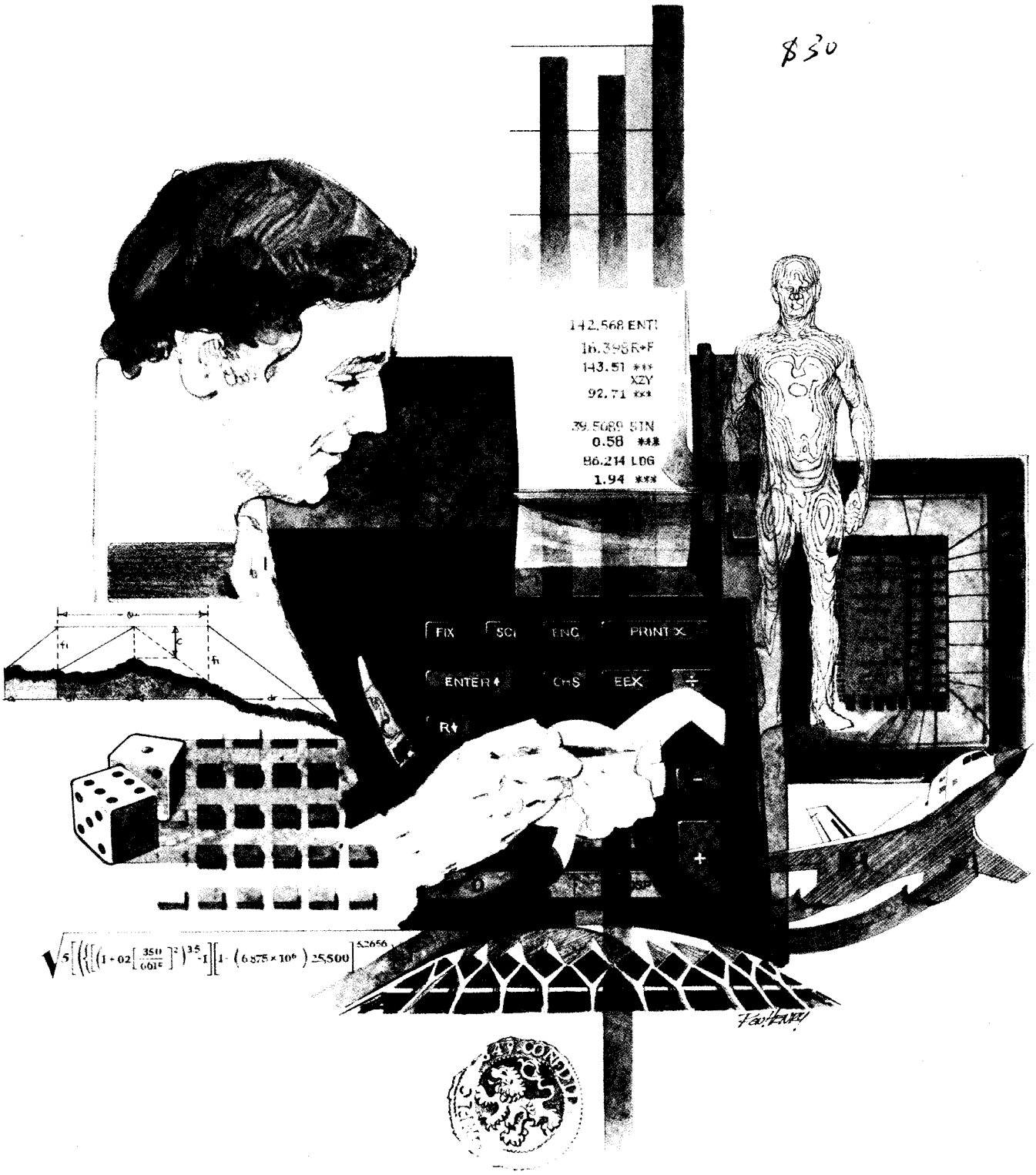
HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Industrial Engineering



INTRODUCTION

In an effort to provide continued value to it's customers, Hewlett-Packard is introducing a unique service for the HP fully programmable calculator user. This service is designed to save you time and programming effort. As users are aware, Programmable Calculators are capable of delivering tremendous problem solving potential in terms of power and flexibility, but the real genie in the bottle is program solutions. HP's introduction of the first handheld programmable calculator in 1974 immediately led to a request for program **solutions** — hence the beginning of the HP-65 Users' Library. In order to save HP calculator customers time, users wrote their own programs and sent them to the Library for the benefit of other program users. In a short period of time over 5,000 programs were accepted and made available. This overwhelming response indicated the value of the program library and a Users' Library was then established for the HP-67/97 users.

To extend the value of the Users' Library, Hewlett-Packard is introducing a unique service—a service designed to save you time and money. The Users' Library has collected the best programs in the most popular categories from the HP-67/97 and HP-65 Libraries. These programs have been packaged into a series of low-cost books, resulting in substantial savings for our valued HP-67/97 users.

We feel this new software service will extend the capabilities of our programmable calculators and provide a great benefit to our HP-67/97 users.

A WORD ABOUT PROGRAM USAGE

Each program contained herein is reproduced on the standard forms used by the Users' Library. Magnetic cards are not included. The Program Description I page gives a basic description of the program. The Program Description II page provides a sample problem and the keystrokes used to solve it. The User Instructions page contains a description of the keystrokes used to solve problems in general and the options which are available to the user. The Program Listing I and Program Listing II pages list the program steps necessary to operate the calculator. The comments, listed next to the steps, describe the reason for a step or group of steps. Other pertinent information about data register contents, uses of labels and flags and the initial calculator status mode is also found on these pages. Following the directions in your HP-67 or HP-97 **Owners' Handbook and Programming Guide,** "Loading a Program" (page 134, HP-67; page 119, HP-97), key in the program from the Program Listing I and Program Listing II pages. A number at the top of the Program Listing indicates on which calculator the program was written (HP-67 or HP-97). If the calculator indicated differs from the calculator you will be using, consult Appendix E of your **Owner's Handbook** for the corresponding keycodes and keystrokes converting HP-67 to HP-97 keycodes and vice versa. No program conversion is necessary. The HP-67 and HP-97 are totally compatible, but some differences do occur in the keycodes used to represent some of the functions.

A program loaded into the HP-67 or HP-97 is not permanent—once the calculator is turned off, the program will not be retained. You can, however, permanently save any program by recording it on a blank magnetic card, several of which were provided in the Standard Pac that was shipped with your calculator. Consult your **Owner's Handbook** for full instructions. A few points to remember:

The Set Status section indicates the status of flags, angular mode, and display setting. After keying in your program, review the status section and set the conditions as indicated before using or permanently recording the program.

REMEMBER! To save the program permanently, **clip** the corners of the magnetic card once you have recorded the program. This simple step will protect the magnetic card and keep the program from being inadvertently erased.

As a part of HP's continuing effort to provide value to our customers, we hope you will enjoy our newest concept.

TABLE OF CONTENTS

Program Description I

Program Title Discounted Cash-Flow / Present-Value Analysis

Contributor's Name Hernan C. Anzola

Address Stanford University/Escondido Village Apt. 96-H

City Stanford **State** California **Zip Code** 94305

Program Description, Equations, Variables 1) given a series of up to 22 cash flows (F_j) j=0 to n, the program calculates the value of "i" (internal rate of return) that equals to 0 the equation $\Sigma F_j/(1+i)^j$. The program applies the Newton Formula for sucessive aproximations: $i_k = i_{k-1} - S_{k-1}/S'_{k-1}$ where: $S = \Sigma F_j/(1+i)^j$ j=0 to n

S' = derivative of S respect to i = $\Sigma -j/(1+i) \times F_j/(1+i)^j$

After each iteration the program displays the value of i_k given by the Newton Formula.

2) Given F_0, i and n the program calculates the value of $F_1=F_2=...=F_n$ that makes the expression for S (see above) equal to 0.

3) Given F_0, i and $F_1=F_2=....=F_n$ the program calculates the value of n that makes S = 0.

4) Given up to 22 cash flows (0,1,2,..,n) the program calculates the present value (PV) of the series for any given discount rate (i).

5) After the unknown in 1), 2), 3) or 4) has been calculated the program can display the following values:

j, $F_j/(1+i)^j$ and $\Sigma F_k/(1+i)^k$ for j=1 to n.

6) $n = -Ln(1-iF_0/F_1)/Ln(1+i)$ $\quad F_1=F_2=..=F_n = iF_0/[1-(1+i)^{-n}]$

Operating Limits and Warnings 1) no more than 22 cash flows (0,1,...,21) should be used. 2) when calculating "n" the combination of the values for F_0, i and $F_1=F_2=....=F_n$ can make the program unfeasible, in that case ERROR will be displayed. 3)After "n" has been calculated and you press E to get the sequential display of the discounted series, the program will m periods where m is equal to the integer part of the n found.

Program Description II

Sketch(es)

Sample Problem(s) Listed are the cash flow associated with a prosed investment:

End of year	Cash flow ($)
0	-55,280
1	12,000
2	12,000
3	12,000
4	12,000
5	42,280

What is the internal rate of return of that investment?

Solution(s)

keystrokes:

5 [A]	0.00
55280 [CHS] [R/S]	1.00
4 [B]	1.00
12000 [R/S]	5.00
42280 [R/S]	0.00
[f] [A]	10.56 (on PAUSE)
	14.58 "
	15.00 "
	15.00
internal rate of return with a precision of 0.001 %	15.00

Press [E] and the program will display seq. j, $F_j/(1+i)^j$ and $\sum F_j/(1+i)^j$

Reference(s) Mao, James. T.; "Corporate Financial Decisions"; Pavan Publishers, Palo Alto, California, 1976

Program Description II

Sketch(es)

Sample Problem(s) Listed are the cash flows associated with a proposed investment:

End of year	cash flow ($)
0	-1,000
1	500
2	400
3	300
4	100

What is the Present Value when the discount rate is 10% ?
" " " " " " " " " " 20%?
" " " internal rate of return ?

Solution(s) Keystrokes:

4 [A]	0.00	
1000 [CHS] [R/S]	1.00	
500 [R/S]	2.00	
400 [R/S]	3.00	
300 [R/S]	4.00	
100 [R/S]	0.00	
10 [f] [B]	78.82	PV @ 10 %
20 [f] [B]	-83.72	PV @ 20 %
[f] [A] (after 3 iterations)	14.49	int. rate of ret.%

Reference(s) Weston & Brigham, "Managerial Finance",Fifth Edition;
The Dryden Press, Hinsdale, Illinois, 1975

Program Description II

Sketch(es)

Sample Problem(s) A company plans an expansion involving $300,000 to be raised by selling stock. The equipment will be depreciated in 10 years by the straight line method. The expected net profit per year will be $45,000. What is the economic payout time when i = 8%?
The cash flow per year is equal to the net profit plus depreciation charges ($300,000/10 = 30,000); this is $45,000 + $30,000 = $75,000.

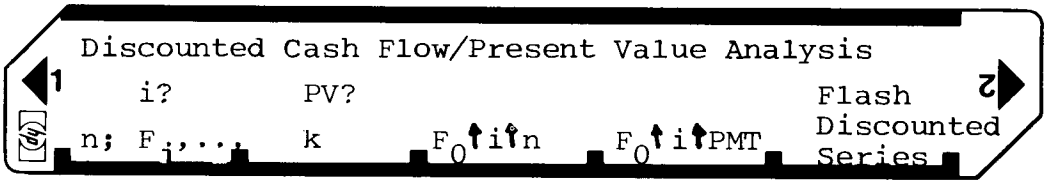
Solution(s)

keystrokes:	
300000 [CHS] [ENTER]	-300000.00
8 [ENTER]	8.00
75000 [D]	5.01 years

* If you want to obtaing for each year the value of $Fj/(1+i)^j$ and its accumulated value, press [E].

Reference(s) Schweyer Herbert, "Process Engimeering Economics",McGraw-Hill, New York, 1955

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2			
	If the unknown is the internal rate of			
	return (i) or the present value (PV)			
	do steps 2 and 3:			
2	Input n (number of periods after 0)	n	A	0.00
3	Input the cash flow series $F_0,..,F_n$	F_j	R/S	j+1
	*Repeat step 3 "n+1" times. Each time			
	the calculator will display the seq.			
	number of the cash flow you should			
	enter: 0,1,2,...,n. After the n-th			
	cash flow has been entered the cal-			
	culator will display zero			0.00
4	Optional: if at any period (j) you			
	want to enter "k" equal cash flows			
	$F_j = F_{j+1} = ... = F_{j+k}$; input "k"	k	B	j
	and continue with step 3.			
5	If the unknown is "i" :		f A	i (%)
	After each iteration the value of i			
	obtained at that point from the New-			
	ton formula will be displayed for 1 sec.			i (%)
	* For a new case go to step 2			
5	If the unknown is Present Value (PV):	i (%)	f B	PV
	* For a new case using a diferent "i"			
	repeat the step again.			
2	If the unknown is $F_1=F_2=..=F_n$ = PMT :			
	Input F_0 value	F_0	ENT	F_0
	Input i value	i (%)	ENT	i (%)
	Input n value	n	C	PMT
	* For a new case repeat the step again.			
2	If the unknown is n:			
	Input F_0 value	F_0	ENT	F_0
	Input i value	i (%)	ENT	i (%)
	Input PMT value ($PMT=F_1=F_2=....=F_n$)	PMT	D	n
	* For a new case repeat the step again.			
**	OPTIONAL: If after the calculator has		E	j
	displayed the unknown value (i, PV, n			$F_j/(1+i)^j$
	or PMT) you want to see the discounted			$\sum F_j/(1+i)^j$
	and accumulated value for each year of			
	the series (in flash mode), beginning with year 1, PRESS [E]			

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL A	31 25 11	To enter n and the series of cash flows.
002	CF 1	35 61 01	
003	CF 2	35 61 02	
004	CF 0	35 61 00	
005	CL REG	31 43	
006	STO C	33 13	
007	1	01	
008	CHS	42	
009	X≠I	35 24	
010	LBL 0	31 25 00	Load the cash flows in R_0 to R_n ($0 < n \leq 21$) 22 cash flows in total.
011	ISZ	31 34	
012	LBL 2	31 25 02	
013	RC I	35 34	
014	R/S	84	
015	STO (i)	33 24	
016	LBL 8	31 25 08	
017	RC I	35 34	
018	RCL C	34 13	
019	X ≠ Y	32 61	
020	GTO 0	22 00	
021	0	00	
022	RTN	35 22	
023	LBL B	31 25 12	To load k equal and consecutive cash flows ($F_j = F_{j+1} = .. = F_{j+k}$)
024	+	61	
025	1	01	
026	-	51	
027	STO E	33 15	
028	RC I	35 34	
029	R/S	84	
030	STO D	33 14	
031	STO (i)	33 24	
032	LBL 4	31 25 04	
033	RCL D	34 14	
034	ISZ	31 34	
035	STO (i)	33 24	
036	RCL E	34 15	
037	INT	31 83	
038	RC I	35 34	
039	X ≠ Y	32 61	
040	GTO 4	22 04	
041	F? 1	35 71 01	
042	RTN	35 22	
043	GTO 8	22 08	
044	LBL C	31 25 13	To calculate PMT equal to $F_1 = F_2 = ... = F_n$, when F_0, i and n are given.
045	CL REG	31 43	
046	STO C	33 13	
047	R↓	35 53	
048	GSB c	32 22 13	
049	R↓	35 53	
050	STO 0	33 00	
051	CHS	42	
052	R↑	35 54	
053	FRAC	32 83	
054	X	71	
055	GSB 6	31 22 06	
056	RCL C	34 13	
057	INT	31 83	
058	CHS	42	
059	Y^X	35 63	
060	CHS	42	
061	1	01	
062	+	61	
063	÷	81	
064	STO D	33 14	
065	SF 3	35 51 03	
066	RTN	35 22	
067	LBL 5	31 25 05	
068	0	00	
069	X≠I	35 24	
070	SF 1	35 51 01	
071	RCL C	34 13	
072	INT	31 83	
073	STO E	33 15	
074	GSB 4	31 22 04	
075	RTN	35 22	
076	LBL D	31 25 14	To calculate n when F_0, i and $PMT = F_1 = F_2 = .. = F_n$ are given.
077	CL REG	31 43	
078	STO D	33 14	
079	R↓	35 53	
080	GSB c	32 22 13	
081	R↓	35 53	
082	STO 0	33 00	
083	CHS	42	
084	R↑	35 54	
085	X	71	
086	RCL D	34 14	
087	+	81	
088	1	01	
089	-	51	
090	CHS	42	
091	LN	31 52	
092	CHS	42	
093	GSB 6	31 22 06	
094	LN	31 52	
095	÷	81	
096	ST I	35 33	
097	INT	31 83	
098	RCL C	34 13	
099	+	61	
100	STO C	33 13	
101	RC I	35 34	
102	SF 3	35 51 03	
103	RTN	35 22	
104	LBL d	32 25 14	To calculate the internal rate of return (i) by using the Newton formula. $F = \sum F_j/(1+i)^j$ is store in R_D
105	0	00	
106	X≠I	35 24	
107	STO E	33 15	
108	RCL 0	34 00	
109	STO D	33 14	
110	LBL e	32 25 15	
111	ISZ	31 34	
112	RCL (i)	34 24	

REGISTERS

0 F_0	1 F_1	2 F_2	3 F_3	4 F_4	5 F_5	6 F_6	7 F_7	8 F_8	9 F_9
S0 F_{10}	S1 F_{11}	S2 F_{12}	S3 F_{13}	S4 F_{14}	S5 F_{15}	S6 F_{16}	S7 F_{17}	S8 F_{18}	S9 F_{19}
A F_{20}	B F_{21}	C n.i	D used	E used	I used				

67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	GSB 6	31 22 06	and $F'=\sum -j/(1+i)^{j} \times F_j/(1+i)^{j}$
114	RC I	35 34	
115	GSB 9	31 22 09	
116	Y^x	35 63	
117	÷	81	
118	GSB 9	31 22 09	
119	RCL D	34 14	
120	X⇄Y	35 52	
121	+	61	
122	STO D	33 14	
123	GSB 9	31 22 09	
124	F? 0	35 71 00	
125	GTO 1	22 01	
126	LST X	35 82	
127	GSB 6	31 22 06	
128	÷	81	
129	RC I	35 34	
130	X	71	
131	CHS	42	
132	RCL E	34 15	
133	+	61	
134	STO E	33 15	
135	LBL 1	31 25 01	
136	RC I	35 34	
137	RCL C	34 13	
138	INT	31 83	
139	X≠Y	32 61	
140	GTO e	22 31 15	
141	F? 0	35 71 00	If flag 0 is ON Returns to Sub.E
142	RTN	35 22	
143	F? 2	35 71 02	If flag 2 is ON
144	RTN	35 22	Returns to Sub.
145	RCL C	34 13	b.
146	FRAC	32 83	
147	RCL D	34 14	
148	RCL E	34 15	
149	÷	81	
150	-	51	
151	EEX	43	
152	2	02	
153	X	71	
154	PAUSE	35 72	To flash the new value of i given by the Newton formula (i_j)
155	EEX	43	
156	2	02	
157	÷	81	
158	ENTER	41	
159	ENTER	41	
160	RCL C	34 13	
161	FRAC	32 83	
162	-	51	
163	ABS	35 64	To compare i_j to i_{j-1}; if the absolute value of the difference is <= than .001 then i_j is the internal rate of return.
164	EEX	43	
165	CHS	42	
166	3	03	
167	X > Y	32 81	
168	GTO 3	22 03	

STEP	KEY ENTRY	KEY CODE	COMMENTS
169	R↓	35 53	
170	R↓	35 53	
171	GSB 7	31 22 07	
172	STO C	33 13	
173	GTO d	22 31 14	
174	LBL 3	31 25 03	After the value of i has been found, this routine store it in R_C (fraction) and displays it as a pertentage.
175	R↓	35 53	
176	R↓	35 53	
177	GSB 7	31 22 07	
178	STO C	33 13	
179	FRAC	32 83	
180	EEX	43	
181	2	02	
182	X	71	
183	RTN	35 22	
184	LBL c	32 25 13	To transform a given i from % to fraction and store it in R_C
185	EEX	43	
186	2	02	
187	÷	81	
188	GSB 7	31 22 07	
189	STO C	33 13	
190	RTN	35 22	
191	LBL E	31 25 15	To flash (after the unknown has been calculated) j, $F_j/(1+i)^j$, $\sum F_j/(1+i)^j$ for j=1,n
192	F? 3	35 71 03	
193	GSB 5	31 22 05	
194	SF 0	35 51 00	
195	GSB d	32 22 14	
196	RCL D	34 14	
197	CF 0	35 61 00	
198	RTN	35 22	
199	LBL b	32 25 12	To calculate the present value (PV) of n given cash flows (F_j)
200	CF 3	35 61 03	
201	GSB c	32 22 13	
202	SF 2	35 51 02	
203	GSB d	32 22 14	
204	RCL D	34 14	
205	RTN	35 22	
206	LBL a	32 25 11	To calculate the internal rate of return (i)
207	CF 3	35 61 03	
208	GTO d	22 31 14	
209	RTN	35 22	
210	LBL 6	31 25 06	Group of statements used several times
211	RCL C	34 13	
212	FRAC	32 83	
213	1	01	
214	+	61	
215	RTN	35 22	
216	LBL 7	31 25 07	Group of statements used several times
217	RCL C	34 13	
218	INT	31 83	
219	+	61	
220	RTN	35 22	
221	LBL 9	31 25 09	To flash X if flag 0 is ON
222	F? 0	35 71 00	
223	- X -	31 84	
224	RTN	35 22	

LABELS

A load n and Fi	B load k equal Fj	C to calc. PMT	D to calc. n	E flash results
a calc. i	b calc. PV	c used	d used	e used
0 used	1 used	2 used	3 used	4 used
5 used	6 used	7 used	8 used	9 used

FLAGS

0 flash results
1 used
2 used
3 used

SET STATUS

FLAGS		TRIG	DISP
	ON OFF		
0	☐ ☒	DEG ☒	FIX ☒
1	☐ ☒	GRAD ☐	SCI ☐
2	☐ ☒	RAD ☐	ENG ☐
3	☐ ☒		n 2

Program Description I

Program Title DEPRECIATION SCHEDULES

Contributor's Name HEWLETT-PACKARD COMPANY
Address Corvallis Division
1000 N.E. Circle Boulevard
City Corvallis, OR 97330 **tate** **Zip Code**

Program Description, Equations, Variables

Three methods of depreciation are commonly used: straight-line, sum-of-the-years'-digits, and declining balance. This program evaluates the depreciation schedules for these three methods, and calculates the crossover point between straight line and declining balance depreciation. For the schedules, the output is the annual depreciation amount (DEP), remaining depreciable amount (RDV), remaining book value (RBV), and the total depreciation to date (TOT DEP), as well as an increment for the next year's schedule.

An option is available to output the depreciation schedule beginning at a specified year. Pressing f E sets and clears the print flag. Successive use of f E will alternately display 1.00 and 0.00, indicating that the print mode is on or off respectively.

Values for the last year of an asset with fractional years life (i.e., the 21st year's values for an asset with 20.5 years life) are calculated correctly. However, all other values represent a full year's depreciation. For this reason only integer values (whole number, 1.0, 2.0, 17.0 etc.) may be entered for YR (the D key). The program makes no checks on this value and generates invalid results if other than whole numbers are entered.

Straight Line Depreciation

The annual depreciation allowance using this method is determined by dividing the cost or other basis of valuation (starting book value) less its estimated salvage value by its useful life expectancy. This program develops the starting book value (SBV), salvage value (SAL), life expectancy (LIFE), and first year of the schedule (YR). (The schedule may be started at any point in the useful life.)

Fractional years life must be entered as an integer plus a fraction. Thus a life of 12 years 3 months would be keyed in as 12.25 for LIFE.

Operating Limits

Sum of the Years' Digits Depreciation

The sum-of-the-years' digits method is an accelerated form of depreciation, allowing more depreciation in the early years of an asset's life than allowed under the straight line method. This program generates the schedule output, given the starting book value (SBV), the salvage value (SAL), expected useful life in years (LIFE), and beginning year (YR) for the schedule. (The schedule may be started at any point in the useful life.)

Fractional years asset life must be entered as an integer plus a fraction. Thus a life of 12 years 3 months would be keyed in as 12.25 for LIFE.

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

Variable Rate Declining Balance Depreciation

The variable rate declining balance method is another form of accelerated depreciation; as such it provides for more depreciation in earlier years and decreasing depreciation in later years. The program generates the depreciation schedule given the starting book value (SBV), salvage value (SAL), useful life expectancy (LIFE), the declining rate factor (FACT), and the first year of the desired schedule (YR). The schedule may be started at any point in the useful life.

The "variable rate" is indicated as either a factor or percent with equal frequency in the business community. Thus, "1.5 declining balance factor" and "150% declining balance" have the same meaning. The number to be keyed in for FACT (E) in this program, should be in factor form, that is 1.25, 1.5, 2, and not 125, 150 or 200.

This method of depreciation is unique in that it may generate depreciation greater than the depreciable value for some assets, while it may not generate sufficient depreciation for others. The crossover calculation (f D) is provided to assist in determining the best time to switch to straight line depreciation (tax laws permitting) so that an asset may be fully depreciated.

Fractional years life must be entered as an integer and a decimal. Thus, a life of 12 years 3 months would be keyed in as 12.25.

Crossover Point

As indicated in the description above, the declining balance method of depreciation may not fully depreciate an asset in the asset's lifetime. In these circumstances there is an optimum point in the useful life where a switch from the declining balance method to the straight line method should be made. This is the "crossover point", the first year in which the depreciation by the straight line method is greater than if depreciation were continued using declining balance method. (In accordance with Internal Revenue Service Publication 534, the straight line depreciation is determined by dividing the remaining depreciable value by the remaining useful life.)

Operating Limits :

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

Given the starting book value (SBV), salvage value (SAL), useful life expectancy (LIFE), and declining balance factor (FACT), this routine calculates the last year that the declining balance method should be used, and the remaining life and remaining book value after this "last year" so that a switch to straight line depreciation can be made. As in the previous routine, the factor (FACT) should be entered in factor form (1.25, 1.5, 2.0), not as a percent (125, 150, 200).

The crossover routine (f D) may be used with the declining balance (f C) and straight line (f A) depreciation routines as follows:

1. Use f D to determine the "crossover point" and associated values.
2. Use f C to generate a declining balance depreciation schedule for the early years up to and including the year indicated as being the "last year". Since the same input values are used, only a value for YR (D) need be keyed in before pressing f C.
3. Now use f A to generate a straight line depreciation schedule for the remaining years. The remaining book value at the end of the last "declining balance year" is keyed in for starting book value (A), and the remaining life is keyed in for the asset's life (C). There is no need to enter the salvage value as it has been retained throughout this process.

   For this portion of the depreciation schedule, the value for "total depreciation to date" will be in error by an amount equal to the amount depreciated during the declining balance calculations.

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

Depreciation Schedules

where:

K = value for YR
$TOTDEP_K$ = total depreciation for years 1 through K.
W = integer portion of LIFE
F = decimal portion of LIFE
(i.e., for a LIFE of 12.25 years W = 12 and F = .25)

Straight Line Schedule

$$DEP_K = \frac{SBV - SAL}{LIFE}$$

$$DEP_K \text{ (last year)} = \left(\frac{SBV - SAL}{LIFE}\right) \cdot F$$

$$TOTDEP_K = (K) \cdot \left(\frac{SBV - SAL}{LIFE}\right)$$

Solution(s)

$$RDV_K = (LIFE - K) \cdot \left(\frac{SBV - SAL}{LIFE}\right)$$

$$RBV_K = RDV_K + SAL$$

Reference(s)

Program Description II

Sketch(es)

Sample Problem(s)

Sum-of-the-Years'-Digits Schedule

$$SOYD = \frac{(W + 1)(W + 2F)}{2}$$

$$DEP_K = \left(\frac{LIFE + 1 - K}{SOYD}\right) \cdot (SBV - SAL)$$

$$TOTDEP_K = \left[1 - \frac{(W - K + 1) \times (W - K + 2F)}{2 \times (SOYD)}\right] \cdot (SBV - SAL)$$

$$RDV_K = \left[\frac{(W - K + 1) \times (W - K + 2F)}{2 \times (SOYD)}\right] \cdot (SBV - SAL)$$

$$RBV_K = RDV_K + SAL$$

Variable Rate Declining Balance Schedule

Solution(s)

$$DEP_K = SBV \cdot \left(1 - \frac{FACT}{LIFE}\right)^{K-1} \cdot \left(\frac{FACT}{LIFE}\right)$$

$$TOTDEP_K = SBV \cdot \left[1 - \left(1 - \frac{FACT}{LIFE}\right)^{K}\right]$$

$$RDV_K = (SBV - SAL) - TOTDEP_K$$

$$RBV_K = RDV_K + SAL$$

Crossover Point—Declining Balance to Straight Line

Reference(s)

$$SBV \left(1 - \frac{FACT}{LIFE}\right)^{K-1} \cdot \left(\frac{FACT}{LIFE}\right) > \frac{(SBV - SAL) - TOT\,DEP_{K-1}}{L + 1 - K}$$

where $TOTDEP_{K-1}$ is determined as shown above.

The largest integer value for K which maintains the above relationship is the "last year" to use the Declining Balance depreciation method.

Program Description 11

Sketch(es)

Sample Problem(s)

Example 1:

For a starting book value of $375,000, a salvage value of $30,000 and an expected life of 40 years, generate the 1st year's depreciation schedule using each of the common methods. Assume a declining balance factor of 1.5. Then jump ahead to the 15th year and generate the data for that year.

Solution(s)

Keystrokes:	Outputs:	
375000 STO A 30000 STO B 40 STO C 1 STO D		
Straight Line		
■ A →	1.00	(1st year)
R/S →	8625.00	(1st year's depreciation)
R/S →	336375.00	(remaining depreciable value)
R/S →	366375.00	(remaining book value)
R/S →	8625.00	(total depreciation to date)

Now jump ahead to the 15th year.

Keystrokes:	Outputs:	
15 STO D ■ A →	15.00	(15th year)
R/S →	8625.00	(15th year's depreciation)
R/S →	215625.00	(remaining depreciable value)
R/S →	245625.00	(remaining book value)
R/S →	129375.00	(total depreciation after 15 years)
SOYD		
1 STO D ■ B →	1.00	(1st year)
R/S →	16829.27	(1st year's depreciation)
R/S →	328170.73	(remaining depreciable value)
R/S →	358170.73	(remaining book value)

Reference(s)

Program Description 11

Sketch(es)

Sample Problem(s)

R/S →	16829.27	(total depreciation to date)

Jump ahead to the 15th year.

15 STO D ■ B →	15.00	(15th year)
R/S →	10939.02	(15th year's depreciation)
R/S →	136737.80	(remaining depreciable value)
R/S →	166737.80	(remaining book value)
R/S →	208262.20	(total depreciation 1st through 15th year)

Declining Balance

1 STO D 1.5 STO E ■ C →	1.00	(1st year)
R/S →	14062.50	(1st year's depreciation)
R/S →	330937.50	(remaining depreciable value)
R/S →	360937.50	(remaining book value)
R/S →	14062.50	(total depreciation to date)

Solution(s)

Keystrokes:	**Outputs:**	
Now jump to the 15th year.		
15 STO D ■ C →	15.00	(15th year)
R/S →	8235.18	(15th year's depreciation)
R/S →	181369.51	(remaining depreciable value)
R/S →	211369.51	(remaining book value)
R/S →	163630.49	(total depreciation 1st through 15th year)

Reference(s)

Program Description II

Sketch(es)

Sample Problem(s)

Example 2:

Having just performed the previous calculation, determine the crossover point and the associated remaining life and remaining book value. Generate the depreciation data for the declining balance "last year," and then switch to the straight line method to generate the depreciation data for the year following the declining balance "last year."

Solution(s)

Keystrokes:	Outputs:	
■ D →	18.00	(last year to use declining balance)
R/S →	22.00	(asset's remaining life after 18 years)
R/S →	188471.01	(remaining book value after 18th year)
18 STO D ■ C →	18.00	(18th year)
R/S →	7343.03	(18th year's depreciation)
R/S →	158471.01	(remaining depreciable value)
R/S →	188471.01	(remaining book value)
R/S →	186528.99	(total depreciation 1st through 18th year)
188471.01 STO A 22 STO C		
1 STO D ■ A →	1.00	(1st year)
R/S →	7203.23	(19th year's depreciation)

Note:

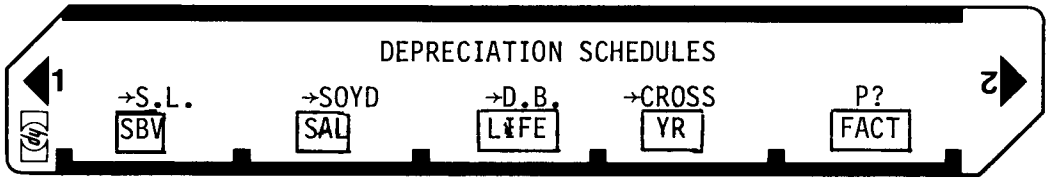
Although 1 was keyed in for YR—the first year of straight line depreciation—this is the 19th year of the asset's life.

Reference(s)

R/S →	151267.78	(remaining depreciable value)
R/S →	181267.78	(remaining book value)

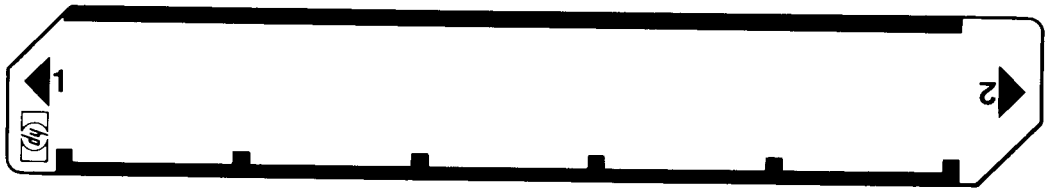
etc.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2			
2	Optional: Select print mode		f E	1.00 or 0.00
3	Key in all of the following:			
	• Starting book value	SBV	STO A	SBV
	• Salvage value	SAL	STO B	SAL
	• Life of the asset	LIFE	STO C	LIFE
4	For depreciation schedules,			
	key in:			
	• Year for which depreciation			
	is to be calculated.	YR	STO D	YR
5	To calculate straight line			
	depreciation schedule		f A	YR
			R/S	DEP
			R/S	RDV
			R/S	RBV
			R/S	TOT DEP
			R/S	YR + 1
			etc.	
	For new case go to steps 3 and			
	4 and change appropriate			
	inputs.			

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
6	Calculate the SOYD schedule		f B	YR
			R/S	DEP
			R/S	RDV
			R/S	RBV
			R/S	TOT DEP
			R/S	YR + 1
			etc.	
	For new case go to steps 3 and			
	4 and change appropriate			
	inputs.			
7	Calculate the declining balance			
	schedule (the appropriate			
	factor must be entered).	FACT	STO E	FACT
			f C	YR
			R/S	DEP
			R/S	RDV
			R/S	RBV
			R/S	TOT DEP
			R/S	YR + 1
			etc.	
	For new case go to steps 3 and			
	4 and change appropriate			
	inputs.			
8	To find crossover point the			
	declining balance factor must			
	be stored.	FACT	STO E	FACT
9	Calculate last year to use de-			
	clining balance method.		f D	LAST YEAR
10	Calculate remaining life.		R/S	REM LIFE
11	Calculate remaining book			
	value.		R/S	RBV

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	Straight Line
002	F0?	16 23 00	
003	SPC	16-11	
004	RCLD	36 14	k
005	GSB9	23 09	
006	RCLA	36 11	$\frac{SBV-SAL}{LIFE} \rightarrow R_I$
007	RCLB	36 12	
008	-	-45	
009	RCLC	36 13	
010	÷	-24	
011	STOI	35 46	DEP
012	GSB9	23 09	
013	RCLC	36 13	
014	RCLD	36 14	(LIFE-YR)DEP=RDV_k
015	-	-45	
016	RCLI	36 46	
017	x	-35	
018	GSB9	23 09	
019	RCLB	36 12	
020	+	-55	RBV_k
021	GSB9	23 09	
022	RCLI	36 46	$\left(\frac{SBV-SAL}{LIFE}\right)$ YR=TOT DEP
023	RCLD	36 14	
024	x	-35	
025	GSB9	23 09	
026	1	01	
027	GSBD	23 14	
028	RCLC	36 13	
029	RCLD	36 14	k≤LIFE?
030	X≤Y?	16-35	
031	GTOa	22 16 11	- - - - - - - - - -
032	RTN	24	
033	*LBLb	21 16 12	SOYD
034	F0?	16 23 00	
035	SPC	16-11	
036	RCLD	36 14	k
037	GSB9	23 09	
038	RCLA	36 11	
039	RCLB	36 12	
040	-	-45	
041	STO8	35 08	
042	RCLC	36 13	
043	GSB2	23 02	$\left(\frac{LIFE+1-k}{SOYD}\right)$(SBV-SAL)
044	STO7	35 07	
045	RCLC	36 13	
046	1	01	
047	+	-55	
048	RCLD	36 14	
049	-	-45	
050	RCL7	36 07	
051	÷	-24	
052	RCL8	36 08	
053	x	-35	
054	GSB9	23 09	DEP_k
055	RCLC	36 13	
056	RCLD	36 14	
057	-	-45	
058	X<0?	16-45	
059	GTO3	22 03	
060	GSB2	23 02	
061	RCL7	36 07	
062	÷	-24	
063	STO4	35 04	
064	RCL8	36 08	
065	x	-35	
066	*LBL3	21 03	
067	STO6	35 06	RDV_k
068	GSB9	23 09	
069	RCLB	36 12	
070	+	-55	
071	GSB9	23 09	RBV_k=RDV_k+SAL
072	1	01	
073	RCL4	36 04	
074	-	-45	
075	RCL8	36 08	
076	x	-35	
077	GSB9	23 09	TOT DEP_k
078	1	01	
079	GSBD	23 14	
080	RCLC	36 13	
081	RCLD	36 14	k≤LIFE?
082	X≤Y?	16-35	
083	GTOb	22 16 12	- - - - - - - - - -
084	RTN	24	
085	*LBL2	21 02	
086	ENT↑	-21	
087	FRC	16 44	$\frac{(1+W)(2F+W)}{2}$
088	ENT↑	-21	
089	+	-55	
090	X≠Y	-41	= SOYD
091	INT	16 34	
092	+	-55	
093	LSTX	16-63	
094	1	01	
095	+	-55	
096	x	-35	
097	2	02	
098	÷	-24	- - - - - - - - - -
099	RTN	24	Declining Balance
100	*LBLc	21 16 13	
101	F0?	16 23 00	
102	SPC	16-11	
103	RCLD	36 14	
104	GSB9	23 09	k
105	GSB4	23 04	
106	RCLD	36 14	
107	1	01	
108	-	-45	
109	Y^x	31	
110	RCLA	36 11	
111	x	-35	
112	RCL8	36 08	

REGIS...

0	1	2	3	4 Used	5 Used	6 RDV_k	7 Used	8 Used	9 TOT DEP
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A SBV	B SAL	C LIFE	D YR	E FACTOR	I SBV-SAL/LIFE

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	×	-35	
114	STOI	35 46	
115	GSB9	23 09	DEP_k
116	1	01	
117	RCL7	36 07	
118	RCLD	36 14	
119	Y^x	31	
120	-	-45	
121	RCLA	36 11	
122	×	-35	(SBV-SAL)-TOT DEP_k
123	STO9	35 09	
124	RCLA	36 11	
125	RCLB	36 12	
126	-	-45	
127	RCL9	36 09	
128	-	-45	
129	GSB9	23 09	RDV_k
130	RCLB	36 12	
131	+	-55	
132	GSB9	23 09	
133	RCL9	36 09	RBV_k
134	GSB9	23 09	
135	1	01	TOT DEP_k
136	GSBD	23 14	
137	RCLC	36 13	
138	RCLD	36 14	
139	X≤Y?	16-35	K≤LIFE?
140	GTOe	22 16 13	
141	RTN	24	- - - - - - - - - -
142	*LBLD	21 14	
143	RCLD	36 14	To add to register D
144	+	-55	
145	STOD	35 14	
146	RTN	24	
147	*LBL4	21 04	- - - - - - - - - -
148	1	01	
149	RCLE	36 15	FACT/LIFE→R_8
150	RCLC	36 13	
151	÷	-24	
152	STO8	35 08	1-FACT/LIFE→R_7
153	-	-45	
154	STO7	35 07	
155	RTN	24	- - - - - - - - - -
156	*LBLe	21 16 15	
157	F0?	16 23 00	Print/pause
158	GTO0	22 00	
159	SF0	16 21 00	
160	1	01	
161	RTN	24	
162	*LBL0	21 00	
163	0	00	
164	CF0	16 22 00	
165	RTN	24	
166	*LBL9	21 09	
167	F0?	16 23 00	
168	GTO1	22 01	
169	R/S	51	
170	RTN	24	
171	*LBL1	21 01	
172	PRTX	-14	
173	RTN	24	- - - - - - - - - -
174	*LBLd	21 16 14	
175	0	00	Crossover point
176	STOD	35 14	
177	GSB4	23 04	
178	*LBL8	21 08	
179	RCL7	36 07	
180	1	01	
181	GSBD	23 14	
182	1	01	
183	-	-45	
184	Y^x	31	
185	RCLA	36 11	
186	×	-35	
187	RCL6	36 06	
188	λ	-35	
189	RCL7	36 07	
190	RCLD	36 14	
191	1	01	
192	-	-45	
193	Y^x	31	
194	RCLA	36 11	
195	×	-35	
196	RCLB	36 12	
197	-	-45	
198	STO9	35 09	
199	RCLC	36 13	
200	1	01	
201	+	-55	
202	RCLD	36 14	
203	-	-45	
204	÷	-24	
205	X≠Y	-41	
206	X>Y?	16-34	
207	GTO8	22 08	
208	RCLD	36 14	
209	1	01	
210	-	-45	
211	GSB9	23 09	Last year
212	RCLC	36 13	
213	X≠Y	-41	
214	-	-45	
215	GSB9	23 09	Remaining life
216	RCL9	36 09	
217	RCLB	36 12	
218	+	-55	
219	GTO9	22 09	RBV
220	R/S	51	

LABELS

A	B	C	D	E
[a] St.Line	[b] SOYD	[c] DEC BAL	[d] CROSS	[e] SCHED?
[0] Used	[1] Used	[2] SOYD	[3] Used	[4] Used
[5]	[6]	[7]	[8] Used	[9] Used

FLAGS

[0]	Print?
[1]	
[2]	
[3]	

SET STATUS

FLAGS	ON	OFF
0	☐	☑
1	☐	☑
2	☐	☑
3	☐	☑

TRIG	
DEG	☑
GRAD	☐
RAD	☐

DISP	
FIX	☑
SCI	☐
ENG_2	☐
n	____

Program Description I

Program Title Invoicing and Inventory Control

Contributor's Name T.R. Cardoso
Address 258 Taylor Ave.,
City Glen Ellyn **State** Illinois **Zip Code** 60137

Program Description, Equations, Variables This program permits automatic price extension, sub and grand totalling of units and dollars, and automatic removal of units from inventory. Additionally, inventory review and separate inventory addition and subtraction are available options. Error routines are incorporated to recover from unit input error as well as to prevent accidental tampering of permanent inventory and price data. Unlimited number of line items and associated prices are possible via separate data cards.

Inventory and price are stored together in a single register as: UNITS.DOLLARS. Since only 10 digits are available, units.dollars must be accomodated in this space. The program is set up for six digits of units(up to 999,999) and four digits of dollars(up to $99.99). Registers used for permanent storage of units.dollars are: R_4-R_9 and R_{S0} - R_{S9}, a total of 16. Once unit.dollar information is stored in the appropriate registers and notations made of the access code, a data card is passed through the calculator to record this information for later use. Unlimited amount of data can thus be recorded for use, requiring only that each card's code and associated product be notated for reference.

Operating Limits and Warnings Inventory units are stored without modification, i.e. any positive integer. Dollars(price/unit) must be input as a decimal following associated units, i.e. xxxxxx.nnnn, where last two numbers are cents. If larger dollar/unit are required, program must be modified at steps 30 and 82(such change will result in change to possible number of units stored in "inventory").

Program Description II

Sketch(es)

Sample Problem(s) Store 10,000 units product A @ 2.31/unit in reg. 4(code 4) 15,000 units product B @ 12.15/unit in reg. 5(code 5) and 25000 units product C @ 6.35/unit in R_{S4} (code 14).

What would customer X's invoice sub total be if he ordered 500 units of A, 1000 units of B and 2000 units of C? What inventory would be remaining after this transaction? Review inventory.

After above, enter 5000 units each of A, B and C into inventory. What is inventory total after this?

Solution(s) Data storage (would normally be available on data cards):

A: 10000.0231 STO 4 (note manner of dollar entry)

B: 15000.1215 STO 5

C: 25000.0635 f P-S STO4 f P-S (stored in R_{S4})

Keystrokes for problem:

reset	(f) (A)	-----	0.00	
enter code	4 (A)	-----	4.	
enter units	500 (B)	-----	1155.00	(dollars/500 units)
Code "B"	5 (A)	-----	5.	
	1000 (B)	-----	12150.00	(dollars/1000 units)
Code "C"	14 (A)	-----	14.	
	2000 (B)	-----	12700.00	(dollars/2000 units)
Sub Ttl.	(C)	-----	3500***	(sub total units)
			26005	(sub total dollars)
Rev. Inv.	(4) (A)	-----	4.	(code for "A")
	(f) (D)	-----	9500.	(remaining inventory of "A")
	(5) (A)	-----	5.	
	(f) (D)	-----	14000.	(remaining inventory of "B")
	(14) (A)	-----	14.	
	(F) (D)	-----	23000.	(remaining inventory of "C")

Reference(s)

To add inventory:

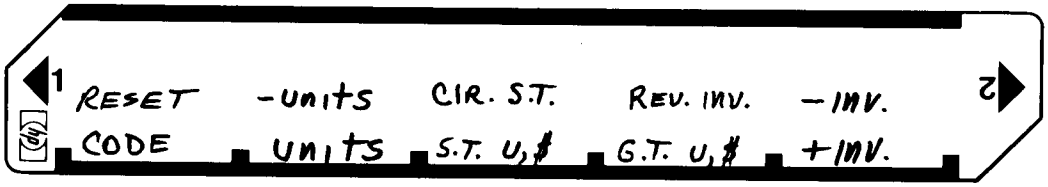
enter code	4 (A)	------	4.	access code
enter units	5000 (E)	------	5000.	number of units entered into "A" invent.
code	5 (A)	------	5.	
	5000 (E)	------	5000.	number of units entered into "B" invent.
code	14 (A)	------	14.	
	5000 (E)	------	5000.	number of units entered into "C" invent.
rev. invent.	4 (A)	------	4.	
	(f) (D)	------	14500.	number of "A" units <u>now</u> in inventory
	5 (A)	------	5.	
	(f) (D)	------	19000.	number of "B" units <u>now</u> in inventory
	14 (A)	------	14.	
	(f) (D)	------	28000.	number of "C" units <u>now</u> in inventory

NOTE: If units input are in error and code has not been changed, re-input units and press (f) (B) to remove from sub total and return units back to inventory. If code has been changed, re-input code and units.

To readjust inventory for physicals taken, input or subtract via (E) or (f) (E) as required.

For new customer, clear sub total via (f) (C) and input appropriate code. Sub total will start from zero, but Grand Total will continue with running unit and dollar totals, recallable by (D).

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Prepare data cards per instructions on page 1.			
1	Load side 1 of program			
2	Load side 1 and/or side 2 of data card			
3	Clear non-permanent registers		f A	0.00
4	Enter product code(corresponding to register number on data card)		n A	n.
5	Enter units sold	nnnnnn	B	nnnnnn.
	Options:			
	Recall sub-total		C	units***
				dollars
	Recall grand total		D	units***
				dollars
	Add to inventory : input code	n	A E	units
	Subtract from inventory: input code	n	A fE	units
	Review inventory remaining: input code	n	A fD	units
	Clear sub-total		f C	0.00
	Recover error:			
	input code (if changed)	n	A	n.
	input unit error	nnnnnn	f B	0.00
	Note: If non-available code is input "Error" will register. Use Clx and input correct code. If "Error" shows after units are input, this indicates lack of inventory. Review inventory. No operations occur if inventory is lacking, so no recovery is necessary. Prices can be updated by changing appropriate registers and recording on data card.			

FLAGS	SET STATUS		
	FLAGS	TRIG	DISP
0	ON OFF 0 ☐ ☒ 1 ☐ ☒ 2 ☐ ☒ 3 ☐ ☒	DEG ☒ GRAD ☐ RAD ☐	FIX ☒ SCI ☐ ENG ☐ n ____
1			
2			
3			

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f lbl A	31 25 11	Code Accesses Inventory. PRICE STORED IN R_4-R_9 + R_{50}-R_{59} Via SEPARATE DATA CARD
	3	03	
	h x≠y	35 52	
	g x≤y	32 71	
	GTO 1	22 01	
	1	01	
	9	09	
	h x↔y	35 52	
	g x>y	32 81	
010	GTO 1	22 01	shows "ERROR" if Inaccessable Register is input.
	h ST I	35 33	
	DSP 0	23 00	
	h RTN	35 22	
	f lbl 1	31 25 01	ERROR Routine
	0	00	
	÷	81	
	h RTN	35 22	
	f lbl B	31 25 12	Extend PRICE/unit to APPROPRIATE Reg.
	STO A	33 11	
020	RCL i	34 24	
	f INT	31 83	
	RCL A	34 11	
	−	51	
	f x<0	31 71	Show "ERROR" if no STOCK REMAINING in Inventory. (no operations take place).
	GTO 1	22 01	
	RCL A	34 11	
	STO −i	33 51 24	
	STO +0	33 61 00	
	STO +2	33 61 02	
030	RCL i	34 24	
	g FRAC	32 83	
	1	01	
	0	00	
	0	00	
	X	71	
	X	71	
	STO +1	33 61 01	
	STO +3	33 61 03	
	DSP 2	23 02	
040	h RTN	35 22	
	f lbl C	31 25 13	Recall sub TOTAL flash units then dollars.
	RCL 0	34 00	
	DSP 0	23 00	
	f −x−	31 84	
	RCL 1	34 01	
	DSP 2	23 02	
	h RTN	35 22	
	f lbl D	31 25 14	Recall GRAND Total (sum of sub Totals) and flash units then dollars.
	RCL 2	34 02	
050	DSP 0	23 00	
	f −x−	31 84	
	RCL 3	34 03	
	DSP 2	23 02	
	h RTN	35 22	
	f lbl E	31 25 15	
	STO +i	33 61 24	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	DSP 0	23 00	INPUT Inventory into APPROPRIATE Reg.
	h RTN	35 22	
	g lbl a	32 25 11	Non-permanent Register Reset
060	0 −	00	
	STO 0	33 00	
	STO 1	33 01	
	STO 2	33 02	
	STO 3	33 03	
	STO A	33 11	
	STO B	33 12	
	STO C	33 13	
	STO D	33 14	
	STO E	33 15	
070	4	04	
	h ST I	35 33	
	0	00	
	DSP 2	23 02	
	h RTN	35 22	
	g lbl b	32 25 12	— Units — ERROR Routine Subtracts extension FROM APPROPRIATE Registers.
	RCL A	34 11	
	STO +i	33 61 24	
	STO −0	33 51 00	
	STO −2	33 51 02	
080	RCL i	34 24	
	g FRAC	32 83	
	1	01	
	0	00	
	0	00	
	X	71	
	X	71	
	STO −1	33 51 01	
	STO −3	33 51 03	
	0	00	
090	DSP 2	23 02	
	h RTN	35 22	
	g lbl c	32 25 13	CLEARS Sub Total
	0	00	
	STO 0	33 00	
	STO 1	33 01	
	DSP 2	23 02	
	h RTN	35 22	
	g lbl d	32 25 14	Reviews Inventory After code is input.
	RCL i	34 24	
100	f INT	31 83	
	DSP 0	23 00	
	h RTN	35 22	
	g lbl e	32 25 15	Inventory Subtract Routine to adjust PER physical INVENTORY AS NEEDED.
	STO −i	33 51 24	
	DSP 0	23 00	
	h RTN	35 22	
	R/S	84	
110			

REGISTERS

0	1	2	3	4	5	6	7	8	9
S.T. Units	S.T. #	G.T. Units	G.T. #	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE	INV. PRICE

A	B	C	D	E	I
Units STORE					CODE

Program Description I

Program Title PRODUCTION MONITOR & RECORD PROG #1

Contributor's Name ROBERT K. Mc DONALD
Address 3587 PINE RIDGE WAY
City SAN JOSE **State** CAL **Zip Code** 95127

Program Description, Equations, Variables TAKES 2 ENT., "n" OF UNITS PER JOB (ORDER LOT, & OR ETC.) & HOURS TO COMPLETE & COMPUTES AN EFFICIENCY "n" (SUCH AS UNITS PER SECOND, MINUTE, OR HOUR AS DESIRED) FOR EACH PAIR OF DATA ENTRIES, THEN STORING THE RAW DATA FOR FUTURE RECALL.

THE RAW DATA PLUS THE "n" OF JOBS & WKs IS STORED SIMULTANEOUSLY IN 3 SEPERATE SETS OF REGISTERS WHICH REPRESENTS WK $\Sigma+$, MTH. $\Sigma+$, & YR $\Sigma+$ THAT MAY BE SEPERATELY RCL. AT WILL. THE PROGRAM AUTOMATICLY ADDS 1 FOR EACH PAIR DATA POINTS TO A COUNTER REG & 1 OR DECIMAL TO WKLY COUNTER EACH TIME THE WK REG. IS CLEARED TO PROVIDE ($\bar{x}$ WK CAL.) OF THE MTH. & YR. RECALL (SEE PROG DESCRIPTION PAGE #2) THE WK. COUNTER IS CALLED UP BY [R/S] AFTER WK AUTO DSP. TO BE MODIFIED IF WK IS SHORT X DAYS, THE 1 or DECIMAL IS THEN ENT. BY [R/S] WHICH ALSO CLEARS WK REG & DSP. CRD TO REMIND USER TO W/DATA IF DESIRED. MTH. REGISTERS MAY ALSO CLEARED FOR SUBSEQUENT MTH. $\Sigma+$ WHILE CONTINUING YR $\Sigma+$ FOR YR TO DATE $\bar{x}$ & TOTALS. YR $\Sigma+$ REG. MAY NOT BE SEPERATELY CLEARED BY PROG.

SEE PAGE #2 FOR DISCRIPTION OF AUTO-DSP MEANING.

NOTE: THERE ARE ERROR BLOCKS IN PROG. TO PREVENT STO. ERRORS

Operating Limits and Warnings WK'S REGISTER MUST BE CLEARED BEFORE RESULTS ARE CORRECT FROM MTH & YR'S RCL. DELETE ONLY GOOD FOR LAST ENTRY!

Program Description I

Program Title PRODUCTION MONITOR & RECORD
PROG #1 REVISION A

Contributor's Name Robert K. McDonald

Address 3587 PINE RIDGE WAY

City SAN JOSE **State** CAL **Zip Code** 95127

Program Description, Equations, Variables THIS REVISION PROVIDES FOR DIRECT CONVERSION OF HR:MIN:SEC ENTRIES TO HRS IF DESIRED (DELETE STEP 005 IF NOT) IT ALSO SPEEDS UP DATA INPUT TIME BY USING F?0 AS AN INLINE OPERATION RATHER THAN "GSB" OPERATION.

IT WAS ALSO NECESSARY TO REPOSITION SUB "LBL8" TO GAIN THE ONE STEP FOR HR:MIN:SEC CONVERSION & STILL MAINTAIN ERROR BLOCK PROTECTION THAT PREVENTS AN UNWANTED R/S FROM DESTROYING DATA ALREADY STORED. THE "GTO-UNUSED LBL" SERVES AS AN ABSOLUTE STOP OR BLOCK, (GTO 3).

005	H←	31 74

DELETE IF HR:MIN:SEC CONVERSION NOT DESIRED.

THE REG. "0" TEST STEP'S PREVIOUSLY LOCATED@ 212 213 & 217 WERE ALSO FOUND NOT NECESSARY & DELETED.

Operating Limits and Warnings BE SURE TO CONVERT HRS IN THE TEST PROBLEMS PAGE 2 & 3 TO HRS:MIN:SEC [g] [→H.MS] IF STEP "005" IS USED.

NOTE: STEP'S "060" & "209" (GTO 3) MAY BE OMITTED FOR MORE PROG STEPS IF SUB-ROUTINES ARE FURTHER RE-ARANGED SO THAT RECALL ONLY SUB'S FOLLOWS THE RUN COMPLETIONS.

Program Description 11

Sketch(es)

Sample Problem(s) LISTED IS A PROBLEM INVOLVING DATA FROM AN ELECTRO-MASK PATTERN GENERATOR W/THE EFFICIENCY n BASED ON FLASHES PER SECOND:

JOB#	1. (KEY)	2. (KEY)	3. (KEY)	4. KEY	
FLASHES:	500 [A]	1000 [A]	2500 [A]	10000 [A]	1ST WK's
HOURS:	.02 [R/S]	.14 R/S	.18 [R/S]	.56 [R/S]	INPUTS
F.P.S.	(6.94)	(1.98)	(3.86)	(4.96)	← EFF. n

(1ST WK MUST BE CLEARED BEFORE 2ND WK ENT.)

[F] [C] → (SEE SOLUTION FOR AUTO DSP.). [R/S] 1 (WK *COUNTER). [R/S] CLREG & REQ. CRD ([CLX] MAY ALSO BE USED IF DATA IS NOT TO BE KEPT)

FLASHES:	9567 [A]	10260 [A]	675 [A]	15001 [A]	2ND WK's
HOURS:	.48 [R/S]	.98 [R/S]	.08 [R/S]	1.32 [R/S]	INPUTS
F.P.S.	(5.54)	(2.91)	(2.34)	(3.16)	EFF. n

[F] [C] → AUTO DSP. · [R/S] 1 (WK *COUNTER). [R/S] CL REG & CRD REQ

Solution(s)

KEY IN [F] [C] 1st & 2nd WK's DATA RCL AUTO DSP.

FL:	14000.00	35503.00
HR:	0.90	2.86
x̄ FPS	4.32	3.45
X JOB HRS:	0.23	0.72
X JOB FL	3500.00	8875.75
HIGH F.P.S	6.94	5.54
LOW FPS	1.98	2.34
n JOBS n<2 FPS	1.00	0.00
TOTAL n JOBS	4.00	4.00

KEY IN [F] [D] FOR MTH RCL

FL:	49503.00	
x̄ WK FL:	24751.50	KEY IN [F] [E] FOR YR RCL (IT IS THE SAME AS
HOURS:	3.76	
x̄ WK HRS:	1.88	
x̄ F.P.S.	3.66	
x̄ JOB HRS:	.47	
x̄ JOB FL:	6187.88	
n OF JOBS: n<2 FPS:	1	
x̄ WK's n<2 FPS:	0.50	

AUTO DSP STOPS →

	4.00	4.00
[R/S] → WK COUNTER MODIFY FOR SHORT WK	1.00	1.00
[R/S]	CRD **	CRD **

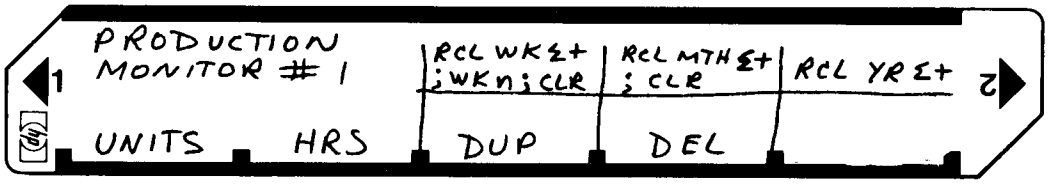
** ENTER CARD FOR DATA HOLD

PROGRAM STOPS

n OF WK's:	2.00	MTH FOR THIS RUN)
TOTAL JOBS:	8.00	
x̄ WK TOT JOBS:	4.00	

[R/S] CLEARS MTH REG & SHOWS CARD DISP TO REMIND OF DATA RETENTION & CLEARS WK's REG.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	LOAD BOTH SIDES OF PROG CARD			
2.	LOAD BOTH SIDES OF DATA CARD			
	(UNLESS BEGINNING OF YR)			
3.	INPUT UNITS VALUE n	500	A	500.00
4.	INPUT HOUR VALUE h [R/S] OR [B]	.02	R/S	6.94
5.	PROGRAM PAUSES 1 SEC TO COPY			
	EFF. "n" WHILE STORING DATA TO			
	SAVE TIME (OMIT 021 IF DESIRED)			
	& HALTS ON SAME n			6.94
6.	(OPTION) IF UNITS "n" IS REPEATED			
	BUT HRS CHANGED KEY IN NEW HR. n+	.07	B	1.98
7.	DELETE — PAUSES 1 SEC. ON		D	1.98
	DELETED F.P.S. & THEN W/DRAWS			
	UNDESIRED DATA FROM REGS HALT-			
	ING ON THE CONTENTS OF LOW REG			6.94
	PRESS [h] [X⇄Y] TO SEE HIGH REG		h X⇄Y	6.94
8.	DUP - LAST ENTRY		C	1.98
9.	RCL WK DATA, AT COMPLETION TOTAL		F C	AUTO DSP
	n OF JOBS AUTO DSP.			2.00
10.	AFTER WK's DATA IS COPIED OFF ON			
	PAPER PRESS R/S TO BRING UP			
	WK-COUNTER n WHICH MAY BE ALTERED			
	TO DECIMAL FOR SHORT WK		R/S	1.00
11.	W/ 1.00 OR ALTERED DECIMAL IN "X" PRESS			
	R/S AGAIN TO CLEAR WK & DSP			
	W/DATA REMINDER		R/S	CRD
12.	MTH RCL USE ONLY AFTER CLR WK		F D	AUTO DSP
	PROG HALTS ON $\bar{x}$ WK TOTAL OF JOBS			2.00
13.	CLEAR MTH FOR NEW MTH'S DATA			
	WHICH RESULTS IN W/Data REMINDER		R/S	CRD
	(AS W/WK ONLY ACCESSABLE AT END OF AUTO DSP.)			
14.	RCL YR DATA, COMPLETES ON		F E	AUTO DSP
	$\bar{x}$ WK TOTAL JOBS (NO CLR AVAIL)			2.00
	(SEE PAGE 2 FOR COMPLETE			
	AUTO DSP. DATA.			

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001 *	LBL A	31 25 11	TEMP. STO OF RAW DATA (*)
002	STO A	33 11	
003	R/S	84	
004 *	LBL B	31 25 12	USE OR OMITT (*)
005	H←	31 74	
006	STO B	31 12	DUP. ACCESS
*	LBL C	31 25 13	TEMP. STO LAST HIGH & LOW F.P.S.
	RCL C	34 13	
	RCL 9	34 09	
010	P≠S	31 42	
	STO 9	33 09	
	X≠Y	35 52	
	STO 7	33 07	
	P≠S	31 42	
*	LBL 1	31 25 1	DEL. ACCESS
	RCL A	34 11	COMPUTE F.P.S. RATE & TEMP. STO
	RCL B	34 12	
	GSB 2	31 22 02	
	ST I	35 33	DSP F.P.S.
020	PAUSE	35 72	TEST FOR CORRECT P≠S ORIENTATION
	RCL 8	34 08	
	X=0?	31 51	
	GSB 6	31 22 06	SET LOW STO-R TO ACCEPT FUTURE TESTS
	RCL 9	34 09	
	X=0?	31 51	
	GSB 0	31 22 00	JOB COUNTER ADDS 1 TO WK, MTH, & YR STO-REG.
	1	01	
	F?0	35 7 100	
	CHS	42	
030	STO + 0	33 6 100	
	STO + 1	33 6 101	
	STO + 2	33 6 102	
	RCL A	34 11	STO n UNITS IN WK, MTH, & YR STO. REG. (STO+)
	F?0	35 7 100	
	CHS	42	
	STO + 3	33 6 103	
	STO + 4	33 6 104	
	STO + 5	33 6 105	
	RCL B	34 12	STO HRS. IN WK, MTH, & YR STO-REG (STO+)
040	F?0	35 7 100	
	CHS	42	
	STO + 6	33 6 106	
	STO + 7	33 6 107	
	STO + 8	33 6 108	
	RCL I	35 34	TEST FOR F.P.S. n<2
	2	02	
	X>Y?	32 81	
	GSB 4	31 22 04	
	F?0	35 7 100	DEL. FLAG TEST
050	GTO 8	22 08	TEST FOR HIGH F.P.S & STO
	RCL C	34 13	
	RCL I	35 34	
	X>Y?	32 81	
	STO C	33 13	
	RCL 9	34 09	TEST FOR LOW F.P.S.
	X>Y?	32 81	
	GSB 5	31 22 05	& STO
	RCL I	35 34	COMPLETE RUN & RCL F.P.S.
	RTN	35 22	
060	GTO 3	22 03	ERROR BLOCK
*	LBL 8	31 25 08	DEL LAST ENTRY OF HIGH & LOW F.P.S. AND CFO FOR COMPLETION OF RUN
	P≠S	31 42	
	RCL 9	34 09	
	RCL 7	34 07	
	P≠S	31 42	
	STO C	33 13	
	X≠Y	35 52	
	STO 9	33 09	
	CFO	35 6 100	
070	RTN	35 22	
*	LBL 0	31 25 00	LOW REG. PREP. SUB.
	9	09	
	STO 9	33 09	
	RTN	35 22	
*	LBL 2	31 25 02	THIS SUB. COMPUTES F.P.S. FROM FLASHES PER HOUR
	÷	81	
	3	03	
	6	06	
	0	00	
080	0	00	
	÷	81	
	RTN	35 22	
*	LBL 4	31 25 04	n<2 COUNTER ADDS 1 TO WK, MTH, & YR REG. FOR JOB'S W/F.P.S. UNDER 2 (ALSO HAS DELETE FLAG TEST
	1	01	
	F?0	35 7 100	
	CHS	42	
	P≠S	31 42	
	STO + 0	33 6 100	
	STO + 1	33 6 101	
090	STO + 2	33 6 102	
	P≠S	31 42	
	RTN	35 22	
*	LBL 5	31 25 05	STO LOW F.P.S. SUB.
	RCL I	35 34	
	STO 9	33 09	
	RTN	35 22	
*	LBL C	32 25 13	WK DATA RECALL W/ 5 SEC AUTO DSP.
	RCL 3	34 03	
	−X−	31 84	
100	RCL 6	34 06	
	−X−	31 84	
	GSB 2	31 22 02	
	−X−	31 84	
	RCL 6	34 06	
	RCL 0	34 00	
	÷	81	
	−X−	31 84	
	RCL 3	34 03	
	RCL 0	34 00	
110	÷	81	
	−X−	31 84	
	RCL C	34 13	

REGISTERS

0 n WK	1 n MTH	2 n YR	3 UNITS WK	4 UNITS MTH	5 UNITS YR	6 HRS WK	7 HRS MTH	8 HRS YR	9 LOW F.P.S. WK
S0 n<2 WK	S1 n<2 MTH	S2 n<2 YR	S3	S4	S5	S6	S7 TEMP. HIGH F.P.S.	S8 USED	S9 TEMP. LOW F.P.S.
A LST UNITS	B LST HRS	C HIGH F.P.S. WK	D n OF WKS PER MTH	E n OF WKS PER YR	I USED				

67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
	−X−	31 84	
	RCL 9	34 09	
	−X−	31 84	
	P≠S	31 42	
	RCL 0	34 00	
	P≠S	31 42	
	−X−	31 84	
120	RCL 0	34 00	
	R/S	84	
	2	02	PREP FOR n OF WKS COUNTER
	3	03	
	STO I	35 33	
	1	01	ACCESS TO MODIFY WK COUNTER "n"
	R/S	84	
	STO+(i)	33 61 24	ADD WK "n" COUNTER TO MTH & YR STO-REG.
	ISZ	31 34	
	STO+(i)	33 61 24	
130	0	00	CLEAR WK'S STO-REG'S
	STO 0	33 00	
	STO 3	33 03	
	STO 6	33 06	
	STO 9	33 09	
	STO C	33 13	
	P≠S	31 42	
	STO 0	33 00	
	P≠S	31 42	
	W/DATA	31 41	W/DATA REMINDER DSP.
140	R/S	84	
*	LBL d	32 25 14	MTH DATA RECALL
	2	02	
	3	03	
	STO I	35 33	
	RCL 4	34 04	
	GSB 7	31 22 07 *	
	RCL 7	34 07	
	GSB 7	31 22 07 *	
	RCL 4	34 04	
150	RCL 7	34 07	
	GSB 2	31 22 02	
	−X−	31 84	
	RCL 7	34 07	
	RCL 1	34 01	
	÷	81	
	−X−	31 84	
	RCL 4	34 04	
	RCL 1	34 01	
	÷	81	
160	−X−	31 84	
	P≠S	31 42	
	RCL 1	34 01	
	GSB 7	31 22 07 *	
	RCL D	34 14	
	−X−	31 84	
	P≠S	31 42	
	RCL 1	34 01	
	GSB 7	31 22 07 *	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	R/S	84	
170	0	00	CLEAR MTH STO-REG.
	STO 1	33 01	
	STO 4	33 04	
	STO 7	33 07	
	STO D	33 14	
	P≠S	31 42	
	STO 1	33 01	
	P≠S	31 42	
	W/DATA	31 41	W/DATA REMINDER DSP
	R/S	84	
180 *	LBL e	32 25 15	YR RECALL DATA
	2	02	
	4	04	
	STO I	35 33	
	RCL 5	34 05	
	GSB 7	31 22 07 *	
	RCL 8	34 08	
	GSB 7	31 22 07 *	
	RCL 5	34 05	
	RCL 8	34 08	
190	GSB 2	31 22 02	
	−X−	31 84	
	RCL 8	34 08	
	RCL 2	34 02	
	÷	81	
	−X−	31 84	
	RCL 5	34 05	
	RCL 2	34 02	
	÷	81	
	−X−	31 84	
200	P≠S	31 42	
	RCL 2	34 02	
	GSB 7	31 22 07 *	
	P≠S	31 42	
	RCL E	34 15	
	−X−	31 84	
	RCL 2	34 02	
	GSB 7	31 22 07 *	
	R/S	84	
	GTO 3	22 03	ERROR BLOCK
210 *	LBL 7	31 25 07	x̄ WK * COMPUTE SUB-ROUTINE
	−X−	31 84	
	RCL(i)	34 24	
	÷	81	
	−X−	31 84	
	RTN	35 22	
*	LBL D	31 25 14	DEL HEADING
	SF0	35 51 00	
	GTO 1	22 01	
*	LBL 6	31 25 06	P≠S ORIENTATION CORRECTION SUB
220	P≠S	31 42	
	RTN	35 22	

LABELS

A UNITS	B HRS	C → DUP	D DEL	E	
a	b	c RCL WK DATA	d RCL MTH DATA	e RCL YR DATA	
0 9 STO 9	1 DEL-ACC	2 ÷3600 ÷	3 ERROR B	4 LOW STO	
5 STO LOW	6 P≠S CORRECT	7 X WK LOOP	8 DEL HIGH LOW	9 USED	

FLAGS

0 USED	
1	
2	
3	

SET STATUS

FLAGS			TRIG		DISP	
	ON	OFF				
0	☐	☒	DEG	☒	FIX	☒
1	☐	☐	GRAD	☐	SCI	☐
2	☐	☐	RAD	☐	ENG	☐
3	☐	☐			n	2

Program Description I

Program Title 67 - Learning Curve

Contributor's Name George J. Sellers
Address 1033 Bishop Walsh Rd.
City Cumberland State Md. Zip Code 21502

Program Description, Equations, Variables

$$Y_n = A n^b$$

$$\alpha = 2^b \qquad b = (\log_{10} \alpha)/(\log_{10} 2)$$

$$\bar{Y}_{i-f} = \frac{A}{(\Delta n + 1)(b+1)} \left[(n_f + .5)^{(b+1)} - (n_i - .5)^{(b+1)} \right]$$

Y_n = value at unit n
A = value for initial unit
b = slope of learning curve equation (n -.1520 usually)
α = learning curve factor (n .90 usually)
$\bar{Y}_{i-f}$ = average unit value between n_i and n_f
n_i = initial unit number for average
n_f = final unit number for average
$\Delta n = n_f - n_i$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s) Manufacturing of a product yeilds data which exhibits a learning curve factor of .90 (α) and an initial unit cost of $500. What is the projected unit cost at unit 1000? An order is anticipated for 600 units when 1000 units have been produced. What is the average unit cost from unit 1001 thru 1600? If a unit price of $150 must be reached by unit 2000 to be competative what learning curve factor must be acheived?

Solution(s) Enter program.

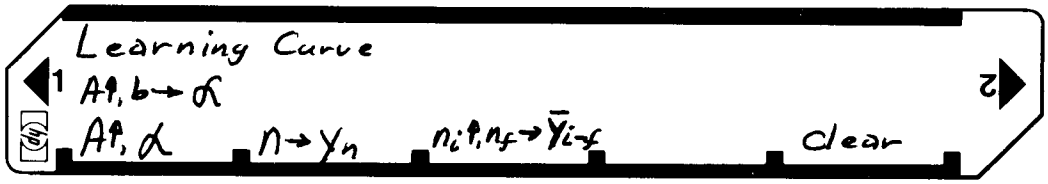
500 [↑], .90 [A], 1000 [B] $\quad Y_{1000} = \$174.97$

1001 [↑], 1600 [C] $\quad \bar{Y}_{1001 \to 1600} = \$168.38$

2000 [↑], 150 [↑], 500 [D] $\quad \alpha = .8960$

Reference(s)

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter Program		E	
2	Enter A		↑	
3	α		A	
4	n		B	Yn
5	n_i		↑	
6	n_f		C	$\bar{Y}_{i-f}$
	for A, b			
7	Enter A		↑	
8	b		f a	α
	go to step 4 or 5.			
9	Enter n		↑	
	Yn		↑	
	A		D	α

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL E	31 25 15	
	CL Reg	31 43	
	CLX	44	
	RTN	35 22	
	LBL A	31 25 11	
	log	31 53	
	2	02	
	log	31 53	
	÷	81	
010	LBL a	32 25 11	
	STO 2	33 02	
	R↓	35 53	
	STO 1	33 01	
	RCL 2	34 02	
	2	02	
	log	31 53	
	X	71	
	10^x	32 53	
	RTN	35 22	
020	LBL B	31 25 12	
	STO 8	33 08	
	RCL 2	34 02	
	y^x	35 63	
	RCL 1	34 01	
	X	71	
	STO 3	33 03	
	RTN	35 22	
	LBL C	31 25 13	
	.	83	
030	5	05	
	+	61	
	STO 5	33 05	
	R↓	35 53	
	last x	35 82	
	−	51	
	STO 4	33 04	
	RCL 5	34 05	
	RCL 2	34 02	
	1	01	
040	+	61	
	STO 9	33 09	
	y^x	35 63	
	RCL 4	34 04	
	RCL 9	34 09	
	y^x	35 63	
	−	51	
	RCL 1	34 01	
	X	71	
	RCL 9	34 09	
050	÷	81	
	RCL 5	34 05	
	RCL 4	34 04	
	−	51	
	÷	81	
	RTN	35 22	
	LBL D	31 25 14	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	STO 1	33 01	
	÷	81	
	log	31 53	
060	x⇌y	35 52	
	log	31 53	
	÷	81	
	RCL 1	34 01	
	x⇌y	35 52	
	GTO a	22 31 11	
070			
080			
090			
100			

FLAGS	SET STATUS		
	FLAGS	TRIG	DISP
0	ON OFF	DEG ☑	FIX ☑
1	0 ☐ ☑	GRAD ☐	SCI ☐
2	1 ☐ ☑	RAD ☐	ENG ☐
3	2 ☐ ☑		n 2
	3 ☐ ☑		

LABELS

A Enter A, a	B Enter n	C Enter n_i, n_f	D Enter n, y_n, A	E Clear
a	b	c	d	e
0	1	2	3	4
5	6	7	8	9

REGISTERS

0	1 A	2 b	3	4 n_i -.5	5 n_f +.5	6	7	8 n	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title $\bar{x}$ AND R CONTROL CHARTS

Contributor's Name

Address

City **State** **Zip Code**

Program Descripti

In quality control, a chart is used to decide periodically whether a process is in statistical control. The use of such a chart facilitates the detection and elimination of assignable causes of process variation, thereby reducing rejects and rework, improving product quality, and lowering inspection cost. The x chart and R chart are two of the most frequently encountered, they deal with measurement data.

Suppose x_{ij} represents the j^{th} data point from the i^{th} sample, $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$. This program computes (1) the sample mean $\bar{x}$ and the sample range R_i, (2) the over-all mean $\bar{\bar{x}}$ and the average range $\bar{R}$, (3) the upper control limit $U_{\bar{x}}$ and the lower control limit $L_{\bar{x}}$ for $\bar{x}$, and (4) the upper control limit U_R and the lower control limit L_R for R.

Equations:

1.

$$\bar{x}_i = \sum_{j=1}^{n} x_{ij}/n$$

$$R_i = x_{max} - x_{min}$$

where x_{max} is the maximum of the x values and x_{min} is the minimum of the x values in the i^{th} sample.

2.

$$\bar{\bar{x}} = \sum_{i=1}^{m} \bar{x}_i/m$$

$$\bar{R} = \sum_{i=1}^{m} R_i/m$$

Operating Limits a

3.

$$L_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R}$$

$$U_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$

where A_2 is the factor for the $\bar{x}$ chart, which can be found in the following table.

4.

$$L_R = D_3\bar{R}$$

$$U_R = D_4\bar{R}$$

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

D_3 and D_4 are factors for the R chart, which can be found in the table.

Factors for determining from R the 3-sigma control limits for x and R charts.

Number of observations in subgroup n	Factor for x chart A_2	Factors for R chart	
		Lower limit D_3	Upper limit D_4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
11	0.29	0.26	1.74
12	0.27	0.28	1.72
13	0.25	0.31	1.69
14	0.24	0.33	1.67
15	0.22	0.35	1.65
16	0.21	0.36	1.64
17	0.20	0.38	1.62
18	0.19	0.39	1.61
19	0.19	0.40	1.60
20	0.18	0.41	1.59

All factors are based on the normal distribution.

Operating Limits a

The table is reproduced from *Statistical Quality Control,* by Grant and Leavenworth, 1972, with permission of McGraw-Hill Book Company.

Program Description 11

Sketch(es)

Sample Problem(s)

Example:

For the following set of data, find the lower and upper control limits for $\bar{x}$ and R.

	i \ j	1	2	3	4	5
Sample	1	10.04	10.00	10.02	10.01	10.02
	2	10.00	10.01	10.03	10.02	10.01
	3	10.02	10.02	10.02	10.04	10.01

(Note: n = 5, A_2 = 0.58, D_3 = 0, D_4 = 2.11)

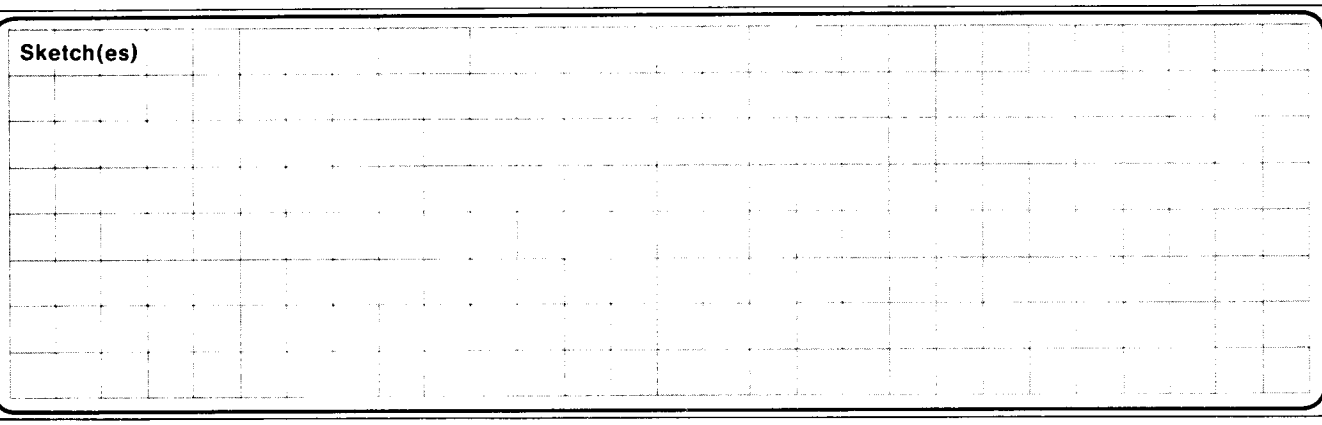
Solution(s)

Keystrokes:	Outputs:	
A →	0.00	
B →	1.00	
10.04 C →	10.04 ***	
	1.00 ***	
10 C →	10.00 ***	
	2.00 ***	
10.02 C →	10.02 ***	
	3.00 ***	
11.11 C →	11.11 ***	(error)
	4.00 ***	
11.11 D →	11.11 ***	(correction)
	3.00 ***	
10.01 C →	10.01 ***	
	4.00 ***	
10.02 C →	10.02 ***	
	5.00 ***	
E →	10.04 ***	($x_{1\ max}$)
E →	10.00 ***	($x_{1\ min}$)
f A →	10.02 ***	($\bar{x}_1$)
f A →	0.04 ***	(R_1)
10 C →	10.00 ***	
	1.00 ***	
10.01 C →	10.01 ***	
	2.00 ***	
10.03 C →	10.03 ***	
	3.00 ***	
10.02 C →	10.02 ***	
	4.00 ***	

Reference(s)

Program Description II

Sketch(es)



Sample Problem(s)

10.01 C → 10.01 ***
5.00 ***

E → 10.03 *** ($x_{2\ max}$)
E → 10.00 *** ($x_{2\ min}$)
f A → 10.01 *** ($\bar{x}_2$)
f A → 0.03 *** (R_2)

10.02 C → 10.02 ***
1.00 ***
10.02 C → 10.02 ***
2.00 ***
10.04 C → 10.04 *** (error)
3.00 ***
10.04 D → 10.04 *** (correction)
2.00 ***
10.02 C → 10.02 ***
3.00 ***
10.04 C → 10.04 ***
4.00 ***

Solution(s)

10.01 C → 10.01 ***
5.00 ***

E → 10.04 *** ($x_{3\ max}$)
E → 10.01 *** ($x_{3\ min}$)
f A → 10.02 *** ($\bar{x}_3$)
f A → 0.03 *** (R_3)

f B → 10.02 *** ($\bar{\bar{x}}$)
f B → 0.03 *** ($\bar{R}$)

0.58 f C → 10.00 *** ($L_{\bar{x}}$)
f C → 10.04 *** ($U_{\bar{x}}$)

Reference(s)

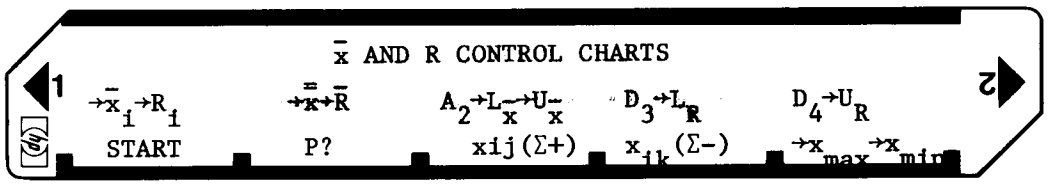
0 f D → 0.00 *** (L_R)

2.11 f E → 0.07 *** (U_R)

Reference:

Grant and Leavenworth, *Statistical Quality Control*, McGraw-Hill, 1972

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2			
2	Initialize		A	0.00
3	To set print mode*		B	1.00
4	Do 5~9 for i=1, 2, . . . , m			
5	Do 6~7 for j=1, 2, . . . , n			
6	Input x_{ij}	x_{ij}	C	j
7	If you made a mistake in inputting x_{ik}, then correct by ** →	x_{ik}	D	j-1
8	Calculate: x_{max}		E	x_{imax}
	x_{min}		E	x_{imin}
9	Calculate: the mean $\bar{x}_i$		f A	$\bar{x}_i$
	the range R_i		f A	R_i
10	Calculate: $\bar{\bar{x}}$		f B	$\bar{\bar{x}}$
	$\bar{R}$		f B	$\bar{R}$
11	Calculate the $\bar{x}$ limits:			
	the lower	A_2	f C	$L_{\bar{x}}$
	the upper		f C	$U_{\bar{x}}$
12	Calculate L_R	D_3	f D	L_R
13	Calculate U_R	D_4	f E	U_R
14	For a new case, go to 2			
	*Note: to clear print mode press →		0 STO E	
	**Note: If there are two or more x_{ik}'s entered incorrectly (one follows the other), then do not try to correct them, go to step 2.			

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	CLRG	16-53	Initialize
003	CF0	16 22 00	
004	CF1	16 22 01	
005	0	00	
006	RTN	24	
007	*LBLB	21 12	
008	1	01	
009	STOE	35 15	Store 1 in R_E for print.
010	RTN	24	
011	*LBLC	21 13	
012	STO0	35 00	
013	RCL4	36 04	
014	STOA	35 11	
015	RCL5	36 05	
016	STOB	35 12	
017	RCL0	36 00	
018	GSB9	23 09	
019	F1?	16 23 01	
020	GTO1	22 01	Input x_{ij}
021	0	00	
022	STO1	35 01	
023	STO2	35 02	
024	STO3	35 03	
025	X⇄Y	-41	
026	STO4	35 04	
027	STO5	35 05	
028	SF1	16 21 01	
029	*LBL1	21 01	
030	RCL4	36 04	
031	X⇄Y	-41	
032	X>Y?	16-34	
033	STO4	35 04	
034	RCL5	36 05	
035	X⇄Y	-41	
036	X≤Y?	16-35	
037	STO5	35 05	
038	F0?	16 23 00	
039	CHS	-22	
040	ST+2	35-55 02	
041	X²	53	
042	F0?	16 23 00	
043	CHS	-22	
044	ST+3	35-55 03	
045	RCL1	36 01	
046	1	01	
047	F0?	16 23 00	
048	CHS	-22	
049	+	-55	
050	STO1	35 01	
051	GSB9	23 09	
052	RTN	24	
053	*LBLE	21 15	x_{max}, x_{min}
054	GSB7	23 07	
055	RCL4	36 04	
056	GSB9	23 09	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	R/S	51	
058	*LBLE	21 15	
059	RCL5	36 05	
060	GSB9	23 09	
061	RTN	24	
062	*LBLa	21 16 11	
063	CF1	16 22 01	
064	RCL6	36 06	
065	1	01	
066	+	-55	
067	STO6	35 06	
068	RCL2	36 02	$\bar{x}_i$
069	RCL1	36 01	
070	÷	-24	
071	GSB9	23 09	
072	ST+7	35-55 07	
073	R/S	51	
074	*LBLa	21 16 11	
075	RCL4	36 04	
076	RCL5	36 05	
077	-	-45	R_i
078	ST+8	35-55 08	
079	GSB9	23 09	
080	GSB7	23 07	
081	R/S	51	
082	*LBLb	21 16 12	
083	RCL7	36 07	$\bar{\bar{x}}$
084	RCL6	36 06	
085	÷	-24	
086	GSB9	23 09	
087	RTN	24	
088	*LBLb	21 16 12	
089	RCL8	36 08	
090	RCL6	36 06	
091	÷	-24	
092	STO3	35 03	$\bar{R}$
093	GSB9	23 09	
094	GSB7	23 07	
095	R/S	51	
096	*LBLc	21 16 13	
097	RCL3	36 03	
098	x	-35	
099	RCL7	36 07	$L_{\bar{x}}$
100	RCL6	36 06	
101	÷	-24	
102	X⇄Y	-41	
103	-	-45	
104	GSB9	23 09	
105	R/S	51	
106	*LBLc	21 16 13	
107	LSTX	16-63	$U_{\bar{x}}$
108	2	02	
109	x	-35	
110	+	-55	
111	GSB9	23 09	
112	GSB7	23 07	

REGIS...

0	1	2	3	4	5	6	7	8	9
x_{ij}	n	Σx_{ij}	Σx_{ij}^2, $\bar{R}$	x_{max}	x_{min}	m	$\Sigma \bar{x}_i$	ΣR_i	Used
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
Last x_{max}	Last x_{min}			1 for print	

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	R/S	51	
114	*LBL d	21 16 14	
115	RCL 3	36 03	L_R
116	×	-35	
117	GSB 9	23 09	
118	GSB 7	23 07	
119	R/S	51	
120	*LBL e	21 16 15	
121	RCL 3	36 03	U_R
122	×	-35	
123	GSB 9	23 09	
124	GSB 7	23 07	
125	RTN	24	
126	*LBL D	21 14	Correction x_{ik}
127	STO 0	35 00	
128	RCL A	36 11	
129	STO 4	35 04	
130	RCL B	36 12	
131	STO 5	35 05	
132	RCL 0	36 00	
133	SF 0	16 21 00	
134	GSB C	23 13	
135	RCL A	36 11	
136	STO 4	35 04	
137	RCL B	36 12	
138	STO 5	35 05	
139	CF 0	16 22 00	
140	RCL 1	36 01	
141	RTN	24	
142	*LBL 9	21 09	Subroutine for print.
143	RCL E	36 15	
144	X>0?	16-44	
145	GTO 8	22 08	
146	R↓	-31	
147	RTN	24	
148	*LBL 8	21 08	
149	R↓	-31	
150	PRTX	-14	
151	RTN	24	
152	*LBL 7	21 07	Subroutine for space.
153	RCL E	36 15	
154	X>0?	16-44	
155	SPC	16-11	
156	R↓	-31	
157	RTN	24	
160			
170			
180			
190			
200			
210			
220			

LABELS

A Start	B Print	C x_{ij} (Σ+)	D x_{ik} (Σ-)	E x_{max}, x_{min}	
a $\bar{x}_{ij}$, R_i	b $\bar{\bar{x}}$, $\bar{R}$	c $L_{\bar{x}}$, $U_{\bar{x}}$	d L_R	e U_R	
0	1 j>1	2	3	4	
5	6	7 Space	8 Print	9 Print?	

FLAGS

0 Correction	
1 1st data	
2	
3	

SET STATUS

FLAGS			TRIG		DISP	
	ON	OFF				
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	2

Program Description I

Program Title SINGLE- AND MULTI-SERVER QUEUES

Contributor's Name

Address

City **State** **Zip Code**

Program Descripti

I. Infinite Customers

Suppose there are n ($n \geq 1$) identical stations available to service calls from an infinite number of customers. Let λ be the arrival rate of customers (Poisson input), μ be the service rate of each server (exponential service), and let the service discipline be first-come, first-served. Assume all customers wait in a single line and are directed to whichever station is available. Assume further that, no customers are lost from the queue.

This program computes the following values for given n, λ and μ.

Equations:

1. The intensity factor

$$\rho = \frac{\lambda}{\mu}$$

(ρ must be less than n)

2. The probability that all servers are idle

$$P_0 = \left[\sum_{k=0}^{n-1} \frac{\rho^k}{k!} + \frac{\rho^n}{n!\left(1 - \frac{\rho}{n}\right)} \right]^{-1}$$

3. The probability that all servers are busy

$$P_b = \frac{\rho^n P_0}{n!\left(1 - \frac{\rho}{n}\right)}$$

Operating Limits a

4. The average number of customers in the queue

$$L_q = \frac{\rho P_b}{n - \rho}$$

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

5. The average number of customers in the system (waiting or being served)

$$L = L_q + \rho$$

6. The average waiting time in the queue

$$T_q = \frac{L_q}{\lambda}$$

7. The average flow time through the system

$$T = \frac{L}{\lambda}$$

8. The probability of waiting longer than time t

$$P(t) = P_b\, e^{-(n\mu - \lambda)\, t}$$

Remarks:

1. n must be an integer greater than or equal to 1.
2. $\rho < n$, otherwise the queue increases without bound.
3. λ and μ are rates, that is, numbers per unit time.

II. Finite Customers

Operating Limits

Suppose there are n ($n \geq 1$) identical stations available to service calls. This program handles the case in which demand arises from a finite rather than an infinite population of customers.

Let the number of customers m be fixed; let a be the mean time between service calls; and s be the mean time to serve one customer. Given m, n, s and a, this program computes the following values.

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Descripti

Equations:

1. The average number of customers in the system (waiting or being served)

$$L = \frac{\sum_{k=0}^{m} k\, Q_k}{\sum_{k=0}^{m} Q_k}$$

where

$$Q_0 = 1$$

$$(m - k + 1)\, \rho\, Q_{k-1} = \begin{cases} kQ_k & \text{if } 1 \leq k \leq n \\ nQ_k & \text{if } n < k \leq m \end{cases}$$

and

$$\rho = \frac{s}{a}$$

2. The average flow time through the system

$$T = aL$$

3. The average number of customers in the queue

$$L_q = m\left[(\rho + 1)\left(\frac{L}{M} - 1\right) + 1\right]$$

Operating Limits a

4. The average waiting time in the queue

5. The over-all efficiency factor of the system

$$F = -(\rho + 1)\left(\frac{L}{m} - 1\right)$$

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

Remarks:

1. For large values of m and/or small values of ρ, the calculation of Q_k in the routine under f c may underflow. To avoid this, the program tests to see if $Q_k < 10^{-90}$. If it does, the program will halt its recursive solution for Q_k and go directly to the calculation of L. This should not affect the calculated value of L.

2. For certain combinations of m, n, s and a, an overflow condition will occur. In that case, the program halts and the display shows all 9's.

3. The execution time for L depends on m; the larger m is, the longer it takes. A rough estimate of the time for this routine (f c) is given by m/30 minutes.

4. Suppose instead of knowing s and a, the service rate μ of each server and the arrival rate λ are given. Then the following formulas can be used to compute s and a in order to run this program.

$$s = \frac{1}{\mu}$$

$$a = \frac{1}{\lambda}$$

Note that $$\rho = \frac{\lambda}{\mu}$$

Operating Limits

References:

1. H. M. Wagner, *Principles of Operations Research with Applications to Managerial Decisions*, Prentice-Hall, 1969.

2. James Martin, *Systems Analysis for Data Transmission*, Prentice-Hall, 1972.

3. Hillier and Lieberman, *Introduction to Operations Research*, Holden-Day, 1970.

4. Peck and Hazelwood, *Finite Queuing Tables*, John Wiley and Sons, 1958.

Program Description II

Sketch(es)

Sample Problem(s)

Example 1:

Bank customers arrive at a bank on the average of 1.2 customers per minute. They join a common queue for 3 tellers, each teller serves at a rate of 30 customers per hour. Find ρ, P_0, P_b, L_q, L, T_q, T and the probability P(2) that a customer will have to wait for more than 2 minutes.

(Note: Service rate $\mu = \frac{30}{60} = 0.5$ customers per minute
Arrival rate $\lambda = 1.2$ customers per minute)

Solution(s)

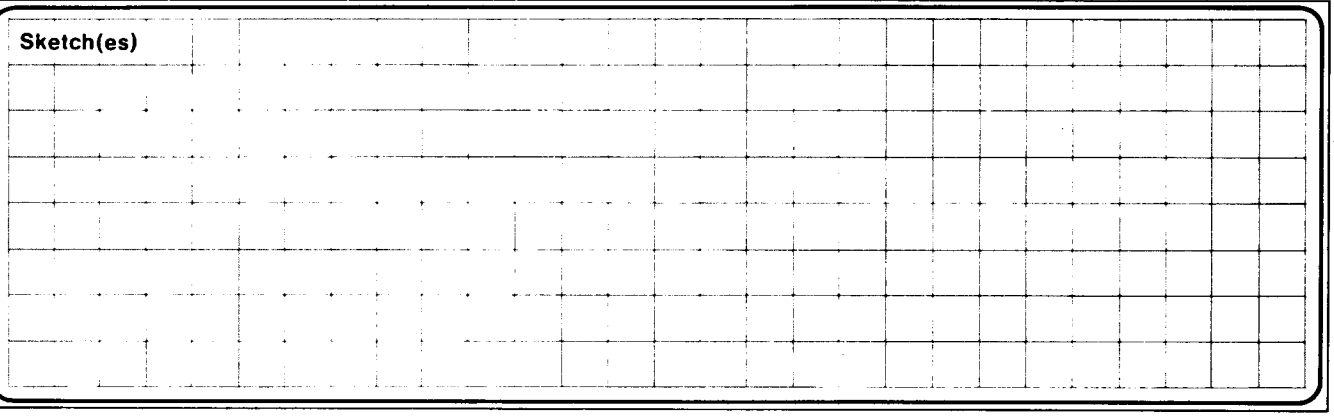
Keystrokes: .5 ENTER↑ 1.2 ENTER↑ 3 A → **Outputs:**

	0.5 ***	(μ)
	1.20 ***	(λ)
	3.00 ***	(n)
	2.40 ***	(ρ)
B →	0.06 ***	(P_0)
B →	0.65 ***	(P_b)
C →	2.59 ***	(L_q)
C →	4.99 ***	(L)
D →	2.16 ***	(T_q)
D →	4.16 ***	(T)
2 E →	2.00 ***	(t)
	0.36 ***	(P(t))

Reference(s)

Program Description II

Sketch(es)



Sample Problem(s)

Example 2:

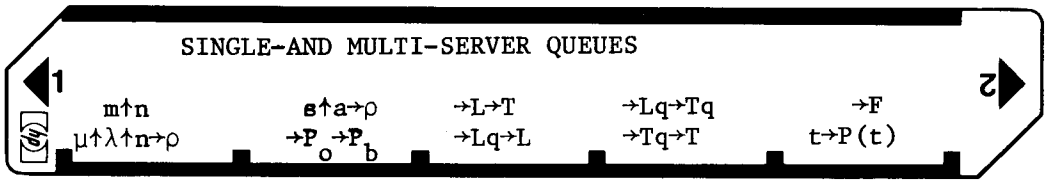
A laundromat has 12 washers which require an average of 4 hours of service after every 60 hours of operation. If there is only one service person in the laundromat, find ρ, L, T, L_q, T_q and F.

Keystrokes:		Outputs:	
12 ENTER↑ 1 f A	→	12.00 ***	(m)
		1.00 ***	(n)
4 ENTER↑ 60 f B	→	4.00 ***	(s)
		60.00 ***	(a)
		0.07 ***	(ρ)
f C	→	1.64 ***	(L)
f C	→	98.66 ***	(T)
f D	→	0.95 ***	(L_q)
f D	→	57.24 ***	(T_q)
f E	→	0.92 ***	(F)

Solution(s)

Reference(s)

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2			
2	For finite customers go to 11			
3	Do 4 ~ 9 for infinite customers			
4	Input μ	μ	ENTER↑	
	λ	λ	ENTER↑	
	' n	n	A	ρ
5	Calculate P_o		B	P_o
	P_b		B	P_b
6	Calculate: L_q		C	L_q
	L		C	L
7	Calculate: T_q		D	T_q
	T		D	T
8	Input t to calculate P(t)	t	E	P(t)
9	For a different t, go to 8			
10	For a new case, go to 2			
11	Do 12 ~ 16 for finite customers			
12	Input: number of customers	m	ENTER↑	
	number of servers	n	f A	m
13	Input: service time	s	ENTER↑	
	arrival time	a	f B	ρ
14	Calculate: customers in system		f C	L
	time through system		f C	T
15	Calculate: queue length		f D	L_q
	waiting time in queue		f D	T_q
16	Calculate efficiency factor F		f E	F
17	For a new case, go to 2			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	GSB9	23 09	
003	STO1	35 01	
004	STOI	35 46	
005	R↓	-31	ρ
006	STO2	35 02	
007	X≷Y	-41	
008	STO5	35 05	
009	÷	-24	
010	STO3	35 03	
011	PRTX	-14	
012	R/S	51	
013	*LBLB	21 12	
014	1	01	
015	STO4	35 04	
016	0	00	
017	*LBL1	21 01	
018	RCL4	36 04	
019	+	-55	
020	LSTX	16-63	
021	RCL3	36 03	
022	x	-35	
023	RCL1	36 01	
024	RCLI	36 46	
025	-	-45	
026	1	01	
027	+	-55	
028	÷	-24	
029	STO4	35 04	P_o, P_b
030	R↓	-31	
031	DSZI	16 25 46	
032	GTO1	22 01	
033	1	01	
034	RCL3	36 03	
035	RCL1	36 01	
036	÷	-24	
037	-	-45	
038	RCL4	36 04	
039	X≷Y	-41	
040	÷	-24	
041	STOI	35 46	
042	+	-55	
043	1/X	52	
044	SPC	16-11	
045	PRTX	-14	
046	R/S	51	
047	*LBLB	21 12	
048	RCLI	36 46	
049	x	-35	
050	STOI	35 46	
051	PRTX	-14	
052	R/S	51	
053	*LBLC	21 13	
054	RCLI	36 46	
055	RCL3	36 03	
056	x	-35	
057	RCL1	36 01	
058	RCL3	36 03	
059	-	-45	
060	÷	-24	
061	STO4	35 04	L_q, L
062	SPC	16-11	
063	PRTX	-14	
064	R/S	51	
065	*LBLC	21 13	
066	RCL3	36 03	
067	+	-55	
068	STO6	35 06	
069	PRTX	-14	
070	R/S	51	
071	*LBLD	21 14	
072	RCL4	36 04	
073	RCL2	36 02	T_q, T
074	÷	-24	
075	SPC	16-11	
076	PRTX	-14	
077	R/S	51	
078	*LBLD	21 14	
079	RCL6	36 06	
080	RCL2	36 02	
081	÷	-24	
082	PRTX	-14	
083	R/S	51	
084	*LBLE	21 15	
085	SPC	16-11	$P(t)$
086	PRTX	-14	
087	RCL1	36 01	
088	RCL5	36 05	
089	x	-35	
090	RCL2	36 02	
091	-	-45	
092	x	-35	
093	CHS	-22	
094	e^x	33	
095	RCLI	36 46	
096	x	-35	
097	PRTX	-14	
098	SPC	16-11	
099	R/S	51	
100	*LBL9	21 09	Print u, λ, n.
101	R↓	-31	
102	R↓	-31	
103	SPC	16-11	
104	PRTX	-14	
105	R↑	16-31	
106	PRTX	-14	
107	R↑	16-31	
108	PRTX	-14	
109	RTN	24	
110	*LBLa	21 16 11	m, n
111	GSB8	23 08	
112	STO2	35 02	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	n, m	λ, n	ρ	L_q, k	u, Q_k, L	$L, \Sigma Q_k$	$\Sigma_k Q_k, -F$	a	Used
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Used, P_b

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	R↓	-31	
114	STO1	35 01	
115	R/S	51	
116	*LBLb	21 16 12	ρ
117	GSB8	23 08	
118	STO8	35 08	
119	÷	-24	
120	STO3	35 03	
121	PRTX	-14	
122	R/S	51	
123	*LBLc	21 16 13	
124	CLX	-51	
125	STO7	35 07	
126	1	01	
127	STO4	35 04	
128	STO5	35 05	
129	STO6	35 06	
130	*LBL3	21 03	
131	RCL2	36 02	
132	RCL4	36 04	
133	X>Y?	16-34	
134	X≷Y	-41	
135	RCL3	36 03	
136	X≷Y	-41	
137	÷	-24	
138	RCL1	36 01	
139	RCL4	36 04	
140	-	-45	
141	1	01	L
142	+	-55	
143	x	-35	
144	RCL5	36 05	
145	x	-35	
146	STO5	35 05	
147	EEX	-23	
148	CHS	-22	
149	9	09	
150	0	00	
151	X>Y?	16-34	
152	GTO2	22 02	
153	R↓	-31	
154	ST+6	35-55 06	
155	RCL4	36 04	
156	x	-35	
157	ST+7	35-55 07	
158	RCL1	36 01	
159	RCL4	36 04	
160	1	01	
161	+	-55	
162	STO4	35 04	
163	X≤Y?	16-35	
164	GTO3	22 03	
165	*LBL2	21 02	
166	RCL7	36 07	
167	RCL6	36 06	
168	÷	-24	
169	STO5	35 05	
170	SPC	16-11	
171	PRTX	-14	
172	R/S	51	
173	*LBLc	21 16 13	T
174	RCL8	36 08	
175	x	-35	
176	PRTX	-14	
177	R/S	51	
178	*LBLd	21 16 14	L_q
179	RCL5	36 05	
180	RCL1	36 01	
181	÷	-24	
182	1	01	
183	-	-45	
184	RCL3	36 03	
185	1	01	
186	+	-55	
187	x	-35	
188	STO7	35 07	
189	1	01	
190	+	-55	
191	RCL1	36 01	
192	x	-35	
193	SPC	16-11	
194	PRTX	-14	
195	R/S	51	
196	*LBLd	21 16 14	T_q
197	RCL8	36 08	
198	x	-35	
199	PRTX	-14	
200	R/S	51	
201	*LBLe	21 16 15	
202	RCL7	36 07	
203	CHS	-22	F
204	SPC	16-11	
205	PRTX	-14	
206	SPC	16-11	
207	R/S	51	
208	*LBL8	21 08	Print m,n,s,a.
209	R↓	-31	
210	SPC	16-11	
211	PRTX	-14	
212	R↑	16-31	
213	PRTX	-14	
214	RTN	24	
220			

LABELS

A ...→ρ	B→P_o,→P_b	C→L_q,→L	D→T_q,→T	E t→P(t)	0
a m↑n→	b S↑a→ρ	c→L,→T	d→L_q,→T_q	e→F	1
0	1 P_o,P_b	2 L	3 K	4	2
5	6	7	8 Print	9 Print	3

FLAGS

0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☑
1	☐	☑
2	☐	☑
3	☐	☑

TRIG	
DEG	☑
GRAD	☐
RAD	☐

DISP	
FIX	☑
SCI	☐
ENG	☐
n	2

Program Description I

Program Title TWO WAY ANALYSIS OF VARIANCE (WITH REPLICATIONS) FIXED EFFECTS MODEL

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City BATON ROUGE **State** LA. **Zip Code** 70806

Program Description, Equations, Variables A TRADITIONAL EQUAL CELL N, 2 WAY ANOVA IS COMPUTED USING THE FOLLOWING FORMULAS:

SUM OF SQUARES = SS

$$SS_{TOTAL} = \sum_i \sum_j \sum_k X_{ijk}^2 - \left(\sum_i \sum_j \sum_k X_{ijk}\right)^2 / nrc$$

$$SS_{Row} = \sum_i \left(\sum_j \sum_k X_{ijk}\right)^2 / nc - \left(\sum_i \sum_j \sum_k X_{ijk}\right)^2 / nrc$$

$$SS_{Cols} = \sum_j \left(\sum_i \sum_k X_{ijk}\right)^2 / nr - \left(\sum_i \sum_j \sum_k X_{ijk}\right)^2 / nrc$$

$$SS_{INTERACTION} = \sum_i \sum_j \left(\sum_k X_{ijk}\right)^2 / n - SS_{Row} - SS_{Col} + \left(\sum_i \sum_j \sum_k X_{ijk}\right)^2 / nrc$$

$$SS_{ERROR} = \sum_i \sum_j \sum_k X_{ijk}^2 - \sum_i \sum_j \left(\sum_k X_{ijk}\right)^2 / n$$

DEGREES OF FREEDOM: — $df_{Row} = r-1$, $df_{Col} = c-1$, $df_{INT.} = (r-1)(c-1)$

$df_{ERROR} = rc(n-1)$

MEAN SQUARES: — $MS_{Row} = SS_{Row} / df_{Row}$, $MS_{Col} = SS_{Col} / df_{Col}$, $MS_{INT.} = SS_{INT} / df_{INT.}$

$MS_{ERROR} = SS_{ERROR} / df_{ERROR}$ [$F = MS_{EFFECT} / MS_{ERROR}$] for Row, Col, INT.

ω^2 ASSOCIATION: $\omega^2_{Row} = \dfrac{SS_{Row} - (r-1) MS_{ERROR}}{MS_{ERROR} + SS_{TOTAL}}$, $\omega^2_{Col} = \dfrac{SS_{Col} - (c-1) MS_{ERROR}}{MS_{ERROR} + SS_{TOTAL}}$

$$\omega^2_{INT} = \frac{SS_{INT} - (r-1)(c-1) MS_{ERROR}}{MS_{ERROR} + SS_{TOTAL}}$$

Operating Limits and Warnings A MAXIMUM OF 16 CELLS ARE ALLOWED (ie; Row X Cols ≤ 16) IF THIS LIMIT IS EXCEEDED, AN "ERROR" CONDITION WILL SHOW IN THE DISPLAY. ONLY ERRORS MADE WHILE ENTERING DATA IN A CELL CAN BE CORRECTED, EXCEPT FOR THE LAST CELL ENTRY! ω^2 VALUES THAT ARE NEGATIVE SHOULD BE TREATED AS 0.

Program Description II

Sketch(es)

Sample Problem(s) A 2 X 4 FIXED EFFECTS ANOVA — TWO LEVELS OF SOCIAL REINFORCEMENT A_1 & A_2 AND FOUR LEVELS OF DEPRIVATION $B_1 \cdots B_4$

	B_1	B_2	B_3	B_4
A_1	3	4	7	7
	6	5	8	8
	3	4	7	9
	3	3	6	8
A_2	1	2	5	10
	2	3	6	10
	2	4	5	9
	2	3	6	11

Solution(s) 2 ↑ 4 ↑ 4 [A] → 0.00

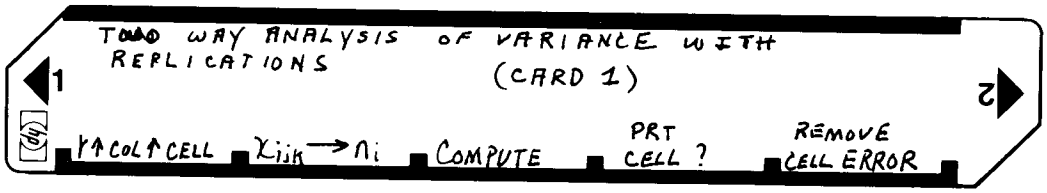
3[B]6[B]3[B]3[B] → 4.00/1.00 4[B]5[B]4[B]3[B] · · · 10[B]10[B]9[B]11[B] → 8.00/8.00

[C] →

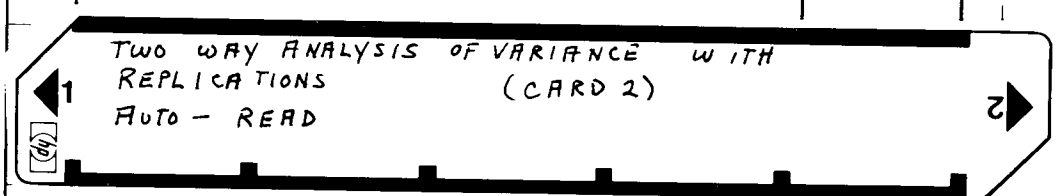
$SS_{TOT} = 235.50$	$MS_{INT} = 6.46$
$SS_{ROW} = 3.13$	$MS_{ERROR} = 0.77$
$SS_{COL} = 194.50$	$F_{ROW} = 4.05$
$SS_{INT} = 19.38$	$F_{COL} = 84.11$
$SS_{ERROR} = 18.50$	$F_{INT} = 8.38$
$df_{ROW} = 1.00$	$\omega^2_{ROW} = .0100$
$df_{COL} = 3.00$	$\omega^2_{COL} = .8134$
$df_{INT} = 3.00$	$\omega^2_{INT} = .0722$
$df_{ERROR} = 24.00$	
$MS_{ROW} = 3.13$	
$MS_{COL} = 64.83$	

Reference(s) KIRK, R.E. EXPERIMENTAL DESIGN: PROCEDURES FOR THE BEHAVIORAL SCIENCES. BROOKS/COLE PUBLISHING COMP., CALIF., 1968.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	LOAD SIDE 1 AND SIDE 2			
2	OPTIONAL PRT. CELL & SUM MODE		D	
3	INPUT # of Rows*	# of Rows	↑	
4	INPUT # of Cols*	# of Cols	↑	
5	INPUT # IN CELL** (ALL REGS. ARE CLEARED)	# IN CELL	A	0.00
	* Rows x Cols ≤ 16			
	** CELL SIZES MUST BE EQUAL			
6	PERFORM (6) FOR $i=1,2\cdots r$, $j=1,2\cdots c$, $k=1,2\cdots n$	X_{ijk}	B	n_k / CELL #
7	OPTIONAL - CORRECT ERRONEOUS X_{ijk}***	UNWANTED X_{ijk}	E	
	*** CORRECT ONLY WITHIN A CELL AND CANNOT CORRECT LAST CELL ENTRY.			
8	BEGIN COMPUTATIONS		C	SS TOTAL
				SS Row
9	INSERT CARD 2 IN READER AFTER PRESSING (C) IN (8)			SS Col
				SS INT
				SS ERROR
				df_{Row}
				df Col
				df INT
				df ERROR
				MS Row
				MS Col
				MS INT
				F_{Row}
				F Col
				F INT
				w^2_{Row}
				w^2 Col
				w^2 INT



STEP	INSTRUCTIONS
1	INSERT CARD 2 IN READER AFTER PRESSING (C) ON CARD 1

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	INITIALIZE & STORE Rows Cols #IN CELL
002	CLRG	16-53	
003	P≠S	16-51	
004	CLRG	16-53	
005	STOA	35 11	
006	R↓	-31	
007	STOB	35 12	
008	R↓	-31	
009	STOC	35 13	
010	R↑	16-31	
011	×	-35	
012	1	01	
013	E	06	
014	X≠Y	-41	
015	X>Y?	16-34	
016	GTO9	22 09	
017	1	01	
018	STOI	35 46	
019	0	00	
020	RTN	24	
021	*LBL9	21 09	ERROR CHECK FOR Row X Col > 16
022	0	00	
023	÷	-24	
024	RTN	24	
025	*LBLB	21 12	ENTRY OF Xijk
026	F1?	16 23 01	
027	PRTX	-14	
028	ST+i	35-55 45	
029	X²	53	
030	ST+0	35-55 00	
031	RCLD	36 14	
032	1	01	
033	+	-55	
034	STOD	35 14	
035	RCLA	36 11	
036	RCLD	36 14	
037	X=Y?	16-33	
038	GSB1	23 01	
039	RTN	24	
040	*LBL1	21 01	COMPUTE & STORE CELL & Row sums & sums of squares
041	PSE	16 51	
042	RCLE	36 15	
043	1	01	
044	+	-55	
045	STOE	35 15	
046	RCLi	36 45	
047	F1?	16 23 01	
048	SPC	16-11	
049	F1?	16 23 01	
050	PRTX	-14	
051	F1?	16 23 01	
052	SPC	16-11	
053	RCLI	36 46	
054	1	01	
055	7	07	
056	X≠I	16-41	
057	R↓	-31	
058	R↓	-31	
059	ST+i	35-55 45	
060	ISZI	16 26 46	
061	X²	53	
062	ST+i	35-55 45	
063	R↑	16-31	
064	X≠I	16-41	
065	0	00	
066	STOD	35 14	
067	RCLB	36 12	
068	RCLE	36 15	
069	X=Y?	16-33	
070	GSB2	23 02	
071	ISZI	16 26 46	
072	RCLI	36 46	
073	1	01	
074	-	-45	
075	RTN	24	
076	*LBLD	21 14	SET FLAG FOR PRINTING OF CELL DATA & SUM
077	SF1	16 21 01	
078	RTN	24	
079	*LBLE	21 15	REMOVE CELL ERROR
080	ST-i	35-45 45	
081	X²	53	
082	ST-0	35-45 00	
083	RCLD	36 14	
084	1	01	
085	-	-45	
086	STOD	35 14	
087	RTN	24	
088	*LBL2	21 02	CLEAR & RESET FOR NEXT Row
089	1	01	
090	7	07	
091	X≠I	16-41	
092	STOE	35 15	
093	RCLi	36 45	
094	X²	53	
095	ISZI	16 26 46	
096	ISZI	16 26 46	
097	ST+i	35-55 45	
098	DSZI	16 25 46	
099	DSZI	16 25 46	
100	0	00	
101	STOi	35 45	
102	RCLE	36 15	
103	X≠I	16-41	
104	0	00	
105	STOE	35 15	
106	RTN	24	
107	*LBLC	21 13	BEGIN GENERATION OF SUMS OF SQUARES & ANOVA TABLE
108	RCL0	36 00	
109	STOE	35 15	
110	0	00	
111	STO0	35 00	
112	1	01	

REGISTERS

0 USED	1 CELL 1	2 CELL 2	3 CELL 3	4 CELL 4	5 CELL 5	6 CELL 6	7 CELL 7	8 CELL 8	9 CELL 9
S0 CELL 10	S1 CELL 11	S2 CELL 12	S3 CELL 13	S4 CELL 14	S5 CELL 15	S6 CELL 16	S7 USED	S8 USED	S9 USED
A # IN CELL	B # COLS.	C # Rows	D USED	E USED	I USED				

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	STOI	35 46	
114	STOD	35 14	
115	*LBLe	21 16 15	
116	RCLB	36 12	
117	RCLC	36 13	
118	×	-35	
119	RCLD	36 14	
120	+	-55	
121	X=Y?	16-33	
122	GTO3	22 03	
123	RCLi	36 45	
124	ST+0	35-55 00	
125	RCLB	36 12	
126	RCLI	36 46	
127	+	-55	
128	STOI	35 46	
129	GTOe	22 16 15	
130	*LBL3	21 03	
131	RCLD	36 14	
132	RCLB	36 12	
133	1	01	
134	+	-55	
135	X=Y?	16-33	
136	GTO4	22 04	
137	RCLD	36 14	
138	1	01	
139	+	-55	
140	STOI	35 46	
141	STOD	35 14	
142	RCL0	36 00	
143	X^2	53	
144	P≠S	16-51	
145	ST+7	35-55 07	
146	P≠S	16-51	
147	0	00	
148	STO0	35 00	
149	RCLI	36 46	
150	GTOe	22 16 15	
151	*LBL4	21 04	
152	0	00	
153	STO0	35 00	
154	1	01	
155	6	06	
156	STOI	35 46	
157	*LBL6	21 16 12	
158	RCLi	36 45	
159	ST+0	35-55 00	
160	DSZI	16 25 46	
161	GTO6	22 16 12	
162	1	01	
163	9	09	
164	STOI	35 46	
165	RCLA	36 11	
166	RCLB	36 12	
167	×	-35	
168	ST÷i	35-24 45	
169	DSZI	16 25 46	
170	RCLA	36 11	
171	ST÷i	35-24 45	
172	DSZI	16 25 46	
173	RCLC	36 13	
174	RCLA	36 11	
175	×	-35	
176	ST÷i	35-24 45	
177	RCL0	36 00	
178	X^2	53	
179	RCLA	36 11	
180	RCLB	36 12	
181	×	-35	
182	RCLC	36 13	
183	×	-35	
184	STOA	35 11	
185	÷	-24	
186	STO0	35 00	
187	*LBL5	21 05	
188	RCL0	36 00	
189	ST-i	35-45 45	
190	ISZI	16 26 46	
191	RCLI	36 46	
192	2	02	
193	0	00	
194	X≠Y?	16-32	
195	GTO5	22 05	
196	RCLE	36 15	
197	RCL0	36 00	
198	-	-45	
199	STOE	35 15	
200	P≠S	16-51	
201	RCL7	36 07	
202	RCL8	36 08	
203	X≠Y	-41	
204	STO8	35 08	
205	R↓	-31	
206	STO7	35 07	
207	RCLE	36 15	
208	RCL7	36 07	
209	-	-45	
210	STOD	35 14	
211	RCL7	36 07	
212	RCL8	36 08	
213	-	-45	
214	RCL9	36 09	
215	-	-45	
216	STO7	35 07	
217	RCLE	36 15	BEGIN PRINT ROUTINE
218	SPC	16-11	
219	PRTX	-14	
220	RCL9	36 09	
221	PRTX	-14	
222	RCL8	36 08	
223	PRTX	-14	
224	PSE	16 51	

LABELS

A YOUR COL. CELL INIT.	B $X_{ijk} \rightarrow n$	C COMPUTE	D STF 1	E Σ−
a	b USED	c	d	e USED
0	1 USED	2 USED	3 USED	4 USED
5 USED	6	7	8	9 ERROR

FLAGS

0	—
1	USED
2	—
3	—

SET STATUS

FLAGS	ON	OFF
0	☐	☑
1	☐	☑
2	☐	☑
3	☐	☑

TRIG	
DEG	☑
GRAD	☐
RAD	☐

DISP	
FIX	☑
SCI	☐
ENG	☐
n	2

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	RCL7	36 07	
002	PRTX	-14	
003	RCLD	36 14	
004	PRTX	-14	
005	SPC	16-11	
006	RCLC	36 13	
007	1	01	
008	-	-45	
009	STOC	35 13	
010	PRTX	-14	
011	ST÷9	35-24 09	
012	RCLB	36 12	
013	1	01	
014	-	-45	
015	STOB	35 12	
016	PRTX	-14	
017	ST÷8	35-24 08	
018	RCLB	36 12	
019	RCLC	36 13	
020	×	-35	
021	STOI	35 46	
022	PRTX	-14	
023	ST÷7	35-24 07	
024	RCLA	36 11	
025	RCLB	36 12	
026	-	-45	
027	RCLC	36 13	
028	-	-45	
029	RCLI	36 46	
030	-	-45	
031	1	01	
032	-	-45	
033	PRTX	-14	
034	RCLD	36 14	
035	X≠Y	-41	
036	÷	-24	
037	STOD	35 14	
038	SPC	16-11	
039	RCL9	36 09	
040	PRTX	-14	
041	RCL8	36 08	
042	PRTX	-14	
043	RCL7	36 07	
044	PRTX	-14	
045	RCLD	36 14	
046	PRTX	-14	
047	SPC	16-11	
048	9	09	
049	STOI	35 46	
050	*LBL7	21 07	
051	RCLi	36 45	
052	RCLD	36 14	
053	÷	-24	
054	PRTX	-14	
055	DSZI	16 25 46	
056	RCLI	36 46	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	6	06	
058	X≠Y?	16-32	
059	GTO7	22 07	
060	SPC	16-11	
061	DSP4	-63 04	
062	RCLC	36 13	
063	RCL9	36 09	
064	×	-35	
065	RCLC	36 13	
066	RCLD	36 14	
067	×	-35	
068	-	-45	
069	RCLD	36 14	
070	RCLE	36 15	
071	+	-55	
072	÷	-24	
073	PRTX	-14	
074	RCLB	36 12	
075	RCL8	36 08	
076	×	-35	
077	RCLB	36 12	
078	RCLD	36 14	
079	×	-35	
080	-	-45	
081	RCLD	36 14	
082	RCLE	36 15	
083	+	-55	
084	÷	-24	
085	PRTX	-14	
086	RCLB	36 12	
087	RCLC	36 13	
088	×	-35	
089	RCL7	36 07	
090	×	-35	
091	RCLB	36 12	
092	RCLC	36 13	
093	×	-35	
094	RCLD	36 14	
095	×	-35	
096	-	-45	
097	RCLD	36 14	
098	RCLE	36 15	
099	+	-55	
100	÷	-24	
101	PRTX	-14	
102	RTN	24	
103	R/S	51	
110			

REGISTERS

0 —	1 —	2 —	3 —	4 —	5 —	6 —	7 MS_{INT}	8 MS_{COL}	9 MS_{ROW}
S0 USED	S1 USED	S2 USED	S3 USED	S4 USED	S5 USED	S6 USED	S7 USED	S8 USED	S9 —
A N	B df_{COL}	C df_{ROW}	D MS_{ERROR}	E SS_{TOTAL}	I USED				

Program Description I

Program Title Multiple Linear Regression for 3 Independent Variables

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables Regression coefficients a, b, c, and d can be found by solving the following system of equations. Gauss' elimination method is applied.

$$\Sigma t_i = na + b\,\Sigma x_i + c\,\Sigma y_i + d\,\Sigma z_i$$

$$\Sigma x_i t_i = a\,\Sigma x_i + b\,\Sigma (x_i)^2 + c\,\Sigma (x_i y_i) + d\,\Sigma (x_i z_i)$$

$$\Sigma y_i t_i = a\,\Sigma y_i + b\,\Sigma (x_i y_i) + c\,\Sigma (y_i)^2 + d\,\Sigma (y_i z_i)$$

$$\Sigma z_i t_i = a\,\Sigma z_i + b\,\Sigma (z_i x_i) + c\,\Sigma (y_i z_i) + d\,\Sigma (z_i)^2$$

Also the multiple correlation coefficient is

$$R^2 = \frac{a\,\Sigma t_i + b\,\Sigma x_i t_i + c\,\Sigma y_i t_i + d\,\Sigma z_i t_i - \frac{1}{n}(\Sigma t_i)^2}{\Sigma t_i^{\,2} - \frac{1}{n}(\Sigma t_i)^2}$$

This program also allows the user to choose a regression with zero intercept (i.e., a = 0).

Multiple linear regression with two independent variables can also be calculated by using this program; refer to the examples for details.

Operating Limits and Warnings

The set of data points must not be collinear nor coplanar.

Program Description II

Sketch(es)

Sample Problem(s) A set of data points are given as the following:

i	1	2	3	4	5
x_i	7	1	11	11	7
y_i	25	29	56	31	52
z_i	6	15	8	8	6
t_i	60	52	20	47	33

Find the regression coefficients a, b, c, d, R^2, sums of squares, and sums of cross products.

Solution(s) Load side one and two of card 1.

[A] 7 [↑] 25 [↑] 6 [↑] 60 [C]---→ 1, 1 [↑] 29 [↑] 15 [↑] 52 [C]---→2,.....

7 [↑] 52 [↑] 6 [↑] 33 [C]---→ 5 .....

(Σx_i = 37, Σy_i = 193, Σz_i = 43, Σt_i = 212,

Σxy = 1525, Σxz = 275, Σxt = 1440, Σyz = 1593, Σyt = 7301, Σzt = 1874,

Σx^2 = 341, Σy^2 = 8267, Σz^2 = 425, Σt^2 = 10002)

Load side one and two of card 2. Switch to NORM.

[C]---→ a = 103.447, b = -1.284, c = -1.037, d =-1.339; [D]---→ R^2 = 0.999

7 [↑] 25 [↑] 6 [E]---→ $\hat{t}$ = 60.50

Reference(s) Draper & Smith "Applied Regression Analysis" John Wiley & Sons, Inc. 1966

Program Description II

Sketch(es)

i	1	2	3	4	5
x	1	2	3	4	5
y	2	3	9	11	7
z	3	7	7	9	3
t	14	29	42	53	28

Sample Problem(s) Example 2: Decide the regression line for the above set of data points.

Solution:

Load side 1 and side 2 of card 1. [A] [B]

1[↑]2[↑]3[↑]14[C]→ 1(x_1), 2(y_1), 3(z_1), 14(t_1), 1.(i)

2[↑]3[↑]7[↑]29[C]→ .....,

3[↑]9[↑]7[↑]42[C]→ .....,

4[↑]11[↑]9[↑]53[C] > .....,

5[↑]7[↑]3[↑]28[C]→ .....,

[E]→15(Σx), 32(Σy), 29(Σz), 166(Σt).

[f][D]→114(Σxy), 89(Σxz), 550(Σxt), 210(Σyz), 1272(Σyt), 1100(Σzt).

[f][E]→55(Σx^2), 264(Σy^2), 197(Σz^2), 6394(Σt^2).

To store data on a card, [f][WRITE DATA].

Load side 1 and side 2 of card 2. Switch to [NORM]

[C]→1.000....-8(a), 1.000(b), 2.000(c), 3.000(d).

[D]→1.000(R^2)

The tiny value of "a" suggests zero intercept. Therefore load data card and

[f][C]→1.000(b), 2.000(c), 3.000 (d)

[D]→1.000(R^2), 4[↑]11[↑]9[E] →53($\hat{t}$), 5[↑]7[↑]3[E]→28($\hat{t}$).

Therefore the set of data points is an exact zero intercept regression line.

Reference(s)

Program Description II

Sketch(es)

i	1	2	3	4
x	1.5	0.45	1.8	2.8
y	0.7	2.3	1.6	4.5
t	2.1	4.0	4.1	9.4

Sample Problem(s) Example 3: For the above set of data points, find the regression line with two independent variables.

i.e., $t = a + bx + cy$

Solution: Simply consider all the z_i's as zero, and treat this problem as an 3 independent variable linear regression.

Keystrokes:

Load side 1 and side 2 of card 1. [A] [B]

1.5[↑].7[↑]0[↑]2.1[C] → 1.5(x_1), 0.7(y_1), 0(z_1), 2.1(t_1), 1(i).

.45[↑]2.3[↑]0[↑]4 [C] → .....,

1.8[↑]1.6[↑]0[↑]4.1[C] →.....,

2.8[↑]4.5[↑]0[↑]9.4[C] →.....,

[E] →6.55, 9.10, 0, 19.6 (Σx, Σy, Σz, Σt)

[f][D] →17.57, 0, 38.65, 0, 59.53, 0. (Σxy, Σxz, Σxt, Σyz ...)

[f][E] →13.53, 28.59, 0, 125.58 (Σx^2, Σy^2, Σz^2, Σt^2)

Load side 1 and side 2 of card 2. Switch to [NORM].

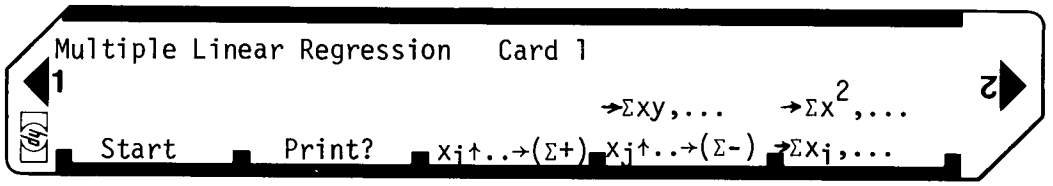
[C] →-0.097(a), 0.791(b), 1.627(c), 0(d).

[D] →0.998 (R^2)

2[↑]3[↑]0[E] →6.366($\hat{t}$)

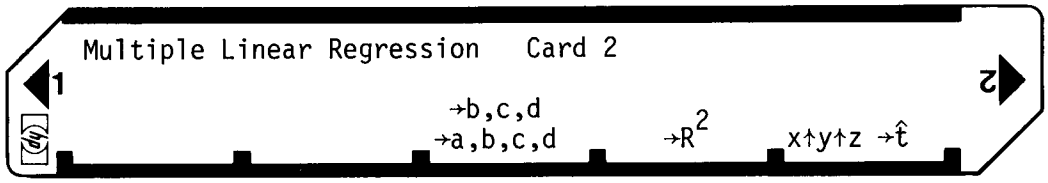
Reference(s)

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and 2 of card 1			
2	Initialize		A	0.00
3	To set print mode*		B	1.00
4	Do step 5 6 for i = 1, 2, ..., n			
5	Input data: x_i	x_i	↑	
	y_i	y_i	↑	
	z_i	z_i	↑	
	t_i	t_i	C	i
6	If you made a mistake in inputting x_j, y_j, z_j, t_j, then correct by ---→	x_j	↑	
		y_j	↑	
		z_j	↑	
		t_j	D	j - 1
7	(optional) Recall the sums		E	$\Sigma x_i, \Sigma y_i, \Sigma z_i$ Σt_i
8	(optional) Recall the sums of products		f D	$\Sigma xy, \Sigma xz, \Sigma xt$ $\Sigma yz, \Sigma yt, \Sigma zt$
9	(optional) Recall the sums of squares		f E	$\Sigma x_i^2, \Sigma y_i^2,$ $\Sigma z_i^2, \Sigma t_i^2$
10	(Optional) To record data, press f WRITE DATA and record.			
11	Load side 1 and side 2 of card 2.			
12	For zero intercept, go to step 14.			
13	Calculate normal regression coefficients		C	a,b,c,d
	then go to step 15			
14	Calculate zero intercept regression coefficients		f C	b,c,d
15	Calculate the correlation coefficient		D	R^2
16	Calculate estimated $\hat{t}$ from regression			
	input x	x	↑	
	y	y	↑	
	z	z	E	$\hat{t}$
17	Repeat step 16 for different (x, y, z)'s			
18	For a different regression, load data card			
	and go to step 12.			
	USER INSTRUCTIONS Continued next page			

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
19	For a new case, go to step 1			
	NOTE: *To clear print mode, press→		CLE 0	

97 Program Listing I Card 1

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	CF0	16 22 00	
003	CF1	16 22 01	
004	CLRG	16-53	
005	P≠S	16-51	
006	CLRG	16-53	
007	P≠S	16-51	
008	0	00	
009	RTN	24	
010	*LBLB	21 12	
011	SF0	16 21 00	
012	1	01	
013	RTN	24	
014	*LBLC	21 13	
015	X≠I	16-41	
016	STx1	35-35 01	
017	STx2	35-35 02	
018	STx3	35-35 03	
019	STx4	35-35 04	
020	X≠I	16-41	
021	STOD	35 14	
022	GSB0	23 00	
023	ST+4	35-55 04	
024	X²	53	
025	GSB0	23 00	
026	ST+0	35-55 00	
027	R↓	-31	
028	STOC	35 13	
029	GSB0	23 00	
030	ST+3	35-55 03	
031	P≠S	16-51	
032	ST+5	35-55 05	
033	X²	53	
034	GSB0	23 00	
035	ST+8	35-55 08	
036	P≠S	16-51	
037	R↓	-31	
038	STOB	35 12	
039	GSB0	23 00	
040	ST+2	35-55 02	
041	P≠S	16-51	
042	ST+0	35-55 00	
043	X²	53	
044	GSB0	23 00	
045	ST+2	35-55 02	
046	P≠S	16-51	
047	R↓	-31	
048	STOA	35 11	
049	GSB0	23 00	
050	ST+1	35-55 01	
051	ST+5	35-55 05	
052	X²	53	
053	GSB0	23 00	
054	ST+6	35-55 06	
055	RCLA	36 11	
056	RCLB	36 12	
057	x	-35	
058	GSB0	23 00	
059	ST+7	35-55 07	
060	P≠S	16-51	
061	ST+1	35-55 01	
062	P≠S	16-51	
063	RCLA	36 11	
064	RCLD	36 14	
065	x	-35	
066	GSB0	23 00	
067	ST+9	35-55 09	
068	RCLB	36 12	
069	RCLC	36 13	
070	x	-35	
071	GSB0	23 00	
072	P≠S	16-51	
073	ST+3	35-55 03	
074	ST+7	35-55 07	
075	RCLB	36 12	
076	RCLD	36 14	
077	x	-35	
078	GSB0	23 00	
079	ST+4	35-55 04	
080	RCLC	36 13	
081	RCLD	36 14	
082	x	-35	
083	GSB0	23 00	
084	ST+9	35-55 09	
085	RCLA	36 11	
086	RCLC	36 13	
087	x	-35	
088	GSB0	23 00	
089	ST+6	35-55 06	
090	P≠S	16-51	
091	ST+8	35-55 08	
092	F0?	16 23 00	
093	GSB9	23 09	
094	RCLI	36 46	
095	1	01	
096	GSB0	23 00	
097	+	-55	
098	STOI	35 46	
099	RCL4	36 04	
100	STOA	35 11	
101	RCLI	36 46	
102	STOB	35 12	
103	ST÷1	35-24 01	
104	ST÷2	35-24 02	
105	ST÷3	35-24 03	
106	ST÷4	35-24 04	
107	F0?	16 23 00	
108	GSB8	23 08	
109	RTN	24	
110	*LBL9	21 09	
111	RCLA	36 11	
112	PRTX	-14	

Initialize

Set flag for print

Input x_i, y_i, z_i, t_i, and calculate

Print x_i, y_i, z_i, t_i

REGISTERS

0 $\Sigma(t^2)$	1 $\Sigma x/n$	2 $\Sigma y/n$	3 $\Sigma z/n$	4 $\Sigma t/n$	5 $\Sigma x, \Sigma xt$	6 Σx^2	7 $\Sigma(xy)$	8 $\Sigma(xz)$	9 $\Sigma(xt)$
S0 $\Sigma y, \Sigma(yt)$	S1 $\Sigma(xy), \Sigma t$	S2 $\Sigma(y)^2$	S3 $\Sigma(yz)$	S4 $\Sigma(yt)$	S5 $\Sigma z, \Sigma(zt)$	S6 $\Sigma zx, \Sigma t^2/n$	S7 $\Sigma(yz)$	S8 $\Sigma(z)^2$	S9 $\Sigma(zt)$

A	B	C	D	E	I
temp x, Σt, a	temp y, b	temp z, c	temp t, d	Used	Index

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	RCLB	36 12	
114	PRTX	-14	
115	RCLC	36 13	
116	PRTX	-14	
117	RCLD	36 14	
118	PRTX	-14	
119	RTN	24	
120	*LBL8	21 08	
121	DSP0	-63 00	Print i
122	PRTX	-14	
123	DSP2	-63 02	
124	SPC	16-11	
125	RTN	24	
126	*LBL0	21 00	
127	F1?	16 23 01	Change sign for correction
128	CHS	-22	
129	RTN	24	
130	*LBLD	21 14	
131	SF1	16 21 01	Correction
132	GSBC	23 13	
133	CF1	16 22 01	
134	RTN	24	
135	*LBLE	21 15	
136	RCL1	36 01	
137	RCLI	36 46	
138	x	-35	
139	PRTX	-14	
140	RCL2	36 02	
141	RCLI	36 46	Recall Σx, Σy, Σz, Σt
142	x	-35	
143	PRTX	-14	
144	RCL3	36 03	
145	RCLI	36 46	
146	x	-35	
147	PRTX	-14	
148	RCL4	36 04	
149	RCLI	36 46	
150	x	-35	
151	PRTX	-14	
152	SPC	16-11	
153	RTN	24	
154	*LBLd	21 16 14	
155	RCL7	36 07	
156	PRTX	-14	
157	RCL8	36 08	
158	PRTX	-14	
159	RCL9	36 09	Recall Σxy, Σxz, Σxt, Σyz, Σyt, Σzt
160	PRTX	-14	
161	P≠S	16-51	
162	RCL3	36 03	
163	PRTX	-14	
164	RCL4	36 04	
165	PRTX	-14	
166	RCL9	36 09	
167	PRTX	-14	
168	P≠S	16-51	
169	SPC	16-11	
170	RTN	24	
171	*LBLe	21 16 15	
172	RCL6	36 06	
173	PRTX	-14	
174	P≠S	16-51	Recall Σx², Σy², Σz², Σt²
175	RCL2	36 02	
176	PRTX	-14	
177	RCL8	36 08	
178	PRTX	-14	
179	P≠S	16-51	
180	RCL0	36 00	
181	PRTX	-14	
182	SPC	16-11	
183	RTN	24	

LABELS					FLAGS
A Start	B Print	C Input	D Correction	E Σx, Σy, ...	0 Print
a	b	c	d Σxy, Σxz, ...	e Σx², Σy², ...	1 Correction
0 CHS	1	2	3	4	2
5	6	7	8 Print i	9 Print	3

SET STATUS				
FLAGS		TRIG	DISP	
	ON OFF			
0	☐ ☑	DEG ☑	FIX ☑	
1	☐ ☑	GRAD ☐	SCI ☐	
2	☐ ☑	RAD ☐	ENG ☐	
3	☐ ☑		n 2	

Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLc	21 16 13	
002	SF1	16 21 01	
003	*LBLC	21 13	
004	0	00	
005	STOE	35 15	
006	5	05	
007	STOD	35 14	
008	RCL5	36 05	
009	STOC	35 13	
010	RCL9	36 09	
011	STO5	35 05	
012	GSBb	23 16 12	
013	0	00	1st elimination
014	STOE	35 15	
015	1	01	
016	0	00	
017	STOD	35 14	
018	P≠S	16-51	
019	RCL0	36 00	
020	RCL4	36 04	
021	STO0	35 00	
022	X≠Y	-41	
023	P≠S	16-51	
024	STOC	35 13	
025	GSBb	23 16 12	
026	0	00	
027	STOE	35 15	
028	1	01	
029	5	05	
030	STOD	35 14	
031	P≠S	16-51	
032	RCL5	36 05	
033	RCL9	36 09	
034	STO5	35 05	
035	X≠Y	-41	
036	P≠S	16-51	
037	STOC	35 13	
038	GSBb	23 16 12	
039	*LBL2	21 02	
040	RCL6	36 06	
041	ST÷6	35-24 06	
042	ST÷7	35-24 07	
043	ST÷8	35-24 08	
044	ST÷9	35-24 09	
045	6	06	
046	STOE	35 15	
047	5	05	2nd elimination
048	STOD	35 14	
049	P≠S	16-51	
050	RCL1	36 01	
051	P≠S	16-51	
052	STOC	35 13	
053	GSBb	23 16 12	
054	5	05	
055	STOE	35 15	
056	1	01	
057	0	00	
058	STOD	35 14	
059	P≠S	16-51	
060	RCL6	36 06	
061	P≠S	16-51	
062	STOC	35 13	
063	GSBb	23 16 12	
064	*LBL3	21 03	
065	P≠S	16-51	
066	RCL2	36 02	
067	ST÷2	35-24 02	
068	ST÷3	35-24 03	
069	ST÷4	35-24 04	
070	P≠S	16-51	3rd elimination and calculate a, b, c, d
071	1	01	
072	1	01	
073	STOE	35 15	
074	5	05	
075	STOD	35 14	
076	P≠S	16-51	
077	RCL7	36 07	
078	P≠S	16-51	
079	STOC	35 13	
080	GSBb	23 16 12	
081	P≠S	16-51	
082	RCLA	36 11	
083	STO1	35 01	
084	X²	53	
085	RCLB	36 12	
086	÷	-24	
087	STO6	35 06	
088	RCL9	36 09	
089	RCL8	36 08	
090	X≠0?	16-42	
091	÷	-24	
092	STOD	35 14	
093	RCL3	36 03	
094	x	-35	
095	RCL4	36 04	
096	-	-45	
097	CHS	-22	
098	RCL2	36 02	
099	P≠S	16-51	
100	÷	-24	
101	STOC	35 13	
102	RCL7	36 07	
103	x	-35	
104	CHS	-22	
105	RCLD	36 14	
106	RCL8	36 08	
107	x	-35	
108	-	-45	
109	RCL9	36 09	
110	+	-55	
111	RCL6	36 06	
112	÷	-24	

REGISTERS

0 $\Sigma(t^2)$	1 $\Sigma x/n$	2 $\Sigma y/n$	3 $\Sigma z/n$	4 $\Sigma t/n$	5 $\Sigma x, \Sigma xt$	6 Σx^2	7 $\Sigma(xy)$	8 $\Sigma(xz)$	9 $\Sigma(xt)$
S0 $\Sigma y, \Sigma(yt)$	S1 $\Sigma(xy), \Sigma t$	S2 $\Sigma(y)^2$	S3 $\Sigma(yz)$	S4 $\Sigma(yt)$	S5 $\Sigma z, \Sigma(zt)$	S6 $\Sigma ex, \Sigma t^2/n$	S7 $\Sigma(yz)$	S8 $\Sigma(z^2)$	S9 $\Sigma(zt)$
A temp x, Σt, a	B temp y, b	C temp z, c	D temp t, d	E Used	I Index				

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	STOB	35 12	
114	RCL1	36 01	
115	×	-35	
116	CHS	-22	
117	RCLC	36 13	
118	RCL2	36 02	
119	×	-35	
120	-	-45	
121	RCLD	36 14	
122	RCL3	36 03	
123	×	-35	
124	-	-45	
125	RCL4	36 04	
126	+	-55	
127	F1?	16 23 01	
128	0	00	
129	STOA	35 11	
130	F1?	16 23 01	
131	GTO7	22 07	
132	PRTX	-14	
133	*LBL7	21 07	
134	RCLB	36 12	
135	RCLC	36 13	
136	RCLD	36 14	
137	GTO9	22 09	
138	*LBL6	21 16 12	Subroutine for elimination
139	RCLE	36 15	
140	1	01	
141	+	-55	
142	STOE	35 15	
143	STOI	35 46	
144	RCLC	36 13	
145	GSBa	23 16 11	
146	RCLE	36 15	
147	4	04	
148	X=Y?	16-33	
149	RTN	24	
150	5	05	
151	+	-55	
152	X=Y?	16-33	
153	RTN	24	
154	5	05	
155	+	-55	
156	X=Y?	16-33	
157	RTN	24	
158	5	05	
159	+	-55	
160	X=Y?	16-33	
161	RTN	24	
162	GTO6	22 16 12	
163	*LBLa	21 16 11	Multiply and subtract
164	RCLi	36 45	
165	×	-35	
166	RCLI	36 46	
167	RCLD	36 14	
168	+	-55	
169	STOI	35 46	
170	X≷Y	-41	
171	ST-i	35-45 45	
172	RTN	24	
173	*LBLE	21 15	
174	RCLD	36 14	Input x, y, z, and calculate t
175	×	-35	
176	X≷Y	-41	
177	RCLC	36 13	
178	×	-35	
179	+	-55	
180	X≷Y	-41	
181	RCLB	36 12	
182	×	-35	
183	+	-55	
184	RCLA	36 11	
185	+	-55	
186	*LBL8	21 08	
187	PRTX	-14	
188	SPC	16-11	
189	CF1	16 22 01	
190	RTN	24	
191	*LBLD	21 14	
192	RCL5	36 05	
193	RCLB	36 12	
194	×	-35	
195	P≷S	16-51	
196	RCL1	36 01	
197	RCLA	36 11	
198	×	-35	Calculate R^2
199	+	-55	
200	RCL0	36 00	
201	RCLC	36 13	
202	×	-35	
203	+	-55	
204	RCL5	36 05	
205	RCLD	36 14	
206	×	-35	
207	+	-55	
208	RCL6	36 06	
209	-	-45	
210	P≷S	16-51	
211	LSTX	16-63	
212	RCL0	36 00	
213	-	-45	
214	CHS	-22	
215	÷	-24	
216	GTO8	22 08	
217	*LBL9	21 09	
218	R↓	-31	
219	R↓	-31	Print x, y, z
220	PRTX	-14	
221	R↑	16-31	
222	PRTX	-14	
223	R↑	16-31	
224	GTO8	22 08	

LABELS

A	B	C →a, b, c, d	D → R^2	E x↑y↑z→t̂	0 Print
a	b Subroutine	c x and -	d	e	1
0	1	2	3 3rd elim.	4	2
5	6	7	8 Print	9 Print x, y, z	3

FLAGS

	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

SET STATUS

TRIG		DISP	
DEG	☒	FIX	☒
GRAD	☐	SCI	☐
RAD	☐	ENG	☐
		n	3

Program Description I

Program Title	SIMULTANEOUS EQUATIONS IN SIX UNKNOWNS				
Contributor's Name	Robert E. DeBolt				
Address	9667 Taylor Court				
City	Pickerington	State	Ohio	Zip Code	43147

Program Description, Equations, Variables

Coefficient Matrix:

$$\begin{Bmatrix} r1 & s1 & t1 & u1 & v1 & w1 & k1 \\ r2 & s2 & t2 & u2 & v2 & w2 & k2 \\ r3 & s3 & t3 & u3 & v3 & w3 & k3 \\ r4 & s4 & t4 & u4 & w4 & w4 & k4 \\ r5 & s5 & t5 & u5 & v5 & w5 & k5 \\ r6 & s6 & t6 & u6 & v6 & w6 & k6 \end{Bmatrix}$$

By Crout's method, let (a_{ij}) be the elements of the given matrix and (A_{ij}) be the elements of the derived matrix. Then

$$A_{ii} = a_{ii} - \sum_{k=1}^{i-1} A_{ik}A_{ki} \qquad \text{(diagonal terms)}$$

$$A_{ij} = a_{ij} - \sum_{k=1}^{j-1} A_{ik}A_{kj} \qquad (i > j, \text{ gives the lower half})$$

$$A_{ij} = \left\{a_{ij} - \sum_{k=1}^{i-1} A_{ik}A_{kj}\right\} / A_{ii} \qquad (i < j, \text{ gives the upper half})$$

The solution vector is

$$X_i = A_{i,n+1} - \sum_{k=i+1}^{n} A_{ik}X_k \qquad (i = 1, \ldots, n)$$

Operating Limits and Warnings

1. Re-order the equations, such that r1 is not zero.
2. "Error" implies inconsistency.

Program Description II

Sketch(es)

Sample Problem(s) **Compute the solution for the following set of equations:**

Variables and coefficient matrix:

r	s	t	u	v	w	k
17	34	170	748	3816.5	19669	1781.6
34	170	748	3816.5	19669	105325.625	4864.65
170	748	3816.5	19669	105325.625	573286.75	22810.975
748	3816.5	19669	105325.625	573286.75	3172438.532	90845.9625
3816.5	19669	105325.625	573286.75	3172438.532	17757325.57	412295.4438
19669	105325.625	573286.75	3172438.532	17757325.57	100361561.9	1856770.791

Solution(s)

r = -11.52568830
s = -28.86312210
t = 45.32824695
u = 1.755025950
v = -2.615475715
w = .1994145369

Reference(s)

Nielsen, Kaj L., Methods in Numerical Analysis, page 185, The Macmillan Company, 1956.

Program Description II

Sketch(es)

Sample Problem(s) Compute the determinant and the inverse of the coefficient matrix in the preceding problem.

1. In order to compute the determinant of the coefficient matrix, less the $\underline{k}$ vector, do the following:

   1.1 Record the values obtained after calculation for the following:

   s2 => record c1 t3 => record c2

   u4 => record c3 v5 => record c4

   w6 => record c5

   1.2 The determinant = r1 x c1 x c2 x c3 x c4 x c5

2. The inverse may be computed by substituting each column of the identity matrix of order 5 for the $\underline{k}$ vector. The solutions obtained by solving the system with this program represent the respective column vectors of the inverse matrix.

Solution(s) determinant =

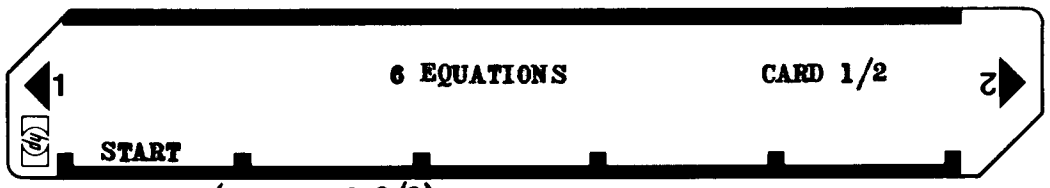
$17 \times 102 \times 484.5 \times 2180.25 \times 9447.7507 \times 39365.555 = 6.812303266 \times 10^{17}$

$A^{-1} =$

.23704060	-.00407230	-.07938403	.00976420	-.00381044	-.00057157
-.00407230	.30094782	-.06239595	-.06620895	.02375172	-.00206822
-.07938403	-.06239595	.06240250	.00928796	-.00859995	.00095261
.00976420	-.06620895	.00928796	.01782172	-.00603319	.00051864
.00381044	.02375172	-.00859995	-.00603319	.00264614	-.00025403
-.00057157	-.00206822	.00095261	.00051864	-.00025403	.00002540

Reference(s)

User Instructions



RCL (for card 2/2)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Load side 1 and side 2 of card 1/2.			
2.	Place side 1 of card 2/2 inte reader slot but do not engage.			
3.	Enter r1:	r1	A	r1
4.	Enter s1, t1, u1, v1, w1, k1, r2, s2, t2, u2, ... thru v5 followed by R/S each entry:		R/S	
5.	Immediately upon entry of v5:R/S, engage card 2/2 in the card reader. The card will be read automatically. The calculator will stop with value A_{55} after side 2 of the card has been entered.			A_{55}
6.	Enter w5, k5, r6, s6, t6, ... thru k6 followed by R/S each entry:		R/S	
7.	After entry of k6, the calculator will run for approximately 20 seconds and will stop with solution r.			r
8.	To display all solutions:		A	r
			R/S	s
			R/S	t
			R/S	u
			R/S	v
			R/S	w
	Note: If, during step 5, you fail to engage card 2/2 in the card reader, then do the following steps:			
9.	Prepare for Merge:		g MERGE	
10.	Enter card 2/2, side 1 and side 2.			
11.	Start program:		R/S	A_{55}
12.	Go to Step 6.			

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL B	31 25 12	
	x	71	
	-	51	
	f LBL C	31 25 13	
	RCL 0	34 00	
	÷	81	
	STO(i)	33 24	
	f DSZ	31 33	
	h RTN	35 22	
010	f LBL 0	31 25 00	RCL 10
	0	00	
	GTO D	22 14	
	f LBL 1	31 25 01	RCL 11
	1	01	
	GTO D	22 14	
	f LBL 2	31 25 02	RCL 12
	2	02	
	GTO D	22 14	
	f LBL 3	31 25 03	RCL 13
020	3	03	
	GTO D	22 14	
	f LBL 4	31 25 04	RCL 14
	4	04	
	GTO D	22 14	
	f LBL 5	31 25 05	RCL 15
	5	05	
	GTO D	22 14	
	f LBL 6	31 25 06	RCL 16
	6	06	
030	GTO D	22 14	
	f LBL 7	31 25 07	RCL 17
	7	07	
	GTO D	22 14	
	f LBL 8	31 25 08	RCL 18
	8	08	
	GTO D	22 14	
	f LBL 9	31 25 09	RCL 19
	9	09	
	f LBL D	31 25 14	
040	1	01	
	0	00	
	+	61	
	h X:I	35 24	
	RCL(i)	34 24	
	h X:Y	35 52	
	h X:I	35 24	
	h R↓	35 53	
	f LBL E	31 25 15	
	x	71	
050	-	51	
	h RTN	35 22	
	g LBLfa	32 25 11	Overlay
	g MERGE	32 41	control.
	h PAUSE	35 72	
	R/S	84	
	h SPACE	35 84	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	f LBL A	31 25 11	START:
	STO 0	33 00	with r1.
	R/S	84	Enter: s1.
060	h X:I	35 24	
	2	02	
	4	04	
	h X:I	35 24	
	f GSB C	31 22 13	
	R/S	84	t1
	f GSB C	31 22 13	
	R/S	84	u1
	f GSB C	31 22 13	
	R/S	84	w1
070	f GSB C	31 22 13	
	R/S	84	v1
	f GSB C	31 22 13	
	R/S	84	k1
	f GSB C	31 22 13	
	R/S	84	r2
	STO 1	33 01	
	R/S	84	s2
	RCL 1	34 01	
	RCL E	34 15	
080	f GSB E	31 22 15	
	STO 0	33 00	
	R/S	84	t2
	RCL 1	34 01	
	RCL D	34 14	
	f GSB B	31 22 12	
	R/S	84	u2
	RCL 1	34 01	
	RCL C	34 13	
	f GSB B	31 22 12	
090	R/S	84	v2
	RCL 1	34 01	
	RCL B	34 12	
	f GSB B	31 22 12	
	R/S	84	w2
	RCL 1	34 01	
	RCL A	34 11	
	f GSB B	31 22 12	
	R/S	84	k2
	RCL 1	34 01	
100	f GSB 9	31 22 09	
	f GSB C	31 22 13	
	R/S	84	r3
	STO 2	33 02	
	R/S	84	s3
	RCL 2	34 02	
	RCL E	34 15	
	f GSB E	31 22 15	
	STO 1	33 01	
	R/S	84	t3
110	RCL 2	34 02	
	RCL D	34 14	
	f GSB E	31 22 15	

REGISTERS

0	1	2	3	4	5	6	7	8	9
s	t	u	v	w	r	used	used	used	used
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
used	used	used	used	used	used	used	used	used	used

A	B	C	D	E	I
used	used	used	used	used	used

67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 1	34 01	
	f GSB 8	31 22 08	
	STO 0	33 00	
	R/S	84	u3
	RCL 2	34 02	
	RCL C	34 13	
	f GSB E	31 22 15	
120	RCL 1	34 01	
	f GSB 7	31 22 07	
	f GSB C	31 22 13	
	R/S	84	v3
	RCL 2	34 02	
	RCL B	34 12	
	f GSB E	31 22 15	
	RCL 1	34 01	
	f GSB 6	31 22 06	
	f GSB C	31 22 13	
130	R/S	84	w3
	RCL 2	34 02	
	RCL A	34 11	
	f GSB E	31 22 15	
	RCL 1	34 01	
	f GSB 5	31 22 05	
	f GSB C	31 22 13	
	R/S	84	k3
	RCL 2	34 02	
	f GSB 9	31 22 09	
140	RCL 1	34 01	
	f GSB 4	31 22 04	
	f GSB C	31 22 13	
	R/S	84	r4
	STO 3	33 03	
	R/S	84	s4
	RCL 3	34 03	
	RCL E	34 15	
	f GSB E	31 22 15	
	STO 2	33 02	
150	R/S	84	t4
	RCL 3	34 03	
	RCL D	34 14	
	f GSB E	31 22 15	
	RCL 2	34 02	
	f GSB 8	31 22 08	
	STO 1	33 01	
	R/S	84	u4
	RCL 3	34 03	
	RCL C	34 13	
160	f GSB E	31 22 15	
	RCL 2	34 02	
	f GSB 7	31 22 07	
	RCL 1	34 01	
	f GSB 3	31 22 03	
	STO 0	33 00	
	R/S	84	v4
	RCL 3	34 03	
	RCL B	34 12	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	f GSB E	31 22 15	
170	RCL 2	34 02	
	f GSB 6	31 22 06	
	RCL 1	34 01	
	f GSB 2	31 22 02	
	f GSB C	31 22 13	
	R/S	84	w4
	RCL 3	34 03	
	RCL A	34 11	
	f GSB E	31 22 15	
	RCL 2	34 02	
180	f GSB 5	31 22 05	
	RCL 1	34 01	
	f GSB 1	31 22 01	
	f GSB C	31 22 13	
	R/S	84	k4
	RCL 3	34 03	
	f GSB 9	31 22 09	
	RCL 2	34 02	
	f GSB 4	31 22 04	
	RCL 1	34 01	
190	f GSB 0	31 22 00	
	f GSB C	31 22 13	
	R/S	84	r5
	STO 4	33 04	
	R/S	84	s5
	RCL 4	34 04	
	RCL E	34 15	
	f GSB E	31 22 15	
	STO 3	33 03	
	R/S	84	t5
200	RCL 4	34 04	
	RCL D	34 14	
	f GSB E	31 22 15	
	RCL 3	34 03	
	f GSB 8	31 22 08	
	STO 2	33 02	u5
	R/S	84	
	RCL 4	34 04	
	RCL C	34 13	
	f GSB E	31 22 15	
210	RCL 3	34 03	
	f GSB 7	31 22 07	
	RCL 2	34 02	
	f GSB 3	31 22 03	
	STO 1	33 01	
	R/S	84	v5
	RCL 4	34 04	
	RCL B	34 12	
	f GSB E	31 22 15	
	RCL 3	34 03	
220	f GSB 6	31 22 06	
	RCL 2	34 02	
	f GSB 2	31 22 02	
	RCL 1	34 01	
	GTO f a	22 31 11	

LABELS				
A START	B used	C used	D used	E used
a used	b	c	d	e
0 used	1 used	2 used	3 used	4 used
5 used	6 used	7 used	8 used	9 used

FLAGS
0
1
2
3

SET STATUS		
FLAGS	TRIG	DISP
ON OFF	DEG ☒	FIX ☒
0 ☐ ☒	GRAD ☐	SCI ☐
1 ☐ ☒	RAD ☐	ENG ☐
2 ☐ ☒		n 2
3 ☐ ☒		

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	RCL 9	34 09	
	f GSB E	31 22 15	
	STO 0	33 00	
	R/S	84	w5
	RCL 4	34 04	
	RCL A	34 11	
	f GSB E	31 22 15	
	RCL 3	34 03	
	f GSB 5	31 22 05	
010	RCL 2	34 02	
	f GSB 1	31 22 01	
	RCL 1	34 01	
	RCL 8	34 08	
	f GSB B	31 22 12	
	R/S	84	k5
	RCL 4	34 04	
	f GSB 9	31 22 09	
	RCL 3	34 03	
	f GSB 4	31 22 04	
020	RCL 2	34 02	
	f GSB 0	31 22 00	
	RCL 1	34 01	
	RCL 7	34 07	
	f GSB B	31 22 12	
	STO 0	33 00	
	R/S	84	r6
	STO 5	33 05	
	R/S	84	s6
	RCL 5	34 05	
030	RCL E	34 15	
	f GSB E	31 22 15	
	STO 4	33 04	
	R/S	84	t6
	RCL 5	34 05	
	RCL D	34 14	
	f GSB E	31 22 15	
	RCL 4	34 04	
	f GSB 8	31 22 08	
	STO 3	33 03	
040	R/S	84	u6
	RCL 5	34 05	
	RCL C	34 13	
	f GSB E	31 22 15	
	RCL 4	34 04	
	f GSB 7	31 22 07	
	RCL 3	34 03	
	f GSB 3	31 22 03	
	STO 2	33 02	
	R/S	84	v6
050	RCL 5	34 05	
	RCL B	34 12	
	f GSB E	31 22 15	
	RCL 4	34 04	
	f GSB 6	31 22 06	
	RCL 3	34 03	
	f GSB 2	31 22 02	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 2	34 02	
	RCL 9	34 09	
	f GSB E	31 22 15	
060	STO 1	33 01	
	R/S	84	w6
	RCL 5	34 05	
	RCL A	34 11	
	f GSB E	31 22 15	
	RCL 4	34 04	
	f GSB 5	31 22 05	
	RCL 3	34 03	
	f GSB 1	31 22 01	
	RCL 2	34 02	
070	RCL 8	34 08	
	f GSB E	31 22 15	
	RCL 1	34 01	
	RCL 6	34 06	
	f GSB E	31 22 15	
	RCL 0	34 00	
	h X:Y	35 52	
	STO 0	33 00	
	R/S	84	k6
	h X:Y	35 52	
080	h R↓	35 53	
	h X:Y	35 52	
	RCL 5	34 05	
	h X:Y	35 52	
	STO 5	33 05	
	h R↓	35 53	
	f GSB 9	31 22 09	
	RCL 4	34 04	
	f GSB 4	31 22 04	
	RCL 3	34 03	
090	f GSB 0	31 22 00	
	RCL 2	34 02	
	RCL 7	34 07	
	f GSB E	31 22 15	
	RCL 1	34 01	
	RCL 5	34 05	
	f GSB B	31 22 12	soln: w
	RCL 5	34 05	
	RCL 4	34 04	
	RCL 6	34 06	
100	f GSB E	31 22 15	
	STO 3	33 03	v
	RCL 7	34 07	
	RCL 4	34 04	
	RCL 8	34 08	
	f GSB E	31 22 15	
	RCL 3	34 03	
	RCL 9	34 09	
	f GSB E	31 22 15	
	STO 2	33 02	u
110	0	00	
	g GSBfe	32 22 15	
	f GSB 1	31 22 01	

REGISTERS

0	1	2	3	4	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 3	34 03	
	f GSB 2	31 22 02	
	RCL 2	34 02	
	f GSB 3	31 22 03	
	STO 1	33 01	t
	4	04	
	g GSBfe	32 22 15	
120	f GSB 5	31 22 05	
	RCL 3	34 03	
	f GSB 6	31 22 06	
	RCL 2	34 02	
	f GSB 7	31 22 07	
	RCL 1	34 01	
	f GSB 8	31 22 08	
	STO 0	33 00	s
	9	09	
	g GSBfe	32 22 15	
130	RCL A	34 11	
	g GSB E	31 22 15	
	RCL 3	34 03	
	RCL B	34 12	
	f GSB E	31 22 15	
	RCL 2	34 02	
	RCL C	34 13	
	f GSB E	31 22 15	
	RCL 1	34 01	
	RCL D	34 14	
140	f GSB E	31 22 15	
	RCL 0	34 00	
	RCL E	34 15	
	f GSB E	31 22 15	
	STO 5	33 05	r
	f LBL A	31 25 11	RCL solutions.
	RCL 5	34 05	r
	R/S	84	
	RCL 0	34 00	s
	R/S	84	
150	RCL 1	34 01	t
	R/S	84	
	RCL 2	34 02	u
	R/S	84	
	RCL 3	34 03	v
	R/S	84	
	RCL 4	34 04	w
	R/S	84	
	GTO A	22 11	
	g LBL fe	32 25 15	
160	1	01	
	0	00	
	+	61	
	h STI	35 33	
	RCL(i)	34 24	
	RCL 4	34 04	
	h RTN	35 22	

STEP	KEY ENTRY	KEY CODE	COMMENTS
170			
180			
190			
200			
210			
220			

LABELS					FLAGS
A	B	C	D	E	0
a	b	c	d	e	1
0	1	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS		TRIG	DISP
	ON OFF		
0	☐ ☒	DEG ☒	FIX ☒
1	☐ ☒	GRAD ☐	SCI ☐
2	☐ ☒	RAD ☐	ENG ☐
3	☐ ☒		n 2

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Antennas
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Thermal and Transport Sciences
EE (Lab)
Industrial Engineering
Aeronautical Engineering
Control Systems
Beams and Columns
High-Level Math
Test Statistics
Geometry
Reliability/QA
Medical Practitioner
Anesthesia
Cardiac
Pulmonary
Chemistry
Optics
Physics
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Games
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Avigation
Calendars
Photo Dark Room
COGO-Surveying
Astrology
Forestry

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DEPRECIATION SCHEDULES

INVOICING AND INVENTORY CONTROL

PRODUCTION MONITOR AND RECORD

LEARNING CURVE

$\bar{x}$ and R CONTROL CHART

SINGLE- AND MULTI-SERVER QUEUES

TWO WAY ANALYSIS OF VARIANCE WITH REPLICATIONS FIXED EFFECTS MODEL

MULTIPLE LINEAR REGRESSION FOR 3 INDEPENDENT VARIABLES

SIMULTANEOUS EQUATIONS IN SIX UNKNOWNS

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