Program Number: C2-117
May 7, 1959

TITLE: Lin's Solution of Polynomials

AUTHOR: W. Hollabaugh
Lehigh University

ABSTRACT:

DISCLAIMER:

Program Number: C2-117
May 7, 1959

TITLE: Lin's Solution of Polynomials

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Description:

This is a program to determine the complex roots of polynomials of order $\underline{n}$ by direct application of the method developed by Dr. Shih-nge Lin.

Method of Program:

Lin's method uses an iterative process of dividing by a quadratic factor and modifying the factor until a "remainder" after division by the factor becomes less than some "accuracy factor", ε, which is a part of the data.

Reference to sources:

The sources used are these:

A method of Successive Approximations for Evaluating the Real and Complex Roots of Cubic and Higher Order Equations, S. Lin, Journal of Mathematics and Physics, Cambridge, Mass., Volume 20, Aug. 1941, pp. 232-42.

A method of Finding Roots of Algebraic Equations, S. Lin, Journal of Mathematics and Physics, Cambridge, Mass., Volume 22, June 1943, pp. 60-77.

Introduction to Numerical Analysis (book), F.B. Hildebrand, McGraw-Hill Book Company, Inc., N.Y., 1956, pp. 468-72.

Subroutines required:

The Floating Point Interpretive Routine (24.0), Floating Point Input and Output (11.3-12.3 or 11.6-12.6)

Limitations and inherent errors in the program:

The program imposes no limitations on Lin's method, and has all of the limitations of Lin's method. These limitations are: The program can handle equations with all real or all complex roots, but has trouble, i.e., fails to converge or converges too slowly, when both types of roots are present. It has occasionally solved equations where both types of roots are present, but this is apparently the exception rather than the rule. It is assumed that if the problem to be solved has both kinds of roots, the real roots will first be located and removed by another method.

Program Number: C2-117

May 7, 1959

Input:

The equation to be solved must be of the following form:

$$x^n + a_1x^{n-1} + a_2x^{n-2} + \dots + a_{n-1}x + a_n = 0$$

The n coefficients, n itself, and the accuracy factor ε are the required data. The coefficients are assumed real.

Output:

The routine prints the roots in complex form, and also the remainders as desired - see below.

Operating procedure:

The following procedure is to be followed in order to find the roots of a polynomial of order n: It

1. Floating Point (24.0) and the input and output routines must be stored in 1100 (or the program tape modified accordingly - no program addresses refer to floating point routine addresses other than 1100). No function routines are required.
2. The program must be stored in memory with space provided for storage of (3+6n) intermediate and final results in consecutive locations; these locations may be anywhere, with the initial address of these locations, designated α, stored as the address of the instruction in 0101.
3. To start the program, transfer to the initial location of the program. When the input light comes on, type n in hexadecimal (q=31) and give the computer a start.
4. At the second input instruction, data is to be stored as follows, the floating point input format being used:
   a. The accuracy factor, ε, is to be stored in location α.
   b. The n coefficients of the polynomial are stored in the succeeding n locations (a is not entered).

   The problem solution will be continued following the data input.
5. The transfer control button is used as follows to control the operation of the program:
   a. If the transfer control button is left up, the program will determine the roots and print them out without printing any intermediate results.
   b. If the transfer control button is depressed at any time, the remainder aftereach iteration will be printed. After each remainder is printed, the computer will come to a floating point input instruction and will stop with the input light on. At this time a new accuracy factor may be input if desired. The format for input is: The floating point input code word (start compute) - The accuracy factor (start compute) - -0000000 (start compute)(start compute).

A start or input of data will allow the computer to continue normally until a new remainder has been found, at which time the cycle is repeated.

c. If the remainder which has been printed out in "b" above is considered satisfactory by the operator, he may have the computer accept it and the corresponding factor of the polynomial by lifting the transfer control button before starting the computer after the input instruction.

d. If the transfer control button is depressed and it is desired to have the computer discontinue printing out the remainders, the transfer control button may be lifted at any time except during a five second period after any printout or during the printout itself.

6. When, at any time during the program, a factor and its remainder have been accepted, the computer will print a slash ("/"), and continue to find additional factors, or, if all the factors have been found, to find the roots. There will be a total number of slashed equal to one less than the number of root pairs, any odd root being counted as a pair.
7. After all factors have been found, the roots of the factors are found and printed out. They are printed one pair to a line, each root consisting of two numbers, the first part being the real part and the second the imaginary part. The flexowriter should be set for printout in four or more columns (carriage returns are programmed).
8. After the roots have been printed out, the remainder will be computed for each factor on the basis of the original equation and printed out; there will be one remainder per line, and one remainder for each factor. There will be no remainder for any odd root.
9. At the completion of the program the computer will stop (Z0063) in 0415. A start signal will restart the program for a new equation.

Storages:

The following storages are associated with the program:

1. The program itself requires $6\frac{1}{2}$ tracks for storage of instructions and constants. No storages are used in tracks 62 or 63.
2. In addition, the program requires (6n+3) locations for storage of data, intermediate results, and answers. These locations are all referred to the address of instruction 0101, designated α:

Location	Contents.
α	Accuracy factor ε.
$\alpha + 1$ to $\alpha + n$	Coefficients of original polynomial, a_1 to a_n.
$\alpha + n + 1$ to $\alpha + 3n + 2$	Intermediate results.
$\alpha + 3n + 3$ to $\alpha + 4n + 3$	The quadratic factors
$\alpha + 4n + 4$ to $\alpha + 6n + 3$	Roots, real part followed by imaginary part.

Notes: The following comments are pertinent:

1. Under some conditions the reaminder may reach a point of oscillation, and some cyclic pattern be printed. The only recourse is to accept the remainder at this point.

2. As indicated in one of the sample problems, the accuracy of the roots is not directly indicated by the size of the remainder. The simplest way to determine the accuracy of the roots is to change the coefficients slightly and observe the change in roots.

3. The original data is retained during the operation of the problem; however, $\underline{n}$ must be supplied every time the solution is restarted.

4. The program tape accompanying this write-up is prepared as follows:

   a. α = 0700 has been inserted into instruction 0101.
   b. At the end of the program a special check has been provided in order to check that the tape has been stored correctly and that the program is working correctly. The check takes the form of a sixth-degree equation which is not allowed to go to complete solution; instructions for use of the tape are on the tape. Although answers will be printed out during the course of the check, they are not the correct answers to the problem, but are only a check to be compared with the numbers on the tape. This is because a very large accuracy factor has been employed.

Sample problems - Two sample problems are here included. The first of these is a quartic equation, and includes notes as to what the various parts of the print out from the computer. The second sample problem is for a tenth degree polynomial. In this solution it may be observed that the remainder for the fifth pair of roots is 5.7, which is larger than any of the roots. However, the roots have been checked, and found to be accurate when rounded to five significant figures to less than one-half the last figure. In this print-out, only a few of the remainders are shown; when the problem was run, all of the remainders were allowed to print, making a total of 210 remainers were printed. The total time for this solution, including data input time, was 1 hour 11 minutes.

```
Program: Solution of n-th order equations - 590113

Solution of a fourth order polynomial equation:
Coefficients: 1, 1.5, 30.25, 10, 100.
Factor of convergence approximately zero.
                       transfer to beginning of program
.0003432 <-            "n" in hexadecimal
4 <-                   accuracy index (convergence factor)
+064100 2 -0000000 + 044101 15000 302500 100000 1000000 -0000000''
 ^input codes^                  \_____ coefficients _____/  ^input code
.9549152-  01-    .1952080   01    .9549152- 01-    .1952080-  01 } roots
.6545085-  00     .5074689   01    .6545085- 00     .5074689-  01 }
.0000000   00 } remainders
.4103780   04- }
```

(Typed by Operator)

Total elapsed time from data input to stop at end of program:
2 minutes and 40 seconds.

The above problem is now repeated, but the transfer control switch down to show remainders after each iteration of the process; data input is not repeated.

(Typed by Operator)

```
4 <----"n"
.1485142   02  }
.1676613   01  }
.1767474   00  }
.1584676   01- }       intermediate remainders
.1931727   02- }
.5128681   03- }
.1187026   03- }
.2411008   04- }

.9549152-  01-    .1952080   01    .9549152-  01-    .1952080-  01 } roots
.6545085-  00     .5074689   01    .6545085-  00     .5074689-  01 }
.0000000   00 } remainders
.4103780   04- }
```

Total elapsed time for this solution: 3 minutes and 10 seconds.

Print-out of results of solution of quartic equation.

Program: Solution of n-th order
Program: Lin's Solution of Polynomials - 590528

Solution of a tenth order polynomial equation:
Coefficients: -14.9, 114.5, -497.5, 1395.6, -2511.9, 4978.9, -7714.7, 7028, -5475, 3750.
Accuracy factor: 0.0000002

```
.0004000
f' <——"n" in hexadecimal
+064700'2'-0000000'+024701'-0001490'11450'-0049750'139560' }  Input data - on tape to
-0251190'497890'-0771470'702800'-0547500'375000'-0000000'' }  avoid errors
.4425329   04
.2044182   05
.5014247   04
.1805057   04
.6978523   03    Remainders for first factor
.3075277   03
.1504788   03
.7423221   02
        <—————— Indicates remainders not shown
.9765624   03-
/.3882432   04
.1086110   04    Remainders for second factor - remainder could not be
                 reduced to less than 0.000137, probably due to rounding
.1373291   03-   in floating point.  Remainder accepted manually.
.1373291   03-
.1373291   03-
/.1952562   04
.2916982   08
.2357193   04    Remainders for third factor
.5139978   03

.3128052   03-
/.3482675   03
.1417612   03    Remainder for fourth factor - remainder accepted manually
                 as being small enough to give required accuracy.
.26222604   03-

.5141854-  01-   .9879913  00   .5141854- 01-   .9879913-  00 }
.1326429   01    .3902183  00   .1326429  01    .3902184-  00 } First six roots
.6305227-  00    .1718944  01   .6305227- 00    .1718944-  01 }
```

.2887565	01	.3883364	01	.2887565	01	.3883365-	01	Last four roots
.3917947	01	.3190586	01	.3917947	01	.3190586-	01	
.0000000	00	Remainders obtained by dividing the original equation by the five quadratic factors, and for each one, taking the absolute value of the two terms of the remainder and adding them, then printing.						
.1445103	01-							
.2639770	02-							
.1864502	01							
.5727630	01							

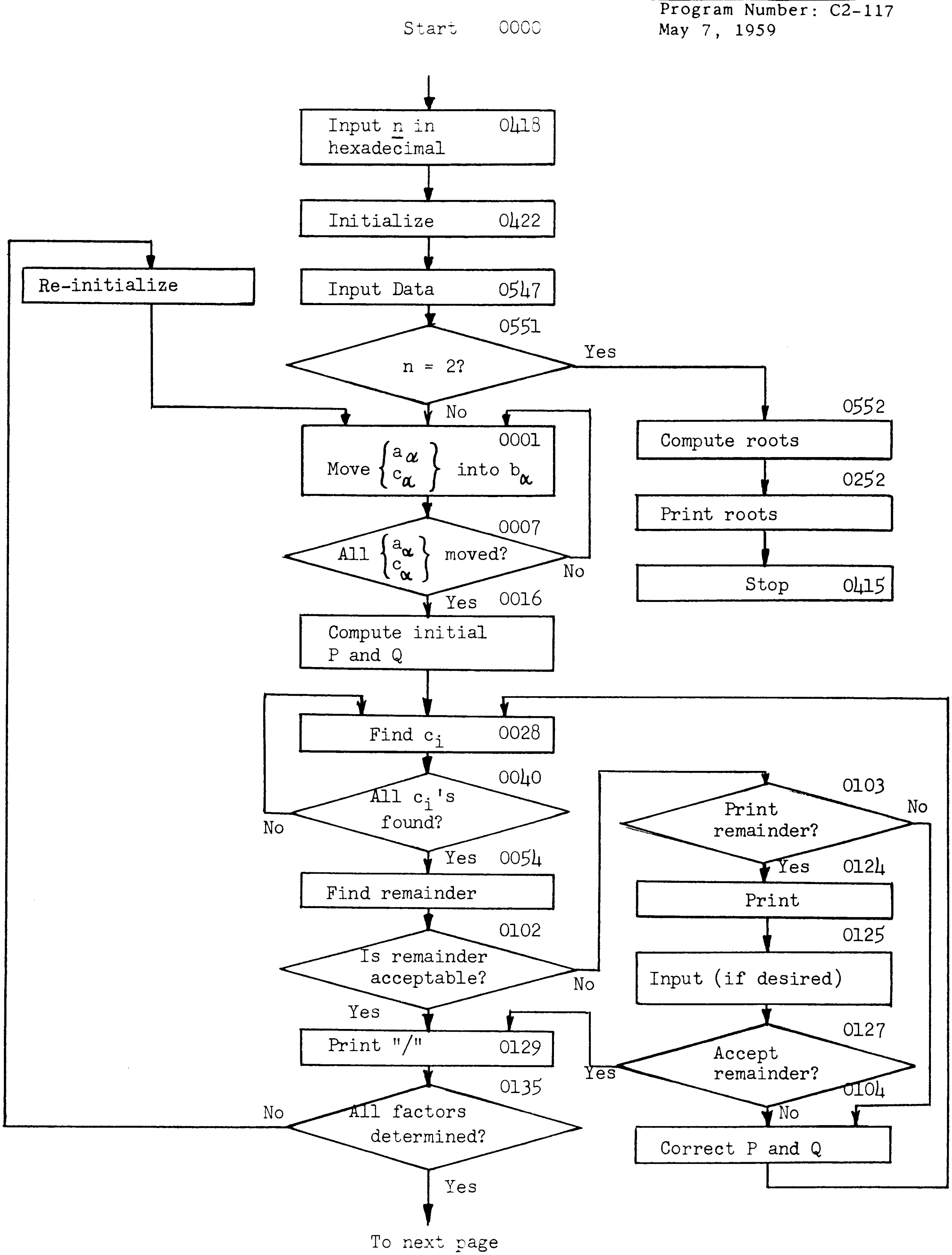
The equation to be solved was:

$$x^{10} - 14.9x^9 + 114.5x^8 - 497.5x^7 + 1395.6x^6 - 2511.9x^5 + 4978.9x^4 - 7714.7x^3 + 7028x^2 - 5475x + 3750 = 0$$

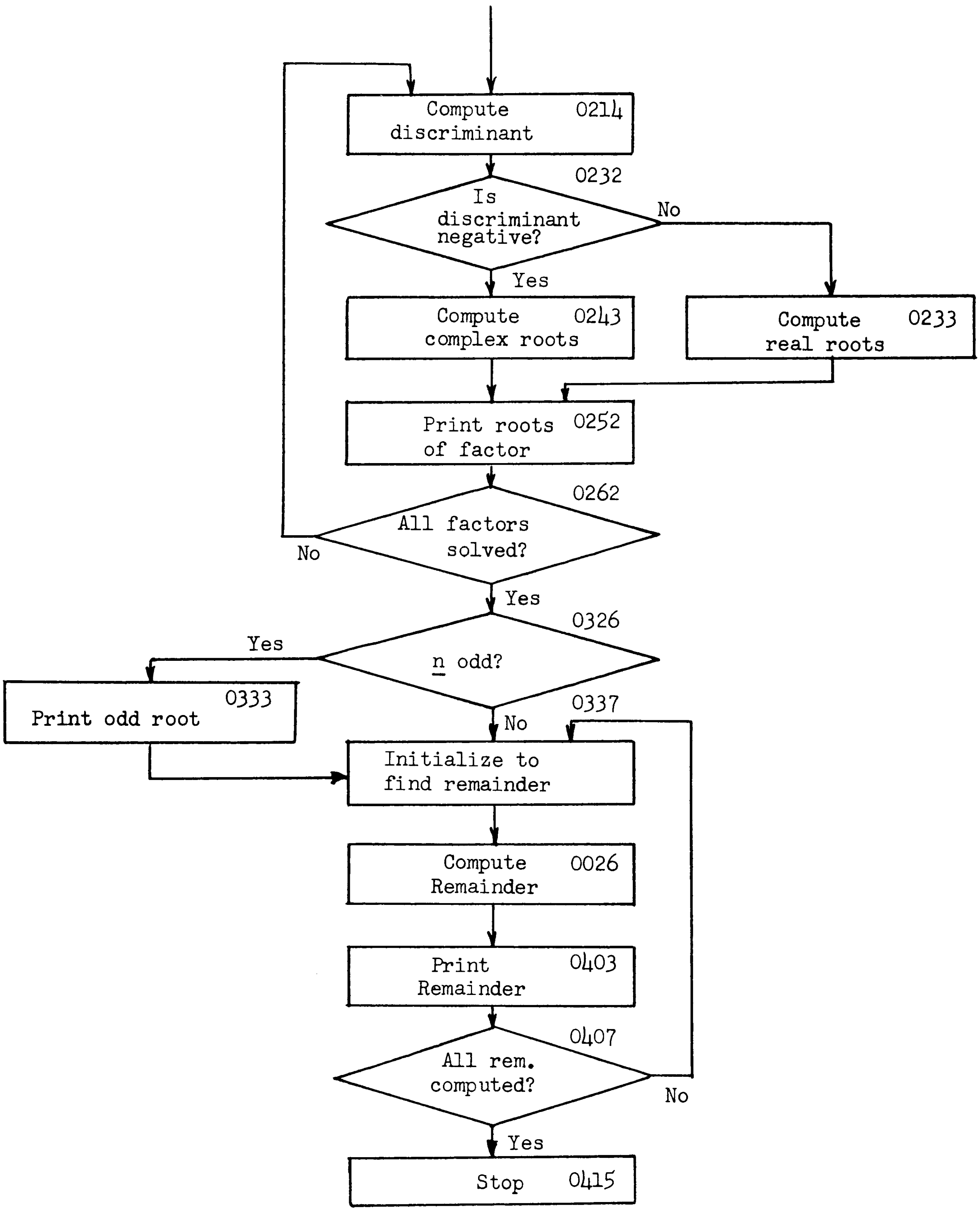
It was found that this equation is satisfied by the following:

$$x = \begin{array}{l} -0.051419 \pm 0.98799j \\ 1.3264 \pm 0.39022j \\ 0.63052 \pm 1.7189j \\ 2.8876 \pm 3.8834j \\ 3.9179 \pm 3.1906j \end{array}$$

accuract to the five significant figures indicated.


Start 0000
Input n in hexadecimal 0418
Initialize 0422
Input Data 0547
0551
n = 2?
Yes
No
0552
Compute roots
0252
Print roots
Stop 0415
Re-initialize
0001
Move {aα, cα} into bα
0007
All {aα, cα} moved?
No
Yes 0016
Compute initial P and Q
Find ci 0028
0040
All ci's found?
No
Yes 0054
Find remainder
0102
Is remainder acceptable?
No
Yes
Print "/" 0129
0135
All factors determined?
No
Yes
To next page
0103
Print remainder?
No
Yes 0124
Print
0125
Input (if desired)
0127
Accept remainder?
Yes
0104
No
Correct P and Q

From Last Page



PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL				PAGE 1 OF 13
JOB NO.	PROGRAM NO. C2-117	PROGRAM PREPARED BY: W.F. Hollabaugh	PROGRAM CHECKED BY: POOL Review	DATE 07/05/59
PROBLEM: Lin's Solution of Polynomials				TRACK 00

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES	
	'							
	'	☒						
		00	U	0416	'			
		01	B	0018	'	B[α +2n-1]	flag	Move a's c's into b's
		02	Y	0621	'			
		03	B	zzzz	'	☒	[α +1]	
		04	H	zzzz	'		[α +1+n]	
		05	B	0621	'			
		06	S	0004	'			
		07	T	0016	'	☒		
		08	B	0003	'			
		09	A	0626	'	1 at 29		
		10	Y	0003	'			
		11	B	0004	'	☒		
		12	A	0626	'	1 at 29		
		13	Y	0004	'			
		14	U	0003	'			
		15			'	☒		
		16	x R	1100	'			Find initial P's and Q's
		17	x U	1100	'			
		18	B	zzzz	'	b_{m-1}	[α +2m-1]	
		19	D	zzzz	'	☒ b_{m-2}	[α +2m-2]	
		20	H	zzzz	'	P	[α +3m+3]	
		21	B	zzzz	'	b_m	[α +2m]	
		22	D	zzzz	'	b_{m-2}	[α +2m-2]	
		23	x Y	0000	'	☒		
		24	H	zzzz	'	-Q	[α +3m+4]	
		25	x E	0000	'			
		26	B	0056	'			
		27	Y	0621	'	☒		
		28	x R	1100	'			
		29	x U	1100	'			
		30	P	zzzz	'	c_{i-1}	[α +2m+3]	
		31	M	zzzz	'	☒ P	[α +3m+3]	

FORM LP-10
SC 0532

☒ CARRIAGE RETURN
' = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE
	C2-117	W.F. Hollabaugh	POOL Review	07/05/59

PROBLEM: Lin's Solution of Polynomials

TRACK 00

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		32	xY	0000	'		
		33	A	zzzz	'	b_i	[α +m+1] } Find c_i
		34	P	zzzz	'	c_{i-2}	[α +2m+2]
		35	N	zzzz	'	☒ -Q	[α +3m+4]
		36	H	zzzz	'	c_i	[α +2m+4]
		37	xE	0000	'		
		38	B	0621	'		
		39	S	0036	'	☒	
		40	T	0054	'		
		41	B	0034	'		
		42	A	0626	'	1 at 29	
		43	Y	0034	'	☒	
		44	A	0626	'	1 at 29	
		45	Y	0030	'		
		46	A	0626	'	1 at 29	
		47	Y	0036	'	☒	
		48	B	0033	'		
		49	A	0626	'	1 at 29	
		50	Y	0033	'		
		51	U	0028	'	☒	
		52			'		
		53			'		
		54	xR	1100	'		
		55	xU	1100	'	☒	
		56	P	zzzz	'	c_{m-2}	[α +3m+1]
		57	M	zzzz	'	-Q	[α +3m+4]
		58	A	zzzz	'	b_m	[α +2m] } Find
		59	xB	0000	'	☒	Remainder
		60	H	0623	'	$b_m - Qc_{m-2}$	
		61	B	zzzz	'	c_{m-1}	[α +3m+2]
		62	xB	0000	'		
		63	A	0623	'	☒ $b_m - Qc_{m-2}$	

FORM LP-12

☒ CARRIAGE RETURN

' = CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE
	C2-117	W.F. Hollabaugh	POOL Review	07/05/59

PROBLEM: Lin's Solution of Polynomials

TRACK: 01

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CARRIAGE RETURN	CONTENTS OF ADDRESS	NOTES
	/							
	/	[X]						
		00	U	zzzz	/			[0101];[0403]
		01	S	0700	/		ε	[α]
		02	T	0128	/			
		03	800 T	0123	/	[X]		
		04	B	zzzz	/		b_m	[α +2m]
		05	D	zzzz	/		c_{m-2}	[α +3m+1]
		06	xY	0000	/			
		07	H	zzzz	/	[X]	-Q′	[α +3m+4] Correct
		08	xU	0000	/			P & Q
		09	M	zzzz	/		c_{m-3}	[α +3m]
		10	A	zzzz	/		b_{m-1}	[α +2m-1]
		11	D	zzzz	/	[X]	c_{m-2}	[α +3m+1]
		12	H	zzzz	/		P	[α +3m+3]
		13	xE	0000	/			
		14	B	0524	/		H[α +2m+2]	
		15	Y	0034	/	[X]		
		16	A	0626	/		1 at 29	α +2m+3
		17	Y	0030	/			
		18	A	0626	/		1 at 29	α +2m+4
		19	Y	0036	/	[X]		
		20	B	0620	/		Z[α +1+m]	
		21	Y	0033	/			
		22	U	0026	/			
		23	A	zzzz	/	[X]	ε	[α]
		24	xP	0000	/			Print remainder
		25	xI	0000	/			Input ε, if desired
		26	C	0623	/			
		27	800 T	0104	/	[X]		
		28	xE	0000	/			
		29	xP	1943	/			
		30	B	0625	/		m at 29	
		31	S	0627	/	[X]	2 at 29	

Royal McBee Corporation
DATA PROCESSING DIV.
PORT CHESTER, NEW YORK

FORM LP-10

[X] CARRIAGE RETURN

/ CONDITIONAL STOP CODE

ROYAL McBEE J13541X

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.:

PROGRAM NO.: C2-117

PROGRAM PREPARED BY: W.F. Hollabaugh

PROGRAM CHECKED BY: POOL Review

DATE: 07/05/59

PROBLEM: Lin's Solution of Polynomials

TRACK: 01

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		32	H	0625	'	m at 29	
		33	B	0625	'	m at 29	
		34	S	0628	'	3 at 29	
		35	T	0214	'	☒	
		36	B	0222	'	Z[α +2m+4]	
		37	Y	0003	'		
		38	B	0019	'		
		39	S	0627	'	☒ 2 at 29	
		40	Y	0019	'		
		41	Y	0022	'		
		42	A	0626	'	1 at 29	
		43	Y	0018	'	☒	
		44	Y	0110	'		Address modification
		45	A	0626	'	1 at 29	
		46	Y	0021	'		
		47	Y	0058	'	☒	
		48	Y	0104	'		
		49	B	0020	'		
		50	A	0627	'	2 at 29	
		51	Y	0020	'	☒	
		52	Y	0031	'		
		53	Y	0112	'		
		54	A	0626	'	1 at 29	
		55	Y	0024	'	☒	
		56	Y	0035	'		
		57	Y	0057	'		
		58	Y	0107	'		
		59	B	0056	'	☒	
		60	S	0627	'	2 at 29	
		61	Y	0056	'		
		62	Y	0105	'		
		63	Y	0111	'	☒	

☒ CARRIAGE RETURN

' = CONDITIONAL STOP CODE

PREPARED FOR:				PAGE 5 OF 13
LGP-30 RPC-4000 USERS ORGANIZATION - POOL				
JOB NO.:	PROGRAM NO.: C2-117	PROGRAM PREPARED BY: W.F. Hollabaugh	PROGRAM CHECKED BY: POOL Review	DATE: 07/05/59
PROBLEM: Lin's Solution of Polynomials				TRACK: 02

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	⊠					
		00	A	0626	'	1 at 29	
		01	Y	0061	'		
		02	S	0627	'	2 at 29	
		03	Y	0109	'	⊠	
		04	B	0524	'	H[α +2m+2]	
		05	Y	0034	'		
		06	A	0626	'	1 at 29	α +2m+3
		07	Y	0030	'	⊠	
		08	A	0626	'	1 at 29	
		09	Y	0036	'		
		10	B	0620	'	Z[α +m+1]	
		11	Y	0033	'	⊠	
		12	Y	0004	'		
		13	U	0001	'		
		14	B	0020	'		
		15	A	0627	'	⊠ 2 at 29	
		16	Y	0223	'		
		17	A	0626	'	1 at 29	
		18	Y	0225	'		
		19	xP	1649	'	⊠	Carriage return
		20	xR	1100	'		
		21	xU	1100	'		
		22	B	zzzz	'	c_i=last P	[α +2m+4]
		23	C	zzzz	'	⊠	[ ]
		24	S	zzzz	'	$-c_2$=- last q	[α +2m+5]
		25	H	zzzz	'		[ ]
		26	B	zzzz	'	P	[α +3m+3]
		27	D	0631	'	⊠ 2	
		28	H	0623	'	P/2	
		29	P	0623	'	P/2	
		30	M	0623	'	$P^2/4$	
		31	A	zzzz	'	⊠ -Q	[α +3m+4]

⊠ CARRIAGE RETURN

' = CONDITIONAL STOP CODE

PREPARED FOR:				PAGE 6 OF 13
LGP-30 RPC-4000 USERS ORGANIZATION - POOL				
JOB NO.:	PROGRAM NO.: C2-117	PROGRAM PREPARED BY: W.F. Hollabaugh	PROGRAM CHECKED BY: POOL Review	DATE: 07/05/59
PROBLEM: Lin's Solution of Polynomials				TRACK: 02

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES	
	'							
	'	☒						
		32	T	0243	'			Compute roots of factor
		33	xR	0000	'			
		34	H	0622	'			
		35	S	0623	'	☒		
		36	C	zzzz	'		[α +4M=6]	
		37	S	0622	'			
		38	S	0623	'			
		39	C	zzzz	'	☒	[α +4m+4]	
		40	H	zzzz	'		[α +4m+5]	
		41	H	zzzz	'		[α +4m+7]	
		42	U	0251	'			
		43	xB	0000	'	☒		
		44	xR	0000	'			
		45	H	zzzz	'		[α +4m+5]	
		46	xT	0000	'			
		47	C	zzzz	'	☒	[α +4m+7]	
		48	S	0623	'			
		49	H	zzzz	'		[α +4m+4]	
		50	H	zzzz	'		[α +4m+6]	
		51	B	zzzz	'	☒	[α +4m+4]	Print roots of factor
		52	xP	0000	'			
		53	B	zzzz	'		[α +4m+5]	
		54	xP	0000	'			
		55	B	zzzz	'	☒	[α +4m+6]	
		56	xP	0000	'			
		57	B	zzzz	'		[α +4m+7]	
		58	xP	0000	'			
		59	xE	0000	'	☒		
		60	B	0619	'			
		61	S	0257	'			
		62	T	zzzz	'		[0325];[0415]	
		63	B	0226	'	☒		

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☒ CARRIAGE RETURN

' — CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY:	PROGRAM CHECKED BY:	DATE
	C2-117	W.F. Hollabaugh	POOL Review	07/05/59

PROBLEM: Lin's Solution of Polynomials

TRACK: 03

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		00	A	0627	'	2 at 29	
		01	Y	0226	'		
		02	A	0626	'	1 at 29	
		03	Y	0231	'	☒	
		04	B	0239	'		
		05	A	0629	'	4 at 29	
		06	Y	0239	'		
		07	Y	0249	'	☒	
		08	Y	0251	'		
		09	A	0626	'	1 at 29	
		10	Y	0240	'		
		11	Y	0245	'	☒	
		12	Y	0253	'		
		13	A	0626	'	1 at 29	} Address
		14	Y	0236	'		Modification
		15	Y	0250	'	☒	
		16	Y	0255	'		
		17	A	0626	'	1 at 29	
		18	Y	0241	'		
		19	Y	0247	'	☒	
		20	Y	0257	'		
		21	xP	1649	'		Carriage return
		22	xR	1100	'		
		23	xU	1100	'	☒	
		24	U	0226	'		
		25	A	0627	'	2 at 29	
		26	T	0337	'		
		27	xP	1649	'	☒	Carriage return
		28	B	0222	'	Z[α +2m+4]	
		29	Y	0334	'		
		30	xR	1100	'		
		31	xU	1100	'	☒	

☒ CARRIAGE RETURN

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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JOB NO.	PROGRAM NO.	PROGRAM PREPARED BY	PROGRAM CHECKED BY	DATE
	C2-117	W.F. Hollabaugh	POOL Review	07/05/59

PROBLEM: Lin's Solution of Polynomials

TRACK 03

PROGRAM INPUT CODES	LOCATION	OPERATION	ADDRESS	CARRIAGE RETURN	CONTENTS OF ADDRESS	NOTES
	32	C	0623			
	33	xP	0000			
	34	S	zzzz			[ ]
	35	XP	0000	☒		
	36	XE	0000			
	37	B	0624		n	
	38	H	0623		n=m	
	39	B	0101	☒	S[α]	
	40	A	0624		n at 29	α+n
	41	Y	0058			
	42	A	0624		n at 29	α+2n
	43	A	0624	☒	n at 29	α+3n
	44	A	0626		1 at 29	α+3n+1
	45	Y	0056			
	46	A	0626		1 at 29	α+3n+2
	47	Y	0061	☒		
	48	A	0626		1 at 29	α+3n+3
	49	Y	0031			
	50	A	0626		1 at 29	α+3n+4
	51	Y	0035	☒		
	52	Y	0057			
	53	xP	1649			Carriage return
	54	B	0101		s[α]	
	55	A	0626	☒	1 at 29	α+1
	56	Y	0033			
	57	A	0624		n at 29	α+m+1
	58	A	0624		n at 29	α+2n+1
	59	A	0626	☒	1 at 29	α+2n+2
	60	Y	0034			
	61	A	0626		1 at 29	α+2n+3
	62	Y	0030			
	63	A	0626	☒	1 at 29	α+2n+4

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☒ CARRIAGE RETURN

' = CONDITIONAL STOP CODE

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PROBLEM: Lin's Solution of Polynomials				TRACK: 04

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		00	Y	0036	'		
		01	R	0100	'		
		02	U	0026	'		
		03	xP	0000	'	☒	Remainder
		04	xE	0000	'		
		05	B	0618	'	M[α +4n]	
		06	S	0057	'		
		07	T	0415	'	☒	
		08	B	0031	'		
		09	A	0627	'	2 at 29	
		10	Y	0031	'		
		11	A	0626	'	☒ 1 at 29	
		12	Y	0035	'		
		13	Y	0057	'		
		14	U	0353	'		
		15	xZ	0063	'	☒	End of program
		16	C	0623	'		
		17	xP	0000	'		
		18	xI	0000	'		Input "n" here
		19	N	0626	'	☒ 1 at 29	
		20	H	0624	'	n at 29	
		21	H	0625	'		
		22	B	0101	'	S[α]	α
		23	Y	0123	'	☒	
		24	A	0626	'	1 at 29	α +1
		25	Y	0003	'		
		26	A	0624	'	n at 29	α +n+1
		27	Y	0004	'	☒	
		28	Y	0033	'		
		29	Y	0620	'		
		30	A	0624	'	n at 29	α +2n+1
		31	S	0627	'	☒ 2 at 29	α +2n-1

☒ CARRIAGE RETURN

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PROBLEM:	TRACK
Lin's Solution of Polynomials	04

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		32	Y	0018	'		
		33	Y	0110	'		
		34	S	0626	'	1 at 29	α +2n-2
		35	Y	0019	'	☒	
		36	Y	0022	'		
		37	A	0627	'	2 at 29	α +2n
		38	Y	0021	'		
		39	Y	0058	'	☒	
		40	Y	0104	'		
		41	A	0627	'	2 at 29	α +2n+2
		42	Y	0034	'		
		43	Y	0524	'	☒	
		44	A	0626	'	1 at 29	α +2n+3
		45	Y	0030	'		
		46	Y	0523	'		
		47	A	0626	'	☒ 1 at 29	α +2n+4
		48	Y	0036	'		
		49	Y	0222	'		
		50	U	0451	'		
		51	A	0624	'	☒ n at 29	α +3n+4
		52	Y	0024	'		
		53	Y	0035	'		
		54	Y	0057	'		
		55	Y	0107	'	☒	
		56	Y	0231	'		
		57	Y	0600	'		
		58	S	0626	'	1 at 29	α +3n+3
		59	Y	0020	'	☒	
		60	Y	0031	'		
		61	Y	0112	'		
		62	Y	0226	'		
		63	Y	0557	'	☒	

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☒ CARRIAGE RETURN

' — CONDITIONAL STOP CODE

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PROBLEM: Lin's Solution of Polynomials				TRACK 05

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		00	S	0626	'	1 at 29	α +3n+2
		01	Y	0061	'		
		02	S	0626	'	1 at 29	α +3n+1
		03	Y	0056	' ☒		
		04	Y	0105	'		
		05	Y	0111	'		
		06	S	0626	'	1 at 29	α +3n
		07	Y	0109	' ☒		
		08	A	0624	'	n at 29	α +4n
		09	Y	0618	'		
		10	S	0626	'	1 at 29	α +4n-1
		11	U	0514	' ☒		
		12			'		
		13			'		
		14	A	0624	'	n at 29	α +5n-1
		15	A	0624	' ☒	n at 29	α +6n-1
		16	Y	0619	'		
		17	B	0617	'	T[0325]	
		18	H	0262	'		
		19	B	0222	' ☒	B[α +2n+4]	
		20	A	0626	'	1 at 29	α +2n+5
		21	Y	0224	'		
		22	B	0630	'	1 fl. pt.	
		23	C	zzzz	' ☒	$c_0=1$	[α +2n+3]
		24	H	zzzz	'	$c_{-1}=0$	[α +2n+2]
		25	B	0231	'	A[α +3n+4]	
		26	A	0624	'	n at 29	α +4n+4
		27	Y	0239	' ☒		
		28	Y	0249	'		
		29	Y	0251	'		
		30	A	0626	'	1 at 29	α +4n+5
		31	Y	0240	' ☒		

☒ CARRIAGE RETURN

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PROBLEM:	TRACK
Lin's Solution of Polynomials	05

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		32	Y	0245	'		
		33	Y	0253	'		
		34	A	0626	'	1 at 29	α +4n+6
		35	Y	0250	'	☒	
		36	Y	0236	'		
		37	Y	0255	'		
		38	A	0626	'	1 at 29	α +4n+7
		39	Y	0241	'	☒	
		40	Y	0247	'		
		41	Y	0257	'		
		42	B	0544	'	Y0100	
		43	A	0626	'	☒ 1 at 29	0102
		44	Y	0100	'		
		45	xR	1100	'		
		46	xU	1100	'		
		47	xI	0000	'	☒	Data Input here
		48	xE	0000	'		
		49	B	0627	'	2 at 29	
		50	S	0624	'	n at 29	
		51	T	0001	'	☒	quadratic?
		52	B	0003	'	B[α +1]	
		53	Y	0556	'		α +1
		54	A	0626	'	1 at 29	α +2
		55	Y	0562	'	☒	
		56	B	zzzz	'		[α +1]
		57	H	zzzz	'		[α +3n+3]
		58	B	0616	'		
		59	H	0262	'	☒	
		60	xR	1100	'		
		61	xU	1100	'		
		62	B	zzzz	'		[α +2]
		63	xY	0000	'	☒	

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☒ CARRIAGE RETURN

' — CONDITIONAL STOP CODE

PREPARED FOR: LGP-30 RPC-4000 USERS ORGANIZATION - POOL

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	C2-117	W.F. Hollabaugh	POOL Review	07/05/59

PROBLEM: Lin's Solution of Polynomials

TRACK 06

PROGRAM INPUT CODES	STOP	LOCATION	OPERATION	ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
	'						
	'	☒					
		00	H	zzzz	'		[α+3n+4]
		01	U	0226	'		
,000 0014	'	02			'		
		03			'	☒	
		04			'		
		05			'		
		06			'		
		07			'	☒	
		08			'		
		09			'		
		10			'		
		11			'	☒	
		12			'		
		13			'		
		14			'		
		15			'	☒	
		16	U	0415	'		
		17	T	0325	'		
,000 0014	'	18	M	zzzz	'		[α +4n]
		19	B	zzzz	'	☒	[α +6n-1]
		20	Z	zzzz	'		[α +1+n]
		21	H	zzzz	'		[α +2n-1]
		22			'		
		23			'	☒	
		24			'	n at 29	
		25			'	m at 29	
		26		4	'	1 at 29	
		27		8	'	☒ 2 at 29	
		28		J	'	3 at 29	
		29		10	'	4 at 29	
		30	4000	0002	'	1 fl. pt.	
		31	4000	0004	'	☒ 2 fl. pt.	

FORM LP-10

☒ CARRIAGE RETURN