =      1.1667120

FOR Y =      1.000000E0        GAMMA FUNCTION =      1.0000000

FOR Y =       .000000E0        GAMMA FUNCTION =      1.0000000

FOR Y =      -.700000E0        GAMMA FUNCTION =      2.9015490

FOR Y =     -1.700000E0        GAMMA FUNCTION =     -4.2776701

FOR Y =     -2.700000E0        GAMMA FUNCTION =      2.5179236


ATTEMPTED TO TAKE GAMMA FUNCTION OF   -.300000E+01
```

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SAMPLE INPUT (FOR BES)

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=BEFFM
- PLT,A BES
- FOR TEST
C     MAIN PROGRAM TO TEST BESSEL FUNCTION SUBROUTINE FOR REAL ARGUMENT
C     AND ORDER.
C
      DIMENSION BJ(250),BY(250),BI(250),BK(250),TX(20),TFNU(20),IN(10)
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,110) NX,NU,NON
      READ (5,111) (TX(I), I=1,NX)
      READ (5,111) (TFNU(I), I=1,NU)
      READ (5,110) (IN(I), I=1,NON)
C
C     LOOP TO TAKE ALL POSSIBLE VALUES, ONE FROM EACH TABLE.
C
      DO 10 I=1,NX
      DO 10 J=1,NU
      DO 10 K=1,NON
      X=TX(I)
      FNU=TFNU(J)
      N=IN(K)
      N1=IABS(N)+1
C
C     CALLING SEQUENCE.
C
      CALL BESY(X,FNU,N,BJ,BY)
      GO TO 2
    3 CALL BESK (X,FNU,N,BI,BK)
      GO TO 4
C
C     OUTPUT.
C
    2 WRITE (6,102) X,FNU,N
      WRITE (6,103) (BJ(L),L=1,N1)
      WRITE (6,104) (BY(L),L=1,N1)
      GO TO 3
    4 WRITE (6,105) (BI(L), L=1,N1)
      WRITE (6,106) (BK(L), L=1,N1)
   10 CONTINUE
      GO TO 1
C
C     FORMAT STATEMENTS.
C
  100 FORMAT (77H1MAIN PROGRAM TO TEST BESSEL FUNCTION SUBROUTINE FOR RE
     1AL ARGUMENT AND ORDER.////)
  102 FORMAT (5X2HX=E14.7,5X,3HNU=E14.7,5X,2HN=I5//)
  103 FORMAT(17H0OUTPUT FROM BESJ//(5E17.8))
  104 FORMAT(17H0OUTPUT FROM BESY//(5E17.8))
  105 FORMAT(17H0OUTPUT FROM BESI//(5E17.8))
  106 FORMAT(17H0OUTPUT FROM BESK//(5E17.8))
  110 FORMAT (14I5)
  111 FORMAT (4F15.0)
      END
. XQT TEST
   8    1    2
            3.              4.              6.              7.
            8.        2.404826        3.957678        7.015587
            0.
   9   -9
. FIN
```

SAMPLE OUTPUT (FROM BES)

```
MAIN PROGRAM TO TEST BESSEL FUNCTION SUBROUTINE FOR RAND ARGUMENT AND ORDER.

    X=   .3000000+01      NU=   .0000000        N=    0

OUTPUT FROM BESJ

   -.26005197-00     .33005807-00     .48609128-00     .30906273-00     .13207419-00
    .43028437-01     .11793977-01     .25472946-02     .49344181-03     .84305030-04

OUTPUT FROM BESY

    .37685002-00     .32467478-00    -.14040044-00    -.53854163-00    -.91648281-00
   -.19059450+01    -.54764701+01    -.10839934+02    -.87149888+02    -.44465947+03

OUTPUT FROM BESI

    .24300037-00     .19482677-00     .11178256+00     .47783725-01     .16215908-01
    .45409037-02     .10795685-02     .22265772-03     .40511860-04     .65904643-05

OUTPUT FROM BESK

    .69776157-00     .80456378-00     .13354705+01     .24538573+01     .61431850+01
    .18875487+02     .68028707+02     .20455087+03     .14434094+04     .79932146+04
    X=   .3000000+01      NU=   .0000000        N=   -0

OUTPUT FROM BESJ

   -.26005197-00    -.33005807-00     .48609128-00    -.30906274-00     .13207420-00
   -.43028448-01     .11793941-01    -.25473940-02     .49387803-03    -.86622138-04

OUTPUT FROM BESY

    .37685002-00    -.32467478-00    -.14040044-00     .53854163-00    -.91648281-00
    .19059450+01    -.54764701+01     .10839934+02    -.87149888+02     .44465947+03

OUTPUT FROM BESI

    .24300037-00     .19482677-00     .11178255+00     .47783726-01     .16215903-01
    .45409197-02     .10795057-02     .22289814-03     .39313078-04     .13223598-04

OUTPUT FROM BESK

    .69776157-00     .80456378-00     .13354705+01     .24538573+01     .61431850+01
    .18875487+02     .68028707+02     .20455087+03     .14434094+04     .79932146+04
    X=   .4000000+01      NU=   .0000000        N=    0

OUTPUT FROM BESJ

   -.39714682-00    -.66043396-01     .34412816-00     .43017148-00     .28112907-00
    .13208466-00     .49087576-01     .15176070-01     .40286678-02     .93860185-03

OUTPUT FROM BESY

   -.16940730-01     .39792570-00     .21590358-00    -.18202212-00    -.48805676-00
   -.79586140-00    -.15006917+01    -.37062238+01    -.11471092+02    -.42178143+02

OUTPUT FROM BESI

    .20700198-00     .17075056-00     .11762652+00     .41124745-01     .25990997-01
    .92443508-02     .28091218-03     .75698479-03     .17967811-03     .38284325-04
```

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OUTPUT FROM FESK

.60929767-00	.68157588-00	.95008555-00	.16316414+01	.33975776+01
.84268166+01	.24864618+02	.81820672+02	.71083696+03	.13251685+04

X= .6000000+01 NU= .0000000 N= -9

OUTPUT FROM FESJ

-.39714052-00	.66243394-01	.36412614-00	-.03017148-00	.28112907-00
-.13208766-00	.40067577-01	-.15176042-01	.00286026-02	-.93850866-03

OUTPUT FROM FESY

-.16940730-01	-.39792570-00	.21590358-00	.18202912-00	-.48807676-00
.79585140-00	-.15064917+01	.37062238+01	-.11471092+02	.42178143+02

OUTPUT FROM FESI

.20700198-00	.17975096-00	.11762651+00	.41124745-01	.25950996-01
.92403524-02	.28091105-02	.75700786-03	.17958739-03	.38658269-04

OUTPUT FROM FESK

.60929767-00	.68157588-00	.95008555-00	.16316414+01	.33975776+01
.84268166+01	.24864618+02	.81820672+02	.71083696+03	.13251685+04

X= .6000000+01 NU= .0000000 N= 9

OUTPUT FROM FESJ

.15064528-00	-.27668385-00	-.24287337-00	.11476837+00	.35740159-00
.36208705-00	.24583607-00	.12958644-00	.56531096-01	.21165325-01

OUTPUT FROM FESY

-.28819465-00	-.17501071-00	.22985792-00	.32824893-00	.98300996-01
-.19706097-00	-.42682507-00	-.65659082-00	-.11052194+01	-.22906607+01

OUTPUT FROM FESI

.16665750-00	.15205155-00	.11597369+00	.74735767-01	.41237923-01
.19751870-01	.83181300-02	.31155905-02	.10484288-02	.31978041-03

OUTPUT FROM FESK

.50186317-00	.54217526-00	.68258821-00	.09723406-00	.16708223+01
.32369071+01	.70748173+01	.17386671+02	.07643623+02	.14407628+03

X= .6000000+01 NU= .0000000 N= -9

OUTPUT FROM FESJ

.15064528-00	.27668385-00	-.24287337-00	-.11476837+00	.35740160-00
-.36208705-00	.24583608-00	-.12958667-00	.56532010-01	-.21165356-01

OUTPUT FROM FESY

-.28819465-00	.17501071-00	.22985792-00	-.32824893-00	.98300994-01
.19706097-00	-.42682507-00	.65659082-00	-.11052194+01	.22906607+01

OUTPUT FROM FESI

.16665750-00	.15205155-00	.11597369+00	.74735768-01	.41237921-01
.19751870-01	.83181300-02	.31156095-02	.10483768-02	.31907812-03

OUTPUT FROM FESK

.50186317-00	.54217526-00	.68258821-00	.09723406-00	.16708223+01
.32369071+01	.70748173+01	.17386671+02	.07643623+02	.14407628+03

X= .7000000+01 NU= .0000000 N= 9

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```
OUTPUT FROM FESJ

    .30007628-00    -.46628088-02    -.30141722-00    -.16755560-00    .15779817-00
    .34709632-00     .33019661-00     .23358759-00     .12797054-00    .58920517-01

OUTPUT FROM FESY

   -.25909737-01    -.30066723-00    -.60526611-01     .26808060-00    .29037998-00
    .63702226-01    -.19030679-00    -.40537102-00    -.41143524-00   -.99210523-00

OUTPUT FROM FESI

    .15373817-00     .14028956-00     .11308796+00     .77670165-01    .46500517-01
    .24516852-01     .11860615-01     .40261715-02     .18337722-02    .63475376-03

OUTPUT FROM FESK

    .46584500-00     .45506925-00     .60815059-00     .84558787-00    .13320367+01
    .23689801+01     .47171368+01     .10455460+02     .25628057+02    .69037875+02
    Y=   .5000000+01      NU=   .0000000          N=   -9


OUTPUT FROM FESJ

    .30007628-00     .46628088-02    -.30141722-00     .16755560-00    .15779817-00
   -.34709632-00     .33019661-00    -.23358757-00     .12797052-00   -.58920491-01

OUTPUT FROM FESY

   -.25909737-01     .30066723-00    -.60526611-01    -.26808060-00    .29037998-00
   -.63702226-01    -.19030679-00     .40537102-00    -.41143524-00    .99210523-00

OUTPUT FROM FESI

    .15373817-00     .14028956-00     .11308796+00     .77670185-01    .46500519-01
    .24516848-01     .11860621-01     .40261280-02     .18337449-02    .63466530-03

OUTPUT FROM FESK

    .46584500-00     .45506925-00     .60815059-00     .84558787-00    .13320367+01
    .23689801+01     .47171368+01     .10455460+02     .25628057+02    .69037875+02
    Y=   .5000000+01      NU=   .0000000          N=    0


OUTPUT FROM FESJ

    .17165079-00     .23863672-00    -.11299171+00    -.29113218-00   -.10577742+00
    .18577874-00     .33757507-00     .32058905-00     .22345896-00    .12672088+00

OUTPUT FROM FESY

    .22352149-00    -.15806051-00    -.24303662-00     .26542198-01    .28208326-00
    .25860104-00     .37558048-01    -.20006397-00    -.28767000-00   -.57527605-00

OUTPUT FROM FESI

    .14303177-00     .13814288-00     .10989612+00     .79194786-01    .50500330-01
    .28694054-01     .14432741-01     .67449155-02     .28291585-02    .10845986-02

OUTPUT FROM FESK

    .43662707-00     .46714981-00     .55241038-00     .73935860-00    .11069263+01
    .18462605+01     .34147784+01     .60684470+01     .15609560+02    .38187566+02
    Y=   .5000000+01      NU=   .0000000          N=   -9
```

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continued

OUTPUT FROM FESI

.1438317-00	.1[illegible]142[illegible]-00	.1098961[illegible]+00	.79194786-01	.5050[illegible]330-01
.2[illegible]-01	.1[illegible]32[illegible]-01	.67449121-02	.08291458-02	.108[illegible]806-02

OUTPUT FROM FESK

.43662707-00	.4[illegible]149[illegible]1-00	.552410[illegible]-00	.73975[illegible]60-00	.110[illegible]263+01
.18462[illegible]00+01	.3[illegible]1477[illegible]+01	.6[illegible]684[illegible]70+01	.15609[illegible]60+02	.381[illegible]7566+02

Y= .[illegible]+01 NU= .000000 N= 0

OUTPUT FROM FESJ

-.23971701-06	.51014701-00	.47175[illegible]89-00	.19899099-00	.647[illegible]709-01
.1635[illegible]57-01	.3[illegible]48[illegible]01-00	.6006891[illegible]-03	.02165022-04	.12517292-04

OUTPUT FROM FESY

.50952[illegible]36-00	.10274[illegible]-00	-.4[illegible]4473[illegible]-00	-.00878746-00	-.159[illegible]272+01
-.44919[illegible]15+01	-.17[illegible]5601+00	-.80764[illegible]80+02	-.05309[illegible]70+03	-.293[illegible]116+04

OUTPUT FROM FESI

.2769[illegible]05-00	.20[illegible]9[illegible]6-00	.10298367+00	.07095457-01	.104[illegible]638-01
.2396[illegible]70-02	.46[illegible]6[illegible]900-03	.77850351-04	.11474023-04	.15000421-05

OUTPUT FROM FESK

.7737005[illegible]-00	.92177678-00	.15399077+01	.04831[illegible]07+01	.102[illegible]0284+02
.3751565[illegible]+02	.16[illegible]231[illegible]+03	.86700[illegible]73+03	.02136[illegible]16+04	.355[illegible]732+05

Y= .[illegible]+01 NU= .000000 N= 0

OUTPUT FROM FESJ

-.23971-01-06	-.51014701-00	.47175489-00	-.19899099-00	.647[illegible]704-01
-.1635[illegible]-01	.3[illegible]4[illegible]5[illegible]-00	-.60035[illegible]70-03	.00312038-04	-.5130[illegible]970-06

OUTPUT FROM FESY

.50902[illegible]36-00	-.10274[illegible]-00	-.4[illegible]4473[illegible]-00	.00878[illegible]46-00	-.159[illegible]272+01
.44919[illegible]15+01	-.17[illegible]5601+00	.80764[illegible]80+02	-.05309[illegible]70+03	.293[illegible]116+04

OUTPUT FROM FESI

.2769[illegible]05-00	.20[illegible]9[illegible]6-00	.10298367+00	.07095455-01	.104[illegible]645-01
.2396[illegible]15-02	.46[illegible]603[illegible]5-03	.77257[illegible]78-04	.15041765-04	-.2282[illegible]119-04

OUTPUT FROM FESK

.7737005[illegible]-00	.92177678-00	.15399077+01	.04831[illegible]07+01	.102[illegible]0284+02
.3751565[illegible]+02	.16[illegible]231[illegible]+03	.86700[illegible]73+03	.02136[illegible]16+04	.355[illegible]732+05

Y= .[illegible]+01 NU= .000000 N= 9

OUTPUT FROM FESJ

-.3994[illegible]204-00	-.49[illegible]97[illegible]05-01	.37443[illegible]29-00	.42823[illegible]41-00	.274[illegible]947-00
.1279[illegible]-52-00	.4[illegible]5534[illegible]-01	.1[illegible]2453[illegible]-01	.07364790-02	.860[illegible]558-03

OUTPUT FROM FESY

.1587[illegible]55[illegible]-06	.40[illegible]542[illegible]-00	.20342351-00	-.19694785-00	-.5010[illegible]836-00
-.8177[illegible]2[illegible]-00	-.16[illegible]433[illegible]+01	-.39254090+01	-.12321[illegible]13+02	-.458[illegible]690+02

OUTPUT FROM FESI

.2082[illegible]35-00	.17044[illegible]6-00	.11752[illegible]04+00	.06668871-01	.255[illegible]574-01
.9027[illegible]9[illegible]-02	.27[illegible]791[illegible]7-03	.72[illegible]5753[illegible]8-03	.17061404-03	.359[illegible]171+04

OUTPUT FROM FESK

.6127[illegible]09[illegible]-00	.68576518-00	.95892918-00	.16549[illegible]88+01	.346[illegible]598[illegible]+01
.8664[illegible]14[illegible]+01	.25[illegible]616[illegible]+03	.85[illegible]6404[illegible]+02	.02803845+03	.141[illegible]7495+04

Y= .[illegible]+01 NU= .000000 N= -9

continued

```
OUTPUT FROM FESJ

   -.39960004-00     .65797005-01     .37443729-00    -.02823841-00     .27478947-00
   -.12701550-00     .46455328-01    -.10245732-01     .97364721-02    -.86027088-03

OUTPUT FROM FESY

    .15872550-06    -.40254270-00     .20342751-00     .19694765-00    -.50100836-00
    .81778020-00    -.15243574+01     .30254 00+01    -.12321513+02     .45807490+02

OUTPUT FROM FESI

    .20820035-00     .17044946-00     .11752404+00     .40668071-01     .25507573-01
    .90273911-02     .27790101-02     .79577311-03     .17054178-03     .36310142-04

OUTPUT FROM FESK

    .61277697-00     .61576518-00     .95892918-00     .16549083+01     .34675985+01
    .86609146+01     .25761673+02     .85564045+02     .72803045+03     .14117495+04
    Y=   .7015587+01      W=   .0000000          N=    0


OUTPUT FROM FESJ

    .30011574-00     .12076502-04    -.30011577-00    -.17111480-00     .15377262-00
    .34606740-00     .36007555-00     .27522791-00     .12933501-00     .59778169-01

OUTPUT FROM FESY

   -.21234346-01     .30236207-00    -.60962880-01     .26532290-00     .29187723-00
    .67509657-01    -.19564672-00     .40216258-00    -.40688042-00     .98167124-00

OUTPUT FROM FESI

    .15356000-00     .14015100-00     .11303555+00     .77703167-01     .46500811-01
    .24586231-01     .11735621-01     .40547491-02     .18477750-02     .64077830-03

OUTPUT FROM FESK

    .46574750-00     .49746357-00     .60716025-00     .84364144-00     .13286749+01
    .23587532+01     .46008358+01     .10382320+02     .25409740+02     .68371774+02
    Y=   .7015587+01      W=   .0000000          N=   -9


OUTPUT FROM FESJ

    .30011574-00    -.12076502-04    -.30011577-00     .17111480-00     .15377262-00
   -.34606740-00     .36007555-00    -.27522791-00     .12933502-00    -.59778182-01

OUTPUT FROM FESY

   -.21234346-01     .30236207-00    -.60962880-01    -.26532290-00     .29187723-00
   -.67509657-01    -.19564672-00     .40216258-00    -.40688042-00     .98167124-00

OUTPUT FROM FESI

    .15356000-00     .14015100-00     .11303555+00     .77703167-01     .46500810-01
    .24586230-01     .11735657-01     .40547566-02     .18477162-02     .64078875-03

OUTPUT FROM FESK

    .46574750-00     .49746357-00     .60716025-00     .84364144-00     .13286749+01
    .23587532+01     .46008358+01     .10382320+02     .25409740+02     .68371774+02

EXECUTION TERMINATED BY AN ATTEMPT TO READ THRU END OF-DATA.
ABOVE FAULT AT INTERNAL SEQUENCE NUMBER    00108  IN  TEST
```

000 0054

SAMPLE INPUT (FOR MATAB)

Test programs for real matrix addition and subtraction.

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=BEFFM
- PLT,A MATAB
- FOR TEST3
C     MAIN PROGRAM TO TEST 1107 MATRIX PACKAGE - REAL MATRIX ADDITION
C     AND SUBTRACTION.  SET J=1 FOR ADDITION J=0 FOR SUBTRACTION.
C
      DIMENSION A(64),B(64),C(64)
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,101) J,L,M,N
      N1 = L*N
      READ (5,102) (A(I),I=1,N1)
      READ (5,102) (B(I),I=1,N1)
C
      IF (J.EQ.0) GO TO 2
C
      CALL MKA(A,B,C,M,N)
      GO TO 3
C
    2 CALL MKS(A,B,C,M,N)
      GO TO 4
C
C     OUTPUT.
C
    3 WRITE (6,103) (C(I),I=1,N1)
      GO TO 1
    4 WRITE (6,104) (C(I),I=1,N1)
C
C     FORMAT STATEMENTS.
C
  100 FORMAT (59H1MAIN PROGRAM TO TEST REAL MATRIX ADDITION AND SUBTRACT
     1ION.////)
  101 FORMAT (4I5)
  102 FORMAT(F10.0)
  103 FORMAT(//36H MATRIX C FOR REAL ADDITION ROUTINE.//(1H E20.8))
  104 FORMAT(//39H MATRIX C FOR REAL SUBTRACTION ROUTINE.//(1H E20.8))
      END
- XQT TEST3
    1    3    3    3
         2.
         3.
         4.
         1.
         4.
         1.
         2.
         1.
         4.
         1.
         2.
         0.
         3.
         7.
         2.
         1.
         8.
         5.
    0    3    3    3
         2.
         3.
         4.
         1.
         4.
         1.
         2.
         1.
```


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4.
1.
2.
0.
3.
7.
2.
1.
8.
5.
- FIN

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SAMPLE OUTPUT (FROM MATAB)

Test program for real matrix addition and subtraction.

```
MAIN PROGRAM TO TEST REAL MATRIX ADDITION AND SUBTRACTION.


MATRIX C FOR REAL ADDITION ROUTINE.

        .30000000+01
        .50000000+01
        .40000000+01
        .40000000+01
        .11000000+02
        .30000000+01
        .30000000+01
        .90000000+01
        .90000000+01

MATRIX C FOR REAL SUBTRACTION ROUTINE.

        .10000000+01
        .10000000+01
        .40000000+01
       -.20000000+01
       -.30000000+01
       -.10000000+01
        .10000000+01
       -.70000000+01
       -.10000000+01
```

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SAMPLE INPUT (FOR MATAB)

Test program for real matrix multiplication.

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=BEEF 4
- PLT,A MATA3
- FOR TEST4
C     MAIN PROGRAM TO TEST 1107 MATRIX PACKAGE - REAL MATRIX MULTIPLICAT
C     ION.
C
      DIMENSION A(3,3),B(3,3),C(3,3)
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,101) M, N, L
      READ (5,102) ((A(I,J),J=1,L),I=1,M)
      READ (5,102) ((B(I,J),J=1,N),I=1,L)
C
      CALL MXM(A,B,C,M,N,L)
C
C     OUTPUT.
C
      WRITE (6,103) ((I,J,C(I,J),J=1,N),I=1,M)
      GO TO 1
C
C     FORMAT STATEMENTS.
C
  100 FORMAT(49H1MAIN PROGRAM TO TEST REAL MATRIX MULTIPLICATION.////)
  101 FORMAT(3I5)
  102 FORMAT(F10.0)
  103 FORMAT(4X2H I,3X2H J,8X7H C(I,J)//(1H 2I5,E20.8))
      END
- XQT TEST4
    3    3    3
        3.
        2.
        2.
        4.
        3.
        0.
        5.
        0.
        5.
        1.
        1.
        1.
        1.
        1.
        1.
        1.
        1.
        1.
    3    3    3
        3.
        2.
        2.
        4.
        3.
        0.
        5.
        0.
        5.
        2.
        2.
        2.
        2.
        2.
        2.
        2.
        2.
        2.
- FIN
```


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SAMPLE OUTPUT (FOR MATAB)

Test program for real matrix multiplication.

```
MAIN PROGRAM TO TEST REAL MATRIX MULTIPLICATION.

    I     J          C(I,J)

    1     1         .70000000+01
    1     2         .70000000+01
    1     3         .70000000+01
    2     1         .10000000+01
    2     2         .10000000+01
    2     3         .10000000+01
    3     1         .10000000+02
    3     2         .10000000+02
    3     3         .10000000+02
    I     J          C(I,J)

    1     1         .14000000+02
    1     2         .14000000+02
    1     3         .14000000+02
    2     1         .20000000+01
    2     2         .20000000+01
    2     3         .20000000+01
    3     1         .20000000+02
    3     2         .20000000+02
    3     3         .20000000+02

EXECUTION TERMINATED BY AN ATTEMPT TO READ THRU END-OF-DATA.
ABOVE FAULT AT INTERNAL SEQUENCE NUMBER    00105  IN  TEST4
```

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SAMPLE INPUT (FOR MATAB)

Test program for complex matrix postmultiplication.

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=BEFFM
- PLT,A MATAB
- FOR TEST
C     MAIN PORGRAM TO TEST 1107 MATRIX PACKAGE - COMPLEX MATRIX POSTMULT
C     IPLICATION.
C
      DIMENSION A(2,3,3), B(2,3), C(2,3,3)
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,101) M, N
      READ (5,102) ((A(1,I,J),A(2,I,J),J=1,N),I=1,M)
      READ (5,102) (B(1,I),B(2,I),I=1,N)
C
      CALL CMXMD(A,B,C,M,N)
C
C     OUTPUT.
      WRITE (6,103) ((I,J,C(1,I,J),C(2,I,J),J=1,N),I=1,M)
      GO TO 1
C
C     FORMAT STATEMENTS.
C
  100 FORMAT(56H1MAIN PROGRAM TO TEST COMPLEX MATRIX POSTMULTIPLICATION.
     1////)
  101 FORMAT(2I5)
  102 FORMAT(2F10.0)
  103 FORMAT (25H POSTMULTIPLICATION OF A.//4X2H I,3X2H J,18X7H A(I,J)//
     1 (1H 2I5,2E20.8))
      END
- XQT TEST
    3    3
         2.          1.
         2.          1.
         3.          1.
         4.          1.
         5.          1.
         6.          1.
         7.          1.
         8.          1.
         9.          1.
         2.          1.
         2.          1.
         2.          1.
    3    3
         1.          1.
         2.          2.
         3.          3.
         4.          4.
         5.          5.
         6.          6.
         7.          7.
         8.          8.
         9.          9.
         2.          2.
         1.          1.
         0.          0.
- FIN
```

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SAMPLE OUTPUT (FROM MATAB)

Test program for complex matrix postmultiplication.

```
MAIN PROGRAM TO TEST COMPLEX MATRIX POSTMULTIPLICATION.

POSTMULTIPLICATION OF A.

    I    J                    A(I,J)

    1    1        .30000000+01          .40000000+01
    1    2        .30000000+01          .40000000+01
    1    3        .50000000+01          .50000000+01
    2    1        .70000000+01          .60000000+01
    2    2        .90000000+01          .70000000+01
    2    3        .11000000+02          .80000000+01
    3    1        .13000000+02          .90000000+01
    3    2        .15000000+02          .10000000+02
    3    3        .14999999+02          .11000000+02
POSTMULTIPLICATION OF A.

    I    J                    A(I,J)

    1    1       -.00000000             .40000000+01
    1    2       -.00000000             .40000000+01
    1    3       -.00000000             .00000000
    2    1       -.00000000             .16000000+02
    2    2       -.00000000             .10000000+02
    2    3       -.00000000             .00000000
    3    1       -.00000000             .27999998+02
    3    2       -.00000000             .16000000+02
    3    3       -.00000000             .00000000

EXECUTION TERMINATED BY AN ATTEMPT TO READ THRU END-OF-DATA.
ABOVE FAULT AT INTERNAL SEQUENCE NUMBER    00105  IN  TEST
```

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SAMPLE INPUT (FOR MATAB)

Test program for complex matrix transpose.

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=BEEF M
- PLT,A MATAB
- FOR TEST
C     MAIN PROGRAM TO TEST 1107 MATRIX PACKAGE - COMPLEX MATRIX TRANSPOS
C     E.
C
      DIMENSION A(2,5,3),C(2,3,5)
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,101) M, N
      READ (5,102) ((A(1,I,J),A(2,I,J),J=1,N),I=1,M)
C
      CALL CMXT(A,C,M,N)
C
C     OUTPUT.
C
      WRITE (6,103) ((I,J,C(1,I,J),C(2,I,J),J=1,N),I=1,M)
      GO TO 1
C
C     FORMAT STATEMENTS.
C
  100 FORMAT (47H1MAIN PROGRAM TO TEST COMPLEX MATRIX TRANSPOSE.////)
  101 FORMAT (2I5)
  102 FORMAT (2F10.0)
  103 FORMAT (31H COMPLEX MATRIX TRANSPOSE OF A.//4X2H I,3X2H J, 19X7H A
     1(I,J)//(1H 2I5,2E20.8))
      END
- XQT TEST
    5    3
        6.          8.
        4.         -2.
        1.          0.
        0.         10.
        6.         -2.
        4.         -4.
        2.         -8.
        8.          3.
        4.         -2.
        3.          2.
        4.          6.
        2.         -8.
        3.         -2.
        2.         -1.
        1.          0.
- FIN
```

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SAMPLE OUTPUT (FROM MATAB)

Test program for complex matrix transpose.

000 0054

```
MAIN PROGRAM TO TEST COMPLEX MATRIX TRANSPOSE.


COMPLEX MATRIX TRANSPOSE OF A.

    I    J                    A(I,J)

    1    1        .60000000+01        .80000000+01
    1    2        .00000000           .10000000+02
    1    3        .20000000+01       -.80000000+01
    2    1        .40000000+01       -.20000000+01
    2    2        .60000000+01       -.20000000+01
    2    3        .80000000+01        .30000000+01
    3    1        .10000000+01        .00000000
    3    2       -.40000000+01       -.40000000+01
    3    3       -.40000000+01       -.20000000+01
    4    1        .00000000           .10000000+02
    4    2        .20000000+01       -.80000000+01
    4    3        .30000000+01        .20000000+01
    5    1        .60000000+01       -.20000000+01
    5    2        .80000000+01        .30000000+01
    5    3       -.40000000+01        .60000000+01

EXECUTION TERMINATED BY AN ATTEMPT TO READ THRU END-OF-DATA.
ABOVE FAULT AT INTERNAL SEQUENCE NUMBER    00105  IN  TEST
```

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SAMPLE INPUT (FOR CINV1)

```
- RUN HIDOLL,ZJ1190,3,10
- ASG A=REFFM
- PLT,A INV,CINV1
- FOR TEST2
C     MAIN PROGRAM TO TEST DETERMINANT EVALUATION AND MATRIX INVERSION
C     OF COMPLEX AND REAL MATRICES.  SET IER=0 FOR COMPLEX MATRIX, IER=1
C     FOR REAL MATRIX.  DIVIDE CHECK USED FOR SINGULARITY.
C
      DIMENSION AREAL(50),BIMAG(50),K(1),IK(1)
      EQUIVALENCE (AREAL(1),K(1)),(AREAL(2),K(2)),(AREAL(3),K(3)),(BIMAG
     1(1),IK(1)),(BIMAG(2),IK(2)),(BIMAG(3),IK(3))
C
C     PROGRAM INITIALIZATION.
C
      WRITE (6,100)
    1 READ (5,101) N, IER
      KN=N*N
      M=KN+3
      IF (IER.EQ.0) GO TO 2
      READ (5,102) (AREAL(L), L=M,4,-1)
      K(2)=N
      K(3)=N
      GO TO 5
    2 READ (5,103) (AREAL(L),BIMAG(L), L=M,4,-1)
      IK(2)=N
      IK(3)=N
C
C     CALL SEQUENCE.
C
      CALL CINV1 (AREAL,BIMAG,IER)
      IF (IER.EQ.1) GO TO 7
      IF (IER.EQ.-1) GO TO 8
      GO TO 10
    5 DO 6 L=1,M
      BIMAG(L)=0.0
    6 CONTINUE
      CALL CINV1(AREAL,BIMAG,IER)
      IF (IER.EQ.1) GO TO 7
      IF (IER.EQ.-1) GO TO 8
      GO TO 11
C
C     OUTPUT.
C
    7 WRITE (6,104)
      GO TO 1
    8 WRITE (6,105)
      GO TO 1
   10 WRITE (6,106) AREAL(1),BIMAG(1)
      WRITE (6,107) (AREAL(L),BIMAG(L), L=M,4,-1)
      GO TO 1
   11 WRITE (6,108) AREAL(1)
      WRITE (6,109) (AREAL(L), L= M,4,-1)
      GO TO 1
C
C     FORMAT STATEMENTS.
C
  100 FORMAT(96H1MAIN PROGRAM TO TEST INVERSION AND DETERMINANT EVALUATI
     1ON OF GENERAL COMPLEX AND REAL MATRICES.////)
  101 FORMAT(2I5)
  102 FORMAT(F10.0)
  103 FORMAT(F10.0,F10.0)
```

continued

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```
  104 FORMAT(20H MATRIX IS SINGULAR.//)
  105 FORMAT(31H MATRIX NOT IN ACCEPTABLE FORM.//)
  106 FORMAT(15H DETERMINANT = 2E20.8//)
  107 FORMAT(16H INVERSE MATRIX.//(1H 2E20.8))
  108 FORMAT(15H DETERMINANT = E20.8//)
  109 FORMAT(16H INVERSE MATRIX.//(1H E20.8))
      END
- XQT TEST2
    3     1
    9.3746
    3.0416
    2.4371
    3.0416
    6.1832
    1.2163
    2.4371
    1.2163
    8.4429
    3     0
    9.3746     9.3746
    3.0416     3.0416
    2.4371    -2.4371
    3.0416     3.0416
    6.1832     6.1832
    1.2163     1.2163
    2.4371    -2.4371
    1.2163     1.2163
    3.4429     3.4429
- FIN
```

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SAMPLE OUTPUT (FROM CINV1)

```
MAIN PROGRAM TO TEST INVERSION AND DETERMINANT EVALUATION OF GENERAL COMPLEX AND REAL MATRICES.


DETERMINANT =          .30265028+03

INVERSE MATRIX.

         .10803262-00
        -.85503731-01
         .54773283-01
        -.85503731-01
         .21345058-00
        -.50908796-01
         .54773283-01
        -.50908796-01
         .10216365-00
DETERMINANT =         -.10818158+03          .10818158+03

INVERSE MATRIX.

         .99952539-01        -.99952539-01
        -.47707260-01         .47707260-01
         .94703922-01        -.94703922-01
        -.47707260-01         .47707260-01
         .13289001-00        -.13289001-00
        -.94978225-01         .94978225-01
         .94703922-01        -.94703922-01
        -.94978225-01         .94978225-01
         .24580333-00        -.24580333-00


EXECUTION TERMINATED BY AN ATTEMPT TO READ THRU END-OF-DATA.
ABOVE FAULT AT INTERNAL SEQUENCE NUMBER    00106  IN  TEST2
```

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COST ESTIMATE

For the jobs listed on the Sample Input, the processing times are listed below. The current rate for the University of Notre Dame is $480./hour for computer time with an additional charge of $10. for postage and handling.

Charge to user = computer costs + postage and handling + network overhead

Program	*Processing Time (in seconds)*	*Computer costs*	*Charge to user**
GAMMA	16	$2.51	$12.51
BES	23	$3.74	$13.74
MATAB (add. & sub.)	32	$4.67	$14.67
MATAB (multiplic.)	43	$6.11	$16.11
MATAB (postmul ip.)	29	$4.23	$14.23
MATAB (transpose)	32	$4.74	$14.74
CINV1	32	$4.82	$14.82

* A figure for network overhead must still be added to the totals in this column.

CONTENTS—BEEFM

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DESCRIPTIVE TITLE	Bio-Medical Multivariate Statistical Programs
CALLING NAME	BMD
INSTALLATION NAME	University of Notre Dame Computing Center
AUTHOR(S) AND AFFILIATION(S)	School of Medicine University of California, Los Angeles UNIVAC Division of Sperry Rand Corporation College of Business Administration and Computing Center University of Notre Dame
LANGUAGE	FORTRAN IV
COMPUTER	UNIVAC 1107
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Elizabeth Hutcheson, EIN Technical Representative, Computing Center, University of Notre Dame, Notre Dame, Ind. 46556 Tel.: (219) 283-7784

FUNCTIONAL ABSTRACT

The BMD system is a package of computer programs designed to do both basic data processing and the subsequent statistical analysis. The programs have been prepared in an easy-to-use parametric form so that the researcher may adapt them to a wide variety of statistical problems. For further details of the package, see the User Instructions. The BMD is available at the University of Notre Dame in its 1967 edition.

REFERENCES

Dixon, W.J. (Ed.), *BMD: Biomedical Computer Programs*, (Univ. of Calif. Press, Berkeley, 1967, 1970).

Univ. of Notre Dame Computing Center, *BMD for the UNIVAC 1107*, (Rough draft, 1967 ed. of BMD). Available from Univ. of Notre Dame Computing Center, Notre Dame, Ind.

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USER INSTRUCTIONS

The computer routines which constitute the BMD multivariate statistical package are designed for use by statisticians and researchers; their use does not require the services of a computer programmer. The user of the statistical system enters his data on punched cards in an easy-to-use and flexible format. A problem header card is also punched which defines the size and options to be used for each analysis to be performed. Detailed instructions for the preparation of these cards is included in Ref. 1 and 2.

The card decks are then forwarded to the UNIVAC 1107 or 1108 computer installation where system cards are added These systems cards call the appropriate computer program and define any tape files used. The analysis is then performed on the computer and the print-outs sent back to the researcher. Many computer installations are able to perform this service (even for large computations) for researchers within a day.

Keypunching of the basic input can, however, often be a detailed and time consuming operation. Researchers should contact the keypunching department before they start accumulating their raw data so that it can be collected in a format lending itself to rapid, accurate transcription.

The following programs comprise the BMD package:

Name	*Description*
BMD01D	SIMPLE DATA DESCRIPTION This program computes simple averages and measures of dispersion of variables, omitting those values which the user specifies for exclusion from the computations.
BMD02D	CORRELATION WITH TRANSGENERATION This program computes simple correlation coefficients, averages and measures of dispersion on entering variables and/or transgenerated variables from selected cases whose values for specified variables have a precise logical relationship in agreement with a specified Boolean expression. Cross-tabulation plots are optional.
BMD03D	CORRELATION WITH ITEM DELETION This program computes a simple correlation matrix,

continued

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Name *Description*

omitting values of variables that the user specifies to be deleted. Blanks as well as other codes may be specified for deletion, e.g., to indicate missing values.

BMD04D ALPHANUMERIC FREQUENCY COUNT (1 COLUMN DATA)
This program computes frequencies of legal characters on one-column data. Any legal numeric, alphabetic, or special character is counted. The input data may be on cards, or on magnetic tape in Field Data mode.

BMD05D GEN_RAL PLOT INCLUDING HISTOGRAMS
This program provides a method by which graphs and histograms can be produced.

BMD06D DESCRIPTION OF STRATA
Cases are separated into groups based on specified intervals of one variable, the conditioning variable. For these selected groups, computations are performed for any other variables which are designated as the conditioned variables. Univariate descriptions and correlation coefficients are included.

BMD07D DESCRIPTION OF STRATA WITH HISTOGRAMS
This program groups the data into a specified number of groups based on the order of entry of the data or into groups whose values for a base variable are within intervals established by specified cut points. For these groups, histograms are printed for each variable. The number of classes or categories of the histograms may be specified or they may be computed by the program. Univariate descriptions and correlation coefficients are included.

BMD08D CROSS TABULATION WITH VARIABLE STACKING
This program computes two-way frequency tables of data input. Frequency tables are computed from specified ranges of the original variables, variables after transgeneration, stacked variables or combinations of these. Data input may be positive or negative integers only.

BMD09D CROSS TABULATION, INCOMPLETE DATA
This program performs cross-tabulations of input data,

continued

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Name	*Description*
	excluding from cross-tabulation specified special values or codes used to designate missing values. The program differentiates between blanks and zeros in testing for special values.
BMD10D	DATA PATTERNS FOR DICHOTOMIES This program finds frequencies and patterns of any one particular specified code in the input data. Frequent use will be for a code representing missing values.
BMD11D	DATA PATTERNS FOR POLYCHOTOMIES This program prints patterns of one-column data and item numbers or case numbers to identify cases having these data patterns. If desired, original data may be recoded by the program before the data patterns are printed.
BMD01M	PRINCIPAL COMPONENT ANALYSIS This program computes the principal components of standardized data and rank-orders each standardized case by the size of each principal component separately.
BMD02M	REGRESSION ON PRINCIPAL COMPONENTS This program computes the principal components of standardized data and rank-orders each standardized case by the size of each principal component separately. Each dependent variable is regressed on the first, first two, first three and all principal components when each component is expressed in terms of standardized data.
BMD03M	GENERAL FACTOR ANALYSIS This program performs a principal component solution and an orthogonal rotation of the factor matrix. Data input to this program may be in the form of raw data, a correlation matrix, or a factor matrix. Data input may be read in from punched cards, Field Data or binary tape.
BMD04M	DISCRIMINANT ANALYSIS FOR TWO GROUPS This program computes a linear function of p variables measured on each individual of two groups. This function can serve as an index for discrimination between the groups. It is determined from

continued

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Name	*Description*
	from the criterion of "best" in that the difference between the mean indices for the two groups divided by a pooled standard deviation of the indices is maximized.
BMD05M	DISCRIMINANT ANALYSIS FOR SEVERAL GROUPS This program directs the computation of a set of linear functions for the purpose of classifying an individual into one of several groups. The input data consist of a set of observations for each of the classification groups; each observation consists of the values of a set of variables, and each observation contains a value for each of the variables.
BMD06M	CANONICAL ANALYSIS This program computes the canonical correlations between two sets of variables.
BMD07M	STEPWISE DISCRIMINANT ANALYSIS This program performs a multiple discriminant analysis in a stepwise manner. At each step one variable is entered into the set of discriminating variables. The entering variable is selected by the following equivalent criteria; the variable with the largest F value (see computational procedure), or the variable which when partialed on the previously entered variables has the highest multiple correlation with the groups, or the variable which gives the greatest decrease in the ratio of within to total generalized variances. A variable is deleted if its F value becomes too low. The program also computes canonical correlations and coefficients for canonical variables. It plots the first two canonical variables to give an optimal two-dimensional picture of the dispersion.
BMD01R	SIMPLE LINEAR REGRESSION This program performs simple linear regression analysis on a single or combined treatment groups with unequal sample sizes. (The words "treatments groups" are used here to describe categories.) The "within" cross-products sums and coefficients are computed; thus, analysis-of-covariance information is also provided in the output.

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Names	*Description*
BMD02R	STEPWISE REGRESSION This program computes a sequence of multiple linear regression equations in a stepwise manner. At each step one variable is added to the regression equation. The variable added is the one which makes the greatest reduction in the error sum of squares. Equivalently, it is the variable which has highest partial correlation with the dependent variable partialed on the variables which have already been added; and equivalently, it is the variable which, if it were added, would have the highest F value. In addition, variables can be forced into the regression equation. Non-forced variables are automatically removed when their F values become too low. Regression equations with or without the regression intercept may be selected.
BMD03R	MULTIPLE REGRESSION WITH CASE COMBINATIONS This program performs multiple regression and correlation analysis on the data within various combinations of subsamples from the same population.
BMD04R	PERIODIC REGRESSION AND HARMONIC ANALYSIS This program performs periodic or harmonic regression analysis using the regression function of the Fourier series form. Periodic regressions are computed successively up to the harmonic specified by the user.
BMD05R	POLYNOMIAL REGRESSION This program computes polynomial regressions of the form $Y = \alpha + \beta_1 X + \beta_2 X^2 + \cdots + \beta_k X^k$ (k^{th} degree), where k is some positive integer.
BMD06R	ASYMPTOTIC REGRESSION This program performs asymptotic regression analysis using the modified exponential funtion of the form, $Y = \alpha + \beta_\mu x.$ By making a transgeneration (or successive transgenerations) on the dependent variable Y, other equations can be used.

continued

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Name	*Description*
BMD01S	LIFE TABLE AND SURVIVAL RATE This program computes proportions surviving, survival rates and standard errors for successively reduced time periods and prints a plot of the cumulative proportion surviving.
BMD02S	CONTINGENCY TABLE ANALYSIS This program computes two-way frequency and percentage tables, chi squares, contingency coefficients, and maximum likelihood ratios. Each variable may be categorized in several different ways; each way is referred to as a categorization.
BMD03S	BIOLOGICAL ASSAY; PROBIT ANALYSIS This program obtains maximum likelihood estimates for the parameters α and β in the probit equation $y = \alpha + \beta x$. An iterative scheme is used. As an option, an estimate of the natural (threshold) response rate is also obtained.
BMD04S	GUTTMAN SCALE PREPROCESSOR This program performs the initial step of BMD06S and BMD07S (GUTTMAN SCALE NO. 2, PARTS 1 AND 2). It weights the input data, checks the data, determines the frequencies of responses, combines those responses which have frequencies less than N% (N is user-specified) of the total respondents, ranks the respondents by the Cornell technique, and determines the errors.
BMD05S	GUTTMAN SCALE NO. 1 This program takes the data on many variables, assigns proper weights to the data, ranks the respondents (or cases) from most favorable to least favorable, and assigns a Guttman scale score for each respondent. This procedure is widely used for data from attitude or opinion questionnaires.
BMD06S	GUTTMAN SCALE NO. 2, PART 1 This program performs the initial steps for GUTTMAN SCALE NO. 2. The Problem, Response, and Reflection (if any) Cards are read and processed. The input data are read into the computer, weighted, and checked for valid values.

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Name	*Description*
BMD07S	GUTTMAN SCALE NO. 2, PART 2 This program performs the major computations of GUTTMAN SCALE NO. 2. It reads and processes any Forced Combination Cards and performs any and all combinations of responses which will give the best possible Guttman scale the program can produce. During the running of the program, the respondents are ranked by the Cornell technique after each combination and the errors to each response are determined.
BMD08S	GUTTMAN SCALE NO. 2, PART 3 This program performs the final steps of GUTTMAN SCALE NO. 2. In this program, weights are assigned to all zero responses such that no additional errors are introduced. Guttman scale scores are assigned, and the final results specified by the user are printed out.
BMD09S	TRANSGENERATION This program performs selected transgenerations on specified variables in the data. Any of the transgeneration codes listed in the BMD manual may be selected. Input may be from punched cards, from Field Data tape, or from binary tape.
BMD10S	TRANSPOSTION OF LARGE MATRICES This program performs no analysis but is designed to convert large matrices to the form required by some programs which do perform statistical analysis (e.g., to convert data from "case-wise" to "variable-wise" form for use in BMD01V). Large matrices are read in from cards or Field Data tape, transposed, and written out on Field Data tape.
BMD01T	AMPLITUDE AND PHASE ANALYSIS This program computes the amplitude and phase of moderately wide-band noise and noise contaminated by extraneous noise. The amplitude and phase are determined from a pair of finite moving averages on the sample noise. A generalized Tukey filter with a variable number of triangles and resolutions is used.

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Name	*Description*
BMD02T	AUTOCOVARIANCE AND POWER SPECTRAL ANALYSIS This program computes the autocovariance, power spectrum, cross covariance, cross spectrum, transfer function, and coherence function of time series.
BMD01V	ANALYSIS OF VARIANCE FOR ONE-WAY DESIGN This program computes an analysis-of-variance table for one variable of classification, with unequal group sample sizes.
BMD02V	ANALYSIS OF VARIANCE FOR FACTORIAL DESIGN This program computes an analysis of variance for a factorial design.
BMD03V	ANALYSIS OF COVARIANCE FOR FACTORIAL DESIGN This program computes a full factorial analysis of covariance.
BMD04V	ANALYSIS OF COVARIANCE WITH MULTIPLE COVARIATES This program is designed to compute analysis-of-covariance information for one analysis-of-variance variable with multiple covariates and unequal treatment group sizes. Cases may be specified by the user as being in certain treatment groups, or cases may be placed in treatment groups by the program in accordance with a specified Boolean expression.
BMD05V	GENERAL LINEAR HYPOTHESIS This program performs the calculations required for a general linear hypothesis model. The independent variables are of two general types, variables used to specify the analysis-of-variance classification, and variables used as covariates. By use of these variables, the program can be used for balanced or unbalanced analysis-of-variance or covariance designs and missing-value problems.
BMD06V	GENERAL LINEAR HYPOTHESIS WITH CONTRASTS This program is similar to BMD05V in that it is designed to estimate and test the statistical significance of the parameters which occur in the general linear hypothesis model. This program is more general in that it can test the statistical significance of any real valued linear function

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Name	*Description*
	of the parameters. It is less general in that higher order simultaneous tests cannot be made. Thus, this program can test the hypothesis $\beta_1 = \beta_2 = 0$.
BMD07V	MULTIPLE RANGE TESTS This program computes an analysis-of-variance table for one variable of classification, with unequal group sizes. The treatment group or category means are ranked in increasing order; and a multiple range test, using significant ranges input by the user, is performed on the ranked means. A maximum of 9 range tests may be done on the ranked means.
BMD08V	ANALYSIS OF VARIANCE This program performs analysis of variance for any hierarchial design with equal cell sizes. This includes the nested, partially nested and partially crossed, and fully crossed designs. The model is specified by indicating the nesting relationship of the indices. Separate analyses may be performed on several dependent variables simultaneously. Each analysis of variance table includes an expected mean square in terms of the population variance components. For this calculation each index may be specified as fixed or random from a finite or infinite population.

REFERENCES

Dixon, W.J. (Ed.), *BMD: Biomedical Computer Programs*, (Univ. of Calif. Press, Berkeley, 1967, 1970).

Univ. of Notre Dame Computing Center, *BMD for the UNIVAC 1107*, (Rough draft, 1967 ed. of BMD). Available from Univ. of Notre Dame Computing Center, Notre Dame, Ind.

Anderson, T.W., *Introduction to Multivariate Statistical Analysis*, (John Wiley & Sons, Inc., New York, 1958). This text surveys most of the procedures used by BMD Programs.

Cooley, W.W. and Lohnes, P.R., *Multivariate Procedures for the Behavioral Sciences*, (John Wiley and Sons, Inc., New York, 1962). The MIT statistical package is described in this text.

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REFERENCES

Dixon, W.J., and Massey, F.J., *Introduction to Statistical Analysis*, (McGraw-Hill Book Co., Inc., New York, 1957), 2nd ed. Statistical definitions, simpler standard statistical procedures, and reference tables for tests and estimation techniques are included.

Kendall, M.G., *A Course in Multivariate Analysis*, (Hafner Pub. Co., New York, 1957), Ch. I. The first chapter of this text gives an introduction to the scope and problems considered by multivariate statistical analysis.

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SAMPLE INPUT AND OUTPUT

See Dixon, W.J. (Ed.), *BMD: Biomedical Computer Programs*, (Univ. of Calif. Press, Berkeley, 1967).

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COST ESTIMATE

See references listed in USER INSTRUCTIONS.

Charge to user = computer time + postage and handling + network overhead

= computer time + $10.00 + network overhead

CONTENTS—BMD

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DESCRIPTIVE TITLE	UNIVAC 1107 Linear Programming Package
CALLING NAME	LP1107
INSTALLATION NAME	The University of Notre Dame Computing Center
AUTHOR(S) AND AFFILIATION(S)	UNIVAC Division of Sperry Rand
LANGUAGE	Sleuth II/FORTRAN IV
COMPUTER	UNIVAC 1107
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Elizabeth Hutcheson, EIN Technical Representative, Computing Center, Univ. of Notre Dame, Notre Dame, Ind. 46556 Tel.: (219) 283-7784

FUNCTIONAL ABSTRACT

LP1107 is a generalized program for the solution of linear programming problems. More specifically, the LP1107 command structure is a mathematical programming control language; used to prepare a control sequence for a specific programming job.

Either the dual or simplex algorithm, or both, can be used. LP1107 incorporates a true programming language with logical capabilities and full macro capabilities. If a group of commands is being used repetitively, the user may incorporate it into his macro command library and issue the macro command instead. Single and double precision arithmetic are included.

REFERENCES

UNIVAC Systems Programming Library Services, *UP3897 1107LP User's Manual (preliminary)*, (UNIVAC, Sperry Rand Building, New York, 1964).

Aronofsky, J.S., "Growing Applications of Linear Programming with a View Towards Understanding Principles on Which Future LP Systems Must be Based," *Communications of the ACM*, (June 1964).

Copies of these references are available through the local UNIVAC representatives or from the EIN Office at the cost of reproduction and mailing.

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USER INSTRUCTIONS

The user is directed to the references for a full description of the operating system and programming language.

REFERENCES

UNIVAC Systems Programming Library Services, *UP3897 1107LP User's Manual (preliminary)*, (UNIVAC, Sperry Rand Building, New York, 1964).

Aronofsky, J.S., "Growing Applications of Linear Programming with a View Towards Understanding Principles on Which Future LP Systems Must be Based," *Communications of the ACM*, (June 1964).

Copies of these references are available through the local UNIVAC representatives or from the EIN Office at the cost of reproduction and mailing.

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SAMPLE INPUT

The problem shown is that described in *Introduction to Linear Programming* by Charnes, Cooper and Henderson, (John Wiley & Sons, New York, 1953).

```
∇ RUN SMITH, 077707,5,20
∇ XQT CUR
TRW F
IN F
TRW F
∇  XQT 1107LP
SET CASE1 TO (NUT-MI)  ; DEFINE CONTENTS OF CASE1
SET CASE2 TO (X     )  ; DEFINE CONTENTS OF CASE2
TITLE                  ; NEXT CARD CONTAINS PAGE HEADING
 1107LP RUN ON NUT-MIX PROBLEM
LOAD                   ; LOAD SHARE FORMAT MATRIX
ROW ID
     1     +MA-CAS
     1     +MA+PEA
     1     +MB-CAS
     1     +MB+PEA
     1     +XX+CAS
     1     +XX+PEA
     1     +XX+HAZ
MATRIX
             XX+CAS  1.0
             XX+PEA  1.0
             XX+HAZ  0.6
       MA/CAS$$$$$$  0.5
       MA/CASMA-CAS -0.5
       MA/CASMA+PEA -0.25
       MA/CASXX+CAS  1.0
       MA/PEA$$$$$$  0.5
       MA/PEAMA-CAS  0.5
       MA/PEAMA+PEA  0.75
       MA/PEAXX+PEA  1.0
       MA/HAZ$$$$$$  0.5
       MA/HAZMA-CAS  0.5
       MA/HAZMA+PEA -0.25
       MA/HAZXX+HAZ  1.0
       MB/CAS$$$$$$  0.35
       MB/CASMB-CAS -0.75
       MB/CASMB+PEA -0.5
       MB/CASXX+CAS  1.0
```

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```
      MB/PEA$$$$$$   0.35
      MB/PEAMB-CAS   0.25
      MB/PEAMB+PEA   0.5
      MB/PEAXX+PEA   1.0
      MB/HAZ$$$$$$   0.35
      MB/HAZMB-CAS   0.25
      MB/HAZMB+PEA  -0.50
      MB/HAZXX+HAZ   1.0
      MD/CAS$$$$$$   0.25
      MD/CASXX+CAS   1.0
      MD/PEA$$$$$$   0.25
      MD/PEAXX+PEA   1.0
      MD/HAZ$$$$$$   0.25
      MD/HAZXX+HAZ   1.0
⍝
⍝     SLACK PRICES
      XX+CAS$$$$$$   0.65
      XX+PEA$$$$$$   0.25
      XX+HAZ$$$$$$   0.35
ENDATA
LISTPR      ; OUTPUT LABELS, COSTS, AND STATUS FLAGS
MATRIX      ; OUTPUT MATRIX TABLEAU WITHOUT UNIT POSITIVES.
EQLIST      ; OUTPUT MATRIX IN EQUATION FORM.
MIXMAP      ; OUTPUT MATRIX IN COMPACT, CODED FORM.
GOGOGO      ; OBTAIN OPTIMAL, FEASIBLE;RATIONAL SOLUTION.
DPMODE      ; INVERT TO CURRENT BASIS IN DOUBLE PRECISION.
SPMODE      ; RETURN TO SINGLE PRECISION.
GOGOGO      ; RESOLVE IN CASE INVERSION INCOMPLETE.
PRIMAL      ; OUTPUT ACTIVITY LEVELS AT SOLUTION.
DUAL        ; OUTPUT SHADOW PRICES.
REDCST      ; OUTPUT REDUCED COSTS OF NON BASIS VARIABLES.
RANGES      ; OUTPUT PRIMAL AND DUAL BASIS.
ERRORS      ; COMPUTE AND OUTPUT PRIMAL AND DUAL ERRORS.
ENDJOB      ; RETURN TO MONITOR.
∇ FIN
```

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SAMPLE OUTPUT

```
XQT 1107LP                                                    .000.000.001

SET CASE1 TO (NUT-MI)      DEFINE CONTENTS OF CASE1
SET CASE2 TO (X     )      DEFINE CONTENTS OF CASE2
TITLE                      NEXT CARD CONTAINS PAGE HEADING
LOAD                       LOAD SHARE FORMAT MATRIX


 1107LP RUN ON NUT-MIX PROBLEM                                .000.001.001

LOADER STATISTICS
STRUCTURAL MATRIX
   7 ROWS     9 COLUMNS     21 NON-ZERO ELEMENTS  33.3 PCT. DENSE
      .250000 IS SMALLEST ELEMENT      1.000000 IS LARGEST ELEMENT

COST VECTOR
   12 NON-ZERO ELEMENTS  75.0 PCT. DENSE
      .250000 IS SMALLEST ELEMENT       .650000 IS LARGEST ELEMENT

RHS VECTOR
   3 NON-ZERO ELEMENTS  42.9 PCT. DENSE
     .600000 IS SMALLEST ELEMENT       1.000000 IS LARGEST ELEMENT
   0 INITIAL INFEASIBILITIES   0 INITIAL ARTIFICIALS


 1107LP RUN ON NUT-MIX PROBLEM                                .000.003.001


LIST PRINT REPORT


FLAG FUNCTION
   1-ORIGINAL BASIS
   2-CURRENT BASIS
   3-DESIRED BASIS
   4-FREE VARIABLE
   5-FROZEN VARIABLE
   6-INVERSION CONTROL
```

continued

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PVNO IS THE PIVOT VECTOR COUNT AT THE TIME THE VARIABLE LEFT THE BASIS

	LABEL	COST	FLAG	1	2	3	4	5	6	PVNO
1	MA-CAS	.000000		YES	YES	NO	NO	NO	NO	0
2	MA+PEA	.000000		YES	YES	NO	NO	NO	NO	0
3	MB-CAS	.000000		YES	YES	NO	NO	NO	NO	0
4	MB+PEA	.000000		YES	YES	NO	NO	NO	NO	0
5	XX+CAS	.650000		YES	YES	NO	NO	NO	NO	0
6	XX+PEA	.250000		YES	YES	NO	NO	NO	NO	0
7	XX+HAZ	.350000		YES	YES	NO	NO	NO	NO	0
8	MA/CAS	.500000		NO	NO	NO	NO	NO	NO	0
9	MA/PEA	.500000		NO	NO	NO	NO	NO	NO	0
10	MA/HAZ	.500000		NO	NO	NO	NO	NO	NO	0
11	MB/CAS	.350000		NO	NO	NO	NO	NO	NO	0
12	MB/PEA	.350000		NO	NO	NO	NO	NO	NO	0
13	MB/HAZ	.350000		NO	NO	NO	NO	NO	NO	0
14	MD/CAS	.250000		NO	NO	NO	NO	NO	NO	0
15	MD/PEA	.250000		NO	NO	NO	NO	NO	NO	0
16	MD/HAZ	.250000		NO	NO	NO	NO	NO	NO	0

END OF LIST PRINT.

1107LP RUN ON NUT-MIX PROBLEM .000.005.001

CASE NUT-MIX MATRIX TABLEAU

LABEL	COST	BASIS	MA/CAS	MA/PEA	MA/HAZ
COST	.000000	.000000	.500000	.500000	.500000
ROW LABEL					
1 MA-CAS	.000000	.000000	-.500000	.500000	.500000
2 MA+PEA	.000000	.000000	-.250000	.750000	-.250000
3 MB-CAS	.000000	.000000	.000000	.000000	.000000
4 MB+PEA	.000000	.000000	.000000	.000000	.000000
5 XX+CAS	.650000	1.000000	1.000000	.000000	.000000
6 XX+PEA	.250000	1.000000	.000000	1.000000	.000000
7 XX+HAZ	.350000	.600000	.000000	.000000	1.000000

continued

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1107LP RUN ON NUT-MIX PROBLEM .000.006.001

CASE NUT-MIX MATRIX TABLEAU

LABEL	MB/CAS	MB/PEA	MB/HAZ	MD/CAS	MD/PEA
COST	.350000	.350000	.350000	.250000	.250000
ROW LABEL					
1 MA-CAS	.000000	.000000	.000000	.000000	.000000
2 MA+PEA	.000000	.000000	.000000	.000000	.000000
3 MB-CAS	-.750000	.250000	.250000	.000000	.000000
4 MB+PEA	-.500000	.500000	-.500000	.000000	.000000
5 XX+CAS	1.000000	.000000	.000000	1.000000	.000000
6 XX+PEA	.000000	1.000000	.000000	.000000	1.000000
7 XX+HAZ	.000000	.000000	1.000000	.000000	.000000

1107LP RUN ON NUT-MIX PROBLEM .000.007.001

CASE NUT-MIX MATRIX TABLEAU

LABEL	MD/HAZ
COST	.250000
ROW LABEL	
1 MA-CAS	.000000
2 MA+PEA	.000000
3 MB-CAS	.000000
4 MB+PEA	.000000
5 XX+CAS	.000000
6 XX+PEA	.000000
7 XX+HAZ	1.000000

END OF MATRIX TABLEAU

continued

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```
 1107LP RUN ON NUT-MIX PROBLEM                                    .000.008.001
EQLIST        OUTPUT MATRIX IN EQUATION FORM.

 1107LP RUN ON NUT-MIX PROBLEM                                    .000.009.001

   CASE NUT-MIX                    EQLIST OUTPUT

   EQUATION    1 LABEL MA-CAS COST =     .000000 ORIGINAL BI =       .000000
   +   1.00000(MA-CAS) =   .50000(MA/CAS) +   .50000(MA/PEA) +   .50000(MA/HAZ)

   EQUATION    2 LABEL MA+PEA COST =  .000000 ORIGINAL BI =   .000000
   +   1.00000(MA+PEA) =    .25000(MA/CAS) +  .75000(MA/PEA) =   .25000(MA/HAZ)

   EQUATION    3 LABEL MB-CAS COST =     .000000 ORIGINAL BI =       .000000
   +   1.00000(MB-CAS) =    .75000(MB/CAS) +   .25000(MB/PEA) +  .25000(MB/HAZ)

   EQUATION    4 LABEL MB+PEA COST =      .000000 ORIGINAL BI =      .000000
   +   1.00000(MB+PEA) =   .50000(MB/CAS) +    .50000(MB/PEA) +  .50000(MB/HAZ)

   EQUATION    5 LABEL XX+CAS COST =      .650000 ORIGINAL BI =     1.000000
   +   1.00000(XX+CAS) +  1.00000(MA/CAS) +   1.00000(MB/CAS) + 1.00000(MD/CAS)

   EQUATION    6 LABEL XX+PEA COST =      .250000 ORIGINAL BI =  1.000000
   +   1.00000(XX+PEA) +  1.00000(MA/PEA) +   1.00000(MB/PEA) + 1.00000(MD/PEA)

   EQUATION    7 LABEL XX+HAZ COST =    .350000 ORIGINAL BI =    .600000
   +   1.00000(XX+HAZ) +  1.00000(MA/HAZ) +  1.00000(MB/HAZ) +  1.00000(MD/HAZ)
   END EQLIST OUTPUT
```

continued

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1107LP RUN ON NUT-MIX PROBLEM .000.011.001

MTXMAP OUTPUT

CASE NUT-MIX ITERATION 0 OBJECTIVE VALUE .000000

	COST	BAS/ICS	MAS/CAS	MAP/EAS	MAH/AZ	MBS/CAS	MBP/EAS	MBH/AZ	MDC/AS	MDP/EA	MDH/AZ
COST	.	.	5	5	5	5	5	5	5	5	5
MA-CAS	.	.	-5	5	5	.	.	.	.	.	.
MA+PEA	.	.	-5	5	-5	.	.	.	.	.	.
MB-CAS	.	.	.	.	.	-5	5	5	.	.	.
MB+PEA	.	.	.	.	.	-5	5	-5	.	.	.
XX+CAS	5	1	1	.	.	1	.	.	1	.	.
XX+PEA	5	1	.	1	.	.	1	.	.	1	.
XX+HAZ	5	5	.	.	1	.	.	1	.	.	1

1107LP RUN ON NUT-MIX PROBLEM .000.012.001

THE MATRIX ELEMENTS ARE REPRESENTED AS FOLLOWS

CODE	MAGNITUDE OF ELEMENTS GREATER THAN	EQUAL TO OR LESS THAN	OCCURENCES
0	0.0	0.0001	0
2	0.0001	0.001	0
3	0.001	0.01	0
4	0.01	0.1	0
5	0.1	0.9999	25
1	=1.0		11
6	1.0	10.0	0
7	10.0	100.0	0
8	100.0	1000.0	0
9	1000.0		0

END MTXMAP OUTPUT

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```
1107LP RUN ON NUT-MIX PROBLEM                                    .000.013.001

GOGOGO        OBTAIN OPTIMAL, FEASIBLE, RATIONAL SOLUTION.

STAGE   0  PVCNT  0  OBFVAL     1.110000 NET CHANGES   0
          96  MS FOR DOZ
ITCNT   0 DJBAD 1000.000 KOLAY  9 NOLAY   9 ART   0 INF   0
         135  MS FOR SSS
          26  MS FOR UPDATE
          65  MS FOR OPTMIZ
          78  MS FOR PIVGEN

STAGE   1  PVCNT  5  OBFVAL     1.160000 NET CHANGES   5
         220  MS FOR DOZ
ITCNT   5 DJBAD 1000.000 KOLAY  0 NOLAY   0 ART   0 INF   0
         111  MS FOR SSS
          49  MS FOR UPDATE
          32  MS FOR OPTMIZ
           4  MS FOR PIVGEN

STAGE   2  PVCNT  5  OBFVAL     1.160000 NET CHANGES   5

DPMODE        INVERT TO CURRENT BASIS IN DOUBLE PRECISION.
INVERSION FINISHED WITH   0 NOT REMOVED AND   0 NOT ENTERED
SPMODE        RETURN TO SINGLE PRECISION
GOGOGO        RESOLVE IN CASE INVERSION INCOMPLETE.

STAGE   0  PVCNT  5  OBFVAL     1.160000 NET CHANGES   5
          99  MS FOR DOZ
ITCNT   5 DJBAD 1000.000 KOLAY  9 NOLAY   9 ART   0 INF   0
         137  MS FOR SSS
          94  MS FOR UPDATE
          33  MS FOR OPTMIZ
           2  MS FOR PIVGEN

STAGE   1  PVCNT  5  OBFVAL     1.160000 NET CHANGES   5

PRIMAL        OUTPUT ACTIVITY LEVELS AT SOLUTION.
```

continued

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1107LP RUN ON NUT-MIX PROBLEM .000.014.001

PRIMAL OUTPUT

CASE NUT-MIX ITERATION 5 OBJECTIVE VALUE 1.160000

LABEL	COST	ACTIVITY	LABEL	COST	ACTIVITY
XX+PEA	.250000	.500000	XX+HAZ	.350000	.100000
MA/CAS	.500000	1.000000	MA/PEA	.500000	.500000
MA/HAZ	.500000	.500000	MB/PEA	.350000	.000000
MB/HAZ	.350000	.000000			

END PRIMAL OUTPUT

1107LP RUN ON NUT-MIX PROBLEM .000.016.001

DUAL OUTPUT

CASE NUT-MIX ITERATION 5 OBJECTIVE VALUE 1.160000

LABEL	COST	SHADOW PRICE	LABEL	COST	SHADOW PRICE
MA-CAS	.000000	.350000	MA+PEA	.00000	.100000
MB-CAS	.000000	.200000	MB+PEA	.00000	.100000
XX+CAS	.650000	.700000	XX+PEA	.25000	.250000
XX+HAZ	.350000	.350000			

END DUAL OUTPUT

1107LP RUN ON NUT-MIX PROBLEM .000.018.001

REDCST OUTPUT

CASE NUT-MIX ITERATION 5 OBJECTIVE VALUE 1.160000

LABEL	COST	REDUCED COST	LABEL	COST	REDUCED COST
MA-CAS	.000000	.350000	MA+PEA	.00000	.100000
MB-CAS	.000000	.200000	MB+PEA	.00000	.100000
XX+CAS	.650000	.050000	MB/CAS	.35000	.150000
MD/CAS	.250000	.450000	MD/PEA	.25000	.000000
MD/HAZ	.250000	.100000			

END REDCST OUTPUT

continued

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1107LP RUN ON NUT-MIX PROBLEM .000.020.001

DUAL RANGE OUTPUT

CASE NUT-MIX ITERATION 5 OBJECTIVE VALUE 1.160000

		- - - - - - LIMITS OF RANGE - - - - - -			
LABEL	ORIG. ACT.	LABEL	INCREMENT	LABEL	INCREMENT
MA-CAS	.000000	XX+HAZ	-.066667	MA/HAZ	.333333
MA+PEA	.000000	MA/HAZ	-.500000	XX+HAZ	.100000
MB-CAS	.000000	XX+HAZ	-.050000	MB/HAZ	.000000
MB+PEA	.000000	MB/HAZ	-.000000	MB/PEA	.000000
XX+CAS	1.000000	XX+HAZ	-.200000	MA/HAZ	1.000000
MB/CAS	.000000	MB/HAZ	-.000000	XX+HAZ	.200000
MD/CAS	.000000	XX+HAZ	-.200000	MA/HAZ	1.000000
MD/PEA	.000000		-9999.000000	XX+PEA	.500000
MD/HAZ	.000000		-9999.000000	XX+HAZ	.100000

END DUAL RANGE OUTPUT

1107LP RUN ON NUT-MIX PROBLEM .000.021.001

PRIMAL RANGE OUTPUT

CASE NUT-MIX ITERATION 5 OBJECTIVE VALUE 1.160000

		- - - - - - LIMITS OF RANGE - - - - - -			
LABEL	COST	LABEL	INCREMENT	LABEL	INCREMENT
XX+PEA	.250000	MD/PEA	-.000000	MA+PEA	.100000
XX+HAZ	.350000	MA+PEA	-.100000	MB-CAS	.100000
MA/CAS	.500000	XX+CAS	-.050000		9999.000000
MA/PEA	.500000	MA+PEA	-.100000		9999.000000
MA/HAZ	.500000	XX+CAS	-.100000	MA+PEA	.100000
MB/PEA	.350000	MB-CAS	-.100000	MB/CAS	.075000
MB/HAZ	.350000	MB-CAS	-.100000	MB+PEA	.100000

END PRIMAL RANGE OUTPUT

continued

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1107LP RUN ON NUT-MIX PROBLEM .000.023.001

DUAL ERROR ANALYSIS

LABEL	Z(J)	C(J)	ERROR
XX+PEA	.250	.250	.00000000
XX+HAZ	.350	.350	.00000000
MA/CAS	.500	.500	.00000000
MA/HAZ	.500	.500	.00000000
MB/PEA	.350	.350	.00000000
MB/HAZ	.350	.350	.00000000

MAXIMUM DUAL ERROR OF .00000000 FOR VARIABLE

1107LP RUN ON NUT-MIX PROBLEM .000.024.001

PRIMAL ERROR ANALYSIS

LABLE	ORIG B(I)	CALC B(I)	ERROR
MA-CAS	.000	.000	-.00000000
MA+PEA	.000	.000	-.00000000
MB-CAS	.000	.000	-.00000000
MB+PEA	.000	.000	-.00000000
XX+CAS	1.000	1.000	-.00000000
XX+PEA	1.000	1.000	-.00000000
XX+HAZ	.600	.600	-.00000000

MAXIMUM PRIMAL ERROR OF .00000000 FOR VARIABLE

1107LP RUN ON NUT-MIX PROBLEM .000.025.001

ENDJOB RETURN TO MONITOR.

RUN TIME 0 HRS 0 MIN 21 SEC

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COST ESTIMATE

For the program listed on the Sample Input, computer time was 21 seconds. At the current rate for the University of Notre Dame ($480./hr. plus input-output charges), the chargeable computer cost was $4.18.

Charge to user = computer costs + postage and handling + network overhead

= $4.18 + $10.00 + network overhead

= $14.18 + network overhead

CONTENTS—LP1107

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000 0057

DESCRIPTIVE TITLE	UNIVAC 1107 PERT/COST, PERT/TIME System
CALLING NAME	PERT (library tape)
INSTALLATION NAME	The University of Notre Dame Computing Center
AUTHOR(S) AND AFFILIATION(S)	UNIVAC Division of Sperry Rand Corporation
LANGUAGE	SLEUTH II and COBOL
COMPUTER	UNIVAC 1107
PROGRAM AVAILABILITY	Listings available
CONTACT	Elizabeth Hutcheson, EIN Technical Representative, Computing Center, University of Notre Dame, Notre Dame, Ind. 46556 Tel. (219) 283-7784

FUNCTIONAL ABSTRACT

The UNIVAC 1107 PERT System provides for integrated time and cost planning and control of research and development programs through implementation of the "work package" costing concept of the Department of Defense/National Aeronautics and Space Administration. The system is composed of two major program modules, PERT/COST and PERT/TIME, which generate reports for the project being analyzed. These reports include activity and event reports, a Work package/Activity listing, a Charge number analysis, etc., from PERT/TIME, and reports on the structure of labor and material costs from PERT/COST.

REFERENCES

PERT/COST General Reference Manual, (UP-4013), (UNIVAC Division of Sperry Rand Corp., N.Y.).

UNIVAC 1107/1108 PERT and CPM: Techniques in the Project Management, (UP 3952), (UNIVAC Division of Sperry Rand Corp., N.Y.).

Available through the local UNIVAC representative or through the EIN Office at the cost of reproduction and mailing.

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USER INSTRUCTIONS

Potential users are directed to the references listed below for a full discussion of the options and constraints in effect.

REFERENCES

PERT/COST General Reference Manual, (UP-4013), (UNIVAC Division of Sperry Rand Corp., N.Y.).

UNIVAC 1107/1108 PERT and CPM: Techniques in the Project Management, (UP 3952), (UNIVAC Division of Sperry Rand Corp., N.Y.).

Available through the local UNIVAC representative or through the EIN Office at the cost of reproduction and mailing.

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SAMPLE INPUT and SAMPLE OUTPUT

Sample I/O is included in the references listed in the USER INSTRUCTIONS; interested persons are directed to these documents.

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COST ESTIMATE

See references listed in USER INSTRUCTIONS.

CONTENTS—PERT

pages

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DESCRIPTIVE TITLE	Inquirer II System for Content Analysis
CALLING NAME	I/II
INSTALLATION NAME	Washington University Computing Facilities
AUTHOR(S) AND AFFILIATION(S)	J. Philip Miller Washington University Computing Facilities
LANGUAGE	PL/I
COMPUTER	S/360 under OS
PROGRAM AVAILABILITY	Source listings and complete documentation available from Documentation Librarian, Computing Facilities, Box 1152, Washington University, St. Louis, Mo. 63130
CONTACT	J. Philip Miller, Computing Facilities, Box 1152, Washington University, St. Louis, Mo. 63130 Tel.: (314) 863-0100 ext. 4041

FUNCTIONAL ABSTRACT

The Inquirer II is a set of computer programs comparable to, but more flexible than, its predecessor, the General Inquirer, developed by Stone and his colleagues at Harvard. The original version of the General Inquirer System was designed for problems encountered in the content analysis of textual and verbal data. The General Inquirer was implemented for the IBM 7090-7094 computer along with the IBM 1401 computer. A later version of the General Inquirer was designed by Psathas and Miller to be used only with an IBM 1401 computer with an IBM 1311 disk drive. Stone originally described the General Inquirer as "a set of computer programs to (a) identify, systematically within text, instances of words and phrases that belong to categories specified by the investigator; (b) count occurrences and specify co-occurrences of these categories; (c) print and graph tabulations; (d) perform statistical tests; (e) sort and regroup sentences according to whether they contain instances of a particular category of combination of categories." The Inquirer II contains these capabilities and also

continued

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allows for more elaborate analysis of the data. The I/II is able to make more elaborate contextual searches of the data and provide more options to the potential users. These options are described in detail in the *Inquirer II Programmer's Guide.*

Content analysis may be defined as a research technique which includes a systematic identification of theoretically relevant constructs in textual data. Content analysis is usually performed so that inferences can be made about the source or originator of the message, the message itself or the intended receiver of the message. The investigator communicates the constructs and the rules by which they may be identified within the corpus of text by means of dictionary. This dictionary is either one of his own construction or one which has been utilized in previous research.

REFERENCES

Miller, J. Philip, editor, *Inquirer II Programmer's Guide,* 2nd Edition, 1970, Washington University, (Available from Documentation Librarian, Computing Facilities, Box 1152, Washington University, St. Louis, Mo. for $5.00)

Stone, P.J., Dunphy, D.C., Smith, M.S., and Ogilvie, D.M. The General Inquirer: *A Computer Approach to Content Analysis*, Cambridge, Mass., The MIT Press, 1966.

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USER INSTRUCTIONS

The primary inputs to the system are the data to be analyzed and a dictionary of concepts.

The major task in using the Inquirer II system is the creation of a dictionary of content analysis categories, called *concepts*. A concept consists of a number of language signs that together represent a variable in the investigator's theory.

The Sample Output appended gives a general idea of the process of presenting the data and formulating the dictionary of concepts. A thorough understanding for the user will be obtained by sending for the complete documentation, in particular the *Inquirer II Programmer's Guide*.[1]

REFERENCES

1. Miller, J. Philip, editor, *Inquirer II Programmer's Guide*, 2nd Edition, 1970, Washington University, (Available from Documentation Librarian, Computing Facilities, Box 1152, Washington University, St. Louis, Mo. for $5.00).

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SAMPLE INPUT

QQA004I * NEW TITLE ENCOUNTERED

$Renee's delusional system from Autobiography of a Schizophrenic Girl, in Landis p 182-3$

<<F15>>

<p1> Very soon after the beginning of analysis I understood that my fear was a cover for guilt, a quilt infinite and awful. During the early sessions, masturbation and the hostility I harbored toward everyone seemed to lie at the bottom. I literally hated people, without knowing why. In dreams and frequently in waking fantasies I constructed an electric machine to blow up the earth and everyone with it. This was my greatest, most terrible revenge.

$Renee's delusional system from Autobiography of a Schizophrenic Girl, in Landis p 182-3$
<p1>
<<F15>>

QQA002I * BEGINNING OF NEW DOCUMENT OF LEVEL 1

<p2> Later, considering them appropriate, I no longer felt guilty about these fantasies, nor did the quilt have an actual object . It was too pervasive, too enormous, to be founded on anything definite, and it demanded punishment. The punishment was indeed horrible, sadistic --- it consisted, fittingly enough, of being guilty. For to feel oneself guilty is the worst that can happen, it is the punishment of punishments. Consequently, I could never be relieved of it as though I had been truly punished. Quite the reverse, I felt more and more guilty, immeasurably guilty. Consequently, I sought to discover what was punishing me so dreadfully, what was making me so guilty.

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SAMPLE OUTPUT

KWIC of data file

```
other beings. A formidable interdependence bound all men under the scourge of culpability. Everyone  P15*
f it as some vast world-like entity encompassing all men. At the top were those who gave orders, who P15*
were guilty. Since every man was responsible for all other men, each of his acts had a repercussion  P15*
**********        3 INSTANCES OF All

s desk like a puppet, separated from everything, alone under a blinding light, waving his arms like  P15*
**********        1 INSTANCES OF Alone

never deliver me of the load. Because, as I have already said, the most dreadful punishment was to m P15*
**********        1 INSTANCES OF Already

ty about these fantasies, nor did the guilt have an actual object . It was too pervasive, too enormo P15*
and frequently in waking fantasies I constructed an electric machine to blow up the earth and everyo P15*
 of my words seemed strange. Every now and then, an innner voice interrupted sneeringly, "Ah, Ah!"an P15*
**********        3 INSTANCES OF An

                Very soon after the beginning of analysis I understood that my fear was a cover for  P15*
**********        1 INSTANCES OF Analysis

          It was only when I was near "Mama," my analyst, that I felt a little better. ,,,I saw the  P15*
**********        1 INSTANCES OF Analyst

 my fear was a cover for guilt, a guilt infinite and awful. During the early sessions, masturbation  P15*
tructed an electric machine to blow up the earth and everyone with it. This was my greatest, most te P15*
lly hated people, without knowing why. In dreams and frequently in waking fantasies I constructed an P15*
oo enormous, to be founded on anything definite, and it demanded punishment. The punishment was inde P15*
an innner voice interrupted sneeringly, "Ah, Ah!"and mockingly repeated what I had said.             P15*
n truly punished. Quite the reverse, I felt more and more guilty, immeasurably guilty. Consequently, P15*
ndependence of each part that inspired such fear and prevented my recognizing her even though I knew P15*
o relate what had happened sinc e the last visit and relived it in the telling. But the sound of my  P15*
d awful. During the early sessions, masturbation and the hostility I harbored toward everyone seemed P15*
ved it in the telling. But the sound of my voice and the meaning of my words seemed strange. Every n P15*
th, then the nose, then the cheeks, then one eye and the other. Perhaps it was this independence of  P15*
 everything was there, posed, congealed, stupid. And the terror, the mad anguish, mounted in me.     P15*
diculous. "Ah, ah! then the teacher said, said," and the voice dwelt stiltedly on "said, said."I str P15*
he meaning of my words seemed strange. Every now and then, an innner voice interrupted sneeringly, " P15*
y, abominable, intolerably guilty, without cause and without motive. Any punishment, the very worst, P15*
a blinding light, waving his arms like a maniac. And I saw my little sister, rolling on the kitchen  P15*
**********        16 INSTANCES OF And

osed, congealed, stupid. And the terror, the mad anguish, mounted in me.                            P15*
**********        1 INSTANCES OF Anguish

erably guilty, without cause and without motive. Any punishment, the very worst, could be imposed on P15*
**********        1 INSTANCES OF Any
```

continued

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Dictionary Compiler output--
Concept Name Paragraph

```
BEGIN COMPILATION OF SOURCE PROGRAM
                    *     AGE_TIME=01.
                    *     SOM_PSYCH_REF=02.
                    *     BODY_PARTS=02,03.
                    *     INT_BDY_PTS=02,03,04.
                    *     EXT_BDY_PTS=02,03,05.
                    *     GEN_BDY_PTS=02,03,06.
                    *     SOM_COND=02,07.
                    *     HEALTH=02,07,08.
                    *     ILLNESS=02,07,09.
                    *     DEATH=02,07,10.
                    *     TREATMENTS=11.
                    *     TESTS=12.
                    *     NON_SPEC_REF=13.
                    *     OBJ_ORIENT=14.
                    *     RETAIN=14,15.
                    *     EXPELL=14,16.
                    *     ATTAIN=14,17.
                    *     GENDER=18.
                    *     MALE=18,19.
                    *     FEMALE=18,20.
                    *     NEUTER=18,21.
                    *     AUTH_FIG=22.
                    *     TREAT_FIG=22,23.
                    *     LEGAL_FIG=22,24.
                    *     SENSE=25.
                    *     VISUAL=25,26.
                    *     AUDITORY=25,27.
                    *     GUSTATORY=25,28.
                    *     OLFACTORY=25,29.
                    *     DERMAL=25,30.
                    *     ACTION_NORM=31.
                    *     PASSIVE=31,32.
                    *     ACTIVE=31,33.
                    *     SEXUAL_ACT=34.
                    *     SEX_ACT=34,35.
                    *     FORE_PLAY=34,36.
                    *     PRE_FORE_PLAY=34,37.
                    *     SOCIAL_ACT=38.
                    *     AGGRESSIVE=38,39.
                    *     FRIENDLY=38,40.
                    *     ISOLATE=38,41.
                    *     COMMUNICATE=38,42.
                    *     DOMINATE=38,43.
                    *     SUBMIT=38,44.
                    *     HELP=38,45.
                    *     DIRECTION=46.
                    *     APPROACH=46,47.
                    *     AVOID=46,48.
                    *     ACHIEVE=49.
                    *     SUCCESS=49,50.
                    *     FAIL=49,51.
                    *     COG_PROC=52.
                    *     CONTEMPLATE=52,53.
                    *     COG_AWARE=52,54.
                    *     UNCERTAIN=52,55.
                    *     DECIDE=52,56.
                    *     REGARD=57.
                    *     POSITIVE=57,58.
                    *     NEGATIVE=57,59.
                    *     FORTUNE=60.
                    *     GOOD_FORT=60,61.
                    *     BAD FORT=60,62.
```

continued

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Dictionary Compiler-- List of Concept

Name Paragraph and start of Entry Name Paragraph

```
*     ANGER=63,64.
*     LOVE=63,65.
*     HATE=63,66.
*     FEAR=63,67.
*     HAPPY=63,68.
*     SAD=63,69.
*     DISTRESS=63,70.
*     EMOTION_POS=63,71.
*     EMOTION_NEG=63,72.
*     UNDEFINED_NEED=73.
*     OBSTACLES=74.
*     OBST_PRES=74,75.
*     STRUGGLE=74,76.
*     SELF=77.
*     SPEC_OTHERS=78.
*     NON_SPEC_OTHERS=79.
*      SENT_LENGTH = 90.
*      LONG_SENT = 90,91.
*      SHORT_SENT = 90,92.
*      SENT_TYPE = 93.
*      QUESTION = 93,94.
*      DECLARE = 93,95.
*     ABOMINABLE  :  NEGATIVE.
*     ABOUT  :  IF WORD (-4,-2) = 'UP' & WORD (-3,-1) = 'AND'
*               THEN HEALTH
*               ELSE IF WORD (-2,-1) = 'BRING'|
*                       WORD (-2,-1) = 'BROUGHT'|
*                       WORD (-2,-1) = 'COME'
*               THEN SUCCESS
*               ELSE IF WORD (1,2) = 'TO'
*               THEN ACTIVE
*               ELSE.
*     ACT:      IF WORD (-2,-1) = 'SEXUAL' |
*                  WORD (-2,-1) = 'SEX'
*               THEN SEX_ACT
*               ELSE IF WORD (1,1) = 'UP'
*               THEN AGGRESSIVE
*               ELSE IF WORD (1,1) = 'UPON'
*               THEN ACTIVE
*               ELSE ACTIVE.
*     ALL:      IF ORDER(WORD (-3,-2) = 'FREE', WORD (-2,-1) = 'FOR')
*               THEN AGGRESSIVE
*               ELSE IF WORD (1,3) = 'OVER'
*               THEN ACHIEVE
*               ELSE.
*     ALONE:    ISOLATE.
*     ANALYSIS:  CONTEMPLATE.
*     ANALYST:  TREAT_FIG; NEUTER.
*     ANGUISH:  SAD; EMOTION_NEG.
*     ANY:  NON_SPEC_REF.
*     ANYTHING:  NON_SPEC_REF.
*     APPARENT:  DECIDE.
*     APPARENTLY:
*     APPROPRIATE:  POSITIVE.
*     ARM:  EXT_BDY_PTS.
*     ARMS:     IF WORD (-3,-1) = 'OPEN'
*               THEN FRIENDLY
*               ELSE IF WORD (-3,-2) = 'UP' & WORD (-2,-1) = 'IN'
*               THEN AGGRESSIVE
*               ELSE EXT_BDY_PTS.
*     ASSOCIATE:  IF WORD (-2,-1) = 'AN' |
*                    WORD (-2,-1) = 'THE'
*                 THEN
*                 ELSE CONTEMPLATE.
*     AT:       IF WORD (-3,-1) = 'FLY' | WORD (-3,-1) = 'FLEW'
*               THEN AGGRESSIVE
```

continued

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Portion of Entry Name Paragraph of Dictionary

```
*                ELSE IF WORD (1,2) = 'WELL'
*                THEN HEALTH
*                ELSE.
*     FELT:      IF WORD (1,5) = 'FOR'
*                THEN (LOVE; EMOTION_POS)
*                ELSE IF WORD (1,2) = 'WELL'
*                THEN HEALTH
*                ELSE.
*     FIGURE:    IF WORD (-2,-1) = 'A' | WORD (-2,-1) = 'THE' |
*                   WORD (-2,-1) = 'THIS' | WORD (-2,-1) = 'THESE' |
*                   WORD (-2,-1) = 'THOSE'
*                THEN
*                ELSE IF WORD (1,3) = 'OUT'
*                THEN DECIDE
*                ELSE CONTEMPLATE.
*     FIT:       IF WORD (-2,-1) = 'THROW' | WORD (-5,-1) = 'HAVE' |
*                   WORD (-5,-1) = 'HAD'
*                THEN AGGRESSIVE
*                ELSE IF WORD (1,2) = 'IN' & WORD (2,3) = 'WITH'
*                THEN SUBMIT
*                ELSE.
*     FOUND:     IF WORD (1,2) = 'OUT'
*                THEN SUCCESS
*                ELSE GOOD_PORT.
*     FROM:      IF WORD (-3,-1) = 'SHRANK' | WORD (-3,-1) = 'SHRINK' |
*                   WORD (-3,-1) = 'SHRUNK' | ORDER(WORD (-3,-1) = 'GET',
*                   WORD (-2,-1) = 'AWAY') | WORD (-3,-1) = 'REACH' |
*                   WORD (-3,-1) = 'RAN' | WORD (-3,-1) = 'RUN'
*                THEN AVOID
*                ELSE IF WORD (-2,-2) = 'GET' & WORD (-1,-1) = 'BACK'
*                THEN APPROACH
*                ELSE.
*     GAVE:      IF WORD (1,2) = 'IN' | WORD (1,3) = 'UP' | WORD (1,5) = 'WAY'
*                THEN SUBMIT
*                ELSE EXPELL.
*     GET:       IF WORD (1,3) = 'AROUND' | WORD (1,2) = 'UP'
*                THEN ACTIVE
*                ELSE IF WORD (1,3) = 'AWAY' | WORD (1,3) = 'OUT' |
*                        WORD (1,3) = 'OFF'
*                THEN AVOID
*                ELSE IF WORD (1,2) = 'BACK' | WORD (1,2) = 'IN' |
*                        WORD (1,2) = 'ON' | WORD (1,1) = 'TO' |
*                        WORD (1,1) = 'AROUND' & WORD (2,2) = 'TO' |
*                        WORD (1,1) = 'DOWN' & WORD (2,2) = 'TO'
*                THEN APPROACH
*                ELSE IF ORDER(WORD (1,2) = 'HANG', WORD (2,3) ='OF') |
*                ORDER(WORD (1,3) = 'TO', WORD (2,4) = 'BOTTOM',
*                WORD (3,5) = 'OF') | WORD (1,2) = 'THROUGH' |
*                WORD (1,1) = 'AWAY' & WORD (2,2) = 'WITH'
*                THEN SUCCESS
*                ELSE IF WORD (1,1)= 'HOLD' & WORD (2,2) = 'OF' |
*                ORDER(WORD (1,4) = 'IN', WORD (2,5) = 'WAY')
*                THEN AGGRESSIVE
*                ELSE IF ORDER(WORD (1,2) = 'WIND', WORD (2,3) = 'OF') |
*                ORDER(WORD (1,3) = 'THING', WORD (2,4) = 'ACROSS',
*                WORD (3,5) = 'TO'   )
*                THEN COMMUNICATE
*                ELSE IF WORD (1,1) = 'RID' & WORD (2,2) = 'OF'
*                THEN EXPELL
*                ELSE IF WORD (1,1) = 'THE' & WORD (2,2) = 'BETTER' &
*                WORD (3,3) = 'OF'
*                THEN DOMINATE
*                ELSE IF WORD (1,1) = 'IN' & WORD (2,2) = 'ON'
*                THEN FRIENDLY
*                ELSE IF WORD (1,1) = 'OVER'
*                THEN OBST_PRES
```

continued

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CONCEPTS: Listing of Tagged File

Renee's delusional system from Autobiography of a Schizophrenic Girl

ID FIELD OF LEVEL 2 = F15

ID FIELD OF LEVEL 1 = p1

SENTENCE 1; 22 WORDS
CURRENT ID p1

Very	soon AGE_TIME	after	the	beginning AGE_TIME	of	analysis COG_PROC CONTEMPLATE	I SELF	understood	that NON_SPEC_REF

my SELF	fear EMOTION_NEG EMOTION FEAR	was	a	cover	for	guilt, EMOTION_NEG EMOTION FEAR	a	guilt EMOTION_NEG EMOTION FEAR	infinite	and	

awful REGARD NEGATIVE	.

SENTENCE 2; 18 WORDS
CURRENT ID p1

During	the	early	sessions,	masturbation PRE_FORE_PLAY SEXUAL_ACT	and	the	hostility EMOTION_NEG ANGER EMOTION	I SELF	harbored	

toward DIRECTION APPROACH	everyone NON_SPEC_OTHERS GENDER NEUTER	seemed	to	lie SOCIAL_ACT AGGRESSIVE COMMUNICATE	at	the	bottom	.

SENTENCE 3; 7 WORDS
CURRENT ID p1

I SELF	literally	hated EMOTION_NEG ANGER EMOTION	people, NON_SPEC_OTHERS GENDER NEUTER	without	knowing COG_AWARE DECIDE COG_PROC	why	.

SENTENCE 4; 21 WORDS
CURRENT ID p1

In	dreams UNDEFINED_NEED	and	frequently	in	waking	fantasies	I SELF	constructed ACTIVE ACTION_NORM	an	electric	machine	to

blow SOCIAL_ACT AGGRESSIVE	up	the	earth	and	everyone NON_SPEC_OTHERS GENDER NEUTER	with	it NON_SPEC_REF	.	

SENTENCE 5; 7 WORDS
CURRENT ID p1

This	was	my SELF	greatest, REGARD POSITIVE	most	terrible REGARD NEGATIVE	revenge	.

continued

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Tabulation of tagged file

enee's delusional systes from Autobiography of a Schizophrenic Girl, in Landis p 182-3

CONCEPT NAME	TOTAL FREQ	WORD INDEX 75	CONCEPT INDEX 57	WD - CONC INDEX 29	SENTENCE FREQ	SENTENCE INDEX 5	SNTC - CONC INDEX 5
AUDITORY							
GUSTATORY							
OLFACTORY							
DERMAL							
PASSIVE							
ACTIVE	1	1.33	1.75	3.44	1	20.00	20.00
SEX_ACT							
FORE_PLAY							
PRE_FORE_PLAY	1	1.33	1.75	3.44	1	20.00	20.00
AGGRESSIVE	2	2.66	3.50	6.89	2	40.00	40.00
FRIENDLY							
ISOLATE							
COMMUNICATE	1	1.33	1.75	3.44	1	20.00	20.00
DOMINATE							
SUBMIT							
HELP							
APPROACH	1	1.33	1.75	3.44	1	20.00	20.00
AVOID							

continued

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Tabulation of tagged file

Renee's delusional system from Autobiography of a Schizophrenic Girl, in Landis p 182-3

CONCEPT NAME	TOTAL FREQ	WORD INDEX 75	CONCEPT INDEX 57	WD - CONC INDEX 29	SENTENCE FREQ	SENTENCE INDEX 5	SNTC - CONC INDEX 5
SUCCESS							
FAIL							
CONTEMPLATE	1	1.33	1.75	3.44	1	20.00	20.00
COG_AWARE	1	1.33	1.75	3.44	1	20.00	20.00
UNCERTAIN							
DECIDE	1	1.33	1.75	3.44	1	20.00	20.00
POSITIVE	1	1.33	1.75	3.44	1	20.00	20.00
NEGATIVE	2	2.66	3.50	6.89	2	40.00	40.00
GOOD_FORT							
BAD_FORT							
ANGER	2	2.66	3.50	6.89	2	40.00	40.00
LOVE							
HATE							
FEAR	3	4.00	5.26	10.34	1	20.00	20.00
HAPPY							
SAD							
DISTRESS							
EMOTION_POS							

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COST ESTIMATE

It is difficult to offer a precise cost estimate for a given task. A full treatment of a 5000-word text would cost *approximately* $500.

CONTENTS—I/II

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DESCRIPTIVE TITLE	Basic Information Retrieval System
CALLING NAME	BIRS
INSTALLATION NAME	Michigan State University Information Systems Laboratory
AUTHOR(S) AND AFFILIATION(S)	John F. Vinsonhaler, Ph.D. John M. Hafterson Stuart W. Thomas, Jr. Michigan State University
LANGUAGE	USASI Full FORTRAN
COMPUTER	CDC 3600, CDC 6500, CDC 6600 IBM 360 G-level GE 600 Series, others
PROGRAM AVAILABILITY	Decks and listings are currently available at cost from Michigan State University for non-profit institutions. The program is distributed to profit-making institutions by Hygain Technologies, 65 Whitney Street, Westport, Conn. Maintenance for all users is provided by Hygain Technologies.
CONTACT	Dr. John F. Vinsonhaler, Director, Information Systems Laboratory, 309 Computer Center, Michigan State University, East Lansing, Mich. 48823 Tel.: (517) 353-7284

FUNCTIONAL ABSTRACT

BIRS is a general purpose system of programs for the behavioral sciences and education. Essentially, BIRS is a set of fundamental program modules designed to allow scholars and scientists to use their own locally based computer to construct and maintain a variety of information systems. Search, maintenance, and index creation are performed automatically. Thus, BIRS may be viewed as a set of essential tools; the research worker may use these tools to construct the type of information system which best meets his immediate needs.

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It is not economically practical for individual educators and social scientists to develop their own special purpose programming system; they must share the costs of system developments by exchanging programs. General purpose systems like BIRS (with machine, data, and application independent programming) are ideally suited for free exchange among computer users.

REFERENCES

Vinsonhaler, J.F., Ed., *Technical Manual for the Basic Indexing and Retrieval System, BIRS 2.0*, Michigan State University, East Lansing, Mich., 1968.

Vinsonhaler, J.F., and Hafterson, J.M., Eds., *Technical Manual for the Basic Indexing and Retrieval System, Appendix I, BIRS 2.5*, Michigan State University, East Lansing, Mich., 1969.

Thomas, Jr., S.W., and Vinsonhaler, J.F., Eds., *Technical Manual for the Basic Information Analysis System, BIRS Technical Manual, Appendix II, BIAS 1.0*, Michigan State University, East Lansing, Mich., 1969.

Documentation is available at cost from the Information Systems Laboratory and from Hygain Technologies.

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USER INSTRUCTIONS

See the references cited below. The nature and complexity of the system can be studied in brief with the help of the samples of input and output following.

REFERENCES

Vinsonhaler, J.F., Ed., *Technical Manual for the Basic Indexing and Retrieval System, BIRS 2.0*, Michigan State University, East Lansing, Mich., 1968.

Vinsonhaler, J.F., and Hafterson, J.M., Eds., *Technical Manual for the Basic Indexing and Retrieval System, Appendix I, BIRS 2.5*, Michigan State University, East Lansing, Mich., 1969.

Thomas, Jr., S.W. and Vinsonhaler, J.F., Eds., *Technical Manual for the Basic Information Analysis System, BIRS Technical Manual, Appendix II, BIAS 1.0*, Michigan State University, East Lansing, Mich., 1969.

Thomas, Jr., S.W., Hafterson, J.M., and Vinsonhaler, J.F., *Some Observations on the Structure and Operation of an Information Analysis System: Paper of the Institute No. 62*, (Michigan State University, East Lansing, Mich., 1969).

Vinsonhaler, J.F., Hafterson, J.M., and Thomas, Jr., S.W., "BIRS, A General Purpose Information Management System for Education and Social Science," *Proceedings of SHARE XXXIV*, (1970).

Documentation is available at cost from the Information Systems Laboratory and from Hygain Technologies.

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SAMPLE INPUT AND OUTPUT

Information Storage: Creating the Information File

INPUT FOR BIRS PROCESSING

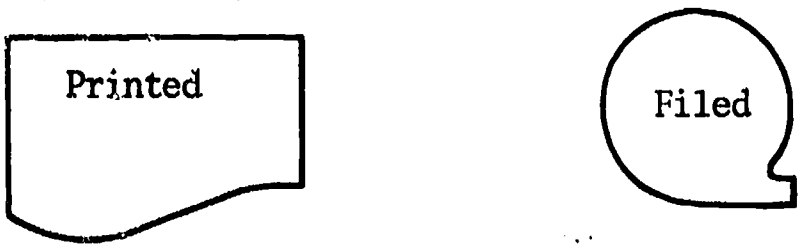
```
*$IFMP
*$DELIMITER IS ≠
*$NEW FILE
*$ABSTRACT
  ≠STATE   MICHIGAN
  ≠PUBLIC LAW   89-10
  ≠TITLE   AUGMENTATION OF SPECIAL EDUCATION AND PRE-EDVOCATIONAL TRAINING
  PROGRAMS.

  ≠DESCRIPTORS   EMOTIONALLY DISTURBED,   READING DISABILITY,
  PREVOCATIONAL EDUCATION,   RESIDENTIAL SCHOOL
  ≠TOTAL CHILDREN   90
  ≠TOTAL EXPENDITURE   $47,000
  ≠INSTRUCTION SALARIES = $39,658,   MATERIALS = $1,542,   OTHER = 0
  ≠PROJECT PARTICIPANTS
                              TMR      EMR      HH
  NUMBER OF TEACHERS           5        3       0
  OTHER PERSONNEL              0        0       2

  ≠SUMMARY
       THIS PROJECT IS TO REDUCE THE NUMBER OF GRADE LEVELS PER CLASSROOM
  IN OUR SCHOOL  PROVIDE GREATER INDIVIDUALIZATION OF INSTRUCTION WITHIN
  THE CLASSROOMS AND, TO EXPOSE OUR EMOTIONALLY DISTURBED CHILDREN TO
  GREATER SOCIALIZATION PROGRAMS
          .
          .
          .
       other data elements preceded by *$ABSTRACT
          .
          .
          .
*$END
```

OUTPUT FROM BIRS PROCESSING

INFORMATION FILE — CONTAINING DATA RECORDS



continued

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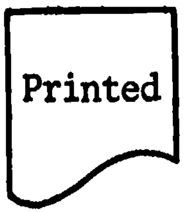
Information Indexing: Preparing a Key Word Index

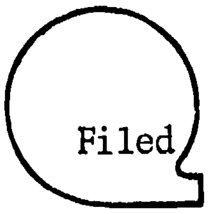
INPUT FOR BIRS PROCESSING

```
*$PIP

*$DELIMITER ≠

*$USE FIELDS

    PUBLIC LAW,STATE
*$BOOK INDEX
*$END
```

OUTPUT FROM BIRS PROCESSING

Index for the Information File





```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

(PUBLIC LAW)

     89-10          1, 22-60

     89-313         2-21, 100-350

     TITLE IV       50, 53, 500-650

(STATE)

     ALABAMA        200-250, 301

     ALASKA         10-11, 22
       .
       .
       .
       .
```

continued

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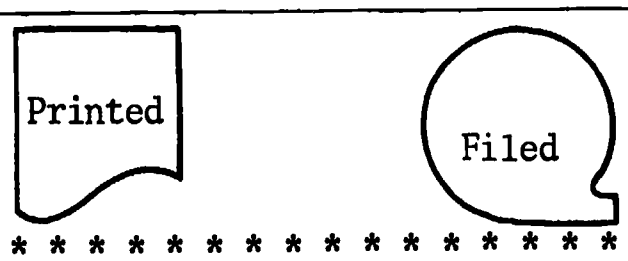
Information Retrieval: Preparing a List of Particular Types of Projects

INPUT FOR BIRS PROCESSING

```
*$DFSP
*$DELIMITER ≠
*$QUESTION
  ≠STATE,MICHIGAN.AND.(#DESCRIPTORS,EMOTIONALLY DISTURBED.OR.
  EMOTIONALLY HANDICAPPED)
*$END
*$IFRP
*$DELIMITER ≠
*$PRINT LINES 1 TO 5
*$END
```

OUTPUT FROM BIRS PROCESSING

SEARCH REPORT



* *

```
ABSTRACT 1     RELEVANCE 1.00
≠STATE   MICHIGAN
≠PUBLIC LAW   89-10
≠TITLE   AUGMENTATION OF SPECIAL EDUCATION AND PRE-VOCATIONAL TRAINING
PROGRAMS


ABSTRACT 35    RELEVANCE 1.00
≠STATE   MICHIGAN
≠PUBLIC LAW   TITLE IV-A
≠TITLE   IMPROVEMENT OF SPECIAL ASSISTANCE FOR EMOTIONALLY DISTURBED
```

continued

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Information Analysis: Preparing a Statistical Report

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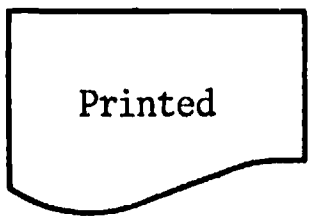
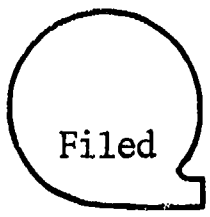
INPUT FOR BIRS PROCESSING

```
*$IRPG
*$DELIMITER  ≠

*$DIMENSION
STATES = ≠STATE,MICHIGAN,HAWAII,ILLINOIS,MISSOURI

*$DIMENSION
PURPOSE = ≠INSTRUCTION,SALARIES,MATERIALS,TOTAL(SALARIES,MATERIALS)

*$DEFINE DATA
COST = .SUM.≠INSTRUCTION

*$TABLE
ALLOCATION OF FUNDS FOR INSTRUCTION (COST) = PURPOSE,STATES
```

OUTPUT FROM BIRS PROCESSING

TABULAR REPORT





* *

TABLE---ALLOCATION OF FUNDS FOR INSTRUCTION
DATA----COST
ROWS----SALARIES, MATERIALS, TOTAL
COLUMNS-MICHIGAN, HAWAII, ILLINOIS, MISSOURI

SECTION 1 OF 1 SECTION(S) PAGE 1

	MICHIGAN	HAWAII	ILLINOIS	MISSOURI
SALARIES	80385.00	69717.00	71800.00	41154.00
MATERIALS	4642.00	826.00	5600.00	1011.00
TOTAL	85027.00	70543.00	77400.00	42165.00

* *

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COST ESTIMATE

Unfortunately, cost estimates for the sample program are unavailable. The average cost for complete processing is about $15.00 per abstract per year for most applications, including file maintenance, searching, and report generation.

Charge to user = computer costs + network overhead

= $15.00/abstract per year + network overhead

CONTENTS—BIRS

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DESCRIPTIVE TITLE	Matching Factor Solutions
CALLING NAME	MATCHFS
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service (ETS)
AUTHOR(S) AND AFFILIATION(S)	Program due to: R. Pennell, ETS Adaptation due to: J. Barone, ETS
LANGUAGE	F4STAT (Statistically augmented FORTRAN IV)
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Office of Data Analysis Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

It frequently happens that two factor solutions are obtained in a study, and the question arises as to the extent of similarity. Cliff's[1] approach to the problem is succinctly stated in the abstract of his paper,

> Two problems are considered. The first is that of rotating two factor solutions orthogonally to a position where corresponding factors are as similar as possible. A least-squares solution for transformations of the two factor matrices is developed. The second problem is that of rotating a factor matrix orthogonally to a specified target matrix.

The present program performs least squares, procrustes rotations on a target (T) and a data (D) matrix following the general approach of Cliff.

General Description

The mathematical basis for the program is summarized briefly in the following outline.

continued

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Case I: Find an A and B such that transformation $(E'E)$ = minimum

where

$$E = TA - DB \ .$$

A and B are given by

$$T'D = Q$$
$$Q = A\Gamma B'$$

where A , B' and Γ are the Eckart and Young[2] decomposition of Q .

Case II: Find a C such that transformation $(E'E)$ = minimum

where

$$E = T - DC$$

C is given by

$$C = B'A'$$

Case II is the typical target-matching situation were T is held fixed and D rotated to a least-squares fit.

The program can handle matrices as large as 125 rows (variables) X 50 columns.

REFERENCES

1. Cliff, N., "Orthogonal Rotation to Congruence," Psychometrika, *31*, pp. 33–42, (1966).

2. Eckart, C.T., and Young, G., "The Approximation of One Matrix by Another of Lower Rank," Psychometrika, *1*, pp. 211–218, (1936).

3. Pennell, R.J., and Young, F.W., "An IBM System/360 Program for Orthogonal Rotation to Congruence," Behavioral Science, *12*, p. 165, (1967).

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USER INSTRUCTIONS

Card Preparation

Problem Card

Columns	*Parameter*	*Format*	*Description*
1– 5	NR	I5	Number of rows (variables) ≤ 125
6–10	NCT	I5	Number of columns in target matrix (≤ 50)
11–15	NCD	I5	Number of columns in data matrix (≤ 50)
16–20	ICASE	I5	Case option 1: Simultaneous rotations 2: Target matching 0: Both 1 and 2
21–25	IFMT	I5	Format option 0: Use same format for target and data matrices ≠ 0: Read in a different format for the data matrix

Title Card

Name of problem in Cols. 1–80

Format Card for Target Matrix

The format specification may start in any column. The word FORMAT is not used.

Target Matrix Cards

The program will read the punched data, row by row, according to the format specified for a row in Format Card for Target Matrix.

Format Card for Data Matrix

(Omit this card if IFMT = 0; the program will read the data matrix using the format specified in Format Card for Target Matrix.)

Data Matrix Cards

The program will read the punched data, row by row, according to the format specified for a row in Format Card for Data Matrix (Format Card for Target Matrix if IFMT = 0).

continued

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System Control Cards

JOB Card will be prepared

System Card 1

Columns	*Contents*
1–37	//STEPNAME EXEC GITNGO,NAME=MATCHFS

System Card 2

Columns	*Contents*
1–19	//GO.SYSIN DD *

System Card 3

Columns	*Contents*
1– 2	//

Job Deck

JOB Card
System Card 1
System Card 2
Problem Card
Title Card
Format Card for Target Matrix
Target Matrix Cards
Format Card for Data Matrix (optional)
Data Matrix Cards
Blank Card
System Card 3

May be repeated for additional problems

000 0060

SAMPLE INPUT

To illustrate the use of the program some simple artificial data were contrived. One factor solution describes four tests in terms of two factors, while the other solution shows the four tests in terms of three factors. Both Case I, for simultaneous rotations, and Case II, for target matching are illustrated.

```
//            JOB  (....
//STEPNAME  EXEC  GITNGO,NAME=MATCHFS
//GO.SYSIN  DD    *
     4    2    3    0    0

(3F8.3)
    0.700   0.100
    0.800   0.000
    0.100   0.700
    0.000   0.800
    0.760   0.320   0.500
    0.500   0.500  -0.400
    0.520  -0.360   0.500
    0.500  -0.500  -0.400

//
```

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SAMPLE OUTPUT

CASE 1 SIMULTANEOUS ROTATIONS

TRANSFORMATION FOR FIRST MATRIX

	1	2
1	0.785	-0.619
2	0.619	0.785

AFTER ROTATION

	1	2
1	0.611	-0.355
2	0.628	-0.496
3	0.512	0.488
4	0.496	0.628

TRANSFORMATION FOR SECOND MATRIX

	1	2
1	0.994	0.059
2	0.060	-0.998
3	0.086	0.016

AFTER ROTATION

	1	2
1	0.818	-0.267
2	0.492	-0.476
3	0.539	0.398
4	0.433	0.522

CASE 2 FIRST MATRIX AS A TARGET

TRANSFORMATION TO TARGET

	1	2
1	0.744	0.662
2	0.665	-0.747
3	0.058	0.066

AFTER ROTATION

	1	2
1	0.808	0.297
2	0.682	-0.069
3	0.177	0.646
4	0.016	0.678

COEFFICIENTS OF CONGRUENCE
0.9861 0.9741

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COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed, and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $2.30.

Charge to user = computer costs + postage and handling + network overhead

= $2.30 + $5.00 + network overhead

= $7.30 + network overhead

CONTENTS—

000 0060

DESCRIPTIVE TITLE	Matrix Decomposition for Points of View Analysis
CALLING NAME	MATDEC
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service
AUTHOR(S) AND AFFILIATION(S)	J. Ferris Educational Testing Service
LANGUAGE	FORTRAN IV
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Deck and listings presently available
CONTACT	Mr. Ernest Anastasio, Off. of Data Anal. Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

The purpose of MATDEC is to decompose a rectangular matrix (i.e., a data matrix, X, dimensioned number of variables by number of subjects) into three matrices U, Γ, and W, according to Horst's[1] development (Ref. 1, pp. 364-382), where Γ is a diagonal matrix of eigenvalues and U and W contain the corresponding eigenvectors. It is intended as a first step in Tucker and Messick's approach to an individual differences model for multidimensional scaling.[2]

As is, MATDEC will handle up to 100 variables or subjects, whichever is the lesser dimension of the data matrix. The program uses F4STAT (FORTRAN IV Statistical System) and, in particular, the routine SDGEXT to develop the characteristic roots and vectors of the crossproducts matrix. Further information about F4STAT can be obtained from Mr. Van Hassel, Educational Testing Service, (609) 921-9000, ext. 2557.

REFERENCES

1. Horst, P., *Matrix Algebra for Social Scientists*, (Holt, Rinehart & Winston, New York, 1963).

2. Tucker, L.R., and Messick, S., "An Individual Differences Model for Multidimensional Scaling," Psychometrika, *28*, 333-367 (1963).

USER INSTRUCTIONS

Input Deck

Title Card

Parameters	*Columns*	*Contents*
NV	1– 4	Number variables
N	5– 8	Number of subjects
IRC	9–12	1: input is rowwise 2: input is columnwise
IT	13–16	Tape unit containing input 5: input on cards
IR	17–20	1: input tape is to be rewound 0: input tape is not to be rewound

NOTE: Data matrix is dimensioned NV by N.

Variable–Format Card (optional: card input; IT=5)

Standard FORTRAN format card but delete word FORMAT.

Data Cards (optional)

Follow format on Variable-Format Card.

NOTE: If IRC=1 and an entire matrix row (N entries) is on a single Data Card, then the numbers of Data Cards = NV.

System Control Cards

JOB Card will be prepared by Educational Testing Service personnel.

System Card 1

Columns	*Contents*
1–36	//STEPNAME EXEC GITNGO,NAME=MATDEC

System Card 2

Columns	*Contents*
1–19	//GO.SYSIN DD *

System Card 3

Columns	*Contents*
1– 2	//

continued

000 0061

000 0061

Job Deck

JOB Card
System Card 1
System Card 2
Title Card

Parameter Card
Variable-Format Card (optional)
Data Cards (optional)

May be repeated for additional programs.

System Card 3

Description of Output

Printed Output: The parameters NV, N, IRC, IT, and IR are printed at the beginning of the job, and the title is printed at the top of each new page. The raw data are printed followed by the cross-products matrix. An abbreviated form of Γ (the diagonal elements only) is followed by U and W as labeled.

Tape Output: In addition, output will be written in binary on tape unit 3 in the following order.

(1) the 72-position array TITLE
(2) the diagonal elements of Γ

when NV $\leq$ N:

(3) the matrix U, rowwise
(4) the matrix W, columnwise

or, when NV > N:

(3) the matrix W, columnwise
(4) the matrix U, rowwise

If there are additional runs, FT03F002 (OS/360 file number; see contact person for further information) etc., will contain the subsequent output blocks. Note that U, Γ, and W are written in double precision.

000 0061

SAMPLE INPUT

```
//JOBNAME  JOB (....
//STEPNAME EXEC GITNGO,NAME=MATDEC
//GO.SYSIN DD *
SAMPLE CASE TITLE LINE
   6   4   1   5
(4F1.0)
1649
5524
9452
4267
3155
7831
//
```

SAMPLE OUTPUT


```
NO. OF VARIABLES =      6
NO. OF SUBJECTS =     4
IRC = 1
INPUT TAPE =  5
IR = 0    (1 MEANS REWIND)

ROW     1 OF DATA MATRIX

          1.00000     6.00000     4.00000     9.00000

ROW     2 OF DATA MATRIX

          5.00000     5.00000     2.00000     4.00000

ROW     3 OF DATA MATRIX

          9.00000     4.00000     5.00000     2.00000

ROW     4 OF DATA MATRIX

          4.00000     2.00000     6.00000     7.00000

ROW     5 OF DATA MATRIX

          3.00000     1.00000     5.00000     5.00000

ROW     6 OF DATA MATRIX

          7.00000     8.00000     3.00000     1.00000
```

CROSS-PRODUCTS

	1	2	3	4
1	181.00000	134.00000	119.00000	97.00000
2	134.00000	146.00000	95.00000	109.00000
3	119.00000	95.00000	115.00000	124.00000
4	97.00000	109.00000	124.00000	176.00000

EIGENVALUES (GAMMA)

	1
1	22.25328
2	9.30737
3	5.82712
4	1.48615

EIGENVECTORS (W')

	1	2	3	4
1	0.53954	-0.60364	-0.37722	-0.44969
2	0.49038	-0.25521	0.78853	0.26949
3	0.45743	0.16536	-0.48038	0.72983
4	0.50910	0.73698	0.07187	-0.43876

continued

ROW 1 OF MATRIX U

0.44458	0.55434	0.52843	0.09266

ROW 2 OF MATRIX U

0.36403	-0.10912	0.23738	-0.80504

ROW 3 OF MATRIX U

0.45489	-0.44619	-0.42886	-0.13300

ROW 4 OF MATRIX U

0.42453	0.34661	-0.39660	0.03220

ROW 5 OF MATRIX U

0.31194	0.26276	-0.40941	0.25284

ROW 6 OF MATRIX U

0.43055	-0.54087	0.39443	0.51056

COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $2.13.

Charge to user = computer costs + postage and handling + network overhead

= $2.13 + $5.00 + network overhead

= $7.13 + network overhead

CONTENTS—MATDEC

000 0062

DESCRIPTIVE TITLE	Analysis of Change-over Experiments
CALLING NAME	ZFE-03, ZFE-04
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service (ETS)
AUTHOR(S) AND AFFILIATION(S)	Procedure: G. Beall formerly of Gillette Razor Co. Program: V. Halfmann formerly of ETS
LANGUAGE	FORTRAN
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Off. of Data Anal. Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

The class of designs covered by this program is latin squares or Youden rectangles (incomplete latin squares). These may be repeated fully or in part. The design may be defective, i.e., certain whole rows may be missing, but no allowance has been made for missing cells, i.e., single observations.

The purpose of this program is primarily to analyze the results for effect of treatment with allowance for carry-over of preceding treatment. There is also direct testing of the significance of carry-over. There is included parallel estimation and testing of significance without allowance for carry-over. The program is self-contained and does not require any external subroutines, such as might be presumed to exist in one form or another at computation centers.

The program, as presently stored, allows analysis for designs up to 40 rows (or blocks). This is limited by the dimensions of the data matrices. It could be readily enough changed to 500 or 1000 if such an experiment were involved. The analysis has been contrived so that such change does not increase the size of the matrix involved in equation solving.

continued

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Explanation

The basic equations are,

1. $y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk}$

where y_{ijk} is an observation assumed built of a general level μ, effect of the ith row or individual α_i, the jth period or column β_j, the kth treatment γ_k and extraneous variability ε_{ijk}. This equation obtains for the first column or period when there has been no conditioning period. For the following periods,

2. $y_{ijk\ell} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_\ell + \varepsilon_{ijk\ell}$

where the effect of the ℓth treatment in the preceding period is δ_ℓ. For a conditioned experiment Equ. (2) obtains in all columns.

The data actually considered are the differences within rows such as,

$$y_{ijk\ell} - y_{i'j'k'\ell'} = \beta_j - \beta_{j'} + \gamma_k - \gamma_{k'} + \delta_\ell - \delta_{\ell'}$$
$$(j' \neq j\ ,\ k' \neq k\ ,\ \ell' \neq \ell)\ .$$

These differences are then set forth in a matrix. Thus for an unconditioned latin square for which the first line is,

Design:	(1)	(2)	(4)	(3)
Result:	4	5	7	6

we may consider the two differences,

$$y_{111} - y_{1221} = \beta_1 - \beta_2 + \gamma_1 - \gamma_2 - \delta_1 + \varepsilon_{111} - \varepsilon_{1221}$$
$$y_{1221} - y_{1342} = \beta_2 - \beta_3 + \gamma_2 - \gamma_4 + \delta_1 - \delta_2 + \varepsilon_{1221} - \varepsilon_{1342}$$

which results in two lines of the matrix as follows:

β_1	β_2	β_3	β_4	γ_1	γ_2	γ_3	γ_4	δ_1	δ_2	δ_3	δ_4	Result
+1	−1			+1	−1			−1				−1
	+1	−1			+1		−1	+1	−1			−2

Least-squares equations are in the same form. For instance, to get the equation associated with β_2, each line is multiplied by its content in the β_2 column and the product accumulated over all columns. For each set of effects (β, γ or δ), the last equation is replaced by a condition equation,

continued

000 0062

000 0062

$$\sum_j \hat{\beta}_j = \sum \hat{\gamma}_k = \sum_\ell \hat{\delta}_\ell = 0 .$$

The analysis without carry-over (SANS DELTA) is gotten by replacing, temporarily, all equations appropriate to δ by $\hat{\delta}_\ell = 0$.

The analysis without treatment (SANS GAMMA) is obtained by the temporary replacement, $\hat{\gamma}_k = 0$.

The residual variability is gotten in several steps. First the variability residual on β , γ and δ is

$$3. \quad \sum_{ijk} y^2_{ijk} + \sum_{ijk\ell} y^2_{ijk\ell} - \sum_j \hat{\beta}_j (\sum_{ik} y_{ijk} + \sum_{ik\ell} y_{ijk\ell})$$

$$- \sum_k \hat{\gamma}_k (\sum_{ij} y_{ijk} + \sum_{ij\ell} y_{ijk\ell}) - \sum_\ell \hat{\delta}_\ell \sum_{ijk} y_{ijk\ell} .$$

Secondly, an estimate of $\hat{\mu}$ is made by finding from Equ. (1) or (2) the mean of the values

$$y'_{ijk} = y_{ijk} - \hat{\beta}_j - \hat{\gamma}_k$$

$$y'_{ijk\ell} = y_{ijk\ell} - \hat{\beta}_j - \hat{\gamma}_k - \hat{\delta}_\ell .$$

Thirdly, estimates of $\hat{\alpha}_i$ are made by finding the mean of the values

$$y''_{ijk} = y_{ijk} - \hat{\mu}$$

$$y''_{ijk\ell} = y'_{ijk\ell} - \hat{\mu} .$$

The residual variability as from equation (3) is then further and finally reduced by

$$\hat{\mu} \sum_{ijk\ell} y_{ijk\ell} + \sum_i \alpha_i \sum_{jk\ell} y_{ijk\ell} .$$

Residual variability on the effects of $\hat{\mu}$, rows and columns only (SANS DELTA & SANS GAMMA) is gotten by the formula familiar in analysis of variance.

continued

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The test of significance for treatments without allowance for carry-over is based on residual variability SANS DELTA less residual variability SANS DELTA & SANS GAMMA. The test with allowance for carry-over is from residual variability on FULL MATRIX less that on SANS GAMMA. The test for carry-over is from residual variability on FULL MATRIX less that on SANS DELTA.

It need only be added that there is incorporated a test on whether the situation is underdetermined. The program counts the number of different row patterns, multiples this number by the number of columns, and checks whether the result exceeds the number of independent parameters to be estimated. In the case of underdetermination, it refuses to analyze. A second type of refusal arises if the simultaneous equations prove insoluble, which may arise if the design is redundant. Finally, if there is no residual freedom, the program will estimate the parameters but declare F = 0.

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USER INSTRUCTIONS

Because there are two experimental designs for change-over experiments, two programs have been written. The first, ZFE-03, analyzes the results from a design that did not include a conditioning week. The second, ZFE-04, analyzes the results from a design that did include a conditioning week. In each case the Parameter Card will give the number of treatments, the number of columns of result, the number of columns of treatment patterns, and the number of rows. In the unconditioned experiment the number of columns of results will equal the number of columns of treatment patterns. In the conditioned experiment, the number of columns of treatment patterns will be one greater than the number of columns of results.

Input

Parameter Card

Columns	*Contents*
1– 5	Total number of treatments possible
6–10	Number of columns in treatment pattern
11–15	Number of columns of results
16–20	Number of rows of treatments and results

Note: For an experiment with a conditioning period, the number of columns in the treatment pattern will be one greater than the number of columns of results. For an unconditioned experiment, the two numbers will be identical.

Row of Design Cards (one for each row)

Format	*Contents*
6I5	Statement of treatments

Row of Result Cards (one for each row)

Format	*Contents*
6F5.0	Statement of results

System Control Cards

JOB Card will be prepared by ETS personnel.

continued

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System Card 1

Columns	*Contents*
1–30	//STEPNAME EXEC GITNGO,NAME=
31–36	ZFE-03 or ZFE-04 (see above)

System Card 2

Columns	*Contents*
1–19	//GO.SYSIN DD *

System Card 3

Columns	*Contents*
1– 2	//

Job Deck

JOB Card
System Card 1
System Card 2
Input Deck
System Card 3

Output

The design and results are printed out. The least squares estimates for columns and treatments are printed (SANS DELTA) as they are found without consideration of carry-over. Then the estimates for columns, treatments and carries-over are shown (FULL MATRIX). Finally, the analyses for significance are printed. There is a test for treatment, without allowance for carry-over, a test for treatment with allowance, and a test for carry-over. In each case there is shown the variance ratio, F, with its two statements of freedom.

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SAMPLE INPUT

```
//                    JOB            (....
//STEPNAME  EXEC  GITNGO,NAME=ZFE-03
//GO.SYSIN  DD    *
     7     4     4  18
     1     2     4   7
     2     3     5   1
     4     5     7   3
     5     6     1   4
     6     7     2   5
     7     1     3   6
     2     6     4   3
     3     7     5   4
     4     1     6   5
     5     2     7   6
     6     3     1   7
     7     4     2   1
     1     2     4   7
     2     3     5   1
     3     4     6   2
     4     5     7   3
     6     7     2   5
   55.   37.   47. 45.
   37.   25.   25. 38.
   24.   24.   29. 46.
   36.   44.   39. 52.
   42.   54.   50. 55.
   49.   37.   56. 62.
   42.   45.   35. 32.
   55.   60.   52. 60.
   54.   60.   57. 54.
   42.   44.   46. 44.
   46.   48.   54. 47.
   42.   54.   42. 42.
   49.   42.   47. 48.
   34.   43.   46. 54.
   52.   55.   42. 42.
   38.   38.   26. 28.
   50.   62.   50. 61.
   42.   49.   51. 63.
//
```

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SAMPLE OUTPUT

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ESTIMATES OF VARIABLES

SANS DELTA		FULL MATRIX
	BETA	
-1.3858		-1.3742
-0.1037		-0.1668
-1.3409		-1.3384
2.8304		2.8795
	GAMMA	
-1.9907		-1.4136
-1.1776		-0.5279
4.1289		3.8279
-0.6008		-0.9817
0.1367		-0.6040
-1.2811		-1.4894
0.7846		1.1887
	DELTA	
-0.0		0.7361
-0.0		2.8368
-0.0		0.7053
-0.0		-0.1414
-0.0		-2.0391
-0.0		-1.4626
0.0		-0.6351

ANALYSIS

FACTORS	D.F.	RESIDUAL VAR.
MU ROWS COLUMNS CONTROL	51.	2188.37
CONTROL FACTORS PLUS TREATMENTS	45.	1973.20

$$F_{6.,45.} = \frac{(\ 2188.37 - 1973.20\ )/\ 6.}{1973.20\ /\ 45.} = 0.82$$

FACTORS	D.F.	RESIDUAL VAR.
MU ROWS COLUMNS CARRIES-OVER CONTROL	45.	2045.65
CONTROL FACTORS PLUS TREATMENTS	39.	1874.19

$$F_{6.,39.} = \frac{(\ 2045.65 - 1874.19\ )/\ 6.}{1874.19\ /\ 39.} = 0.59$$

FACTORS	D.F.	RESIDUAL VAR.
MU ROWS COLUMNS TREATMENTS CONTROL	45.	1973.20
CONTROL FACTORS PLUS CARRIES-OVER	39.	1874.19

$$F_{6.,39.} = \frac{(\ 1973.20 - 1874.19\ )/\ 6.}{1874.19\ /\ 39.} = 0.34$$

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COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $3.80.

Charge to user = computer costs + postage and handling + network overhead

= $3.80 + $5.00 + network overhead

= $8.80 + network overhead

CONTENTS—ZFE-03, ZFE-04

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DESCRIPTIVE TITLE	Multivariate-Analysis of Variance
CALLING NAME	MANOVA
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service (ETS)
AUTHOR(S) AND AFFILIATION(S)	Elliot M. Cramer, ETS Amended by: Charles C. Hall, ETS
LANGUAGE	FORTRAN II
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Off. of Data Anal. Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

MANOVA performs univariate and multivariate analyses of variance, of covariance, and of regression. It is quite general and, initially at least, runs should be coordinated with the Office of Computation Sciences through the contact person until the user becomes familiar with the preparation of parameter cards involved. It will perform univariate and multivariate analyses of variance with complete factorial designs or incomplete designs, and with or without covariates, discriminant analyses and canonical correlations. An exact solution in either the orthogonal or nonorthogonal case is provided, and options include single- or multiple-degree-of-freedom contrasts in the main effect or interactions, transformation of variables, and orthogonal polynomial contrasts with equally- or unequally-spaced points. Reanalyses may be done with different criteria, covariates, contrasts and models.

Limitations include a total of 40 variables, no more than 100 nonvacant cells, and up to eight factors with a maximum of 20 levels in each. There is no limitation on the number of subjects.

continued

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REFERENCES

Bock, R.D., "Programming Univariate and Multivariate Analysis of Variance," Technometrics, 5, 95–117 (1963).

Clyde, D.J., Cramer, E.M., & Sherin, R., *Revised Manova Program* (The University of Miami Biometric Laboratory, Coral Gables, Florida, 1967).

Graybill, F.A., *An Introduction to Linear Statistical Models* (McGraw–Hill Book Co., Inc., New York, 1961) 223–253.

Morrison, D.F., *Multivariate Statistical Methods* (McGraw–Hill Book Co., Inc., New York, 1967) 159–206.

Rao, C.R., *Advanced Statistical Methods in Biometric Research* (John Wiley & Sons, Inc., New York, 1952) 236–272.

Roy, S.N., *Some Aspects of Multivariate Analysis* (John Wiley & Sons, Inc., New York, 1957) 76–86.

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USER INSTRUCTIONS

Input

Input to the program consists of a variable number of cards depending upon the options used. The choice of the options is generally indicated by a 1 punch in a particular column of the Problem Card.

The types of cards used, identification, a summary description of contents and order of cards follow.

Title Card

Columns	*Contents*
1– 5	TITLE
6–80	Any title; multiple card may be used

Problem Card

Columns	*Contents* (b represents blank)
1– 4	PROB
6– 7	No. of variables ($\leq$ 40)
8	No. of factors ($\leq$ 8)
9	n: No. of Variable-Format Cards b: standard format
10	1: variable names supplied b: numbers used
11	1: subset of variables used as criteria b: all variables used
12	1: Significance Test Cards read b: standard ordering
13	1: last effect on Significance Test Cards obtained as residual and tested b: no test on residual effect
14	1: correlation between observed error variables and canonical variables printed b: correlation not printed
15	4: Input data on tape 4 b: Input data on tape 5

NOTE: Data on tape 5 *must* have LRL $\leq$ 70, RCT = 1, Block $\leq$ 70, Type 1. Tape labels *must* be bypassed by 7044 operator. (See contact person for further information.)

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Problem Card

Columns	*Contents* (b represents blank)
16	1: cell means not printed b: cell means printed
17	1: transformations of data b: no transformations
18	1: reduced model matrix printed b: matrix not printed
19	1: correlations among model parameters printed b: correlation not printed
20	1: reduced model matrix read in (Col. 12 = 1) b: matrix not read
21	1: mean omitted from model (Col. 12 = 1) b: mean included
22	1: sum of product matrix printed b: matrix not printed

Variable-Name Card (optional: PROB Col. (10) = 1)

Columns	*Contents*
1–10	Name of first variable
11–20	Name of second variable
⋮	⋮
71–80	Name of eighth variable Use number of names equal to number of variables.

Variable-Subset Card (optional: PROB Col. (11) = 1)

Columns	*Contents*
1– 2	Number of criteria (right-justified)
3– 4	Number of covariates (right-justified)
5–80	Of the V variables, punch variable numbers followed by covariates in 2-digit fields. Use additional cards if necessary starting in Col 1.

continued

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Contrast Cards (entered for every factor in same order as factor codes)

Columns	*Contents* (b represents blank)
1	letter ID of factor (not W)
2	b: regular contrasts 1: special contrasts 2: orthogonal polynomial contrasts on following card 3: orthogonal comparison of i + first level minus average of previous levels
3– 4	Levels for this factor (right-justified $\leq$ 20)
5–20	b: no partition of factor If partitioning to be done, punch degrees of freedom for each partition in 2–digit fields.
21–60	b: level codes are punched in Data Cards Level cards are punched in 2–digit fields otherwise.
61–80	Factor name

Special Contrast Cards (optional: Contrast Card Col. (2) = 1)

Columns	*Contents*
1–80	Square matrix with as many rows as levels in factor in 5–digit fields. Each row begins on new card; they must sum to zero.

(Contrast Card Col. (2) = 2)

Columns	*Contents*
1–80	For orthogonal polynomials, specify metric in 5–digit fields.

Significance Test Cards (optional: PROB Col. (12) = 1)

Columns	*Contents*
1–80	Code letters for effects of design separated by commas, followed by period. W denotes nesting. Ex: B,A,AB.

Variable-Format Cards (optional: PROB Col. (9) = n)

Columns	*Contents*
1–80	Variable format for one subject. Include level code for each factor and include parentheses.

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Transformation Card (optional: PROB Col. (17) = 1)

Columns	*Contents*	
1 to number of variables	b:	no transformation
	1:	square root transformation
	2:	log transformation
	3:	arcsin transformation
	4–9:	user's transformation; subroutine SPECTR must be changed

Data Cards (Format designated by PROB Col. (9))

Data must include: numbered level code(s) followed by scores. All Data Cards for one subject must be in order. Deck is followed by as many blank cards as there are Data Cards for one subject.

Reduced Model Matrix Cards (optional: PROB Col. (20) = 1)

First row of reduced model matrix punched in 5-column fields. Continue for remainder of rows in reduced model matrix.

Reanalysis Card (optional)

Columns	*Contents* (b represents blank)	
1– 5	ANALY	
6	b:	all variables used as criteria
	1:	subset used as criteria
7	b:	standard or diagonal ordering
	1:	Significance Test Cards read
8	b:	previous contrasts used
	1:	new contrasts used
9	b:	residual effect not tested
	1:	residual effect tested
10	b:	reduced model matrix not read
	1:	reduced model matrix read
11	b:	general mean included
	1:	general mean omitted
12	b:	print complete statistical analysis
	1:	print estimates of effects only

continued

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Variable-Subset Cards (optional: ANALY Col. (6) = 1)
Same format as previous Variable-Subset Cards

Contrast and Special Contrast Cards (optional: ANALY Col. (8) = 1)
Same format as previous Contrast Cards

Significance Test Cards (optional: ANALY Col. (7) = 1)
Same format as previous Significance Test Cards

Reduced Model Matrix Cards (optional: ANALY Col. (10) = 1)
Same format as previous Reduced Model Matrix Cards

Finish Card (placed at end of all problems)

Columns	*Contents*
1– 6	FINISH

System Control Cards
JOB Card will be prepared by ETS personnel.

System Card 1

Columns	*Contents*
1–36	//STEPNAME EXEC GITNGO,NAME=MANOVA

System Card 2

Columns	*Contents*
1–19	//GO.SYSIN DD *

System Card 3

Columns	*Contents*
1– 2	//

Job Deck

JOB Card
System Card 1
System Card 2
Input Deck
System Card 3

continued

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Output

The output is dependent upon the specifications in the input cards. It may include

1. description and identification of variables and factors
2. means and standard deviations
3. reduced model matrix
4. correlations of effects
5. univariate analysis table (ANOVA)
6. multivariate

   (a) error correlations
   (b) estimates of effects tested against the error term
   (c) analysis of regression if there are covariates

7. a page with multivariate and univariate tests for each effect. In the program, sufficient diagnostic output is given to isolate an error. For more detail, consult the complete writeup (Ref. 1).

Restrictions

No. of variables ($\leq$ 40)
No. of factors ($\leq$ 8)
No. of levels for each factor ($\leq$ 20)
No restriction on number of subjects

REFERENCES

Clyde, D.J., Cramer, E.M., & Sherin, R., *Revised MANOVA Program* (The University of Miami Biometric Laboratory, Coral Gables, Florida, 1967).

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SAMPLE INPUT

```
// JOB      (....
//STEPNAME  EXEC  GITNGO,NAME=MANOVA
//GO.SYSIN  DD    *
TITLE PROBLEM 1 FROM HALL AND CRAMER MANOVA PROGRAM WRITTEN IN FORTRAN II
TITLE 2X2 FACTORIAL DESIGN WITH 6 CRITERIA
TITLE REANALYZE WITH 1 CRITERION AND 5 COVARIATES
PROB  6211   1   11
        ONE       TWO      THREE      FOUR      FIVE       SIX
A  2                                                          ALPHA
B  2                                                          BETA
(2I1,10X,6F6.0)
115   41    569.  156.  104.  506.  4.    9.
115   42    475.  120.  105.  366.  4.    16.
115   43    641.  83.   82.   815.  4.    16.
115   44    779.  104.  104.  331.  4.    17.
115   45    587.  98.   53.   564.  3.    13.
115   46    841.  129.  71.   519.  5.    5.
115   47    907.  90.   49.   416.  3.    16.
115   48    698.  76.   53.   492.  4.    9.
115   49    849.  132.  89.   459.  5.    1.
115   50    505.  166.  207.  474.  4.    -9.
126   51    557.  91.   62.   513.  3.    26.
126   52    649.  114.  52.   416.  4.    16.
126   53    714.  81.   50.   491.  4.    0.
126   54    611.  125.  80.   630.  3.    25.
126   55    713.  84.   57.   471.  4.    4.
126   56    644.  97.   63.   453.  4.    5.
126   57    593.  83.   55.   546.  4.    8.
126   58    536.  125.  85.   364.  3.    24.
126   59    988.  109.  94.   554.  4.    7.
126   60    584.  120.  91.   503.  4.    4.
218   71    935.  72.   67.   623.  4.    12.
218   72    846.  96.   79.   539.  4.    2.
218   73    704.  109.  45.   355.  2.    7.
218   74    953.  142.  67.   432.  3.    22.
218   75    553.  97.   80.   495.  3.    16.
218   76    592.  82.   67.   362.  2.    17.
218   77    529.  85.   50.   657.  2.    14.
218   78    556.  99.   67.   589.  1.    18.
218   79    419.  103.  77.   452.  3.    15.
218   80    598.  78.   59.   397.  4.    0.
229   81    662.  75.   48.   385.  4.    14.
229   82    668.  88.   48.   361.  2.    8.
229   83    519.  110.  48.   391.  3.    11.
229   84    449.  90.   66.   484.  4.    9.
229   85    647.  80.   56.   482.  4.    2.
229   86    589.  64.   44.   337.  3.    15.
229   87    846.  73.   60.   598.  4.    6.
229   88    748.  96.   65.   601.  4.    10.
229   89    763.  135.  92.   480.  2.    12.
229   90    578.  102.  65.   683.  3.    -8.
                                                  <--- Blank Card
ANALY1
 1 5 5 1 2 3 4 6
/*
```

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SAMPLE OUTPUT

MULTIVARIATE ANALYSIS OF VARIANCE
DATED 3/21/68

PROBLEM 1 FROM HALL AND CRAMER MANOVA PROGRAM WRITTEN IN FORTRAN II
2X2 FACTORIAL DESIGN WITH 6 CRITERIA
REANALYZE WITH 1 CRITERION AND 5 COVARIATES

PROBLEM 1 6 VARIABLES 2 FACTORS

ONE TWO THREE FOUR FIVE SIX

6 CRITERIA 0 COVARIATES WITH THE FOLLOWING VARIABLES
ONE TWO THREE FOUR FIVE SIX

FACTOR A 2 LEVELS ALPHA
DEVIATION CONTRASTS

FACTOR B 2 LEVELS BETA
DEVIATION CONTRASTS

FORMAT OF DATA CARDS
(2I1,10X,6F6.0)

4 CELLS

MEANS AND STANDARD DEVIATIONS

FACTOR A	FACTOR B			VARIABLE ONE	TWO	THREE	FOUR	FIVE	SIX
1	1	10 OBS							
			M	685.100	115.400	91.700	494.200	4.000	9.300
			SD	153.122	30.497	46.094	133.073	0.667	8.367
1	2	10 OBS							
			M	658.900	102.900	68.900	494.100	3.700	11.900
			SD	130.096	17.760	15.868	74.866	0.483	9.927
2	1	10 OBS							
			M	668.500	96.300	65.800	490.100	2.800	12.300
			SD	183.563	19.889	11.717	108.459	1.033	7.134
2	2	10 OBS							
			M	646.900	91.300	59.200	480.200	3.300	7.900
			SD	119.088	20.769	14.172	116.118	0.823	6.757

COMPLETE FACTORIAL WITH NO MISSING CELLS

REDUCED MODEL MATRIX

FACTOR A	FACTOR B	PARAMETER 1	2	3	4
1	1	1.000	1.000	1.000	1.000
1	2	1.000	1.000	-1.000	-1.000
2	1	1.000	-1.000	1.000	-1.000
2	2	1.000	-1.000	-1.000	1.000

CORRELATIONS OF CONTRASTS WITH STANDARD DEVIATIONS OF CONTRASTS DIVIDED BY STANDARD DEVIATIONS OF VARIABLES ON DIAGONAL

CONTRAST	1	2	3	4
1	0.158			
2	0.000	0.158		
3	0.000	-0.000	0.158	
4	0.000	-0.000	0.000	0.158

continued

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WITHIN CELLS CORRELATIONS OF CRITERIA WITH STANDARD DEVIATIONS ON DIAGONAL ADJUSTED FOR 0 COVARIATES

VARIABLE	ONE	TWO	THREE	FOUR	FIVE	SIX
ONE	148.533					
TWO	-0.063	22.762				
THREE	-0.171	0.633	26.208			
FOUR	0.080	-0.122	0.021	110.182		
FIVE	0.295	-0.122	0.076	0.074	0.778	
SIX	-0.097	-0.058	-0.261	-0.117	-0.440	8.141

ESTIMATES ADJUSTED FOR 0 COVARIATES

CONTRAST	CRITERIA ONE	TWO	THREE	FOUR	FIVE	SIX
A						
1	7.150	7.675	8.900	4.500	0.400	0.250
LAST 2	-7.150	-7.675	-8.900	-4.500	-0.400	-0.250
B						
1	11.950	4.375	7.350	2.500	-0.050	0.450
LAST 2	-11.950	-4.375	-7.350	-2.500	0.050	-0.450
AB						
1	1.150	1.875	4.050	-2.450	0.200	-1.750
LAST 2	-1.150	-1.875	-4.050	2.450	-0.200	1.750

TEST OF AB

TESTS OF SIGNIFICANCE USING WILKS LAMBDA CRITERION AND CANONICAL CORRELATIONS

TEST OF ROOTS	F	DFHYP	DFERR	P LESS THAN	R
1 THROUGH 1	0.557	6.000	31.000	0.761	0.312

VARIABLE	UNIVARIATE F TESTS F(1, 36)	MEAN SQ	P LESS THAN	STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS 1
ONE	0.002	52.899	0.961	-0.167
TWO	0.271	140.625	0.606	0.169
THREE	0.955	656.099	0.335	0.222
FOUR	0.020	240.101	0.889	-0.135
FIVE	2.642	1.600	0.113	0.744
SIX	1.848	122.500	0.182	-0.327

TEST OF B

TESTS OF SIGNIFICANCE USING WILKS LAMBDA CRITERION AND CANONICAL CORRELATIONS

TEST OF ROOTS	F	DFHYP	DFERR	P LESS THAN	R
1 THROUGH 1	0.726	6.000	31.000	0.632	0.351

VARIABLE	UNIVARIATE F TESTS F(1, 36)	MEAN SQ	P LESS THAN	STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS 1
ONE	0.259	5712.089	0.614	0.510
TWO	1.478	765.624	0.232	-0.098
THREE	3.146	2160.899	0.085	1.052
FOUR	0.021	249.998	0.887	0.051
FIVE	0.165	0.100	0.687	-0.267
SIX	0.122	8.100	0.729	0.362

continued

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TEST OF A

TESTS OF SIGNIFICANCE USING WILKS LAMBDA CRITERION AND CANONICAL CORRELATIONS

TEST OF ROOTS	F	DFHYP	DFERR	P LESS THAN	R
1 THROUGH 1	3.286	6.000	31.000	0.013	0.624

VARIABLE	UNIVARIATE F TESTS F(1, 36)	MEAN SQ	P LESS THAN	STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS 1
ONE	0.093	2044.853	0.763	-0.123
TWO	4.548	2356.224	0.040	0.487
THREE	4.613	3168.399	0.039	0.188
FOUR	0.067	809.997	0.798	0.110
FIVE	10.569	6.400	0.002	0.998
SIX	0.038	2.500	0.847	0.558

DISCRIMINANT SCORES

CONTRAST	1
1	0.757

CORRELATIONS BETWEEN VARIABLES AND COMPOSITE SCORES

VARIABLE	1
ONE	0.064
TWO	0.446
THREE	0.449
FOUR	0.054
FIVE	0.679
SIX	0.041

MULTIVARIATE ANALYSIS OF VARIANCE

PROBLEM 1 REANALYSIS 1 WITH THE FOLLOWING 1 CRITERIA AND 5 COVARIATES
FIVE ONE TWO THREE FOUR SIX

SOURCE	SS	DF	MS	F	P LESS THAN
WITHIN CELLS	15.453	31	0.498		
REGRESSION	6.347	5	1.269	2.546	0.048
A	5.849	1	5.849	11.734	0.002
B	0.097	1	0.097	0.195	0.662
AB	0.614	1	0.614	1.232	0.276

ESTIMATES ADJUSTED FOR 5 COVARIATES

CRITERIA

CONTRAST	FIVE
A	
1	0.417
LAST	
2	-0.417
B	
1	-0.052
LAST	
2	0.052
AB	
1	0.128
LAST	
2	-0.128

RAW REGRESSION COEFFICIENTS

COVARIATES	WITHIN CELLS
ONE	0.001
TWO	-0.008
THREE	0.005
FOUR	-0.000
SIX	-0.037

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COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $5.28.

Charge to user = computer costs + postage and handling + network overhead

= $5.28 + $5.00 + network overhead

= $10.28 + network overhead

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DESCRIPTIVE TITLE	Structure-Factor Least-Squares Refinement Program for IBM 7090
CALLING NAME	ORFLS-PX
INSTALLATION NAME	University of Pittsburgh The Computer Center
AUTHOR(S) AND AFFILIATION(S)	Dr. Ryonosuke Shiono Crystallography Laboratory University of Pittsburgh
LANGUAGE	FORTRAN II, except SMI, which is in FAP(UMAP).
COMPUTER	IBM 7090 with 32K core storage 2–3 magnetic-tape units in addition to system input/output.
PROGRAM AVAILABILITY	Proprietary; usage permitted, but program deck or listing not available
CONTACT	Dr. Ryonosuke Shiono, Crystallography Laboratory, 300 Thaw Hall, University of Pittsburgh, Pittsburgh, Pa. 15213 Tel.: (412) 621-3500 ext. 7124

FUNCTIONAL ABSTRACT

ORFLS-PX is an extensively modified version of the FORTRAN least-squares program by Busing, Martin, and Levy. Their program,

> performs successive cycles of refinement using the full matrix of the normal equations. The parameters which may be adjusted include several scale factors, an overall temperature factor coefficient, the neutron scattering factors, individual atom multipliers, atomic coorinates, and isotropic or anisotropic individual atom temperature factor coefficients. The parameters to be varied may be specified arbitrarily, and structures of any symmetry may be accommodated. The refinement may be based either on the structure factors or their squares, and the observations may be weighted individually, or the use of unit weights may be specified.[1]

Features of ORFLS-PX

1. Reflexion-data input may be from cards or from magnetic tape

continued

2. Uses atomic-scattering-factor table of f versus sinθ
3. External scale factors now refer to F_{obs}, rather than to F_{cal}'s
4. Weighting scheme may be changed or weights modified by a subroutine
5. Limitations on maximum number of atoms, parameters to be used; number of parameters to be refined have been enlarged
6. Isotropic and anisotropic temperature factors for atoms may be used in mixed fashion
7. Anomalous dispersion correction may be made[2]
8. Calculated structure factors, together with the scales F_{obs} are written on a binary tape, which may be used as an input for the Fourier program or for a new cycle of the least-squares program.[3]
9. Using an output tape as the input, a part of the structure may be added as fixed contribution for a partial-mode calculation, (this either saves time in calculation or extends the limit of number of atoms to be used)
10. Different set of parameters may be refined in successive cycles of full-matrix refinement, when not all the parameters can be refined at the same time

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General Description of the Program Setup

To provide more storage space for the parameter refinement, ORFLS-PX is divided into three separate core-load packages: MAIN(1), MAIN(2), and MAIN(3).

MAIN(1) reads the reflexion data on cards or on tape, interpolates the atomic-scattering factors for each kind, and assigns the weight according to the specification. This part may be bypassed if a tape from a previous cycle of calculation is used as the input. Otherwise, the program produces an intermediate output tape.

MAIN(2) reads back the MAIN(1) tape, one reflexion at a time and calculates structure factor and the necessary derivatives for least-squares refinement. The calculated structure factors and scaled F_{obs}' are on the output binary tape. This tape is rewound at the end of every cycle so that the data on this tape are the result of latest calculation. This tape may be used as the input for fixed contribution in a partial-mode calculation.

MAIN(3) prints out the correlation matrix and other information on various agreements at the end of all calculation.

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Card formats used for reflexion data and atomic parameters and for symmetry operations are identical to many other interconnected programs on the IBM 7090 and IBM 1130 as well as the IBM 1620. Usually, the user has only to punch a few Control Cards to run any one of the programs.

The Data and Parameter Cards are identical to those in the Block-Diagonal Least-Squares programs[3] on the IBM 7090 and 1130, and so the user may easily switch from one program to another.

The reflexion-data file on magnetic tape has, again, the same format between this and Block-Diagonal, E, Fourier and other programs on the IBM 7090 (see Ref. 3), and it may be used interchangeably.

ORFLS-PX is an independent program, as compared to some others incorporated in a big system, permitting one to write a subroutine to fit a particular problem, and replace the dummy variables provided in the program by one's own.

REFERENCES

1. Busing, W.R., Martin, K.O., and Levy, H.A., "A FORTRAN Crystallographic Least-Squares Program," ORNL Tech. Mem. No. TM305 (Oak Ridge National Laboratories, Oak Ridge, 1962). The modified version of this program is used for calculations that involve scattering data and crystallographic structures. Additional information can be obtained through the contact person.

2. Ibers, J.A., and Hamilton, W.C., "Dispersion Correction and Crystal Structure Refinement," Acta Cryst. *17*, (1964), 781-782.

3. Additional information can be obtained through the contact person.

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USER INSTRUCTIONS

Note for Punching Cards for the Michigan System

The input routine used in FORTRAN in the Michigan System has one bad feature insofar as the standard IBM FORTRAN users are concerned. The I/O routine ignores any blanks in numeric field, whereas the IBM version considers these as zero. As a result, if the following zeros are not punched in an integer field, or in a floating-point number without a decimal point, the Michigan program will take the last punched digit (rather than the last column of the specified field) as the last digit of the field. Therefore, care must be taken to insure that all the cards are punched for the system.

Recommendation: Always punch decimal point in a floating-point number field.

Card Format

Title Card

Any Hollerith characters (alphanumeric) may be punched on Cols. 1–72. The information punched here will be printed on the output as heading.

Control Card No. 1 (5I5, 6F8.4)

Parameter	*Columns*	*Contents*
JB	5	0: Input reflexion data from cards 1: Input reflexion data on tape 9. An output tape of the data-reduction program, E program, or that of the least-squares program (this program or block-diagonal program) may be used. The program uses only h, k, ℓ indices, F_{obs}, σ, ID from the input tape, so that this mode may be used when an input tape contains no atomic f's (data-reduction or E-program output) or some change in weight or atomic f's is desired 2: Input reflexion on cards. Run only the Part I to produce an intermediate output tape (Tape 10) for use in Patterson synthesis

continued

Parameter	*Columns*	*Contents*
		3: Input reflexion data on tape from a previous least-squares calculation. The tape should be mounted on tape 10. All information on the tape is used without change, the program bypasses Part I, and the Cell-Constant Card, the Atomic-Scattering Cards, the Reflexion-Data Cards, and the remainder of this card are irrelevant
JA	10	0: Refine F_{obs}
		1: Refine on $(F_{obs})^2$. This causes $(F_{obs})^2$ to be written on tape 10. Do not use this mode if F_{obs}'s are already squared
JW	15	0: Standard error σ's are punched on the Data Cards and/or they will be assigned by the subroutine MODIFY
		1: Hughes' weighting scheme. When specified, F_{min} (*not* $4F_{min}$) value should be punched as A in Cols. 26–33
		2: Cruickshank's weighting scheme. A, B, C values below should be supplied.
		3: $\omega = 1/(\sin\theta/\lambda)$
		4: Constant weight, $\omega = 1.0$
JC	20	0: Subroutine MODIFY is not used
		1: Enter subroutine MODIFY
JD	25	0: Normal
		1: Set $\omega = 0.0$ for unobserved reflexion with ID = 1
A	26–33	F_{min}, value for Hughes' or A for Cruickshank's scheme. This may be used for any other purpose in your MODIFY subroutine
B	34–41	For Cruickshank's B or blank
C	42–49	For Cruickshank's C or blank
D	50–57	For use in MODIFY subroutine
E	58–65	
F	66–73	

continued

Weight ω is taken as $\omega = 1/(\sigma)^2$. If $\sigma = 0$, then the program sets $\omega = 0$. What is punched on the Reflexion-Data Cards or calculate according to some scheme and write on the tape is σ and not ω. F_{obs} values used here are those on the input cards, or on the tape 9, and they are not affected by the scale factors that the user provides.

Hughes' Scheme (Ref. 1)

$\omega = 1/|F_o|^2$, if $F_o \geq 4F_{min}$;

$\omega = 1/|4F_{min}|^2$, if $F_o < 4F_{min}$;

$\omega = 0$, if $F_o = 0$.

Cruickshank's Scheme (Ref. 2)

$\omega = 1/(A + BF_o + CF_o^2)$.

Cell Constant Card (3F7.3, 4F7.4)

Columns	*Contents*
1– 7	a
8–14	b
15–21	c
22–28	cosα
29–35	cosβ
36–42	cosγ
43–49	λ (wavelength used)

a, b, c, and λ are in angstrom units.

Atomic-Scattering-Factor Cards (7F10.4)

This is the table of f versus sinθ, eight cards per atomic kind (51 entries of f). Atomic f's are punched in increasing order of corresponding sinθ value[3] from 0.00 to 1.00 with an increment of 0.02. A 1620 FORTRAN program or similar one on the 1130 computer prepares the cards from the literature value. The order of sets for each atomic kind determines the number to be used on the parameter cards. Up to ten sets. A blank card terminates the atomic f cards.

continued

Reflexion-Data Cards (3I9, 2F9.2, F9.0, I5, 2F6.3)

The output of the 1130 data-processing program is in this format.

Parameter	*Columns*	*Contents*
	1– 9	h ⎤
	10–18	k ⎥ indices
	19–27	ℓ ⎦
	28–36	F_{obs}
	37–45	σ, if used, or blank
	53–54	Scale-factor designation. 1~20. If blank, 1.0 is assumed
	59	0: Observed reflexion 1: Unobserved reflexion
RA	60–65	Extra fields for any desired values if needed
RB	66–71	The values will be transferred to the input and the output tape of the refinement part and available in the calculation. Blank if not used

A blank card terminates the reflexion data.

Control Card No. 2 (I6I5)

Parameter	*Columns*	*Contents*
NC	5	The number of cycles to be run. If NC = 0, a set of structure factors will be calculated but no refinement will be made
NA	8–10	The number of atoms in the asymmetric unit, which are used in the parameter cards
NQ	14–15	The number of scale factors used and appearing in the parameter list
ITF	20	0: Isotropic temperature factors and anisotropic temperature factors, or mixed 1: Conversion on the parameter cards of isotropic temperature factors to anisotropic mode before refining. If some of the atoms have already anisotropic temperature factors, this will not affect them.

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Parameter	*Columns*	*Contents*
NV	23–25	Number of parameters to be varied and refined. If NC = 0 (unrefined structure factors are used), then NV is irrelevant.
NAS	29–30	Number of anomalous scattering atoms in the parameter cards to apply the correction. The parameter cards for those atoms must be grouped and placed in front of other atoms.
NPT	35	0: normal calculation 1: Partial-mode calculation. Ac, Bc are taken from the input tape and added to the current calculated values. This assumes that an output tape of previous calculations is mounted on tape 10 for use as input data. Any atom with anomalous dispersion correction should be in the new part and may not be in the input tape.
NPRN	40	0: Print structure factors for every cycle. 1: Print only the final structure factors and suppress the printout of other cycles.
NR	45	0: Normal calculation with no parameter-selection change 1: First run of repeat calculations with change in Parameter-Selection Cards. This makes the program go back and read a new set of Control Cards. 2: Second and more run of the above cycle. The program will go back and read more Control Cards 3: Final run of the recycling. The program terminates at the end of this specification.
NRW	50	0: Normal 1: Copy back the final output results on tape 4 to tape 10. For this, tape 10 must have the protector ring in. This copying takes place only when the final calculation has been run successfully.

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Parameter	*Columns*	*Contents*
ISTP	55	0: Program will be terminated, if a nonpositive definite temperature factor results. 1: Program will proceed in the above case by resetting the temperature factor to 0.0001 (for isotropic) or the original value (for anisotropic).

Control Card No. 3 (6I5)

Parameter	*Columns*	*Contents*
NF	5	The number of different x-ray form factors. NF = 0 for neutron diffraction
ICENT	10	1: Centrosymmetric 2: Noncentrosymmetric
NS	14–15	The number of Symmetry Cards. For centrosymmetric structure, NS is equal to one-half the number of equivalent positions. The original x, y, z should be included. ($1 \leq NS \leq 24$)
IFSQ	20	1: Refine (scale $\underline{\underline{x}}$ F) 2: Refine (scale $\underline{\underline{x}}$ $F)^2$
IXFE	25	0: No extra tape for ORFFE[3] 1: Extra tape for ORFFE. This may not be specified if the input tape 9 is used. 2: Punch the same on cards for ORFFE.

Symmetry Cards (F11.6, 2I2, F11.6, 2I2, F11.6, 2I2)

For a centrosymmetric structure, those positions related by the center of symmetry are not required. The basic x, y, z position must be included. For a centered-lattice, those symmetries related by pure translations are not required, but the atom multiplier should be increased.

0	blank
x	1
-x	-1
y	2
-y	-2
z	3
-z	-3

continued

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Parameters	*Columns*	*Contents*
	1–11	translational part of x
	12–13 14–15	symmetry for x direction
	16–26	translational part of y
	27–28 29–30	symmetry for y direction
	31–41	translational part of z
	42–43 44–45	symmetry for z direction

Scale-Factor Cards (8F9.6)

Parameters	*Columns*	*Contents*
	1– 9	first scale factor S_1
	10–18	second scale factor S_2

If there are more than eight scale factors, continue to additional cards. All scale factors in this program apply to the F_{obs} value, rather than to the F_{cal} values. When an output tape of a previous calculation is used as the input, F_{obs} values were already scaled so that the scale factors used here should be 1.0.

Atomic-Parameter Cards

a) First Card (A6, 3X, 5F9.6, 2F6.2)

Parameters	*Columns*	*Contents*
	1– 6	Any 6 Hollerith characters identifying atom i
	10–18	X-ray scattering factor identifier, to specify which atomic f to use. (1.0 ~ 10.0) For neutron problem, this is the neutron-scattering factor itself.
	19–27	A multiplier, a_i, this number is usually 1.0, except for a special position or disordered atom, or for a centered-lattice.
	28–36	x_i, fractional coordinate
	37–45	y_i
	46–54	z_i

continued

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Columns	*Contents*
55–60	$\Delta f'$, $\Delta f''$ — if anomalous dispersion correction is applied, the values are taken as constant for $\sin\theta$ value.

b) Second Card (6F9.6)

Columns	*Contents*
1– 9	T_i, the isotropic temperature factor, or β_{11}
10–18	β_{22}, (if the field for β_{22} is zero, the program assumes isotropic temperature factor
19–27	β_{33}
28–36	β_{12}
37–45	β_{13}
46–54	β_{23}

The above Atomic Parameter Cards may be prepared from the SFII Coordinate Cards (7070 or 1620) by a 1620 program,[3] and also may be converted back to SFII form. If anomalous dispersion correction is applied for some atoms, the Parameter Cards for those atoms should be placed first.

Parameter-Selection Cards (7211)

These cards specify the NV parameters to be varied, each column of the cards for each parameter, in the order,

Columns	*Contents*		
1	NQ scale factors		
2	scattering factor multiplier	or	scattering factor multiplier
3	x_i		x_i
4	y_i		y_i
5	z_i		z_i
6	B_i		β_{11}
7			β_{22}
8			β_{33}
9			β_{12}

continued

Columns	*Contents*	
10		β_{13}
11		β_{23}
⋮		⋮

Punch 0 for holding constant
1 for refinement

The set of six or 11 columns repeat for all atoms used. Continue from Col. 72 of one card to Col. 1 of a next card. At present the total number of parameters to be used including those not to be varied is 811. This card is not used if the number of cycle is zero (unrefined structure factors only).

The number of parameters to be specified for each atom is either six or 11, depending on whether the temperature factor of an atom is isotropic or anisotropic. When using mixed mode of temperature factors, that is, some atoms have isotropic and others have anisotropic temperature factors, care must be taken to count and fill up the columns properly for six or 11. There should be no gap between atoms, and the order of atoms here are identical to the order in which the atomic Parameter Cards are read.

Please note that these Parameter Selection Cards are different from the corresponding ones used for the Block-Diagonal Least-Squares programs[3] (7090, 1130) by Shiono.

Assembly of Cards

7090 ID Card (Name, time estimate, etc.)

$$ Comment card(s) to specify scratch or private tapes on 10 and 4.

$NEEDS 10

$HALT (If a private tape is used)

$REMOVE TAPES (If a private tape is used with ring on)

$EXECUTE,I/O DUMP

Program deck (binary cards)

$DATA

Title Card

Control Card No. 1

Cell Constant Card

continued

Atomic-Scattering-Factor Cards (Set of eight, as many sets as necessary up to ten. The order of f's corresponds to the specification on parameter cards.)

Blank Card (to terminate the atomic f's)

Reflexion-Data Cards (as many as necessary)

Blank Card (to terminate the reflexions)

Control Card No. 2

Control Card No. 3

Symmetry Card(s)

Scale Factor Card(s)

Atomic-Parameter Cards (pair of cards for each atom)

Parameter-Selection Card(s) (not used if unrefined structure factors desired)

If JB = 3, Control Card No. 2 follows immediately after Control Card No. 1, and the cards between them are not used.

If JB = 1, omit the Reflexion-Data Cards and a blank card behind them. Control Card No. 2 follows the blank card behind the atomic f's.

If JB = 1, mount the input tape on Tape 9, and a scratch tape on Tape 10. If JB = 3, mount the input tape on Tape 10. If JB = 2, the output is on Tape 10.

The calculated results will be written on Tape 4, and this may be used as an input to the Fourier program or as an input to a later cycle of least-squares program.[3]

When starting with the reflexion on cards, tapes 10 and 4 must have their protector rings on.

Refinement Cycles With Different Set of Parameters Varied

Since the total number of parameters to be varied and refined at a time is limited (at present 181) by the size of core storage, sometimes it is necessary to refine a part of the total structure in a cycle or two and then switch the part to be refined until all the desired parameters have been refined. This may be done by punching a 1, 2 or 3 in Col. 45 of the Control Card No. 2.

Example of a setup of cards is shown below.

continued

Program deck

$DATA

First set of Control Cards for the first selection, 1 in Control Card No. 2, Col. 45.

For second or more refinement cycles,

Title Card
Control Card No. 1 JB = 3 (Col. 5)
Control Card No. 2 NR = 2 (Col. 48)
Control Card No. 3
Symmetry Cards
Parameter Selection Cards

Repeat above set of cards as many as necessary. For the final set of parameter selection (this may follow the first set immediately),

Title Card
Control Card No. 1 JB = 3 (Col. 5)
Control Card No. 2 NR = 3 (Col. 45)
Control Card No. 3
Symmetry Cards
Parameter Selection Cards

Symmetry Cards are usually redundant, but have to be present each time.

If certain part of the total structure is not going to be refined in all cycles, it will be faster to have this part calculated first and use the output tape as the input for fixed contribution.

Program Deck Makeup

MAIN(1)
SCAT
SBTP
MODIFY (Dummy)
BREAK CARD
MAIN(2)
CALC
TEST
SMI
SBTOP
PTOSB
DTOD

continued

```
OLDIOH
PATCH (Dummy)
RESETX (Dummy)
RESETB (Dummy), RSETW
BREAK CARD
MAIN(3)
BREAK CARD
```

A BREAK CARD is recognized as a card with 12, 7 and 9 punches on Col. 1 and rest of the columns all blank up to Col. 72.

Magnetic Tape Assignment

Logical tape addresses used in the program as compiled, are as follows.

Symbolic	*Logical*	*Physical*	
NTPA	7	B1	Michigan System Input
NTPB	6	A3	Michigan System Output (print)
NTPF	5	A3	Michigan System Output (card)
NTPG	10	A5	Output of Part I, Input of Part II
NTPC	9	B5	Tape input data to Part I (if used) or output tape of parameters to be used in ORFFE.[3]
NTPE	4	A4	Output of Part II (identical format of NTPG)

Specification of the Subroutines for the User

1. MODIFY Subroutine

This subroutine is entered, if so specified, in the Part I, to modify reflexion data. After reading a reflexion from card or tape, the main program calculates the Bragg angle and the weight according to the specification and enters this subroutine, just before writing the reflexion on another tape,

```
SUBROUTINE MODIFY (FH,FK,FL,FOBS, FCAL, AΦ,AC,BΦ,BC,SIG,
                   Q,ID,SINT,CA,CB,CC,CD,CE,CF,RA,RB)
```

Parameters	*Contents*
FH,FK,FL	Miller indices h,k,ℓ

continued

Parameters	*Contents*
FOBS	observed F (or F^2), punched on card or from Tape 9
FCAL	calculated F
AΦ	observed F, real part
AC	calculated F, real part
BΦ	observed F, imaginary part
BC	calculated F, imaginary part
SIG	standard error of F
Q	designation for scale factor
ID	0 or 1 for observed or unobserved
SINT	sine theta (Bragg angle)
CA,CB,etc.	A,B,C,D,E,F punched on the Control Card
RA,RB	Extra values on reflexion data on tape. These values may be entered from the input card. Partial difference Fourier requires A_{cal}, B_{cal} (partial) be transferred to RA,RB here. (see Fourier writeup)[3]

The values such as FCAL, AΦ, AC, BΦ, BC are meaningful only when the input is the output tape of a previous structure factor (or least-squares) calculation.

In order to exclude a reflexion from the least-squares refinement, SIG should be set to 0.0, which will in turn set ω (weight) = 0. Should a reflexion be omitted entirely from the rest of the processing, set ID = 10.

The following three subroutines are explained in Ref. 4 and the user should consult that report. Only the dimension of some arrays have been changed in the current program and they are listed here.

```
SUBROUTINE PATCH (I,TJ,HJ,HHJ)
  DIMENSION HJ(3), HHJ(6)

SUBROUTINE RESETX (XYZ)
  DIMENSION XYZ (3,85)

SUBROUTINE RESETB (BETA)
  DIMENSION BETA (6,85)
```

continued

1. RSETW Subroutine

This subroutine is entered for each reflexion after the completion of the structure factor calculation and before the weight is multiplied to various values in derivative calculation.

```
SUBROUTINE RSETW (FOBS,FCAL,A,B,SIGYO,SINT,ID)
RETURN
END
```

FOBS	F_{obs} value already scaled
FCAL	F_{cal} (absolute)
A,B	A,B part of F_{cal} with signs
SIGYO	σ, for zero weight, set $\sigma = 0$
SINT	$\sin\theta$ value
ID	0 for observed and 1 for unobserved

Any changes made here will not affect the contents of Input Tape 10 unless it is so specified to copy back the final Output Tape 4 to Tape 10.

When the user is supplying his subroutine to replace a dummy subroutine in the binary deck, this may be done in two ways,

(a) Compile and punch out the object deck of the subroutine first, and then place this binary deck in front of the dummy subroutine which is going to be replaced, but not before the BREAK Card preceding that part of the program. The system will use the first subroutine loaded.

(b) You may compile a subroutine and execute the entire program at the same time. For this, place the source deck instead of the binary deck of the subroutine as in (a), with a card $COMPILE FORTRAN, PUNCH OBJECT, PRINT OBJECT preceding it. The system first compiles the subroutine and then executes the entire program.

In either case, the cards for MODIFY should be placed in front of the Binary Deck, and those for PATCH, RESETX, RESETB or RSETW should be placed immediately behind the first BREAK Card. If the compilation is done with the execution, Tape 9 is needed in compilation and therefore, cannot be used as the input tape.

Atoms in Special Positions

Atoms in special positions have to be handled differently from other atoms in general positions. Three subroutine entries are

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provided to cope with the situation, if necessary, and they are PATCH, RESETX, and RESETB. The dummy subroutine provided with the deck may be replaced by a user's subroutine, by placing the source statement cards preceded by a $COMPILE FORTRAN Card, or the compiled Binary Cards in front of the one to be replaced.

The detailed instructions for handling special positions are given in Ref. 4, pp. 14–22.

Reflexion-Tape Record Format

The program uses the identical record format for the intermediate-input-reflexion data, and the output of structure-factor calculation. This format is further identical to that of the Fourier Input Tape, so that either the intermediate tape (Tape 10) or the final output (Tape 4) may be used as an input of the Fourier program[3] for calculating Patterson summation or Fourier summation, respectively.

The tape is written in binary mode, and the first record is different from the rest of the data.

First Record (13 words)

$1/4 \cdot a^{*2}$, $1/4 \cdot b^{*2}$, $1/4 \cdot c^{*2}$, $1/4 \cdot a^*b^*\cos\gamma^*$, $1/4 \cdot a^*c^*\cos\beta^*$, $1/4 \cdot b^*c^*\cos\alpha^*$, a, b, c, $\cos\alpha$, $\cos\beta$, $\cos\gamma$, λ.

Second to the (last–1) Record (26 words)

h, k, ℓ, F_{obs}, F_{cal}, A_{obs}, A_{cal}, B_{obs}, B_{cal}, σ, Q, ID, $(\sin\theta/\lambda)^2$, $\sin\theta$, $(f_i, i=1, 10)$, RA, RB.

Parameters	*Contents*
h,k,ℓ	Miller indices
σ	Standard error
Q	Scale-factor identifier
ID	0 or 1 for observed or unobserved
RA,RB	Extra values

Only ID is in fixed-point number (integer).

Last Record

Identical to the preceding reflexion data except h = 999. This is used to recognize the end of data.

continued

Programmed Termination

In several points of the program execution, the run will be terminated before completion when certain conditions are not met.

1. Parameter Selection Cards Error

   If the number of parameters to be refined does not match the sum of 1's punched on the Parameter Selection Cards, the program will exit.

2. Nonpositive-Definite Temperature Factor

   If a temperature factor becomes nonpositive-definite after applying a shift, the program will terminate any further refinement (Reason 1).

3. No Improvement in Refinement

   If $\Sigma\omega(\Delta F)^2/$(No. of observation-No. of Parameters) is not decreasing from the previous cycle, the refinement will be terminated at the end of current cycle (Reason 2).

4. Singular Matrix

   If the matrix to solve the shifts is a singular matrix, the refinement will be terminated. When this happens, the matrix elements printed may be partially inverted.

Limitations

The program deck as compiled has the following capacity for various variables.

Variables	*Maximum Limit*	
Number of reflexions	no limit (one magnetic tape)	
Number of atoms	85	85
Number of scale factors	20	20
Number of total parameters	811	811
Number of parameters to be refined	181	181
Number of symmetry relations	24	24
Number of different kind of atoms	10	10
Number of anomalous dispersing atoms	10	10

The part 2 of the program has some locations available for the use of user's subroutines PATCH, RESETX, RESETB and RSETW.

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When a structure has some variables beyond the limit of the numbers listed above, it may be possible to change the program to handle the structure by recompiling the program with changed dimension statements.

With the partial mode, unlimited number of atoms may be used with multiple passes.

Output

I. Card

New scale factors, and the atomic parameters will be punched out for every cycle of refinement. These cards are in the format identical to the input, and may be used in further refinement. If so specified, the input cards for ORFFE[3] may be punched.

II. Print

All information on the two Control Cards (Nos. 2 and 3) as well as the Parameter Cards will be printed first. For each cycle, all structure factors, the agreements and the old and new parameters will be printed. Also one more set of structure factors will be calculated and printed out using the last parameters. If intermediate printing is suppressed, structure factors are printed only from the last calculation.

At the end, the correlation matrix for the parameter, agreement indices for various groups of reflexions and average $(\Delta F/k\sigma)^2$ will be printed out.

NOTE: If a private tape is used for Tape 10 and/or 4, a card with $HALT punched in Cols. 1–5 should be inserted immediately behind the $$ Card(s) for comment. This will halt the program and enable operator to mount the tape.

REFERENCES

1. Hughes, E.W., "The Crystal Structure of Melamine," J. Amer. Soc., *63*, 1737–52 (June, 1941).

2. Pepinsky, R., Robertson, J.M., and Speakman, J.C., editors, "Proceedings of Conference on Computing Methods and the Phase Problem in X-Ray Crystal Analysis Held at University of Glasgow in 1960," (Bergamon, New York, 1961), p. 45.

3. Additional information may be obtained through the contact person.

continued

4. Busing, W.R., Martin, K.O., and Levy, H.A., "A FORTRAN Crystallographic Least-Squares Program," ORNL Tech. Mem. No. TM305 (Oak Ridge National Laboratories, Oak Ridge, 1962). The modified version of this program is used for calculations that involve scattering data and crystallographic structures. Additional information can be obtained through the contact person.

5. Ibers, J.A., and Hamilton, W.C., "Dispersion Correction and Crystal Structure Refinement," Acta Cryst. *17*, (1964), 781–782.

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SAMPLE INPUT

```
$ DATA
TEST STRUCTURE OF U MO C-2        ACTA. 17, 272 (1964)
   0    0    1    0    0  20.
 5.625 3.249  10.980                        .70926
   92.0000   91.5488   90.2096   88.2013   85.7514   83.0623   80.3408        1
   77.6645   75.0885   72.6012   70.7006   67.8789   65.6365   63.4953        2
   61.4569   59.5156   57.6656   55.9006   54.2128   52.5939   51.0467        3
   49.5686   48.1595   46.8144   45.5283   44.2965   43.1127   41.9782        4
   40.8910   39.8500   38.8523   37.8948   36.9744   36.0866   35.2322        5
   34.4101   33.6190   32.8575   32.1239   31.4164   30.7328   30.0727        6
   29.4350   28.8180   28.2207   27.6434   27.0857   26.5487   26.0298        7
   25.5274   25.0402     .0000     .0000     .0000     .0000     .0000        8
   42.0000   41.7204   40.8910   39.6552   38.1626   36.5453   34.9354        1
   33.3890   31.9567   30.6142   29.3460   28.1393   26.9869   25.8978        2
   24.8729   23.9170   23.0234   22.1838   21.3883   20.6265   19.9051        3
   19.2227   18.5804   17.9743   17.4005   16.8556   16.3349   15.8397        4
   15.3686   14.9208   14.4945   14.0876   13.6978   13.3208   12.9596        5
   12.6144   12.2868   11.9758   11.6782   11.3926   11.1143   10.8463        6
   10.5886   10.3421   10.1066    9.8801    9.6618    9.4491    9.2434        7
    9.0448    8.8534     .0000     .0000     .0000     .0000     .0000        8
    6.0000    5.9888    5.9401    5.8578    5.7461    5.6088    5.4502
    5.2741    5.0853    4.8883    4.6849    4.4785    4.2735    4.0731
    3.8775    3.6885    3.5109    3.3448    3.1883    3.0414    2.9044
    2.7771    2.6594    2.5511    2.4535    2.3648    2.2841    2.2107
    2.1432    2.0817    2.0258    1.9749    1.9279    1.8850    1.8459
    1.8103    1.7778    1.7481    1.7209    1.6952    1.6706    1.6476
    1.6262    1.6062    1.5873    1.5694    1.5522    1.5347    1.5174
    1.5006    1.4842    0.        0.        0.        0.        0.

        0         0         2   26.                    1    1
        0         0         4  278.                    1    0
        0         0         6   56.                    1    0
        0         0         8  181.                    1    0
        1         1         1  113.                    1    0
        1         1         2  333.                    1    0
        1         1         3  144.                    1    0
        1         2         1   49.                    1    0
        1         2         2   53.                    1    0
        1         2         3  154.                    1    0
        2         0         0  178.                    1    0
        2         0         1  210.                    1    0
        2         0         2   25.                    1    1
        2         1         0  124.                    1    0
        2         1         1   68.                    1    0
        2         1         2   80.                    1    0
        2         2         0  134.                    1    0
        2         2         1  170.                    1    0
        3         0         2  122.                    1    0
        3         0        12  183.                    1    0
        3         1        11   79.                    1    0
        3         3         1  151.                    1    0
        4         0         1  182.                    1    0
        4         1        10  155.                    1    0
        5         1         2  192.                    1    0

  1    4    1    0   13    2    0    0    0    0    1
  3    1    2    1    0
            1              2              3
 .5        -1             -2   0.5       3


1.0
U        1.0     1.0     .0819    .25     .1421    -15.   13.0
0.20
MO       2.0     1.0     .4191    .25     .8986    -1.7   0.9
0.39
C 1      3.0     1.0     .153     .25     .752
0.61
C 2      3.0     1.0     .751     .25     .005
0.00
10010110010110010110010 11.
```

000 0064

TEST STRUCTURE OF U MO C-2 ACTA. 17, 272 (1964)

A= 5.625, B= 3.249, C= 10.980, COSA= -.0000, COSB= -.0000, COSC= -.0000, LAMBDA= .7093

HUGHES WEIGHTING, FMIN= 20.0

ATOMIC SCATTERING FACTORS

92.0 42.0 6.0 -.0 .0 .0 .0 .0 .0 .0

NUMBER OF SCALE FACTORS SPECIFIED IS 1

BASED ON F

ISOTROPIC AND ANISOTROPIC TEMP. FACTORS

NUMBER OF SCATTERING FACTOR TABLES IS 3

NUMBER OF ATOMS IN ASYMMETRIC UNIT IS 4

NUMBER OF ATOMS WITH DISPERSION CORRECTION IS 2

CENTROSYMMETRIC

NUMBER OF SYMMETRY CARDS IS 2

NUMBER OF SCALE FACTORS IS 1

SYMMETRY INFORMATION

TRANSFORMED X	TRANSFORMED Y	TRANSFORMED Z
-.000000 1-0	-.000000 2-0	-.000000 3-0
.500000-1-0	-.000000-2-0	.500000 3-0

NUMBER OF PARAMETERS READ IS 25

NUMBER OF PARAMETERS TO BE REFINED IS 13

INPUT DATA

SCALE	P(I)	KI(I)
1	1.0000	1

ATOM	F	O	X	Y	Z	B(B11)	B22	B33	B12	B13	B23
1	1.00 0	1.0000 0	.0819 1	.2500 0	.1421 1	.2000 1					
2	2.00 0	1.0000 0	.4191 1	.2500 0	.8986 1	.3900 1					
3	3.00 0	1.0000 0	.1530 1	.2500 0	.7520 1	.6100 1					
4	3.00 0	1.0000 0	.7510 1	.2500 0	.0050 1	.0000 1					

continued

TEST STRUCTURE OF U MO C-2 ACTA. 17, 272 (1964)

CALCULATED F BASED ON PARAMETERS BEFORE CYCLE 1

H	K	L	F(OBS)	F(CALC)	A	B	SINE	SIG(O)	(O-C)/SIG(O)	IQ	ID
0	0	2	26.0000	20.5575	-17.9495	-10.0212	.065	80.0000	.0680	1	1
0	0	4	278.0000	299.9247	-295.7436	-49.9053	.129	278.0000	-.0789	1	0
				⋮	⋮	⋮					
3	3		151.0000	159.2828	155.7473	33.3733	.380	151.0000	-.0549	1	0
4	0	1	182.0000	194.7788	-191.2908	-36.6962	.254	182.0000	-.0702	1	0
4	1	10	155.0000	152.6271	147.1829	40.4007	.424	155.0000	.0153	1	0
5	1	2	192.0000	192.8319	187.8644	43.4871	.340	192.0000	-.0043	1	0

AGREEMENT FACTORS BASED ON PARAMETERS BEFORE CYCLE 1

SUM(W*(O-C)**2) IS .6939E-01

SQRTF(SUM(W*(O-C)**2)/(NO-NV)) IS .0760

	NUMERATOR	DENOMINATOR	R
R FACTOR INCLUDING UNOBS	154.164	3440.000	.045
R FACTOR OMITTING UNOBS	146.349	3389.000	.043
WEIGHTED R FACTOR INCLUDING UNOBS	.263	4.605	.057
WEIGHTED R FACTOR OMITTING UNOBS	.253	4.583	.055

TEST STRUCTURE OF U MO C-2 ACTA. 17, 272 (1964)

PARAMETERS AFTER LEAST SQUARES CYCLE 1

PARAMETER	OLD	CHANGE	NEW	ERROR
SCALE FACTOR	1.0000000	.0037115	1.0037115	.0283736
U				
FORM FACTOR	1.0000000		1.0000000	
MULTIPLIER	1.0000000		1.0000000	
X	.0819000	-.0012466	.0806533	.0016965
Y	.2500000		.2500000	
Z	.1421000	.0004068	.1425068	.0008369
ATOMIC B	.2000000	-.0092766	.1907234	.1886939
⋮		⋮		⋮
C 2				
FORM FACTOR	3.0000000		3.0000000	
MULTIPLIER	1.0000000		1.0000000	
X	.7510000	-.0301996	.7208003	.0225634
Y	.2500000		.2500000	
Z	.0050000	-.0061485	-.0011485	.0173400
ATOMIC B	.0000000	1.6818284	1.6818284	1.9679505

ESTIMATED AGREEMENT FACTORS BASED ON PARAMETERS AFTER CYCLE 1

SUM(W*(O-C)**2) IS .3529E-01

SQRTF(SUM(W*(O-C)**2)/(NO-NV)) IS .0542

continued

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TEST STRUCTURE OF U MO C-2 ACTA. 17, 272 (1964)

CALCULATED F BASED ON PARAMETERS BEFORE CYCLE 2

H	K	L	F(OBS)	F(CALC)	A	B	SINE	SIG(O)	(O-C)/SIG(O)	IQ	ID
0	0	2	26.0965	20.0279	-17.2174	-10.2313	.065	80.0000	.0756	1	1
0	0	4	279.0318	298.0844	-293.9271	-49.6104	.129	278.0000	-.0683	1	0
0	0	6	56.2078	57.9914	50.4084	28.6706	.194	80.0000	-.0222	1	0
0	0	8	181.6718	176.0955	173.8244	33.3538	.258	181.0000	.0257	1	0
1	1	1	113.4194	111.5944	-110.2726	-17.1248	.130	113.0000	.0161	1	0
1	1	2	334.2359	314.6329	-311.1165	-46.9083	.142	333.0000	.0587	1	0
1	1	3	144.5345	145.2431	143.4101	23.0027	.159	144.0000	-.0049	1	0
1	2	1	49.1819	48.7262	-41.5077	-25.5215	.230	80.0000	.0057	1	0
1	2	2	53.1967	52.8388	47.8116	22.4942	.236	80.0000	.0045	1	0
1	2	3	154.5716	137.8471	132.2144	39.0024	.247	154.0000	.1082	1	0
2	0	0	178.6607	176.7828	174.3810	29.0419	.126	178.0000	.0105	1	0
2	0	1	210.7794	217.1951	-214.1845	-36.0378	.130	210.0000	-.0304	1	0
2	0	2	25.0928	25.2177	-24.6249	-5.4356	.142	80.0000	-.0016	1	1
2	1	0	124.4602	129.1477	-122.5902	-40.6296	.167	124.0000	-.0377	1	0
2	1	[illegible]	68.2524	70.5149	-67.5469	-20.2428	.170	80.0000	-.0282	1	0
2	1	[illegible]	80.2969	83.3624	82.7058	10.4424	.179	80.0000	-.0382	1	0
2	2	0	134.4973	132.5550	-130.4895	-28.4506	.252	134.0000	.0070	1	0
2	2	1	170.6310	164.6388	160.8063	35.3167	.254	170.0000	.0351	1	0
3	0	2	122.4528	120.4900	-111.0855	-46.6674	.200	122.0000	.0160	1	0
3	0	12	183.6792	179.2926	172.2991	49.5869	.431	183.0000	.0239	1	0
3	1	11	79.2932	81.3062	69.6187	41.9991	.417	80.0000	-.0251	1	0
3	3	1	151.5604	150.1268	146.4191	33.1587	.380	151.0000	.0095	1	0
4	0	1	182.6755	188.3604	-184.6502	-37.2011	.254	182.0000	-.0311	1	0
4	1	10	155.5753	156.7659	151.2343	41.2762	.424	155.0000	-.0077	1	0
5	1	2	192.7126	189.7096	184.8885	42.4972	.340	192.0000	.0156	1	0

AGREEMENT FACTORS BASED ON PARAMETERS BEFORE CYCLE 2

SUM(W*(O-C)**2) IS .3582E-01

SQRTF(SUM(W*(O-C)**2)/(NO-NV)) IS .0546

	NUMERATOR	DENOMINATOR	R
R FACTOR INCLUDING UNOBS	116.299	3452.768	.034
R FACTOR OMITTING UNOBS	110.105	3401.578	.032
WEIGHTED R FACTOR INCLUDING UNOBS	.189	4.605	.041
WEIGHTED R FACTOR OMITTING UNOBS	.174	4.583	.038

continued

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TEST STRUCTURE OF U MO C-2 ACTA. 17, 272 (1964)

CORRELATION MATRIX

1	1.0000	.0424	-.1581	.7396	-.1126	-.0477	.2227	.0030	-.1603	.2436	-.0826	.0598	.2489
2	1.0000	.0655	.0513	.1258	-.0040	-.1101	.1467	.0723	.0797	.0907	.0042	.1213	
3	1.0000	-.1651	-.0552	.0273	-.1087	.0916	-.1553	-.4591	-.2431	.3275	.2424		
4	1.0000	-.0635	-.3191	.0740	-.0222	.0106	.1986	-.0746	-.0870	.4436			
5	1.0000	-.0040	-.0592	.3686	.3758	.0534	.3955	-.0963	-.2244				
6	1.0000	.3857	-.0936	.1643	.0846	-.0805	-.1663	-.1475					
7	1.0000	-.1715	-.0166	.1372	-.1361	-.2988	-.2061						
8	1.0000	.0396	.1430	.2138	.2034	-.0466							
9	1.0000	-.0286	.1441	-.4963	-.0912								
10	1.0000	.3886	-.0739	-.0410									
11	1.0000	-.0326	-.1519										
12	1.0000	-.0781											
13	1.0000												

continued

DISAGREEMENT INDEX FOR VARIOUS GROUPS

SINE THETA UP TO	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
NO. REFLEXION	1	12	7	2	3	0	0	0	0	0
R FACTOR	.233	.036	.038	.013	.018	.000	.000	.000	.000	.000

	HKL	HKO	OKL	HOL	HOO	OKO	OOL	ALL
NO. REFLEXION	13	2	0	5	1	0	4	25
R FACTOR	.034	.022	.000	.026	.011	.000	.058	.034

	EEE	EEO	EOE	OEE	EOO	OEO	OOE	OOO
NO. REFLEXION	7	3	3	3	1	2	2	4
R FACTOR	.039	.032	.025	.019	.033	.084	.043	.012

OBS. ONLY	SUM FOBS	SUM FCAL	SCALE,	UNOBS. ONLY	SUM FOBS	SUM FCAL	TOTAL SCALE
	3401.58	3385.20	.995		51.19	45.25	.994

F VALUE UP TO	10.	20.	30.	40.	50.	60.	70.	80.	90.	100.	OVER 100
NO. REFLEXION	0	0	0	0	1	2	1	1	1	0	17
AVER. W*DELTSQ	.000	.000	.000	.000	.000	.000	.001	.001	.001	.000	.002
NO. REFLEXION	0	0	2	0	0	0	0	0	0	0	0
AVER. W*DELTSQ	.000	.000	.003	.000	.000	.000	.000	.000	.000	.000	.000

SINE THETA UP TO	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
NO. REFLEXION	0	11	7	2	3	0	0	0	0	0
AVER. W*DELTSQ	.000	.001	.002	.000	.000	.000	.000	.000	.000	.000
NO. REFLEXION	1	1	0	0	0	0	0	0	0	0
AVER. W*DELTSQ	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

000 0064

COST ESTIMATE

Unfortunately, exact figures are not available for central-processor time. The program listed on the Sample Input used approximately 10.8 minutes of central-processor time. At the current rate of $250/hour at the University of Pittsburgh, the chargeable computer time was approximately $45.00.

Cost to user = computer time + network overhead

= $45.00 (estimated) + network overhead

CONTENTS—ORFLS-PX

000 0064

000 0065

DESCRIPTIVE TITLE	Factor Analysis by Direct "Oblimin" Method
CALLING NAME	OBLIMIN
INSTALLATION NAME	Educational Testing Service (ETS) Office of Data Analysis Research
AUTHOR(S) AND AFFILIATION(S)	Procedure due to: R. Jennrich, UCLA Program due to: R. Jennrich and H. Harman, ETS Adaptation due to: J. Barone, ETS
LANGUAGE	FORTRAN IV
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Office of Data Anal. Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

Factor analysis provides that the final solution be in terms of either uncorrelated factors or correlated factors. Beginning in the mid-1940's, following the leadership of Thurstone, there was a trend toward the acceptance of oblique factors. This trend has continued to the present day but, unfortunately, efficient objective means for getting oblique "simple structure" solutions have not generally been available even with modern computers. In 1958, John B. Carroll introduced a whole class of methods for oblique transformation to simple structure. These have come to be known by the term "oblimin" (Ref. 1, pp. 324–326), since they involve *oblique* factors and the *minimization* of a function. The oblimin criterion, which is to be minimized, is given in normalized form by,

$$1. \qquad B = \sum_{p<q=1}^{m} \left[n \sum_{j=1}^{n} (v_{jp}^2/h_j^2)(v_{jq}^2/h_j^2) - \gamma \sum_{j=1}^{n} v_{jp}^2/h_j^2 \sum_{j=1}^{n} v_{jq}^2/h_j^2 \right]$$

continued

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000 0065

The v's in these expressions are the elements of the reference-factor structure matrix, i.e., the correlations between the original variables and the reference factors. Actually, what is desired is to have the primary factor pattern exhibit the principles of simple structure, i.e., large values and near-zero values. In the Thurstone school the "reference structure V" is sought that exhibits the simple structure principles, and then the primary factor pattern is obtained by multiplying the matrix V by a diagonal matrix.

The foregoing indirect, and somewhat awkward, procedure has recently been replaced by a direct approach (Ref. 2). Instead of working with the reference factors that are biorthogonal to the primary factors, Jennrich and Sampson set up a criterion for the direct determination of the primary factors that exhibit the simple structure principles. That criterion may be put in the form,

$$2. \qquad F(A) = \sum_{p<q=1}^{m} \left[\sum_{j=1}^{n} a_{jp}^2 a_{jq}^2 - \frac{\delta}{n} \sum_{j=1}^{n} a_{jp}^2 \sum_{j=1}^{n} a_{jq}^2 \right] ,$$

where A is the matrix of primary factor coefficients. Of course, the loadings may be normalized by rows just as in equation 1. An important difference is that the γ in the indirect method ranges between zero and one, while the δ in equation 2 should be zero or negative.

The object of OBLIMIN is to minimize equation 2. The criterion employed is,

$$\frac{F_{i-1} - F_i}{F_0} \leq \varepsilon \quad ,$$

where i is the iteration number. The output is an oblique factor solution satisfying the principles of simple structure, more or less. When δ is equal to zero, the factors are most oblique. For negative values of δ, the factors become less oblique as δ gets smaller. The solution consists of the factor pattern, the correlations among the factors, and the factor structure. At the present time, the program is limited to n = 100 variables and m = 15 factors.

REFERENCES

Harman, H.H., *Modern Factor Analysis*, Second edition, revised, (University of Chicago Press, Chicago, Ill., 1967)

Jennrich, R.I., & Sampson, P.F., "Rotation for Simple Loadings," *Psychometrika*, 1966, *31*, 313–323.

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USER INSTRUCTIONS

System Control Cards

JOB Card will be prepared by ETS personnel.

System Card 1

Columns	*Contents*
1–37	//STEPNAME EXEC GITNGO,NAME=OBLIMIN

System Card 2

Columns	*Contents*
1–19	//GO.SYSIN DD *

System Card 3

Columns	*Contents*
1– 2	//

Problem Card

Parameter	*Columns*	*Format*	*Description*
N	3– 5	I3	Number of variables ($\leq$ 100)
M	6–10	I5	Number of factors ($\leq$ 15)
DEL	11–15	F5.1	Delta (except for experimental purposes, $\delta \leq 0$; if several values are used, smallest goes in this field)
EPS	16–25	F10.6	Convergence criterion (usually = .00001)
MAXI	26–30	I5	Maximum number of iterations (usually 50)
IF	31–35	I5	Original factor pattern option: 1 = orthogonal (usual case, requires no additional input) 0 = oblique (correlations among the original factors must be input in addition to the pattern)

continued

000 0065

000 0065

Parameter	*Columns*	*Format*	*Description*
K	36–40	I5	Kaiser normalization option: 1 = used (usual case) 0 = not used
DINC	41–45	F5.1	Delta increment (must be a positive number)
DEND	46–50	F5.1	Largest delta
NOSTOP	51–55	I5	1 = additional problem(s) to follow 0 = last problem

NOTE: The last three fields may be blank if only one value of delta and one problem are run.

Format Card

The format specification starts in Col. 2 and may not extend beyond Col. 72. The word FORMAT is *not* used. The standard FORTRAN variable format is followed.

Data Cards

Keypunch original factor pattern by rows according to its format, starting each variable on a new card.

Factor Correlations Cards

When the original factor pattern is oblique, a "0" must be put in Col. 35 of the Problem Card, and the following cards must be inserted at this point,

(a) FORMAT Cards (Cols. 2–72)

(b) Correlations among factors, starting a new card for each factor

Title Card

Name of problem in Cols. 2–80.

Order of Cards

JOB Card
System Card 1
System Card 2
Problem Card
Format Card

continued

000 0065

000 0065

Data Cards
Factor Correlations Cards
Title Card
/*
System Card 3

Description of Output

See Functional Abstract for a description of the output of OBLIMIN.

000 0065

000 0065

SAMPLE INPUT

```
//            JOB  (....
//STEPNAME    EXEC  GITNGO,NAME=OBLIMIN
//GO.SYSIN    DD    *
     8    2  0.0  0.000010   50    1    1 -0.5 -2.0    0
 (2F10.5)
   0.85600  -0.32400
   0.84800  -0.41200
   0.80800  -0.40900
   0.83100  -0.34200
   0.75000   0.57100
   0.63100   0.49200
   0.56900   0.51000
   0.60700   0.35100
/*
//
```

000 0065

000 0065

SAMPLE OUTPUT

DELTA = 0.00

ROTATION FOR DIRECT OBLIMIN LOADINGS

ITERATION	DIROBL CRITERION
0	2.905183
1	2.683994
2	0.731741
3	0.072721
4	0.072715

AFTER ROTATION WITH KAISER NORMALIZATION

FACTOR PATTERN

1	0.88272	0.06520
2	0.95632	-0.02946
3	0.92599	-0.04505
4	0.88163	0.03492
5	0.00471	0.94040
6	-0.00647	0.80317
7	-0.06549	0.79280
8	0.10374	0.64627

FACTOR CORRELATIONS

1	1.00000	0.47149
2	0.47149	1.00000

FACTOR STRUCTURE

1	0.91346	0.48139
2	0.94243	0.42143
3	0.90475	0.39154
4	0.89810	0.45060
5	0.44809	0.94262
6	0.37221	0.80012
7	0.30831	0.76192
8	0.40845	0.69518

continued

000 0065

DELTA = -0.50

ROTATION FOR DIRECT OBLIMIN LOADINGS

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DELTA = -1.00

ROTATION FOR DIRECT OBLIMIN LOADINGS

.
.
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DELTA = -1.50

ROTATION FOR DIRECT OBLIMIN LOADINGS

.
.
.

DELTA = -2.00

ROTATION FOR DIRECT OBLIMIN LOADINGS

ITERATION	DIROBL CRITERION		
0	9.111930	9	7.357594
1	9.050656	10	7.303166
2	8.985585	11	7.282603
3	8.874997	12	7.275172
4	8.695285	13	7.272531
5	8.426510	14	7.271598
6	8.080988	15	7.271269
7	7.735189	16	7.271153
8	7.487005	17	7.271112

AFTER ROTATION WITH KAISER NORMALIZATION

continued

000 0065

000 0065

FACTOR PATTERN

1	0.86186	0.14201
2	0.92372	0.05725
3	0.89278	0.03949
4	0.85778	0.11269
5	0.09845	0.90789
6	0.07392	0.77446
7	0.01569	0.75917
8	0.16504	0.63294

FACTOR CORRELATIONS

1	1.00000	0.30538
2	0.30538	1.00000

FACTOR STRUCTURE

1	0 90522	0.40520
2	0.94121	0.33934
3	0.90484	0.31213
4	0.89219	0.37464
5	0.37570	0.93795
6	0.31043	0.79704
7	0.24753	0.76396
8	0.35833	0.68334

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COST ESTIMATE

Exact figures for the program listed on the Sample Input are not available. As an approximate guide to the user, an OBLIMIN run whose parameters lie within the specified range will cost less than $20.00 with a typical cost of less than $10.00.

Approximate cost to user = computer time + postage and handling + network overhead

= $10.00 + $5.00 + network overhead

= $15.00 + network overhead

CONTENTS—OBLIMIN

000 0065

000 0066

DESCRIPTIVE TITLE	Unrestricted Maximum Likelihood Factor Analysis
CALLING NAME	UMLFA
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service
AUTHOR(S) AND AFFILIATION(S)	K. G. Jöreskog Educational Testing Service G. Gruvaeus Educational Testing Service
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Office of Data Anal. Research, Educational Testing Service, Rosedale Road, Princeton, New Jersey 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

UMLFA performs a factor analysis of a given correlation matrix. "The factor loadings and the unique variances are estimated by Lawley's method of maximum likelihood. The computational procedure...makes use of the method of Fletcher and Powell for numerical minimization of a function. Any number of factors can be extracted, and each factor is rotated, using Kaiser's varimax method. The goodness of fit of the maximum likelihood solution is tested by Lawley's chi-square test based on the likelihood ratio technique."[1]

The program is able to handle up to 75 variables and 30 factors. However, the input correlation matrix must be positive definite.

REFERENCES

1. Jöreskog, K.G., "A Computer Program for Unrestricted Maximum Likelihood Factor Analysis," Educ. Testing Service Res. Mem. RM-66-20 (1966).

000 0066

000 0066

USER INSTRUCTIONS

Specification of Input

360 O.S./JCL cards (job control)

```
Col. 1          Col. 16

//          JOB
//JOBLIB    DD  DSN=OCS.SAPGM,DISP=SHR
//GO       EXEC PGM=UMLFA,TIME=2,REGION=150K,ACCT=xxxxx
//FT06F001 DD  SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3458)
//FT07F001 DD  SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3520)
//FTXXF001 DD  SPACE=(CYL,(1,1)),DISP=NEW,UNIT=2314
                  [Note:  Replace XX in above card with
                          number punched in Cols. 29-30
                          of parameter card no. 2.]
//FT05F001 DD  *
       (UMLFA control cards and data go here)
/*
//
```

Heading Card

Any information may be punched in Cols. 1–72.

Parameter Card

Column	Value or Variable	Description	(Recommended Value)
1– 5	P	Number of variables	
6–10	K	Lower bound for number of factors	($\geq$ 1)
11–15	K	Upper bound for number of factors	($\leq$ 30)
16–20	NP	Sample size	
21–25	MAXITER	Maximum number of iterations	(safely, 3P)
26–30		Scratch tape number	
31–35	CRV	Convergence criterion	(usually 1.0)
41	1/0	Print/don't print original correlation matrix and partial correlation matrices with some variables eliminated	
42	1/0	Print/don't print technical output related to the iterative process	(usually 0)

continued

000 0066

43	1/0	Print/don't print intermediate results when some variables are eliminated, and the reproduced correlations and residuals for the final solution
44	1/0	Punch/don't punch unrotated factor matrix (0, unless it is desired to use the result for input to another rotation program)
45	1/0	Suppress/don't suppress boundary elimination
46	1/0	Nonstandard/standard parameters
47	1/0	Read/don't read starting vector of uniquenesses
48	1/0	Nonstandard/standard output
49	1/0	Calculates/does not calculate to more than 3-place accuracy by Ortega's method
50–80		Must be blank

Columns 45–49 are intended for experimentation and ordinarily would be left blank.

Nonstandard Parameter Cards (optional)

If Col. 46 in the parameter cards is 1, two nonstandard parameter cards must be inserted at this point. The user should refer to the write-up for the definition of these parameters.

Data-Format Card

The standard FORTRAN variable format is followed; i.e., a card of the form (ηFω.d) must be punched.

Correlation Cards

The correlation cards punched according to the format specified in nonstandard parameter cards must be prepared in row order, each row beginning on a new card. Only the lower half of the correlation matrix *excluding* the main diagonal is punched; i.e., there will be P - 1 rows of input.

Starting Configuration (optional)

If Col. 47 in the parameter card is 1, an arbitrary starting configuration may be entered. This will consist of

(a) a format card

(b) the starting uniquenesses for the variables punched according to the format (a) above.

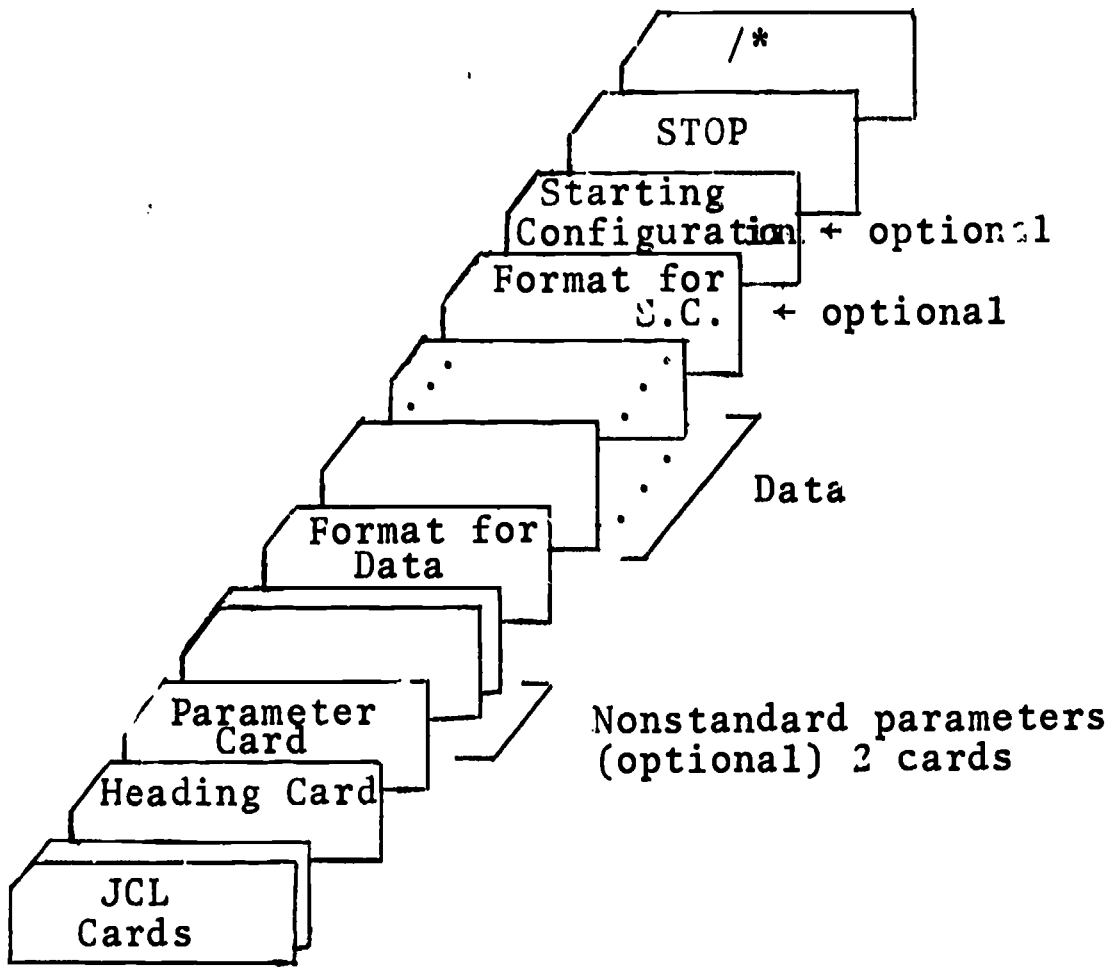
continued

000 0066

Stop Card

At the end of the last case, a card punched STOP in Cols. 1–4 must be placed.

The input deck should be in the following order.



Description of Output

The output is dependent upon the options selected in Cols. 41–44 of the parameter card. For purposes of illustration the sample input did not contain any punches after Col. 40, so that a minimum output resulted. The following items are printed:

(1) input parameters

(2) maximum likelihood solution (labeled "unrotated factor matrix")

(3) uniqueness for each variable

(4) varimax solution

continued

000 0066

(5) a test of goodness of fit for the specified number of factors.

Note: With items (2), (3), and (4) there appear a string of numbers for diagnostic purposes. *These should be ignored!*

REFERENCES

Jöreskog, K.G., "A Computer Program for Unrestricted Maximum Likelihood Factor Analysis," Educational Testing Service Res. Mem. RM-66-20 (1966).

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SAMPLE INPUT

A listing of the input data cards and the related output are presented below. Although the data used have the entire matrix punched, it would not have been necessary. Data punched through the diagonal value for each row would have been sufficient.

```
EIGHT VARIABLES--ALL 41 ON BLANK
    8    3    3  305   40    4 1.0
 (3X,8F8.5)
 21 0.84600 1.00000 0.88100 0.82600 0.37600 0.32600 0.27700 0.41500
 31 0.80500 0.88100 1.00000 0.80100 0.38000 0.31900 0.23700 0.34500
 41 0.85900 0.82600 0.80100 1.00000 0.43600 0.32900 0.32700 0.36500
 51 0.47300 0.37600 0.38000 0.43600 1.00000 0.76200 0.73000 0.62900
 61 0.39800 0.32600 0.31900 0.32900 0.76200 1.00000 0.58300 0.57700
 71 0.30100 0.27700 0.23700 0.32700 0.73000 0.58300 1.00000 0.53900
 81 0.38200 0.41500 0.34500 0.36500 0.62900 0.57700 0.53900 1.00000
STOP
```

000 0066

000 0066

SAMPLE OUTPUT

UNRESTRICTED MAXIMUM LIKELIHOOD FACTOR ANALYSIS

EIGHT VARIABLES--ALL 41 ON BLANK

5/29/68

PARAMETERS

P= 8

K1= 3

K2= 3

N= 305

MAXITER= 40

CRV= 1.000

MAXIMUM LIKELIHOOD SOLUTION FOR 3 FACTORS

UNROTATED FACTOR MATRIX

0	8	3	305	5	9
0.846	-0.189	0.348			
1.000	0.000	0.000			
0.881	-0.055	0.164			
0.826	-0.160	0.368			
0.376	-0.876	-0.031			
0.326	-0.725	-0.093			
0.277	-0.704	-0.130			
0.415	-0.543	-0.204			

continued

UNIQUE VARIANCES

0	8	305	6	9			
0.127	0.000	0.194	0.156	0.090	0.359	0.411	0.491

VARIMAX-ROTATED FACTOR MATRIX

0	8	3	305	5	9
0.883	0.275	-0.129			
0.936	0.204	0.287			
0.872	0.196	0.088			
0.875	0.239	-0.145			
0.234	0.919	-0.105			
0.185	0.779	-0.021			
0.129	0.757	0.004			
0.254	0.648	0.157			

TEST OF GOODNESS OF FIT FOR 3 FACTORS

CHISQUARE WITH 8 DEGREES OF FREEDOM IS 22.5993

PROBABILITY LEVEL IS 0.00

000 0066

COST ESTIMATE

For the job listed on the Sample Input, the total running time on the IBM 360/65 amounted to 3.80 seconds. At the current rate at Educational Testing Service (a rather complicated function of the ratio of CPU time to actual wall-clock running time), the total computer charge for the run amounted to $10.40. (The wall-clock/CPU-clock ratio was approximately 25:1.)

Charge to user = computer time + postage and handling + network overhead

= $10.40 + $5.00 + network overhead = $15.40

CONTENTS—UMLFA

pages

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000 0067

DESCRIPTIVE TITLE	Rao Constellation and Distance Analysis
CALLING NAME	DISCRIM2
INSTALLATION NAME	Michigan State University Computer Institute for Social Science Research
AUTHOR(S) AND AFFILIATION(S)	Stuart Thomas Computer Institute for Social Science Research Michigan State University
LANGUAGE	FORTRAN
COMPUTER	CDC 3600
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Dr. Anders Johanson, Programming Supervisor, Applications Programming, Computer Laboratory, Computer Center, Michigan State University, East Lansing, Mich. 48823 Tel.: (517) 355-4684

FUNCTIONAL ABSTRACT

This program implements the method titled "Constellation and Distance Analysis" when first published by C.R. Rao[1] and later called "Multiple Discriminant Analysis" when presented independently by Bryan[2] and by Lubin. The method operates on a set of variates measured on individuals in several groups. It determines linear combinations of the variates, called discriminant functions, which maximize the ratio of between-group variability to pooled, within-group variability, producing the output listed below. The user can have the program handle data input or write his own subroutine to read data and perform preliminary data manipulations.

Output

1. Job Description

   User comments
   Number of groups and variables
   Options selected

continued

000 0067

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2. Group Summary Statistics

Identification
Number observations specified on group card
Mode of data input and input unit
Format statement (if data read by program rather than user)
First observation in the group (raw and transformed)
Variable means and variances
Variable intercorrelation matrix (optional)

3. Overall Data Summary

Overall means
Overall variances
Overall correlation matrix

4. Discriminant Function Information

Discriminant criterion
Percent trace accounted for by criterion
Rao's chi-square and degrees of freedom for the function
Function weights for raw data
Function weights for data adjusted to unit variances (optional)
Mean discriminant score for each group

5. Overall Discriminant Statistics

Group centroids in discriminant space (optional)
Intercentroid distance matrix (optional)
Back solution of discriminant equation (optional)

6. Discriminant Scores (optional)

Capacity

Number of variables must not exceed 30
Number of groups must not exceed 50
Number of observations in any given group must not exceed 9,999
Number of scores (if requested) must not exceed 10 per respondent

REFERENCES

1. Rao, C.R., *Advanced Statistical Methods in Brometric Research*, (John Wiley & Sons, Inc., New York, 1952) Ch. 9.

2. Bryan, J.G., "The Generalized Discriminant Function: Mathematical Foundation and Computational Routine," Harvard Educational Review, *21*, 2, (1951), 90–95.

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USER INSTRUCTIONS

DISCRIM is called from the CISSR library tape by the name DISCRIM2. The routine is available in relocatable object deck form; however, unless extensive recoding of data is required, use of the library tape is recommended. The user may supply his own recoding subroutine for use with the object deck form.

Complete instructions on the options available and the use of the program are found in the references cited below.

REFERENCES

"CISSR Technical Report No. 1," (The Mich. State Univ., East Lansing, Mich.).

Thomas, S., "DISCRIM2, CISSR Technical Report No. 33, (The Mich. State Univ., East Lansing, Mich.). Available from the EIN Office at the cost of reproduction and mailing.

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SAMPLE INPUT

```
'JOB,015525,THOMAS,3.0,APHL
'EQUIP,27=(CISSR),MT(193),RO
'LOADMAIN,27,3.0,3000
$ROUTINE,DISCRIM2
$DISCRIM TEST DATA
SIZE      3    5    0    1    1    1    1    1    1
SCORES    2   PU
GROUP     1    5    0    1    1
(5F5.0)
    1     2    3    4    5
    2     4    5    7    9
    3     6    9   12   16
    4     5    7    9    1
    5     9    7    8    6
GROUP     2    5    0    1    1
(5F5.0)
   11    13   15   17   19
   12    14   15   16
   13    13   13   13   13
   14    15   15   19   21
   15    16   17   18   19
GROUP     3    4    0    1    1
(5F5.0)
   21    40   50   60   70
   22    43   49   65   71
   23    45   48   64   72
   24    47   47   66   73
ENDATA
```


000 0067

SAMPLE OUTPUT

000 0067

```
3                                   MULTIPLE DISCRIMINANT ANALYSIS
        IMPLEMENTED BY COMPUTER INSTITUTE FOR SOCIAL SCIENCE RESEARCH
                                     MICHIGAN STATE UNIVERSITY

                 DISCRIM TEST DATA
SIZE CARD SPECIFIES  5 VARIABLES, 3 GROUPS
SCORES CARD REQUESTS  2 SCORES PER RESPONDENT OUTPUT TO 00


                  DATA SUMMARY FOR GROUP     1
SIZE CARD SPECIFIES        5 OBSERVATIONS
FORMAT FOR GROUP       1 ** (5F5.0)
DATA INPUT BY PROGRAM  FROM LOGICAL UNIT 60
FIRST RAW OBSERVATION FOR GROUP     1

 VARIABLE       1           2           3           4           5
 VALUE      1.0000+000  2.0000+000  3.0000+000  4.0000+000  5.0000+000
FIRST TRANSFORMED OBSERVATION FOR GROUP     1

 VARIABLE       1           2           3           4           5
 VALUE      1.0000+000  2.0000+000  3.0000+000  4.0000+000  5.0000+000
COMPUTATIONS BASED ON       5 OBSERVATIONS AFTER DROPPING        0
VARIABLE MEANS AND VARIANCES IN GROUP     1

 VARIABLE       1           2           3           4           5
 MEAN       3.0000+000  5.2000+000  6.2000+000  8.0000+000  7.4000+000
 VARIANCE   2.5000+000  6.7000+000  5.2000+000  8.5000+000  3.1300+001

CORRELATION MATRIX FOR GROUP     1


            1           2           3           4           5

    1  1.0000+000  9.1627-001  6.9338-001  5.4233-001 -1.6957-001

    2  9.1627-001  1.0000+000  7.1156-001  5.6317-001  1.4847-001

    3  6.9338-001  7.1156-001  1.0000+000  9.7769-001  4.6246-001

    4  5.4233-001  5.6317-001  9.7769-001  1.0000+000  5.5177-001

    5 -1.6957-001  1.4847-001  4.6246-001  5.5177-001  1.0000+000
```

continued

000 0067

000 0067

DATA SUMMARY FOR GROUP 2

SIZE CARD SPECIFIES 5 OBSERVATIONS

FORMAT FOR GROUP 2 = (5F5.0)

DATA INPUT BY PROGRAM FROM LOGICAL UNIT 60

FIRST RAW OBSERVATION FOR GROUP 2

VARIABLE	1	2	3	4	5
VALUE	1.1000+001	1.3000+001	1.5000+001	1.7000+001	1.9000+001

FIRST TRANSFORMED OBSERVATION FOR GROUP 2

VARIABLE	1	2	3	4	5
VALUE	1.1000+001	1.3000+001	1.5000+001	1.7000+001	1.9000+001

COMPUTATIONS BASED ON 5 OBSERVATIONS AFTER DROPPING 0

VARIABLE MEANS AND VARIANCES IN GROUP 2

VARIABLE	1	2	3	4	5
MEAN	1.3000+001	1.4200+001	1.5000+001	1.6600+001	1.4400+001
VARIANCE	2.5000+000	1.7000+000	2.0000+000	5.3000+000	7.3800+001

CORRELATION MATRIX FOR GROUP 2

	1	2	3	4	5
1	1.0000+000	8.4887-001	4.4721-001	3.4340-001	3.8651-001
2	8.4887-001	1.0000+000	8.1349-001	6.9961-001	2.8123-001
3	4.4721-001	8.1349-001	1.0000+000	7.6787-001	2.4693-001
4	3.4340-001	6.9961-001	7.6787-001	1.0000+000	4.7782-001
5	3.8651-001	2.8123-001	2.4693-001	4.7782-001	1.0000+000

DATA SUMMARY FOR GROUP 3

SIZE CARD SPECIFIES 4 OBSERVATIONS

FORMAT FOR GROUP 3 = (5F5.0)

DATA INPUT BY PROGRAM FROM LOGICAL UNIT 60

FIRST RAW OBSERVATION FOR GROUP 3

VARIABLE	1	2	3	4	5
VALUE	2.1000+001	4.0000+001	5.0000+001	6.0000+001	7.0000+001

FIRST TRANSFORMED OBSERVATION FOR GROUP 3

VARIABLE	1	2	3	4	5
VALUE	2.1000+001	4.0000+001	5.0000+001	6.0000+001	7.0000+001

COMPUTATIONS BASED ON 4 OBSERVATIONS AFTER DROPPING 0

continued

000 0067

VARIABLE MEANS AND VARIANCES IN GROUP 3

VARIABLE	1	2	3	4	5
MEAN	2,2500+001	4,3750+001	4,8500+001	6,3750+001	7,1500+001
VARIANCE	1,6667+000	8,9167+000	1,6667+000	6,9167+000	1,6667+000

CORRELATION MATRIX FOR GROUP 3

	1	2	3	4	5
1	1,0000+000	9,9438-001	-1,0000+000	8,3450-001	1,0000+000
2	9,9438-001	1,0000+000	-9,9438-001	8,8074-001	9,9438-001
3	-1,0000+000	-9,9438-001	1,0000+000	-8,3450-001	-1,0000+000
4	8,3450-001	8,8074-001	-8,3450-001	1,0000+000	8,3450-001
5	1,0000+000	9,9438-001	-1,0000+000	8,3450-001	1,0000+000

OVERALL MEANS AND VARIANCES BASED ON 14 TOTAL OBSERVATIONS

VARIABLE	1	2	3	4	5
MEAN	1,2143+001	1,9429+001	2,1429+001	2,7000+001	2,8214+001
VARIANCE	6,7363+001	2,7503+002	3,3519+002	6,0185+002	8,4926+002

	1	2	3	4	5
1	1,0000+000	9,4330-001	9,2378-001	9,0543-001	8,7013-001
2	9,4330-001	1,0000+000	9,9012-001	9,9167-001	9,6863-001
3	9,2378-001	9,9012-001	1,0000+000	9,9426-001	9,7563-001
4	9,0543-001	9,9167-001	9,9426-001	1,0000+000	9,8353-001
5	8,7013-001	9,6863-001	9,7563-001	9,8353-001	1,0000+000

continued

000 0067

DISCRIMINANT FUNCTION NUMBER 1

DISCRIMINANT CRITERION FOR THIS FUNCTION 1.7242+002

PERCENT OF TRACE 9.2960+001

RAO-S CHI-SQUARE FOR THIS FUNCTION IS 5.1597+001 WITH 6 DEGREES OF FREEDOM

NORMED FUNCTION WEIGHTS

VARIABLE	1	2	3	4	5
WEIGHT	5.9922-001	-5.2618-001	-6.0280-001	-1.1874-002	-2.3633-002

STANDARDIZED FUNCTION WEIGHTS

VARIABLE	1	2	3	4	5
STD. WT.	3.3011-001	-5.8571-001	-7.3855-001	-1.9552-002	-4.6227-002

GROUP MEAN SCORES ON THIS FUNCTION

GROUP	1	2	3
MEAN SCR	-4.9457+000	-9.2613+000	-4.1220+001

DISCRIMINANT FUNCTION NUMBER 2

DISCRIMINANT CRITERION FOR THIS FUNCTION 1.3057+001

PERCENT OF TRACE 7.0398+000

RAO-S CHI-SQUARE FOR THIS FUNCTION IS 2.6431+001 WITH 4 DEGREES OF FREEDOM

NORMED FUNCTION WEIGHTS

VARIABLE	1	2	3	4	5
WEIGHT	9.0155-001	-4.3111-001	2.5524-002	2.0384-002	-1.6650-002

STANDARDIZED FUNCTION WEIGHTS

VARIABLE	1	2	3	4	5
STD. WT.	7.1677-001	-6.9257-001	4.5131-002	4.8440-002	-4.7001-002

GROUP MEAN SCORES ON THIS FUNCTION

GROUP	1	2	3
MEAN SCR	6.6098-001	6.0798+000	2.7706+000

continued

000 0067

GROUP CENTROIDS IN DISCRIMINANT SPACE

	1	2	3
1	-4,9457+000	-9,2613+000	-4,1220+001
2	6,6098-001	6,0798+000	2,7706+000

INTERCENTROID DISTANCES IN DISCRIMINANT SPACE

	1	2	3
1	0,0000+000	6,9274+000	3,6336+001
2	6,9274+000	0,0000+000	3,2130+001
3	3,6336+001	3,2130+001	0,0000+000

0 OBSERVATIONS DROPPED FROM SCORES COMPUTATION FOR GROUP 1 DUE TO PARITY ERRORS
0 OBSERVATIONS DROPPED FROM SCORES COMPUTATION FOR GROUP 2 DUE TO PARITY ERRORS
0 OBSERVATIONS DROPPED FROM SCORES COMPUTATION FOR GROUP 3 DUE TO PARITY ERRORS

BACK SOLUTION OF DISCRIMINANT EQUATION

	1	2
1	-1,7462-007	1,3970-008
2	-5,4250-008	3,1665-008
3	2,2631-007	9,8720-008
4	-1,8254-007	1,3411-007
5	9,2387-007	1,2293-007

000 0067

COST ESTIMATE

For the job listed on the Sample Output, the total processing time was 17.007 seconds. At the current rate for the Michigan State University's CDC 3600 ($245/hr.), the computer time cost $1.16 plus a charge for input and output. A 10% surcharge will be assessed if billed to a non-University account. In addition, there is a consulting fee of $10./hr. for work done by the Applications Programming Group.

Charge to user = computer costs + consulting + network overhead
= $1.20 (approx.) + consulting + network overhead

CONTENTS—DISCRIM2

000 0067

000 0068

DESCRIPTIVE TITLE	Nonmetric Multidimensional Scaling
CALLING NAME	KRUSKAL
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service (ETS)
AUTHOR(S) AND AFFILIATION(S)	Program due to: J.B. Kruskal, R.F. Long, Bell Telephone Laboratories Modification due to: D. Kirk, Educational Testing Service
LANGUAGE	FORTRAN
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Office of Data Analysis Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

The latest version of the multidimensional scaling program written by J.B. Kruskal of Bell Telephone Labs is available. In addition to the improvements made from earlier versions, a much faster sort has been incorporated into the program and a multi-calculation facility using random starting configurations within one machine run, has been made available. This feature, in addition to being more efficient than the old technique of punching cards for subsequent runs, increases the chances of converging to a global minimum within one machine run with the corresponding savings in time and cost.

A modification to the output was made so that normally only the best of many possible configurations is printed. However, each final configuration and even the individual iterations may be printed (as was done in Kruskal's version) if desired.

The program will handle 60 subjects scaled in up to ten dimensions. Calculations can be repeated up to 99 times on as many as 1800 data values.

continued

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REFERENCES

Kruskal, J.B., "Multidimensional Scaling by Optimizing Goodness of Fit to a Nonmetric Hypothesis," Psychometrika, *29*, pp. 1–27, (1964).

Kruskal, J.B., "Nonmetric Multidimensional Scaling: A Numerical Method," Psychometrika, *29*, pp. 115–129, (1964).

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USER INSTRUCTIONS

Input

Program input may be broken down into five types of cards.

1. Control Cards governing the types of calculations desired
2. a Title Card identifying the run
3. a Parameter Card indicating size of matrix, replications, perturbations and print options
4. a Format Card identifying the form of the input data
5. the data

Control Cards

These are used, basically, to override preset program constants, if desired. They may be inserted in any order with the restriction that the "similarities" or "dissimilarities" option must be the last specified. They may be punched one per card or connected by commas. For a complete description see Ref. 1. The following may be used. (Punch # for = on an 029 keypunch.)

Control Options (begin in Col. 1)	*Explanation* (pre-set value is in parentheses)
DIMMAX = *integer*	Maximum dimension (2)
DIMMIN = *integer*	Minimum dimension (2)
DIMDIF = *integer*	Step size from maximum to minimum (1)
ITERATIONS = *integer*	Limitations for convergence (50)
DIAGONAL PRESENT DIAGONAL ABSENT	Data specification (present)
MATRIX HALFMATRIX	Data specification (matrix)
CUTOFF = *floating pt.*	Values $\leq$ cutoff are discarded (0.0)
WEIGHTS	Indicates weights for data follow (no weights)
R = *floating pt.* > *1*	Metric space (2)
PRIMARY SECONDARY	Equal distance stress contribution (PRIMARY)

continued

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Control Options (begin in Col. 1)	*Explanations* (pre-set value is in parentheses)
SFORM 1 SFORM 2	Different stress formulae (see Ref. 1) (SFORM 1) *Note:* Ref. 1 indicates that the standard option has proven superior in all cases tested.
NOCARDS CARDS	Final configuration punch option (NOCARDS) *Note:* When CARDS is requested, only the best configuration is punched.
CONFIGURATION	Identification of configuration deck (no configuration)
STRMIN = *floating point*	Satisfactory stress value (.01)
SFGRMN = *floating point*	Satisfactory gradient minimum (0.0)
SRATST = *floating point*	Satisfactory change in successive stress values (.999)
SIMILARITIES DISSIMILARITIES	Definition of data measurement (dissimilarities) *Note:* This option must be the last one specified.

Title Card

The Title Card may have any identification punched in Col. 1–72. It follows the SIMILARITIES or DISSIMILARITIES Card.

Parameter Card

The Parameter Card follows the Title Card.

Columns	*Contents*
1– 3	Size of data matrix
4– 6	No. of replications (i.e., No. of values for each matrix entry)
7– 9	No. of perturbations (i.e., No. of separate calculations with initial random configuration, $\leq$ 99)
10–12	1: print iteration values 0: do not print iteration values

continued

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Columns	*Contents*
13–15	1: print final configuration for each perturbation 0: do not print final configuration

Format Card for Input Data

This is a regular Fortran format enclosed by parentheses,

Ex: (10 F 8.3)

A slight modification of this format is used to print the data as part of the output; care must be taken to assure that the entire number is printed. Since decimals on the Data Cards will override the format specifications, only the field width need be of concern when punching the Data Cards. However, data punched .821, .342, etc. with a format of (8 F 5.0) will read correctly but will print as zeros. With a format of F w.d, w should be at least three greater than the number of significant digits desired.

Data Cards

Data matrix input is *by rows* according to format specified on the Format Card. Begin each row on a new card, the count will be determined by the size of the data matrix. If a half matrix is being read, it is convenient to consider it as the lower triangular matrix, including or excluding the diagonal.

Following the last Data Card, a Control Card, COMPUTE, is placed. A Stop Control Card follows the last Compute Card for the entire data deck. Multiple cases may be handled on one machine run.

Compute Card

Columns	*Contents*
1– 7	COMPUTE

Stop Card

Columns	*Contents*
1– 4	STOP

System Control Cards

JOB Card will be prepared by ETS personnel.

continued

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System Card 1

Columns	*Contents*
1–37	//STEPNAME EXEC GITNGO,NAME=KRUSKAL

System Card 2

Columns	*Contents*
1–19	//GO.SYSIN DD *

System Card 3

Columns	*Contents*
1– 2	//

Job Deck

Job Card
System Card 1
System Card 2
Data Deck
System Card 3

Output

The output is virtually self-explanatory. An added feature is the printout of the various control cards and the input data matrix so that visual checking for errors may be made.

Normally, the stress and best configuration are printed with a history of the stresses, number of iterations, and a convergence code for each perturbation. From rather limited experience it has been found that a minimum is generally located within ten perturbations (i.e., no smaller values were found when 40 or 50 were used).

When the CARDS punch option is requested, only the best configuration is punched.

Limitations

The present program will handle 60 objects scaled in up to ten dimensions. 1800 data values may be read, and up to 99 perturbations may be performed.

REFERENCES

1. Kruskal, J.B., "Nonmetric Multidimensional Scaling: A Numerical Method," Psychometrika, *29*, pp. 115–129, (1964).

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SAMPLE INPUT

```
//KRT2    JOB (....
//STEPNAME  EXEC  GITNGO,NAME=KRUSKAL
//GO.SYSIN  DD    *
DIMMIN#1
ITERATIONS#50
SIMILARITIES
  TEST CASE WITH NEW WRITEUP
  5  1 10
(5F5.2)
9.3  0.57 6.1  2.0  1.5
1.0  8.5  5.5  3.3  4.0
2.1  5.3  7.3  3.9  1.1
5.0  6.2  1.6  8.9  2.8
1.3  4.1  1.0  2.5  8.8
COMPUTE
STOP
/*
//
```

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SAMPLE OUTPUT


```
CONTROL CARDS
DIMMIN#1
ITERATIONS#50
SIMILARITIES
  TEST CASE WITH NEW WRITEUP
NO. OBJECTS#     5 REPLICATIONS#       1 PERTURBATIONS#
                10 ITERATION PRINT#    0 PERTURBATION PRINT#  0

9.30  0.57  6.10  2.00  1.50
1.00  8.50  5.50  3.30  4.00
2.10  5.30  7.30  3.90  1.10
5.00  6.20  1.60  8.90  2.80
1.30  4.10  1.00  2.50  8.80
COMPUTE


THE BEST CONFIGURATION OF   5 POINTS IN  2 DIMENSIONS
                                         HAS STRESS  0.037

BEST CONFIGURATION
     1      2
 1 -1.052 -0.677
 2  0.529  0.769
 3 -0.750  0.588
 4  0.059 -0.350
 5  1.215 -0.300

              HISTORY OF PERTURBATIONS
         CODE      STRESS      ITERATIONS
          2.0       0.225          20.0
          2.0       0.230          20.0
          2.0       0.184          23.0
          2.0       0.037          24.0
          2.0       0.037          26.0
          2.0       0.037          26.0
          2.0       0.037          32.0
          2.0       0.037          30.0
          2.0       0.037          34.0
          2.0       0.037          30.0

 CODES--%1<ZERO STRESS,%2<MINIMUM ACHIEVED,
     %3<SATISFACTORY STRESS REACHED,%4<MAXIMUM ITERATIONS USED


THE BEST CONFIGURATION OF   5 POINTS IN  1 DIMENSIONS
                                         HAS STRESS  0.317


BEST CONFIGURATION
     1
 1 -1.493
 2  1.451
 3 -0.042
 4 -0.533
 5  0.617

              HISTORY OF PERTURBATIONS
         CODE      STRESS      ITERATIONS
          2.0       0.409          17.0
          2.0       0.413          25.0
          2.0       0.381          22.0
          2.0       0.318          20.0
          2.0       0.317          27.0
          2.0       0.447          15.0
          2.0       0.399          15.0
          2.0       0.378          17.0
          2.0       0.423          16.0
          2.0       0.367          20.0

 CODES--%1<ZERO STRESS,%2<MINIMUM ACHIEVED,
     %3<SATISFACTORY STRESS REACHED,%4<MAXIMUM ITERATIONS USED

 ***********************************************
```

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COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $3.66.

Charge to user = computer costs + postage and handling + network overhead

= $3.66 + $5.00 + network overhead

= $8.66 + network overhead

CONTENTS—KRUSKAL

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DESCRIPTIVE TITLE	Plot
CALLING NAME	PLOT
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service (ETS)
AUTHOR(S) AND AFFILIATION(S)	University of Michigan
LANGUAGE	MAP
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Off. of Data Anal. Research, Educational Testing Service Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

A flexible plot routine originally written for the 7090 at the University of Michigan and adapted to their system, has been modified for the operating system at ETS. Although the program is written in assembly language, the necessary linkage to FORTRAN and FORTRAN I/O has been written. It is intended to be called, therefore, by a FORTRAN program and will produce plots in the normal output stream as determined by the various calls, to different entry points in the subroutine. The standard approach is to call PLOT1, PLOT2, PLOT3, and PLOT4 in that order. PLOT1 sets up the information required to construct the graph, PLOT2 prepares the grid and sets up the information required by PLOT3 to place points in the graph, PLOT3 places the plotting characters at the specified points in the graph, and PLOT4 prints the completed graph with values along the X and Y axes and a centered vertical label down the left side of the graph.

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USER INSTRUCTIONS

PLOT1

PLOT1 sets up the information required to construct the graph. It consists of five arguments, the first of which is the first location of a five-word vector. The calling sequence is

CALL PLOT1 (NSCALE(1), NHL, NSBH, NVL, NSBV)

The five arguments are defined as follows.

NSCALE(1)—controls the scaling and number of decimals printed. If this is 0, the values 0, 3, 0, 3 are used for NSCALE(2) through NSCALE(s), respectively.

NSCALE(2)—if this has the value n, the numbers printed along the y axis are 10^n times their true value.

NSCALE(3)—the number of decimal places printed for y values.

NSCALE(4)—if this has the value n, the numbers printed along the x axis are 10^n times their true value.

NSCALE(5)—the number of decimal places printed for X values.

NHL—number of horizontal lines—must be two or greater.

NSBH—number of spaces between horizontal lines—must be one or greater.

NVL—number of vertical lines—must be two or greater.

NSBV—number of spaces between vertical lines—must be one or greater.

NOTE: If different values for NSCALE(1) through NSCALE(5) are desired, then the call to NSCALE(1) should be the name of a five-entry array containing the desired values.

PLOT2

PLOT2 prepares the grid and sets up the information required by PLOT3 to place a point correctly in the graph. The calling sequence is

CALL PLOT2 (IMAGE, XMAX, XMIN, YMAX, YMIN)

If PLOT1 has not been called prior to PLOT2, the following default configuration is used: NSCALE(1) = 0, NHL = 6, NSBH = 9, NVL = 11, NSBV = 9. The five arguments are defined as follows.

IMAGE—the region used to hold the image of the graph. A dimension of 2000 should be sufficient.

continued

XMAX—largest X value to be plotted.

XMIN—smallest X value to be plotted.

YMAX—largest Y value to be plotted.

YMIN—smallest Y value to be plotted.

PLOT3

PLOT3 places the plotting character in the graph for each point (X,Y). Its calling sequence is

CALL PLOT3 (BCD, X, Y, NDATA, INT)

The five arguments are defined as follows.

BCD—plotting character used. Example: (1H*).

X—the first element of a floating point vector of X values.

Y—the first element of a floating point vector of Y values.

NDATA—the number of points to be plotted.

INT—the number of bytes between the characteristics of numbers used as coordinates (short = 4, long = 8).

PLOT4

PLOT4 will print the completed graph with values along the X and Y axes with a centered vertical label down the left side. The calling sequence is

CALL PLOT4 (NCHAR, LABEL)

The two arguments are defined as follws.

NCHAR—the number of characters in the label.

LABEL—the location of the first character of the label. The following example is representative.

CALL PLOT4 (18, 'ANY VERTICAL LABEL')

System Control Cards

JOB Card will be supplied by ETS.

System Card 1

Columns	*Contents*
1–22	//PROG EXEC FORTGCLC,

continued

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System Card 2

Columns	*Contents*
1–32	// REGION.GO=120K,ACCT.GO=0200

System Card 3

Columns	*Contents*
1–18	//FORT.SYSIN DD *

System Card 4

Columns	*Contents*
1–36	//LKED.LIB DD DSN=OCS.SAPGM,DISP=SHR

System Card 5

Columns	*Contents*
1–19	//LKED.SYSIN DD *

System Card 6

Columns	*Contents*
11–27	INCLUDE LIB(PLOT)

System Card 7

Columns	*Contents*
1– 2	/*

System Card 8

Columns	*Contents*
1– 2	//

Job Deck

JOB Card
System Card 1
System Card 2
System Card 3
Input Deck
System Card 4
System Card 5
System Card 6
System Card 7
System Card 8

continued

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The preceding information should suffice for a high percentage of the graphs required. A subroutine has been written to insert BCD information in the body of the graph, and additional features exists to handle semi-log and log-log plots, but have not been completely checked out as yet. Anyone wishing to use these options should consult the contact person.

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SAMPLE INPUT

EXAMPLE 1

```
//  (JOB CARD)
//PROG   EXEC FORTGCLG,
//   REGION.GO=120K,ACCT.GO=02000
//FORT.SYSIN  DD *
        DIMENSION X1(100),X2(100),X3(100).GRAPH(2000),IN(5)
        REAL*8  GRAPH2(1000)
        COMMON GRAPH,NVL,NSBV
        EQUIVALENCE(GRAHP,GRAPH2)
        DIMENSION A(100)
        NDATA = 100
        DO 2 I=1,100
        A(I) = I
        X1(I) = A(I)/100.
        X2(I) = 1.-X1(I)
2        X3(I) = X1(I) * X1(I)
        NHL=6
        NSBH=9
        NVL=6
        NSBV=19
        IN(1)=1
        IN(2)=0
        IN(3)=1
        IN(4)=0
        IN(5)=1
        CALL PLOT1 (IN,NHL,NSBH,NVL,NSBV)
        CALL PLOT2(GRAPH,100.,0.,1.,0.)
        CALL PLOT3(1H*,A,X1,NDATA,4)
        CALL PLOT3(1H",A,X2,NDATA,4)
        CALL PLOT3(1H#,A,X3,NDATA,4)
        CALL INSH(18,6,5,'MACHINE AVAILABILITY')
        CALL INSH(9,35,5,'PROGRAMMING DEMANDS ')
        CALL INSH(40,45,4,'BLOOD PRESSURE   ')
        WRITE (6,5)
5       FORMAT (1H1,40X,'SO YOU THINK YOU HAVE TROUBLE-----')
        CALL PLOT4(40,'READ THIS V/E/R/Y  CAREFULLY                ')
        WRITE (6,8)
 8       FORMAT(1H0,40X,'WILL THESE SOON BE REVERSED?',50X,'DBK')
        END
//LKED.LIB DD DSN=OCS.SAPGM,DISP=SHR
//LKED.SYSIN DD *
                INCLUDE LIB(PLOT)
        INCLUDE LIB(INSH)
/*
//
```

continued

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EXAMPLE 2

Control cards are not listed in this example.

```
      REAL*8 GRAPH2(1000)
      EQUIVALENCE (GRAPH,GRAPH2)
      DATA BLANK/'    '/,BCD/'*'/
      POL(ANGLE) =.25 * ANGLE
      RMAX = 4.
      NSBV=79
      NVL=2
      CALL PLOT1 (0,2,47,2,79)
      CALL PLOT2 (GRAPH,RMAX,-RMAX,RMAX,-RMAX)
      DO 1 I=1,2000
1      GRAPH(I)=BLANK
      DELTAY = RMAX/24.
      DELTAX=RMAX/40.
      IMAX = 2.*RMAX+1.
      DO 4 I=1,49
4      CALL PLOT3(1HI,0.,RMAX-FLOAT(I-1)*DELTAY,1,4)
      DO 5 I=1,IMAX
5      CALL PLOT3(1H+,0.,RMAX-FLOAT(I-1),1,4)
      DO6 I=1,81
6      CALL PLOT3(1H-,-RMAX+FLOAT(I-1)*DELTAX,0.,1,4)
      DO 7 I=1,IMAX
7      CALL PLOT3(1H+,-RMAX+FLOAT(I-1),0.,1,4)
      DO 12 I=1,140
      THET = .1 * FLOAT(I)
      SWITCH = PLOT3(BCD,POL(THET)*COS(THET),POL(THET)*SIN(THET),1,4)
12       CONTINUE
 13   CALL OMIT(3)
      CALL INSH(44,1,3,'90 DEGREES  ')
      CALL INSH(2,26,3,'180 DEGREES ')
      CALL INSH(71,26,3,' 0 DEGREES  ')
      CALL INSH (44,47,3,'270 DEGREES ')
       WRITE (6,9)
9      FORMAT(1H1,40X,' A SLIGHTLY DIFFERENT EXAMPLE')
      CALL PLOT4(26,'POLAR PLOT OF THE SPIRAL            ')
      END
```

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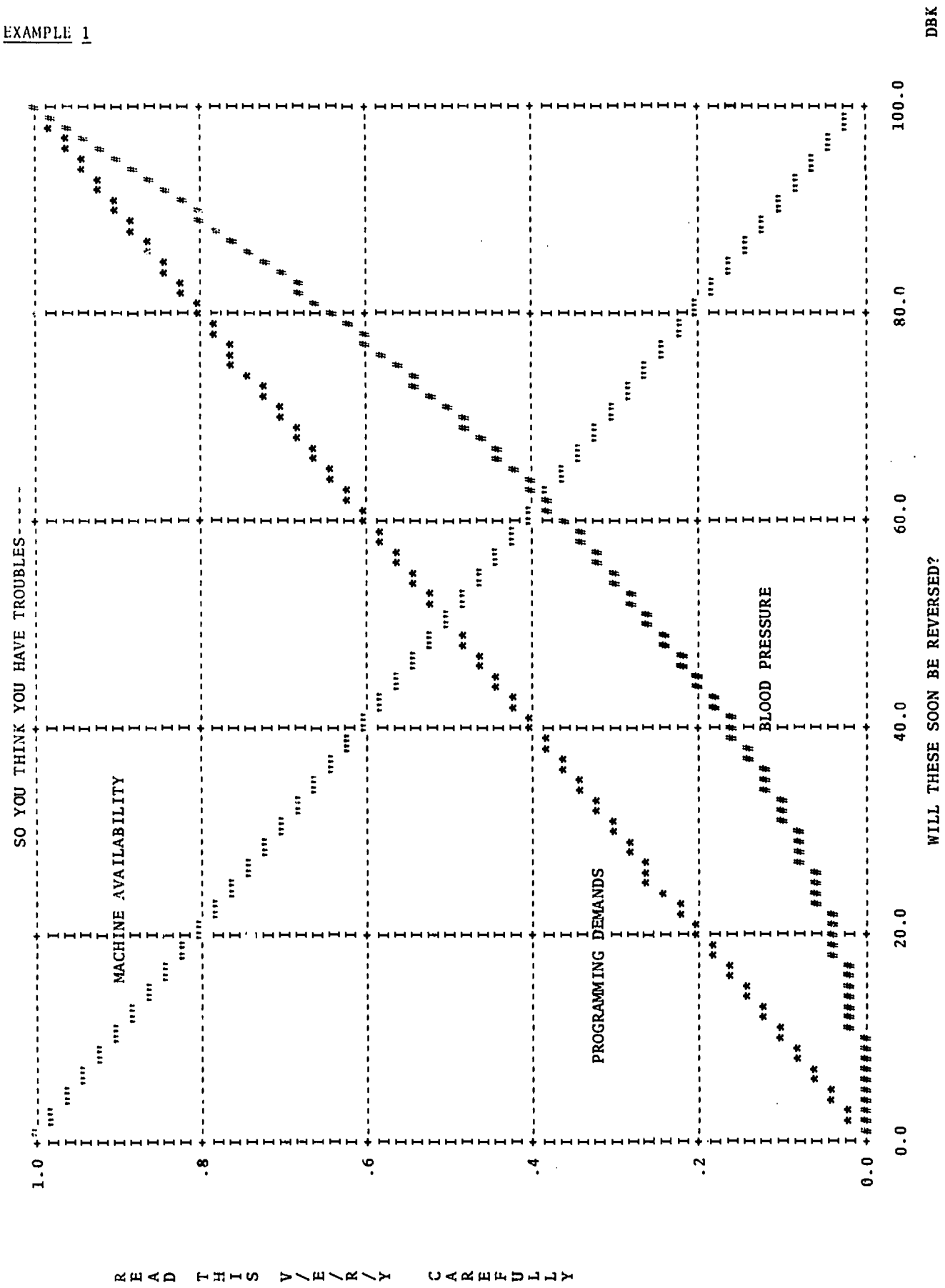
SAMPLE OUTPUT

EXAMPLE 1



continued

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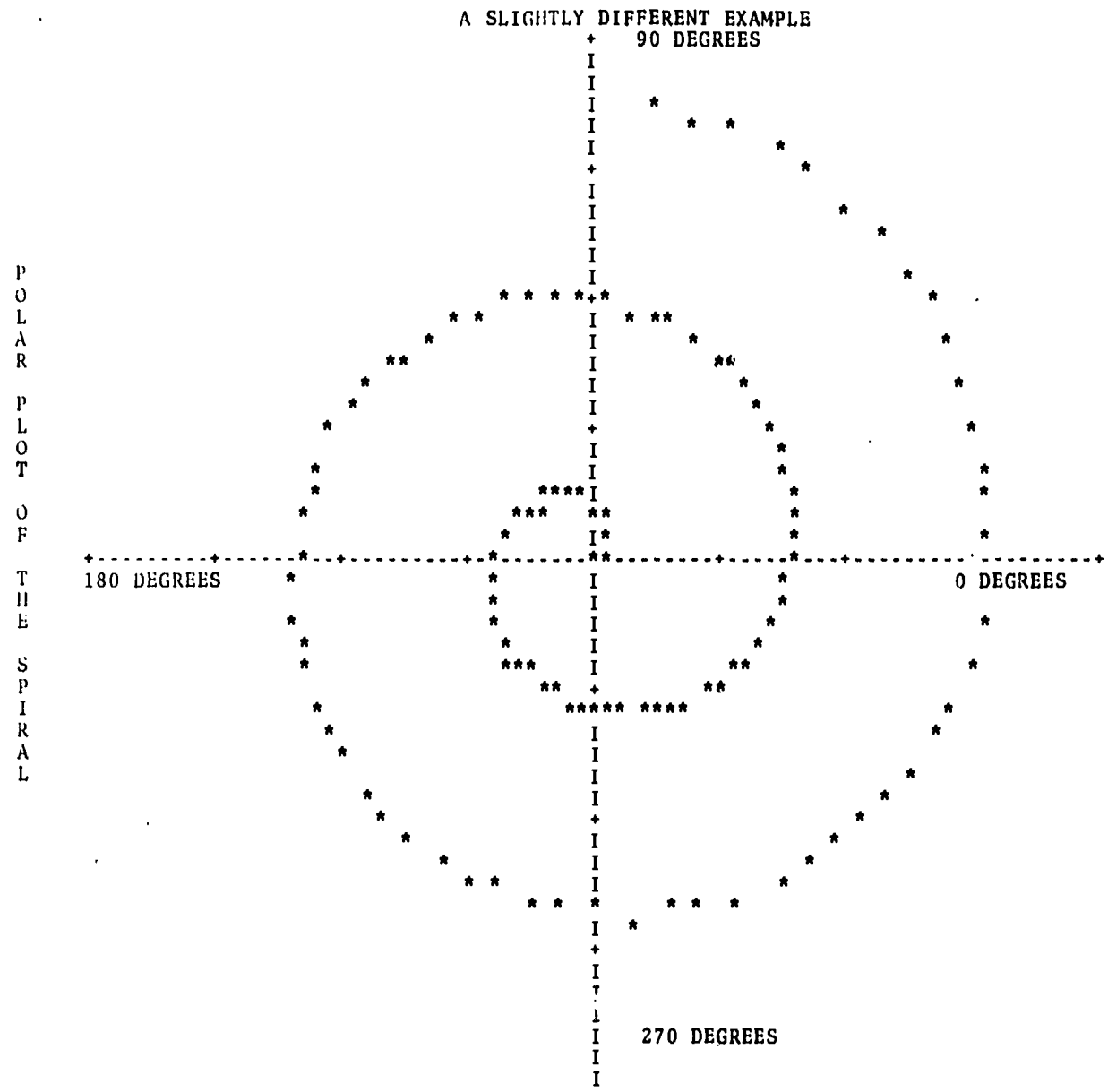
EXAMPLE 2


A SLIGHTLY DIFFERENT EXAMPLE
90 DEGREES
180 DEGREES
0 DEGREES
270 DEGREES
POLAR PLOT OF THE SPIRAL

COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for Example 1 in the Sample Input were $2.01.

Example 1

Charge to user = computer costs + postage and handling + network overhead

= $2.01 + $5.00 + network overhead

= $7.01 + network overhead

Computer costs for Example 2 in the Sample Input were $2.09.

Example 2

= $2.09 + $5.00 + network overhead

= $7.09 + network overhead

CONTENTS—PLOT

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DESCRIPTIVE TITLE	Multidimensional Scalogram Analysis
CALLING NAME	MSA-I
INSTALLATION NAME	Office of Data Analysis Research Educational Testing Service
AUTHOR(S) AND AFFILIATION(S)	Procedure due to: L. Guttman, J. Lingoes, University of Michigan Program due to: J. Lingoes, University of Michigan Adaptation due to: D. Kirk, Educational Testing Service Advisor on use: H. Harman, Educational Testing Service
LANGUAGE	MAP
COMPUTER	IBM 360/65
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Mr. Ernest Anastasio, Off. of Data Anal. Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540 Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

MSA-I is a program to map types (individuals having the same profile over a set of variables or items) onto an Euclidean space with minimum dimensionality. No assumptions are required about the underlying distributions, the scaling properties of the items, or their ordering. The only requirement is that the categories of each item be mutually exclusive and exhaustive. Types are represented as points in space, each item is a partition of the space, and each category is a region. All types who fall in a given category of a particular item are constrained to be closer to boundary markers of the same category than to delimiters of other categories of the same item. The program we have is a modification of the MSA-I package as distributed

continued

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by Dr. Lingoes. An option or modification provides additional plots for each category with the number inserted in the plots corresponding to the response to the item rather than the ID number as in the distributed version.

References and some copies of the substantial literature related to this problem are available through the contact person.

REFERENCE

Lingoes, J.C., "Multiple Scalogram Analysis—A Set-theoretic Model for Analyzing Dichotomous Items," J. of Ed. & Psych. Meas., *23*, pp. 501-524, (1963).

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USER INSTRUCTIONS

Input Deck

Title Card

Columns	*Contents*
1–80	Title information

Control Card (zeros and blanks treated alike)

Columns	*Contents*
1– 4	Number of variables ($\leq$ 50)
5– 8	Number of subjects ($\leq$ 100)
9–12	Precoded switch 1: values are integers in the range 1–20 0 or blank: values are not in this range
13–16	If precoded switch is 1, leave this blank If precoded switch is 0 or blank, punch number of intervals into which data are to be coded.
17–20	Smallest frequency to be permitted after coding. Blank indicates no lower limits are desired.
21–24	1: card output of coded data is desired 0: card output is not desired
25–28	Number of types of nonredundant profiles. If program is to determine redundancies, set this item to the number of subjects.
29–32	Minimum number of dimensions (default is 1)
33–36	Maximum number of dimensions (either 2 or 3)
37–40	Number of iterations (default is 25)
41–44	1: item plots for each item 0: no item plots It is suggested that this be set to 1.
45–48	Cutoff criterion for coefficient of contiguity. Floating point ($0 < c \leq 1.00$)
49–52	Code to indicate mean is to be substituted for missing data.

continued

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Frequency Card Deck (Use if Number of types of nonredundant profiles ≠ 0.

Columns	*Contents*
1– 2	Frequency for first type
3– 4	Frequency for second type
⋮	⋮
71–72	Frequency for thirty-sixth type

If there are more than 36 types, continue onto another card.

Format Card

Data Deck

Multiple cases may be run, each with its own Input Deck.

Job Deck

The program is currently available and may be executed as follows.

```
//JOB card (will be provided by ETS personnel)
//EXEC GITNGO,NAME=MSAX
//GO.SYSIN DD *
(Insert Input Deck or Decks here)
/*
```

Output

The output will depend upon the options selected in the Control Card.

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SAMPLE INPUT

```
//DKMSA   JOB (....
//EXEC GITNGO,NAME=MSAX
//GO.SYSIN DD *
1TEST FOR G-L(MSA-I) FOR A PERFECT UNIDIMENSIONAL SCALE OF 3
                                                  CATAGORIES.
   3   7       3           7   2   2       1 1.0
 4 1 1 2 1 1 1
(3F1.0)
333
332
322
222
221
211
111
/*
```

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SAMPLE OUTPUT

TEST FOR G-L(MSA-I) FOR A PERFECT UNIDIMENSIONAL SCALE OF 3 CATAGORIES.

VARIABLE	SCORE RANGE	CODED INTERVAL
1	0.100000E 01 TO 0.300000E 01	0.100000E 01
2	0.100000E 01 TO 0.300000E 01	0.100000E 01
3	0.100000E 01 TO 0.300000E 01	0.100000E 01

FREQUENCY DISTRIBUTION FOR RANKED CODED DATA

VAR.	1	2	3	4	5	6	7	8	9
1	1	3	3						
2	2	3	2						
3	3	3	1						

SCORES FOR EACH SUBJECT ON EACH VECTOR

VECTOR	1	2	3
SUBJECT			
1	-529.	509.	
2	-409.	69.	
3	-230.	-320.	
4	0.	-517.	
5	230.	-320.	
6	409.	69.	
7	529.	509.	

LINGOES MULTIVARIATE ANALYSIS OF CONTINGENCIES

CATEGORY WEIGHTS

VECTOR 1. ETA =.811

CATEGORY	1	2	3	4	5	6	7	8
VARIABLE								
1	529.	213.	-389.					
2	469.	0.	-469.					
3	389.	-213.	-529.					

VECTOR 2 ETA =.368

CATEGORY	1	2	3	4	5	6	7	8
VARIABLE								
1	509.	-256.	86.					
2	289.	-385.	289.					
3	86.	-256.	509.					

continued

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GUTTMAN-LINGOES OUTER-POINT SCALOGRAM ANALYSIS COORDINATES
FOR M = 2.

DIMENSION	1	2
TYPE		
1	-100.000	30.643
2	-77.180	-25.472
3	-43.381	-74.921
4	0.000	-100.000
5	43.382	-74.921
6	77.180	-25.471
7	100.000	30.644

COEFFICIENT OF CONTIGUITY =0.100000E 01 FOR 1 ITERATIONS.

OUTER-POINT MATRIX

TYPE = 1 (4)
3 3 -3

TYPE = 2 (1)
3 -3 -2

TYPE = 3 (1)
-3 -2 2

TYPE = 4 (2)
-2 2 -2

TYPE = 5 (1)
2 -2 -1

TYPE = 6 (1)
-2 -1 1

TYPE = 7 (1)
-1 1 1

continued

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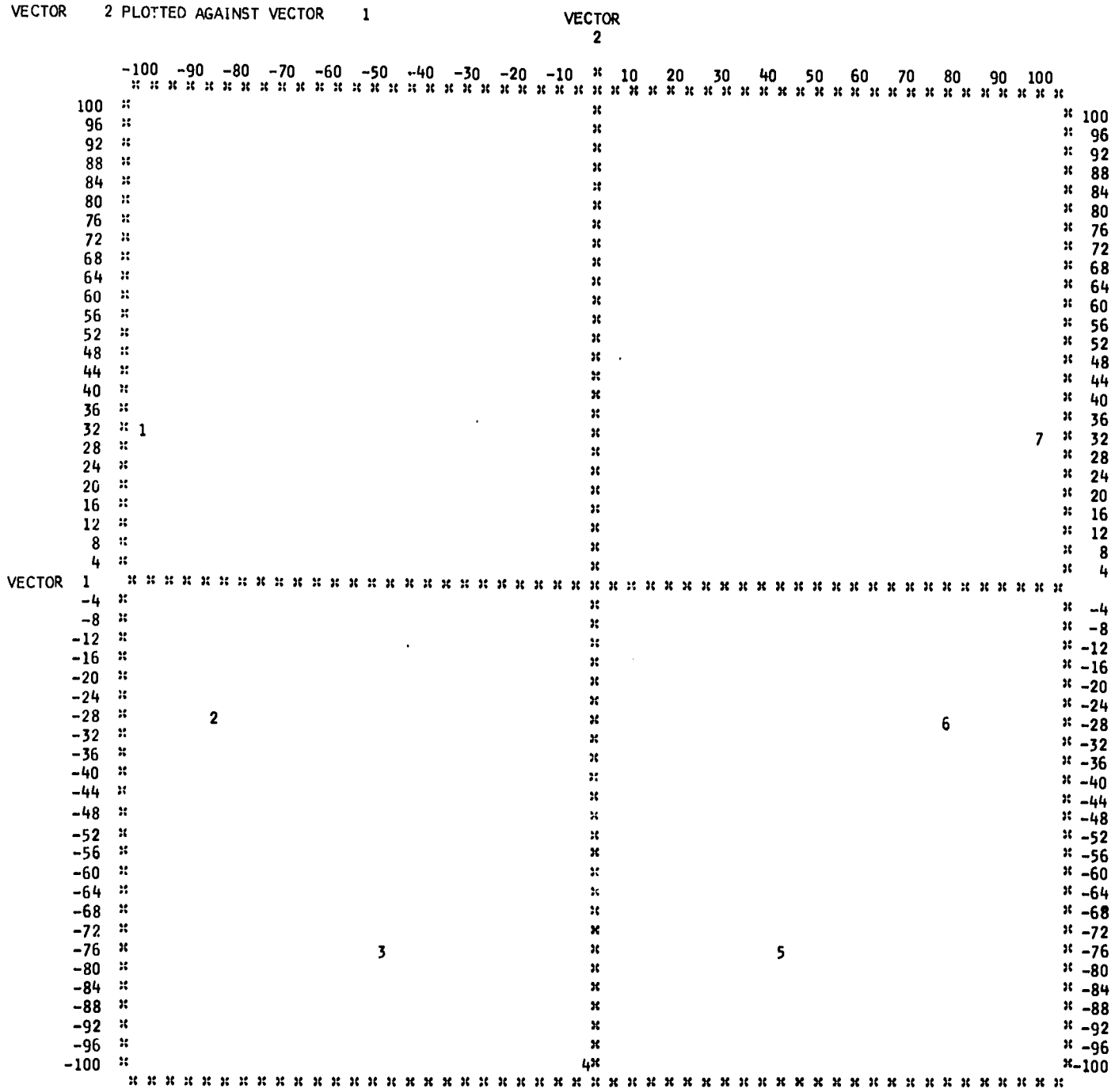
VECTOR PLOTS
VECTOR 2 PLOTTED AGAINST VECTOR 1



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COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $2.67.

Charge to user = computer costs + postage and handling + network overhead

= $2.67 + $5.00 + network overhead

= $7.67 + network overhead

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DESCRIPTIVE TITLE	Simulation Package for University Research and Training
CALLING NAME	SPURT
INSTALLATION NAME	Vogelback Computing Center Northwestern University
AUTHOR(S) AND AFFILIATION(S)	Gustave J. Rath Department of Industrial Engineering and Management Sciences Martin Goldberg Leonard Weiner Northwestern University
LANGUAGE	CDC FORTRAN IV
COMPUTER	CDC 6400
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Lorraine Borman, EIN Technical Representative, Vogelback Computing Center, Northwestern University, 2129 Sheridan Road, Evanston, Ill. 60201 Tel.: (312) 492-3682

FUNCTIONAL ABSTRACT

SPURT is a comprehensive package of USASI Standard FORTRAN routines that are designed for use in simulation modelling. These useful routines, ranging from simple to complex, enable the average FORTRAN programmer to employ simulation techniques without having to learn the semantic and syntactic rules of a new programming language.

The SPURT package is made up of six main parts.

I. *CLOCK Generation—SPURT1*

II. *Stochastic Generators—SPURT2*

III. *Statistical Computations—SPURT3*

IV. *Analog Simulators—SPURT4*

V. *List-Processing and Queue-Manipulation—SPURT5*

VI. *Matrix and Graphical Output—SPURT6*

continued

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The following is a listing and brief discussion of the various subroutines contained in each of the six SPURT parts.

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CLOCK Generation—SPURT1: to implement discrete-time simulation models; to cause events to occur in the proper time sequence

The CLOCK subroutine consists basically of two lists:

Master Time List—contains events scheduled to happen in the future

Master Time Queue—contains events that could not take place at the time when they were scheduled to and, therefore, have been rescheduled; i.e., they have been blocked and are waiting in a queue.

Events can be stored on either list.

CLOCK recognizes two basic kinds of events:

Exogenous—those that are *external* to the user's routine; these are read from Data Cards by the CLOCK

Endogenous—those that are *internal* to the user's routine; these are generated dynamically and then are maintained by the CLOCK

Stochastic Generators—SPURT2: to generate samples from various probability distributions and to calculate sample values

Subroutine	*Usage*
STOGN1	Permits sampling from a discrete empirical probability distribution defined by the user
STOGN2	Enables the user to approximate a continuous distribution by means of a piecewise linear distribution
UNIFRM	Permits the user to sample real values from a uniform distribution in a defined interval
RANDIN	Provides a uniform distribution of integers in a defined interval
NORMAL	Allows the user to obtain a random sample from a normal distribution with given mean and standard deviation
NEGEXP	Permits the user to obtain a random sample from the negative exponential distribution
POISSN	Provides the user with a random sample from the Poisson distribution

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ERLANG	Provides a random sample from the Erlang distribution
DISCRT	Permits sampling from a step function describing a discrete cumulative distribution of integer values
LINEAR	Provides the user with a random sample from a cumulative distribution that is obtained by linear interpolation in a nonequidistant table of real values
DRAW	Provides a boolean value of TRUE or FALSE
RANPER	Generates a uniformly distributed, random permutation of the integers 1, 2, ···, M

Statistical Computations—SPURT3: to calculate statistical parameters and histograms of data arrays

Subroutine	*Usage*
STIX1 STIX2 STIX3	Three interrelated subroutines to accumulate and print out a frequency table and to produce a CalComp plot of a normalized histogram of the table
STIX4	Evaluates the mean, standard deviation, maximum value, and minimum value of an array of real numbers
STIX5	Evaluates the correlation coefficient between two arrays of real numbers
STIX6	Ranks an array of real numbers and produces the median and range of the data within the array
STIX7	Produces a statistical description of the data found in an array, including the sample size, mean, standard deviation, standard error, minimum and maximum values, range, and a printed histogram plot

Analog Simulators—SPURT4: to enable the simulation of analog-computer problems on a digital computer

Subroutine	*Usage*
ANALOG SECND	These two subroutines make it possible to obtain output similar to a hybrid computer

continued

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List-Processing and Queue-Manipulation—SPURT5: lists are mXn arrays; entries in lists are mX1 arrays.

Subroutine	*Usage*
ADFIFO	Adds an entry at the bottom of the list; it can be removed only after all the elements presently on the list are gone (builds first-in last-out list)
ADLIFO	Adds an entry at the top of the list; it will be removed before any other entry presently on the list (builds last-in first-out list)
REMOVE	Removes the top (or first) entry from a list
PURGE	Destroys the contents of a list
DISPL	Prints the contents of a list

Additional subroutines in SPURT5 provide the capability to rank lists and to delete or to insert entries into lists.

Matrix and Graphical Output—SPURT6: output is facilitated through printing and graphical output

Subroutine	*Usage*
OUT	Prints out a square matrix with column and row headings
NSOUT	Prints out a nonsquare matrix with column and row headings
GRAPH	Produces two-dimensional graphs of plots, using a CalComp plotter

REFERENCES

1. Rath, G.J., "Description of the Simulation Package for University Research and Teaching," Northwestern Univ. Vogelback Computing Ctr., SPURT, Rev. E (1968; unpublished).

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USER INSTRUCTIONS

SPURT is separated into six sections (Parts) in the Vogelback Program Library. All of the routines contained in any one Part will be loaded with the user's program when he places that Part name in the argument list of a Library Card. The following listing shows which routines are included in each part of SPURT.

Program Library Name (Part)					
SPURT1	SPURT2	SPURT3	JRT4	SPURT5	SPURT6
SPURT User Routines Loaded:					
CLOCK	STOGN1	OUT	ANALOG	ADFIFO	TIMELP
SETCLK	STOGN2	IOUT	SECND	ADLIFO	PAGE
ANALOG	STOGN6	NSOUT		REMOVE	DIAGNS
SECND	UNIFRM	INSOUT		PURGE	DIAGNW
	RANDIN	GRAPH		DISPL	
	NORMAL	STIX1		IDISPL	
	NEGEXP	STIX2		NUMLST	
	POISSN	STIX3		RANKQS	
	ERLANG	STIX4		INRKQS	
	DISCRT	STIX5		RANKQL	
	LINEAR	STIX6		INRKQL	
	DRAW	STIX7		SEARCH	
	HISTD			INSERT	
	RANPER			DELETE	
SPURT Internal Routines Loaded:					
ZZXXQ9Q		QRLQPB			BLKDATU
LODLST					
PURGER					
Common Blocks Used:					
CLOCK1		SPRTFT		SZSYSP	QPLOTQ
SPRTIO		SPRTIO		SPRTFT	SZSYSP
		SZSYSP		SPRTIO	SPRTFT
		QPLOTQ			SPTMSG
		SPRTPL			SPRTIO
					QPAGEQ
SPURT Part Core Requirements (octal):					
6500	4000	21300 + 6400		5700	5000
Part Core Requirements When Loaded with SPURT6 (octal):					
7600	6600	22500 + 7600		7100	—

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NOTE: Whenever any of the SPURT routines is called from the library, *SPURT6 must also be called.* Therefore, *every* use of the Library Card for SPURT will include SPURT6 in the argument list.

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Application Hints

All user-written subroutines should have as their first executable instruction a call to the user-written subroutine TRACE, passing as a parameter the name of the calling subroutine. For example, the first executable statement in subroutine FACTORY, say, should be CALL TRACE (7HFACTORY). Thus, as each subroutine within the simulation model initiates execution, it will call on the TRACE routine, which can be constructed to print a short message giving the current simulated time, the name of the calling subroutine, and the status of key system variables.

It should be emphasized that TRACE is a user-written closed subroutine. Therefore, it is the user's responsibility to construct the printout to include the simulation time, calling subroutine name, and all key system variables.

Segment coding is suggested because discrete-time simulation models are characterized by a chain of events and/or activities. Each event and activity is well defined in setting up the problem solution. This implies that each event or activity within the model should be coded as a closed subroutine. In doing this, it is good practice to place into a common block all variables used by more than one routine. Segmentation of this sort will also allow the easy generation of closed subroutines to handle data input, statistical analysis, printouts, and facilities for a TRACE routine.

Error-Indicator Subroutines

DIAGNS and/or DIAGNW

```
SUBROUTINE DIAGNS (NAME,NUMBR)
SUBROUTINE DIAGNW (NAME,NUMBR)
```

where NUMBR is an integer and NAME is a Hollerith constant.

The user may wish to incorporate calls to DIAGNW and/or DIAGNS in his main program. These are called by most of the SPURT subroutines and functions whenever an error condition arises during a run. If the error is of a serious nature, DIAGNS is called; it causes a program termination after an appropriate diagnostic message has been printed on the standard output unit. For less serious errors, DIAGNW is called by the SPURT routine detecting the error; control is returned to the calling routine after DIAGNW

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prints out a message. (See Ref. 1 for a listing of all diagnostic messages.)

The user is given the ability to force SPURT to continue execution of a program after detecting a normally fatal SPURT error condition during the run. To continue, the user *must preset the third word of* COMMON/SZSYSP *to nonzero in his main program.* This causes all calls (by SPURT) to DIAGNS to be handled as calls to DIAGNW.

CAUTION: The disablement of the termination feature of DIAGNS will merely cause an incorrect value to be stored in X; however, with many other SPURT routines (e.g., CLOCK), *infinite loops may occur when this feature is disabled. This option is to be used with extreme care!*

REFERENCES

1. Rath, G.J., "Description of the Simulation Package for University Research and Teaching," Northwestern Univ. Vogelback Computing Ctr., SPURT, Rev. E (1968; unpublished).

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USER INSTRUCTIONS—SPURT1: CLOCK Generation

SUBROUTINE CLOCK (L,NEWT,NEWJ)
SUBROUTINE SETCLK (MTL,JUMP,LMTL,MTQ,JUMQ,LMTQ)
TYPE INTEGER L,NEWT,NEWJ,MTL,JUMP,LMTL,MTQ,JUMQ,LMTQ

The primary function of CLOCK is the manipulation of two lists: a Master Time List and a Master Time Queue. Events and their type number and scheduled time of occurrence can be stored on either list. The Master Time List contains events that are scheduled to happen; the Master Time Queue contains events that could not take place at the time when they were originally scheduled to and, therefore, have been rescheduled. That is, they were blocked and so are waiting in a queue. CLOCK causes events to occur at the proper simulation time. (Unless otherwise noted, all references to *time* here will mean *simulated time*.)

The Master Time List consists of two one-dimensional arrays: MTL and JUMP. Both are of the same size and must be dimensioned in the user's program. The MTL array contains the time at which the events are scheduled to occur. The JUMP array contains the number of the event type. The ith element of MTL and the ith elements of JUMP constitute an event. LMTL stands for the length of the Master Time List (LMTL $\leq$ that of MTL). NEVEN is the variable that contains the surrent number of events in the Master Time List.

NOTE: The value of NEVEN is maintained by the CLOCK and should not be changed by the user. It is intended for use on a *read-only* basis.

The Master Time Queue is very similar to the Master Time List, except that it contains blocked events. The variables MTQ, JUMQ, LMTQ, and NEVEQ correspond exactly to the variables MTL, JUMP, LMTL, and NEVEN for the Master Time List. Thus, MTQ is a one-dimensional array containing event types. Both arrays are dimensioned by the user in his program and must have the same dimension. Also, LMTQ must be defined (LMTQ $\leq$ dimension of MTQ). NEVEQ is the current number of events in the Master Time Queue.

CLOCK recognizes two basic kinds of events: exogenous (external to the user's program and the CLOCK subroutine) and endogenous (internal to the program).

Exogenous events are read in on data cards as input data, one event per card. The data cards must be arranged by the user in time sequence. To have SETCLK or CLOCK read an exogenous event, the user must specify the logical unit number (LUN) from which the cards are

continued

to be read. If the data cards follow the program on the standard system input, LUN = 5. If the value for LUN is not set between 1 and 99, the reading of exogenous events is suppressed.

Endogenous events are not read in on data cards and are created in the user's program.

The basic function of CLOCK is to cause events to happen when they are scheduled. When CLOCK is initialized, the first exogenous event is read (if a valid LUN has been specified) and is placed on the Master Time List. Subsequently, whenever the normal CALL CLOCK statement is used, the subroutine causes the event to be taken from the Master Time List or Master Time Queue, whichever has the earliest time of occurrence (ties are decided in favor of the Master Time Queue) and returned to the user's program. Whenever an exogenous event is deleted from the Master Time List, the next exogenous event is automatically read (if LUN is valid) and placed on the Master Time List in sequence. CLOCK works with only one event at a time and stops when all exogenous events have been read in and both lists are empty.

The user initializes CLOCK with the following call: CALL SETCLK(MTL, JUMP,LMTL,MTQ,JUMQ,LMTQ). The parameters in the calling sequence are the same as those described above.

If the user wishes to read an exogenous event, then common block CLOCK1 must be accessed (see Ref. 1, p. 3.9) and LUN preset equal to 5 (see Ref. 1, p. 3.4).

The user calls CLOCK with CALL CLOCK(L,NEWT,NEWJ). The only variables that will change in the course of the user's program are L, NEWT, and NEWJ. Thus, SETCLK is called only when it is desired to initialize both clock lists. Here, NEWT contains the time of the event and NEWJ contains the number of the event type. Since CLOCK works with only one event at a time, NEWT and NEWJ will always contain the time and type number of the present event being worked with. Each event type is considered to be the parameter of a computer GO TO statement in the user's program and represents the jump address of an event to be executed (Ref. 1, Appendix).

The variable L takes on integer values from 2 through 9; the value must be chosen by the user and determines the function of the call statement. *Example:* Consider the use of L in the following calls to the CLOCK subroutine.

L = 2: used for loading the Master Time List with the event (NEWT, NEWJ)—

continued

CALL CLOCK(2,NEWT,NEWJ)

The parameter value of L equal to 2 denotes that the Master Time List is to be loaded with event type NEWJ that is scheduled to occur at time NEWT.

L = 3: used to delete from both lists all events of a given type NEWJ occurring at a given time NEWT—

CALL CLOCK(3,NEWT,NEWJ)

This call to CLOCK is used to delete the occurrence of event type NEWJ at a scheduled time of NEWT from both the Master Time List and the Master Time Queue. For example, CALL CLOCK(3,8,1) requests that event (8,1) be deleted from both lists.

L = 4: used for calling the next scheduled event—

CALL CLOCK(4,NEWT,NEWJ)

Here, a request has been made of the CLOCK for the next scheduled event and its time of occurrence. CLOCK returns a value in NEWT equal to the time of occurrence of the next event type. The value of the event-type code is returned in NEWJ.

L = 5: used for loading a blocked event (NEWT,NEWJ) on the Master Time Queue—

CALL CLOCK(5,NEWT,NEWJ)

A blocked event (NEWT,NEWJ) is to be loaded onto the Master Time Queue. The user is cautioned that NEWT must *not* contain the time at which the event was blocked. If this is included, the clock will hang in an endless loop. NEWT is the *next* time of occurrence of the event type NEWJ *after* it has been blocked.

L = 6: produces the next scheduled time of occurrence (i.e., NEWT for an event of type NEWJ—

CALL CLOCK(6,NEWT,NEWJ)

This call to the CLOCK requests the next scheduled time of occurrence of event type NEWJ. The answer to the request is returned in NEWT. For example, CALL CLOCK(6,NEWT,4) will return to the user (in NEWT_ the next time of occurrence of event type 4. If a request for the next scheduled time of occurrence of event type NEWJ cannot be satisfied (e.g., if that event type is not on the CLOCK lists), then the value returned in NEWT is negative.

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L = 7: purges (deletes) both lists of all events of type NEWJ—

```
CALL CLOCK(7,0,NEWJ)
```

Here, the CLOCK is requested to delete from both the Master Time List and the Master Time Queue all occurrences of the event type specified by NEWJ. Note that the second parameter (NEWT) is denoted as 0, as this parameter is ignored by this request but must be filled in the calling sequence.

L 8: purges the Master Time List of all events of type NEWJ—

```
CALL CLOCK(8,0,NEWJ)
```

This request is similar to 7, except that it deletes all events of type NEWJ from the Master Time List only.

L = 9: purges the Master Time Queue of all events of type NEWJ—

```
CALL CLOSK(9,0,NEWJ)
```

This request is similar to 7 also, except that it deletes all events of type NEWJ from the Master Time Queue only.

NOTE: If an event is blocked for some reason, the user must place it on the Master Time Queue, at a later scheduled time, by using a different form of the CALL CLOCK (Ref. 1, p. 3.4).

The unit in which event times are measured is decided by the user in terms of the process being simulated. However, *event times must be nonnegative integers.*

The user has access to the values of NEVEN, NEVEQ, and LUN, used by the CLOCK. These values are placed in the labeled common block CLOCK1. (See Ref. 1, p.3.9.) NEVEN and NEVEQ should be accessed only on a read-only basis by the user. CLOCK sets and updates both variables.

If the user wants to run a real-time simulation, he can use FUNCTION TIMELP, which provides the elapsed CP time between successive calls.

TIMELP

```
REAL FUNCTION TIMELP (NPRINT)
TYPE INTEGER NPRINT
```

If the user wants to attempt a simulation in real time, he may find FUNCTION TIMELP useful. This routine prints (at the user's option) and returns the CDC 6400 central processor elapsed time (in seconds)

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between consecutive calls to TIMELP. An initializing call to TIMELP should be made at the beginning of execution of the routine to be timed. TIMELP can also be used to time any particular portion of a FORTRAN program.

A zero value of NPRINT suppresses printing by TIMELP. A nonzero NPRINT will print the legend CP TIME SINCE LAST CALL .. xx.xxx SECONDS. In either case, TIMELP contains the elapsed time. The call to TIMELP takes the form CALL TIMELP (NPRINT).

Job Deck Structure

```
Job Cards
Run(s)
LIBRARY(SPURT1,SPURT6)
LGO.
7-8-9 (EOR Card)
Main-Problem Card(s)
   PROGRAM(INPUT,OUTPUT,PUNCH,PLOT,TAPE5=INPUT, 1 TAPE6=OUTPUT,
   TAPE7=PUNCH,TAPE17=PLOT)
   .
   .
   .
   END
Subroutine Card(s)
   SUBROUTINE ACTION1
   .
   .
   .
   END
   .
   .
   .
   SUBROUTINE ACTIONZ
   .
   .
   .
   END
7-8-9 (EOR Card)
Data Cards
6-7-8-9 (EOI Card)
```

NOTE: The file assignments on the Main-Program header card are the standard SPURT assignments.

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SAMPLE INPUT

```
                SUBROUTINE EXAMPL3                                                  SPTS9  0
          C                                                                         SPTS9 10
          C                                                                         SPTS9 20
          C     THIS PROGRAM IS PART OF THE NORTHWESTERN UNIVERSITY                 SPTS9 30
          C                                                                         SPTS9 40
          C                       S  P  U  R  T                                     SPTS9 50
          C                                                                         SPTS9 60
          C        A SIMULATION PACKAGE FOR UNIVERSITY RESEARCH AND TEACHING        SPTS9 70
          C                                                                         SPTS9 80
          C     ******************************************************************SPTS9 90
          C                                                                         SPTS9100
000002          COMMON /CLOCK1/ DUMM1,NEVEN,DUMM2,NEVEQ,LUN                         SPTS9110
000002          COMMON    MTL(500), JUMP(500), MTQ(100), JUMQ(100)                  SPTS9120
          C                                                                         SPTS9130
          C                                                                         SPTS9140
          C     THE FOLLOWING CARDS ARE COPIES OF THE EXOGENOUS EVENTS TO BE READ SPTS9150
          C     NEWT    NEWJ                                                        SPTS9160
          C      2       5                                                          SPTS9170
          C      5       1                                                          SPTS9180
          C     24       8                                                          SPTS9190
          C                                                                         SPTS9200
          C     END OF EXOGENOUS EVENTS LIST                                        SPTS9210
          C                                                                         SPTS9220
          C     INITIALIZATION                                                      SPTS9230
000002          LMTL=500                                                            SPTS9240
000003          LMTQ=100                                                            SPTS9245
000004          L=1                                                                 SPTS9250
000005          MM=JJ=-1                                                            SPTS9260
000007          LUN=5                                                               SPTS9270
000010          DUM=TIMELP(0)                                                       SPTS9280
000013          CALL SETCLK (MTL,JUMP,LMTL,MTQ,JUMQ,LMTQ)                           SPTS9290
000017          DUM=TIMELP(1)                                                       SPTS9300
000022          PRINT 140                                                           SPTS9310
000025          PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                               SPTS9320
          C                                                                         SPTS9330
          C     DUMMY ROUTINE TO LOAD ENDOGENOUS EVENTS ON MASTER_TIME_LIST         SPTS9340
          C                                                                         SPTS9350
000043          L=2                                                                 SPTS9360
000044          DO 20 I=1,10                                                        SPTS9370
000046          F=I                                                                 SPTS9380
000047          JJ=(ABS(COS(F)))*7.0+1.0                                            SPTS9390
000056          MM=2*I/JJ                                                           SPTS9400
000063          CALL CLOCK (L,MM,JJ)                                                SPTS9410
000065    20    PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                               SPTS9420
000105          DUM=TIMELP(1)                                                       SPTS9430
          C                                                                         SPTS9440
          C     CALL OUT NEXT EVENT                                                 SPTS9450
          C                                                                         SPTS9460
000110    30    L=4                                                                 SPTS9470
000111          CALL CLOCK (L,MM,JJ)                                                SPTS9480
000114          PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                               SPTS9490
000132          DUM=TIMELP(1)                                                       SPTS9500
000135          GO TO (100,200,300,400,500,600,700,800),JJ                          SPTS9510
          C                                                                         SPTS9520
000151    100   K=100                                                               SPTS9530
000152          PRINT 120, K,MM                                                     SPTS[illegible]
000162          GO TO 30                                                            SPT[illegible]
```

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SPURT1

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```
        C                                                                   SPTS9560
000163  200   K=200                                                         SPTS9570
000164        PRINT 120, K,MM                                               SPTS9580
000174        L=5                                                           SPTS9590
000175        MM=MM+3                                                       SPTS9600
000177        JJ=3                                                          SPTS9610
000200        CALL CLOCK (L,MM,JJ)                                          SPTS9620
000203        PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                         SPTS9630
000221        DUM=TIMELP(1)                                                 SPTS9640
000224        GO TO 30                                                      SPTS9650
        C                                                                   SPTS9660
000224  300   K=300                                                         SPTS9670
000225        PRINT 120, K,MM                                               SPTS9680
000235        GO TO 30                                                      SPTS9690
        C                                                                   SPTS9700
000236  400   K=400                                                         SPTS9710
000237        PRINT 120, K,MM                                               SPTS9720
000247        L=3                                                           SPTS9730
000250        J=NEVEN/2+1                                                   SPTS9740
000252        JJ=JUMP(J)                                                    SPTS9750
000255        MM=MTL(J)                                                     SPTS9760
000260        CALL CLOCK (L,MM,JJ)                                          SPTS9770
000262        PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                         SPTS9780
000300        DUM=TIMELP(1)                                                 SPTS9790
000303        GO TO 30                                                      SPTS9800
        C                                                                   SPTS9810
000303  500   K=500                                                         SPTS9820
000304        PRINT 120, K,MM                                               SPTS9830
000314        L=6                                                           SPTS9840
000315        JJ=3                                                          SPTS9850
000316        CALL CLOCK (L,MM,JJ)                                          SPTS9860
000321        PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                         SPTS9870
000337        DUM=TIMELP(1)                                                 SPTS9880
000341        L=9                                                           SPTS9890
000343        CALL CLOCK (L,MM,JJ)                                          SPTS9900
000345        PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                         SPTS9910
000363        DUM=TIMELP(1)                                                 SPTS9920
000366        GO TO 30                                                      SPTS9930
        C                                                                   SPTS9940
000366  600   K=600                                                         SPTS9950
000367        PRINT 120, K,MM                                               SPTS9960
000377        L=2                                                           SPTS9970
000400        MM=MM+5                                                       SPTS9980
000402        JJ=1                                                          SPTS9990
000403        CALL CLOCK (L,MM,JJ)                                          SPTS9 0
000406        PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                         SPTS9 10
000424        DUM=TIMELP(1)                                                 SPTS9 20
000427        GO TO 30                                                      SPTS9 30
        C                                                                   SPTS9 40
000427  700   K=700                                                         SPTS9 50
000430        PRINT 120, K,MM                                               SPTS9 60
000440        L=8                                                           SPTS9 70
000441        CALL CLOCK (L,MM,JJ)                                          SPTS9 80
000444        PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                         SPTS9 90
000462        DUM=TIMELP(1)                                                 SPTS9100
000465        GO TO 30                                                      SPTS9110
        C                                                                   SPTS9120
000465  800   K=800                                                         SPTS9130
```

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continued

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```
000466          PRINT 120, K,MM                                          SPTS9140
000476          L=7                                                      SPTS9150
000477          CALL CLOCK (L,MM,JJ)                                     SPTS9160
000502          PRINT 130,        MM,JJ,L,NEVEN,NEVEQ                    SPTS9170
000520          DUM=TIMELP(1)                                            SPTS9180
000523          GO TO 30                                                 SPTS9190
          C                                                              SPTS9200
          C                                                              SPTS9210
000523    120   FORMAT (1H0,*ENTITY *,I5,*   ACTIVATED AT SIMULATION TIME =  *,I8)SPTS9220
000523    130   FORMAT (1H0,30X          I8,14X,I8,14X,I8,10X,I10,10X,I10)  SPTS9230
000523      140 FORMAT(30X,      *SIMULATED TIME*10X*JUMP ADDR*19X,        SPTS9240
                1 *L*16X*NEVEN*16X*NEVEQ*///)                            SPTS9250
000523          END                                                      SPTS9260
```

000 0071

SAMPLE OUTPUT

```
*****     CLOCK          *****          DATE  01/27/70     PAGE NO.  49          NORTHWESTERN UNIVERSITY  S P U R T

.. CP TIME SINCE LAST CALL ..    .047 SECONDS
                         SIMULATED TIME          JUMP ADDR                L                NEVEN                NEVEQ

                                -1                  -1                   1                  0                   0
                                 0                   4                   2                  1                   0
                                 1                   3                   2                  2                   0
                                 0                   7                   2                  3                   0
                                 1                   5                   2                  4                   0
                                 5                   2                   2                  5                   0
                                 1                   7                   2                  6                   0
                                 2                   6                   2                  7                   0
                                 8                   2                   2                  8                   0
                                 2                   7                   2                  9                   0
                                 3                   6                   2                 10                   0
.. CP TIME SINCE LAST CALL ..    .046 SECONDS

                                 0                   4                   4                  9                   0

.. CP TIME SINCE LAST CALL ..    .006 SECONDS

ENTITY   400   ACTIVATED AT SIMULATION TIME =        0
                                 2                   6                   3                  8                   0

.. CP TIME SINCE LAST CALL ..    .009 SECONDS
                                 .                   .                   .
                                 .                   .                   .
                                 .                   .                   .
```

continued

```
ERROR ENCOUNTERED IN ROUTINE ...CLOCK

    REQUEST FOR NEXT SCHEDULED TIME OF OCCURANCE OF EVENT UNSATISFIED ... EVENT NOT ON LISTS

PROGRAM CONTINUING...

*****************************************************************************************************
                          -99999                3                6                3                0
 .. CP TIME SINCE LAST CALL ..    .039 SECONDS

                          -99999                3                9                3                0
 .. CP TIME SINCE LAST CALL ..    .006 SECONDS

                               3                6                4                2                0
 .. CP TIME SINCE LAST CALL ..    .006 SECONDS
                                                .                .                .
                                                .                .                .
                                                .                .                .

ERROR ENCOUNTERED IN ROUTINE ...CLOCK
    BOTH CLOCK LISTS EXHAUSTED.

JOB TERMINATED.
```

USER INSTRUCTIONS—SPURT2: Stochastic Generators

The STOGN (stochastic-generating) functions enable the user to generate samples from various user-defined probability distributions and calculate sample values.

All of the STOGN functions that produce random values use the standard library random-number-generating function RANF. Unless otherwise preset, the seed (and, therefore, the entire stream of numbers generated) is the same for each run. To change the seed, the user should CALL RANSET (SEED) during his simulation system initialization. A convenient value for SEED may be determined by SEED = TIME(0). This should produce a new seed each time.

NOTE: The user is cautioned to use a TYPE statement in all of his routines that use the stochastic generators. Failure to specify the routine name as a TYPE INTEGER could result in improper evaluation of mixed-mode expressions.

STOGN1

```
REAL FUNCTION STOGN1(NN,XXX,ORD,K)
TYPE REAL XXX, ORD
TYPE INTEGER NN, K
```

STOGN1 is a discrete, empirical, probability distribution, defined by the user. This FORTRAN function accesses a user-defined probability distribution that is called by VALUE = STOGN1 (NN,XXX,ORD,K). For each empirical probability distribution that the user employs, he must define two two-dimensional arrays XXX and ORD, with the 2nd subscript of these two arrays being the identification number that the user assigns to the probability distribution. K is the name of the probability distribution. Any allowable variable names of TYPE REAL may be substituted for XXX and ORD. The arrays must be dimensioned in the user's program, along with defining the variable NN.

STOGN2

```
REAL FUNCTION STOGN2(NN,XXX,ORD,K)
TYPE REAL XXX, ORD
TYPE INTEGER NN, K
```

STOGN2 enables the user to approximate a continuous probability distribution by means of a piecewise linear one. The statement VALUE = STOGN2(NN,XXX,ORD,K) will cause to be returned values that represent a random sample from a particular distribution. Otherwise, the same rules apply to the general case for STOGN2 as for STOGN1.

continued

000 0071
SPURT2

STOGN6

```
REAL FUNCTION STOGN6(N,P)
TYPE REAL P
TYPE INTEGER N
```

STOGN6 enables th user to obtain a random sample from the negative binomial distribution, with parameters N (number of successful trials) and P (probability of success). S is the value returned by STOGN6 and represents the number of unsuccessful trials. The call is of the form S = STOGN6(N,P). The user is cautioned to observe the restrictions of $N \geq 0$ and $0.0 < P < 1.0$.

UNIFRM, NORMAL

```
REAL FUNCTION UNIFRM(A,B)
REAL FUNCTION NORMAL(A,B)
TYPE REAL A,B
```

UNIFRM obtains a sample of real values that are equally likely to fall between the values A and B, where $A < B$. The user is able to sample from a uniform distribution defined on the interval from A to B. The function is called by XNUM = UNIFRM(A,B).

NORMAL allows the user to obtain a random sample from a normal distribution, with mean A and standard deviation B. FUNCTION NORMAL is called by XNUM = NORMAL(A,B).

RANDIN

```
INTEGER FUNCTION RANDIN(A,B)
TYPE INTEGER A,B
```

RANDIN(A,B) provides a uniform distribution of integers between the limits of A and B. The value is one of the integers A, A + 1, ···, B − 1, B, where $A < B$, with equal probability of each. The call to this function is of the form NUM = RANDIN(A,B).

LINEAR, DRAW

```
REAL FUNCTION LINEAR(A,B)
LOGICAL FUNCTION DRAW(A)
TYPE REAL A,B
```

LINEAR provides the user with a random supply from a (cumulative) distribution function F, which is obtained by linear interpolation in a nonequidistant table defined by A and B, such that A(i) = F(B(i)). It is assumed that A and B are one-dimensional real arrays of the same length, that the first and last elements of A are equal to 0.0

continued

and 1.0, respectively, and that A(i) < A(j) and B(i) < B(j) for i < j. The call to LINEAR is XNUM = LINEAR(A,B).

DRAW returns a value of .TRUE. with the probability A and .FALSE. with the probability 1 − A. DRAW is always .TRUE. if A ≥ 1 and is always .FALSE. if A ≤ 0. Consider the following example of the use of the function DRAW: IF (DRAW(0.72)) 20, 30. This will transfer control to statement 20 with a probability of occurrance of 0.72 and to statement 30 with a probability of 0.28.

NEGEXP, ERLANG

```
REAL FUNCTION NEGEXP(A)
REAL FUNCTION ERLANG(A,B)
TYPE REAL A,B
```

NEGEXP obtains a random sample from the negative exponential distribution with mean 1/A, defined by −(1/A) [ln(random number)]. This is the same as random "waiting time" in a Poisson-distributed arrival pattern with expected number of arrivals per unit time equal to A. A call to FUNCTION NEGEXP could be XNUM = NEGEXP(A) or XNUM = NEGEXP(1.0/XMEAN).

ERLANG obtains a random sample from the Erlang distribution with mean 1/A and standard deviation 1/(A√B). It is defined by B basic drawings of a random number, if B is an integer value, or, otherwise, by B + 1 drawings. Both A and B must be greater than zero in the call to ERLANG: XNUM = ERLANG(A,B).

POISSN

```
INTEGER FUNCTION POISSN(A)
TYPE REAL A
```

POISSN provides a random sample from the Poisson distribution with parameter A. It is obtained by n + 1 basic drawings of random numbers, where n is the function value defined as the smallest non-negative integer for which

$$\prod_{i=0}^{n} \mathrm{RANF}(0) < e^{-A},$$

where RANF is the random-number-generating function. When the parameter of A is greater than 20.0, the value is approximated by the integer value of NORMAL(A, SQRT(A)) or, when this is negative, by zero. A sample call is of the form NUM = POISSN(A).

continued

DISCRT

INTEGER FUNCTION DISCRT(A)
TYPE REAL A

The one-dimensional real array A is interpreted as a step function of the subscript, defining a discrete (cumulative) distribution function. The function value is an integer in the range [lsb − 1, usb − 1], where lsb and usb are the lower and upper subscript bounds of the array. It is defined as the smallest i, such that A(i + 1) > μ, where μ is the basic random number produced by RANF and where A(usb) = 1.0. The call is of the form NUM = DISCRT(A).

HISTD

INTEGER FUNCTION HISTD(A)
TYPE REAL A

HISTD provides the user with the random value of an integer in the range [lsb, usb], where lsb and usb are the lower and upper subscript bounds of the one-dimensional real array A. The latter is interpreted as a histogram defining the relative frequencies of the values.

This function is more time-consuming than the function DISCRT, where the cumulative distribution function is given, but it is more useful if the frequency histogram is dynamically updated at run time. A sample call is NUM = HISTD(A).

RANPER

SUBROUTINE RANPER(N,M)
TYPE INTEGER N,M

Subroutine RANPER generates a uniformly distributed, random permutation of the integers 1, 2, ···, M and stores it in the array N, where N is an integer-valued array of dimension M(≥1). RANPER is called by CALL RANPER(N,M).

continued

000 0071

Job Deck Structure

```
Job Cards
Run(s)
LIBRARY(SPURT1,SPURT6)
LGO.
7-8-9 (EOR Card)
Main-Problem Cards
   PROGRAM(INPUT,OUTPUT,PUNCH,PLOT,TAPE5=INPUT, 1 TAPE6=OUTPUT,
   TAPE7=PUNCH,TAPE17=PLOT)
   .
   .
   .
   END
Subroutine Card(s)
   SUBROUTINE ACTION1
   .
   .
   .
   END
   .
   .
   .
   SUBROUTINE ACTIONZ
   .
   .
   .
   END
7-8-9 (EOR Card)
Data Cards
6-7-8-9 (EOI Card)
```

NOTE: The file assignments shown on the Main-Program header card are the standard SPURT assignments.

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SAMPLE INPUT

```
                SUBROUTINE TESTGEN                                      SPTS1  0
          C                                                             SPTS1 10
          C     ***************************************************************SPTS1 20
          C                                                             SPTS1 30
          C     THIS PROGRAM IS PART OF THE NORTHWESTERN UNIVERSITY     SPTS1 40
          C                                                             SPTS1 50
          C                       S  P  U  R  T                         SPTS1 60
          C                                                             SPTS1 70
          C        A SIMULATION PACKAGE FOR UNIVERSITY RESEARCH AND TEACHING  SPTS1 80
          C                                                             SPTS1 90
          C     ***************************************************************SPTS1100
          C                                                             SPTS1110
          C                                                             SPTS1120
          C     ***************************************************************SPTS1130
          C                                                             SPTS1140
          C     THIS IS A TEST PROGRAM TO CHECK THE RESULTS OF THE      SPTS1150
          C     THE RANDOM NUMBER GENERATORS OF THE SPURT PACKAGE       SPTS1160
          C     THIS ROUTINE WILL ALSO CHECK THE PERFORMANCE OF THE HISTOGRAM  SPTS1170
          C     AND PLOT PACKAGE  ( STIX1,STIX2,STIX3,GRAPH,ENDPLT)     SPTS1180
          C                                                             SPTS1190
          C     ***************************************************************SPTS1200
          C                                                             SPTS1210
000002          INTEGER RANDIN,POISSN,HISTD,DISCRT                      SPTS1220
000002          TYPE LOGICAL DRAW                                       SPTS1230
000002          REAL NORMAL,LINEAR                                      SPTS1240
000002          REAL NEGEXP                                             SPTS1250
000002          DIMENSION X4(5)                                         SPTS1260
000002          COMMON /QPLOTQ/ A(5),PLOTSW                             SPTS1270
000002          DIMENSION XXX2(3,2), ORD2(3,2), XXX1(5,1), ORD1(5,1)    SPTS1280
000002          COMMON VALUES1(104)                                     SPTS1290
               1         ,VALUES2(104), VALUES3(104), VALUES7(104), VALUES8(104), SPTS1300
               1VALUES9(104)                                            SPTS1310
000002          DATA (X4=,15,,35,,35,1,5,1,0)                           SPTS1320
000002          DATA (XXX2=0,2,0,7,1,0,0,4,0,99,1,0),(ORD2=4,0,5,0,6,0,11,0,15,0,1SPTS1330
               15,0),(XXX1=0,0,0,15,0,50,0,85,1,00),(ORD1=0,0,1,0,2,0,3,0,4,0)  SPTS1340
000002          DUM=TIMELP(0)                                           SPTS1350
000005          CALL STIX1(VALUES2,7,0,3,0,40,VALUE,6HSTOGN1,6)         SPTS1360
000013          DO 10 I=1,10000                                         SPTS1370
000015          VALUE=STOGN1(3,XXX2,ORD2,1)                             SPTS1380
000021          CALL STIX2(VALUES2,7,0,3,0,40,VALUE,6HSTOGN1,6)         SPTS1390
000027       10 CONTINUE                                                SPTS1400
000031          CALL STIX3(VALUES2,7,0,3,0,40,VALUE,6HSTOGN1,6)         SPTS1410
000040          DUM=TIMELP(1)                                           SPTS1420
000043          CALL STIX1(VALUES1,4,0,0,0,40,VALUE,6HSTOGN2,6)         SPTS1430
000051          DO 30 I=1,10000                                         SPTS1440
000053          VALUE=STOGN2(5,XXX1,ORD1,1)                             SPTS1450
000057          CALL STIX2(VALUES1,4,0,0,0,40,VALUE,6HSTOGN2,6)         SPTS1460
000065       30 CONTINUE                                                SPTS1470
000067          CALL STIX3(VALUES1,4,0,0,0,40,VALUE,6HSTOGN2,6)         SPTS1480
000076          DUM=TIMELP(1)                                           SPTS1490
000101          CALL STIX1(VALUES9,40,0,0,0,40,VALUE,6HSTOGN6,6)        SPTS1500
000107          DO 70 I=1,10000                                         SPTS1510
000111          VALUE=STOGN6(10,0,5)                                    SPTS1520
000114          CALL STIX2(VALUES9,40,0,0,0,40,VALUE,6HSTOGN6,6)        SPTS1530
000122       70 CONTINUE                                                SPTS1540
000124          CALL STIX3(VALUES9,40,0,0,0,40,VALUE,6HSTOGN6,6)        SPTS1550
000133          DUM=TIMELP(1)                                           SPTS1560
```

continued

000 0071

000 0071

```
000136          CALL STIX1(VALUES1,21.0,-21.0,42,VALUE,6HRANDIN,6)          SPTS1570
000144          DO 90 I=1,10000                                             SPTS1580
000146          VALUE=RANDIN(-20,20)                                        SPTS1590
000151          CALL STIX2(VALUES1,21.0,-21.0,42,VALUE,6HRANDIN,6)          SPTS1600
000160     90   CONTINUE                                                    SPTS1610
000162          CALL STIX3(VALUES1,21.0,-21.0,42,VALUE,6HRANDIN,6)          SPTS1620
000171          DUM=TIMELP(1)                                               SPTS1630
000174          CALL STIX1(VALUES1,4.0,-4.0,40,VALUE,6HNORMAL,6)            SPTS1640
000202          DO 100 I=1,10000                                            SPTS1650
000204          VALUE=NORMAL(0.0,1.0)                                       SPTS1660
000207          CALL STIX2(VALUES1,4.0,-4.0,40,VALUE,6HNORMAL,6)            SPTS1670
000215    100   CONTINUE                                                    SPTS1680
000217          CALL STIX3(VALUES1,4.0,-4.0,40,VALUE,6HNORMAL,6)            SPTS1690
000226          DUM=TIMELP(1)                                               SPTS1700
000231          CALL STIX1(VALUES1,20.0,0.0,40,VALUE,6HPOISSN,6)            SPTS1710
000237          DO 110 I=1,10000                                            SPTS1720
000241          VALUE=POISSN(5.0)                                           SPTS1730
000243          CALL STIX2(VALUES1,20.0,0.0,40,VALUE,6HPOISSN,6)            SPTS1740
000252    110   CONTINUE                                                    SPTS1750
000254          CALL STIX3(VALUES1,20.0,0.0,40,VALUE,6HPOISSN,6)            SPTS1760
000263          DUM=TIMELP(1)                                               SPTS1770
000266          CALL STIX1(VALUES1,10.0,0.0,40,VALUE,6HERLANG,6)            SPTS1780
000274          DO 130 I=1,10000                                            SPTS1790
000276          VALUE=ERLANG(0.5,2.0)                                       SPTS1800
000301          CALL STIX2(VALUES1,10.0,0.0,40,VALUE,6HERLANG,6)            SPTS1810
000307    130   CONTINUE                                                    SPTS1820
000311          CALL STIX3(VALUES1,10.0,0.0,40,VALUE,6HERLANG,6)            SPTS1830
000320          DUM=TIMELP(1)                                               SPTS1840
000323          CALL STIX1(VALUES1,4.5,.5,40,VALUE,5HHISTD,5)               SPTS1850
000331          DO 140 I=1,10000                                            SPTS1860
000333          VALUE=HISTD(X4)                                             SPTS1870
000335          CALL STIX2(VALUES1,4.5,.5,40,VALUE,5HHISTD,5)               SPTS1880
000344    140   CONTINUE                                                    SPTS1890
000346          CALL STIX3(VALUES1,4.5,.5,40,VALUE,5HHISTD,5)               SPTS1900
000355          DUM=TIMELP(1)                                               SPTS1910
000360          CALL STIX1(VALUES1,1.5,-.5,10,VALUE,4HDRAW,4)               SPTS1990
000366          DO 170 I=1,10000                                            SPTS1  0
000370          IF(DRAW(0.69)) 162,164                                      SPTS1 10
000373      162 VALUE=1.0                                                   SPTS1 20
000375          GO TO 166                                                   SPTS1 30
000375      164 VALUE=0.0                                                   SPTS1 40
000376      166 CONTINUE                                                    SPTS1 50
000376          CALL STIX2(VALUES1,1.5,-.5,10,VALUE,4HDRAW,4)               SPTS1 60
000405    170   CONTINUE                                                    SPTS1 70
000407          CALL STIX3(VALUES1,1.5,-.5,10,VALUE,4HDRAW,4)               SPTS1 80
000416          DUM=TIMELP(1)                                               SPTS1 90
000421          RETURN                                                      SPTS1100
000421          END                                                         SPTS1110
```

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***** STIX3 ***** DATE 01/27/70 PAGE NO. 2 NORTHWESTERN UNIVERSITY S P U R T

THIS DATA IS ACCOMPANIED BY GRAPH NUMBER 1

STOGN1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION
10000	5.101	.700

	UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN	CUMULATIVE PROBABILITY
UNDERFLOW								
	3.000	0	0.000	0.000	100.000	.588	-3.001	.001
	3.100	0	0.000	0.000	100.000	.608	-2.858	.002
	3.200	0	0.000	0.000	100.000	.627	-2.715	.003
	3.300	0	0.000	0.000	100.000	.647	-2.573	.005
	3.400	0	0.000	0.000	100.000	.667	-2.430	.008
	.		.	.	.		.	.
	.		.	.	.		.	.
	.		.	.	.		.	.

***** GRAPH ***** DATE 01/27/70 PAGE NO. 3 NORTHWESTERN UNIVERSITY S P U R T

GRAPH NUMBER 1 HAS JUST BEEN PLOTTED ON CALCOMP

THE PLOT IS OF ...

STOGN1

VS.

FREQUENCY (PER CENT)

END OF OUTPUT BY GRAPH

.. CP TIME SINCE LAST CALL .. 5.395 SECONDS

continued

000 0071

***** STIX3 ***** DATE 01/27/70 PAGE NO. 10 NORTHWESTERN UNIVERSITY S P U R T

THIS DATA IS ACCOMPANIED BY GRAPH NUMBER 5

NORMAL

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION
10000	.007	1.006

	UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN	CUMULATIVE PROBABILITY
UNDER/LOW								
	-4.000	0	0.000	0.000	100.000	-567.722	-3.984	.000
	-3.800	0	0.000	0.000	100.000	-539.336	-3.785	.000
	-3.600	1	.010	.010	99.990	-510.950	-3.586	.000
	-3.400	0	0.000	.010	99.990	-482.564	-3.387	.000
	-3.200	8	.080	.090	99.910	-454.178	-3.189	.001
	-3.000	11	.110	.200	99.800	-425.791	-2.990	.001
	-2.800	15	.150	.350	99.650	-397.405	-2.791	.003
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	3.000	18	.180	99.860	.140	425.791	2.976	.999
	3.200	5	.050	99.910	.090	454.178	3.175	.999
	3.400	6	.060	99.970	.030	482.564	3.373	1.000
	3.600	2	.020	99.990	.010	510.950	3.572	1.000
	3.800	0	0.000	99.990	.010	539.336	3.771	1.000
OVERFLOW	XXXXXXXXXXXXXX	1	.010	100.000	.000	567.722	3.970	1.000
	4.200	0	0.000	100.000	.000	596.108	4.169	1.000

continued

000 0071

2/70

***** INSOUT ***** DATE 01/27/70 PAGE NO. 38 NORTHWESTERN UNIVERSITY S P U R T

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
201	202	203	204	205	206	207	208	209	210

***** STIX3 ***** DATE 01/27/70 PAGE NO. 18 NORTHWESTERN UNIVERSITY S P U R T

THIS DATA IS ACCOMPANIED BY GRAPH NUMBER 9

DRAW

ENTRIES IN TABLE 10000 MEAN ARGUMENT .690 STANDARD DEVIATION .463

	UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN	CUMULATIV PROBABILIT
UNDERFLOW	-.500	0	0.000	0.000	100.000	-.725	-2.572	.00
	-.300	0	0.000	0.000	100.000	-.435	-2.139	.01
	-.100	0	0.000	0.000	100.000	-.145	-1.707	.04
	.100	3103	31.030	31.030	68.970	.145	-1.275	.10
	.300	0	0.000	31.030	68.970	.435	-.842	.20
	.500	0	0.000	31.030	68.970	.725	-.410	.34
	.700	0	0.000	31.030	68.970	1.015	.022	.50
	.900	0	0.000	31.030	68.970	1.305	.455	.67
	1.100	6897	68.970	100.000	.000	1.595	.887	.81
	1.300	0	0.000	100.000	.000	1.885	1.319	.90
OVERFLOW	xxxxxxxxxx	0	0.000	100.000	.000	2.175	1.752	.96
	1.700	0	0.000	100.000	.000	2.465	2.184	.98

EDUCATIONAL INFORMATION NETWORK
000 0071
SPURT 2

continued

***** STIX3 ***** DATE 01/27/70 PAGE NO. 16 NORTHWESTERN UNIVERSITY S P U R T

THIS DATA IS ACCOMPANIED BY GRAPH NUMBER 8

HISTO

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION
10000	2.500	.915

	UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN	CUMULATIVE PROBABILITY
UNDERFLOW								
	.500	0	0.000	0.000	100.000	.200	-2.187	.014
	.600	0	0.000	0.000	100.000	.240	-2.078	.019
	.700	0	0.000	0.000	100.000	.280	-1.969	.025
	.800	0	0.000	0.000	100.000	.320	-1.859	.032
	.900	0	0.000	0.000	100.000	.360	-1.750	.040
	1.000	0	0.000	0.000	100.000	.400	-1.640	.050
	1.100	1471	14.710	14.710	85.290	.440	-1.531	.063
	:		:			:	:	
	4.000	0	0.000	85.390	14.610	1.600	1.640	.949
	4.100	1461	14.610	100.000	.000	1.640	1.749	.960
	4.200	0	0.000	100.000	.000	1.680	1.859	.968
	4.300	0	0.000	100.000	.000	1.720	1.968	.975
	4.400	0	0.000	100.000	.000	1.760	2.077	.981
OVERFLOW	XXXXXXXXXXXX4.500	0	0.000	100.000	.000	1.800	2.187	.986
	4.600	0	0.000	100.000	.000	1.840	2.296	.989

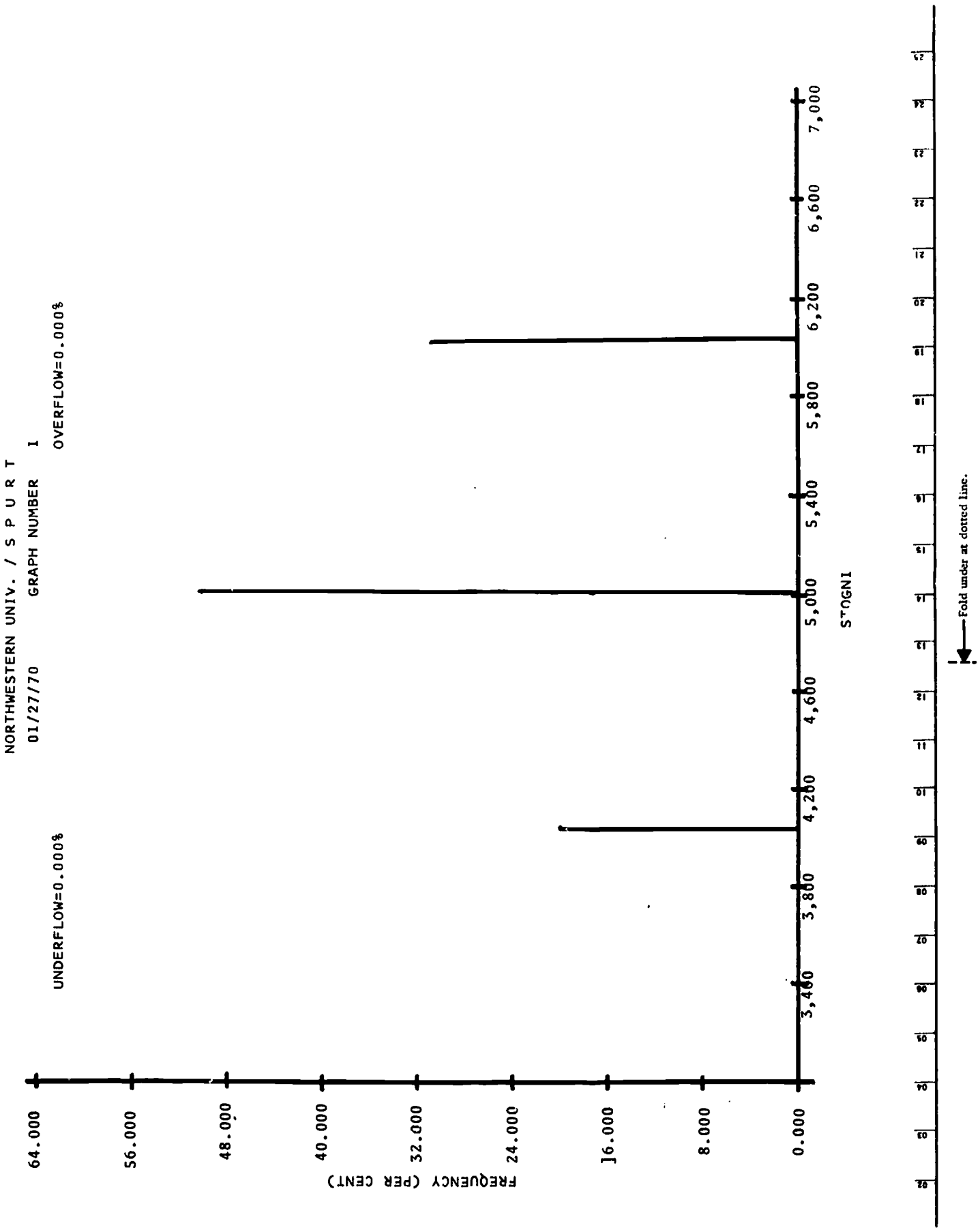
***** INSOUT ***** DATE 01/27/70 PAGE NO. 32 NORTHWESTERN UNIVERSITY S P U R T

C1 C2 C3 C4 C5 C6 C7 C8 C9 C10

11 12 13 14 15 16 17 18 19 20

continued

000 0071



000 0071

USER INSTRUCTIONS—SPURT3: Statistical Computations

STIX1, STIX2, STIX3

```
SUBROUTINE STIX1, STIX2, and STIX 3 (TABLE,VMAX,VMIN,NINK,VAB,
   ITITLE,LNTHTL)
TYPE REAL VAB,TABLE,VMAX,VMIN
TYPE INTEGER NINK,LNTHL
ITITLE is a Hollerith constant
```

These three subroutines accumulate and print out a frequency table and, optionally, plot a CalComp histogram. The calls to these STIX are

```
CALL STIX1(TABLE,VMAX,VMIN,NINK,VAB,ITITLE,LNTHTL)
CALL STIX2(TABLE,VMAX,VMIN,NINK,VAB,ITITLE,LNTHTL)
CALL STIX3(TABLE,VMAX,VMIN,NINK,VAB,ITITLE,KNTHTL)
```

VAB is the variable being accumulated; TABLE is the frequency table used for accumulating a count of the different values of the variable VAB; NINK is the number of increments desired in the table; VMAX and VMIN are the maximum and minimum values, respectively, in the table.

The dimension TABLE must be specified in the user's program and *must have at least NINK + 4 entries*. The additional four entries count those values of VAB that are either greater or less than the range specified by VMAX and VMIN (i.e., overflow and underflow) and also accumulate a running sum and sum of squares for use by STIX3.

ITITLE is a Hollerith constant (defined either in a DATA statement or in the calling sequence) that is used to label the plot produced by STIX. LNTHTL is the length of the title, specified as the *number of characters in ITITLE*.

NOTE: The user is required to pass the same parameters to STIX1, STIX2, and STIX3 for each user-defined frequency table being built and plotted.

The three routines are used as follows. STIX1 will initialize the frequency table to zero. STIX2 will add a one to the proper counter in TABLE associated with the current value of VAB. STIX3 will print out the frequency table TABLE and a plot of the histogram will occur at the user's option. If a CalComp plot has been made, the user is cautioned to place a call to ENDPLT before any possible program terminations. (See Ref. 1, p. 6.3.)

continued

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SPURT3

STIX4

```
SUBROUTINE STIX4 (X,N,XMIN,XMAX,STADEV,XBAR)
TYPE REAL X,XMIN,XMAX,STADEV,XBAR
TYPE INTEGER N
```

STIX4 takes a one-dimensional array X(1), ···, X(N), which represents values of a variable X, and computes the mean (XBAR), standard deviation (STADEV), maximum value (XMAX), and the minimum value (XMIN). The call is of the form CALL STIX4 (X,N,XMIN, XMAX,STADEV,XBAR), where X is an array of length N that is defined in the calling program. XMIN, XMAX, STADEV, and XBAR are the values returned by the arguments of STIX4.

STIX5

```
SUBROUTINE STIX5 (X,Y,N,CORR)
TYPE REAL X,Y,CORR
TYPE INTEGER N
```

STIX5 requires two one-dimensional arrays, X(1), ···, X(N) and Y(1), ···, Y(N), which represent the values of two variables X and Y. If the correlation coefficient of these two arrays is desired, then the following call is made to STIX5: CALL STIX5 (X, Y,N,CORR). This call will return to the user in CORR the value of the correlation coefficient between the two arrays X and Y.

STIX6

```
SUBROUTINE STIX6 (A,N,AMEDIAN,RANGE)
TYPE REAL A,AMEDIAN,RANGE
TYPE INTEGER N
```

STIX6 is designed to rank a one-dimensional array A and return the value of the median and the range of the data contained in the N data entries of A. STIX6 is called by CALL STIX6 (A,N, AMEDIAN,RANGE). The routine uses a bubble sort to rank the data. This enables the user to call STIX6, with dummy parameters for AMEDIAN and RANGE, and use it just to sort a one-dimensional array.

NOTE: For ranking two-dimensional arrays, see List-Processing and Queue-Manipulation, SPURT4: subroutines RANKQS, IRNKQS, RANKQL, and IRNKQL.

STIX7

```
SUBROUTINE STIX7 (X,N,XI,XF,DX,MUNIT,ISTAT,MODE,IHIST,ITITLE,LNTH)
TYPE REAL X,XI,XF,DX
```

continued

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TYPE INTEGER N,ISTAT,MODE,IHIST,LNTH
MUNIT and ITITLE are Hollerith constants

The call for STIX7 is CALL STIX7 (X,N,XI,XF,DX,MUNIT,ISTAT,MODE, IHIST,ITITLE,LNTH). STIX7 will produce a statistical description of the data found in the first N locations of array X. MUNIT is a variable that contains the units in which the members of X are measured. ISTAT is a control parameter. If its value is nonzero, the sample size, mean, standard deviation, standard error, minimum value, maximum value, and range will be printed out. If ISTAT equals zero, these will be suppressed.

In a similar manner, a nonzero value for MODE will cause the mode to be printed out and a nonzero value of IHIST will cause a histogram to be printed on the line printer. ITITLE is the title of the histogram and consists of LNTH characters, where LNTH $\leq$ 90. If the mode and/or histogram is desired, XI, XF, and DX must be defined. (They must always be included in the calling sequence, however.) XI denotes the initial value for the histogram; XF is the final value; DX is the increment. STIX7 is set up to handle 100 increments between XI and XF. The value printed for each DX is the benchmark (median) value of that interval.

WARNING: If ISTAT = MODE = IHIST = 0, *no printout will result. Make sure that at least one of these parameters is nonzero.*

Job Deck Structure

```
Job Cards
Run(s)
LIBRARY(SPURT2,SPURT3,SPURT6)
LGO.
7-8-9 (EOR Card)
Main-Problem Card(s)
   PROGRAM(INPUT,OUTPUT,PUNCH,PLOT,TAPE5=INPUT, 1 TAPE6=OUTPUT,
   TAPE7=PUNCH,TAPE17=PLOT)
   .
   .
   .
   END
Subroutine Card(s)
   SUBROUTINE ACTION1
   .
   .
   .
   END
   .
   .
   .
```

continued

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SPURT3

```
   SUBROUTINE ACTIONZ
   .
   .
   .
   END
```

7–8–9 (EOR Card)
Data Cards
6–7–8–9 (EOI Card)

NOTE: The file assignments on the Main-Program header card are the standard SPURT assignments.

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SAMPLE INPUT

```
                SUBROUTINE TESTCOR                                      SPTS4  0
          C                                                             SPTS4 10
          C     ***************************************************** SPTS4 20
          C                                                             SPTS4 30
          C     THIS PROGRAM IS PART OF THE NORTHWESTERN UNIVERSITY     SPTS4 40
          C                                                             SPTS4 50
          C                        S  P  U  R  T                        SPTS4 60
          C                                                             SPTS4 70
          C        A SIMULATION PACKAGE FOR UNIVERSITY RESEARCH AND TEACHING SPTS4 80
          C                                                             SPTS4 90
          C     ***************************************************** SPTS4100
          C                                                             SPTS4110
          C                                                             SPTS4120
          C     ***************************************************** SPTS4130
          C                                                             SPTS4140
          C     THIS IS A TEST PROGRAM TO CHECK THE RESULTS OF THE      SPTS4150
          C     STIX5(CORRELATION COEF.) ROUTINE OF THE SPURT  PACKAGE  SPTS4160
          C     STIX6 IS ALSO TESTED                                    SPTS4170
          C                                                             SPTS4180
          C     ***************************************************** SPTS4190
          C                                                             SPTS4200
000002          COMMON X(2000),Y(2000)                                  SPTS4210
000002          DO 10 I=1,2000                                          SPTS4220
000004          X(I)=RANF(-1)                                           SPTS4230
000010    10    Y(I)=RANF(-1)                                           SPTS4240
000016          PRINT 80                                                SPTS4250
000021       80 FORMAT(5/,* TEST OF STIX5 AND STIX6*)                   SPTS4260
000021       20 FORMAT(3/,* COEFFICIENT OF CORRELATION BETWEEN *,A7,    SPTS4270
                1* AND *,A7,* = *,F9.5)                                 SPTS4280
000021          DUM=TIMELP(0)                                           SPTS4290
000024          CALL STIX5(X,X,2000,R)                                  SPTS4300
000027          N1=1HX                                                  SPTS4310
000030          N2=1HX                                                  SPTS4320
000032          PRINT 20,N1,N2,R                                        SPTS4330
000044          DUM=TIMELP(0)                                           SPTS4340
000047          CALL STIX5(X,Y,2000,R)                                  SPTS4350
000052          N2=1HY                                                  SPTS4360
000054          PRINT 20,N1,N2,R                                        SPTS4370
000065          DUM=TIMELP(1)                                           SPTS4380
000070          CALL STIX6(X,2000,AMEDIAN,RANGE)                        SPTS4390
000073          PRINT 30,N1,AMEDIAN,RANGE                               SPTS4400
000105          DUM=TIMELP(1)                                           SPTS4410
000110          CALL STIX6(Y,2000,AMEDIAN,RANGE)                        SPTS4420
000113          N1=1HY                                                  SPTS4430
000115          PRINT 30,N1,AMEDIAN,RANGE                               SPTS4440
000126          DUM=TIMELP(1)                                           SPTS4450
000131          RETURN                                                  SPTS4460
          C                                                             SPTS4470
          C                                                             SPTS4480
          C                                                             SPTS4490
000131       30 FORMAT( ///* FOR THE VARIABLE *,A7,* MEDIAN = *,F10.4,10X, SPTS4500
                1*RANGE = *,F10.4)                                      SPTS4510
000131          END                                                     SPTS4520
```

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SPUPT3

SAMPLE OUTPUT

```
*****     STIX4          *****          DATE  01/27/70      PAGE NO.  23


TEST OF STIX4

        MIN =      14.065
        MAX =      18.956
        SIGMA =     1.445
        MEAN =     16.631

    .. CP TIME SINCE LAST CALL ..    .024 SECONDS


TEST OF STIX5 AND STIX6

COEFFICIENT OF CORRELATION BETWEEN X       AND X       =   1.00000

COEFFICIENT OF CORRELATION BETWEEN X       AND Y       =   -.02223
    .. CP TIME SINCE LAST CALL ..    .129 SECONDS

FOR THE VARIABLE X       MEDIAN =      .4946          RANGE =      .9996
    .. CP TIME SINCE LAST CALL ..   1.303 SECONDS

FOR THE VARIABLE Y       MEDIAN =      .4809          RANGE =      .9979
    .. CP TIME SINCE LAST CALL ..   1.273 SECONDS
```

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USER INSTRUCTIONS—SPURT4: Analog Simulators

The following two routines are designed to simulate an analog computer on a digital computer, thereby making it possible to obtain effects similar to those displayed by a hybrid. Both routines operate as integrators in an analog computer, integrating negatively with respect to time. Input (XIN) must be a floating-point number. Output (YOUT and TOUT) is two arrays, one giving values of time and the other giving the corresponding negative integral values. The output arrays are not printed out. Initial conditions Y may also be specified.

ANALOG

```
SUBROUTINE ANALOG(XIN,Y,YOUT,TOUT,T,DELTA,LIMIT,N)
TYPE REAL XIN,Y,YOUT,TOUT,T,DELTA
TYPE INTEGER LIMIT,N
```

Subroutine ANALOG is called in the following form: CALL ANALOG(XIN, Y,YOUT,TOUT,T,DELTA,LIMIT,N). The input value is XIN. YOUT and TOUT are the output arrays of integrated value and time, respectively. The user is cautioned to dimension YOUT and TOUT to the expected size in his program. Integration is carried out at discrete time intervals DELTA and for the number of intervals LIMIT. Any number of successive integrations N can be carried out. Thus, for N = 1, a first-order integration is performed; for N = 2, a second-order integration is performed; etc. Note that LIMIT and N are fixed-point numbers. T is the initial value of time, and TOUT(1) = T. Thus, TOUT(2) = T + DELTA and the last value TOUT(LIMIT) = T + DELTA *(LIMIT −1). Y is a vector of initial conditions of size N, where Y(1) is the initial value for the first-order integration, Y(2) for the second-order, etc. Thus, Y(1) gives the initial value of y; the output, Y(2), gives the initial value of $\int y\,dt$, etc. The array Y(N) must be dimensioned and provided in the user's program.

A second-order integration works exactly as do two successive integrators on an analog computer. Thus, for a positive input, the output array will also be positive.

SECND

```
SUBROUTINE SECND(XIN,YIC,DAMP,FREQ,T,YOUT,TOUT,DELTA,LIMIT)
TYPE REAL XIN,YIC,DAMP,FREQ,T,YOUT,TOUT,DELTA
TYPE INTEGER LIMIT
```

This routine provides the solution to the commonly used control equation

continued

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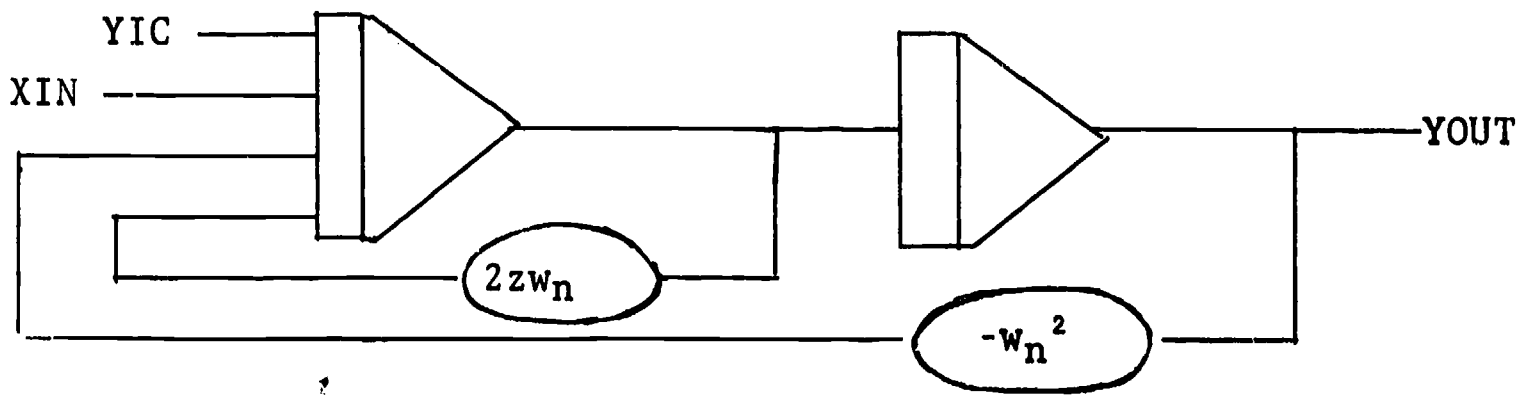
SPURT4

$$F(x) = d^2y/dt^2 = 2zw_n(dy/dt) + w_n^2y,$$

where z is the damping coefficient, w_n is the natural frequency, and F(x) is a constant forcing function (such as a step input). SECND is equivalent to the analog connection



and is similar in operation to the subroutine ANALOG.

The form of the call is CALL SECND(XIN,YIC,DAMP,FREQ,T,YOUT,TOUT, DELTA,LIMIT), where T is the initial value of time, DELTA is the integration interval, LIMIT the number of values calculated, and YOUT and TOUT the output arrays. All are defiend as in subroutine ANALOG. Only LIMIT is fixed-point and YOUT and TOUT must be dimensioned in the user's program. YIC is the initial value of YOUT. Thus, YOUT(1) = YIC. XIN is the forcing function F(x). DAMP is the damping coefficient z. FREQ is the natural frequency w_n.

<u>Job Deck Structure</u>

```
Job Cards
LIBRARY(SPURT5,SPURT6)
LGO.
7-8-9 (EOR Card)
Main-Problem Card(s)
   PROGRAM(INPUT,OUTPUT,PUNCH,PLOT,TAPE5=INPUT, 1 TAPE6=OUTPUT,
   TAPE7=PUNCH,TAPE17=PLOT)
   .
   .
   .
   END
Subroutine Card(s)
   SUBROUTINE ACTION1
   .
   .
   .
   END
```

continued

```
    .
    .
    .
    SUBROUTINE ACTIONZ
    .
    .
    .
    END
7-8-9 (EOR Card)
Data Cards
6-7-8-9 (EOI Card)
```

NOTE: The file assignments shown on the Main-Program header card are the standard SPURT assignments.

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SAMPLE INPUT/OUTPUT

The input for the Analog Simulators (SPURT4) will consist of floating-point numbers that are integrated negatively with respect to time. The output will be two arrays, one giving values of time and the other giving the corresponding negative integral values.

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USER INSTRUCTIONS—SPURT5: List-Processing and Queue-Manipulation

ADFIFO,ADLIFO,REMOVE,PURGE,DISPL,IDISPL,NUMLST

```
SUBROUTINE ADFIFO(LIST,N,M,ENTRY)
SUBROUTINE ADLIFO(LIST,N,M,ENTRY)
SUBROUTINE REMOVE(LIST,N,M,ENTRY)
SUBROUTINE PURGE(LIST,N,M)
SUBROUTINE DISPL(LIST,N,M)
SUBROUTINE IDISPL(LIST,N,M)
INTEGER FUNCTION NUMLST(LIST)
INTEGER N,M
REAL (or INTEGER) LIST,ENTRY
```

The manipulations of queues may be handled by the four subroutines ADFIFO, ADLIFO, REMOVE, and PURGE. REMOVE will remove the top (or first) element from the list. ADLIFO inserts an element at the top of the list, which will be removed before any of the elements presently on the list. ADFIFO adds an entry at the bottom of the list, which will be removed only after all the elements presently on the list are gone. Lists may be manipulated by using both ADLIFO and ADFIFO on the same list array. A printout of the contents of a list may be achieved by use of either DISPL or IDISPL.

The general form of the calls to these routines is as follows.

```
CALL ADFIFO(LIST,N.M.ENTRY)
CALL ADLIFO(LIST,N,M,ENTRY)
CALL REMOVE(LIST,N,M,ENTRY)
CALL PURGE(LIST,N,M)
CALL DISPL(LIST,N,M)
CALL IDISPL(LIST,N,M)
NUM = NUMLST(LIST)
```

In the calling sequence, LIST is the user-defined array of size NXM and ENTRY is the user-defined vector, dimensioned (1,M), used as a buffer. As LIST(1,1) contains the list pointer, only N – 1 entries (each of size 1XM) are allowed in any list.

NOTE: Before loading the initial entry to *any* list, be sure to clear the word LIST(1,1) to zero.

The subroutines are designed to place the contents of a buffer (ENTRY) onto a user-defiend list. The buffer ENTRY should be filled by the user's program before ADFIFO or ADLIFO are called. In the

continued

case of REMOVE, the first entry is taken from the list and placed in the buffer ENTRY. The user may then use its contents.

The integer function NUMLST will return the number of entries in a given list. IQ = NUMLST(LIST3) will assign a value to IQ equal to the number of entries in LIST3.

RANKQS, IRNKQS, RANKQL, IRNKQL

```
SUBROUTINE RANKQS(LIST,N,M,J)
SUBROUTINE IRNKQS(LIST,N,M,J)
SUBROUTINE RANKQL(LIST,N,M,J)
SUBROUTINE IRNKQL(LIST,N,M,J)
INTEGER N,M,J
REAL or INTEGER LIST
```

Four routines are provided to rank queues formed by other SPURT list-processing routines. They may be used by coding of the following form.

```
CALL RANKQS(LIST,N,M,J)
CALL IRNKQS(LIST,N,M,J)
CALL RANKQL(LIST,N,M,J)
CALL IRNKQL(LIST,N,M,J)
```

where LIST is the user-defined array of size NXM and J $\leq$ M represents the "entry" position that is to be used to produce the desired ranking.

Subroutine RANKQS ranks floating-point numbers with the smallest first and IRNKQL ranks integer numbers with the largest first. Similarly, INRKQS ranks integer numbers in ascending order.

SEARCH, INSERT, DELETE

```
INTEGER FUNCTION SEARCH(LIST,N,M,J,ID)
SUBROUTINE INSERT(LIST,N,M,ENTRY,INDEX)
SUBROUTINE DELETE(LIST,N,M,ENTRY,INDEX)
INTEGER N,M,J,INDEX
REAL or INTEGER LIST,ENTRY,ID
```

Three routines are provided to facilitate the locating, deleting, and inserting of entries in the middle of a list. The use of the INTEGER SEARCH function in the form INDEX = SEARCH(LIST,N,M,J,ID), where SEARCH is of type INTEGER, will search LIST (of size NXM) in entry position J for the desired ID. If a match is found, SEARCH returns the position in the list of the first entry to contain the desired ID. If no match is found, SEARCH returns a zero value.

continued

Thus, SEARCH may be used within an arithmetic or logical IF statement to determine the presence or absence of a desired entry. The user may use either an integer or a real variable as the fifth argument in a call to SEARCH.

If the ith entry has been located (say, by using SEARCH), then it may be removed by a call to DELETE in the form of CALL DELETE(LIST, N,M,ENTRY,INDEX), where INDEX is the number of the desired entry to be removed from LIST and placed in ENTRY.

To place a *new* i^{th} entry in the list, a call to INSERT in the form of CALL INSERT(LIST,N,M,ENTRY,INDEX) will create a new i^{th} entry (i is noted by INDEX).

Job Deck Structure

```
Job Cards
Run(s)
LIBRARY(SPURT4,SPURT6)
LGO.
7-8-9 (EOR Card)
Main-Problem Card(s)
   PROGRAM(INPUT,OUTPUT,PUNCH,PLOT,TAPE5=INPUT, 1 TAPE6=OUTPUT,
   TAPE7=PUNCH,TAPE17=PLOT)
   .
   .
   .
   END
Subroutine Card(s)
   SUBROUTINE ACTION1
   .
   .
   .
   END
   .
   .
   .
   SUBROUTINE ACTIONZ
   .
   .
   .
   END
7-8-9 (EOR Card)
Data Cards
6-7-8-9 (EOI Card)
```

SAMPLE INPUT

```
                SUBROUTINE LIST1                                        SPTS8  0
          C                                                             SPTS8 10
          C     ***********************************************************SPTS8 20
          C                                                             SPTS8 30
          C     THIS PROGRAM IS PART OF THE NORTHWESTERN UNIVERSITY     SPTS8 40
          C                                                             SPTS8 50
          C                        S  P  U  R  T                        SPTS8 60
          C                                                             SPTS8 70
          C        A SIMULATION PACKAGE FOR UNIVERSITY RESEARCH AND TEACHING SPTS8 80
          C                                                             SPTS8 90
          C     ***********************************************************SPTS8100
          C                                                             SPTS8110
000002          COMMON A1,B1,C1,A,B,C                                   SPTS8120
000002          INTEGER A,B,C,A1,B1,C1                                  SPTS8130
000002          DIMENSION A1(13,13), B1(12,17), C1(19,7)                SPTS8140
000002          DIMENSION A(20,20), B(10,20), C(20,10), NMROWS(20), NMCOLS(20)  SPTS8150
000002          DIMENSION IENTRY(1,10)                                  SPTS8160
000002          DATA (NMROWS=2HR1,2HR2,2HR3,2HR4,2HR5,2HR6,2HR7,2HR8,2HR9,3HR10,3HSPTS8170
                1R11,3HR12,3HR13,3HR14,3HR15,3HR16,3HR17,3HR18,3HR19,3HR20),(NMCOLSSPTS8180
                2=2HC1,2HC2,2HC3,2HC4,2HC5,2HC6,2HC7,2HC8,2HC9,3HC10,3HC11,3HC12,3HSPTS8190
                3C13,3HC14,3HC15,3HC16,3HC17,3HC18,3HC19,3HC20)         SPTS8200
000002          C=0                                                     SPTS8210
000003          M=0                                                     SPTS8220
000004          DUM=TIMELP(0)                                           SPTS8230
000006    10    I=0                                                     SPTS8240
000007    20    I=I+10                                                  SPTS8250
000011          DO 30 J=1,10                                            SPTS8260
000012          K=I+J                                                   SPTS8270
000014    30    IENTRY(1,J)=K                                           SPTS8280
000021          CALL INSOUT (IENTRY,1,10,NMROWS,NMCOLS)                 SPTS8290
000025          CALL ADFIFO (C,20,10,IENTRY)                            SPTS8300
000030          CALL IDISPL (C,20,10)                                   SPTS8310
000033          DUM=TIMELP(1)                                           SPTS8320
000036          IF ( I .LT. 20) GO TO20                                 SPTS8350
000040          I=0                                                     SPTS8360
000041    40    I=I+100                                                 SPTS8370
000043          DO 50 J=1,10                                            SPTS8380
000044          K=I+J                                                   SPTS8390
000046    50    IENTRY(1,J)=K                                           SPTS8400
000053          CALL INSOUT (IENTRY,1,10,NMROWS,NMCOLS)                 SPTS8410
000057          CALL ADLIFO (C,20,10,IENTRY)                            SPTS8420
000062          CALL IDISPL (C,20,10)                                   SPTS8430
000065          DUM=TIMELP(1)                                           SPTS8440
000070          IF ( I .LT. 200) GO TO 40                               SPTS8450
000072          DO 60 I=1,4                                             SPTS8460
000074          CALL REMOVE (C,20,10,IENTRY)                            SPTS8470
000077          CALL INSOUT (IENTRY,1,10,NMROWS,NMCOLS)                 SPTS8480
000103          CALL IDISPL (C,20,10)                                   SPTS8490
000106          DUM=TIMELP(1)                                           SPTS8500
000111    60    CONTINUE                                                SPTS8510
000113          RETURN                                                  SPTS8520
000113          END                                                     SPTS8530
```

```
*****    IDISPL    *****    DATE  01/27/70    PAGE NO.  33    NORTHWESTERN UNIVERSITY  S P U R T

LIST DISPLAY ROUTINE INITIATED ...

          OUTPUT IN FIXED POINT FORMAT

ENTRY NUMBER    1
     11         12        13        14        15        16        17        18        19
        20

END OF OUTPUT BY IDISPL

.. CP TIME SINCE LAST CALL ..    .042 SECONDS

*****    INSOUT    *****    DATE  01/27/70    PAGE NO.  34    NORTHWESTERN UNIVERSITY  S P U R T

          C1        C2        C3        C4        C5        C6        C7        C8        C9        C10
R1          21        22        23        24        25        26        27        28        29        30
```

continued

```
*****    IDISPL    *****    DATE  01/27/70    PAGE NO.  35    NORTHWESTERN UNIVERSITY  S P U R T

LIST DISPLAY ROUTINE INITIATED ...

                OUTPUT IN FIXED POINT FORMAT


ENTRY NUMBER    1
      11                12          13          14          15          16          17          18          19
          20

ENTRY NUMBER    2
      21                22          23          24          25          26          27          28          29
          30


END OF OUTPUT BY IOISPL


.. CP TIME SINCE LAST CALL ..    .053 SECONDS


*****    INSOUT    *****    DATE  01/27/70    PAGE NO.  36    NORTHWESTERN UNIVERSITY  S P U R T

          C1        C2        C3        C4        C5        C6        C7        C8        C9        C10
R1          101       102       103       104       105       106       107       108       109       110
```


continued

```
*****    IDISPL    *****    DATE  01/27/70    PAGE NO.  37    NORTHWESTERN UNIVERSITY  S P U R T

LIST DISPLAY ROUTINE INITIATED ...

          OUTPUT IN FIXED POINT FORMAT

ENTRY NUMBER    1     102     103     104     105     106     107     108     109
    101
        110

ENTRY NUMBER    2      12      13      14      15      16      17      18      19
     11
         20

ENTRY NUMBER    3      22      23      24      25      26      27      28      29
     21
         30

END OF OUTPUT BY IDISPL

.. CP TIME SINCE LAST CALL ..    .062 SECONDS
```

```
*****    IDISPL    *****    DATE  01/27/70    PAGE NO.  39    NORTHWESTERN UNIVERSITY  S P U R T

LIST DISPLAY ROUTINE INITIATED ...

              OUTPUT IN FIXED POINT FORMAT

ENTRY NUMBER    1
     201      202      203      204      205      206      207      208      209
     210

ENTRY NUMBER    2
     101      102      103      104      105      106      107      108      109
     110

ENTRY NUMBER    3
     11       12       13       14       15       16       17       18       19
     20

ENTRY NUMBER    4
     21       22       23       24       25       26       27       28       29
     30

END OF OUTPUT BY IDISPL

.. CP TIME SINCE LAST CALL ..    .070 SEC  DS

*****    INSOUT    *****    DATE  01/27/70    PAGE NO.  40    NORTHWESTERN UNIVERSITY  S P U R T

          C1       C2       C3       C4       C5       C6       C7       C8       C9       C10
R1       201      202      203      204      205      206      207      208      209      210
```


continued

000 0071

000 0071

```
*****    IDISPL    *****    DATE  01/27/70    PAGE NO.  41    NORTHWESTERN UNIVERSITY  S P U R T

LIST DISPLAY ROUTINE INITIATED ...

          OUTPUT IN FIXED POINT FORMAT

ENTRY NUMBER    1      101     102     103     104     105     106     107     108     109
      101  110

ENTRY NUMBER    2      11      12      13      14      15      16      17      18      19
      20

ENTRY NUMBER    3      21      22      23      24      25      26      27      28      29
      30

END OF OUTPUT BY IDISPL

.. CP TIME SINCE LAST CALL ..    .061 SECONDS

*****    INSOUT    *****    DATE  01/27/70    PAGE NO.  42    NORTHWESTERN UNIVERSITY  S P U R T

          C1      C2      C3      C4      C5      C6      C7      C8      C9      C10
R1        101     102     103     104     105     106     107     108     109     110
```

continued

```
*****   IDISPL   *****      DATE  01/27/70     PAGE NO.  43      NORTHWESTERN UNIVERSITY  S P U R T

*** DISPLAY ROUTINE INITIATED ***

                OUTPUT IN FIXED POINT FORMAT


ENTRY NUMBER     1
      11                12          13          14          15          16          17          18          19
          20

ENTRY NUMBER     2
      21                22          23          24          25          26          27          28          29
          30


END OF OUTPUT BY IDISPL


.. CP TIME SINCE LAST CALL ..    .053 SECONDS


*****   INSOUT   *****      DATE  01/27/70     PAGE NO.  44      NORTHWESTERN UNIVERSITY  S P U R T

          C1          C2          C3          C4          C5          C6          C7          C8          C9          C10
R1            11          12          13          14          15          16          17          18          19          20
```


continued

```
*****    IDISPL    *****    DATE  01/27/70    PAGE NO.  45    NORTHWESTERN UNIVERSITY  S P U R T

LIST DISPLAY ROUTINE INITIATED ...

          OUTPUT IN FIXED POINT FORMAT

ENTRY NUMBER    1
     21         22        23        24        25        26        27        28        29
        30

END OF OUTPUT BY IDISPL

.. CP TIME SINCE LAST CALL ..    .045 SECONDS

*****    INSOUT    *****    DATE  01/27/70    PAGE NO.  46    NORTHWESTERN UNIVERSITY  S P U R T

          C1        C2        C3        C4        C5        C6        C7        C8        C9        C10
R1          21        22        23        24        25        26        27        28        29        30
```

continued

LIST DISPLAY ROUTINE INITIATED ...

OUTPUT IN FIXED POINT FORMAT

NO ENTRIES ON LIST

END OF OUTPUT BY IDISPL

.. CP TIME SINCE LAST CALL .. .030 SECONDS

USER INSTRUCTIONS—SPURT6: Matrix and Graphical Output

OUT, IOUT

```
SUBROUTINE OUT(C,N,NAME)
SUBROUTINE IOUT(K,N,NAME)
TYPE REAL C
TYPE INTEGER N,K
Name is vector of Hollerith constants
```

Subroutine OUT prints out a square matrix with row and column headings. The form of the calling statement is CALL OUT(C,N,NAME), where C is the name of a two-dimensional square array, N is the number of rows (and columns) of the matrix C, and NAME is the name of a vector, dimensioned N in the user's program that contains the names to be printed over the columns (and along the rows). The heading of row j and column j will be the same, for j = 1, ···, N. The vector NAME must contain Hollerith constants of less than or equal to M (installation defined) characters defined in a DATA or assignment statement.

The matrix is printed out in sets of N rows by 10 columns. When the matrix printouts are placed beside one another, the entire matrix is represented.

The call to OUT assumes that *floating-point numbers* are to be printed out in E12.4 format. If the user wishes to print out *fixed-point numbers*, he should CALL IOUT(K,N,NAME), where K is an array of TYPE INTEGER and is to be printed out in I format.

NSOUT, INSOUT

```
SUBROUTINE NSOUT(C,NH,NV,NAMEH,NAMEV)
SUBROUTINE INSOUT(K,NH,NV,NAMEH,NAMEV)
TYPE REAL C
TYPE INTEGER NH,NV,K
NAMEH and NAMEV are vectors of Hollerith constants
```

Subroutine NSOUT is similar to subroutine OUT, except that NSOUT causes a nonsquare matrix, with appropriate row and column headings, to be printed out. The form of the CALL statement is CALL NSOUT(C, NH,NAMEH,NAMEV), where C is a two-dimensional array, NH is the number of rows of the array C, and NV is the number of columns of C. NAMEH is the name of a vector, dimensioned NH in the calling programs, that contains the names of the row headings. NAMEV is the name of a vector, dimensioned NV in the calling program, that contains the names of the column headings.

Calling the NSOUT subroutine causes the matrix C to be printed out

continued

in sets of N rows by 10 columns. The subroutine differs from OUT in that it allows column headings to differ from row headings.

The call to NSOUT assumes that *floating-point numbers* are to be printed out in E12.4 format. If the user wishes to print out *fixed-point numbers*, he should CALL INSOUT(K,NH,NAMEH,NAMEV), where K is an integer array to be printed out in I format.

GRAPH

SUBROUTINE GRAPH(NAMEX,LNTHX,NAMEY,LNTHY,X,Y,N)
TYPE REAL X,Y
TYPE INTEGER LNTHX,LNTHY,N
NAMEX and NAMEY are Hollerith constants

GRAPH produces two-dimensional graphs or plots on the CalComp plotter, requiring two one-dimensional arrays A and B of the same size, where $A = a_1, \cdots, a_n$, $B = b_1, \cdots, b_n$, and yielding a plot whose points are connected by straight line segments. When the user desires to print out a graph, he uses the following statement: CALL GRAPH(NAMEX,LNTHX,NAMEY,LNTHY,X,Y,N), where NAMEX is the label for the X axis. LNTHX is the *number of characters* in the title NAMEX. Similarly, NAMEY is the label for the Y axis and LNTHY is the number of characters in it. X and Y are the names of one-dimensional arrays (of the same size) to be plotted. N is the total number of points to be plotted, plus two. That is, if each array contains p entries, then N would be p + 2.

The following statement must appear immediately before all legal termination points in the user's program: CALL ENDPLT. This finalizes the output for the CalComp plotter. Note that no parameters are to be passed within the call to NEDPLT.

NOTE: The user may have titles of a length greater than M (installation defined) *only* if they are defined as Hollerith characters in the *calling sequence* to the GRAPH subroutine.

PAGE

SUBROUTINE PAGE(NAME)
NAME is a Hollerith constant

This routine is called to produce a page ejection in the printout of a program. It will inset up to M (installation defined) characters, found in NAME, into a heading that includes the date and page number. The most obvious use of NAME is to supply the name of the subroutine calling PAGE. For example, CALL PAGE(NAME). The routines in SPURT that produce page ejections (CLOCK, STIX2, etc.) all do so by calling

continued

PAGE. Thus, if a page number is to be meaningful to the user, he also must eject pages by a call to PAGE.

Job Deck Structure

```
Job Cards
LIBRARY(SPURT3,SPURT6)
LGO.
7-8-9 (EOR Card)
Main-Problem Card(s)
   PROGRAM(INPUT,OUTPUT,PUNCH,PLOT,TAPE5=INPUT, 1 TAPE6=OUTPUT,
   TAPE7=PUNCH,TAPE17=PLOT)
   .
   .
   .
   END
Subroutine Card(s)
   SUBROUTINE ACTION1
   .
   .
   .
   END
   .
   .
   .
   SUBROUTINE ACTIONZ
   .
   .
   .
   END
7-8-9 (EOR Card)
Data Cards
6-7-8-9 (EOI Card)
```

NOTE: The file assignments shown on the Main-Program header card are the standard SPURT assignments.

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SAMPLE INPUT

```
                SUBROUTINE EXAMPL1                                      SPTS2  0
          C                                                             SPTS2 10
          C     ******************************************************SPTS2 20
          C                                                             SPTS2 30
          C     THIS PROGRAM IS PART OF THE NORTHWESTERN UNIVERSITY     SPTS2 40
          C                                                             SPTS2 50
          C                        S  P  U  R  T                        SPTS2 60
          C                                                             SPTS2 70
          C        A SIMULATION PACKAGE FOR UNIVERSITY RESEARCH AND TEACHING SPTS2 80
          C                                                             SPTS2 90
          C     ******************************************************SPTS2100
          C                                                             SPTS2110
000002          COMMON/QPLOTQ/UNUSED(5),IPLTSW                          SPTS2120
000002          DIMENSION T(104)                                        SPTS2130
000002          TYPE REAL NEGEXP                                        SPTS2140
000002          DUM=TIMELP(0)                                           SPTS2150
000005          CALL STIX1 (T,20.0,0.0,100,VALUE,22HDEPTH OF WATER IN TANK,22)  SPTS2160
000013          DO 10 I=1,300                                           SPTS2170
000015          VALUE=20.0-NEGEXP(0.2)                                  SPTS2180
000020    10    CALL STIX2 (T,20.0,0.0,100,VALUE,22HDEPTH OF WATER IN TANK,22)  SPTS2190
000031          CALL STIX3 (T,20.0,0.0,100,VALUE,22HDEPTH OF WATER IN TANK,22)  SPTS2200
000040          DUM=TIMELP(1)                                           SPTS2210
000043          RETURN                                                  SPTS2220
000043          END                                                     SPTS2230
```

continued

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SAMPLE OUTPUT

THIS DATA IS ACCOMPANIED BY GRAPH NUMBER 10

DEPTH OF WATER IN TANK

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION
300	14.665	5.070

	UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN	CUMULATIVE PROBABILITY
UNDERFLOW								
	0.000	6	2.000	2.000	98.000	0.000	-2.892	.002
	.200	0	0.000	2.000	98.000	.014	-2.853	.002
	.400	0	0.000	2.000	98.000	.027	-2.814	.002
	.600	0	0.000	2.000	98.000	.041	-2.774	.003
	.800	0	0.000	2.000	98.000	.055	-2.735	.003
	1.000	0	0.000	2.000	98.000	.068	-2.695	.004
	1.200	0	0.000	2.000	98.000	.082	-2.656	.004
	1.400	0	0.000	2.000	98.000	.095	-2.616	.004
	1.600	0	0.000	2.000	98.000	.109	-2.577	.005
	1.800	0	0.000	2.000	98.000	.123	-2.537	.006
	2.000	0	0.000	2.000	98.000	.136	-2.498	.006
	2.200	1	.333	2.333	97.667	.150	-2.459	.007
		.	.	.	.	.		
		.	.	.	.	.		
		.	.	.	.	.		

continued

	15.600	3	1.000	46.000	54.000	1.064	.184	.573
	15.800	4	1.333	47.333	52.667	1.077	.224	.589
	16.000	5	1.667	49.000	51.000	1.091	.263	.604
	16.200	5	1.667	50.667	49.333	1.105	.303	.619
	16.400	4	1.333	52.000	48.000	1.118	.342	.634
	16.600	7	2.333	54.333	45.667	1.132	.382	.649
	16.800	9	3.000	57.333	42.667	1.146	.421	.663
	17.000	3	1.000	58.333	41.667	1.159	.460	.677
	17.200	4	1.333	59.667	40.333	1.173	.500	.691
	17.400	7	2.333	62.000	38.000	1.186	.539	.705
	17.600	3	1.000	63.000	37.000	1.200	.579	.719
	17.800	7	2.333	65.333	34.667	1.214	.618	.732
	18.000	8	2.667	68.000	32.000	1.227	.658	.745
	18.200	6	2.000	70.000	30.000	1.241	.697	.757
	18.400	10	3.333	73.333	26.667	1.255	.737	.769
	18.600	11	3.667	77.000	23.000	1.268	.776	.781
	18.800	4	1.333	78.333	21.667	1.282	.815	.793
	19.000	8	2.667	81.000	19.000	1.296	.855	.804
	19.200	7	2.333	83.333	16.667	1.309	.894	.814
	19.400	13	4.333	87.667	12.333	1.323	.934	.825
	19.600	12	4.000	91.667	8.333	1.336	.973	.835
	19.800	8	2.667	94.333	5.667	1.350	1.013	.844
OVERFLOW	XXXXXXXXXXXX	17	5.667	100.000	.000	1.364	1.052	.854
	20.200	0	0.000	100.000	.000	1.377	1.092	.862

GRAPH NUMBER 10 HAS JUST BEEN PLOTTED ON CALCOMP

THE PLOT IS OF ...

DEPTH OF WATER IN TANK

VS.

FREQUENCY (PER CENT)

END OF OUTPUT BY GRAPH

continued

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COST ESTIMATE

For the SPURT TESGEN package listed on the Sample Input, the total running time was 91.59 seconds for the central-processor time and 46.597 seconds for the peripheral-processor time. Chargeable computer time was $14.16

Charge to user = computer time + postage and handling + network overhead

= $14.16 + $15.00 + network overhead

= $29.16 + network overhead

CONTENTS—SPURT

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DESCRIPTIVE TITLE	FORTRAN Program to Assist in the Process of Political Reapportionment
CALLING NAME	T8 FSU BELOW
INSTALLATION NAME	Computer Center The Florida State University
AUTHOR(S) AND AFFILIATION(S)	William Below, Consultant Assembly Committee on Elections and Reapportionment California Legislature
LANGUAGE	CDC FORTRAN IV
COMPUTER	CDC 6400-65K
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Raymond Soller, Program Librarian/EIN Techncial Representative, Computing Center, Florida State University, Tallahassee, Fla. 32306 Tel.: (904) 599-4770

FUNCTIONAL ABSTRACT

BELOW is a program to assist with the development of political reapportionment plans using a set of procedures representative of the methods employed by legislatures to reapportion themselves. The actual algorithms utilized by the program are modifications of the computational techniques originally outlined by Stuart Nagel.[1]

The programmed procedures are those which follow. An initial district plan is determined by assigning geographic units to districts. This initial plan is fed into the processor along with demographic and political data for each unit. The program then tests each possible move of a unit from one district to another and then each trade of units between adjacent districts against a set of criteria. If the plan is approved according to the criterion; then the move or trade is made permanent. Where no more useful moves or trades can be made, the results are printed out and the program is terminated.

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The criterion used by the program is expressed as a linear combination of three quantities, SVEA, SVCA, SVPA;

$$CRIT = WE \cdot SVEA + WC \cdot SVCA + SVPA$$

where SVEA, SVCA, and SVPA are measures of population equality, compactness, and conformance to political goals, and WE and WC are weighting coefficients for the purpose of establishing the relative importance of the three quantities. CRIT, the criterion, is recomputed for each tentative move or trade. If its value is less than its previous value, the move or trade is consummated.

Population Equality

The measure of population equality is given by

$$SVEA = \sum_{J=1}^{NDA} \left[\frac{[PD\ (J) - AVGPOP\ (J)]}{AVGPOP\ (J)} \cdot 100 \right]^2$$

where NDA is the number of districts in the area, PD (J) is the population of district J and AVGPOP (J) is the ideal population. SVEA may be described as the sum of the squared fractional deviations from the ideal population for all districts in the area.

Multiplication of the fractional deviation by 100 is not significant to the operation of the program; it simply indicates that the deviation is output as a percentage. The use of the fractional rather than the absolute deviation is significant because it makes the effect of WE, (the relative importance of population equality), independent of the ideal population. Similar considerations apply to the decision to use total rather than average deviation for the area. If average deviation were used, then the proper setting of WE would depend on the number of districts in the area.

The opportunity for the user to set the ideal population for each district independently may at first seem arbitrary. In practice, this allows the program to be used on areas which contain portions of districts as well as whole districts.

This method of measuring population equality does not differ markedly from methods used by others in the field. One obvious alternative, namely, use of the sum of the absolute deviations, might be quite acceptable as a measure of equality to a student government, but it suffers from some computational disadvantages.

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As a population unit moves from one district to another, the absolute deviation changes only if one district is above, while the other is below the ideal population. The formula given here for SVEA however, has the convenient property that when two districts are both above or below the ideal population, a unit moved from one district to the other causes a change in SVEA, proportional to the difference in population between the two districts.

Compactness

The method originally tried for measuring compactness determines the "population moment" around the population center of the district. This method is attractive because it tends to minimize travel distance within the district and keep concentrations of population unbroken by district lines.

If there is a large number of units per district, the population moment method, unfortunately, can yield districts which are numerically compact, yet have very irregular boundaries. Since a legislature, as it reapportions itself, prefers to avoid even the appearance of gerrymandering, the author found the population moment method unsatisfactory for his purposes.

The alternative method, now in use, involves estimation of the perimeter of each district. The estimation is inherently inexact, but tends to produce district lines which are politically acceptable.

The program counts the perimeter elements in the perimeter of each district. A perimeter element is that portion of a unit perimeter which is shared with one other unit. Of course, these elements vary in length, but the program assumes each to have unit length.

One of the attractive features of the perimeter method is that it dispenses with the use of the X and Y coordinates required for the population moment method. What may be unattractive to some users is that the perimeter method does not tend to improve or even affect the overall shape of a district unless the initial district plan deviates widely from the desired characteristics.

Thus, if the program is given a district which is rectangular, and which is much longer than it is wide, the lines will be kept straight, but there will be little or no tendency for that district to change toward a square or circular shape. This property is often quite convenient in the legislative environment.

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In principle, it would be possible to measure the length of each perimeter element, include the data in the information fed to the processor, and work with a true perimeter measurement. Making those measurements, however, would be even more tedious than preparing the X and Y data, and may not necessarily improve program performance.

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Political Considerations

The political portion of the criterion, CRIT, is given by

$$SVPA = \sum_{J=1}^{NDA} WP\ (J) \left[\frac{PAD\ (J) \cdot 100}{PBD\ (J)} - DESPR\ (J) \right]^2$$

where WP (J) is a political weighting coefficient that may be set independently for each district, PAD (J) and PBD (J) are political quantities for district and DESPR (J) is the desired ratio of PAD (J) to PBD (J) expressed as a percentage.

PAD (J) and PDB (J) may stand for different things in different districts according to a number called MODE (J). If MODE (J) were set to 1, for example, and DESPR (J) to 55, then the program would set PAD (J) to equal registered Democrats and PBD (J) to equal total registered voters, and the goal for Democratic registration in that district would be 55%.

In the same manner, setting MODE (J) to 2 or 3 will establish a goal for the percentage of Negroes or persons with a Spanish surname in the population. The information for each unit necessary to establish any of the three proportions is carried in the memory of the processor. Consequently, there are no restrictions on moving a unit between districts with different modes.

Constraints on Moving and Trading

By the inclusion of the one card per unit in the data deck, the user may forbid the program to move or trade any number of units out of their original districts. The most common use of this feature is to ensure that incumbents are left in their own districts. Another use is to protect the integrity of municipal areas.

REFERENCES

1. Nagel, S., "Simplified Bipartisan Computer Redistricting," *Stanford Law Review, 17*, No. 5, May 1965.

2. Below, W., "The Computer as an Aid to Legislative Reapportionment," (Report to California Legislature, Assembly Committee on Elections and Reapportionment).

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Unit Card

One Unit Card is needed for each Census tract, enumeration district, precinct, or other geographical unit.

Columns	*Identification*	*Contents*
1		1: Unit Card label
2– 7	UNIT CODE	alphanumeric unit code used to identify a unique geographic unit.
8–11	PU	population count within the unit
12–15	P1	population characteristic one
16–19	P2	population characteristic two
20–23	P3	population characteristic three
24–27	P4	population characteristic four
		In a single pass of the program the selected data that is tabulated into district totals (P1/P2, P3/POPULATION, P4/POPULATION) is determined by the value of MODE
38–79 partioned into 7 fields of 6 columns	TOUCHLIST	listing of all unit codes which are adjacent to the unit identified in Cols. 2–7.
80	NL	number of neighbors entered into TOUCHLIST field

The TOUCHLIST is used for establishing and maintaining contiguity, so all rules and assumptions concerning contiguity should be considered when compiling the TOUCHLIST. The TOUCHLIST is also used to measure compactness. The computations are more precise if reciprocity is observed. Reciprocity implies that if Unit A is a member of the TOUCHLIST for Unit B, then Unit B is also a member of the TOUCHLIST for Unit A.

TOUCHLIST Continuation Card

If there are more than seven neighbors in a unit's TOUCHLIST the remaining neighbors may be inserted on a Continuation Card. A unit may have as many Continuation Cards as needed.

continued

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Columns	*Identification*	*Contents*
1		2: Unit Continuation Card label
38–79	TOUCHLIST	listing of unit code neighbors continued from previous card
80	NL	number of neighbors entered into the TOUCHLIST field

The total number of entries for the complete TOUCHLIST must not exceed 8500.

"Eight" Card

This card signals the end of the initial district data.

Columns	*Identification*	*Contents*
1		8: "Eight" Card label

Status Card

A Status Card is necessary if the possible moves or trades of a unit out of its district are to be restricted. One card is required required for each such specified unit, and must follow an "Eight" Card.

Columns	*Identification*	*Contents*
1		4: Status Card label
2– 7	UNIT CODE	alphanumeric unit code used to identify a unique geographic unit.
11		1: flag which restricts unit movements

"Nine" Card

This card initiates the district processing, and must follow the status cards if present or an "Eight" Card.

Columns	*Identification*	*Contents*
1		9: "Nine" Card Label

Parameter Update Card

An update pass is possible by changing the label field (Col. 1) to a 5 and by adjusting the proper parameters. All entries must be present even if they repeat the items on the Parameter Card. If it is desired to end the restrictions on a unit, then include a Status Card with a zero in Col. 11.

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Any number of reruns can be made, but each successive run will continually distort its relation to the initial district plan.

Sense Switches

Sense switches can be set from the console by the machine operator or by a SWITCH CARD in the set of system control cards accompanying the job.

SWITCH, n.

where n is a switch from 1 to 6, which should be set on.
sense switch 2 on - suppress most printer output.
sense switch 3 on - (by operator intervention only) Terminates program in orderly manner.
sense switch 5 on - suppress trading mode of operation which normally begins when no more moves can be made

Output

The printed output of the program consists of a one page report for each district and an area summary for the initial plan, for the final plan, and for each successive rerun.

Each district report includes a complete list of the units in the district, a partial list showing only units on the edge of the district (for map drawing), and a numerical description of the district. The quantities "A" and "B" correspond to two of the quantities P1, P2, P3, or P4 according to the mode setting.

One line is printed summarizing the results of each major program loop. These lines appear between the initial and final district report pages. The numbers under NTM and NTT indicate the number of proposed moves and trades in each loop which satisfy the contiguity requirements and hence the number of times the program sections which tentatively recompute the criterion function are entered. These loop summaries are also printed on-line unless sense switch 2 is down.

Error Message

An error condition caused by improper data card punching results in an error message printed both off-line and on-line followed by exit. The message is head by "DATA ERROR" and consists of the following items.

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Item	*Contents*
IRD (1)	Col. 1 of last card read
IRD (2)	Cols. 2–7 of last card read
I	Internal unit counter
J	Internal district counter
K	Internal TOUCHLIST counter
M	See program listing
LPTYP	See program listing
JRET	See program listing

"Not in Area" Message

Each TOUCHLIST entry which does not have a corresponding Unit Card is listed under the heading "ON TOUCHLIST, NOT IN AREA." Two hundred such entries can be accomodated by the program. The presence of unmatched TOUCHLIST entries does not constitute an error condition and is common when a subset of the Unit Cards for an area is used for a program run.

"Not Contiguous" Message

A check for contiguity is made on the initial district plan. If any initial district is not contiguous a message of the form "DISTRICT J NOT CONTIGUOUS" is printed. The program does not stop since this condition is not necessarily disastrous to the program run. The operator may, however, be instructed to terminate execution when this message appears on-line.

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SAMPLE INPUT

```
0        100  25 400  10  -0   -0   -0L.A. CONGESSIONAL REAPPORTIONMENT - BELOW *
3          1 1004376   1   1   -0   -0                                          *
1      1 7021766 9601011   1   -0   -0     6     9     2     3   635  1296      6
1      2 500 803 4981012   1   -0   -0     1     3     4                        3
1      3 4511114 3701013   1   -0   -0     1   635   636     5     4     2      6
1      4 284 961 3921014   1   -0   -0     9     2     3     5                  4
1      5 6591677 7681021   1   -0   -0    75    65     8     9     4   636   6397
2         -0  -0  -0  -0  -0   -0   -0   658   661     3                        3
1      6 8021710 8791031   1   -0   -0     7     9     1  1297                  4
1      7 4011098 5761032   1   -0   -0     8     9     6    10  1297            5
1      8 3811376 4301033   1   -0   -0    10    65     5     9     7            5
1      9 5721554 6741034   1   -0   -0     5     4     1     6     7     8      6
1     35131046962214111 2  1   -0   -0    38    40    44    36    34    23  12947
1     36 4991645 9941113   1   -0   -0    35    43    42    37                  4
1     38 201 706 2921131   1   -0   -0    39    40    35  1294                  4
1     39 9472994128311 32  1   -0   -0    38    40    41   140   141   142  12947
1     40 8592371114611 33  1   -0   -0    39    41    44    35    38            5
1     41151825311123113 4  1   -0   -0    39   139   125    44    40            5
1     42 5421657 7281151   1   -0   -0    36    43    45    48                  4
1     43 7051907101011 52  1   -0   -0    36    44    45    42                  4
1     44 1721579 8701153   1   -0   -0    40    41   125    45    43    35      6
1     45 6631626 8681154   1   -0   -0    44   124   123   122   121   120    487
2         -0  -0  -0  -0  -0   -0   -0    42    43                              2
                 .                        .                 .
                 .                        .                 .
                 .                        .                 .
1   1149 168  -0  -05990  16   -0   -0  1147  1150                              2
1   1150  39  -0  -05991  16   -0   -0  1149  1147                              2
3         17 1004376   1   1   -0   -0                                          *
1   1072141132411726570 0 17   -0   -0  1063  1062  1073  1079  1080  1081  10647
1   1080 6951382 8435708  17   -0   -0  1072  1079  1084  1081                  4
1   1081114426541658570 9 17   -0   -0  1072  1080  1083  1082  1064            5
1   1082 8471756118357 10 17   -0   -0  1081  1083  1109  1110  1069            5
1   1083119924971492571 1 17   -0   -0  1081  1084  1108  1109  1082            5
1   1109 700   0   05737  17   -0   -0  1082  1083  1108  1113  1110            5
1   1110 683   0   05738  17   -0   -0  1082  1109  1112  1111  1069            5
1   1111  16   0   05739  17   -0   -0  1110  1112  1146  1117  1071  1069      6
8         -0  -0  -0  -0  -0   -0   -0                                          *
9         -0  -0  -0  -0  -0   -0   -0                                          *
```


000 0072

SAMPLE OUTPUT

DISTRICT 1 L.A. CONGESSIONAL REAPPORTIONMENT - BELOW
INITIAL

UNITS

1	2	3	4	5	6	7	8	9	35
36	38	39	40	41	42	43	44	45	75
92	93	94	95	96	97	99	100	101	117
119	125	126	133	134	139	140	141	142	143
144	145	146	148	149	164	165	166	169	170
171	172	173	174	175	176	178	179	662	665
666	667	668	669	670	671	672	673	674	675
676	1268	1269	1270	1271	1272	1273	1274	1275	1276
1277	1278	1279	1280	1281	1282	1283	1284	1285	1286
1287	1288	1289	1290	1291	1292	1293	1294	1297	

UNITS ON EDGE OF DISTRICT

1	3	5	7	8	35	36	42	45	75
92	93	94	95	96	97	99	100	101	117
119	125	126	133	134	143	144	146	148	149
166	169	170	176	178	179	662	665	666	668
669	671	673	674	675	676	1288	1290	1294	1297

POPULATION	VARIATION	PCT VARIATION	SQRD VARIATION	WEIGHTED
50625.0000	6865.0000	15.6878	246.1084	246.1084

A	B	PROPORTION	SQRD VARIATION	WEIGHTED
123162.0000	68169.0000	190.6716	6507.9016	65.0790

NO OF UNITS	WP	DESPR	COMPACTNESS	WEIGHTED
99.0000	.0100	100.0000	98.0000	392.0000

TOTAL CONTRIBUTION TO CRITERION = 703.1874

continued

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DISTRICT 2 L.A. CONGESSIONAL REAPPORTIONMENT - BELOW
INITIAL

UNITS

10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	37	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	98	102	103	104	105	106	107	108	109
110	111	112	113	114	115	116	118	120	121
122	123	124	127	128	129	130	131	132	135
136	677	678	679						

UNITS ON EDGE OF DISTRICT

10	11	18	19	20	21	22	23	34	37
48	65	74	76	78	83	85	86	87	89
90	91	98	113	115	116	118	120	121	122
123	124	132	135	136					

POPULATION	VARIATION	PCT VARIATION	SQRD VARIATION	WEIGHTED
51716.0000	7956.0000	18.1810	330.5483	330.5483

A	B	PROPORTION	SQRD VARIATION	WEIGHTED
90056.0000	68748.0000	130.9944	960.6501	9.6065

NO OF UNITS	WP	DESPR	COMPACTNESS	WEIGHTED
104.0000	.0100	100.0000	62.0000	248.0000

TOTAL CONTRIBUTION TO CRITERION = 588.1548

continued

000 0072

DISTRICT 17 L.A. CONGESSIONAL REAPPORTIONMENT - BELOW
INITIAL

UNITS

1072 1080 1081 1082 1083 1109 1110 1111

UNITS ON EDGE OF DISTRICT

1072 1080 1081 1082 1083 1109 1110 1111

POPULATION	VARIATION	PCT VARIATION	SQRD VARIATION	WEIGHTED
6695.0000	-37065.0000	-84.7006	7174.1984	7174.1984

A	B	PROPORTION	SQRD VARIATION	WEIGHTED
11530.0000	6902.0000	167.0530	4496.1086	44.9611

NO OF UNITS	WP	DESPR	COMPACTNESS	WEIGHTED
8.0000	.0100	100.0000	20.0000	80.0000

TOTAL CONTRIBUTION TO CRITERION = 7299.1595

1	2	3	4	5	6	7	8	9	35	36	38	39	40	41	42	43	44	45	75
92	93	94	95	96	97	99	100	101	117	119	125	126	133	134	139	140	141	142	143
144	145	146	148	149	164	165	166	169	170	171	172	173	174	175	176	178	179	662	665
666	667	668	669	670	671	672	673	674	675	676	1268	1269	1270	1271	1272	1273	1274	1275	1276
1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1297	10
.									.									.	
.									.									.	
993	994	995	996	997	998	999	1000	1001	1002	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033
1034	1035	1036	1037	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1063	1062	1073	1074
1075	1076	1077	1078	1079	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098
1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121
1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141
1142	1143	1144	1145	1146	1147	1148	1149	1150	1072	1080	1081	1082	1083	1109	1110	1111			

CHARACTERISTICS OF THE AREA L.A. CONGESSIONAL REAPPORTIONMENT - BELOW

INITIAL

	TOT VAR	WEIGHT	VAR X WEIGHT
EQUALTIY	20392.66467	1.00000	20392.66467
POLITICAL			1073.13172
COMPACTNESS	1219.00000	4.00000	4876.00000

CRITERION = 26341.79639

continued

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LOOP	MOVES	TRADES	COMPACTNESS	EQUALITY	POLITICAL	CRITERION	NTM	NTT
0	0	0	1219.00000	20392.66467	1073.13172	26341.79639		
LOOP	MOVES	TRADES	COMPACTNESS	EQUALITY	POLITICAL	CRITERION	NTM	NTT
1	158	0	1289.00000	9643.07913	948.05748	15747.13661	606	0
2	120	0	1329.00000	5153.01916	930.84078	11399.85994	560	0
3	105	0	1379.00000	2178.37392	917.28298	8611.65690	556	0
4	93	0	1385.00000	827.30062	907.10967	7274.41029	565	0
5	68	0	1339.00000	253.83383	905.14882	6514.98265	555	0
6	45	0	1283.00000	121.17347	920.09572	6173.26920	555	0
7	27	0	1245.00000	95.37615	919.89828	5995.27443	553	0
8	26	0	1217.00000	60.09501	916.89478	5844.98979	545	0
9	13	0	1211.00000	59.23051	909.21067	5812.44119	537	0
10	17	0	1187.00000	66.48433	919.32627	5733.81060	534	0
11	13	0	1169.00000	69.77466	920.85634	5666.63100	533	0
12	15	0	1155.00000	66.44527	929.61987	5616.06513	533	0
13	16	0	1143.00000	51.90356	923.19476	5547.09832	522	0
14	6	0	1139.00000	45.85531	922.50439	5524.35971	525	0
15	13	0	1123.00000	49.64380	922.35721	5464.00101	514	0
16	3	0	1123.00000	43.31775	921.33409	5456.65184	516	0
17	4	0	1121.00000	42.50554	919.94415	5446.44969	514	0
18	6	0	1113.00000	42.82931	919.54397	5414.37328	514	0
19	0	0	1113.00000	42.82931	919.54397	5414.37328	513	0
20	5	16	1091.00000	52.48909	915.98888	5332.47798	519	2498
21	18	9	1059.00000	42.18904	917.03800	5195.22704	514	2367
22	12	13	1023.00000	35.10415	942.11087	5069.21502	498	2217
23	13	9	1011.00000	21.63398	927.43102	4993.06500	485	2150
24	9	6	999.00000	24.35529	920.78191	4941.05720	480	2112
25	12	3	987.00000	32.17103	911.84154	4876.01257	479	2073

continued

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DISTRICT 1 L.A. CONGESSIONAL REAPPORTIONMENT - BELOW
FINAL

UNITS

5	6	7	8	9	75	92	93	94	95
96	97	99	100	101	171	172	173	174	175
176	178	179	662	665	666	667	668	669	670
671	672	673	674	675	675	1268	1269	1270	1271
1272	1273	1274	1275	1276	1277	1278	1279	1280	1281
1282	1283	1284	1285	1286	1287	1288	1289	1290	1291
1292	1293	1297	10	11	12	16	18	19	20
21	22	24	25	65	73	74	76	77	78
79	85	86	87	88	89	90	98	677	678
177	658	659	660	661	663	664			

UNITS ON EDGE OF DISTRICT

5	6	9	92	93	178	179	673	674	675
1288	1290	1291	1292	1297	12	16	22	24	65
77	77	79	85	90	678	177	658	659	664

POPULATION	VARIATION	PCT VARIATION	SQRD VARIATION	WEIGHTED
44359.0000	599.0000	1.3698	1.8737	1.8737

A	B	PROPORTION	SQRD VARIATION	WEIGHTED
98099.0000	59135.0000	167.4102	4544.1301	45.4413

NO OF UNITS	WP	DESPR	COMPACTNESS	WEIGHTED
97.0000	.0100	100.0000	53.0000	212.0000

TOTAL CONTRIBUTION TO CRITERION = 259.3150

continued

DISTRICT 17
FINAL

L.A. CONGESSIONAL REAPPORTIONMENT - BELOW

UNITS

1018	1038	1039	1040	1041	1044	1045	1046	1047	1048
1049	1064	1065	1066	1067	1068	1069	1070	1071	1037
1050	1051	1052	1053	1054	1058	1059	1060	1061	1063
1062	1073	1074	1075	1077	1078	1079	1084	1085	1086
1087	1088	1089	1090	1091	1092	1093	1094	1096	1104
1105	1106	1107	1108	1112	1113	1114	1115	1116	1117
1072	1080	1081	1082	1083	1109	1110	1111		

UNITS ON EDGE OF DISTRICT

1018	1038	1039	1041	1044	1064	1037	1053	1054	1058
1074	1075	1089	1094	1096	1104	1105	1106	1114	1115
1117	1111								

POPULATION	VARIATION	PCT VARIATION	SQRD VARIATION	WEIGHTED
43462.0000	-298.0000	-.6810	.4637	.4637

A	B	PROPORTION	SQRD VARIATION	WEIGHTED
69513.0000	42115.0000	165.0552	4232.1798	42.3218

NO OF UNITS	WP	DESPR	COMPACTNESS	WEIGHTED
68.0000	.0100	100.0000	42.0000	168.0000

TOTAL CONTRIBUTION TO CRITERION = 210.7855

1	2	3	4	5	6	7	8	9	35	36	38	39	40	41	42	43	44	45	75
92	93	94	95	96	97	99	100	101	117	119	125	126	133	134	139	140	141	142	143
14	145	146	148	149	164	165	166	169	170	171	172	173	174	175	176	178	179	662	665
666	667	668	669	670	671	672	673	674	675	676	1268	1269	1270	1271	1272	1273	1274	1275	1276
1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	12 7	1288	1289	1290	1291	1292	1293	1294	1297	10
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
31	32	33	34	37	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
.									.									.	
.									.									.	
.									.									.	
993	994	995	996	997	998	999	1000	1001	1002	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033
1034	1035	1036	1037	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1063	1062	1073	1074
1075	1076	1077	1078	1079	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098
1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121
1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141
1142	1143	1144	1145	1146	1147	1148	1149	1150	1072	1080	1081	1082	1083	1109	1110	1111			

continued

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CHARACTERISTICS OF THE AREA L.A. CONGESSIONAL REAPPORTIONMENT - BELOW

FINAL

	TOT VAR	WEIGHT	VAR X WEIGHT
EQUALTIY	32.17103	1.00000	32.17103
POLITICAL			911.84154
COMPACTNESS	983.00000	4.00000	3932.00000

CRITERION = 4876.01257

* -0 -0 -0 -0 -0 -0 -0 *

DATA ERROR

* 1297 17 1 69 1 2

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COST ESTIMATE

Computer charges are calculated at the rate of $150./computational unit (hour). The sample run consumed 7 minutes of computer time, which should be typical for large jobs of similar complexity.

Therefore, for the sample run shown above,

Approximate charge to user = computer time + postage, handling, and consulting + network overhead

= $17.50 + $7.50 + network overhead

= $25.00 + network overhead

CONTENTS—T8 FSU BELOW

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DESCRIPTIVE TITLE	Equipercentile Equating Program
CALLING NAME	SCORMACH
INSTALLATION NAME	Wharton Computational Services University of Pennsylvania
AUTHOR(S) AND AFFILIATION(S)	Daniel Ashler, Director Wharton Computational Services University of Pennsylvania
LANGUAGE	FORTRAN IV
COMPUTER	IBM System 360/75
PROGRAM AVAILABILITY	Proprietary; usage permitted but program deck or listing not available
CONTACT	Daniel Ashler, Wharton Computational Services, University of Pennsylvania, Philadelphia, Pa. 19104 Tel: (215) 594-6422

FUNCTIONAL ABSTRACT

SCORMACH uses the equipercentile equating method to obtain "comparable" scores (having identical means, standard deviations, and distributions) for several forms of a given test or for different tests. A given score on one test is considered comparable to a given score on another if, in the two (not necessarily distinct) groups of examinees, the same proportions attain less than the respective given scores—i.e., if a score on one test has the same percentile rank as its comparable score on the other test.

The principal output is a table for each pair of tests by which, given a regressed equipercentile score on either test, one can determine the corresponding regressed equipercentile score on the other. If desired, the same information may also be had in the form of a graph produced on a CalComp plotter. Other tables and graphs allow comparisons of raw scores with raw scores, raw scores with regressed scores, etc.

The scores that are of interest here are the examinees' "true scores" on each respective test. Although true scores cannot be observed directly, the characteristics of the distribution

continued

000 0073

of true scores for a given test can be estimated. This estimation, resulting in "regressed" scores, is made by modifying the value of each observed score in accordance with the reliability coefficient of the test.[1] One technique for equating scores is to plot points that correspond to pairs of comparable regressed scores on rectangular coordinates. A smooth curve is drawn through the points; pairs of equated scores are read from this curve. In addition to equating scores, the program predicts scores on one test from raw scores on the other. The predicted score is the regressed score that has the same percentile rank as the predictor raw score on the other test.

The program accepts a set of raw scores and a coefficient of reliability for each of two or more tests. (There is no limit to the number of tests to be equated in a single run.) The scores of the first test (*anchor test*) entered as input are equated with the scores of each subsequent test, one test at a time, by the equipercentile method described above.

The comparability of the scores of different forms (or tests) is specific to the type of groups used in obtaining them. A group that is both representative (of the population of examinees for whom the tests are intended) and large (at least 500 examinees) should be used. Preferably, the same examinees should take all tests to be equated (Ref. 1, p. 758). Although the value of the results is enhanced when all tests are taken by the same examinees and by an equal number of examinees, the program does not require that these conditions be met.

REFERENCES

1. Flanagan, J.C., "Units, Scores, and Norms," in *Educational Measurement*, E.F. Lindquist, Ed. (American Council on Education, Washington D.C., 1951), pp. 752–760.

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USER INSTRUCTIONS

Preparation of Input

System Cards

Wharton Computational Services will prepare the necessary system cards to conform with the current version of the operating system. A cover letter should accompany the data stating whether CalComp output is desired.

Data-Input Cards

A. Provide a score packet for each test to be analyzed, consisting of a Title Card followed by Score Cards for that test. Data for the "anchor" test should come first. Scores of each subsequent test are equated with those of the "anchor" test. There is no limit to the number of tests for which score packets are submitted.

(1) Title Card

Columns	*Contents*
1– 8	Alphabetic title of test. It may *not* include any numeric digits, periods, plus signs or minus signs
9–80	Ignored by the program

(2) Score Cards

Punch as many test scores as desired on each card. Scores must be separated by at least one blank. When Col. 80 of a card is reached, continue in Col. 1 of the next card. (If a score ends in Col. 80, begin the next score in Col. 2 of the next card to have a blank between scores.) The scores need not be in ascending order *but computer time will be saved* if they are. If a score is repeated N times, the score need not be punched N times. Instead, punch the value of N followed by an asterisk followed by the score. For example, if 17 people have the score 112.5, punch 17*112.5. Follow the last score with a blank, a semicolon, at least one more blank, and then the reliability coefficient of the test in the form

XXXXXXXX RELIABILITY IS 0.RRR

where XXXXXXXX represents the test title (exactly as punched in the Title Card) and 0.RRR is the reliability coefficient of the test. (*Note*: The letter Ø is slashed; the number zero is not slashed.)

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B. SCORMACH can also process (in the same run) additional sets of score packets, each of which consists of an "anchor" packet followed by as many other packets as desired. Such additional sets of score packets should be wrapped separately and clearly marked; the anchor packet must be the first packet in each set.

Description of Output

Output from SCORMACH appears in both tables and graphs. For each test, the tables include

(a) an "echo print" of the raw scores of the examinees. This may be omitted if the user so specifies in the cover letter. (It is not included in Sample Output.)

(b) a listing of every raw score attained by the examinees in the group, each with its corresponding percentile rank and regressed score

(c) a listing of the regressed score on the *other* test that corresponds to each raw score attained by the examinees in the group

(d) a listing of the corresponding raw and regressed scores for each integer percentile rank

The graphs include

(a) the percentile ranks of the raw and regressed scores of both tests

(b) the predicted scores of each test, given the raw scores of the other test

(c) the raw scores of both tests at integer percentile values

(d) the regressed equipercentile scores—i.e., regressed scores of test one versus comparable regressed scores of test two

If CalComp plotter output is specified, a graph is produced like the final illustration.

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SAMPLE INPUT

```
SAT VERB
22  3*23 25 3*26 2*27 28 29 4*30 3*31 13*32 3*33 16*34 19*35 20*36 23*37 26*38 3
3*39 27*40 43*41 34*42   49*43 47*44 28*45 33*46 41*47 27*38 29*49 28*50 34*51
21*52 23*53 13*54 10*55 22*56 14*57 11*58 5*59 5*60 9*61 11*62 4*63 4*64 2*65
3*66 2*67 3*68 3*69 2*70 71 73 ;  SAT VERB RELIABILITY IS 0.91
SAT MATH
23 4*27 6*28 2*29 4*30 3*31 14*32 2*33 12*34 10*35 7*36 8*37 18*38 18*39 15*40
27*41 42*42 33*43 36*44 34*45 51*46 40*47 41*48 36*49 31*50 28*51 34*52 20*53 24
*54 35*55 17*56 17*57 9*58  11*59 12*60 9*61 9*62 11*63 6*64 6*65 3*66 4*67 68
2*69 3*70 72 2*73 75 76 ;  SAT MATH RELIABILITY IS 0.89
```


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SAT VERB

RAW SCORE	%ILE RANK	REGRESSED SCORE	RAW SCORE	%ILE RANK	REGRESSED SCORE	RAW SCORE	%ILE RANK	REGRESSED SCORE	RAW SCORE	%ILE RANK	REGRESSED SCORE
22.00	0.066	23.06	36.00	10.512	36.41	49.00	67.740	48.82	61.00	94.678	60.25
23.00	0.329	24.01	37.00	13.338	37.37	50.00	71.485	49.77	62.00	95.992	61.22
25.00	0.591	25.92	38.00	16.557	38.32	51.00	75.558	50.72	63.00	96.978	62.17
26.00	0.854	26.88	39.00	20.434	39.28	52.00	79.172	51.68	64.00	97.503	63.12
27.00	1.183	27.83	40.00	24.376	40.23	53.00	82.063	52.63	65.00	97.897	64.08
28.00	1.380	28.78	41.00	28.975	41.18	54.00	84.428	53.59	66.00	98.226	65.03
29.00	1.511	29.74	42.00	34.034	42.14	55.00	85.940	54.54	67.00	98.555	65.99
30.00	1.840	30.69	43.00	39.488	43.09	56.00	88.042	55.49	68.00	98.883	66.94
31.00	2.300	31.64	44.00	45.795	44.05	57.00	90.407	56.45	69.00	99.277	67.89
32.00	3.351	32.60	45.00	50.723	45.00	58.00	92.050	57.40	70.00	99.606	68.85
33.00	4.402	33.55	46.00	54.731	45.95	59.00	93.101	58.36	71.00	99.803	69.80
34.00	5.650	34.51	47.00	59.593	46.91	60.00	93.758	59.31	73.00	99.934	71.71
35.00	7.950	35.46	48.00	64.060	47.86						

SAT MATH

RAW SCORE	%ILE RANK	REGRESSED SCORE	RAW SCORE	%ILE RANK	REGRESSED SCORE	RAW SCORE	%ILE RANK	REGRESSED SCORE	RAW SCORE	%ILE RANK	REGRESSED SCORE
23.00	0.066	24.36	39.00	13.141	39.45	51.00	66.886	50.77	63.00	95.335	62.09
27.00	0.394	28.13	40.00	15.309	40.40	52.00	70.959	51.72	64.00	96.452	63.04
28.00	1.051	29.08	41.00	18.068	41.34	53.00	74.507	52.66	65.00	97.240	63.98
29.00	1.577	30.02	42.00	22.602	42.28	54.00	77.398	53.60	66.00	97.832	64.92
30.00	1.971	30.96	43.00	27.530	43.23	55.00	81.275	54.55	67.00	98.292	65.87
31.00	2.431	31.91	44.00	32.063	44.17	56.00	84.691	55.49	68.00	98.620	66.81
32.00	3.548	32.85	45.00	36.662	45.11	57.00	86.925	56.43	69.00	98.817	67.75
33.00	4.599	33.79	46.00	42.247	46.06	58.00	88.633	57.38	70.00	99.146	68.70
34.00	5.519	34.74	47.00	48.226	47.00	59.00	89.947	58.32	72.00	99.409	70.58
35.00	6.965	35.68	48.00	53.548	47.94	60.00	91.459	59.26	73.00	99.606	71.53
36.00	8.081	36.62	49.00	58.607	48.89	61.00	92.838	60.21	75.00	99.803	73.42
37.00	9.067	37.57	50.00	63.009	49.83	62.00	94.021	61.15	76.00	99.934	74.36
38.00	10.775	38.51									

continued

RESULT OF INTERPOLATION AND EXTRAPOLATION FOR 50 SAT VERB VALUES AND 49 SAT MATH VALUES

RAW SAT VERB	REGRESSED SAT VERB	%ILE	PREDICTED SAT MATH	RAW SAT MATH	REGRESSED SAT MATH	%ILE	PREDICTED SAT VERB
22.0000	23.0594	0.0657	24.3585	23.0000	24.3585	0.0657	23.0594
23.0000	24.0134	0.3285	27.3773	27.0000	28.1320	0.3942	24.4903
25.0000	25.9212	0.5913	28.4151	28.0000	29.0754	1.0512	27.4475
26.0000	26.8752	0.8541	28.7924	29.0000	30.0188	1.5769	29.9277
27.0000	27.8291	1.1827	29.3113	30.0000	30.9622	1.9711	30.9635
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
68.0000	66.9406	98.8830	67.9434	72.0000	70.5849	99.4087	68.2761
69.0000	67.8945	99.2773	69.6415	73.0000	71.5283	99.6058	68.8484
70.0000	68.8485	99.6058	71.5283	75.0000	73.4151	99.8029	69.8024
71.0000	69.8024	99.8029	73.4151	76.0000	74.3585	99.9343	71.7103
73.0000	71.7103	99.9343	74.3585	-0.0	-0.0	-0.0	-0.0

VALUES COMPUTED FOR INTEGER PERCENTILE RANKS

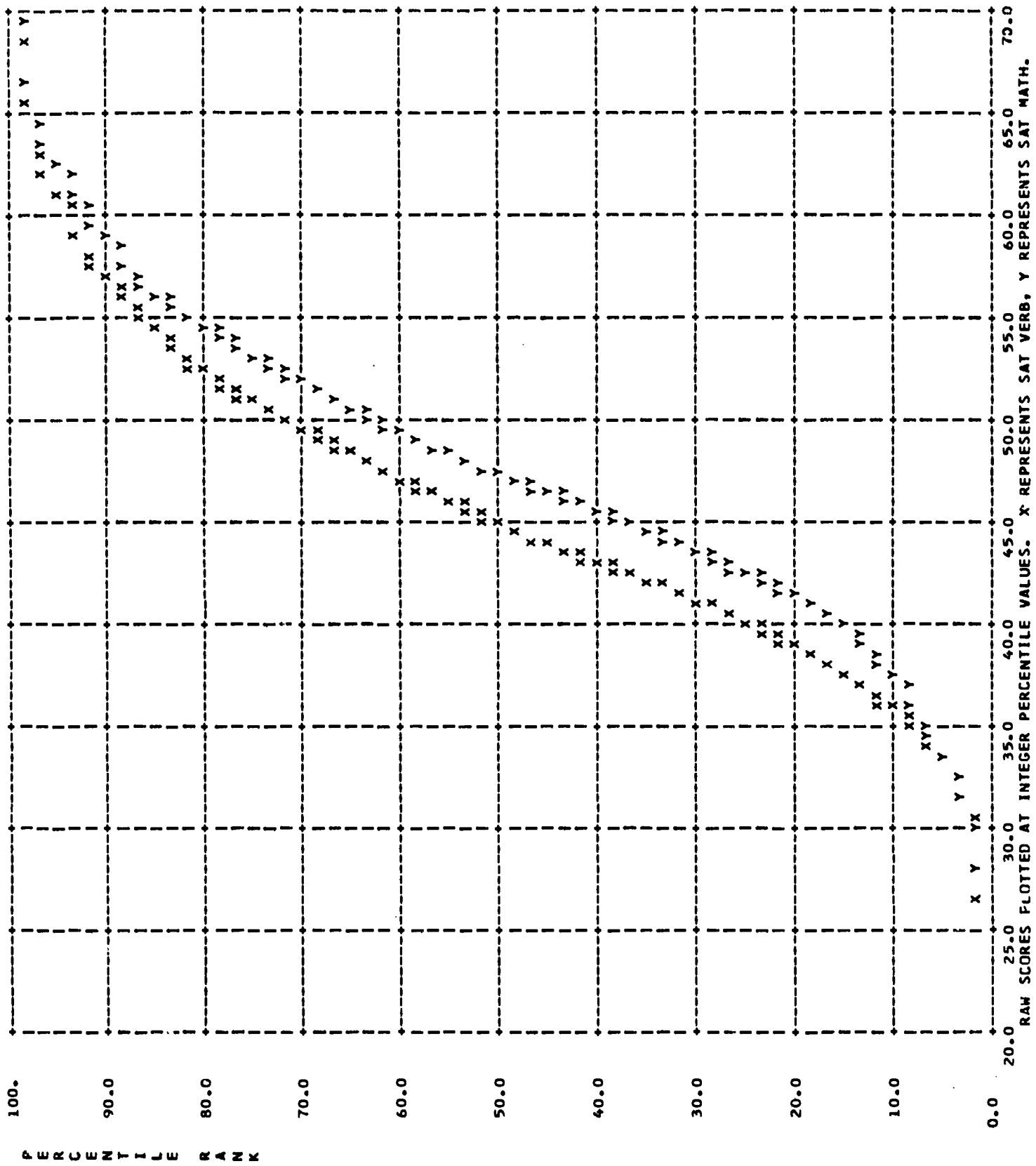
%ILE	RAW SAT VERB	REGRESSED SAT VERB	RAW SAT MATH	REGRESSED SAT MATH	%ILE	RAW SAT VERB	REGRESSED SAT VERB	RAW SAT MATH	REGRESSED SAT MATH
1	26.444	27.299	27.922	29.002	51	45.069	45.066	47.521	47.492
2	30.349	31.023	30.063	31.022	52	45.319	45.304	47.709	47.669
3	31.666	32.280	31.509	32.386	53	45.568	45.542	47.897	47.846
4	32.617	33.188	32.430	33.255	54	45.818	45.780	48.089	48.028
5	33.479	34.010	33.436	34.203	55	46.055	46.007	48.287	48.214
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
46	44.042	44.086	46.628	46.649	96	62.008	61.225	63.595	62.656
47	44.245	44.279	46.795	46.807	97	63.043	62.211	64.695	63.693
48	44.447	44.473	46.962	46.964	98	65.312	64.376	66.366	65.270
49	44.650	44.666	47.145	47.137	99	68.297	67.224	69.556	68.279
50	44.853	44.860	47.333	47.314					

continued

000 0073

000 0073

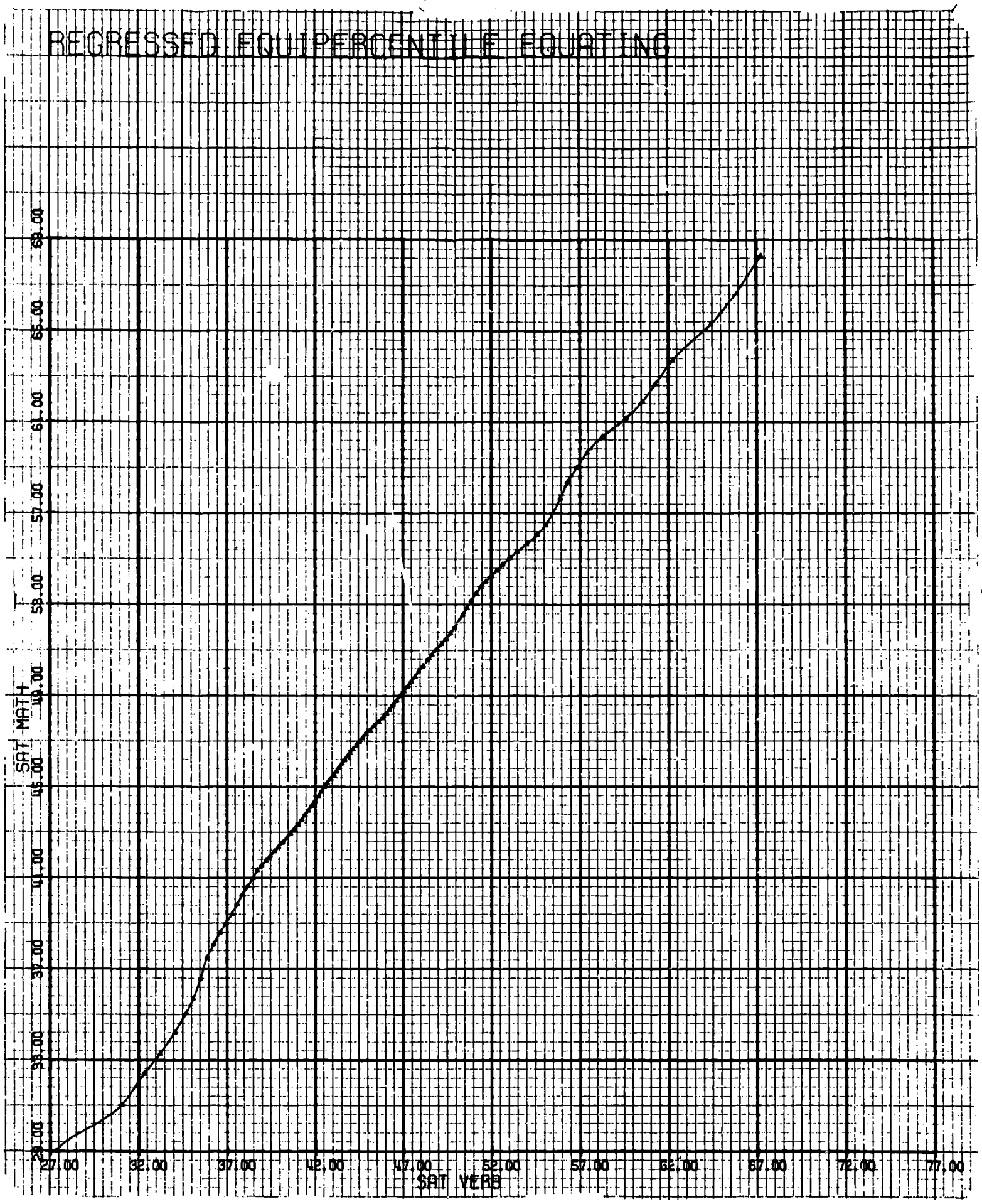
000 0073



continued

000 0073

000 0073



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COST ESTIMATE

For each separate computer run of SCORMACH, there will be a setup charge of $50.00 plus a per-student charge of 10¢ for each test beyond the "anchor" test. Postage, handling, and consulting fees are included. And additional $20.00 charge will be made for each CalComp plot. (If CalComp option is requested, one plot will be produced for each pair of tests equated.)

Charge to user = $50.00 + 10¢/student for each test beyond "anchor" + network overhead

CONTENTS—SCORMACH

pages

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000 0074

DESCRIPTIVE TITLE Multiple Scalogram Analysis

CALLING NAME MSA

INSTALLATION NAME Office of Computational Sciences
Educational Testing Service

AUTHOR(S) AND AFFILIATION(S)

Procedure due to: L. Guttman
J. Lingoes
University of Michigan

Program due to: J. Lingoes
University of Michigan

Adaptation due to: D. Kirk
Educational Testing Service

Advisor on use: H. Harman
Educational Testing Service

LANGUAGE MAP

COMPUTER IBM 360/65

PROGRAM AVAILABILITY Decks and listings presently available

CONTACT Mr. Ernest Anastasio, Office of Data Analysis Research, Educational Testing Service, Rosedale Road, Princeton, N.J. 08540
Tel.: (609) 921-9000 ext. 2552

FUNCTIONAL ABSTRACT

This program performs a multiple scalogram analysis using the method of James Lingoes[1]. Do not confuse this with Guttman-Lingoes Multidimensional scalogram analysis which is available under the name of MSA-I (EIN Abstract 000 0070).

REFERENCES

1. Lingoes, J.C., "A Set-Theoretic Model for Analyzing Dichotomous Items," J. of Ed. Psych. Meas., *23*, pp. 501–524, (1963).

000 0074

000 0074

USER INSTRUCTIONS

Input Deck

Parameter Card A

Columns	*Contents*
1– 3	Number of cases to be run

Title Card

Columns	*Contents*
1	1
2–72	Any title

Parameter Card B

Columns	*Contents*
1– 3	Number of subjects ($\leq$100)
4– 6	Number of items ($\leq$122)
7	1: responses must be dichotomized 0: responses are either 1 or 0
8–10	Reproduceability criterion (normally about .80)
11–16	Chi-square criterion (normally 10.827)
17–20	ID run number (may be alphameric)
21	1: print input data 0: do not print input data
22	1: print debugging output 0: do not print debugging output
23	1: Description Cards present 0: no Description Cards
24	1: Cornell scores printed for scales with two or more items 0: Cornell scores not printed

Parameter Card C (Omit if Col. 7 of Parameter Card B is 0.)

Columns	*Contents*
1– 3	Maximum number of categories for any item

continued

000 0074

Parameter Card D (Omit if number punched on Parameter Card C > 2.)

Columns	*Contents*
1– 3	Response code for item 1, response A
4– 6	Response code for item 1, response B
7– 9	Response code for item 2, response A
⋮	⋮
76–79	Response code for item 13, response B

Note: This card is used when number on Parameter Card C is 2. Punch as many cards as required to satisfy the number of items specified in Parameter Card B (Col. 4–6).

Format Card

Standard FORTRAN format for input data. Omit the word FORMAT.

Description Deck (Omit this deck if Col. 23 of Parameter Card B is 0.)

Columns	*Contents*
1–72	Alphameric description card. Punch one for *each* item.

Data Deck

Punch one subject ID followed by all item codes for the number of items specified according to the format specified on the Format Card.

Multiple case runs will repeat the Input Deck from Title Card through Data Deck, as many times as specified on Parameter Card A.

Job Deck

The program is currently in the system and may be called as follows.

```
//JOB CARD (will be provided by ETS personnel).
//EXEC GITNGO,NAME=MSA
//GO.SYSIN DD *
    (insert Input Deck or Decks here.)
/*
```

continued

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Output

The output will vary according to the options selected. The Sample Input/Output gives a hypothetical example with 8 items and 25 subjects. The output selections included input parameters, Cornell scores and answer patterns ordered by subject ID for scales 1 and 2, and subjects ordered by Cornell scores for scales 1 and 2.

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SAMPLE INPUT

```
//MSATST     JOB (....
//EXEC GITNGO,NAME=MSA
//GO.SYSIN  DD    *
  1
1 THIS WILL TEST MSA WITH A HYPOTHETICAL 2-DIMENSIONAL CASE
0250080.80  3.84TEST1011
(I2,8(2X,I1))
  ITEM NO. 1
  ITEM NO. 2
  ITEM NO. 3
  ITEM NO. 4
  ITEM NO. 5
  ITEM NO. 6
  ITEM NO. 7
  ITEM NO. 8
01  1  0  0  1  0  0  1  1
02  0  0  1  1  0  1  0  0
03  1  0  0  0  1  1  0  0
04  1  0  1  1  0  1  1  0
05  1  1  0  0  1  1  0  1
06  0  0  1  1  0  1  1  0
07  1  0  0  1  0  1  0  0
08  1  0  0  0  1  0  0  1
09  1  0  1  0  1  1  0  0
10  1  0  0  1  1  1  0  1
11  1  0  0  1  1  0  0  1
12  1  0  0  1  1  1  0  0
13  0  1  1  0  1  1  0  0
14  1  0  0  1  0  1  0  1
15  1  1  1  0  1  1  0  0
16  1  0  0  1  0  1  1  0
17  1  1  0  0  1  0  0  1
18  0  0  1  1  1  1  0  0
19  1  0  0  0  1  1  0  1
20  1  0  1  1  0  1  0  0
21  1  0  0  1  0  0  0  1
22  1  0  0  1  0  1  1  1
23  1  1  0  0  1  1  0  0
24  1  0  1  1  1  1  0  0
25  0  0  1  0  1  1  0  0
/*
```

000 0074

SAMPLE OUTPUT

000 0074

THIS WILL TEST MSA WITH A HYPOTHETICAL 2-DIMENSIONAL CASE

ORIGINAL DATA

	1	2	3	4	5	6	7	8
1	1	0	0	1	0	0	1	1
2	0	0	1	1	0	1	0	0
3	1	0	0	0	1	1	0	0
4	1	0	1	1	0	1	1	0
5	1	1	0	0	1	1	0	1
.		.			.			
.		.			.			
.		.			.			
20	1	0	1	1	0	1	0	0
21	1	0	0	1	0	0	0	1
22	1	0	0	1	0	1	1	1
23	1	1	0	0	1	1	0	0
24	1	0	1	1	1	1	0	0
25	0	0	1	0	1	1	0	0

SCALE NO. 1INCLUDES THE FOLLOWING ITEMS

ITEM NO.	REFLECTED	MARGINAL SUM	
1	0	20	ITEM NO. 1
3	1	15	ITEM NO. 3
8	0	10	ITEM NO. 8
6	1	5	ITEM NO. 6

CHI-SQUARE CRITERION = 3.840
PHI = 0.80
REPRODUCIBILITY = 1.000
MIN. MARGINAL REPR. = 0.700
NUMBER IN SCALE = 4

continued

000 0074

000 0074

CORNELL SCORES AND ANSWER PATTERNS ORDERED
BY SUBJECT IDENTIFICATION NUMBER
FOR SCALE NO. 1

ID NUMBER	CORNELL SCORE	ANSWER PATTERN			
		1	3	8	6
1	4	1	1	1	1
2	0	0	0	0	0
3	2	1	1	0	0
4	1	1	0	0	0
5	3	1	1	1	0
6	0	0	0	0	0
7	2	1	1	0	0
8	4	1	1	1	1
9	1	1	0	0	0
10	3	1	1	1	0
11	4	1	1	1	1
12	2	1	1	0	0
13	0	0	0	0	0
14	3	1	1	1	0
15	1	1	0	0	0
16	2	1	1	0	0
17	4	1	1	1	1
18	0	0	0	0	0
19	3	1	1	1	0
20	1	1	0	0	0
21	4	1	1	1	1
22	3	1	1	1	0
23	2	1	1	0	0
24	1	1	0	0	0
25	0	0	0	0	0
COLUMN SUMS FOR THIS SCALE		20	15	10	5

SUBJECTS ORDERED BY CORNELL SCORES
FOR SCALE NO. 1

CORNELL SCORE	ID NUMBER
0	2
0	6
0	13
0	18
0	25
1	15
1	9
.	.
.	.
.	.
3	14
3	19
4	21
4	17
4	11
4	1
4	8

continued

000 0074

SCALE NO. 2INCLUDES THE FOLLOWING ITEMS

ITEM NO.	REFLECTED	MARGINAL SUM	
2	1	20	ITEM NO. 2
4	0	15	ITEM NO. 4
5	1	10	ITEM NO. 5
7	0	5	ITEM NO. 7

CHI-SQUARE CRITERION = 3.840
PHI = 0.80
REPRODUCIBILITY = 1.000
MIN. MARGINAL REPR. = 0.700
NUMBER IN SCALE = 4

CORNELL SCORES AND ANSWER PATTERNS ORDERED

BY SUBJECT IDENTIFICATION NUMBER

FOR SCALE NO. 2

ID NUMBER	CORNELL SCORE	ANSWER PATTERN			
		2	4	5	7
1	2	1	1	0	0
2	4	1	1	1	1
3	3	1	1	1	0
4	2	1	1	0	0
5	4	1	1	1	1
6	3	1	1	1	0
7	2	1	1	0	0
8	1	1	0	0	0
9	3	1	1	1	0
10	2	1	1	0	0
11	0	0	0	0	0
12	2	1	1	0	0
13	1	1	0	0	0
14	1	1	0	0	0
15	4	1	1	1	1
16	0	0	0	0	0
17	4	1	1	1	1
18	4	1	1	1	1
19	3	1	1	1	0
20	1	1	0	0	0
21	3	1	1	1	0
22	0	0	0	0	0
23	0	0	0	0	0
24	1	1	0	0	0
25	0	0	0	0	0
COLUMN SUMS FOR THIS SCALE		20	15	10	5

continued

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SUBJECTS ORDERED BY CORNELL SCORES
FOR SCALE NO. 2

CORNELL SCORE	ID NUMBER
0	11
0	16
0	22
0	23
0	25
1	20
1	13
1	14
1	24
1	8
2	4
2	12
2	7
2	1
2	10
3	21
3	6
3	9
3	19
3	3
4	5
4	17
4	18
4	2
4	15

ALL POSSIBLE SCALES HAVE BEEN FORMED--MULTIPLE SCALOGRAM

ANALYSIS IS FINISHED FOR JOB NO. TEST

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COST ESTIMATE

The pricing algorithm for the Educational Testing Service is based on a complex formula involving the amount of core usage, card-processing, tape and dedicated device usage, lines printed and central processor unit (CPU) elapsed time. Computer costs for the job included in the Sample Input were $1.41.

Charge to user = computer costs + postage and handling + network overhead

= $1.41 + $5.00 + network overhead

= $6.41 + network overhead

CONTENTS—MSA

000 0074

000 0075

DESCRIPTIVE TITLE	Nonmetric Multidimensional Scaling
CALLING NAME	Subroutine KRUSCAL
INSTALLATION NAME	Michigan State University Computer Laboratory
AUTHOR(S) AND AFFILIATION(S)	Alan M. Lesgold Computer Institute for Social Science Research Michigan State University
LANGUAGE	FORTRAN or COMPASS
COMPUTER	CDC 3600
PROGRAM AVAILABILITY	Decks and listings presently available
CONTACT	Dr. Anders Johanson, Programming Supervisor Applications Programming, Computer Laboratory, Computer Center, Michigan State University, East Lansing, Mich. 48823 Tel.: (517) 355-4684

FUNCTIONAL ABSTRACT

KRUSCAL is an implementation of J.B. Kruskal's recently published[1] numerical method for multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis[2]. Given a matrix of similarities or dissimilarities between n variables, the routine outputs a configuration of n points in a specified number of dimensions such that the distance between any two points is a monotone function of the dissimilarity of the two variables corresponding to those two points.

General Description of Input

KRUSCAL will accept as input any matrix or halfmatrix (below major diagonal) with or without the major diagonal, of similarities or dissimilarities, including, among others, correlation coefficients, confusion probabilities, interaction rates among groups, etc. This matrix need not be symmetric, and the program allows for missing data; interpoint distances corresponding to missing data values do not contribute to the stress.

continued

000 0075

000 0075

General Description of Output

The output consists of three sections for the two-dimensional case and two sections for other dimensionalities. In every case, a history of computation is printed, showing for each iteration[1] the following information.

STRESS = Normalized stress achieved[2]

SRAT = The rate of stress improvement = $\frac{STRESS_i}{STRESS_{i-1}}$

SRATAV = Weighted average of SRAT

$= SRAT_i^{1/3} \times SRATAV_{i-1}^{2/3}$

CAGRGL = Cosine of angle between gradient and previous gradient[1]

COSAV = Weighted average of CAGRGL

$= (1/3)CAGRGL_i + (2/3)COSAV_{i-1}$

ACSAV = Weighted average of the magnitude of CAGRGL, computed in the same manner as COSAV

SFGR = Scale factor of gradient, [same as Kruskal's mag(g)][1]

STEP = Step size[1]

Also, in every case, the final number of dimensions is printed. There is an option for printing the interpoint distances in each final configuration, and an option for punching the final configuration onto cards (see description of option cards).

In the two-dimensional case, the final configuration is also plotted (on the line printer, not on the plotter).

REFERENCES

1. Kruskal, J., "Nonmetric Multidimensional Scaling: A Numerical Method", Psychometrika, *29*, pp. 115–129, (June, 1964).

2. Kruskal, J., "Multidimensional Scaling by Optimizing Goodness of Fit to a Nonmetric Hypothesis," Psychometrika, *29*, pp. 1–28, (March, 1964).

000 0075

000 0075

USER INSTRUCTIONS

Calling Sequence

The routine is called in the ordinary manner for calling FORTRAN SUBROUTINES that have no formal parameters.[1,2]

From a FORTRAN program:

```
CALL KRUSCAL
```

From a COMPASS program:

```
BRTJ    ($)KRUSCAL, ,*
SLJ     *+1
00      DICT.
```

Arguments or Parameters

All parameters are read by SUBROUTINE KRUSCAL from the data deck. See Description of Input.

Space Required (Decimal)

The subroutine itself and the subroutines that it contains take a total of 13817 words of core storage. The total amount of core storage taken up by KRUSCAL and all of the routines (including library routines) that it calls is 17285 words.

Error Returns or Error Codes

The message, KRUSCAL, IMPROPER CONTROL CARD, is printed along with the contents of any control card in the data deck that is incorrect. The program then terminates by doing a return to SCOPE through Q8QERROR.

Error Stop

A condition that is logically impossible in the program (i.e., a recognized machine error) will generate the message KRUSCAL and will terminate through Q8QERROR.

Accuracy

Accuracy is not a problem, since the original data values are stored, and the measures used in determining when a solution has been reached are functions, in part, of these original data values.

Caution to Users: Up to 60 variables may be scaled in up to 10 dimensions. Users should be aware of the "local minima" problem.[3]

continued

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000 0075

Flow Chart

The algorithm and logical flow of the program are described in Ref. 3. The following array names have been changed from those recorded in that reference.

In Ref. 3	*In the MSU program version*
DISSIM	DATA
DOTHER	LBLOCK

The subroutines are:

FIT	Uses latest gradient to get new configuration.
SORT	Sorts an array, dragging along one or more other arrays.
NEWSTP	Computes new value of STEP, COSAV, ACSAV, etc.
PRINDIST	Prints inter-point distances of final configuration.
KPACK	Routines for packing and unpacking IJ (see Ref. 3)
COMP	Routines to take powers and roots. Negative numbers are complemented, the root or power is taken, and they are recomplemented. Zero and first powers and roots do not use POWRF.
CCACT	Routine to convert alphanumeric parameter options into numeric parameters and to set switches based on these options.
CCIO	Routine to do numeric conversions for CCACT.

COMP, KPACK, and CCACT are COMPASS routines; the rest are in 3600 FORTRAN.

Description of Input

The input data deck should contain the following, in the order listed.

For each data set:
- Option Cards, if any.
- Configuration Deck, if desired.
- Data Description Deck.
- Data.

continued

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After all the data sets (there may be more than one data set in a run), a STOP card should follow.

Option Cards

Any of the following options may be used. They may be entered in any order. Wherever a *normal case* is mentioned, it refers to the parameter values the program will assume if the particular option card is omitted. All of these options may be punched free-field, but there should not be spaces between the letters of a single word, or the digits of a single number. More than one option can be punched on a single card, but each word or number must be separated from the next word or number by a blank column. In any case, only the *first 72 columns* of the card can be used for specifying an option, and each option must be completely specified on one card, i.e., no continuations to a new card are allowed.

(a). The normal case assumes that the entire matrix of similarities (or dissimilarities) is being input. If only the lower half of the matrix (with or without the major diagonal) is being input, punch the word HALFMATRIX on an option card. Obviously, the program will then assume that the data matrix is symmetric.

(b). If the HALFMATRIX option is chosen, the normal case would be for the major diagonal to be included. If the major diagonal is not included, punch the phrase DIAGONAL ABSENT on one of the option cards.

(c). Missing data values are indicated by filling the appropriate cell of the matrix with a value that is less than the cutoff value, which is normally zero. If a different cutoff is desired, punch the word CUTOFF and a real number on one of the option cards, e.g., CUTOFF 3.0.

(d) Scaling is done using the Minkowski r-metric[4] with a normal case value of r=2.0, giving Euclidean distance. If a different value of r is desired, punch the letter R follow by a real number to specify the value of r that is desired, e.g., R 1.0 will give "city-block" distances.

(e). In the normal case, equal data values corresponding to unequal distances in the configuration *do not* contribute to the stress, and no attempt is made to equalize these distances. This is what Kruscal describes as the "primary" approach.[4] If the "secondary" approach is desired, i.e., if it is desired that unequal distances which correspond to equal data values contribute to the stress, and hence, that an attempt be made to equalize these distances, the word SECONDARY should be punched on an option card.

continued

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(f). In the normal case, scaling is done for two dimensions only. Scaling may be done in any number of dimensions from one to ten. In a non-normal case, the maximum number of dimensions desired can be specified by punching the word DIMMAX followed by an integer specifying the maximum number of dimensions desired (up to ten). Similarly, the minimum number of dimensions can be changed from the normal case (two) to some other value by punching the word DIMMIN followed by an interger specifying the minimum number of dimensions desired. In the normal case, a configuration is computed for every number of dimensions from DIMMAX through DIMMIN. If this is not desired, punch the word DIMDIF followed by an integer on an option card. The scaling will then start with DIMMAX dimensions and proceed down by steps of DIMDIF dimensions until DIMMIN is passed. Thus the normal case is equivalent to the following option card: DIMMAX 2 DIMMIN 2 DIMDIF 1. The option card DIMMAX 10 DIMMIN 2 DIMDIF 3 would cause scaling in 10, 7, and 4 dimensions; note that if DIMMIN had instead been 1, scaling would have been done in 10, 7, 4, and 1 dimensions. Only one or two of the normal case values need be changed; e.g., DIMMAX 10 alone would produce scaling in 10, 9, 8, 7, 6, 5, 4, 3, and 2 dimensions.

(g). Normally, scaling for a given number of dimensions stops if STRESS is less than 0.05, if SFGR is less than or equal to zero, if SRAT is greater than 0.999, or if there have been more than 25 iterations of the scaling routine. A different lower bound can be specified for STRESS by punching the word STRMIN followed by a real number, to specify the requested boundary value, on an option card. A lower bound for SFGR can similarly be specified by punching SFGRMN followed by a real number on an option card. In the same manner an upper bound for SRAT can be specified by punching SRATST followed by a real number and for the number of iterations by punching ITERATIONS followed by an integer.

(h). If it is desired that the final configuration for each number of dimensions be punched onto cards as well as being printed, the word PUNCH should be punched on an option card.

(i). If it is desired that the interpoint distances of the final configuration be printed, the word DISTANCES should be punched on an option card.

Configuration Deck (optional)

Normally, the computer arbitrarily creates a starting configuration for the largest number of dimensions in which scaling has been requested. The results of scaling in each number of

continued

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dimensions are then used as a starting configuration for the next smaller number of dimensions in which scaling has been requested. There is, however, a provision for the specification by the user of a starting configuration. A starting configuration can be used to get more iterations on a previously done scaling job, or more important, to specify a different configuration when the arbitrary configuration results in only locally minimum stress.[4] The configuration specified by the user need not have the same dimensionality as the maximum number of dimensions specified. A useful starting configuration is the principal-axis factor solution to the matrix of similarities. A configuration deck is made up in the following manner:

Card 1: the word CONFIGURATION anywhere in Col. 1–72 on a card.

Card 2: in Col. 1–72, a title for the configuration—any BCD characters may be used.

Card 3:

Columns	*Contents*
1– 3	the number of points (the number of rows) of the configuration matrix
4– 6	the number of dimensions (the number of columns) of the configuration matrix

Card 4:

Columns	*Contents*
1–72	a standard FORTRAN data format for one row of the configuration matrix (This is an F-type format statement; for more information, see Ref. 2.)

Matrix deck: the actual configuration matrix, row by row.

Data Description Cards

Card 1:

Columns	*Contents*
1–72	punch SIMILARITIES if the data are a matrix of similarities; DISSIMILARITIES if the data are a matrix of dissimilarities.

Card 2:

Columns	*Contents*
1–72	the title of the data matrix; any BCD characters may be used.

continued

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Card 3:	*Columns*	*Contents*
	1– 3	the number of objects to be scaled (the order of the data matrix).

Card 4:	*Columns*	*Contents*
	1–72	a FORTRAN F-type format for the longest row of the data matrix. (For more information, see Ref. 2.)

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Data Deck

The data matrix should be inserted at this point. Its form will depend on whether the whole or half matrix is entered. If the whole matrix is entered, it should be entered one row at a time, with each row starting on a new card. If the half matrix is entered and the diagonal is present, then each row should include only the values up to and including the diagonal. If the diagonal is absent, the data matrix starts with row two of the similarity/dissimilarity matrix, and each row includes the values up to but not including the diagonal element.

Compute Card

After the data matrix, the data deck should contain a card with the word COMPUTE punched somewhere in Col. 1–72.

Stop Card

The last card of the job deck should have punched on it the word STOP somewhere in Col. 1–72.

REFERENCES

1. Mich. State Univ. Computer Inst. for Social Science Research, Technical Report 66–1A.

2. Mich. State Univ. Computer Inst. for Social Science Research, Technical Report 66–1B.

3. Kruskal, J., "Nonmetric Multidimensional Scaling: A Numerical Method", Psychometrika, *29*, pp. 115–129, (June, 1964).

4. Kruskal, J., "Multidimensional Scaling by Optimizing Goodness of Fit to a Nonmetric Hypothesis," Psychometrika, *29*, pp. 1–28, (March, 1964).

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```
SAMPLE INPUT
'JOB,015525,KRUSCAL,3.0,APHL
'EQUIP,17=(CISSR BINARY),MT(537),RO
'LOAD,17
'RUN,5.00,2000.
$ROUTINE,KRUSKAL
'MARKEF,69
'LOAD
'RUN,5.00,2000.
DIMMAX              10
DIMMIN               1
HALFMATRIX
CUTOFF            -.05
SECONDARY
ITERAT             100
DISSIMILAR
DISTANCES OF REGULAR HEXAGON
  6
(6F10.9)
0000000000
1000000000000000000
1732050000100000000000000000
2000000000173205000010000000000000000
1732050000200000000017320500001000000000000000000
1000000000173205000020000000001732050000100000000000000000000
COMPUTE
STOP
```

000 0075

000 0075

SAMPLE OUTPUT

```
DIMMAX            10
DIMMIN             1
HALFMATRIX        .0
CUTOFF            .0
SECONDARY         .0
ITERAT           100
DISSIMILAR        .0
DISTANCES OF REGULAR HEXAGON
  6 .0
BECAUSE THE NUMBER OF REPLICATES HAS NOT BEEN SPECIFIIED, IT IS ASSUMED TO BE 1 .
COMPUTE           .0

HISTORY OF COMPUTATION, N=    6, DIMENSION= 10

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        0  0.273  0.800  0.800  0.000  0.000  0.000  0.1134  1.5500
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        1  0.291  1.063  0.880 -0.025 -0.017  0.017  0.0892  1.3892
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        2  0.379  1.303  1.003 -0.400 -0.269  0.269  0.1078  0.6693
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        3  0.194  0.513  0.802 -0.398 -0.355  0.355  0.0967  0.3083
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        4  0.070  0.362  0.615 -0.198 -0.251  0.251  0.1043  0.1684
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        5  0.056  0.796  0.670 -0.865 -0.656  0.656  0.1112  0.0746
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        6  0.014  0.245  0.479  0.336 -0.001  0.445  0.0681  0.0349
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        7  0.006  0.441  0.466 -0.325 -0.215  0.365  0.1178  0.0205
```

continued

000 0075

```
ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

SATISFACTORY STRESS WAS REACHED

THE FINAL CONFIGURATION OF   6 POINTS IN 10 DIMENSIONS HAS STRESS  0.006

FINAL CONFIGURATION
     1      2      3      4      5      6      7      8      9     10
 1  0.534 -0.471 -0.410 -0.391 -0.391  0.080  0.000  0.000  0.000  0.000
 2 -0.255  0.803 -0.351 -0.140 -0.234  0.312  0.000  0.000  0.000  0.000
 3 -0.168 -0.115  0.880 -0.200 -0.275  0.220  0.000  0.000  0.000  0.000
 4 -0.071 -0.226 -0.111  0.953 -0.144  0.071  0.000  0.000  0.000  0.000
 5 -0.077 -0.184 -0.081 -0.157  0.936  0.286  0.000  0.000  0.000  0.000
 6  0.036  0.192  0.072 -0.066  0.108 -0.969  0.000  0.000  0.000  0.000

*********

HISTORY OF COMPUTATION, N=    6, DIMENSION=  9

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        0  0.006  0.800  0.800  0.000  0.000  0.000  0.1178  0.0356

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

SATISFACTORY STRESS WAS REACHED

THE FINAL CONFIGURATION OF   6 POINTS IN  9 DIMENSIONS HAS STRESS  0.006

FINAL CONFIGURATION
     1      2      3      4      5      6      7      8      9
 1  0.534 -0.471 -0.410 -0.391 -0.391  0.080  0.000  0.000  0.000
 2 -0.255  0.803 -0.351 -0.140 -0.234  0.312  0.000  0.000  0.000
 3 -0.168 -0.115  0.880 -0.200 -0.275  0.220  0.000  0.000  0.000
 4 -0.071 -0.226 -0.111  0.953 -0.144  0.071  0.000  0.000  0.000
 5 -0.077 -0.184 -0.081 -0.157  0.936  0.286  0.000  0.000  0.000
 6  0.036  0.192  0.072 -0.066  0.108 -0.969  0.000  0.000  0.000

*********

HISTORY OF COMPUTATION, N=    6, DIMENSION=  8

                    .                    .
                    .                    .
                    .                    .

*********

HISTORY OF COMPUTATION, N=    6, DIMENSION=  5

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        0  0.185  0.800  0.800  0.000  0.000  0.000  0.0329  0.3047
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        1  0.128  0.691  0.762  0.037  0.025  0.025  0.0985  0.2919
```

continued

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```
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        2  0,092  0,722  0,748 -0,816 -0,530  0,547  0,0992  0,1326
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        3  0,034  0,370  0,592 -0,053 -0,216  0,221  0,0661  0,0777
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        4  0,019  0,559  0,581 -0,290 -0,265  0,267  0,1102  0,0527
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        5  0,019  0,983  0,692 -0,948 -0,716  0,716  0,1176  0,0234
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        6  0,003  0,152  0,417  0,911  0,358  0,845  0,0977  0,0139
ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

SATISFACTORY STRESS WAS REACHED

THE FINAL CONFIGURATION OF   6 POINTS IN  5 DIMENSIONS HAS STRESS  0,003

FINAL CONFIGURATION
     1      2      3      4      5
 1  0.557 -0,459 -0,410 -0,395 -0,389
 2 -0.501  0,637 -0,458 -0,178 -0.319
 3 -0.352 -0,242  0,811 -0,226 -0.341
 4 -0.042 -0,200 -0,098  0,961 -0,130
 5 -0.300 -0,346 -0,180 -0,184  0.855
 6  0.638  0,610  0,335  0,022  0,324

*********

HISTORY OF COMPUTATION, N=    6, DIMENSION=  4

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        0  0,154  0,800  0,800 -0,000 -0,000  0,000  0,0536  0,4118
                          .                    .
                          .                    .
                          .                    .
D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
       19  0,104  1,000  0,999  0,926  0,500  0,889  0,0013  0,0021
ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

MINIMUM WAS ACHIEVED
```

continued

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```
THE FINAL CONFIGURATION OF   6 POINTS IN  4 DIMENSIONS HAS STRESS  0,104

FINAL CONFIGURATION
      1       2       3       4
 1  0,714  -0,407  -0,387  -0,437
 2 -0,450   0,751  -0,446  -0,214
 3 -0,271  -0,173   0,917  -0,263
 4  0,008  -0,185  -0,091   0,985
 5 -0,646  -0,632  -0,350  -0,183
 6  0,645   0,646   0,357   0,111

*********

HISTORY OF COMPUTATION, N=    6, DIMENSION=  3

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        0  0,224  0,800  0,800 -0,000 -0,000  0,000  0,0203  0,2267
                    .                            .
                    .                            .
                    .                            .

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
       37  0,010  0,946  0,936  0,212  0,112  0,186  0,0216  0,0045

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

SATISFACTORY STRESS WAS REACHED

THE FINAL CONFIGURATION OF   6 POINTS IN  3 DIMENSIONS HAS STRESS  0,010

FINAL CONFIGURATION
      1       2       3
 1  0,445   0,702  -0,555
 2 -0,468   0,875  -0,135
 3 -0,672   0,277   0,688
 4 -0,445  -0,706   0,547
 5  0,229  -0,958  -0,175
 6  0,911  -0,190  -0,370

*********

HISTORY OF COMPUTATION, N=    6, DIMENSION=  2

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        0  0,117  0,800  0,800  0,000  0,000  0,000  0,1087  0,6382
                    .                            .
                    .                            .
                    .                            .

D=0A
D=0A
D=0A
D=0A
D=0A
D=0A
        8  0,006  0,176  0,467  0,990  0,526  0,989  0,1173  0,0327

ITERATION STRESS   SRAT SRATAV CAGRGL  COSAV  ACSAV    SFGR    STEP
```

continued

000 0075

SATISFACTORY STRESS WAS REACHED

THE FINAL CONFIGURATION OF 6 POINTS IN 2 DIMENSIONS HAS STRESS 0,006

FINAL CONFIGURATION

	1	2
1	0,643	0,772
2	-0,354	0,939
3	-0,995	0,149
4	-0,629	-0,766
5	0,353	-0,934
6	0,982	-0,159

****

HISTORY OF COMPUTATION, N= 6, DIMENSION= 1

ITERATION	STRESS	SRAT	SRATAV	CAGRGL	COSAV	ACSAV	SFGR	STEP
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
0	0,422	0,800	0,800	-0,000	-0,000	0,000	0,0297	0,6275
.								
.								
.								
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
14	0,413	1,000	0,999	-0,326	-0,033	0,554	0,0001	0,0021
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
15	0,413	1,000	0,999	-0,997	-0,669	0,846	0,0006	0,0005
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
D=0A								
16	0,413	1,000	0,999	1,000	0,432	0,948	0,0004	0,0004
ITERATION	STRESS	SRAT	SRATAV	CAGRGL	COSAV	ACSAV	SFGR	STEP

MINIMUM WAS ACHIEVED

THE FINAL CONFIGURATION OF 6 POINTS IN 1 DIMENSIONS HAS STRESS 0,413

FINAL CONFIGURATION

	1
1	1.364
2	1.001
3	-0.366
4	-1.001
5	-1.366
6	0.368

****

****

000 0075

COST ESTIMATE

For the job listed on the Sample Output, the total processing time was 88.912 seconds. At the current rate for the Michigan State University's CDC 3600 ($245./hr.), the computer time cost $6.05 plus a charge for input and output. A 10% surcharge will be assessed if the billing is to a non-University account. In addition, there is a consulting fee of $10./hr. for work done by the Applications Programming Group.

Charge to user = computer costs + consulting + network overhead
= $6.10 (approx.) + consulting + network overhead

CONTENTS—SUBROUTINE KRUSCAL