Notes on the back story of this document:

As told in other *Notes*, when we first met in 1975 I already was the proud owner of a brand-new **HP-25** and my friend ***Fernando del Rey*** was the not-so-proud owner of an **HP-55**, which he found very lacking in his programming capabilities, particularly the fact that its meager 49 steps of program memory were *unmerged*, essentially storing just *keypresses* instead of *complete instructions*, so in practice you could store an average of half that many said complete instructions or less in program memory, which was extremely limiting.

Despite that, Fernando did his best to create non-trivial programs for his *HP-55* but frequently borrowed my *HP-25*, producing little jewels for it, and then the **HP-67** was released and we decided that enough was enough and wanted it *ASAP* whatever the price. I sold my *HP-25* and we promptly ordered our very own expensive, state-of-the-art programmable calcs (I had to play the proverbial *beg, steal and borrow* act to pay for it) and our calc-programming life changed for the best.

My own *HP-67* programming efforts have already been featured in my *Cuaderno ICAI* PDF document, various *UPLE Program Submittals* and several articles in *PPC Calculator Journal*, among several other places, so now I'm collecting here a number of Fernando's *HP-67* programs and drafts, that his earliest efforts won't get lost into oblivion.

> ***Caveat lector**: Like me, while creating them he also documented most HP-67 programs in his own handwriting and in Spanish, as at the time they weren't intended to be shared with anyone else, much less English native speakers. However, as most of them deal with mathematical subjects, it's possible to try and understand what they're doing and the examples can be followed and run with little difficulty.*

List of the 16 Programs and drafts for the HP-67 included in this document:

Sistema de 6 ecuaciones	*(System of 6 linear equations)*
Funcion Gamma	*(Gamma function)*
Resolucion del sistema $f(x, y) = 0$, $g(x, y) = 0$	*(System of 2 non-linear equations)*
6x6 Linear system solution (Draft)	***documented in English***
Polynomial interpolation (Draft)	***documented in English***
Solution to a system of linear equations	***documented in English***
7 Simultaneous equations in 7 unknowns (Draft)	***documented in English***
Raices de polinomios	*(Roots of polynomials)*
Regresion lineal multiple - Polinomio de regresion	*(Multivariable-linear/Polynomial fit)*
Tabla de reduccion de alturas astronomicas	*(Astronomic Altitudes Reduction Table)*
Regresion (borrador)	*(Regression - Draft)*
Bairstow (Polinomios hasta grado 8) (borrador)	*(Bairstow - Polyn. up to 8th deg., Draft)*

Captura de Klingon (borrador)	*(Klingon's Capture game - Draft)*
Muertos y Heridos (borrador)	*(Mastermind-like game - Draft)*
Sistemas de 3 ecuaciones diferenciales (borrador)	*(Systems of 3 diff. equations - Draft)*
Division extendida (borrador)	*(Extended division - Draft)*

Valentin Albillo, 21-12-2021

User Instructions

SISTEMA DE 6 ECUACIONES

1 [x1] [x2] [x3] [x4] [x5] [x6] 2

a61 → (x1) (Comientos de fila an1)

a11 a21 a31 a41 a51

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Introducir caras 1 y 2			
2	Meter los coeficientes de las primeras 5 ecuac			
	- Primer coeficiente de la linea	aij	K	
	- coeficientes a12 hasta a16	aij	R/S	
	- bi	bi	R/S	
	Repetir este paso para i = 1 hasta 5			
	donde K = A para i = 1			
	K = B i = 2			
	K = C i = 3			
	K = D i = 4			
	K = E i = 5			
3	Meter la ultima ecuac y calcular solucio			
	- Meter a61	a61	f A	
	- Meter a62 hasta a66	a6j	R/S	
	- b6	b6	R/S	x1
			RCL A	x2
			RCL B	x3
4	En caso de equivocación se puede		RCL C	x4
	corregir la ultima entrada del		RCL D	x5
	siguiente modo:		RCL E	x6
	- Para borrar aij cuando i ≤ j			
	se debe empezar la linea de nuevo			
	- Para corregir aij cuando i > j o			
	bi pulsar f DSZ e introducir			
	de nuevo el valor correcto de aij			
	o bi			

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL A				GSB 9		
	CL REG				4		
	CF 0				GSB 7		
	CF 1			060	F?. 1		
	CF 2				GTO d		
	STO E				GSB 8		
	LBL 0				GTO 2		
	R/S				LBL D		
	GSB 8				GSB C		
010	GTO 0				STO C		
	LBL B				R/S		
	STO A				RCL 7		
	R/S				RCL A		
	RCL 0			070	GSB 9		
	RCL A				RCL 7		
	GSB 9				RCL B		
	STO E				GSB 9		
	LBL 1				P?. S		
	R/S				RCL 1		
020	5				P?. S		
	LBL 6				RCL C		
	GSB 5				GSB 9		
	RCL (i)				F?. 1		
	RCL A			080	RTN		
	GSB 9				STO E		
	5				SF 1		
	GSB 7				LBL 3		
	F?. 0				R/S		
	GTO d				1		
030	GSB 8				2		
	GTO 1				GTO 6		
	LBL C				LBL d		
	STO A				RCL (i)		
	R/S			090	RCL C		
	RCL 0				GSB 9		
	RCL A				3		
	GSB 9				GSB 7		
	STO B				F?. 2		
	R/S				GTO d		
040	RCL 1				GSB 8		
	RCL A				GTO 3		
	GSB 9				LBL E		
	RCL 6				GSB D		
	RCL B			100	STO D		
	GSB 9				R/S		
	F?. 0				RCL 3		
	RTN				RCL A		
	STO E				GSB 9		
	SF 0				RCL 8		
050	LBL 2				RCL B		
	R/S				GSB 9		
	9				P?. S		
	GTO 6				RCL 2		
	LBL d			110	RCL C		
	RCL (i)				GSB 9		
	RCL B				RCL 5		

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

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL D		
	GSB 9		
	P≥S		
	F?.2		
	GTO e		
	STO E		
	LBL 4		
20	R/S		
	CF 3		
	1		
	4		
	SF 2		
	GTO 6		
	LBL d		
	RCL (i)		
	RCL D		
	GSB 9		
30	ISZ		
	ISZ		
	F?.3		
	RTN		
	GSB 8		
	GTO 4		
	LBL a		
	SF 2		
	GTO E		
	LBL e		
40	STO E		
	R/S		
	RCL 4		
	RCL A		
	GSB 9		
	RCL 9		
	RCL B		
	GSB 9		
	P≥S		
	RCL 3		
50	RCL C		
	GSB 9		
	RCL 6		
	RCL D		
	GSB 9		
	RCL 8		
	RCL E		
	GSB 9		
	P≥S		
	R/S		
60	SF 3		
	SF 2		
	1		
	5		
	GSB 6		
	RCL (i)		
	RCL E		
	GSB 9		
	X≥Y		

STEP	KEY ENTRY	KEY CODE	COMMENTS
	÷		
170	STO E		
	GSB b		
	STO D		
	CF 0		
	GSB b		
	STO C		
	CF 1		
	SF 2		
	GSB b		
	STO B		
180	SF 3		
	GSB b		
	STO A		
	LBL b		
	RCL (i)		
	DSZ		
	RCL E		
	GSB c		
	F?.0		
	RTN		
190	RCL D		
	GSB c		
	F?.1		
	RTN		
	RCL C		
	GSB c		
	F?.2		
	RTN		
	RCL B		
	GSB c		
200	F?.3		
	RTN		
	RCL A		
	LBL c		
	RCL (i)		
	DSZ		
	LBL 9		
	X		
	−		
	RTN		
210	LBL 8		
	RCL E		
	÷		
	STO (i)		
	ISZ		
	RTN		
	LBL 5		
	CHS		
	LBL 7		
	RCL I		
220	+		
	STO I		
	R↓		
	RTN		

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

SET STATUS

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

Program Description

Program Title SOLUCIÓN DE UN SISTEMA DE 6 ECUACIONES

Name FERNANDO DEL REY GARCÍA **Date** 27-Jul-1977

Address

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

Program Description, Equations, Variables, etc.

Este programa calcula la solución de un sistema de 6 ecuaciones con 6 incognitas dado de la forma:

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 + a_{15}x_5 + a_{16}x_6 = b_1$$
$$a_{21}x_1 + a_{22}x_2 + \cdots = b_2$$
$$\cdots$$
$$a_{61}x_1 + a_{62}x_2 + a_{63}x_3 + a_{64}x_4 + a_{65}x_5 + a_{66}x_6 = b_6$$

Primero se reduce el sistema a uno equivalente de la forma

$$x_1 + a'_{12}x_2 + a'_{13}x_3 + a'_{14}x_4 + a'_{15}x_5 + a'_{16}x_6 = b'_1$$
$$x_2 + a'_{23}x_3 + a'_{24}x_4 + a'_{25}x_5 + a'_{26}x_6 = b'_2$$
$$x_3 + a'_{34}x_4 + a'_{35}x_5 + a'_{36}x_6 = b'_3$$
$$x_4 + a'_{45}x_5 + a'_{46}x_6 = b'_4$$
$$x_5 + a'_{56}x_6 = b'_5$$
$$x_6 = b'_6$$

donde se calculan los valores de x_6 hasta x_1 en este orden por sustitución reversiva. Los coeficientes del sistema reducido se pueden obtener en los registros R0-R4 y R50-R54.

Operating Limits and Warnings

Si existe solución pero aparece Error al entrar los coeficientes se debe cambiar el orden de las ecuaciones o de las variables. El mejor modo es dejar las últimas aquellas ecuaciones que empiecen con más ceros si los hay.

Al introducir el valor de b_6 hay que asegurarse que el número que aparece en el registro X suba al registro Y

DO NOT USE THIS SPACE

User Instructions

FUNCION GAMMA

1 | 2

Γ(x) Γ(x)(r) Γ(x)(ext) n!(ext) DSP?

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Introducir ambas caras de la tarjeta.			
2	Para función gamma de precisión	x	A	Γ(x)
3	Para función gamma rápida	x	B	Γ(x)
4	Para función gamma de rango extendido $\Gamma(x) = a \cdot 10^b$	x	C	a*, b*, a
			x≥y	b
			x≥y	a
5	Para factoriales de rango extendido $n! = a \cdot 10^b$	x	D	a*, b*, a
			x≥y	b
			x≥y	a
6	Si se desea cambiar la presentación en pantalla	n	E	DSP(n)

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL B	31 25 12	Desarrollo de $\Gamma(x)$
	STO 0	33 00	
	6	06	
	ST I	35 33	
	R↓	35 53	
	x^2	32 54	
	$1/x$	35 62	
	ENTER↑	41	
	ENTER↑	41	Hace $\sum \frac{1}{x^{2i}} R_i$
010	ENTER↑	41	
	RCL 7	34 07	
	X	71	
	LBL 0	31 25 00	
	RCL (i)	34 24	
	+	61	
	X	71	
	DSZ	31 33	
	GTO 0	22 00	
	RCL 0	34 00	
020	X	71	
	RCL 0	34 00	Añade el resto de los términos del desarrollo
	.	83	
	5	05	
	−	51	
	RCL 0	34 00	
	LN	31 52	
	X	71	
	RCL 0	34 00	
	−	51	
030	RCL 8	34 08	
	+	61	
	+	61	
	F? 2	35 71 02	F? 2 {si = extendidos, no = normales}
	RTN	35 22	
	e^x	32 52	
	RTN	35 22	
	LBL A	31 25 11	F(x) de precisión
	INT	31 83	
	LAST X	35 82	
040	X=Y	32 51	X∈N se va a hacerlo por (X−1)!
	GTO 4	22 04	
	1	01	
	STO 9	33 09	
	R↓	35 53	
	5	05	
	X>Y	32 81	
	GTO 1	22 01	
	1	01	
	+	61	
050	X≥Y	35 52	X<5 aplica $x\Gamma(x)=\Gamma(x+1)$ hasta llegar entre 5 y 6 lo mismo si x>6
	X≤Y	32 71	
	GTO B	22 12	
	LBL 2	31 25 02	
	1	01	
	−	51	
	STO X 9	33 71 09	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	X>Y	32 81	Si 6≥x≥5 se va directamente a B,
	GTO 2	22 02	
	GSB B	31 22 12	
060	RCL 9	34 09	
	X	71	
	RTN	35 22	
	LBL 1	31 25 01	
	X≥Y	35 52	
	LBL 3	31 25 03	
	STO X 9	33 71 09	
	1	01	
	+	61	
	X≤Y	32 71	
070	GTO 3	22 03	
	GSB B	31 22 12	
	RCL 9	34 09	
	÷	81	
	RTN	35 22	
	LBL 4	31 25 04	Cuando x∈N
	1	01	
	−	51	
	n!	35 81	
	RTN	35 22	
080	LBL C	31 25 13	Γ(x) rango extendido
	SF 2	35 51 02	
	GSB B	31 22 12	
	RCL A	34 11	Pasa a 6 cifras decimales
	÷	81	
	INT	31 83	
	LAST X	35 82	
	FRAC	32 83	
	10^x	32 53	
	PAUSE	35 72	Presentación
090	X≥Y	35 52	
	DSP 0	23 00	
	PAUSE	35 72	
	RCL B	34 12	
	GSB C	31 22 15	
	X≥Y	35 52	
	RTN	35 22	
	LBL E	31 25 15	Para fijar DSP
	STO B	33 12	
	ST I	35 33	
100	DSP (i)	23 24	
	R↓	35 53	
	RTN	35 22	
	LBL D	31 25 14	Para n! extend.
	1	01	
	+	61	
	X<0	31 71	No permite n<0 ó n≠int(n)
	GTO B	22 12	
	ENTER↑	41	
	INT	31 83	
110	X≠Y	32 61	
	CHS	42	
	GTO C	22 13	

REGISTERS

0 OCUPADO	1 1/12	2 −1/360	3 1/1260	4 −1/1680	5 1/1188	6 −691/360360	7 1/156	8 $L\sqrt{2\pi}$	9 OCUPADO
S0 [redacted]	S1	S2	S3	S4	S5	S6	S7	S8	S9

A 2,302585093	B OCUPADO	C	D	E	I OCUPADO

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
				170			
120							
				180			
130							
				190			
140							
				200			
150							
				210			
160							
				220			

LABELS

A T(x)	B T(x) (r)	C T(x) ext	D n! ext	E DSP ?	0
a	b	c	d	e	1
) $\Sigma \frac{1}{x^2} R_i$	1 Ciclo	2 Ciclo	3	4 x entero	2 extendidos
5	6	7	8	9	3

FLAGS

	ON	OFF
0	☒	☐
1	☒	☐
2	☒	☐
3	☒	☐

SET STATUS

TRIG

- DEG ☒
- GRAD ☐
- RAD ☐

DISP

- FIX ☒
- SCI ☐
- ENG ☐
- n 6

Program Description

Program Title FUNCION GAMMA

Name FERNANDO DEL REY GARCIA **Date** 28-II-77

Address

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

Program Description, Equations, Variables, etc.

Calcula la función $\Gamma(x)$ mediante la fórmula aproximada:

$$L\Gamma(x) = (x-\tfrac{1}{2})Lx - x + L\sqrt{2\pi} + \frac{1}{12x} - \frac{1}{360x^3} + \frac{1}{1260x^5} - \frac{1}{1680x^7}$$

$$+ \frac{1}{1188x^9} - \frac{691}{360360x^{11}} + \frac{1}{156x^{13}}$$ y la relación $x.\Gamma(x) = \Gamma(x+1)$

En el apartado A calcula $\Gamma(x)$ siempre entre 5 y 6 que es donde tiene más precisión el desarrollo y luego la llera por la fórmula de recurrencia hasta el valor deseado.

En B calcula $\Gamma(x)$ directamente con el desarrollo y por ello es más rápido y de menor precisión.

En C calcula la función $\Gamma(x)$ con rango extendido. Para números muy grandes no se puede expresar la Γ en pantalla. Se pasa el logaritmo neperiano a decimal y de esta forma se obtiene que la parte entera es el exponente de 10 y la parte fraccionaria es el logaritmo de la parte que luego va multiplicada por 10^n

Ej. $L\Gamma(x) = n.m \rightarrow \Gamma(x) = \text{antilog}(m) \cdot 10^n$

En D se calcula $X!$ con rango extendido. Sólo sirve para números naturales.

En E se puede cambiar el número de decimales de presentación en pantalla.

Operating Limits and Warnings

A funciona para X cualquier siempre que este no sea al tiempo entero y ≤ 0 y $X \leq 70$

B funciona para $x > 0$, $x \leq 70$

C funciona para $x > 0$

D funciona para $x \in \mathbb{N}$

DO NOT USE THIS SPACE

User Instructions

RESOLUCION DEL SISTEMA $f(x,y)=0$ $g(x,y)=0$

$x_0 \uparrow y_0 \rightarrow$	$\rightarrow x_n, y_n$	PAUSE?	$f(x,y)$	$g(x,y)$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1º	Definir $f(x,y)$ y $g(x,y)$ en LBL D y E		GTO	D	
	pasando a PRGRM.				
2º	Indicar el número de decimales deseado		DSP	n	
3º	Introducir aproximaciones iniciales	x_0	↑		
		y_0	A		(x_n)
					(y_n)
4º	Si se desea ver x_n e y_n		C		
5º	Si se desea parar el programa manualmente,				
	espérese a una pausa, y entonces		C		
6º	Para seleccionar pausa, o no pausa		D		1, 0

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL A	31 25 11	
	STO 1	33 01	
	X≷Y	35 52	
	STO 0	33 00	
	GSB D	31 22 14	Calcula f(x,y)
	STO 2	33 02	
	STO 6	33 06	
	STO 7	33 07	
	RCL 1	34 01	
010	RCL 0	34 00	
	GSB E	31 22 15	Calcula g(x,y)
	STO 3	33 03	
	STO 8	33 08	
	STO 9	33 09	
	RCL 1	34 01	
	RCL 0	34 00	
	RCL 0	34 00	
	EEX	43	
	4	04	
020	÷	81	Calculo de Δx
	X=0	31 51	
	LAST X	35 82	
	STO 5	33 05	
	−	51	
	STO 4	33 04	
	GSB D	31 22 14	Calcula f(x-Δx,y)
	STO − 6	33 51 06	
	RCL 1	34 01	
	RCL 4	34 04	
030	GSB E	31 22 15	Calcula g(x-Δx,y)
	STO − 8	33 51 08	
	RCL 5	34 05	Deja terminadas
	STO ÷ 6	33 81 06	fx y gx en R6 y R8
	STO ÷ 8	33 81 08	
	RCL 1	34 01	
	RCL 1	34 01	
	EEX	43	
	4	04	Cálculo de Δy
	÷	81	
040	X=0	31 51	
	LAST X	35 82	
	STO 5	33 05	
	−	51	
	STO 4	33 04	
	RCL 0	34 00	
	GSB D	31 22 14	Cálculo de f(x,y-Δy)
	STO − 7	33 51 07	
	RCL 4	34 04	
	RCL 0	34 00	
050	GSB E	31 22 15	Calculo de g(x,y-Δy)
	STO − 9	33 51 09	
	RCL 5	34 05	
	STO ÷ 7	33 81 07	
	STO ÷ 9	33 81 09	
	RCL 3	34 03	RESOLUCION DEL
	RCL 7	34 07	SISTEMA

STEP	KEY ENTRY	KEY CODE	COMMENTS
	X	71	
	RCL 2	34 02	
	RCL 9	34 09	
060	X	71	
	−	51	
	RCL 6	34 06	
	RCL 9	34 09	
	X	71	
	RCL 7	34 07	
	RCL 8	34 08	
	X	71	
	−	−	
	STO 5	33 05	
070	÷	81	h calculada
	STO + 0	33 61 00	
	RND	31 24	
	X≠0	31 61	
	SF 2	35 51 02	
	RCL 2	34 02	
	RCL 8	34 08	
	X	71	
	RCL 3	34 03	
	RCL 6	34 06	
080	X	71	
	−	51	
	RCL 5	34 05	
	÷	81	K calculada
	STO + 1	33 61 01	
	RND	31 24	
	X≠0	31 61	
	SF 2	35 51 02	Enseña xi yi
	RCL 0	34 00	
	F? 1	35 71 01	
090	PAUSE	35 72	
	RCL 1	34 01	
	F? 1	35 71 01	
	PAUSE	35 72	
	F? 2	35 71 02	
	GTO A	22 11	
	LBL B	31 25 12	
	RCL 0	34 00	Enseña xn, yn
	− X −	31 84	
	RCL 1	34 01	
100	− X −	31 84	
	R/S	84	
	LBL C	31 25 13	
	F? 1	35 71 01	
	GTO 0	22 00	Seleccionar modo-
	SF 1	35 51 01	lidad de pausa.
	1	01	
	RTN	35 22	
	LBL 0	31 25 00	
	CF 1	35 61 01	
110	0	00	
	RTN	35 22	
	LBL D	31 25 14	

REGISTERS

0	1	2	3	4	5	6	7	8	9
Xn	Yn	f(x,y)	g(x,y)	x+Δx, y+Δy	Δx, Δy, δ	f_x	f_y	g_x	g_y
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
20			
30			
40			
50			
60			

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

LABELS

Calcule de x_n, y_n	B Enseñe x_n, y_n	C PAUSE?	D $f(x,y)$	E $g(x,y)$	0
	b	c	d	e	1
	1	2	3	4	2
	6	7	8	9	3

FLAGS

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☒	☐
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	____

Program Description

Program Title RESOLUCION DEL SISTEMA $f(x,y)=0$ $g(x,y)=0$

Name FERNANDO DEL REY GARCÍA **Date** 15-4-1978

Address

City State Zip Code

Program Description, Equations, Variables, etc.

Este programa resuelve sistemas de dos ecuaciones dadas de la forma $f(x,y)=0$ $g(x,y)=0$

Utiliza el método de Newton

$$x_n = x_{n-1} + h_{n-1} \qquad y_n = y_{n-1} + k_{n-1}$$

donde h_{n-1} y k_{n-1} se obtienen de

$$\left.\begin{aligned} f_x(x_{n-1},y_{n-1})h_{n-1} + f_y(x_{n-1},y_{n-1})k_{n-1} &= -f(x_{n-1},y_{n-1}) \\ g_x(x_{n-1},y_{n-1})h_{n-1} + g_y(x_{n-1},y_{n-1})k_{n-1} &= -g(x_{n-1},y_{n-1}) \end{aligned}\right\}$$

El usuario deberá introducir una aproximación inicial (x_0,y_0) que el programa irá mejorando hasta una precisión que depende del número de decimales en pantalla

Se hace $f_x = \dfrac{f(x,y)-f(x-\Delta x,y)}{\Delta x}$ $\qquad g_x = \dfrac{g(x,y)-g(x-\Delta x,y)}{\Delta x}$

$$f_y = \frac{f(x,y)-f(x,y-\Delta y)}{\Delta y} \qquad g_y = \frac{g(x,y)-g(x,y-\Delta y)}{\Delta y}$$

Operating Limits and Warnings

Si el sistema que se tiene que resolver para obtener h_{n-1} y k_{n-1} es singular, o casi singular, se obtendrá "Error". Se debe entonces probar si las últimas aproximaciones calculadas son suficientemente buenas o buscar nuevas aproximaciones iniciales.

DO NOT USE THIS SPACE

Program Submittal

☑ New Program

☐ Revision to Program No. _____

HP-67 Serial No. 1702503319 HP-97 Serial No. _____

Program Title 67-6X6 LINEAR SYSTEM SOLUTION

Keyword(s) Underlined in Title 1 6X6 SYSTEM

2 SOLUTION

No. of Steps 222

Category No. 0310

Category Name LINEAR SYSTEM/MATRICIES

Abstract-75 Word Maximum / no special symbols

THIS PROGRAM SOLVES A LINEAR SYSTEM OF 6 SIMULTANEOUS EQUATIONS IN 6 UNKNOWNS BY GAUSSIAN ELIMINATION

Name FERNANDO (First) DEL REY (Last)

Address PONIENTE 25

City MADRID Country SPAIN Postal Code 16

Acceptance Choice: ☑ Two Programs or ☐ One Program and 10 blank cards.

Submittal Checklist: Please use the checklist below to insure submittal of all the proper program documentation.

- ☑ Program Submittal
- ☑ Program Description I
- ☐ Program Description II
- ☐ User Instructions
- ☐ Program Form(s)
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Signature _____ Date _____

Program Description 1

Program Title 6 X 6 LINEAR SYSTEM SOLUTION

Contributor's Name FERNANDO DEL REY

Address PONIENTE 25

City MADRID **Country** SPAIN **Postal Code** 16

Program Description, Equations, Variables

This program calculates the solution of a system of 6 equations in 6 unknowns given as follows:

$$a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + a_{15}X_5 + a_{16}X_6 = b_1$$
$$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 = b_2$$
$$a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + a_{34}X_4 + a_{35}X_5 + a_{36}X_6 = b_3$$
$$a_{41}X_1 + a_{42}X_2 + a_{43}X_3 + a_{44}X_4 + a_{45}X_5 + a_{46}X_6 = b_4$$
$$a_{51}X_1 + a_{52}X_2 + a_{53}X_3 + a_{54}X_4 + a_{55}X_5 + a_{56}X_6 = b_5$$
$$a_{61}X_1 + a_{62}X_2 + a_{63}X_3 + a_{64}X_4 + a_{65}X_5 + a_{66}X_6 = b_6$$

It first reduces to an equivalent like this:

$$X_1 + a'_{12}X_2 + a'_{13}X_3 + a'_{14}X_4 + a'_{15}X_5 + a'_{16}X_6 = b'_1$$
$$X_2 + a'_{23}X_3 + a'_{24}X_4 + a'_{25}X_5 + a'_{26}X_6 = b'_2$$
$$X_3 + a'_{34}X_4 + a'_{35}X_5 + a'_{36}X_6 = b'_3$$
$$X_4 + a'_{45}X_5 + a'_{46}X_6 = b'_4$$
$$X_5 + a'_{56}X_6 = b'_5$$
$$X_6 = b'_6$$

where it calculates the values of X_6 through X_1 in this order by reversive sustitution. The coefficients of the reduced system can be found in registers R0-R9 R50-R54 as shown in the sketch

Operating Limits and Warnings

If the system has solution and you get an Error when entering the data, you should rearrange the order of the equations or the variables. The best way is to leave those equations that start with (more) 0's to the end, in case there are any.

When you input the value of b_6, make sure the number displayed in the X register lifts to the Y register.

Program Description 11

Sketch(es)

1		a'_{12}		a'_{13}		a'_{14}		a'_{15}		a'_{16}		b'_1			1		R_0		R_1		R_2		R_3		R_4		R_5
		1		a'_{23}		a'_{24}		a'_{25}		a'_{26}		b'_2			0		1		R_6		R_7		R_8		R_9		R_{10}
0		0		1		a'_{34}		a'_{35}		a'_{36}		b'_3	→		0		0		1		R_{11}		R_{12}		R_{13}		R_{14}
0		0		0		1		a'_{45}		a'_{46}		b'_4			0		0		0		1		R_{15}		R_{16}		R_{17}
0		0		0		0		1		a'_{56}		b'_5			0		0		0		0		0		R_{18}		R_{19}
0		0		0		0		0		1		b'_6			0		0		0		0		0		0		R_E

Sample Problem(s)

Find the solucion of the system.

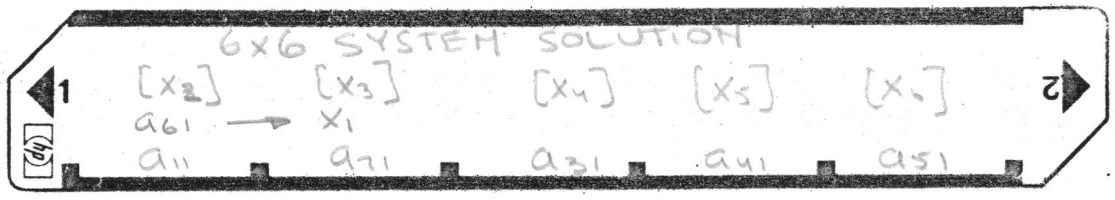
$$x_1 + 2x_2 + 3x_3 + x_4 + 2x_5 + 3x_6 = 19$$
$$2x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = 12$$
$$x_1 - x_2 + x_3 - x_4 + x_6 = 3$$
$$x_1 + x_2 + x_3 = 6$$
$$x_1 + 2x_4 + x_5 + x_6 = 1$$
$$x_3 + x_4 - 3x_5 + x_6 = 1$$

Solution(s)

1 [A] 2 [R/S] 3 [R/S] 1 [R/S] 2 [R/S] 3 [R/S] 19 [R/S]
2 [B] 1 [R/S] 1 [R/S] 1 [R/S] 1 [R/S] 1 [R/S] 12 [R/S]
1 [C] -1 [R/S] 1 [R/S] -1 [R/S] 0 [R/S] 1 [R/S] 3 [R/S]
1 [D] 1 [R/S] 1 [R/S] 0 [R/S] 0 [R/S] 0 [R/S] 6 [R/S]
1 [E] 0 [R/S] 0 [R/S] 2 [R/S] 1 [R/S] 1 [R/S] 1 [R/S]
0 [F] [A] 0 [R/S] 1 [R/S] 4 [R/S] -3 [R/S] 1 [R/S] 1 [R/S] →
→ 4.53 (x_1) [RCL] [A] → 10.13 (x_2) [RCL] [B] → -3.67 (x_3)
[RCL] [C] → -5.00 (x_4) [RCL] [D] → -5.80 (x_5) [RCL] [E] → 12.27 (x_6)

Reference(s)

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2			
2	Input data from the first five equations input first coefficient of the line	a_{i1}	K	
	input a_{i2} through a_{i6}	a_{ij}	R/S	
	input b_i	b_i	R/S	
	Repeat this step for $i=1$ through 5 where K=A for i=1 K=B for i=2 K=C for i=3 K=D for i=4 K=E for i=5			
3	Input last equation and find solution input a_{61}	a_{61}	f A	
	input a_{62} through a_{66}	a_{6j}	R/S	
	input b_6	b_6	R/S	X_1
			RCL A	X_2
			RCL B	X_3
			RCL C	X_4
			RCL D	X_5
			RCL E	X_6
4	In case of mistake you can clear last input a_{ij} or b_i doing as follows.			
	To clear a_{ij} when $i \leq j$ you should start the line again			
	To clear a_{ij} when $i > j$ or b_i do [f][CDS7] and then input again the correct value of a_{ij} or b_i			

SISTEMA DE 6 ECUACIONES

```
* LBL A
  CL REG
  CF 0
  CF 1
  CF 2
  STO E
* LBL 0
  R/S
  GSB 8
10 GTO 0

* LBL B
  STO A
  R/S
  RCL 0
  RCL A
  GSB 9
  RCL 6
  RCL B
  GSB 9
  F? 0
  RTH
  STO E

* LBL 1
  R/S
20 5
* LBL 6
  GSB 5
  RCL (i)
  RCL A
  GSB 9
  5
  GSB 7
  F? 0
  GTO d
30 GSB 8
  GTO 1

* LBL C
  STO A
  R/S
  RCL 0
  RCL A
  GSB 9
40 RCL 1
  RCL A
  GSB 9
  RCL 6
  RCL B
  GSB 9
  F? 0
  RTH
  STO E
  SF 0
50 LBL 2
  R/S
  9
  GTO 6
* LBL d
  RCL (i)
  RCL B
  GSB 9
  4
  GSB 7
60 F? 1
  GTO d
  GSB 8
  GTO 2

* LBL D
  GSB C
  STO C
  R/S
  RCL 2
  RCL A
70 GSB 9
  RCL 7
  RCL B
  GSB 9
  P≠S
  RCL 1
  P≠S
  RCL C
  GSB 9
  F? 1
80 RTH
  STO E
  SF 1
* LBL 3
  R/S
  1
  2
  GTO 6
  LBL d
  RCL (i)
90 RCL E
  GSB 9
  3
  GSB 7
  F? 2
  GTO d
  GSB 8
  GTO 3

* LBL E
  GSB D
100 STO D
  R/S
  RCL 3
  RCL A
  GSB 9
  RCL 8
  RCL B
  GSB 9
  P≠S
  RCL 2
110 RCL C
  GSB 9
  RCL 5
  RCL D
  GSB 9
  P≠S
  F? 2
  GTO e
  STO E
* LBL 4
120 R/S
  CF 3
  1
  4
  SF 2
  GTO 6
* LBL d
  RCL (i)
  RCL D
  GSB 9
130 RCL 1
  GSB 7
  F? 3
  RTH

* LBL a
  SF 2
  GTO E
* LBL e
140 STO E
  R/S
  RCL 4
  RCL A
  GSB 9
  RCL 9
  RCL B
  GSB 9
  P≠S
  RCL 3
150 RCL C
  GSB 9
  RCL 6
  RCL D
  GSB 9
  P≠S
  RCL 8
  RCL E
  GSB 9
  RCL 7
  GSB 9
160 SF 3
  SF 2
  1
  5
  GSB 6
  RCL (i)
  RCL E
  GSB 9
  X≠Y
  ÷
170 STO E

GSB b
  STO D
  CF 0
  GSB b
  STO C
  CF 1
  SF 2
  GSB b
  STO B
180 SF 3
  GSB b
  STO A
  P≠S
* LBL b
  RCL (i)
  DSZ
  RCL E
  GSB C
  F? 0
  RTH
190 RCL D
  GSB C
  F? 1
  RTH
  RCL C
  GSB C
  F? 2
  RTH
  RCL B
  GSB C
200 F? 3
  RTH
  RCL A

* LBL C
  RCL (i)
  DSZ
* LBL 9
  X
  -
  RTH
210 LBL 8
  RCL E
  ÷
  STO (i)
  ISZ
  RTH
* LBL 5
  CHS
* LBL 7
  RCL I
220 +
  STI
  R↓
  RTN
```

ISZ
GSB 8
GTO 4

EUROPE

Program Submittal

☑ New Program

☐ Revision to Program No. _____

HP-67 Serial No. 1702503319 HP-97 Serial No. _____

Program Title (Underline 1 or 2 Keywords) 67 - POLYNOMIAL INTERPOLATION

Keyword(s) Underlined in Title 1 POLYNOMIAL

2 INTERPOLATION

No. of Steps _____

Category No. 03.09

Category Name _____

Abstract-75 Word Maximum / no special symbols

THIS PROGRAM CALCULATES THE POLYNOMIAL OF N-TH ORDER (2<=N<=4) PASSING THROUGH N+1 GIVEN POINTS AND EVALUATES Y(x) FOR NEW VALUES OF X

Name FERNANDO (First) DEL REY (Last)

Address PONIENTE 25

City MADRID Country SPAIN Postal Code 16

Acceptance Choice: ☐ Two Programs or ☐ One Program and 10 blank cards.

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Signature _____ Date _____

Program Description I

Program Title POLYNOMIAL INTERPOLATION

Contributor's Name FERNANDO DEL REY

Address PONIENTE 25

City MADRID Country SPAIN Postal Code 16

Program Description, Equations, Variables

This program calculates the polynomial of n-th order ($2 <= n <= 4$) passing through n+1 given points $(x_1, y_1)(x_2, y_2) \ldots (x_n, y_n)$. The coefficients of the polynomial are calculated and stored for evaluation of $y(x)$ for new values of x, where

$y(x) = ax^4 + bx^3 + cx^2 + dx + e$ given 5 points, or

$y(x) = bx^3 + cx^2 + dx + e$ given 4 points, or

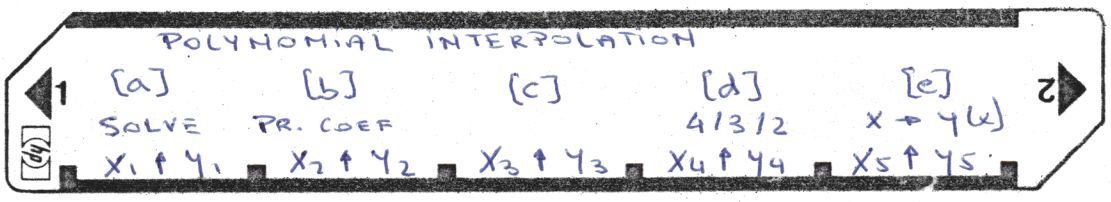
$y(x) = cx^2 + dx + e$ given 3 points

Operating Limits and Warnings

The program will not work if two points are entered with the same value of x

HP EUROPE

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load Side 1 and Side 2			
2	Select order of the polynomial		f E	4/3/2
	(order 4 when card loaded)			
3	Input points (xi, yi) *	X_1	↑	
		Y_1	A	X_1
		X_2	↑	
		Y_2	B	X_2
		X_3	↑	
		Y_3	C	X_3
	Only if necessary →	X_4	↑	
		Y_4	D	X_4
	Only if necessary →	X_5	↑	
		Y_5	E	X_5
4	Calculate coefficients of the polynomial**		f A	(a).(b).c.d.e
5	Evaluate y(x) for new values of x	X	f E	y(x)
6	Optional: if you want to see the coefficients again, after they were calculated**		f B	(a).(b).c.d.e

*Note: Points can be changed independently at any time and will remain stored until changed. (X_5, Y_5) ~~this~~ not used in ~~3~~ order 2 ~~or~~ 3 polynomials. (X_4 Y_4) is not used in order 2 polynomials.

~~**Note: The value of a will not appear in order 2 or 3 polynomials. The value of 3 will not appear in order 2 polynomials.~~

**Note: Coefficient a does not exist for order 2 or 3 polynomials, and it will not appear. The same thing happens with b in order 2 polynomials.

Coefficients a through e are stored in registers R_A - R_E

VERSION ANTIGUA

```
LBL A
1
GTO 8
LBL B
3
GTO 8
LBL C
5
GTO 8
LBL D
7
GTO 8
LBL E
9
LBL 8
STI
R↓
STO(i)
X≷Y
DSZ
SPACE
STO(i)
RTN
LBL a
CLX
STI
GSB 9
STO D
GSB 9
STO A
F?1
GTO 5
GSB 9
STO B
F?0
GTO 1
GSB 9
RCL B
RCL 8
RCL 4
GSB 0
STO E
LBL 1
RCL B
RCL A
RCL 6
RCL 2
GSB 0
ST I
LBL 5

RCL A
RCL D
RCL 4
RCL 0
GSB 0
F?1
GTO 3
RCL E
RCL I
RCL 8
RCL 2
RCL 0
GSB 0
RCL B
RCL 8
RCL 0
GSB 0
LBL 3
F?0
CLX
STO A
F?1
STO B
RCL 6
X
RCL B
-
RCL 4
X
RCL C
+
RCL 7
X
RCL D
-
RCL 0
X
RCL 1
+
STO E
RCL D
RCL C
RCL 0

RCL 2
+
STO D
ST I
GSB 6
RCL 4
RCL D
+
X≷I
RCL 4
X
RCL 2
RCL 0
GSB 7
STO D
RCL B
GSB 7
RCL D
RCL 6
X
RCL 0
RCL 2
X
RCL 4
GSB 7
RCL A
GSB 6
RCL D
X≷Y
STO D
R↓
RCL I
RCL 6
GSB 7
RCL A
X
RCL B
RCL I
GSB 6
RCL C
+
STO C
RCL B
RCL I
RCL 6
+
RCL A
GSB 6
STO B
LBL b

RCL A
F?0
X≠0
-X-
RCL B
F?1
X≠0
-X-
RCL C
-X-
RCL D
-X-
RCL E
-X-
RTN
LBL 9
RCL(i)
ISZ
ISZ
RCL(i)
DSZ
F?3
GTO 9
SF 3
R↓
R↓
LBL 0
-
R↓
-
R↑
÷
RTN
LBL 7
CHS
LBL 7
X
+
RTN
LBL e
↑
↑
↑
RCL A
X
RCL B
+
X
RCL C
+

X
RCL D
+
X
RCL E
+
RTN
LBL d
F?0
GTO 8
SF 0
SF 1
2
RTN
LBL 8
F?1
GTO 8
CF 0
4
RTN
LBL 8
CF 1
3
RTN
```

POLINOMIOS DE COLOCACION GRADOS 2.3.4

RESOLV. → COEFIC 2/3/4 x → P(x)

x_0	y_0	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4

EUROPE

Program Submittal

☑ New Program

☐ Revision to Program No. [ ]

HP-67 Serial No. [1702503319] HP-97 Serial No. [ ]

Program Title [67 - SOLUTION TO A SYSTEM OF]
Underline 1 or 2 Keywords [LINEAR EQUATIONS]

Keyword(s) 1 [LINEAR]
Underlined in Title 2 [EQUATIONS]

No. of Steps [ ]

Category No. [0310]

Category Name [LINEAR SYSTEMS / MATRICES]

Abstract-75 Word Maximum / no special symbols

THIS PROGRAM CAN SOLVE SYSTEMS OF UP TO 7 LINEAR EQUATIONS BY GAUSSIAN ELIMINATION. THIS IS A ONE CARD PROGRAM. NO EXTRA DATA CARDS ARE NEEDED.

Name FERNANDO (First) DEL REY (Last)

Address PONIENTE 25

City MADRID Country SPAIN Postal Code 16

Acceptance Choice: ☑ Two Programs or ☑ One Program and 10 blank cards.

[ ] [ ]

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Signature _____ Date _____

Program Description I

Program Title _____

Contributor's Name _____

Address _____

City _____ Country _____ Postal Code _____

Program Description, Equations, Variables

THIS PROGRAM WORKS WITH THE GAUSSIAN ELIMINATION METHOD. AFTER EACH EQUATION IS INPUT THE PROGRAM ELIMINATES SOME UNKNOWNS FROM IT USING PREVIOUS EQUATIONS AND THEN ELIMINATES ONE UNKNOWN FROM ALL PREVIOUS EQUATIONS. THE SYSTEM IS ENTERED AS:

$$A_{11}X_1 + A_{12}X_2 + \dots + A_{1N}X_N = B_1$$
$$A_{21}X_1 + A_{22}X_2 + \dots = B_2$$
$$\vdots$$
$$A_{N1}X_1 + A_{N1}X_2 + \dots + A_{NN}X_N = B_N$$

AND IS TRANSFORMED BY THE PROGRAM TO THE EQUIVALENT

$$X_1 = B'_1$$
$$X_2 = B'_2$$
$$\vdots$$
$$X_N = B'_N$$

NORMAL OPERATION TIME DEPENDS ON THE NUMBER OF EQUATIONS:

1 -
2 -
3 -
4 -
5 -
6 -
7 - 17"

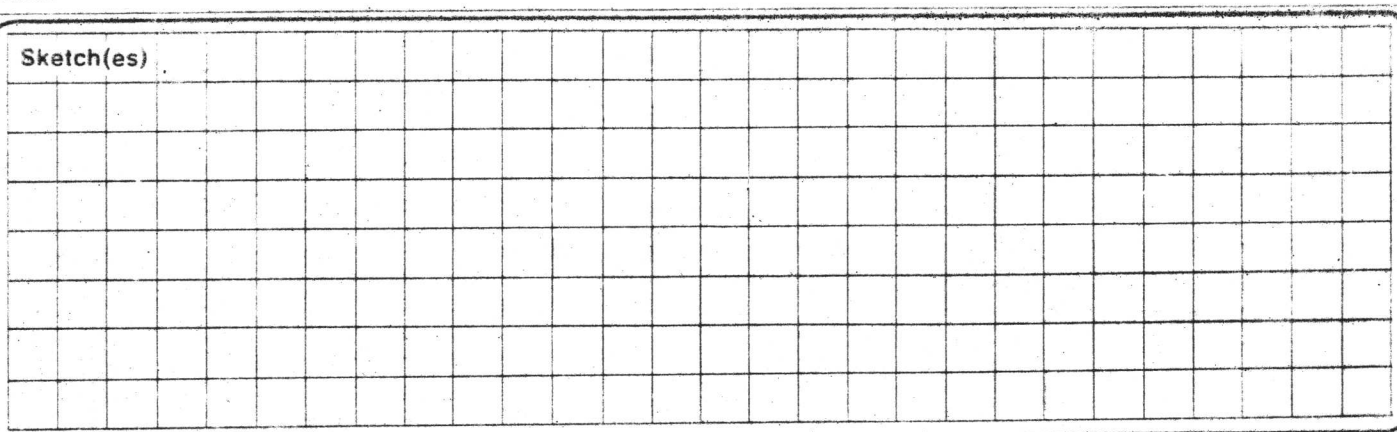
Operating Limits and Warnings

THE SYSTEM MUST HAVE A SINGLE SOLUTION. OTHERWISE YOU WILL GET "Error" IN THE DISPLAY DURING OPERATION.

SOMETIMES YOU CAN GET THE "Error" EVEN IF THE SYSTEM HAS A SINGLE SOLUTION, BUT THIS CAN BE SOLVED BY ENTERING A NEW EQUATION AND LEAVING THE ONE YOU ENTERED BEFORE THE "Error" TO ENTER IT AGAIN LATER.

Program Description 11

Sketch(es)



Sample Problem(s) Solve the system

$3X_1 + 2X_2 - X_3 + 4X_4 - 2X_5 - X_6 - X_7 = 3$ $\quad X_1 = 1,3881$

$0X_1 - 1X_2 + 0X_3 - X_4 + X_5 - 2X_6 - X_7 = -1$ $\quad X_2 = 1,0926$

$2X_1 + 0X_2 + 0X_3 - 2X_4 + 2X_5 + 2X_6 + X_7 = 6$ $\quad X_3 = -0,8082$

$3X_1 - X_2 + X_3 - 2X_4 - 2X_5 + 4X_6 + X_7 = 1$ $\quad X_4 = -0,2253$

$0X_1 + 0X_2 - X_3 + X_4 + X_5 + X_6 - X_7 = -1$ $\quad X_5 = 0,8802$

$2X_1 - 3X_2 + 2X_3 + X_4 + X_5 - X_6 + X_7 = 1$ $\quad X_6 = -0,4834$

$0X_1 + 0X_2 + 0X_3 - 3X_4 - 3X_5 + 4X_6 + 5X_7 = 6$ $\quad X_7 = +1,9796$

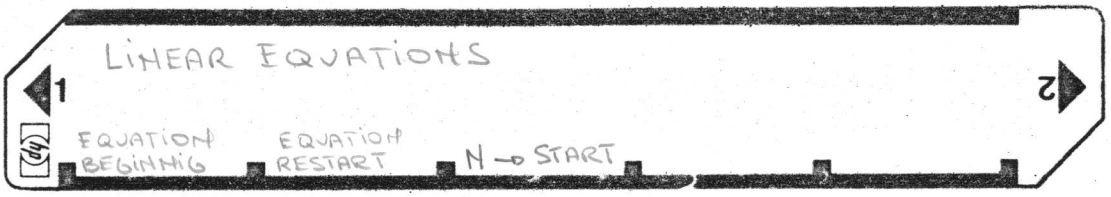
Solution(s) You will find solutions in Register R_1 through R_7

$X_1 = 1,3881$ $\quad X_2 = 1,0926$ $\quad X_3 = -0,8082$ $\quad X_4 = -0,2253$

$X_5 = 0,8802$ $\quad X_6 = -0,4834$ $\quad X_7 = 1,9796$

TIME 15' 30"

Reference(s)



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	LOAD SIDE 1 AND SIDE 2			
2	INPUT NUMBER OF EQUATIONS AND START PROGRAM	N	C	
3	INPUT FIRST COEFFICIENT OF EQUATION	A_{K1}	A	
4	INPUT ALL OTHER COEFFICIENTS	A_{KJ}	R/S	
	REPEAT STEP 4 FOR J=2 THROUGH N			
5	INPUT SECOND MEMBER OF EQUATION	B_K	R/S	K
	REPEAT STEPS 3,4,5 FOR K=1 THROUGH N			
6	FIND SOLUTIONS		RCL K	X_K
	REPEAT STEP 6 FOR K=1 THROUGH			
7	IF YOU MAKE A MISTAKE WHILE ENTERING			
	AN EQUATION YOU MUST RESTART TO ENTER			
	THE SAME EQUATION FROM THE FIRST COEFFICIENT	A_{K1}	B	
	AND THEN GO TO STEP 4			
	NOTE: YOU MAY GET "Error" IN THE DISPLAY			
	WHILE THE CALCULATOR IS OPERATING. YOU			
	MUST THEN LEAVE THE LAST EQUATION ENTER			
	ED TO BE ENTERED LATER AND START WITH			
	THE NEXT ONE.	$A_{K+1,1}$	B	
	GO TO STEP 4			
	IF THE "Error" HAPPENS AFTER LAST			
	EQUATION HAS BEEN ENTERED THEN IT			
	MEANS THAT THE SYSTEM DOES NOT HAVE			
	A SINGLE SOLUTION			

Program Listing 1

Page of

STEP	KEY ENTRY	KEY CODE	COMMENTS
001 *	LBL A	31 25 11	Input first coefficient
	.	83	
	1	01	
	STO+0	33 61 00	
	R↓	35 53	
*	LBL B	31 25 12	Input first coefficient (Restart)
	STO E	33 15	
	GSB e	32 22 15	
*	LBL 6	31 25 06	
010	2	02	
	4	04	
	X=Y	32 51	
	GTO 5	22 05	
	R/S	84	
	STO (i)	33 24	Input coefficients of the equation
	ISZ	31 34	
	RCL I	35 34	
	GTO 6	22 06	
*	LBL 5	31 25 05	
020	GSB 3	31 22 03	
	STO I	35 33	
*	LBL 4	31 25 04	
	R/S	84	Input coefficients of the equation
	STO (i)	33 24	
	GSB d	32 22 14	
	RCL I	35 34	
	ISZ	31 34	
	X≠Y	32 61	
	GTO 4	22 04	
030	RCL E	34 15	
	1	01	
	STO E	33 15	
	R↓	35 53	
*	LBL 1	31 25 01	Prepare for division by the pivot element. If it is zero there is no division.
	X=0	31 51	
	GTO 5	22 05	
	GSB 3	31 22 03	
	STO I	35 33	
	R↑	35 54	
040	GSB d	32 22 14	
	↑	41	
*	LBL 2	31 25 02	Division of the equation by the pivot element
	R↓	35 53	
	X≠Y	35 52	
	STO÷(i)	33 81 24	
	X≠Y	35 52	
	RCL I	35 34	
	ISZ	31 34	
	X≠Y	32 61	
050	GTO 2	22 02	
	R↓	35 53	
	R↓	35 53	
	GSB e	32 22 15	
*	LBL 0	31 25 00	
	2	02	
	4	04	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	−	51	
	X=0	31 51	
	GTO E	22 15	
060	R↓	35 53	Division by the pivot element
	STO÷(i)	33 81 24	
	ISZ	31 34	
	RCL I	35 34	
	GTO 0	22 00	
*	LBL E	31 25 15	Prepare for elimination. If it is the first equation there is no elimination
	GSB a	32 22 11	
	RCL E	34 15	
	X=Y	32 51	
	GTO E	22 15	
070	1	01	
	−	51	
	GSB b	32 22 12	
	GSB D	31 22 14	
	X	71	
	STO I	35 33	
	ISZ	31 34	
	RCL D	34 14	Elimination of unknowns
	RCL (i)	34 24	
	−	51	
080	STO D	33 14	
	ISZ	31 34	
	GSB d	31 22 14	
	GSB 3	31 22 03	
*	LBL c	32 25 13	
	RCL (i)	34 24	
	ISZ	31 34	
	X≥Y	35 52	
	X≥I	35 24	Elimination of unknowns
	X≥Y	35 52	
090	STO − (i)	33 51 24	
	ISZ	31 34	
	R↓	35 53	
	X≥I	35 24	
	X≤Y	32 71	
	GTO c	22 31 13	
*	LBL 5	31 25 05	
	RCL E	34 15	
	1	01	
	+	61	
100	STO E	33 15	
	GSB e	32 22 15	
	+	61	
	2	02	
	−	51	
	STO I	35 33	
	2	02	
	4	04	
	X=Y	32 51	
	Sin-1	32 62	Display "Error"
110	RCL (i)	34 24	
	GTO 1	22 01	Go for a new division and elimination.
*	LBL e	32 25 15	

REGISTERS

0 N.U	1 Used	2 Used	3 Used	4 Used	5 Used	6 Used	7 Used	8 Used	9 Used
S0 Used	S1 Used	S2 Used	S3 Used	S4 Used	S5 Used	S6 Used	S7 Used	S8 Used	S9 Used
A Used	B Used	C Used	D Used	E Used					

Program Listing II

Page of

STEP	KEY ENTRY	KEY CODE	COMMENTS
	2	02	These subroutines take care of the correct use of storage registers
	5	05	
	GSB D	31 22 14	
	STO I	35 33	
	RTN	35 22	
*	LBL d	32 25 14	
	GSB 3	31 22 03	
120	GSB b	32 22 12	
	+	61	
	2	02	
	−	51	
*	LBL D	31 25 14	
	GSB a	32 22 11	
	−	51	
	RTN	35 22	
*	LBL 3	31 25 03	
	GSB b	32 22 12	
130	GSB a	32 22 11	
	−	51	
	LAST x	35 82	
	1	01	
	−	51	
	X	71	
	1	01	
	+	61	
	RTN	35 22	
*	LBL E	31 25 15	Start back elimination. There is no back elimination if it is the first equation
	STO C	33 13	
	1	01	
	X=Y	32 51	
	RTN	35 22	
	STO I	35 33	
	GSB 3	31 22 03	
	2	02	
	−	51	
	STO D	33 14	
	GSB b	32 22 12	
150	GSB D	31 22 14	
	STO B	33 12	
*	LBL 8	31 25 08	
	RCL (i)	34 24	
	STO E	33 15	
	ISZ	31 34	
	CF 0	35 61 00	
	GSB 7	31 22 07	Back elimination
	RCL D	34 14	
	RCL B	34 12	
160	−	51	
	STO D	33 14	
	X>0	31 81	
	GTO 8	22 08	
	RCL B	34 12	
	1	01	
	STO I	35 33	
	STO D	33 14	
	STO E	33 15	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	−	51	
170	STO B	33 12	
*	LBL 9	31 25 09	Reordering of storage registers after all elimination have been performed
	SF 0	35 51 00	
	GSB 7	31 22 07	
	LAST x	35 82	
	RCL C	34 13	
	X=Y	32 51	
	RTN	35 22	
	1	01	
	−	51	
180	RCL D	34 14	
	X=Y	32 51	
	GTO 9	22 09	
	1	01	
	+	61	
	STO D	33 14	
	GTO 9	22 09	
*	LBL 7	31 25 07	Common subroutine used for back elimination and reordering
	RCL I	35 34	
	RCL D	34 14	
190	+	61	
	X≷I	35 24	
	RCL (i)	34 24	
	X≷Y	35 52	
	X≷I	35 24	
	X≷Y	35 52	
	RCL E	34 15	
	X	71	
	STO − (i)	33 51 24	
	F? 0	35 71 00	
200	STO (i)	33 24	
	RCL I	35 34	
	ISZ	31 34	
	RCL B	34 12	
	÷	81	
	FRAC	32 83	
	X≠0	31 61	
	GTO 7	22 07	
	RTN	35 22	
*	LBL a	32 25 11	This subroutine tells who many equations have been entered
210	RCL 0	34 00	
	FRAC	32 83	
	1	01	
	0	00	
	X	71	
	RTN	35 22	
*	LBL b	32 25 12	N+2
	RCL 0	34 00	
	INT	31 83	
	2	02	
220	+	61	
	RTN	35 22	
*	LBL C	31 25 13	START. Enter number of equations
	STO 0	33 00	
	RTN	35 22	

LABELS

A EQ. Begun	B EQ Restart	C START	D Used	E Elimination	FLAGS: 0 Elim / Reord.
a K	b N+2	c Used	d Used	e Used	1
0 Used	1 Pivot division	2 Used	3 Used	4 Used	2
5 Used	6 Used	7 Used	8 Used	9 Reordering	3

SET STATUS

FLAGS	ON	OFF
0	☐	☐
1	☐	☐
2	☐	☐
3	☐	☐

TRIG: DEG ☐ GRAD ☐ RAD ☐

DISP: FIX ☒ SCI ☐ ENG ☐ n 4

EUROPE

Program Submittal

☑ New Program

☐ Revision to Program No. _____

HP-67 Serial No. 1702S03319 HP-97 Serial No. _____

Program Title 6,7-7 SIMULTANEOUS EQUATIONS IN 7 UNKNOWNS

Underline 1 or 2 Keywords

Keyword(s) 1 7

Underlined in Title 2 EQUATIONS

No. of Steps 221

Category No. 0310

Category Name LINEAR SYSTEMS/MATRICES

Abstract-75 Word Maximum / no special symbols THIS ONE CARD PROGRAM SOLVES SYSTEMS OF SEVEN LINEAR EQUATIONS IN SEVEN UNKNOWNS. NO EXTRA DATA CARDS ARE NEEDED.

Name FERNANDO (First) DEL REY (Last)

Address PONIENTE 25

City MADRID Country SPAIN Postal Code 16

Acceptance Choice: ☐ Two Programs or ☐ One Program and 10 blank cards.

Submittal Checklist: Please use the checklist below to insure submittal of all the proper program documentation.

- ☐ Program Submittal
- ☐ Program Description I
- ☐ Program Description II
- ☐ User Instructions
- ☐ Program Form(s)
- ☐ Magnetic Card(s)

ACKNOWLEDGMENT AND AGREEMENT

To the best of my knowledge, I have the right to contribute this program material without breaching any obligation concerning nondisclosure of proprietary or confidential information of other persons or organizations. I am contributing this program material on a nonconfidential nonobligatory basis to Hewlett-Packard Company ("HP") for inclusion in its program library, and I agree that HP may use, duplicate, modify, publish, and sell the program material, and authorize others to do so without obligation or liability of any kind. HP may publish my name and address, as the contributor, to facilitate user inquiries pertaining to this program material.

Signature _____ Date _____

HP EUROPE

Program Description I

Program Title 7 SIMULTANEOUS EQUATIONS IN 7 UNKNOWNS

Contributor's Name FERNANDO DEL REY

Address PONIENTE 25

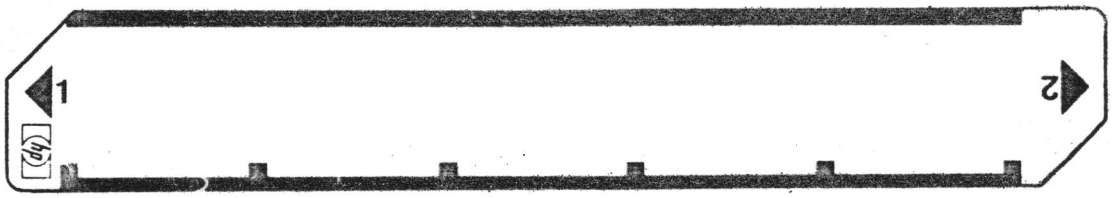
City MADRID **Country** SPAIN **Postal Code** 16

Program Description, Equations, Variables

THIS PROGRAM FINDS THE SOLUTIONS OF SYSTEMS OF 7 EQUATIONS IN 7 UNKNOWNS

Operating Limits and Warnings

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS

Program Listing 1

Page of

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL A	31 25 11	
	1	01	
	STO+0	33 61 00	
	R↓	35 53	
	* LBL B	31 25 12	
	STO E	33 15	
	2	02	
	5	05	
	RCL 0	34 00	
010	−	51	
	STO I	35 33	
	* LBL 6	31 25 06	
	2	02	
	4	04	
	X=Y	32 51	
	GTO 5	22 05	
	R/S	84	
	STO (i)	33 24	
	ISZ	31 34	
020	RCL I	35 34	
	GTO 6	22 06	
	* LBL 5	31 25 05	
	GSB e	32 22 15	
	STO I	35 33	
	* LBL 4	31 25 04	
	R/S	84	
	STO (i)	33 24	
	GSB d	32 22 14	
	RCL I	35 34	
030	ISZ	31 34	
	X≠Y	32 61	
	GTO 4	22 04	
	RCL E	34 15	
	1	01	
	STO E	33 15	
	R↓	35 53	
	* LBL 1	31 25 01	
	X=0	31 51	
	GTO a	22 31 11	
040	GSB e	32 22 15	
	STO I	35 33	
	R↓	35 53	
	GSB d	32 22 14	
	ENT↑	41	
	* LBL 2	31 25 02	
	R↓	35 53	
	X≷Y	35 52	
	STO ÷ (i)	33 81 24	
	X≷Y	35 53	
050	RCL I	35 34	
	ISZ	31 34	
	X≠Y	32 61	
	GTO 2	22 02	
	R↓	35 53	
	R↓	35 53	
	2	02	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	4	04	
	RCL 0	34 00	
	−	51	
060	RCL E	34 15	
	+	61	
	STO I	35 33	
	* LBL 0	31 25 00	
	2	02	
	4	04	
	−	51	
	X=0	31 51	
	GTO 3	22 03	
	R↓	35 53	
070	STO ÷ (i)	33 81 24	
	ISZ	31 34	
	RCL I	35 34	
	GTO 0	22 00	
	* LBL 3	31 25 03	
	RCL 0	34 00	
	RCL E	34 15	
	X=Y	32 51	
	GTO b	22 31 12	
	1	01	
080	−	51	
	9	09	
	RCL 0	34 00	
	−	51	
	×	71	
	STO I	35 33	
	ISZ	31 34	
	RCL D	34 14	
	RCL (i)	34 24	
	−	51	
090	STO D	33 14	
	ISZ	31 34	
	GSB d	32 22 14	
	GSB e	32 22 15	
	* LBL c	32 25 13	
	RCL (i)	34 24	
	ISZ	31 34	
	X≷Y	35 52	
	X≷I	35 24	
	X≷Y	35 52	
100	STO − (i)	33 51 24	
	ISZ	31 34	
	R↓	35 53	
	X≷I	35 24	
	X≤Y	32 71	
	GTO c	22 31 13	
	* LBL a	32 25 11	
	RCL E	34 15	
	1	01	
	+	61	
110	STO E	33 15	
	2	02	
	3	03	

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

Program Listing 11

Page of

STEP	KEY ENTRY	KEY CODE	COMMENTS
	+	61	
	RCL 0	34 00	
	−	51	
	STO I	35 33	
	2	02	
	4	04	
	X=Y	32 51	
120	GTO E	22 15	
	RCL (i)	34 24	
	GTO 1	22 01	
	*LBL d	32 25 14	
	GSB e	32 22 15	
	7	07	
	+	61	
	RCL 0	34 00	
	−	51	
	RTN	35 22	
130	*LBL e	32 25 15	
	9	09	
	RCL 0	34 00	
	−	51	
	RCL 0	34 00	
	1	01	
	−	51	
	X	71	
	1	01	
	+	61	
140	RTN	35 22	
	*LBL b	32 25 22	
	1	01	
	X=Y	32 51	
	RTN	35 22	
	STO I	35 33	
	GSB e	32 22 15	
	2	02	
	−	51	
	STO D	33 14	
150	9	09	
	RCL 0	34 00	
	−	51	
	STO B	33 12	
	* LBL 8	21 25 08	
	RCL (i)	34 24	
	STO E	33 15	
	ISZ	31 34	
	*LBL 7	31 25 07	
	RCL I	35 34	
160	RCL D	34 14	
	+	61	
	X≷I	35 24	
	RCL (i)	34 24	
	X≷Y	35 52	
	X≷I	35 24	
	X≷Y	35 52	
	RCL E	34 15	
	X	71	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	STO − (i)	33 51 24	
170	RCL I	35 34	
	ISZ	31 34	
	RCL B	34 12	
	÷	81	
	FRAC	32 83	
	X≠0	31 61	
	GTO 7	22 07	
	RCL D	34 14	
	RCL B	34 12	
	−	51	
180	STO D	33 14	
	X>0	31 81	
	GTO 8	22 08	
	RCL B	34 12	
	1	01	
	STO I	35 33	
	STO D	33 14	
	−	51	
	STO B	33 12	
	*LBL 9	31 25 09	
190	RCL I	35 34	
	RCL D	34 14	
	+	61	
	X≷I	35 24	
	RCL (i)	34 24	
	X≷Y	35 52	
	X≷I	35 24	
	X≷Y	35 52	
	STO (i)	33 24	
	RCL I	35 34	
200	ISZ	31 34	
	RCL B	34 12	
	÷	81	
	FRAC	32 83	
	X≠0	31 61	
	GTO 9	22 09	
	LAST X	35 82	
	RCL 0	34 00	
	X=Y	32 51	
	RTN	35 22	
210	1	01	
	−	51	
	RCL D	34 14	
	X=Y	32 51	
	GTO 9	22 09	
	1	01	
	+	61	
	STO D	33 14	
	GTO 9	22 09	
	*LBL C	31 25 13	
220	CL REG	31 43	
	RTN	35 22	

LABELS

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

FLAGS

0
1
2
3

SET STATUS

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

RAICES DE POLINOMIOS

Dado un polinomio $P(x)=(a_n+ib_n)x^n+(a_{n-1}+ib_{n-1})x^{n-1}+\dots+(a_0+ib_0)$ este programa utiliza el algoritmo de Newton para determinar una raiz del polinomio. Una vez calculada se reduce el polinomio a otro de grado inferior y se vuelve a aplicar el algoritmo para determinar una nueva raiz. El proceso se va repitiendo hasta que todas las raices hayan sido determinadas.

Las ecuaciones utilizadas son las siguientes:

Algoritmo de Newton: Partiendo de una aproximación x_0 a la raiz, se obtiene la siguiente aproximación x_1 por la expresión

$$x_1 = x_0 - \frac{P(x_0)}{P'(x_0)}$$

El algoritmo se repite sucesivas veces hasta que se considera que se ha alcanzado un valor aceptable. Mas adelante se describe el criterio de convergencia empleado y como modificarlo.

$P(x)$ y $P'(x)$ se evaluan de la siguiente forma:

$$P(x) = (\dots((a_n+ib_n)x + a_{n-1}+ib_{n-1})x + \dots + a_1+ib_1)x + a_0+ib_0$$

$$P'(x) = (\dots(n(a_n+ib_n)x + (n-1)(a_{n-1}+ib_{n-1}))x + \dots + 2(a_2+ib_2))x + a_1+ib_1$$

Una vez se ha determinado una raiz x_0, se reduce el polinomio a uno de grado $n'=n-1$. Los coeficientes del nuevo polinomio son:

$$a_{n'}+ib_{n'} = a_n+ib_n$$

$$a_{n'-1}+ib_{n'-1} = (a_n+ib_n)x_0 + (a_{n-1}+ib_{n-1})$$

$$\vdots$$

$$a_0'+ib_0' = (\dots((a_n+ib_n)x_0 + (a_{n-1}+ib_{n-1}))x + \dots + a_1+ib_1$$

Instrucciones de funcionamiento del programa:

	INPUTS	OUTPUTS
(1) Cargar el programa		
(2) Comentar	XEQ "POL"	GRADO ?
(3) Introducir grado del polinomio	n, R/S	an, bn ?
(4) Introducir todos los coeficientes del polinomio (k=n... 0)	ak ENTER bk R/S	ak-1, bk-1 ?
(5) Convergencia: se observa la convergencia hacia las sucesivas raices mientras corre el programa (k=n... 1)		[k : Pk(x)]
(6) Resultados: Parte real	R/S	R = parte real
Parte imaginaria	R/S	I = parte imaginaria

Se repite n veces para ir viendo parte real e imaginaria de las n raices

NOTAS: * : Puede cambiar en cualquier momento durante la salida de resultados el modo o número de digitos de presentación de los números en pantalla

* : Despues del apartado (3) puede aparecer un mensaje SIZE nnn. Quiere decir que la memoria reservada para datos no es suficiente. Deberá poner el SIZE indicado y reanudar el programa con R/S

* : Si hay una impresora conectada se recomienda poner esta en NORM. La salida de resultados será por impresora, se imprimiran todos los resultados seguidos, sin paradas y sin necesidad de pulsar R/S

* : Las soluciones quedan almacenadas en memorias a partir de R09

$$x_n \begin{cases} I_n \rightarrow R09 \\ R_n \rightarrow R10 \end{cases}$$

$$x_{n-1} \begin{cases} I_{n-1} \rightarrow R11 \\ R_{n-1} \rightarrow R12 \end{cases}$$

```
01♦LBL "POL"
02 FIX 0
03 CF 29
04 CF 01
05 SF 21
06 SF 00
07 "GRADO ?"
08 PROMPT
09 STO 00
10 STO 01
11 STO 03
12 2
13 *
14 10
15 +
16 STO 02
17 SF 25
18 RCL IND X
19 FS?C 25
20 GTO 00
21 1
22 +
23 "SIZE "
24 ARCL X
25 PROMPT
26♦LBL 00
27 ISG 02
28 X<>Y
29 RCL 02
30 STO 04
31♦LBL 01
32 "a"
33 ARCL 03
34 "├, b"
35 ARCL 03
36 "├ ?"
37 PROMPT
38 DSE 04
39 STO IND 04
40 X<>Y
41 DSE 04
42 STO IND 04
43 DSE 03
44 GTO 01
45 FS?C 00
46 GTO 01
47 1
48 STO 05
49 CHS
50 STO 06
51 CLX
52 CF 21
53♦LBL 12
54 RCL 01
55 +
56 STO 04
57 RCL 02
58 STO 03
59 CLX
60 ENTER↑
61♦LBL 10
62 STO L
63 RCL Y
64 RCL 05
65 ST* Z
66 ST* T
67 RDN
68 RCL 06
69 ST* Y
70 ST* L
71 X<> L
72 ST+ T
73 RDN
74 -
75 X<>Y
76 DSE 03
77 RCL IND 03
78 RCL 04
79 FS? 01
80 ST/ X
81 *
82 +
83 FS? 00
84 STO IND 03
85 X<>Y
86 DSE 03
87 RCL IND 03
88 RCL 04
89 FS? 01
90 ST/ X
91 *
92 +
93 FS? 00
94 STO IND 03
95 DSE 04
96 GTO 10
97 R-P
98 FS?C 01
99 GTO 05
100 STO 07
101 X<>Y
102 STO 08
103 SF 01
104 1
105 GTO 12
106♦LBL 05
107 FS?C 00
108 GTO 06
109 1 E-8
110 X>Y?
111 SF 00
112 RDN
113 FIX 0
114 CLA
115 ARCL 01
116 FIX 2
117 "├ : "
118 ARCL X
119 AVIEW
120 RCL 07
121 /
122 RCL 08
123 ST- Z
124 RDN
125 P-R
126 ST- 05
127 X<>Y
128 ST- 06
129 CLX
130 FS? 00
131 SF 01
132 GTO 12
133♦LBL 06
134 RCL 05
135 DSE 03
136 STO IND 03
137 RCL 06
138 DSE 03
139 STO IND 03
140 CHS
141 STO 06
142 FIX 4
143 RND
144 X=0?
145 ISG 06
146 CLX
147 DSE 01
148 GTO 12
149 2
150 ST- 02
151 SF 21
152♦LBL 03
153 ADV
154 "R="
155 DSE 02
156 RCL IND 02
157 ARCL X
158 AVIEW
159 "I="
160 DSE 02
161 RCL IND 02
162 ARCL X
163 AVIEW
164 DSE 00
165 GTO 03
166 ADV
167 .END.
```

CAT 1

LBL'POL
.END. 287 BYTES

REGISTROS

00 - n
01 } Auxiliares
02
03
04
05 } x (aproximación)
06
07 } P'(x)
08
09 a_0 ; I_n
10 b_0 ; R_n
11 a_1 ; I_{n-1}
12 b_1 ; R_{n-1}
⋮ ⋮

FLAGS

00 - Convergencia alcanzada
01 - Calcula P(x)

SIZE = 2n + 11

permite llegar hasta:

0 módulos → n = 6
1 " → n = 38
2 " → n = 70
3 " → n = 102
4 " → n = 134

PROGRAMA 287 Bytes =
= 41 Registros

Ejemplos

$$(2+5i)x^6 + (-1+2i)x^5 + (3-2i)x^4 + (4+0i)x^3 + (0-3i)x^2 + (4+i)x + (8-6i) = 0$$

	XEQ "POL"	
GRADO ?		R=1.1712
	6 RUN	I=0.4185
a6, b6 ?		
	2 ENTER↑	R=-0.4427
	5 RUN	I=-1.2277
a5, b5 ?		
	-1 ENTER↑	R=-0.6436
	2 RUN	I=0.5933
a4, b4 ?		
	3 ENTER↑	R=-1.2475
	-2 RUN	I=-0.2261
a3, b3 ?		
	4 ENTER↑	R=0.3037
	0 RUN	I=0.9661
a2, b2 ?		
	0 ENTER↑	R=0.5830
	-3 RUN	I=-0.8344
a1, b1 ?		
	4 ENTER↑	
	1 RUN	
a0, b0 ?		
	8 ENTER↑	
	-6 RUN	

$$x^7 - 6x^6 + 0x^5 - 4x^4 + 3x^3 - 2x^2 + 1x + 6 = 0$$

	XEQ "POL"	R=6.0956
GRADO ?		I=-7.6215E-11
	7 RUN	
a7, b7 ?		R=0.9728
	1 ENTER↑	I=1.7622E-10
	0 RUN	
a6, b6 ?		R=-0.5637
	-6 ENTER↑	I=-0.9936
	0 RUN	
a5, b5 ?		R=-0.5637
	0 ENTER↑	I=0.9936
	0 RUN	
a4, b4 ?		R=-0.7648
	-4 ENTER↑	I=1.4681E-11
	0 RUN	
a3, b3 ?		R=0.4119
	3 ENTER↑	I=0.9187
	0 RUN	
a2, b2 ?		R=0.4119
	-2 ENTER↑	I=-0.9187
	0 RUN	
a1, b1 ?		
	1 ENTER↑	
	0 RUN	
a0, b0 ?		
	6 ENTER↑	
	0 RUN	

Comentarios sobre el programa

- El criterio de convergencia es que $|p(x)| < 10^{-8}$. Puede cambiarse el valor 10^{-8} por un número mayor o menor, según se desee precisión en las soluciones. Basta cambiar el paso 109

Otro criterio apropiado de convergencia consiste en que la diferencia entre dos aproximaciones sucesivas sea menor que un determinado valor.

$$X_1 = X_0 - \frac{P(X_0)}{P'(X_0)} \quad ; \quad X_0 - X_1 = \frac{P(X_0)}{P'(X_0)} = \Delta x$$

Si por ejemplo queremos establecer el criterio $|\Delta x| < 10^{-8}$ basta con insertar detrás del paso 124 la secuencia de pasos:

```
1 E-8
X>Y ?
SF 00
RDN
```

A continuación se quita esta misma secuencia de los pasos 109 al 112.

Este último criterio parece más apropiado que el utilizado en el programa, pero se ha encontrado que da problemas cuando existen raíces múltiples

- Si en algún caso el programa no consigue alcanzar la convergencia por sí mismo, puede probarse a ver si dándole una aproximación a la solución de forma manual se consigue que así converja. Para ello basta con parar el programa, y teclear lo siguiente:

```
Xr (parte real)      STO 05 }
Xi (parte imaginaria) STO 06 } (nueva aproximación)
                     CF 01 (sólo si está puesto)
                     CLX
                     XEQ 12
```

REGRESION LINEAL MULTIPLE

POLINOMIO DE REGRESION

Dado una serie de puntos $(x_1, x_2, x_3 \ldots x_n, y)$ el programa calcula una linea $y = A_0 + A_1x_1 + A_2x_2 + \ldots + A_nx_n$ que trata de ajustarse a los puntos dados. El método utilizado es el de minimos cuadrados, según el cual los coeficientes se determinan resolviendo el sistema:

$$A_0 \cdot N + A_1 \Sigma x_1 + \ldots\ldots + A_N \Sigma x_n = \Sigma y$$

$$A_0 \Sigma x_1 + A_1 \Sigma x_1^2 + \ldots\ldots + A_N \Sigma x_1 x_n = \Sigma x_1 y$$

$$\vdots \qquad \vdots \qquad \qquad \vdots \qquad \qquad \vdots$$

$$A_0 \Sigma x_n + A_1 \Sigma x_n x_1 + \ldots\ldots + A_N \Sigma x_n^2 = \Sigma x_n y$$

N = número de puntos.

Un caso particular de esto es el polinomio de regresión: dado una serie de puntos (x, y) se trata de ajustar un polinomio de grado n $y = a_0 + a_1x + \ldots a_nx^n$ a los puntos dados. Este caso se reduce al anterior haciendo: $x_i = x^i$.

Para resolver el sistema, el programa invierte la matriz de coeficientes y la multiplica por la columna de términos independientes. Si después de calcular los A_i se desea añadir nuevos puntos, o quitar alguno, el programa reinvierte la matriz antes de seguir adelante.

Para la inversión de matrices se utiliza el método del intercambio, descrito en el programa "Inversión de Matrices" de esta misma colección.

Instrucciones de funcionamiento del programa

	INPUTS	OUTPUTS
(1) Cargar el programa		
(2) Ponerlo en marcha	XEQ "RLM"	LIN ?
(3) Si se desea regresión lineal multiple Ir al paso (6)	R/S	(LIN)
(4) Si se desea polinomio de regresión	N R/S	(POL)
(5) Indicar el grado del polinomio Ir al paso (8)	n (grado) R/S	GRADO?
(6) Indicar el nº de variables x Ir al paso (10)	n R/S	N. VAR x?
(7) Para introducir nuevos puntos (pol)	A	
(8) Este paso se repite mientras no demos otra orden		(PUNTO k) X ?
	X_k R/S	Y ?
	Y_k R/S	
(9) Para quitar algún punto (pol)	B	(PUNTO) X ?
	X R/S	Y ?
	Y R/S	
Ir al paso (8)		
(10) Para introducir nuevos puntos (lin)	A	
(11) Este paso se repite mientras no demos otra orden		(PUNTO k) X1 ?
	$X1_k$ R/S	X2 ?
	⋮	Xn?
	Xn_k R/S	Y ?
	Y R/S	

(12) Para ajustar algún punto (lin) | B |

Ir al paso (11)

(13) Para calcular los coeficientes: | C |

(14) Para ver de nuevo los coeficientes calculados. | D |
Aparecen como en (13)

(15) Para hacer estimaciones $\hat{y}$ (pol) | E |

(16) Este paso se repite mientras no demos nueva orden

(17) Para hacer estimaciones $\hat{y}$ (lin) | E |

(18) Este paso se repite mientras no demos nueva orden

	(PUNTO)
	X1 ?
X1 |R/S|	X2 ?
X2 |R/S|	.
	.
	Xn ?
Xn |R/S|	Y ?
Y |R/S|	
	A_0 = _____
* |R/S|	A_1 = _____
* |R/S|	
	.
	A_N = _____
	X ?
X |R/S|	Y = _____
* |R/S|	
	X1 ?
X1 |R/S|	X2 ?
X2 |R/S|	.
	.
	Xn ?
Xn |R/S|	Y = _____
|R/S| *	

NOTA - Si los puntos dados no permiten determinar los coeficientes Ai, al intentar calcularlos el programa se detendrá con el mensaje ERROR.

* No hay que pulsar |R/S| cuando la impresora esté conectada.

```
01♦LBL "RLM"
02 SF 27
03 CF 29
04 SF 21
05 CLRG
06 FIX 0
07 "LIN ?"
08 CF 23
09 AON
10 PROMPT
11 AOFF
12 FC? 55
13 CF 21
14 ADV
15 FS? 23
16 GTO 47
17 "LIN"
18 AVIEW
19 PSE
20 CF 16
21 "N. VAR. X ?"
22 GTO 49
23♦LBL 47
24 "POL"
25 AVIEW
26 PSE
27 SF 16
28 "GRADO ?"
29♦LBL 49
30 PROMPT
31 1
32 +
33 STO 00
34 X↑2
35 RCL 00
36 2
37 *
38 +
39 10
40 +
41 SF 25
42 RCL IND X
43 FS?C 25
44 GTO 48
45 1
46 +
47 FIX 0
48 "SIZE "
49 ARCL X
50 PROMPT
51♦LBL 48
52 CF 00
53 RCL 00
54 XEQ 00
55 RCL 00
56 X↑2
57 LASTX
58 +
59 10
60 +
61 ENTER↑
62 ENTER↑
63 RCL 00
64 +
65 1
66 -
67 1 E3
68 /
69 +
70 STO 01
71 STO 09
72 GTO A
73♦LBL B
74 SF 17
75♦LBL A
76 FS?C 00
77 XEQ I
78 CF 00
79 FIX 0
80 RCL 10
81 1
82 +
83 FC? 55
84 CF 21
85 ADV
86 "PUNTO "
87 FC? 17
88 ARCL X
89 AVIEW
90 PSE
91 SF 21
92 RCL 09
93 STO 01
94 1
95 STO 02
96 STO IND 01
97 ISG 01
98 FS? 16
99 GTO 50
100♦LBL 51
101 "X"
102 ARCL 02
103 "⊢=?"
104 PROMPT
105 STO IND 01
106 ISG 02
107 X<>Y
108 ISG 01
109 GTO 51
110 GTO 53
111♦LBL 50
112 "X=?"
113 PROMPT
114 ENTER↑
115 ENTER↑
116 ENTER↑
117 1
118♦LBL 52
119 *
120 STO IND 01
121 ISG 02
122 X<>Y
123 ISG 01
124 GTO 52
125♦LBL 53
126 "Y=?"
127 PROMPT
128 STO IND 01
129 RCL 09
130 STO 01
131 1 E-3
132 +
133 STO 02
134 10
135 STO 03
136♦LBL 15
137 RCL IND 01
138 RCL IND 02
139 *
140 FS? 17
141 CHS
142 ST+ IND 03
143 ISG 03
144 CLX
145 ISG 01
146 GTO 15
147 RCL 09
148 STO 01
149 ISG 02
150 GTO 15
151 CF 17
152 GTO A
153♦LBL I
154 RCL 00
155 1
156 -
157 1 E3
158 /
159 STO 01
160 STO 05
161♦LBL 91
162 FS? IND 01
163 GTO 90
164 RCL 01
165 RCL 01
166 RCL 00
167 *
168 +
169 10
170 STO 06
171 STO 07
172 +
173 RCL IND X
174 X=0?
175 GTO 90
176 1/X
177 STO IND Y
178 STO 04
179 X<>Y
180 RCL 01
181 ST+ 07
182 -
183 RCL 05
184 STO 03
185 STO 02
186 +
187 STO 08
188♦LBL 04
189 RCL 02
190 RCL 01
191 X=Y?
192 GTO 07
193 RCL 03
194 X=Y?
195 GTO 06
196 RCL IND 08
197 RCL IND 07
198 *
199 RCL 04
200 *
201 ST- IND 06
202♦LBL 06
203 1
204 ST+ 06
205 ST+ 08
206 ISG 03
207 GTO 04
208 RCL 00
209 ST- 08
210♦LBL 05
211 ST+ 07
212 RCL 05
213 STO 03
214 ISG 02
215 GTO 04
216 GTO 14
217♦LBL 07
218 RCL 00
219 ST+ 06
220 GTO 05
221♦LBL 14
222 STO 06
223 RCL 00
224 ST* 06
225 RCL 01
226 ST+ 06
227 *
228 +
229 10
230 ST+ 06
231 +
232 STO 02
233♦LBL 08
234 RCL 01
235 RCL 03
236 X=Y?
237 GTO 09
238 RCL 04
239 ST* IND 06
240 CHS
241 ST* IND 02
242♦LBL 09
243 RCL 00
244 ST+ 06
245 ISG 02
246 X<>Y
247 ISG 03
248 GTO 08
249 SF IND 01
250 RCL 05
251 STO 01
252♦LBL 13
253 FC? IND 01
254 GTO 91
255 ISG 01
256 GTO 13
257 RCL 00
258♦LBL 00
259 CF IND X
260 DSE X
261 GTO 00
262 RTN
263♦LBL 90
264 ISG 01
265 GTO 91
266 "ERROR"
267 PROMPT
268♦LBL C
269 XEQ I
270 10
271 STO 03
272 RCL 09
273 STO 01
274 1.001
275 RCL 00
276 *
277 -
278 STO 02
279 STO 04
280 CLX
281♦LBL 01
282 RCL IND 02
283 RCL IND 03
284 *
285 +
286 ISG 03
287 STO 06
288 ISG 02
289 GTO 01
290 STO IND 01
291 RCL 04
292 STO 02
293 CLX
294 ISG 01
295 GTO 01
296♦LBL D
297 SF 21
298 ADV
299 CLX
300 STO 02
```

```
301 RCL 09
302 STO 01
303♦LBL 02
304 FIX 0
305 "A"
306 ARCL 02
307 "⊢="
308 FIX 4
309 ARCL IND 01
310 AVIEW
311 ISG 02
312 STO X
313 ISG 01
314 GTO 02
315 CLX
316 RTN
317♦LBL E
318 SF 21
319 FIX 0
320 ADV
321 RCL 09
322 STO 01
323 FS? 16
324 GTO 23
325 1
326 STO 02
327 RCL IND 01
328 STO 03
329 ISG 01
330♦LBL 25
331 "X"
332 ARCL 02
333 "⊢=?"
334 PROMPT
335 RCL IND 01
336 *
337 ST+ 03
338 ISG 02
339 X<>Y
340 ISG 01
341 GTO 25
342 RCL 03
343 GTO 24
344♦LBL 23
345 "X=?"
346 PROMPT
347 1/X
348 ENTER↑
349 ENTER↑
350 ENTER↑
351 RCL IND 01
352 ISG 01
353♦LBL 26
354 *
355 RCL IND 01
356 +
357 ISG 01
358 GTO 26
359 X<>Y
360 RCL 00
361 1
362 -
363 Y↑X
364 /
365♦LBL 24
366 FIX 4
367 "Y="
368 ARCL X
369 AVIEW
370 GTO E
371 .END.
```

CAT

LBL'RLM
.END. 644 BYTES

PROGRAMA = 644 Bytes = 92 Registros

SIZE = $(n+1)^2 + 2(n+1) + 11$

n = número de variables X , o bien
n = grado del polinomio

Se puede llegar hasta:

1 Módulo → n = 3
2 Módulos → n = 7
3 Módulos → n = 10
4 Módulos → n = 12

MEMORIAS

00 – n+1
01 ⎫
02 ⎪
03 ⎪
04 ⎪ Auxiliares
05 ⎪
06 ⎪
07 ⎪
08 ⎪
09 ⎭
10 – N
11 – Σx_i
12 ⎫
13 ⎪ Sumatorias
⋮ ⎭

FLAGS

00 → Matriz sin invertir / Matriz invertida
16 → Reg. lineal multiple / Polinomio de regresión
17 → $\Sigma +$ / $\Sigma -$

00 ÷ n+1 → utilizados por la subrutina de inversión de la matriz para ver las filas y columnas intercambiadas.

```
LBL A       RCL 2
SF 1        Sin
GTO 2       X<0
LBL B       GTO 1
CF 1        R↓
LBL 2       3
F? 1        6
H←          0
STO 2       X≷Y
Cos         −
X≷Y         ↑
F? 1        LBL 1
H←          R↓
STO 1       F? 1
Cos         →HMS
 X          PAUSE
X≷Y         RCL 3
F? 1        F? 1
H←          →HMS
STO 0       R/S
Cos
 X          R0  L
RCL 1       R1  d
Sen         R2  AHL
RCL 0       R3  Hc
Sen
 X
 +
Sen⁻¹
STO 3
 ↑
Sen
RCL 0
Sen
 X
RCL 1
Sen
X≷Y
 −
X≷Y
Cos
RCL 0
Cos
 X
 ÷
Cos⁻¹
```

TABLA DE REDUCCIÓN DE ALTURAS ASTRONÓMICAS

Calcula la altura Hc y azimut Zn de un astro dada el ángulo horario AHL, la latitud L de un observador y la declinación del astro d

Las latitudes y declinaciones son van con signo negativo

El ángulo del meridiano t puede ingresarse en vez de AHL, pero en tal caso los ángulos meridianos de oriente deben ingresarse como números negativos

$$Hc = \text{Sen}^{-1}\left[\text{Sen}\,d\,\text{Sen}\,L + \text{Cos}\,d\,\text{Cos}\,L\,(\text{Cos}\,AHL)\right]$$

$$Zn = \begin{cases} Z & \text{Sen } AHL < 0 \\ 360 - Z & \text{Sen } AHL \geq 0 \end{cases} \qquad Z = \text{Cos}^{-1}\left[\frac{\text{Sen}\,d - \text{Sen}\,L\,\text{Sen}\,Hc}{\text{Cos}\,L\,\text{Cos}\,Hc}\right]$$

Utilización

A) GRADOS EN FORMA G.MS
(los resultados también aparecen en forma G.MS)

L ↑ d ↑ AHL [A] → (Zn), Hc

[X≷Y] → Zn

B) GRADOS EN FORMA DECIMAL
(los resultados también aparecen en forma decimal)

L ↑ d ↑ AHL [B] → (Zn), Hc

[X≷Y] → Zn

C) OTRAS FORMA ANGULARES (Radianes, g. centesimales)

Seleccionar dichas formas angulares y trabajar como en B

REGRESION

```
LBL a
CL REG
P≥S
CL REG
CL X
RTN
LBL A
STO 1
X≥Y
STO 0
X≥Y
Σ+
GSB 0
Σ+
P≥S
RCL 0
STO + 3
RCL 1
STO + 2
RCL 9
RTN
LBL 0
R↓
LAST x
ENTER↑
STO x 0
X≥Y
LN x
STO x 1
X≥Y
P≥S
RTN
LBL B
STO 1
X≥Y
STO 0
X≥Y
Σ-
GSB 0

Σ-
P≥S
RCL 0
STO -3
RCL 1
STO -2
RCL 9
RTN
LBL A
RCL 9
RTN
LBL b
CF 0
CF 1
CLX
STO D
GSB 9
LBL E
RCL C
-x-
RCL A
-x-
RCL B
RTN
LBL 9
P≥S
RCL 8
RCL B
RCL 4
x
RCL 9
÷
F? 2
RTN
STO E
RCL 7
RCL 6
x²
RCL 9
÷
-
STO D
RCL 4
÷
STO C
RCL 4
RCL 6
RCL B
x
-
RCL 9
÷
e^x
STO A
P≥S
RTN
LBL c
1
STO D
CF 0
CF 1
SF 2
P≥S
GSB 9
P≥S
GTO E
LBL c
SF 0
CF 1
SF 2
3
ST I
GSB 1

÷
STO B
RCL E
x
RCL 5
RCL 4
x²
RCL 9
÷
-
÷
÷
STO C
RCL 4
RCL 6
RCL B
x
-
÷
F? 2
e^x
STO A
P≥S
RTN
ST (i)
RCL (i)
RCL (i)
x≥Y
STO (i)
LBL 3
P≥S
x≥Y
STO 8
GSB 3
RTN
LBL 2
RCL (i)
P≥S
RCL (i)
x≥Y
ST (i)
RTN
LBL d
CF 0
SF 1
2
ST I
GSB 1
6
ST I
GSB 4
2
ST I
GSB 1

GTO E
LBL 4
GSB 2
ISZ
GSB 2
ISZ
GSB 9
GSB 2
DSZ
GSB 2
RTN
LBL C
F? 0
GTO 8
F? 1
GTO 7
RCL D
X≠0
GTO 6
R↓
GTO 5
LBL 8
RCL B
x
e^x
RCL A
x
RTN
LBL 7
LN x
LBL 5
RCL B
x
RCL A
+
RTN
LBL 6
R↓

RCL B
y^x
RCL A
x
RTN
LBL D
F? 0
GTO 5
F? 1
GTO 5
RCL D
X≠0
GTO 6
R↓
LBL 5
F? 0
LN x
RCL A
F? 0
LN x
-
RCL B
÷
F? 1
e^x
RTN
LBL 6
R↓
RCL A
÷
RCL B
1/x
y^x
RTN
```

BAIRSTOW

BAIRSTOW
(Polinomios hasta grado 8)
GRADO | ak | ak | RESOLVER | PAUSE ?

```
 LBL A
 CLREG
 STO A
 RTN
 LBL B
 STO (i)
 ISZ
 RTN
 LBL C
 DSZ
 RTN
 LBL D
 RCL A
   2
  X=Y
 GTO 4
  X>Y
 GTO 5
 ST I
20 - RCL 0
   P≥S
  STO 0
   P≥S
  RCL D
   X
  RCL 1
   +
   P≥S
  STO 1
   P≥S
 LBL 0
  RCL (i)
   P≥S
   DSZ
  RCL (i)
  RCL D
   X
   +
   DSZ
40 - STACLE
  RCL (i)
  RCL E
   X
   +
   ISZ
   ISZ
  STO (i)
   P≥S
   ISZ
  RCL A
  RCL I
  X≤Y
 GTO 0
  RCL 0
   P≥S
  STO B
  RCL D
   X
  RCL 1
60  +
  STO C
   2
  ST I
 LBL 1
  RCL (i)
```

```
  RCL E
  RCL B
  STO 9
   X
   +
  RCL D
  RCL C
  STO B
   X
   +
  STO C
  ISZ
  RCL I
  RCL A
80 - X≠Y
  GTO 1
  RCL C
  RCL 9
   X
  RCL B
   X²
   -
  X=0
  GTO 7
  ENTER↑
  ENTER↑
  RCL (i)
  RCL B
   X
  DSZ
  RCL C
  RCL (i)
   X
   -
100 - X²≥Y
   ÷
  RMD
  F?0
  PAUSE
  X≠0
  SF 2
  RCL E
   +
  STO E
   R↓
  RCL (i)
  RCL B
   X
  ISZ
  RCL (i)
  RCL 9
   X
   -
  X≥Y
120 - ÷
  RMD
  F?0
  PAUSE
  X≠0
  SF 2
  RCL D
   +
  STO D
  P≥S
  F?2
  GTO D
```

```
  RCL A
   2
   -
  STO A
  P≥S
 LBL B
  RCL D
   X²
140 - RCL E
   4
   X
   +
   4
   ÷
  X<0
  GTO 6
   √x
  STO E
   1
  PAUSE
   R↓
  RCL D
   2
   ÷
   +
  -X-
  LAST X
  RCL E
160 -
 LBL 3
  -X-
  F?2
  R/S
  CL X
  STO D
  STO E
  GTO D
 LBL 6
  CHS
   √x
   1
  CHS
  PAUSE
   R↓
  RCL D
   2
   ÷
  -X-
180 - X≥Y
  GTO 3
 LBL 4
  RCL 1
  RCL 0
   ÷
[redacted]
  CHS
  STO D
  RCL 2
  RCL 0
[redacted] ÷
  CHS
  STO E
  SF 2
  GTO 8
```

```
 LBL 5
   1
  PAUSE
  RCL 1
  RCL 0
200 - ÷
  CHS
  -X-
  R/S
 LBL 7
  RCL E
   1
   -
  STO E
  RCL D
   1
   +
  STO D
  P≥S
  GTO D
 LBL E
  F?0
  GTO 2
  SF 0
   1
220 RTN
 LBL 2
  CF 0
   0
  RTN
```

CAPTURA DE KLINGON

```
LBL A
 7      GSB E
 8      5
STO 8   X
P≥S     INT
CL REG  1
P≥S     6
GSB E   +
 1
 0
 X
INT
STO 1
GSB E
 1
 0
 X
INT
STO 2
LBL 0
RCL 8
PAUSE
RCL 1
RCL 2
 1
 0
 ÷
 +
STO 7
X≥Y
X>0
GTO 3
 1
 1
 1
RTN
LBL 3
RCL 1
STO 3
RCL 7
STO 4
 3
ST I
GSB 2
ST
GSB 2
RCL 3
ST I
RCL 4
STO 0
GSB e
X≠0
GTO 3
```

```
RCL 3
STO 1
RCL 4
STO 2
GSB E
 .
 9
 6
 -
X>0
GSB 5
GSB E
 .
 0
 6
 -
 .
X<0
GSB 6
RCL 7
R/S
LBL B
 1
STO-8
 R↓
INT
STO I
LAST X
FRAC
 1
 0
 X
STO 0
RCL 2
 -
X≠0
GTO 4
 RCL I
RCL 1
 -
X≠0
GTO 4
 2
 2
 2
RTN
LBL 2
GSB E
 3
 X
INT
 1
 -
```

```
STO + (i)
RCL (i)
 X<0
 CLX
STO (i)
 9
X≤Y
STO (i)
RTN
LBL 4
GSB e
X=0
GTO 4
 .
 0
 7
 3
 7
 -x-
GTO 0
LBL 4
RCL 0
 10^x
 P≥S
STO + (i)
 P≥S
GTO 0
LBL 6
GSB E
 1
 0
 X
INT
ST I
RCL 1
 -
X=0
GTO 6
GSB E
 1
 0
 X
INT
STO 0
GSB e
X≠0
GTO 6
 .
 5
 5
 4
 4
 5
 5
```

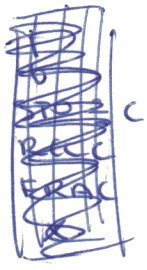
```
 -x-
RCL 0
 10^x
 P≥S
STO + (i)
 P≥S
 RCL I
RCL 0
 1
 0
 ÷
 +
 -x-
 RTN
LBL 5
 0
 1
 7
 .
 0
 1
 7
 -x-
 1
STO-8
RCL 8
PAUSE
 RTN
LBL e
 P≥S
RCL (i)
 P≥S
 RCL 0
 1
 +
 10^x
 ÷
 FRAC
 RND
 RTN
LBL E
 RCL 9
 FT
 +
 5
 y^x
 FRAC
STO 9
 RTN
```

VERSION 2

```
LBL A
SF 2
STO D
CLX
STO 0
LBL 1
RCL 0
1
+
ST I
RCL E
D←R
FRAC
STO E
1
0
X
INT
STO (i)
DSZ
LBL 2
RCL (i)
X=Y
GTO 1
R↓
F? 2
ISZ
DSZ
GTO 2
ISZ (i)
RCL 0
RCL D
X>Y
GTO 1
RTN
```

Puede haber 0 excepto en el 1°

```
LBL B
STO C
CLX
STO B
RCL D
STO 0
LBL 5
RCL D
ST I
RCL C
1
0
÷
STO C
FRAC
1
0
X
INT
LBL 6
RCL (i)
X≷Y
X≠Y
GTO 7
RCL I
RCL 0
—
X≠0
°
1
RCL B
+
STO B
R↑
LBL 7
DSZ
GTO 6
DSZ (i)
GTO 5
RCL B
RTN
```



VERSION 1

```
LBL A
SF 2
STO D
2
STO 0
LBL 1
RCL 0
ST I
RCL E
D←R
FRAC
STO E
1
0
X
INT —
STO (i)
DSZ
LBL 2
RCL (i)
X=Y
GTO 1
R↓
[illegible]
DSZ
GTO 2
ISZ (i)
RCL D
RCL 0
X≤Y
GTO 1
X≷Y
RTN
```

X=0 GTO 1 F? 2 STO 1

No hay ceros

MUERTOS Y HERIDOS

EC DIFER.

151
224
151
073

```
LBL B
STO D
RTN
LBL A
STO 4
STO 2
```

```
LBL B
STO D
RTN
LBL 2
RCL 4
STO D
RCL 3
STO C
RCL 2
STO B
RCL 1
STO A
GSB C
RCL D
  X
STO 5
STO 8
RCL D
RCL C
RCL B
RCL A
GSB D
RCL D
  X
STO 6
STO 9
RCL D
RCL C
RCL B
RCL A
GSB E
RCL D
  X
STO 7
SF 2
LBL 1
  2
  ÷
RCL 4
  +
STO D
RCL 9
  2
  ÷
RCL 3
  +
STO C
RCL 8
  2
  ÷
RCL 2
  +
STO B
RCL D
  2
  ÷
RCL 1
  +
STO A
RCL D
  R↓
GSB C
```

```
RCL D
  X
STO+5
STO+5
STO 8
RCL D
RCL C
RCL B
RCL A
GSB D
RCL D
  X
STO+6
STO+6
STO 9
RCL D
RCL C
RCL B
RCL A
GSB E
RCL D
  X
STO+7
STO+7
F? 2
GTO 1
RCL 4
  +
STO D
RCL 9
RCL 3
  +
STO C
RCL 8
RCL 7
  +
STO B
RCL D
RCL 1
  +
STO A
RCL D
  R↓
GSB C
RCL D
  X
STO+5
RCL D
RCL C
RCL B
RCL A
GSB D
RCL D
  X
STO+6
RCL D
RCL C
RCL B
RCL A
GSB E
RCL D
STO+1
  X
STO+7
  6
STO÷5
STO÷6
STO÷7
```

```
RCL 5
STO+2
RCL 6
STO+3
RCL 7
STO+4
RCL 1
RCL 2
RCL 3
RCL 4
STK
GTO 2
```

0 - h
1 - x
2 - y
3 - z
4 - t
5 - Σk
6 - Σl
7 - Σm
8 - k
9 - l

```
LBL B
STO D
RTN
LBL A
STO 4
  R↓
STO 3
  R↓
STO 2
  R↓
STO 1
```

$y' = f(x, y, v, w)$
$v' = g(x, y, v, w)$
$w' = h(x, y, v, w)$

$x' = f(t, x, y, z)$
$y' = g(t, x, y, z)$
$z' = h(t, x, y, z)$

$y' = f(x, y, z, t)$
$z' = f(x, y, z, t)$
$t' = f(x, y, z, t)$

$x' = f(x, y, z, t)$
$y' = f(x, y, z, t)$
$z' = f(x, y, z, t)$

FORM AC-231 REV.

DAVID TAYLOR RESEARCH CENTER
LBL A
STO 2
X≷Y
STO 1
X≷Y
÷
INT
DSP 0
R/S
DSP 8
RCL 2
X
STO - 1
LBL 2
RCL 1
RCL 2
÷
X=0
GTO 1
5
EEX
CHS
9
+
RND
LBL 1
R/S
RCL 2
X
RCL 1
-
CHS
EEX
8
X
STO 1
GTO 2