

TITLE: Double Precision Sum of Squares or Products Subroutine

AUTHOR: Richard A. Lamm

ABSTRACT:

This program computes the sum of products of deviations of X and Y about their means. The computations are performed with double precision fixed point arithmetic.

DISCLAIMER:

"The authors of this program material, the POOL organization and Royal McBee believe this program to be correct; however, they bear no responsibility, financial or otherwise, for errors resulting from its use. This program is distributed only to individual and installation members of POOL. Further distribution of this manual and accompanying tapes for use by non-members is prohibited."

FOR POOL MEMBERS ONLY

1. **Title:** Double Precision Sum of Squares or Products Subroutine
Author: Richard A. Lamm
Date: October 9, 1959
Installation: Lederle Laboratories, Pearl River, New York
Classification: F

2. **Purpose:** To compute the sum of products of deviations of X and Y about their means using the formula:

$$\text{Sum of Products} = \sum XY - (\sum X \sum Y)/n$$

Computations are performed with double precision fixed point arithmetic. Sums of squares are obtained as the special case in which $Y = X$.

3. **Restrictions:**

- a. All data (coded) must be entered at $q = 30$. The X's must be stored sequentially, beginning in $Lo(X)$, and the Y's must be stored sequentially starting in $Lo(Y)$.
- b. All data (coded) must be non-negative if a sum of products is to be generated. If only sums of squares are to be generated the data need not be non-negative.
- c. Data coding, when practical, should be such that the majority of the data words are four decimal digits in length. This recommendation is contingent upon the anticipated degree of variation.
- d. $\sum X, \sum Y \leq 2^{30} - 1$.
- e. In general, the absolute value of the resulting sum of products must be less than $2^{30} - 1$ to be of utility. This restriction is not applicable if the program using this subroutine contains double precision arithmetic.
- f. The double precision word structure is shown on the flow chart. H refers to the most significant part of the word, L to the least significant part.
- g. No external storage is required for this routine.
- h. All constants and intermediate and final results are stored in $Lo + 0236$ to $Lo + 0263$. The resultant sum of products is designated by Db (D**H**b and D**L**b).

4. **Method:** The sum of products is obtained from the standard formula:

$$\text{Sum of Products} = \sum XY - (\sum X \sum Y)/n$$

The double precision word is held in two storages such that the 29 least significant bits are in one word and the remaining most significant bits are in the second

word. In this way, the 30th position of the most significant part coincides with the first position of the least significant part. This is shown in the word structure on the flow chart.

5. Coding Information:

a. Storage. Three tracks of memory for the program, constants and temporary storage.

b. Calling Sequence.

<u>Location</u>	<u>Order</u>	<u>Address</u>
α	R	Lo
$\alpha + 1$	U	Lo
$\alpha + 2$	M	Lo(X)
$\alpha + 3$	M	Lo(Y)
$\alpha + 4$	Z	n at q = 29
$\alpha + 5$	Z or U	xxxx
$\alpha + 6$	etc.	with Sum of Prod. in acc.

$\alpha + 5$ should contain an error halt (Zxxxx) if no provision is made for double precision arithmetic or a Uxxxx to the double precision arithmetic. An exit to $\alpha + 5$ indicates that the Sum of Products is greater than $2^{30} - 1$.

c. Input. Data must be pre-stored in Lo(X) et seq. and in Lo(Y) et seq.

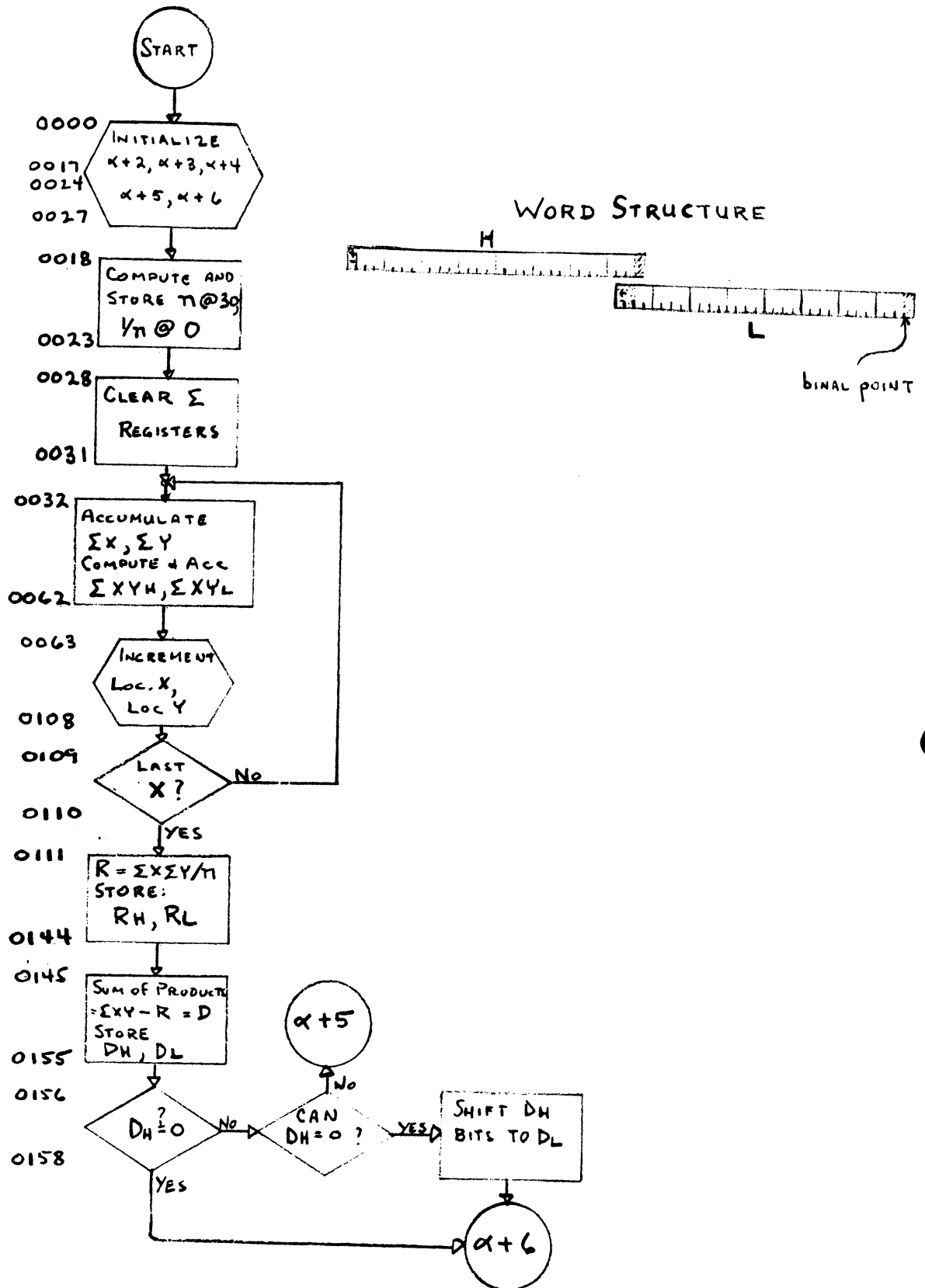
d. Output. If exit is by $\alpha + 6$ the Sum of Products is in the accumulator at q = 30. If exit is by $\alpha + 5$ DHb and DLb are stored in Lo + 0261 and Lo + 0262 respectively.

e. Timing. Approximately $2 + 0.5n$ seconds.

f. Program Stops.

<u>Lo +</u>	<u>Reason</u>	<u>Action</u>
0033	$\sum X \geq 2^{30}$	Recode X's
0036	$\sum Y \geq 2^{30}$	Recode Y's
0042	$\sum XY \geq 2^{59}$	Recode X's and/or Y's

FLOW CHART



LGP-30 CODING SHEET

PREPARED FOR: LGP-30, RPC-4000 Users' Organization - POOL			PAGE OF 1 / 6
JOB NO.	PROGRAM NO. F1-164	PROGRAM PREPARED BY: R.A.LAMM	PROGRAM CHECKED BY: R.A.L.
PROBLEM: DOUBLE PRECISION SUM OF SQUARES OR PRODUCTS			DATE 10/9/59
			TRACK 00

PROGRAM INPUT CODES	STOR	LOCATION	INSTRUCTION		STOR	CONTENTS OF ADDRESS	NOTES
			OPERATION	ADDRESS			
		<input checked="" type="checkbox"/>					CALL. SEQ.
		0000	B	$\alpha + 2$			α R L ₀
		001	Y	0044			$\alpha + 1$ U L ₀
		002	Y	0038			$\alpha + 2$ M L(x)
		003	Y	0032	<input checked="" type="checkbox"/>		$\alpha + 3$ M L(y)
		004	B	0000			$\alpha + 4$ n@29
		005	H	0015			$\alpha + 5$ Z α U
		006	A	0241		1@29	etc.
		007	Y	0024	<input checked="" type="checkbox"/>	B[$\alpha + 3$]	
		008	A	0241		1@29	
		009	Y	0018		B[$\alpha + 4$]	
		100	Y	0016		A[$\alpha + 4$]	
		101	A	0241	<input checked="" type="checkbox"/>	1@29	
		102	Y	0240		U[$\alpha + 5$]	
		103	A	0241		1@29	
		104	Y	0235		U[$\alpha + 6$]	
		105	B	[$\alpha + 2$]	<input checked="" type="checkbox"/>	L ₀ (x)	
		106	A	[$\alpha + 4$]		n@29	
		107	Y	0245			TEST FOR EXIT OF LOOP
		108	B	[$\alpha + 4$]		n@29	
		109	M	0244	<input checked="" type="checkbox"/>	1@1	
		200	C	0253		n@30	
		201	B	C0255		1@30	
		202	D	0253			
		203	C	0259	<input checked="" type="checkbox"/>	n@0	
		204	B	[$\alpha + 3$]			
		205	Y	0035			
		206	Y	0045			
		207	C	0039	<input checked="" type="checkbox"/>		
		208	C	0238		Σ XYL	} SET $\Sigma = 0$
		209	C	0248		Σ XYH	
		300	C	0252		Σ Y	
		301	C	0249	<input checked="" type="checkbox"/>	Σ X	

LGP-30 CODING SHEET

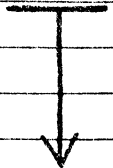
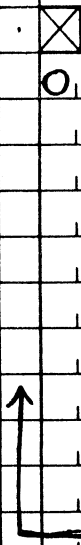
PREPARED FOR: LGP-30, RPC-4000 Users' Organization - POOL			PAGE OF 2 / 6
JOB NO.	PROGRAM NO. F1-164	PROGRAM PREPARED BY: R.A.L.	PROGRAM CHECKED BY: POOL Review
PROBLEM: DOUBLE PRECISION SUM OF SQUARES OR PRODUCTS			DATE 10-9-59
			TRACK 00

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION		STOP	CONTENTS OF ADDRESS	NOTES
			OPERATION	ADDRESS			
		0,0,3,2	B	L(x)			
		3,3	A	0,2,4,9			
		3,4	C	0,2,4,9		ΣX	
		3,5	B	L(y)	☒		
		3,6	A	0,2,5,2			
		3,7	C	0,2,5,2		ΣY	
		3,8	B	L(x)			
		3,9	M	L(y)	☒		
		4,0	N	0,2,5,5		1@30	
		4,1	E	0,2,5,6		WWWWWW	
		4,2	A	0,2,4,8			
		4,3	C	0,2,4,8	☒	ΣXYH	
		4,4	B	L(x)			
		4,5	N	L(y)			
		4,6	M	0,2,4,4		1@1	
		4,7	H	0,2,3,9	☒		TEMP STORAGE I
		4,8	E	0,2,6,3		3WWWWWWQ	
		4,9	A	0,2,3,8		ΣXYL	
		5,0	H	0,2,4,3			TEMP STORAGE II
		5,1	E	0,2,6,3	☒	3WWWWWWQ	
		5,2	C	0,2,3,8		ΣXYL	
		5,3	B	0,2,3,9			T.S.I
		5,4	E	0,2,4,4		1@1	
		5,5	M	0,2,4,1	☒	1@29	
		5,6	C	0,2,3,9			T.S.I
		5,7	B	0,2,4,3			T.S.II
		5,8	E	0,2,4,4		1@1	
		5,9	M	0,2,4,1	☒	1@29	
		6,0	A	0,2,3,9			T.S.I
		6,1	A	0,2,4,8			
		6,2	C	0,2,4,8		ΣXYH	
		6,3	E	0,0,3,5	☒		

LGP-30 CODING SHEET

PREPARED FOR: LGP-30, RPC-4000 Users' Organization - POOL				PAGE 3 / 6
JOB NO.	PROGRAM NO. F1-164	PROGRAM PREPARED BY: R. A. L.	PROGRAM CHECKED BY: POOL Review	DATE 10-9-59
PROBLEM: DOUBLE PRECISION SUM OF SQUARES OR PRODUCTS				TRACK 01

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION		STOP	CONTENTS OF ADDRESS	NOTES
			OPERATION	ADDRESS			
		0100	A	0241		1@29	
		01	Y	0035			
		02	Y	0045			
		03	Y	0039			
		04	B	0032			
		05	A	0241		1@29	
		06	Y	0032			
		07	Y	0038			
		08	Y	0044			
		09	S	0245		B[L(x _n +1)]	
		10	T	0032			
		11	B	0249		ΣX	
		12	N	0252		ΣY	
		13	M	0244		1@1	
		14	E	0242		7WWWWWG	
		15	M	0259		Y _n @0	
		16	C	0250		RL	
		17	B	0249		ΣX	
		18	M	0252		ΣY	
		19	N	0255		1@30	
		20	H	0243		TEMP STORE	
		21	M	0259		Y _n @0	
		22	C	0251		RH	
		23	S	0251		"	
		24	N	0253		n@30	
		25	M	0244		1@1	
		26	A	0243		TEMP STORAGE	
		27	S	0253		n@30	
		28	T	0257			
		29	C	0243		TEMP. STORAGE	
		30	B	0251		RH	
		31	A	0255		1@30	



COMPUTE
R
= ΣXY/n

LGP-30 CODING SHEET

PREPARED FOR: LGP-30, RPC-4000 Users' Organization - POOL			PAGE OF 4 / 6
JOB NO.	PROGRAM NO. FL-164	PROGRAM PREPARED BY R.A.L.	PROGRAM CHECKED BY. POOL Review
PROBLEM: DPSOSOP			DATE 10-9-59
			TRACK 01

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION		STOP	CONTENTS OF ADDRESS	NOTES
			OPERATION	ADDRESS			
		0132	C	0251		RH	
		33	B	0243			TEMP. STORAGE
		34	D	0253		n@30	
		35	M	0244	X	1@1	
		36	A	0250		RL	
		37	H	0243		T.S. II	
		38	E	0263		3WWWWWWQ	
		39	C	0250	X	RL	
		40	E	0243		T.S. II	
		41	E	0244		40000000	
		42	M	0241			
		43	A	0251	X	RH	
		44	C	0251			
		45	B	0238		ΣXYL	
		46	S	0250		RL	
		47	H	0247	X	DLa	
		48	C	0262		DLb	
		49	B	0248		ΣXYH	
		50	S	0251		RH	
		51	H	0261	X	DHb	
		52	T	0202			
		53	H	0246		DHa	
		54	B	0237		Z0232	POSITIVE EXIT
		55	Y	0230	X		
		56	B	0246		DHa	
		57	S	0255		1@30	
		58	T	0203			DHa = 0
		59	S	0255	X	1@30	
		60	T	0216			DHa = 1
		61	S	0255			
		62	T	0210			DHa = 2
		63	S	0255	X		

LGP-30 CODING SHEET

PREPARED FOR: LGP-30, RPC-4000 Users' Organization - POOL			PAGE OF 5 / 6
JOB NO.	PROGRAM NO. F1-164	PROGRAM PREPARED BY: R.A.L.	PROGRAM CHECKED BY: POOL Review
PROBLEM: DPSO SOP			DATE 10-9-59
			TRACK 02

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION		STOP	CONTENTS OF ADDRESS	NOTES
			OPERATION	ADDRESS			
		<input checked="" type="checkbox"/>					
		0,2,0,0	T	0,2,2,4			DHa = 3
		0,1	U	0,2,4,0		U[x+5]	
		0,2	M	0,2,6,0		-1 @ 0	
		0,3	C	0,2,4,6	<input checked="" type="checkbox"/>	DHa	
		0,4	S	0,2,4,7		DLa	
		0,5	C	0,2,4,7		DLa	
		0,6	B	0,2,3,6		Z0231	neg. EXIT
		0,7	U	0,1,5,5	<input checked="" type="checkbox"/>		
		0,8	B	0,2,4,7		DLa	
		0,9	U	0,2,3,0			EXIT U
		1,0	B	0,2,4,7		DLa	
		1,1	T	0,2,1,3	<input checked="" type="checkbox"/>		
		1,2	U	0,2,4,0		U[x+5]	
		1,3	A	0,2,4,4		1 @ 1	
		1,4	A	0,2,4,4			
		1,5	U	0,2,3,0	<input checked="" type="checkbox"/>		EXIT U
		1,6	B	0,2,4,7		DLa	
		1,7	T	0,2,1,4			
		1,8	E	0,2,4,4		1 @ 1	
		1,9	S	0,2,4,4	<input checked="" type="checkbox"/>		
		2,0	T	0,2,2,2			
		2,1	U	0,2,4,0		U[x+5]	
		2,2	B	0,2,4,7		DLa	
		2,3	U	0,2,1,4	<input checked="" type="checkbox"/>		
		2,4	B	0,2,4,7		DLa	
		2,5	T	0,2,2,7			
		2,6	U	0,2,4,0		U[x+5]	
		2,7	A	0,2,4,4	<input checked="" type="checkbox"/>		
		2,8	T	0,2,1,3			
		2,9	U	0,2,4,0		U[x+5]	
		3,0	U	[]		(0231)"-" or (0232)"+"	
		3,1	M	0,2,6,0	<input checked="" type="checkbox"/>	-1 @ 0	

LGP-30 CODING SHEET

PREPARED FOR: LGP-30, RPC-4000 Users' Organization - POOL			PAGE OF 6/6
JOB NO.	PROGRAM NO. F1-164	PROGRAM PREPARED BY: R.A.L.	PROGRAM CHECKED BY: POOL Review
PROBLEM: DPSOSOP			DATE 10-9-59
			TRACK 02

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION		STOP	CONTENTS OF ADDRESS	NOTES
			OPERATION	ADDRESS			
		<input checked="" type="checkbox"/>					
		0232	C0262			DLb	
		33	C0261			DHb=0	
		34	B0262			DLb	
		35	U[x+6]		<input checked="" type="checkbox"/>		
		36	Z0231				
		37	Z0232				
0000019'		38	[			ΣXYL	@30
		39	[<input checked="" type="checkbox"/>	T.S.I	
		40	U[x+5]				
		41					1@29
		42	TWWWWWQ				
		43	[<input checked="" type="checkbox"/>	T.S.II	
		44	40000000				1@1
		45	B[x+4]				
		46	[			DHa	@59
		47	[<input checked="" type="checkbox"/>	DLa	@30
		48	[			ΣXYH	@59
		49	[			ΣX	@30
		50	[			RL	@30
		51	[<input checked="" type="checkbox"/>	RH	@59
		52	[			ΣY	@30
		53	[			π	@30
		54					
		55			<input checked="" type="checkbox"/>		1@30
		56	WWWWWWT				
		57	A0253			π@30	
		58	U0134				
0000005'		59	[<input checked="" type="checkbox"/>	1/π	@0
		60	80000000				-1@0
		61	[			DHb	@59
		62	[			DLb	@30
		63	3WWWWWQ		<input checked="" type="checkbox"/>		