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Calculating & Computing Applications

Date: 7/10/67
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LOCI User Application Newsletter #5

What with the end of one fiscal year and the beginning of another, we are a little late in distributing this issue of the Newsletter. Even so, only two applications have been written up.

L61-67 Numerical Integration by Simpson's Rule, by Goodyear Atomic Division. This program is quite easy to understand, and is of considerable instructional value.

L64-67 Parabolic Regression, by Mr. C. Colbert and Mr. J. Spruit, Fels Research Institute. This is a very useful program for curve fitting of the form $\ln y = a + bx + cx^2$, as originally written. It also includes an ingeneous method of fitting the curve $y = Ae^{bx} + C$.
We further modified it to simply find a fit for $y = a + bx + cx^2$.

We invite you to submit your own program. A method of program exchange can save countless hours among all of our users.

Sincerely,

Ned Chang
Manager, LOCI Division

WANG LABORATORIES, INC. 836 NORTH ST., TEWKSBURY, MASS. 01876, TEL. (617) 851-7311

Calculating & Computing Applications

Numerical Integration by Simpson's Rule
by
Goodyear Atomic Division

The use of Simpson's Rule for numerical integration was programmed for use on a LOCI-2a. The program is useful for integrating a set of measured values from an experiment.

$$I = \int_{x}^{x + nh} f(x)\, dx = h/3 \left[(Y_0 + Y_n) + 4 (Y_1 + Y_3 + ..Y_{n-1}) + 2 (Y_2 + Y_4 + ..Y_{n-2}) \right]$$

where $Y = f(x)$

The area to be integrated is divided into an even (n) number of slices of width h. These will be n + 1 pairs of x, y values from x_0, y_0 to x_n, y_n. The operation of the program is simple. As the points are keyed in according to the instructions on the coding sheets, the printer will print x_2 and the value of the integral to this point. The final tabulation will be the pairs of values (x_2, I_2); ... (x_n, I_n) where the x value serves for identification only. Thus the integration may be stopped at any such point.

Example:

Data

	X	Y
	0	2.
	.25	2.8125
	.50	3.75
	.75	4.8125
h = .25	1.00	6.
(n = 8)	1.25	7.3125
	1.50	8.75
	1.75	10.3125
	2.0	12.

Results

A = 12.66666678

The data was chosen from

$Y = 2 + 3x + x^2$

Exact area calculated from

$\int_0^2 f(x)dx$ is 12 2/3

This, of course, should give exact results since the function is a parabola.

LOCI Program **Date:** 12-20-66 L61-67

NUMERICAL INTEGRATION

Bowdle/Martin

$\int_{x}^{x+nh} f(x)dx$ by Simpson's Rule

$I = \frac{h}{3}\left[(Y_0 + Y_n) + 4(Y_1 \quad Y_3 \quad Y_5 + \text{------} Y_{n-1}) + 2(Y_2 \quad Y_4 \quad Y_6 + \text{----} Y_{n-2})\right]$ where $Y = f(x)$

1) Enter h
2) P_o
3) Enter Y_o
4) Run
5) Enter Y_{odd}
6) Run
7) Enter X_{even}
8) Run
9) Enter Y_{even}
10) Run
11) Step 5 ⟶ 10

Auto-Disp Down

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	x	12	Enter h	20	W⟶S_3	56		40				60			
1	3	23		21	x	12		41				61			
2	÷	17		22	2	22		42				62			
3	LN^{-1}	14		23	x	12		43				63			
4	W⟶S_1	52		24	Cl A	03		44				64			
05	Stop	37	Enter Y_o	25	S_2⟶W	55		45				65			
6	W⟶S_2	54		26	+	13		46				66			
7	Stop	37	Enter Y_{odd}	27	LN^{-1}	14		47				67			
8	x	12		28	+	13		48				68			
9	4	24		29	W⟶S_2	54		49				69			
10	x	12		30	S_3⟶W	57		50				70			
11	Cl A	03		31	-	15		51				71			
12	S_2⟶W	55		32	x	12		52				72			
13	+	13		33	S_1⟶W	53	h/3	53				73			
14	LN^{-1}	14		34	x	12		54				74			
15	+	13		35	LN^{-1}	14		55				75			
16	W⟶S_2	544		36	Write	11	I	56				76			
17	Stop	37		37	0	20		57				77			
18	Write	11		38	7	27		58				78			
19	Stop	37	Enter Y_{even}	39	W⟶PC	40		59				79			

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LOCI User Application Letter #5 L64-67

Parabolic Regression
($\ln y = a + bx + cx^2$)

by

C. Colbert, Investigator
Jan Spruit, Research Assistant
Fels Research Institute

1. Normally, one has a set of data points (x,y) to which a parabola is to be fit.
2. In our case we fit a parabola to data points (x, ln y).
3. In case it is desired to fit a parabola to data points (x, y), Program Card 17-1 must be modified by blanking out steps 44 and 45.
4. In our application we make a first parabolic fit of (x, ln y) where the data points are referred to an arbitrarily chosen y-baseline. This computation gives us a print out of coefficients a, b and c for the parabola $\ln y = a + bx + cx^2$. We then alter all y-values by an equal increment (D_o) and perform a second fit to obtain a new set of coefficients a, b and c. Our objective is to find that increment of D_o which must be applied to the y-values in order to linearize the parabola (i.e., to make c vanish).
5. The iterative computations produce a tabular print out of values of D_o, a, b and c which described the family of successive parabolas.
6. The user of our program may not need to shift the y-baseline, in which case he can replace the STOP code in step 14 of Card 17-1 by the code 20 (the number zero). This user will not be repeating the computation as in our application.

We usually enter the data points (x, y) on tape. These are followed on tape by a part of the program. Alternatively, this part of the program may be provided via punch cards (cards 17A-1 and 17A-2). If this part of the program is on tape, we can leave cards 17-1 and 17-2 in the readers, and the only manual operations are: P_o - Enter D_o - RUN - Enter new D_o - RUN - etc. until the coefficient 'c' vanishes. Details are given on page 3 of the attached PROGRAM DESCRIPTION.

With four cards, the program requires the change from cards 17-1 and 17-2 to 17A-1 and 17A-2. After each iteration, cards 17-1 and 17-2 are agian inserted. Even with the time required to change cards, the program time is slightly shorter than when part of the program is on tape.

LOCI User Application Letter #5 L64-67

PROGRAM DESCRIPTION

Multiple Linear Regression for Parabolic Equation

$\ln y = a + bx + cx^2$

1. Calculate:

$\Sigma y \quad \Sigma x \quad \Sigma x^4$

$\Sigma y^2 \quad \Sigma x^2 \quad \Sigma x^2 y$

$\Sigma xy \quad \Sigma x^3$

2. Calculate:

$S(x^2) = \Sigma x^2 - (\Sigma x)^2/N$

$S(x^4) = \Sigma x^4 - (\Sigma x^2)^2/N$

$S(x^3) = \Sigma x^3 - (\Sigma x)(\Sigma x^2)/N$

$S(xy) = \Sigma xy - (\Sigma x)(\Sigma y)/N$

$S(x^2y) = \Sigma x^2 y - (\Sigma x^2)(\Sigma y)/N$

3. Calculate:

$D = S(x^2)\, S(x^4) - \left[S(x^3)\right]^2$

$e11 = S(x^4)/D$

$e22 = S(x^2)/D$

$e12 = -S(x^3)/D$

4. Calculate:

$b = e11\, S(xy) + e12\, S(x^2y)$

$c = e12\, S(xy) + e22\, S(x^2y)$

$a = \Sigma y/N - b\,\Sigma x/N - c\,\Sigma x^2/N$

In order to change the parabola $\ln y = a + bx + cx^2$ to a straight line $\ln y = a + bx$, the program is repeated with altered y-values until c vanishes. The program is set up for teletype print out of the values for D_o (the increment is added to or subtracted from the original y-values) b, c and a. When no teletype is available, the "WRITE" commands should be changed to "STOP" commands, or else additional commands to store these values should be inserted in the program. The steps requiring change are step 16 on card 17-1, and steps 09, 27 and 58 on card 17A-2

PROGRAM DESCRIPTION (Con't)

Using Two Cards (17-1 and 17-2) and
Data and Program Tape

Changing of cards 17-1 and 17-2 to 17A-1 and 17A-2 and vice versa when performing the iterations can be avoided by putting the program from cards 17A-1 and 17A-2 on the tape following the data portion. The end of the data portion should then read: B-26-A-RUN-followed by steps 9 through 79 shown on card 17A-1 and steps 00 through 59 shown on card 17A-2

Following steps 17, 49 and 74 shown on card 17A-1, and steps 28 and 33 shown on card 17A-2, the small subroutine steps 03 through 06 shown on card 17A-1 should be repeated on the tape in this case.

Step 59 shown on card 17A-2 should be replaced by "P" on the tape which will bring the LOCI back to step 00 on card 17-1 and prepare the LOCI for the next D_o Entry. The procedure then becomes:

1. P_o to start
2. Enter D_o and RUN
3. Repeat 2 for different D_o-values until c vanishes.

2nd Order Regression

$$Y = a + bx + cx^2$$

Because of the wide application of second order regression analysis, we have modified the parabolic regression program as suggested by Messers. Colbert and Spruit.

Two examples appear below. The operationing instructions appear on the program sheets. Two sets of cards (4 cards) are used.

Example 1

	Data		Results
	X	Y	
	0	2.	b = 3.000000140
	.25	2.1825	
	.50	3.75	c = .9999998500
N = 9	.75	4.8125	
	1.00	6.	a = 2.000000076
	1.25	7.3125	
	1.50	8.75	The data was chosen from
	1.75	10.3125	
	2.00	12.	$Y = 2 + 3x + x^2$

Example 2

	Data		Results
	X	Y	
	0	5	b = 2.000000380
	1	7	
	2	9	c = -.0000000570
N = 5	3	11	
	4	13	a = 4.999999585
			The data was chosen from
			Y = 5 + 2x

LOCI Program 17-1 L64-67 **Date:** 3 May 1967

Multiple Linear Regression Line for Parabolic Equation
$ln\ y = a + bx + cx^2$ for changing values of y

Notes:

1. Teletype format code 264 will permit output in four columns:

   D_o b c a

2. Sequences 5 through 13 are for manual keyboard entry of the data points. To enter data from tape, see sequence at top of Program Sheet 17-2.

3. After all y values, a double RUN command is required.

1. AUTO DISP UP
2. Insert cards 17-1 and 17-2
3. P_o to start
4. Enter D_o and RUN
5. Enter x_o and RUN (see note 2)
6. Enter y_o and RUN-RUN (see note 3)
7. Repeat 5 and 6 for all x and y values
8. After last y and RUN-RUN enter number of x-y combinations
9. W-DC (manual position; operation code switches on 42 and RUN)
10. Key in "26"
11. W-PC (manual position; operation code switches on 41 and RUN)
12. Insert cards 17A-1 and 17A-2
13. P_o

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	PRM	36		20	STORE	64		40	W-PC	40		60	$A-S_o$	50	Σx^4
1	$A-S_o$	50		21	MSC	10		41	READ	76	y : :	61	PRM	36	
2	$W-S_3$	56		22	MSC	10		42	+	13		62	S_2-W	55	x^2
3	MSC	10		23	MSC	10		43	A-W	45	$y + D_o$	63	x	12	
4	$A-S_o$	50		24	S_1-W	53	D_o	44	x	12		64	S_1-W	53	x
05	$W-S_1$	52		25	W-A	44		45	L-W	47	$ln\ (y + D_o)$	65	x	12	
6	$W-S_2$	54		26	CLW	02		46	READ	76	x :	66	LN^{-1}	14	x^3
7	$W-S_3$	56		27	MSC	10		47	$W-S_1$	52	$x\ ln\ y$	67	+	13	
8	MSC	10		28	MSC	10		48	S_o-A	51	$\Sigma x \Sigma\ ln\ y$	68	MSC	10	
9	$A-S_o$	50		29	4	24		49	+	13		69	S_1-W	53	Σx^3
10	$W-S_3$	56		30	1	21		50	$A-S_o$	50	$\Sigma x \Sigma\ ln\ y$	70	+	13	
11	MSC	10		31	STORE	64		51	▭	06		71	A-W	45	
12	$A-S_o$	50		32	PRM	36		52	LN^{-1}	14	$x^2\ \Sigma\ ln\ y^2$	72	$W-S_1$	52	Σx^3
13	$W-S_1$	52		33	S_2-W	55	x^2	53	$W-S_2$	54	$x^2\ \Sigma\ ln\ y^2$	73	PRM	36	
14	STOP	37	D_o :	34	▭	06		54	W-A	44		74	S_1-W	53	x
15	$W-S_1$	52	D_o	35	LN^{-1}	14	x^4	55	S_3-W	57	$\Sigma x^2\ \Sigma\ ln\ y^2$	75	x	12	
16	WRITE	11	D_o	36	MSC	10		56	+	13		76	MSC	10	
17	PRM	36		37	S_o-A	51	Σx^4	57	A-W	45		77	MSC	10	
18	4	24		38	+	13		58	$W-S_3$	56	$\Sigma x^2\ \Sigma\ ln\ y^2$	78	S_1-W	53	$ln\ y$
19	6	26		39	6	26		59	RESTORE	65		79	x	12	$x\ ln\ y$

LOCI Program 17-2 L64-67 **Date:** 3 May 1967

	0	4	8	12
S_o	Σ	Σx^4	$\Sigma\ ln\ (y + D_o)$	
S_1	x	Σx^3	$ln\ (y + D_o)$	D_o
S_2	x^2	Σxy	$ln\ (y + D_o)^2$	
S_3	Σx^2	$\Sigma x^2 y$	$\Sigma\ ln\ (y + D_o)^2$	

Note 1: After all y-values, a double run command is required.

Alternate Method of Entering Data (when teletype is available)

1. Make a tape: CTL x-x_o-RUN-y_o-RUN-RUN (see Note 1)-x_1-RUN-y_1-RUN-RUN-etc.-RUN-y_n-RUN-RUN-number of x-y combinations-B-26-A-RUN-STOP. Make tape in a loop.
2. AUTO DISP UP
3. Insert cards 17-1 and 17-2
4. P_o to start
5. Enter D_o and RUN
6. Tape will enter the data and the commands as outlined in steps 5 through 13 on the program sheet 17-1
7. Insert cards 17A-1 and 17A-2
8. P_o

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	CLW	02		20	+	13		40	S_3-W	57	Σx^2	60	+	13	
1	MSC	10		21	A-W	45		41	□	06	$(\Sigma x^2)^2$	61	LN^{-1}	14	
2	S_2-W	55	$\Sigma x\ ln\ y$	22	W-S_3	56	$\Sigma x^2\ ln\ y$	42	DC-W	43	N	62	-	15	
3	W-A	44		23	1	21		43	÷	17		63	A-W	45	S (x^3)
4	LN^{-1}	14		24	7	27		44	MSC	10		64	W-S_1	52	
05	+	13		25	W-PC	40		45	S_o-A	51	Σx^4	65	MSC	10	
6	A-W	45		26	PRM	36		46	LN^{-1}	14		66	S_o-A	51	$\Sigma\ ln\ y$
7	W-S_2	54	$\Sigma x\ ln\ y$	27	S_o-A	51	Σx	47	-	15		67	A-W	45	
8	PRM	36		28	A-W	45		48	A-S_o	50	S (x^4)	68	x	12	
9	S_2-W	55	x^2	29	□	06	$(\Sigma x)^2$	49	PRM	36		69	CLW	02	
10	x	12		30	CLA	03		50	S_o-A	51	Σx	70	S_o-A	51	Σx
11	MSC	10		31	DC-W	43	N	51	A-W	45		71	A-W	45	
12	MSC	10		32	÷	17	$(\Sigma x^2)/N$	52	x	12		72	CLA	03	
13	S_1-W	53	$ln\ y$	33	S_3-W	57	Σx^2	53	S_3-W	57	Σx^2	73	x	12	
14	x	12	$x^2\ ln\ y$	34	+	13		54	x	12		74	DC-W	43	N
15	CLW	02		35	LN^{-1}	14	$(\Sigma x)^2/N$	55	DC-W	43	N	75	÷	17	$(\Sigma x)(\Sigma y)/N$
16	MSC	10		36	-	15		56	÷	17	$(\Sigma x)(\Sigma x^2)/N$	76	MSC	10	
17	S_3-W	57	$\Sigma x^2\ ln\ y$	37	A-W	45	S (x^2)	57	CLA	03		77	S_2-W	55	$\Sigma x\ ln\ y$
18	+	13		38	W-S_2	54		58	MSC	10		78	+	13	
19	LN^{-1}	14		39	CLA	03		59	S_1-W	53	Σx^3	79	READ	76	

LOCI Program 17A-1 L64-67 Date: 3 May 1967

	0	4	8	12
S_o		e_{11}		b
S_1	c	e_{12}		
S_2	e_{22}	S (xy)		
S_3		S (x^2y)		

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	0	20		20	CLA	03		40	x	12		60	CLW	02	
1	9	31		21	DC-W	43	N	41	CLA	03		61	S_1-W	53	D
2	STORE	64		22	÷	17	$(\Sigma x^2)(\Sigma ln y)/N$	42	S_2-W	55	S (x^2)	62	÷	17	
3	MS	10		23	MS	10		43	x	12		63	LN^{-1}	14	S (x^3)D=e_{12}
4	S_o-A	51		24	S_3-W	57	Σx^2 ln y	44	LN^{-1}	14	S(x^2)S(x^4)	64	±	33	$-e_{12}$
05	A-W	45		25	+	13		45	+	13		65	MS	10	
6	x	12		26	LN^{-1}	14		46	S_1-W	53	S (x^3)^2	66	W-S_1	52	$-e_{12}$
7	RESTORE	65		27	-	15		47	-	15		67	CLW	02	
8	P_1	61		28	A-W	45	S (x^2y)	48	A-W	45	D	68	S_2-W	55	S (x^2)
9	LN^{-1}	14	$(\Sigma x)(\Sigma ln y)/N$	29	W-S_3	56		49	W-S_1	52		69	x	12	
10	-	15		30	CLW	02		50	RESTORE	65		70	S_1-W	53	D
11	A-W	45	S (xy)	31	CLA	03		51	CLW	02		71	÷	17	
12	W-S_2	54		32	MS	10		52	S_1-W	53	D	72	LN^{-1}	14	S(x^2)/D=e_{22}
13	CLW	02		33	S_1-W	53	S (x^3)	53	÷	17		73	W-S_2	54	e_{22}
14	CLA	03		34	□	06	S (x^3)^2	54	LN^{-1}	14	e_{11}	74	RESTORE	65	
15	S_3-W	57	Σx^2	35	S_o-A	51	S (x^4)	55	MS	10		75	S_2-W	55	S (xy)
16	x	12		36	CLW	02		56	W-A	44		76	x	12	
17	MS	10		37	LN^{-1}	14	S (x^3)^2	57	A-S_o	50	e_{11}	77	LN^{-1}	14	
18	RESTORE	65		38	W-S_1	52		58	S_1-W	53	S (x^3)	78	W-A	44	e_{11}
19	CLW	02		39	A-W	45	S (x^4)	59	x	12		79	S_1-W	53	$-e_{12}$

LOCI Program 17A-2 L64-67 **Date:** 3 May 1967

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	x	12		20	CLW	02		40	÷	17		60			
1	S_3-W	57	S (x^2y)	21	S_2-W	55	e_{22}	41	LN^{-1}	14	b $\Sigma x/N$	61			
2	x	12		22	x	12		42	W-A	44		62			
3	LN^{-1}	14	$-e_{12}$ S (x^2y)	23	LN^{-1}	14	e_{22} S (x^2y)	43	A-S_o	50		63			
4	+	13		24	+	13		44	S_1-W	53	c	64			
05	A-W	45	b	25	A-W	45	c	45	x	12		65			
6	MS	10		26	W-S_1	52		46	S_3-W	57	Σx^2	66			
7	MS	10		27	WRITE	11	c	47	x	12		67			
8	A-S_o	50		28	MS	10		48	DC-W	43	N	68			
9	WRITE	11	b	29	RESTORE	65		49	÷	17		69			
10	CLW	02		30	DC-W	43	N	50	LN^{-1}	14	c $\Sigma x^2/N$	70			
11	MS	10		31	÷	17		51	+	13		71			
12	S_1-W	53	$-e_{12}$	32	LN^{-1}	14	Σ *ln* y/N	52	MS	10		72			
13	x	12		33	W-S_2	54		53	MS	10		73			
14	S_2-W	55	S (xy)	34	RESTORE	65		54	S_2-W	55	Σ *ln* y/N	74			
15	x	12		35	CLW	02		55	-	15		75			
16	LN^{-1}	14	e_{12} S (xy)	36	S_o-A	51	Σx	56	A-W	45	-a	76			
17	W-A	44		37	A-W	45		57	±	33	a	77			
18	S_3-W	57	S (x^2y)	38	x	12		58	WRITE	11		78			
19	x	12		39	DC-W	43	N	59	STOP	37		79			

2ND ORDER REGRESSION

$$y = a + bx + cx^2$$

DATA

X	Y
x_1	y_1
x_2	y_2
x_3	y_3
x_4	y_4
⋮	⋮
x_n	y_n

1. AUTO DISP UP
2. Insert cards 17-1 and 17-2
3. P_0 to start
4. Key X and RUN
5. Key y and RUN-RUN
6. Repeat 4 and 5 for all x and y values
7. After last y entry key in number of x-y combinations
8. MANUAL SWITCH POSITION
   a) Operation code switches on 42 and RUN
   b) Key in "26"
   c) Operation code switches on 41 and RUN
9. AUTO SWITCH POSITION and RUN
10. Insert cards 17A-1 and 17A-2
11. P_0 Read b
12. RUN Read c
13. RUN Read a

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	PRM	36		20	STORE	64		40	8	30		60	S_2-W	55	x^2
1	A-S_0	50		21	MSC	10		41	W-PC	40		61	x	12	
2	W-S_3	56		22	MSC	10		42	STOP	37		62	S_1-W	53	x
3	MSC	10		23	MSC	10		43				63	x	12	
4	A-S_0	50		24	S_1-W	53		44	STOP	37		64	LN^{-1}	14	x^3
05	W-S_1	52		25	W-A	44		45	W-S_1	52		65	+	13	
6	W-S_2	54		26	CLW	02		46	S_0-A	51		66	MSC	10	
7	W-S_3	56		27	MSC	10		47	+	13		67	S_1-W	53	Σx^3
8	MSC	10		28	MSC	10		48	A-S_0	50		68	+	13	
9	A-S_0	50		29	4	24		49	□	06		69	A-W	45	
10	W-S_3	56		30	2	22		50	LN^{-1}	14		70	W-S_1	52	Σx^3
11	MSC	10		31	STORE	64		51	W-S_2	54		71	PRM	36	
12	A-S_0	50		32	PRM	36		52	W-A	44		72	S_1-W	53	x
13	W-S_1	52		33	S_2-W	55	x^2	53	S_3-W	57		73	x	12	
14				34	□	06		54	+	13		74	MSC	10	
15				35	LN^{-1}	14	x^4	55	A-W	45		75	MSC	10	
16				36	MSC	10		56	W-S_3	56		76	S_1-W	53	
17	PRM	36		37	S_0-A	51	Σx^4	57	RESTORE	65		77	x	12	
18	4	24		38	+	13		58	A-S_0	50		78			
19	4	24		39	5	25		59	PRINT	36		79			

	0	4	8	12
S_0		e_{11}		b
S_1	c	e_{12}		
S_2	e_{22}	S (xy)		
S_3		S (x^2y)		

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	0	20		20	CLA	03		40	x	12		60	CLW	02	
1	9	31		21	DC-W	43	N	41	CLA	03		61	S_1-W	53	D
2	STORE	64		22	÷	17	$(\Sigma x^2)(\Sigma y)/N$	42	S_2-W	55	S (x^2)	62	÷	17	
3	MS	10		23	MS	10		43	x	12		63	LN^{-1}	14	S (x^3)D=e_{12}
4	S_0-A	51		24	S_3-W	57	Σx^2 y	44	LN^{-1}	14	S(x^2)S(x^4)	64	±	33	-e_{12}
05	A-W	45		25	+	13		45	+	13		65	MS	10	
6	x	12		26	LN^{-1}	14		46	S_1-W	53	S $(x^3)^2$	66	W-S_1	52	-e_{12}
7	RESTORE	65		27	-	15		47	-	15		67	CLW	02	
8	P_1	61		28	A-W	45	S (x^2y)	48	A-W	45	D	68	S_2-W	55	S (x^2)
9	LN^{-1}	14	$(\Sigma x)(\Sigma y)$	29	W-S_3	56		49	W-S_1	52		69	x	12	
10	-	15		30	CLW	02		50	RESTORE	65		70	S_1-W	53	D
11	A-W	45	S (xy)	31	CLA	03		51	CLW	02		71	÷	17	
12	W-S_2	54		32	MS	10		52	S_1-W	53	D	72	LN^{-1}	14	S(x^2)/D=e_{22}
13	CLW	02		33	S_1-W	53	S (x^3)	53	÷	17		73	W-S_2	54	e_{22}
14	CLA	03		34	□	06	S $(x^3)^2$	54	LN^{-1}	14	e_{11}	74	RESTORE	65	
15	S_3-W	57	Σx^2	35	S_0-A	51	S (x^4)	55	MS	10		75	S_2-W	55	S (xy)
16	x	12		36	CLW	02		56	W-A	44		76	x	12	
17	MS	10		37	LN^{-1}	14	S $(x^3)^2$	57	A-S_0	50	e_{11}	77	LN^{-1}	14	
18	RESTORE	65		38	W-S_1	52		58	S_1-W	53	S (x^3)	78	W-A	44	e_{11}
19	CLW	02		39	A-W	45	S (x^4)	59	x	12		79	S_1-W	53	-e_{12}

	0	4	8	12
S_0	Σ	Σx^4	Σy	
S_1	x	Σx^3	y	
S_2	x^2	Σxy	y^2	
S_3	Σx^2	$\Sigma x^2 y$	Σy^2	

Note 1: After all y-values, a double run command is required.

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	CLW	02		20	+	13		40	S_3-W	57	Σx^2	60	+	13	
1	MSC	10		21	A-W	45		41	□	06	$(\Sigma x^2)^2$	61	LN^{-1}	14	
2	S_2-W	55	$\Sigma x \ ln\ y$	22	W-S_3	56	Σx^2 y	42	DC-W	43	N	62	-	15	
3	W-A	44		23	1	21		43	÷	17		63	A-W	45	S (x^3)
4	LN^{-1}	14		24	7	27		44	MSC	10		64	W-S_1	52	
05	+	13		25	W-PC	40		45	S_0-A	51	Σx^4	65	MSC	10	
6	A-W	45		26	PRM	36		46	LN^{-1}	14		66	S_0-A	51	Σ y
7	W-S_2	54	Σx y	27	S_0-A	51	Σx	47	-	15		67	A-W	45	
8	PRM	36		28	A-W	45		48	A-S_0	50	S (x^4)	68	x	12	
9	S_2-W	55	x^2	29	□	06	$(\Sigma x)^2$	49	PRM	36		69	CLW	02	
10	x	12		30	CLA	03		50	S_0-A	51	Σx	70	S_0-A	51	Σx
11	MSC	10		31	DC-W	43	N	51	A-W	45		71	A-W	45	
12	MSC	10		32	÷	17	$(\Sigma x^2)/N$	52	x	12		72	CLA	03	
13	S_1-W	53	y	33	S_3-W	57	Σx^2	53	S_3-W	57	Σx^2	73	x	12	
14	x	12	x^2 y	34	+	13		54	x	12		74	DC-W	43	N
15	CLW	02		35	LN^{-1}	14	$(\Sigma x)^2/N$	55	DC-W	43	N	75	÷	17	$(\Sigma x)(\Sigma y)/N$
16	MSC	10		36	-	15		56	÷	17	$(\Sigma x)(\Sigma x^2)/N$	76	MSC	10	
17	S_3-W	57	Σx^2 y	37	A-W	45	S (x^2)	57	CLA	03		77	S_2-W	55	Σx y
18	+	13		38	W-S_2	54		58	MSC	10		78	+	13	
19	LN^{-1}	14		39	CLA	03		59	S_1-W	53	Σx^3	79	STOP	37	

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No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	x	12		20	CLW	02		40	÷	17		60			
1	S_3-W	57	S (x^2y)	21	S_2-W	55	e_{22}	41	LN^{-1}	14	b $\Sigma x/N$	61			
2	x	12		22	x	12		42	W-A	44		62			
3	LN^{-1}	14	$-e_{12}$ S (x^2y)	23	LN^{-1}	14	e_{22} S (x^2y)	43	A-S_0	50		63			
4	+	13		24	÷	13		44	S_1-W	53	c	64			
05	A-W	45	b	25	A-W	45	c	45	x	12		65			
6	MS	10		26	W-S_1	52		46	S_3-W	57	Σx^2	66			
7	MS	10		27	STOP	37	c	47	x	12		67			
8	A-S_0	50		28	MS	10		48	DC-W	43	N	68			
9	STOP	37	b	29	RESTORE	65		49	÷	17		69			
10	CLW	02		30	DC-W	43	N	50	LN^{-1}	14	c $\Sigma x^2/N$	70			
11	MS	10		31	÷	17		51	+	13		71			
12	S_1-W	53	$-e_{12}$	32	LN^{-1}	14	$\Sigma y/N$	52	MS	10		72			
13	x	12		33	W-S_2	54		53	MS	10		73			
14	S_2-W	55	S (xy)	34	RESTORE	65		54	S_2-W	55	$\Sigma y/N$	74			
15	x	12		35	CLW	02		55	-	15		75			
16	LN^{-1}	14	e_{12} S (xy)	36	S_0-A	51	Σx	56	A-W	45	-a	76			
17	W-A	44		37	A-W	45		57	±	33	a	77			
18	S_3-W	57	S (x^2y)	38	x	12		58				78			
19	x	12		39	DC-W	43	N	59	STOP	37		79			

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