

Program Title APPROXIMATION BY A SUM OF 4 WHATEVER FUNCTIONS

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Program Description, Equations, Variables This program computes the coefficients A, B, C, D of the best curve:

$$y = Af_1(x) + Bf_2(x) + Cf_3(x) + Df_4(x) = f(x)$$

The user keys the functions $f_1(x), \dots, f_4(x)$ under the labels LBL1, ..., LBL4 at the beginning of the card 1 (INPUT).

The card 1 is used for data's introduction. The card 2 computes the coefficients A, B, C, D and it also contains the output of $y = f(x)$ for drawing the curve.

The coefficients are found by the least squares method:

$$\begin{cases} A \sum f_1^2 + B \sum f_1 f_2 + C \sum f_1 f_3 + D \sum f_1 f_4 = \sum y f_1 \\ A \sum f_1 f_2 + B \sum f_2^2 + C \sum f_2 f_3 + D \sum f_2 f_4 = \sum y f_2 \\ A \sum f_1 f_3 + B \sum f_2 f_3 + C \sum f_3^2 + D \sum f_3 f_4 = \sum y f_3 \\ A \sum f_1 f_4 + B \sum f_2 f_4 + C \sum f_3 f_4 + D \sum f_4^2 = \sum y f_4 \end{cases}$$

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Operating Limits and Warnings All functions may be defined.

Two functions ($f_1(x), \dots, f_4(x)$) cannot be equal.

The user may introduce at least 4 data pairs.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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$$a = \sum f_1^2 \sum y f_2 - \sum f_1 f_2 \sum y f_1$$

$$h = \sum f_1^2 \sum f_4^2 - (\sum f_1 f_4)^2$$

$$b = \sum f_1^2 \sum f_2 f_3 - \sum f_1 f_2 \sum f_1 f_3$$

$$i = \sum f_1^2 \sum y f_4 - \sum f_1 f_4 \sum y f_1$$

$$c = \sum f_1^2 \sum f_2 f_4 - \sum f_1 f_2 \sum f_1 f_4$$

$$j = dg - ab$$

$$d = \sum f_1^2 \sum f_2^2 - (\sum f_1 f_2)^2$$

$$k = df - bc$$

$$e = \sum f_1^2 \sum f_3^2 - (\sum f_1 f_3)^2$$

$$l = de - b^2$$

$$f = \sum f_1^2 \sum f_3 f_4 - \sum f_1 f_3 \sum f_1 f_4$$

$$m = dh - c^2$$

$$g = \sum f_1^2 \sum y f_3 - \sum f_1 f_3 \sum y f_1$$

$$n = di - ac$$

Coefficients.

$$A = \frac{\sum y f_1 - B \sum f_1 f_2 - C \sum f_1 f_3 - D \sum f_1 f_4}{\sum f_1^2}$$

$$B = \frac{a - Cb - Dc}{d}$$

$$C = \frac{j - Dk}{l}$$

$$D = \frac{nl - kj}{ml - k^2}$$

$$\begin{array}{lll} 1[E] \Rightarrow 0.208 & 7[CH_3][E] \Rightarrow -1.400 & 5[E] \Rightarrow 1.019 \\ 12[E] \Rightarrow 2.222 & 17[CH_3][E] \Rightarrow -2.756 & \end{array}$$

APPROXIMATION SUM 4 WHATEVER FUNCTIONS CARD 1

1 INIT
X: ↑ Y: (+) X: ↑ Y: (-)
COEFFICIENTS
OUTPUT

2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key functions $f_1(x), f_2(x), f_3(x), f_4(x)$ under labels LBL1, LBL2, LBL3, LBL4			
2	Switch to run			
3	Load card 1 after LBL5 Load side 1 card 1		2 MERGE	
4	Clear registers		f a	0.00
5	Input X value	X_i	ENT ↑	X_i
6	Input Y value	Y_i	A	Y_i
7	Repeat steps 5 and 6 for all data pairs			
	The last set of data pairs may be deleted by pressing [B]. Any set of data pairs may be deleted by entering them as in steps 5 and 6 and pressing [B].			
8	Coefficients research The card 2 is automatically load after pressing [D]. The coefficients are stored in registers: $A \hat{=} R1$ $B \hat{=} R2$ $C \hat{=} R3$ $D \hat{=} R4$ and $A \hat{=} X$ $B \hat{=} Y$ $C \hat{=} Z$ $D \hat{=} T$		D	A, B, C, D
9	Make projections based on a X known value Input X known value	X	E	Y
10	For a new case go to step 1			
10'	For adding data pairs, GTO D MERGE Load side 1 and 2 card 1 Goto step 5.		GTO D 2 MERGE	

APPROXIMATION SUM 4 WHATEVER FUNCTIONS CARD 2

1 COEFFICIENTS $Y = f(X)$

2



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Program Listing I

CARD 1

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLE		} Input card 2	057	GSB5		$\Sigma f_2 f_3$
002	NRG			058	RCL4		
003	PSE			059	RCL5		
004	GTOD			060	GSB5		$\Sigma f_1 f_2$
005	*LBLE			061	RCL4		
006	SF1			062	RCL4		
007	*LBLE			063	GSB5		Σf_1^2
008	STO9			064	RCL8		
009	XZY			065	RCL9		
010	STO8			066	CF1		
011	:			067	RTN		
012	1			068	*LBLE		
013	STO1			069	X		
014	RCL8			070	F1?		
015	GSB3	$f_3(x_i)$		071	CHS		} $\Sigma + / \Sigma -$
016	STO6			072	ST+i		
017	RCL6			073	ISZ1		
018	GSB5	Σf_3^2		074	RTN		
019	RCL8			075	*LBLE		INIT
020	GSB4	$f_4(x_i)$		076	CLRG		
021	STO7			077	PZS		
022	RCL6			078	CLRG		
023	GSB5	$\Sigma f_3 f_4$		079	0		
024	RCL6			080	ENT↑		
025	RCL9			081	ENT↑		
026	GSB5	$\Sigma y f_3$		082	ENT↑		
027	RCL7			083	RTN		
028	RCL7						
029	GSB5	Σf_4^2					
030	RCL7						
031	RCL9						
032	GSB5	$\Sigma y f_4$					
033	RCL8						
034	GSB2	$f_2(x_i)$		090			
035	STO5						
036	RCL5						
037	GSB5	Σf_2^2					
038	RCL5						
039	RCL9						
040	GSB5	$\Sigma y f_2$					
041	RCL5						
042	RCL7						
043	GSB5	$\Sigma f_2 f_4$		100			
044	RCL5						
045	RCL6						
046	GSB5	$\Sigma f_2 f_3$					
047	RCL8						
048	GSB1	$f_1(x_i)$					
049	STO4						
050	RCL9						
051	GSB5	$\Sigma y f_1$					
052	RCL4						
053	RCL7						
054	GSB5	$\Sigma f_1 f_4$		110			
055	RCL4						
056	RCL6						

REGISTERS

0	1	2	3	4	5	6	7	8	9
				f_{1i}	f_{2i}	f_{3i}	f_{4i}	x_i	y_i
S0	S1 Σf_3^2	S2 $\Sigma f_3 f_4$	S3 $\Sigma y f_3$	S4 Σf_4^2	S5 $\Sigma y f_4$	S6 Σf_2^2	S7 $\Sigma y f_2$	S8 $\Sigma f_2 f_4$	S9 $\Sigma f_2 f_3$
A $\Sigma y f_1$	B $\Sigma f_1 f_4$	C $\Sigma f_2 f_3$	D $\Sigma f_1 f_2$	E Σf_1^2	I Control				

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*L5LC		Solve coefficients (Automatically start if press [D] in card 1)	057	-		D
002	F#S			058	RCL4		
003	1			059	RCL1		
004	9			060	X		
005	STO1		b	061	RCL2		C
006	RCL0			062	X ²		
007	RCL0		c	063	-		
008	G8B7			064	÷		
009	RCL0		a	065	STO4		B
010	RCLB			066	RCL3		
011	G8B7		d	067	RCL2		
012	RCLD			068	RCL4		
013	RCLA		i	069	X		A
014	G8B7			070	-		
015	RCLD		h	071	RCL1		
016	RCLD			072	÷		
017	G8B7		g	073	STO3		A
018	RCLB			074	RCL7		
019	RCLA		f	075	RCL9		
020	G8B7			076	RCL3		
021	RCLB		e	077	X		A
022	RCLB			078	-		
023	G8B7		n	079	RCL8		
024	RCLC			080	RCL4		
025	RCLA		m	081	X		A
026	G8B7			082	-		
027	RCLC		j	083	RCL6		
028	RCLB			084	÷		
029	G8B7		k	085	STO2		A
030	RCLC			086	RCLA		
031	RCLC		l	087	RCL2		
032	G8B7			088	RCLD		
033	F#S		m	089	X		A
034	5			090	-		
035	STO1		j	091	RCL3		
036	RCL8			092	RCLC		
037	RCL7		k	093	X		A
038	G8B6			094	-		
039	RCL8		l	095	RCL4		
040	RCL9			096	RCLB		
041	G8B6		m	097	X		A
042	RCL9			098	-		
043	RCL7		n	099	RCL5		
044	G8B6			100	÷		
045	RCL9		o	101	STO1		A
046	RCL8			102	RCL4		
047	G8B6		p	103	RCL3		
048	RCL9			104	RCL2		
049	RCL9		q	105	RCL1		A
050	G8B6			106	RTN		
051	RCL5		r	107	*LBL7		
052	RCL1			108	X		
053	X		s	109	CHS		A
054	RCL2			110	RCL5		
055	RCL3		t	111	F#S		
056	X			112	RCL1		

REGISTERS									
0 $\hat{y}$	1 $e/L/A$	2 $f/k/B$	3 $g/j/C$	4 $h/m/D$	5 i/n	6 d	7 a	8 c	9 b
S0	S1 ΣL^2	S2 $\Sigma L_3 L_4$	S3 $\Sigma \gamma L_3$	S4 ΣL_4^2	S5 $\Sigma \gamma L_4$	S6 ΣL_2^2	S7 $\Sigma \gamma L_2$	S8 $\Sigma L_2 L_4$	S9 $\Sigma L_2 L_3$
A $S.L.$	B $S.L.L.$	C $S.L.L.$	D $S.L.L_2$	E ΣL_2^2	I Control				

