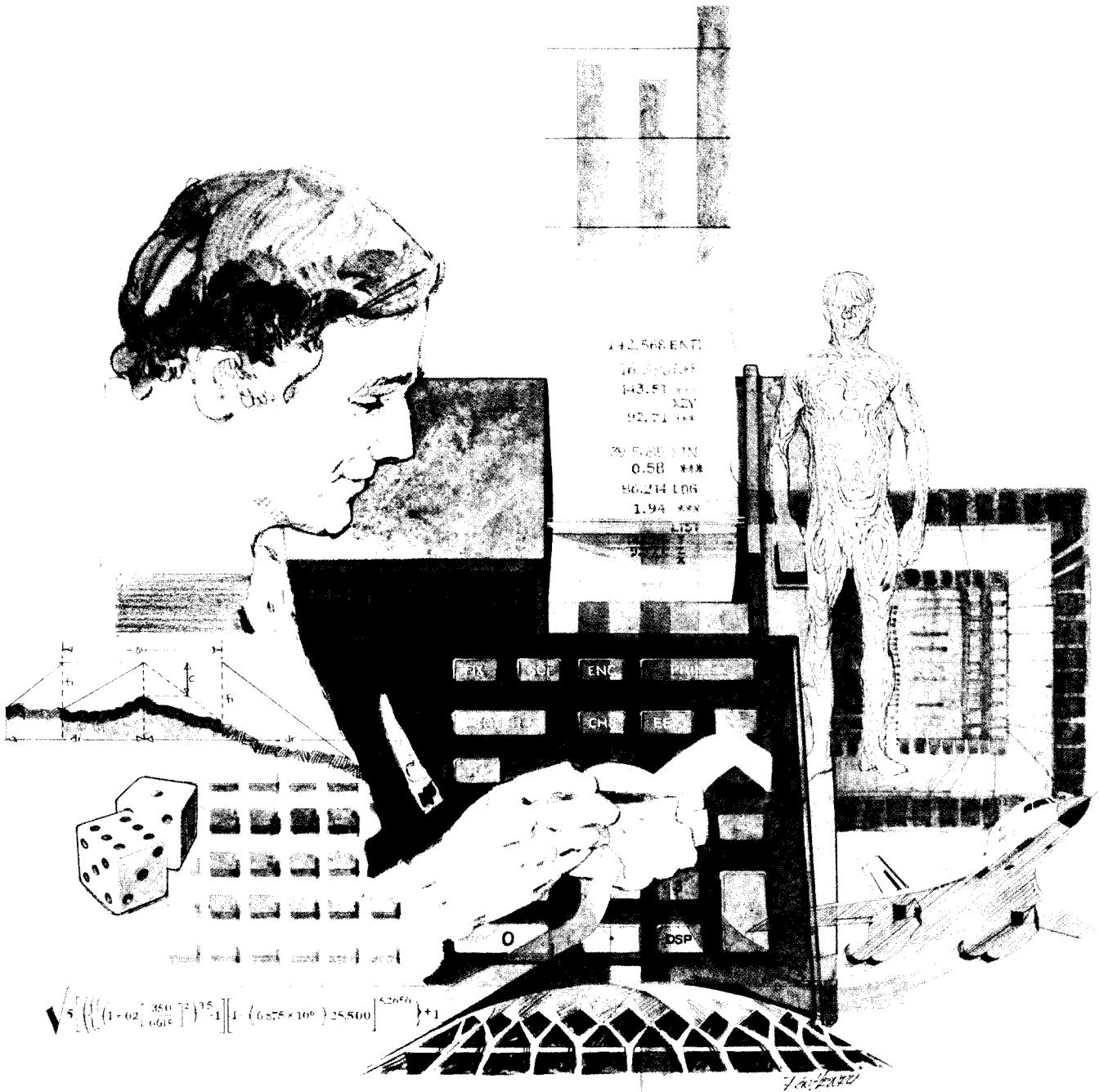


HEWLETT-PACKARD

# IHP-67 IHP-97

Users' Library Solutions

Options/Technical Stock Analysis



## INTRODUCTION

In an effort to provide continued value to its customers, Hewlett-Packard is introducing a unique service for the HP fully programmable calculator user. This service is designed to save you time and programming effort. As users are aware, Programmable Calculators are capable of delivering tremendous problem solving potential in terms of power and flexibility, but the real genie in the bottle is program solutions. HP's introduction of the first handheld programmable calculator in 1974 immediately led to a request for program **solutions** — hence the beginning of the HP-65 Users' Library. In order to save HP calculator customers time, users wrote their own programs and sent them to the Library for the benefit of other program users. In a short period of time over 5,000 programs were accepted and made available. This overwhelming response indicated the value of the program library and a Users' Library was then established for the HP-67/97 users.

To extend the value of the Users' Library, Hewlett-Packard is introducing a unique service—a service designed to save you time and money. The Users' Library has collected the best programs in the most popular categories from the HP-67/97 and HP-65 Libraries. These programs have been packaged into a series of low-cost books, resulting in substantial savings for our valued HP-67/97 users.

We feel this new software service will extend the capabilities of our programmable calculators and provide a great benefit to our HP-67/97 users.

## A WORD ABOUT PROGRAM USAGE

Each program contained herein is reproduced on the standard forms used by the Users' Library. Magnetic cards are not included. The Program Description I page gives a basic description of the program. The Program Description II page provides a sample problem and the keystrokes used to solve it. The User Instructions page contains a description of the keystrokes used to solve problems in general and the options which are available to the user. The Program Listing I and Program Listing II pages list the program steps necessary to operate the calculator. The comments, listed next to the steps, describe the reason for a step or group of steps. Other pertinent information about data register contents, uses of labels and flags and the initial calculator status mode is also found on these pages. Following the directions in your HP-67 or HP-97 **Owners' Handbook and Programming Guide**, "Loading a Program" (page 134, HP-67; page 119, HP-97), key in the program from the Program Listing I and Program Listing II pages. A number at the top of the Program Listing indicates on which calculator the program was written (HP-67 or HP-97). If the calculator indicated differs from the calculator you will be using, consult Appendix E of your **Owner's Handbook** for the corresponding keycodes and keystrokes converting HP-67 to HP-97 keycodes and vice versa. No program conversion is necessary. The HP-67 and HP-97 are totally compatible, but some differences do occur in the keycodes used to represent some of the functions.

A program loaded into the HP-67 or HP-97 is not permanent—once the calculator is turned off, the program will not be retained. You can, however, permanently save any program by recording it on a blank magnetic card, several of which were provided in the Standard Pac that was shipped with your calculator. Consult your **Owner's Handbook** for full instructions. A few points to remember:

The Set Status section indicates the status of flags, angular mode, and display setting. After keying in your program, review the status section and set the conditions as indicated before using or permanently recording the program.

**REMEMBER!** To save the program permanently, **clip** the corners of the magnetic card once you have recorded the program. This simple step will protect the magnetic card and keep the program from being inadvertently erased.

As a part of HP's continuing effort to provide value to our customers, we hope you will enjoy our newest concept.

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# Program Description I

1

**Program Title** PUT & CALL OPTION FAIR VALUES (BLACK-SCHOLES)

**Contributor's Name** William B. Henderson

**Address** 160 Paseo de la Concha #F

**City** Redondo Beach, **State** California **Zip Code** 90277

**Program Description, Equations, Variables** This program computes the theoretical value of a European<sup>1</sup> type put or call option using the valuation formulas of Black & Scholes<sup>2,3</sup>.

The following equations are used:

$$\text{Call Option Value} = P_{\text{stock}} N(d_1) - P_{\text{strike}} N(d_2) \exp^{-Rt}$$

$$\text{Put Option Value} = P_{\text{strike}} N(-d_2) \exp^{Rt} - P_{\text{stock}} N(-d_1)$$

$$\text{where: } d_1 = \frac{\ln(P_{\text{stock}}/P_{\text{strike}}) + (R + \frac{1}{2}V^2)t}{V\sqrt{t}}$$

$$d_2 = \frac{\ln(P_{\text{stock}}/P_{\text{strike}}) + (R - \frac{1}{2}V^2)t}{V\sqrt{t}}$$

$$N(d) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^d \exp^{-z^2/2} dz$$

$$N(-d) = 1 - N(d)$$

The Hedge Ratio for a Call Option =  $N(d_1)$

R is the appropriate interest rate expressed as a decimal.

t is the remaining time to expiration in years.

V is the variance rate of the return on the underlying security.

**Operating Limits and Warnings** The variance term in the equation must be the future variance of the underlying security for the option to be correctly priced. A more complete discussion of this term is available from the program author. A crude estimate of variance may be obtained from the formula:

$$V = \frac{\text{Stock High} - \text{Stock Low}}{\frac{1}{2}(\text{Stock High} + \text{Stock Low})} \quad \text{during the past year.}$$

Out-of-the-money options are extremely sensitive to this term and large errors in value may result from improper choices.

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.

NEITHER HP NOR THE CONTRIBUTOR MAKES ANY EXPRESS OR IMPLIED WARRANTY OF ANY KIND WITH REGARD TO THIS PROGRAM MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. NEITHER HP NOR THE CONTRIBUTOR SHALL BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH OR ARISING OUT OF THE FURNISHING, USE OR PERFORMANCE OF THIS PROGRAM MATERIAL.

# Program Description II

Sketch(es)

- Sample Problem(s)** A. What is the fair market price of a call option with a striking price of 65 and 91 calender days remaining to expiration? The current (risk free) interest rate for a 91-day T-Bill is 4.65%, the current stock price is  $63\frac{1}{4}$  and the estimated variance is 0.125.
- B. What is the fair market price of a put option with the same conditions as (A)?
- C. What is the value of the call option in (A) if the variance term is actually 0.175?
- D. What is the Hedge ratio of the option in (C)?

<u>KEY IN:</u>		<u>DISPLAY:</u>
65,A	---	65.00 ( $P_{\text{strike}}$ )
63.25,B	---	63.25 ( $P_{\text{stock}}$ )
91,C	---	0.25 ( $t$ )
.125,D	---	0.02 ( $V^2$ )
4.65,E	---	0.05 ( $R$ )

**Solution(s)**

SOLVE A:	fA	---	1.14	Convert to 1/16ths: fC -- 1 2/16
SOLVE B:	fE	---	1.00	Put/Call toggle
	fA	---	2.14	Convert to 1/16ths: fC -- 3 1/16
SOLVE C:	.175,D	---	0.03 ( $V^2$ )	
	fE	---	0.00	Put/Call toggle
	fA	---	1.76	Convert to 1/16ths: fC -- 1 12/16
SOLVE D:	fB	---	0.45	

- Reference(s)** (1) A European option can only be exercised at maturity. This differs from an American option which can be exercised at any time through maturity.
- (2) Black, Fischer and Myron Scholes; "The Pricing of Options and Corporate Liabilities". Journal of Political Economy (May/June 1973), pp 637-654.
- (3) Black, Fischer; "Fact and Fantasy In the Use of Options". Financial Analysts Journal (July/August 1975), pp 36-72.

## 3

[illegible]

# 97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA		Striking Price	057	-		
002	STOA			058	XZY		
003	RTN			059	RCL1		$x = d_1$
004	*LBLB		Stock Price	060	+		$t = d_2$
005	STOB			061	GSB0		← Solve $N(d_1)$ or $N(-d_1)$
006	RTN			062	STO9		
007	*LBLC		# Calendar Days	063	RCLB		
008	3			064	x		
009	6		Remaining	065	F0?		} PUT ?
010	5			066	CHS		
011	=		→ yes, remaining	067	XZY		
012	STOC			068	GSB0		← Solve $N(d_2)$ or $N(-d_2)$
013	RTN			069	RCLA		
014	*LBLD		Stock High ↑	070	x		
015	STOE		Stock Low ↓	071	RCLC		
016	R↓			072	RCLD		
017	STOF			073	x		
018	RCL6		→ $\sim \sqrt{2}$	074	e <sup>x</sup>		
019	-			075	=		
020	RCL7			076	F0?		
021	RCL6			077	CHS		
022	+			078	-		} PUT ?
023	2			079	RTN		
024	=			080	*LBL0		
025	=			081	STO4		
026	*LBLD		Variance	082	ABS		
027	XZ		→ $\sqrt{2}$	083	.		
028	STOD			084	3		
029	RTN			085	3		
030	*LBL E		Interest Rate (%)	086	2		
031	EEX			087	6		
032	2		→ Decimal Equivalent	088	7		
033	=			089	x		
034	STOE			090	1		
035	RTN			091	+		
036	*LBLA		→ Option Value	092	1/X		
037	RCLB			093	STO5		
038	RCLA			094	3		
039	=			095	YX		
040	LN			096	.		
041	RCLC			097	9		
042	RCLD			098	3		
043	x			099	7		
044	+			100	2		
045	RCLC			101	9		
046	RCLD			102	6		
047	x			103	x		
048	fx			104	RCL5		
049	STO1			105	XZ		
050	=			106	.		
051	ENT↑			107	1		
052	ENT↑			108	2		
053	RCL1			109	0		
054	2			110	1		
055	=			111	6		
056	STO1			112	7		

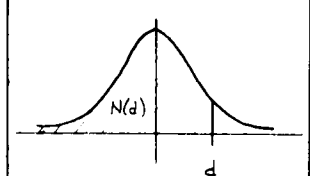
$x = d_1$   
 $t = d_2$   
 ← Solve  $N(d_1)$  or  $N(-d_1)$

} PUT ?  
 ← Solve  $N(d_2)$  or  $N(-d_2)$

} PUT ?

Subroutine for  
 evaluation of  
 cumulative normal  
 density function

$$N(d) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^d e^{-z^2/2} dz$$



Ref:  
 Handbook of  
 Mathematical  
 Functions (AMS 55)

Abramowitz &  
 Stegun

N.B.S. Publication  
 pp 932

$$|E(d)| \leq 10^{-5}$$

## REGISTERS

0	1 Used	2	3	4 Used	5 Used	6 Low	7 High	8 .16	9 Hedge
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A Strike	B Stock	C t	D $\sqrt{2}$	E R	I Used				

# 97 Program Listing II

5

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
113	6			169	+		
114	x			170	RTN		
115	-			171	*LBL2		
116	RCL5			172	1		
117	.			173	ENT↑		
118	4			174	RTN		
119	3			175	*LBL6		
120	6			176	F0?		
121	1			177	GT03		PUT/CALL
122	8			178	SF0		Toggle
123	3			179	1		
124	6			180	RTN		
125	x			181	*LBL3		
126	+			182	CF0		
127	RCL4			183	0		
128	X²			184	RTN		
129	2			185	R/S		
130	÷						
131	eˣ						
132	÷						
133	PI						
134	2			190			
135	x						
136	JX						
137	÷						
138	RCL4						
139	F0?						
140	CHS						
141	X<0?		} PUT ?				
142	GT01						
143	R↓						
144	CHS			200			
145	1						
146	+						
147	RTN						
148	*LBL1						
149	R↓						
150	RTN						
151	*LBL6						
152	RCL9						
153	RTN		→ Hedge Ratio				
154	*LBL6			210			
155	STOI						
156	FRC		→ Contents of				
157	.		X-register in				
158	1		Points . 1/16ths				
159	6						
160	STOB						
161	x						
162	RND						
163	RCL8			220			
164	X=Y?						
165	GSB2						
166	R↓						
167	RCL1						
168	INT						

LABELS					FLAGS	SET STATUS		
A	B	C	D	E	0	FLAGS	TRIG	DISP
Strike	Stock	# Days	✓	R	Used	ON OFF		
a	→ Value	b → Hedge	c → 16ths	d HPL → V²	e PUT ?	0 <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
0	N(d)	1 Used	2 Used	3 Used	4	1 <input type="checkbox"/> <input checked="" type="checkbox"/>	GRAD <input type="checkbox"/>	SCI <input type="checkbox"/>
5		6	7	8	9	2 <input type="checkbox"/> <input checked="" type="checkbox"/>	RAD <input type="checkbox"/>	ENG <input type="checkbox"/>
						3 <input type="checkbox"/> <input checked="" type="checkbox"/>		n 2



# Program Description I

Program Title CALL OPTION EVALUATION

Contributor's Name RICHARD G. DONALD

Address 1561 BLACKHAWK DR

City SUNNYVALE

State

CA

Zip Code 94087

Program Description, Equations, Variables THIS PROGRAM USES THE BLACK-SCHOLES FORMULA FOR THE PRICE OF CALL OPTIONS ALONG WITH PORTIONS OF THE STANDARD PAC "CALCULUS AND ROOTS OF  $f(x)$ ." A SINGLE FUNCTION OF MANY VARIABLES DEFINED AS

$$f(B, R, t, P_E, P_S, V) = P_S g(d_1) - e^{-Rt} g(d_2)$$

$$\text{WHERE } d_1 = \frac{\ln(P_S/P_E) + (R + V^{1/2})t}{V\sqrt{t}}, \quad d_2 = \frac{\ln(P_S/P_E) + (R - V^{1/2})t}{V\sqrt{t}},$$

$$g(x) = \frac{1}{2} + \frac{1}{2} \operatorname{erf}\left(\frac{x}{\sqrt{2}}\right) \quad \text{WHERE THE APPROXIMATION FOR } g(x) \text{ IS}$$

$$g(x) = \begin{cases} 1 - Q(x) & x \geq 0 \\ Q(x) & x < 0 \end{cases}$$

$$\text{WHERE } Q(x) = \frac{e^{-x^2/2}}{\sqrt{2\pi}} \left\{ y \left[ -0.4362 - 0.12y + 0.9371y^2 \right] \right\}$$

$$\text{WITH } y = \frac{1}{1 + 0.3327|x|}$$

$B$  = OPTION PRICE (DOLLARS),  $R$  = INTEREST RATE (WHERE 5% IS ENTERED AS 0.05),  $t$  = TIME (YEARS),  $P_E$  = STRIKE PRICE (DOLLARS),  $P_S$  = CURRENT STOCK PRICE (DOLLARS),  $V$  = VOLATILITY

## Operating Limits and Warnings

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.

NEITHER HP NOR THE CONTRIBUTOR MAKES ANY EXPRESS OR IMPLIED WARRANTY OF ANY KIND WITH REGARD TO THIS PROGRAM MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. NEITHER HP NOR THE CONTRIBUTOR SHALL BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH OR ARISING OUT OF THE FURNISHING, USE OR PERFORMANCE OF THIS PROGRAM MATERIAL.

# Program Description II

7

Sketch(es)

Sample Problem(s) GIVEN THE FOLLOWING STATISTICS ON HEWLETT-PACKARD STOCK ON 3/28/77:

CALL OPTION EXPIRATION:	MAY	AUG
OPTION PRICE :	1 <sup>1</sup> / <sub>16</sub>	3 <sup>3</sup> / <sub>4</sub>
DAYS REMAINING :	56	146
STRIKE PRICE :	80	80
STOCK PRICE :	75 <sup>1</sup> / <sub>2</sub>	75 <sup>1</sup> / <sub>2</sub>

- CALCULATE
- MARKET-ASSIGNED VOLATILITY FOR EACH SERIES
  - SLOPE OF OPTION PRICE WRT STOCK PRICE
  - SLOPE OF OPTION PRICE WRT TIME
  - AUG OPTION PRICE IF VOL WERE 0.30 (HISTORIC VOLATILITY OF HP STOCK)

Solution(s) a) KEY IN MAY PARAMETERS: 1.0625 STO 1, .05 STO 2, 56/365 STO 3, 80 STO 4, 75.5 STO 5, 0.3 (GUESS) STO 6, PRESS E, RESULT = 0.21.

KEY IN AUG PARAMETERS: 3.75 STO 1, 146/365 STO 3, PRESS E, RESULT = 0.26

b) USING AUG PARAMETERS: 0.26 STO 6, PRESS D, RESULT = 0.44

c) USING AUG PARAMETERS: PRESS fd, RESULT = 7.65 %/YEAR

d) USING AUG PARAMETERS: 0.30 STO 6, PRESS C, RESULT = \$4.47

Reference(s) FISCHER BLACK AND MYRON SCHOLES, "THE PRICING OF OPTIONS AND CORPORATE LIABILITIES," JOURNAL OF POLITICAL ECONOMY 81 (MAY/JUNE 1973)

## User Instructions

**BLACK-SCHOLES**  
 1 = OPTION #, 2 =  $t$ , 3 =  $e$ , 4 = STRIKE \$  
 5 = STOCK \$, 6 = VOLATILITY

	func	$f'(B)$	VOL
1			
2			
3			
4			
5			
6			

[illegible]

# 67 Program Listing I

9

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBL A	31 25 11	initialize		RCL C	34 13	$f(x + \frac{\Delta x}{2}) - f(x - \frac{\Delta x}{2})$ $\Delta x$
	R SFZ	35 33			÷	81	
	RCL (i)	34 24			R RTN	35 22	
	f P S S	31 42		060	*LBL C	31 25 13	f(x)
	STO (i)	33 24			1	01	
	f P S S	31 42			f G S B A	31 22 11	
	DSP Z	23 02			0	00	
	R RTN	35 22			STO 1	33 01	
	*LBL R	32 25 15			f G S B 1	31 22 01	
010	R FO?	35 71 00			R RTN	35 22	
	GTO 0	22 00			*LBL E	31 25 15	
	R SF 0	35 51 00			6	06	
	1	01	PAUSE TOGGLE		f G S B A	31 22 11	USE NUMERICAL DIFFERENTIAL TO GENERATE X <sub>i</sub> FROM INITIAL GUESS
	R RTN	35 22		070	f FIX	31 23	
	*LBL 0	31 25 00			f G S B B	31 22 12	
	0	00			RCL B	34 12	
	R C F 0	35 61 00			GTO 0	22 00	
	R RTN	35 22			*LBL 6	31 25 06	
	*LBL Q	32 25 11			RCL 0	34 00	
020	R SF 1	35 51 01			f G S B 1	31 22 01	
	STO E	33 15			STO B	33 12	
	R RTN	35 22			*LBL D	31 25 00	
	*LBL D	31 25 14	f'(x) w.r.t. STOCK PRICE	080	RCL A	34 11	EVALUATE f(x <sub>i</sub> )
	5	05			RCL D	34 00	
	GTO 2	22 02			STO A	33 11	
	*LBL d	32 25 14			-	51	
	3	03			RCL D	34 14	
	*LBL 2	31 25 02			RCL B	34 12	
	f G S B A	31 22 11			STO D	33 14	
030	*LBL B	31 25 12			-	51	
	EEX	43			÷	81	
	CHS	42			X	71	
	2	02	CHOOSE DEFAULT % Δ OR USE 0.01 %		STO - 0	33 51 00	SUB CORRECTION PAUSE AND DISPLAY ROOT
	RCL E	34 15		090	RCL 0	34 00	
	R FI?	35 71 01			R FO?	35 71 00	
	R X = y	35 52			R PSE	35 72	
	R R +	35 53			÷	81	
	f %	31 82			f RND	31 24	
	f X = 0?	31 51			f X ≠ 0?	31 61	
040	R LST X	35 82			GTO 6	22 06	
	STO C	33 13			RCL 0	34 00	
	2	02			R RTN	35 22	
	÷	81	IF X = 0 USE % Δ RATHER THAN % OF X AS Δ X		*LBL 1	31 25 01	RND (CHANGE/X <sub>i+1</sub> ) ACCURATE? IF SO, DISPLAY START BLACK- SCHOLES METHOD
	-	51		100	STO (i)	33 24	
	STO A	33 11			RCL 6	34 06	
	STO 0	33 00			g x <sup>2</sup>	32 54	
	f G S B 1	31 22 01			2	02	
	STO D	33 14			÷	81	
	RCL A	34 11			STO 8	33 08	
050	RCL C	34 13			f G S B 2	31 22 02	
	+	61			STO 7	33 07	
	STO 0	33 00			RCL 8	34 08	
	f G S B 1	31 22 01	f(x + Δx/2)		CHS	42	
	STO B	33 12		110	f G S B 2	31 22 02	$\frac{V^2}{2}$  d <sub>1</sub>  d <sub>2</sub>
	RCL D	34 14			f G S B 3	31 22 03	
	-	51			RCL 4	34 04	

## REGISTERS

0	$X_i$	1	B	2	R	3	t	4	$P_e$	5	$P_s$	6	V	7	TEMP	8	TEMP	9					
S0		S1	B	S2	R	S3	t	S4	$P_e$	S5	$P_s$	S6	V	S7	TEMP	S8	TEMP	S9					
A	$X_{i-1}$			B	$f(x_i)$			C	$\Delta x$			D	$f(x_{i-1})$			E	$\% \Delta$			I	VARIABLE		

# 67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	X	71	$e^{-Rt} P_0 g(d_L)$		.	83	$Q(x)$
	RCL 2	34 02		170	9	09	
	RCL 3	34 03			3	03	
	X	71			7	07	
	$g \cdot e^x$	32 52			1	01	
	$\div$	81			X	71	
	RCL 1	34 01	$P_3 g(d_i)$		RCL 8	34 08	
120	+	61			.	83	
	RCL 7	34 07			1	01	
	$R \times \leq y$	35 52			2	02	
	STO 7	33 07			X	71	
	$R \times \leq y$	35 52		180	-	51	
	fGSB 3	31 22 03			.	81	
	RCL 5	34 05			4	04	
	X	71			3	03	
	RCL 7	34 07			6	06	
	-	51	ANS		2	02	
130	fPSS	31 42			+	61	
	RCL (i)	34 24			RCL 8	34 08	
	fPSS	31 42			X	71	
	STO (i)	33 24			$R \pi$	35 73	
	$R \downarrow$	35 53		190	2	02	
	$R \uparrow$	35 22			X	71	
	*LBL 2	31 25 02			fVX	31 54	
	RCL 2	34 02			$\div$	81	
	+	61			RCL 7	34 07	
	RCL 3	34 03	$\frac{\ln(P/P_0) + (R + \frac{V}{2})t}{V \sqrt{E}}$		fPSS	31 42	
140	X	71			$g \cdot x^2$	32 54	
	RCL 5	34 05			2	02	
	RCL 4	34 04			$\div$	81	
	$\div$	81			$g \cdot e^x$	32 52	
	FLW	31 52		200	$\div$	81	
	+	61			$R F 2 ?$	35 71 02	
	RCL 6	34 06			$R \uparrow$	35 22	
	$\div$	81			CHS	42	
	RCL 3	34 03			1	01	
	fVX	31 54	$\frac{1}{1 + .3327/x + 1}$		+	61	
150	$\div$	81			$R \uparrow$	35 22	
	$R \uparrow$	35 22					
	*LBL 3	31 25 03					
	fPSS	31 42					
	STO 7	33 07					
	fX<0?	31 71		210			
	$R SF 2$	35 51 02					
	$R ABS$	35 64					
	.	83					
	3	03					
160	3	03					
	2	02					
	7	07					
	X	71					
	1	01					
	+	61					
	$R \sqrt{x}$	35 62					
	STO 8	33 08					
	$g \cdot x^2$	32 54		220			

LABELS					FLAGS	SET STATUS		
A INIT	B $X_i \rightarrow f'(x_i)$	C $X_i = f(x)$	D $f'(x)$ with $P_3$	E VOL $\rightarrow$ ROOT	0 PAUSE			
a % $\Delta$	b	c	d $f'(x)$ with $t$	e PAUSE	1 % $\Delta$			
0 PAUSE	1 $f(x)$	2 $f'(x)/d$	3 $Q(x)$	4	2 $Q(x) \times 20$			
5	6	7	8	9	3			
						ON OFF	TRIG	DISP
						0 <input type="checkbox"/> <input checked="" type="checkbox"/>	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
						1 <input type="checkbox"/> <input checked="" type="checkbox"/>	GRAD <input type="checkbox"/>	SCI <input type="checkbox"/>
						2 <input type="checkbox"/> <input checked="" type="checkbox"/>	RAD <input type="checkbox"/>	ENG <input type="checkbox"/>
						3 <input type="checkbox"/> <input checked="" type="checkbox"/>		n _____

# Program Description I

11

**Program Title** Routines for Option Writers

**Contributor's Name** John R. McGinley Jr.

**Address** 235 East 57th St.

**City** New York, **State** N.Y. **Zip Code** 10022

**Program Description, Equations, Variables** Using the Black & Scholes Model (compliments of T.I.) the value of a given option may be calculated given stock & strike prices, an interest rate, the stock's volatility(see below), the days to expiry, and the dividends to be received in the interim. Then the hedge ratio is calculated from which the number of options per share to write is determined. Once done, the max. yield on investment cash flow yield, and the annual rate of return on the lesser of these can be calculated. Finally the high and low break-even points for the stock are figured along with the point of maximum profit (should the option expire or be exercised there).

## Equations

- 1) Cash flow return = Premium divided by Stock Price
- 2) Premium = # Options written X price per option received

$$\text{Value} = P_{\text{stock}} N(D_1) - P_{\text{exer}} N(D_2)e^{-R\Delta t}$$

$$\text{Where } D_1 = \frac{\ln(P_{\text{stock}} \div P_{\text{exer}}) + (R + \frac{1}{2}V^2) \Delta t}{V \sqrt{\Delta t}}$$

$$D_2 = \frac{\ln(P_{\text{stock}} \div P_{\text{exer}}) + (R - \frac{1}{2}V^2) \Delta t}{V \sqrt{\Delta t}}$$

$$N(D_1) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{D_1} e^{-\frac{1}{2}t^2} dt$$

(continued on page 2)

**Note:** Based on the Black and Scholes model published in Financial Analysts Journal, July - August 1975, page 65.

**Operating Limits and Warnings** Option value must be calculated first, then the hedge ratio, followed by the # to write. Only then can the returns (C/F & MYOI) be figured. Latter enables the annual return to be determined. Now the high. low. max points can be calculated. The givens are all remembered until user changed.

One can go directly from getting the number to write to L-M-H without figuring the annualized return first. i.e. sequence must be E, fc, fd, fc, fb.(fa may be used any time after fd.)

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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- 3)  $MYOI = \text{Premium} + (\text{Strike} - \text{Stock prices}) + \text{dividends, all divided by dividends.}$
- 4)  $\text{Annualized return} = (\text{Days in year/days to expiry}) \times \text{lesser of C/F or MYOI.}$
- 5)  $\# \text{Options to write} = 1/\text{hedge ratio.}$
- 6)  $\text{Downside protection (break-even) point} = \text{Strikeprice} - \text{premium}$
- 7)  $\text{Maximum profit point} = \text{Strike price}$
- 8)  $\text{Upside protection point} = ((\text{Premium} + \text{strike} - \text{stock prices}) / \# \text{ Options which are uncovered}) + \text{Strike price.}$  If options are fully covered,  $\text{upside protection} = \text{Strike price} + \text{premium.}$

\*Volatility is the annual standard deviation of the return on the underlying stock. There are several ways of estimating it. One is to keep fitting various values into the equation until the actual price equals the calculated price. Another is to use this equation:

$$\text{Volatility} = \frac{\text{High} - \text{Low}}{1/2 (\text{High} - \text{Low})}$$

where the highs and lows used are those of the stock over a period of time. Experience has shown using this method produces values which are too high. Thus use 6 months' highs and lows (those printed in the newspapers during June & July) or dispense with dividing the denominator by 2.

\*Be careful not to confuse volatility with beta. The beta of a stock or option measures the variability with respect to the market: i.e. if the market goes up ten points, how far should the stock go? Volatility, on the other hand, measures the stock or option's variability with respect only to itself. How much does this stock tend to move around. AT & T has an approximate volatility of .11. National Semiconductor has an approximate volatility of .49! Almost 5 times as volatile. Most brokerage houses can provide you with the numbers they are using as of any given date

Purchase of a Call Option gives the buyer the right, over a specified period of time, to buy so many shares of the stock at a fixed price. Options are traded on several exchanges and move in price with the underlying stock, only with greater percent price changes because of the high leverage. There is usually a certain premium built in to the price of the option which represents the price you pay for the right to buy at a set price. The amount of the premium is emotionally determined, but its theoretical amount can be calculated by this model. Any variations from the theoretical, then, could represent potential profit. Normally most of the premium, if any, is lost by 30 days prior to expiration of the option. Writers of options like to see high premiums when they "write". Buyers of options like to see none.

\* Do not confuse the use of the word premium here with that used above. Here it describes the difference between the selling price of the option and its intrinsic value due to the price of the underlying stock. Above, it means the entire amount of money an option writer obtains for writing the contract.

# Program Description II

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Sketch(es)

**Sample Problem(s)** Given the stock of XYZ Corp. at \$118.25 per share, the Jan 120 option with 35 days to go, a dividend expected of \$1.50, the stock's volatility at .28, and an interest rate of 6%, what is the expected value of the option now? How many options should I write against 100 shares of the stock given its hedge ratio? What are the variously figured returns which I should expect? Where do I make the most money? Where are my break-even points?

Solution(s)	Keystrokes	Display	Keystrokes	Display
1)	120 ↑ 118.25 [A]	\$120	9) [fa]	63.47%
2)	35 ↑ 1.50 [C]	.10 yr.	10) [fb]	"\$111.05", "\$120".
3)	6 [B]	.06		\$128.95
4)	.28 [D]	.28		
5)	[E] (In 11 seconds)	\$3.60		
6)	[fe] (In 7 seconds)	.48		
7)	[fd]	200 sh.		
8)	[fc]	"8.83%", 6.09%		

**Reference(s)** "Fact & Fantasy in the use of options" by Fischer Black (Financial Analysts Journal, July/August 75), "The Pricing of Options and Corporate Liabilities" by Black & Scholes (Journal of Political Economy, May/June 73), "Listed Options by Bear Stearns," "A guide to AMEX options" from the American Stock Exchange. The Thompson & McKinnon Option Letter.





# 67 Program Listing I

15

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS		
001	* f LBL C	31 25 13	Enter time in days & dividend in \$		RCL 1	34 01			
	STO C	33 13			RCL 2	34 02			
	h x-y	35 52			÷	81			
	3	03		060	f Ln	31 52			
	6	06			+	61			
	5	05			X	71			
	÷	81			STO A	33 11			
	STO 3	33 03			RCL 0	34 00			
	h 1/x	35 62			2	02			
					÷	81			
010	STO E	33 15	Enter Volatility		+	61			
	h LST x	35 82			* f LBL 1	31 25 01			
	h RTN	35 22			f x > 0	31 81			
* f LBL D	31 25 14			070	GTO 2	22 02			
STO 4	33 04				CHS	42			
h RTN	35 22				h SF 0	35 51 00			
* f LBL B	31 25 12				* f LBL 2	31 25 02			
EEX	43				STO 6	33 06			
2	02				.	83			
÷	81				3	03			
020	STO 5	33 05	Calculate option value		3	03			
	h RTN	35 22			2	02			
* f LBL E	31 25 15				7	07			
f GSB 5	31 22 05			080	X	71			
RCL 1	34 01				1	01			
X	71				+	61			
STO 8	33 08				h 1/x	35 62			
f GSB 4	31 22 04				STO 9	33 09			
RCL 2	34 02				.	83			
X	71				1	01			
030	RCL 7	34 07	Display option value		2	02			
	CHS	42			CHS	42			
g e <sup>x</sup>	32 52				X	71			
X	71			090	RCL 9	34 09			
CHS	42				g x <sup>2</sup>	32 54			
RCL 8	34 08				.	83			
+	61				9	09			
STO D	33 14				3	03			
h RTN	35 22				7	07			
* f LBL 4	31 25 04				1	01			
040	RCL A	34 11	Hedge ratio SHR		X	71			
	RCL 0	34 00			.	83			
2	02				4	04			
÷	81			100	3	03			
-	51				6	06			
GTO 1	22 01				2	02			
* f LBL 5	31 25 05				+	61			
RCL 4	34 04				+	61			
RCL 3	34 03				RCL 9	34 09			
f √x	31 54				X	71			
050	X	71			STO B	33 12			
	STO 0	33 00			RCL 6	34 06			
	h 1/x	35 62			g x <sup>2</sup>	32 54			
	RCL 5	34 05		110	2	02			
	RCL 3	34 03			÷	81			
	X	71			CHS	42			
	STO 7	33 07							
REGISTERS									
0	1	2	3	4	5	6	7	8	9
√ΔT/ADGE	Stock Px	Strike Px	Decimal time	Volatility	Interest Rate	Used/ # Optn	rt/prem	Used/ MYOI	Used/ c/f
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	99	B Ln(Ps/Pe)	C Dividend	D Option price	E 1/Time	I			

# 67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	g e <sup>x</sup>	32 52			h RTN	35 22	
	2	02		170	* g LBL a	32 25 11	Calculate Annual % return
	h $\pi$	35 73			RCL 8	34 08	
	X	71			RCL 9	34 09	
	f $\sqrt{x}$	31 54			g x > y	32 81	
	$\div$	81			h x-y	35 52	
	RCL B	34 12			RCL E	34 15	
120	X	71			X	71	
	h F? 0	35 71 00			h RTN	35 22	
	GTO 3	22 03		*	f LBL A	31 25 11	Enter strike price & stock cost
	CHS	42			STO 1	33 01	
	1	01		180	h R $\downarrow$	35 53	
	+	61			STO 2	33 02	
*	f LBL 3	31 25 03			DSP 2	23 02	
	h CF 0	35 61 00			1	01	
	h RTN	35 22			2	02	
	* g LBL e	32 25 15	Hedge Ratio Routine		CHS	42	
130	f GSB 5	31 22 05		*	h ST I	35 33	
	STO 0	33 00			h R $\downarrow$	35 53	Calculate high & low break-even points. Also max. profit point.
	h RTN	35 22			h RTN	35 22	
*	g LBL d	32 25 14	Determine # to write in round lots		g LBL b	32 25 12	
	EEX	43		190	RCL 7	34 07	
	2	02			RCL 2	34 02	
	RCL 0	34 00			RCL 1	34 01	
	h 1/x	35 62			-	51	
	DSP 0	23 00			+	61	
	f RND	31 24			RCL 6	34 06	
140	STO 6	33 06			1	01	
	X	71			-	51	
	h RTN	35 22			f x = 0	31 51	
*	g LBL c	32 25 13	Calculate MYOI and cash flow % return		GTO 6	22 06	
	DSP 2	23 02		200	$\div$	81	
	RCL D	34 14			f LBL 7	31 25 07	
	RCL 6	34 06			RCL 2	34 02	
	X	71			+	61	
	STO 7	33 07			f -x-	31 84	
	RCL 2	34 02			RCL 2	34 02	
150	RCL C	34 13			f -x-	31 84	
	+	61			RCL 1	34 01	
	+	61			RCL 7	34 07	
	RCL 1	34 01			-	51	
	-	51		210	f -x-	31 84	
	h LST x	35 82			h RTN	35 22	
	$\div$	81			f LBL 6	31 25 06	
	EEX	43			RCL 7	34 07	
	2	02			GTO (i)	22 24	
	X	71					
160	STO 8	33 08					
	f -x-	31 84					
	RCL 7	34 07					
	RCL 1	34 01					
	$\div$	81					
	EEX	43		220			
	2	02					
	X	71					
	STO 9	33 09					
LABELS						FLAGS	SET STATUS
A Str-Stk Price	B i	C Time-Div	D Vol'ty	E Opt Value	F Used	FLAGS	TRIG DISP
a Ann'l %	b L-M-H	c MYOI-C/F	d # Write	e Hedge R.	1	ON OFF	DEG <input type="checkbox"/> SCI <input type="checkbox"/>
0	1 Used	2 Used	3 Used	4 Used	2	0 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/>	GRAD <input type="checkbox"/> RAD <input type="checkbox"/> ENG <input type="checkbox"/>
5 Used	6	7	8	9	3		n <u>2</u>

# Program Description I

**Program Title** Empirical CBOE Call Pricing

**Contributor's Name** Hewlett-Packard

**Address** 1000 Circle Blvd.

**City** Corvallis

**State** Oregon

**Zip Code** 97330

**Program Description, Equations, Variables** The input variables are the 52 week HIGH and LOW prices of the stock, the dividend yield (Y) in percent, the time (T) on the option in months, the current stock price (Ps), the exercise price of the option (Pe), and the call loan rate on money lent brokers (I).

Combining the high and low prices to form a standard measure of price volatility

$$V = \frac{\text{HIGH} - \text{LOW}}{\frac{\text{HIGH} + \text{LOW}}{2}}$$

Clasing fit the following curves to the CBOE data he studied:

for  $P_s \geq P_E$   
("in the money")

$$P_s \left\{ \left( \frac{P_s}{P_E} - 1 \right) \left( 1 - \frac{T}{45} \right) + T \left[ .01 + \frac{V}{180} - \frac{11-Y-I}{1200} \right] \right\}$$

for  $P_s < P_E$   
("out of the money")

$$P_s \left\{ .4 \left( \frac{P_s}{P_E} - 1 \right) + T^{1/2} \left[ .0267 + \frac{V}{30} - \frac{11-Y-I}{400} \right] \right\}$$

These expressions yield the call premium in dollars. If the underlying stock is ex-dividend for the option period, the premium is reduced by [(months to maturity ÷ 12) x (Annual yield in %)] per cent.

**Operating Limits and Warnings** The formulas are empirical fits. The premiums derived are only estimates. The formulas are not applicable to over-the-counter options since the underlying stocks on the CBOE are uniformly high-volume, large-number-of-shares-outstanding stocks. Dividends are also handled differently on the two markets. Do not neglect to account for dividends, if applicable, per the last lines of the "program description" section above.

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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# Program Description II

## Sketch(es)

**Sample Problem(s)** A certain CBOE Stock yields 6% in dividends, its 52 week range is 25 to 48, last price 40 1/2. The call loan rate for brokers from N.Y. banks is 8%.

- a. What is the estimated premium for 3 month calls with \$45 strike price?
- b. For 2 months at \$35?

## Solution(s)

a)  $8 [E] \quad 48 \div 25 [A] \quad 40.5 \div 6 [B] \quad 3 \div 45 [C] \quad \text{ans } 2.25$

b)  $2 \div 35 [C] \quad \text{ans } 7.38$

c)  $f [B] \quad 6 \div 50 [C] \quad \text{ans } 2.30$

**Reference(s)** This program is a modification of the 65 user contributed program #3942A written by Paul W. Snow. The 65 program was based on. Clasing, H.K. Jr. The Dow Jones - Irwin Guide to Put and Call Options, Homeword, Ill, Dow Jones - Irwin, 1975 chapter 3.

## 19

[illegible]

# 97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS		
001	*LBL6		Dividends paid flag	054	.				
002	SF2		(test cleared)	055	4				
003	RTN			056	x		.4 (Ps - 1) PE		
004	*LBLA			057	.				
005	ST06		LOW	058	0				
006	XZY		HIGH	059	2				
007	ST01			060	6				
008	RTN			061	7				
009	*LBLB			062	RCL1		V/180		
010	XZY	Y		063	6		V/30		
011	ST03	I		064	x		(.0267 + V/30		
012	R4			065	+				
013	RCL4			066	RCL2				
014	+	11-(Y+I)		067	-		-11-Y-I		
015	1			068	RCL5		400		
016	1			069	JX		T 1/2(above)		
017	XZY			070	x		.4 (Ps/PE-1)+T1/2(1)		
018	-			071	+				
019	4			072	RCL3				
020	0			073	x				
021	0	11-Y-I 400		074	F2?				
022	=			075	GSB1		Dividends?		
023	ST02			076	RTN				
024	RCL1			077	*LBL0				
025	RCL6	HIGH-LOW		078	RCL7		T/45		
026	-			079	1				
027	LSTX			080	RCL5				
028	RCL1			081	4				
029	+			082	5				
030	2	V=HI-LO (HI+LO) 2		083	=		1 - T/45		
031	=			084	-		(Ps/PE-1)(1-T/45)		
032	=			085	x				
033	1			086	.				
034	8			087	0		.01 + V/180		
035	0			088	1				
036	=			089	RCL1				
037	ST01	V 180		090	+				
038	RCL3			091	RCL2				
039	RTN			092	3		[.01 + V - 11-Y-I] 180 1200		
040	*LBLC			093	=				
041	RCL3	STRIKE PRICE		094	-				
042	XZY	STOCK PRICE		095	RCL5		T [.]		
043	=	Ps/PE		096	x				
044	1			097	+				
045	-	(Ps/PE) -1		098	RCL3		Ps {(.) (.) + [.]}		
046	ST07			099	x				
047	R4			100	F2?				
048	ST05	TIME		101	GSB1		Dividends?		
049	RCL7	(Ps/PE) - 1 ≥ 0 →		102	RTN				
050	0	Ps ≥ PE → other		103	*LBLE				
051	XZY?	eqn		104	ST04		I		
052	ST06			105	RTN				
053	RCL7								
				110					
REGISTERS									
0	1 V 180	2 11-Y-I 400	3 Ps	4 I	5 T	6 Used	7 Ps-I PE	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A 111,Lo,Y,Ps		B PE,T,Go		C	D	E	I		

## 21

[illegible]



# Program Description I

Program Title      WARRANT & OPTION HEDGING

Contributor's Name      HEWLETT PACKARD

Address      19310 PRUNERIDGE AVE

City      CUPERTINO

State      CA

Zip Code      95014

## Program Description, Equations, Variables

$$\text{CROSS RETURN} = \frac{\frac{\text{CONVERSION PRICE}}{\text{conversion rate}} + \text{warrant price} \times \text{number sold} - \text{stock price}}{\text{warrant price} \times \text{number sold} + .5 \times \text{stock price} + \text{interest}}$$

$$\text{lower break-even point} = \max\{0, \text{stock price} - \text{warrant price} \times \text{number sold}\}$$

$$\text{upper break-even point} = \frac{\text{stock price} - \text{number warrants sold} \times [\text{warrant price} + \text{conversion price}]}{1 - \text{conversion rate} \times \text{number of warrants sold}}$$

$$\text{Cross Return} = \frac{\text{warrant price} - \max\{0, \text{hypothetical price} / \text{conversion rate} - \text{stock price}\} + \text{hypothetical stock price} - \text{stock price}}{\text{warrant price} \times \text{number sold} + .5 \times \text{stock price} + \text{interest}}$$

## Operating Limits and Warnings

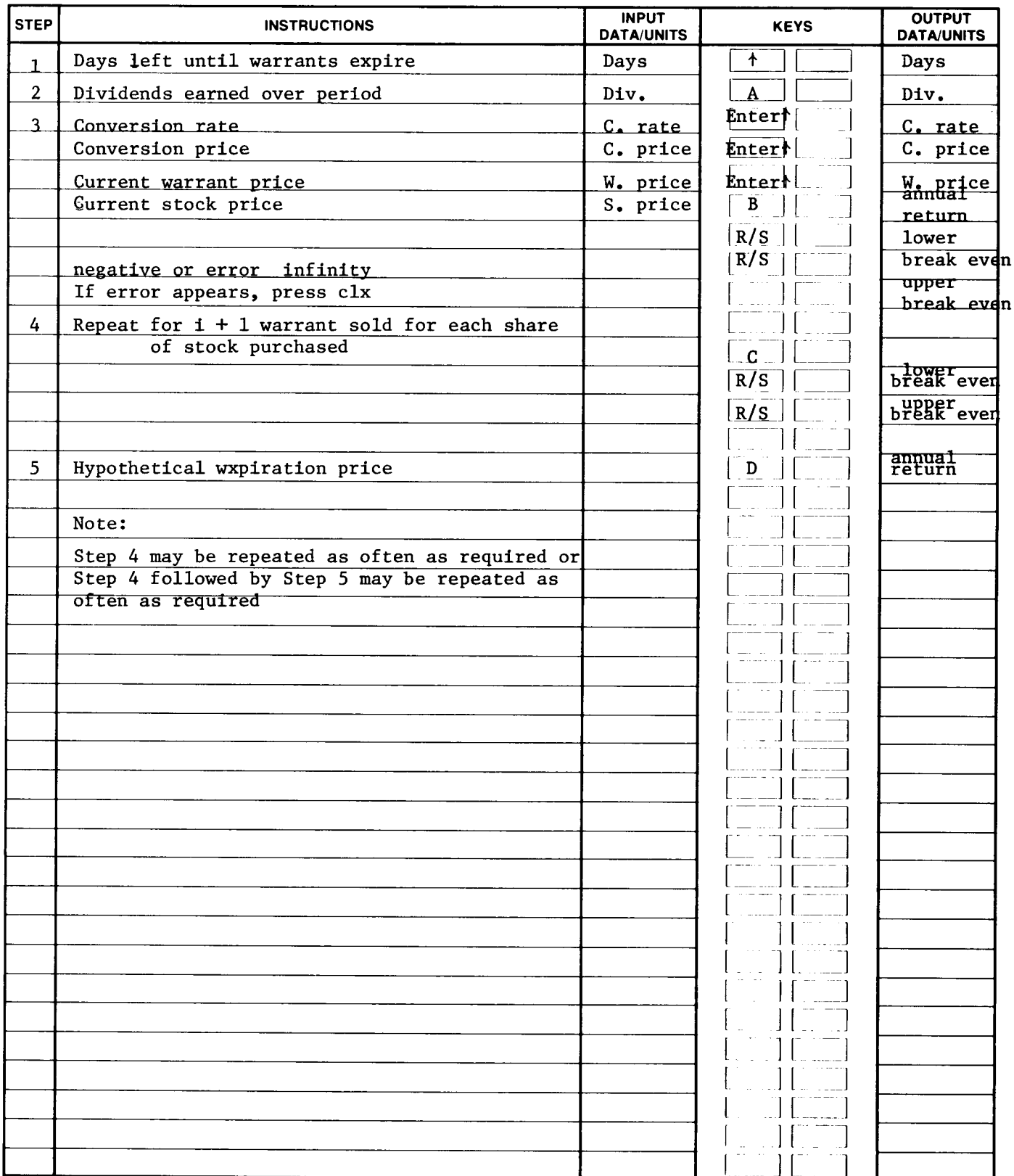
1. The dividends should be the expected amount to be received over a year, since the time of payment is not used the calculated rate of return is the apparent rate rather than the true rate (a very small difference here).
2. The program assumes purchases on 50\$ margin at 10% interest.
3. The program assumes equity of 100% of the price on \$5 whichever is greater on the short sales.
4. program I calculates the rate of return for the most favorable situation (i.e. stock closes at conversion price on the expiration date); program II should be used then.

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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XYZ corporation stock is trading at \$9 3/4 and a warrant, convertible 1 for 1 at \$34, is selling for \$1.75 expiring in 547 days. For various investment strategies<sup>1</sup> what is the maximum return (in percent) lower break even point and upper break even point. Further more, what are the possible returns if we assume various stock closing prices on the expiration date (eg \$5, \$10 and \$20 closing prices).

Reference(s)	
1	One, two, ... warrants sold short for each purchase of stock
2	Infinity: To clear press CLX and continue.
3	Each additional press of C produces an additional warrant sold <sup>1</sup> . For example the first C you get 2 warrants, second C pressed three etc.



# 97Program Listing I

25

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Dividend $\rightarrow R_3$	057	1	01	
002	ST03	35 03		058	+	-55	
003	XZY	-41		059	LN	32	
004	ST00	35 00	Days $\rightarrow R_0$	060	3	03	
005	XZY	-41		061	6	06	
006	RTN	24		062	5	05	
007	*LBLB	21 12		063	x	-35	
008	ST05	35 05	Stock price $\rightarrow R_5$	064	RCL0	36 00	
009	R4	-31		065	$\div$	-24	
010	ST04	35 04	Warr. price $\rightarrow R_4$	066	e <sup>x</sup>	33	
011	R4	-31		067	1	01	
012	ST06	35 06	Conversion price	068	-	-45	
013	R4	-31	$\rightarrow R_6$	069	RCL3	36 03	D
014	ST02	35 02	Conversion rate	070	RCL7	36 07	D/E
015	0	00	$\rightarrow R_2$	071	$\div$	-24	
016	ST01	35 46		072	+	-55	
017	*LBLC	21 13		073	EEX	-23	Annual rate of
018	DSZ1	16 25 46		074	2	02	return
019	RCL1	36 46		075	x	-35	
020	CHS	-22		076	R/S	51	
021	RCL4	36 04		077	x	-35	
022	x	-35		078	RCL5	36 05	
023	RCL6	36 06	B x WP	079	RCL4	36 04	SP - B x WP
024	RCL2	36 02		080	RCL1	36 46	Lower breakeven
025	$\div$	-24		081	CHS	-22	point
026	+	-55	CP/CR + B x WP	082	x	-35	
027	RCL5	36 05		083	-	-45	
028	-	-45	CP/CR + B x WP - SP	084	R/S	51	
029	ST01	35 01		085	RCL5	36 05	
030	5	05		086	RCL1	36 46	
031	RCL4	36 04		087	CHS	-22	
032	XZY?	16-35		088	RCL4	36 04	SP - B(WP + CP)
033	R4	-31		089	RCL6	36 06	
034	RCL1	36 46		090	+	-55	
035	CHS	-22		091	x	-35	
036	x	-35		092	-	-45	
037	.	-62		093	1	01	
038	5	05		094	RCL1	36 46	
039	RCL5	36 05		095	CHS	-22	
040	x	-35	.5 x SP	096	RCL2	36 02	Upper breakeven
041	+	-55		097	x	-35	point
042	1	01		098	-	-45	
043	3	03		099	$\div$	-24	
044	7	07		100	R/S	51	
045	EEX	-23		101	*LBLD	21 14	
046	6	06	$\approx .10/365 \times .5$	102	ST08	35 08	
047	CHS	-22		103	RCL6	36 06	
048	RCL0	36 00		104	RCL2	36 02	
049	RCL5	36 05		105	$\div$	-24	
050	x	-35		106	-	-45	
051	x	-35	.10/365 x .5 x L	107	RCL7	36 07	
052	+	-55	x SP	108	ENT1	-21	
053	ST07	35 07	Equity $\rightarrow R_7$	109	ENT1	-21	
054	RCL1	36 01		110	R4	-31	
055	XZY	-41		111	R4	-31	
056	$\div$	-24	R/E	112	R4	-31	

REGIS. END

0	1	2	3	4	5	6	7	8	9
Days	Return	Conv rate	Div.	Warr. pr.	Stock pr	Conv. pr.	Equity	HSP	
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I	#warr. sold			

[illegible]

# Program Description I

**Program Title** Bull Spread Option Strategy  
**Contributor's Name** Hewlett-Packard  
**Address** 1000 Circle Blvd.  
**City** Corvallis **State** Oregon **Zip Code** 97330

## Program Description, Equations, Variables

$$\text{Upside Breakeven} = \frac{R(C_S + E_S) - (C_L + E_L)}{R - 1}$$

$$\text{Downside Breakeven} = RC_S - C_L$$

Where:

R = The ratio of the calls with higher exercise price sold short to the calls with lower exercise price purchased.

$C_S$  = Market Price of Calls Sold Short

$E_S$  = Exercise Price of Calls Sold Short

$C_L$  = Market Price of Calls Bought Long

$E_L$  = Exercise Price of Calls Bought Long

## Operating Limits and Warnings

On matched hedges, upside breakeven is infinite.

HP-65 will blink 0.00 Hit [CLX] to stop blinking.

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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# Program Description II

## Sketch(es)

N O N E

## Sample Problem(s) I. Matched:

Buy 5 Oct. ITT 25's @ 6

Sell 5 Oct. ITT 30's @ 2 7/8

Calculate Upside and Downside Breakeven's and how much % the stock moves.

## II. Unmatched:

Buy 7 Oct. ITT 25's @ 6

Sell 10 Oct. ITT 30's @ 2 7/8

Calculate Upside and Downside Breakeven's and what % the stock moves

In both cases stock is now selling at 28 3/4.

**Solution(s)** I. 5[A] 2.875[A] 30[A] 5[B] 6[B] 25[B] 28.75 [C]

DBE= [D] = 28.13 % change to reach downside = [D] = - 2.17%

UBE= [E] =  $\alpha$  [CLX] % change to reach upside = [E] = -100.00%

II. 10[A] 2.875 [A] 30[A] 7 [B] 6 [B] 25 [B] 28.75 [C]

DBE= [D] = 26.89 % change to reach downside = [D] = - 6.46%

UBE= [E] = 37.25 % change to reach upside = [E] = 29.57%

If II had followed I directly, input only 10[A] 7[B] [D] [D] [E] [E].

**Reference(s)** This program is a one for one translation of the 65 User's Library program #3769 by Morris A. Nunes, based on an article by D. Turov called "Limitless Option" in Barrons, '75 p 9.

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2 ▶

[illegible]



# 97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
01	*LBLA		Enter # Options	057	-		↓
02	ST01		Shorted	058	÷		
003	RTN			059	RTN		
004	*LBLA		Enter Price of	060	*LBLE		Calculate Percent- age Change in under- lying Stock to go from Current Price to Upside Breakeven Price
005	ST02		Options Shorted	061	RCL7		
006	RTN			062	÷		
007	*LBLA		Enter Exercise Price	063	1		
008	ST03		of Options Shorted	064	-		
009	RTN			065	EEX		
010	*LBLB		Enter # Options	066	2		
011	ST04		Bought Long	067	x		
012	RTN			068	RTN		
013	*LBLB		Enter Price of	069	R/S		
014	ST05		Options Bought Long				
015	RTN						
016	*LBLB		Enter Exercise Price				
017	ST06		of Options Bought Long				
018	RTN						
019	*LBLC		Enter Current Under-				
020	ST07		lying Stock Price				
021	RTN						
022	*LBLC						
023	RCL6		Calculate Downside	080			
024	RCL5		Breakeven Price us-				
025	+		ing the formula:				
026	RCL1						
027	RCL4		$DBE = RC_S - C_L$				
028	÷		↓				
029	RCL2						
030	x						
031	-						
032	RTN						
033	*LBLC			090			
034	RCL7		Calculate Percentage				
035	÷		Change in underlying				
036	1		Stock to go from				
037	-		current price to				
038	EEX		Downside Breakeven				
039	2		Price				
040	x						
041	RTN						
042	*LBLE		Calculate Upside	100			
043	RCL1		Breakeven Price us-				
044	RCL4		ing the formula:				
045	÷		$UBE = \frac{R(C_S - E_S) - (C_L + E_L)}{R - 1}$				
046	ST08						
047	RCL2						
048	RCL3						
049	+						
050	x						
051	RCL5						
052	RCL6						
053	+						
054	-			110			
055	RCL8						
056	1						

## REGISTERS

0	1 # Short	2 Price Short	3 Exercise Price Short	4 # Long	5 Price Long	6 Exercise Price Long	7 Current Stock Price	8 Ratio	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

## 97 Program Listing II

[illegible]

# Program Description I

Program Title Butterfly Options

Contributor's Name Hewlett-Packard

Address 1000 Circle Blvd.

City Corvallis

State Oregon

Zip Code 97330

**Program Description, Equations, Variables** A butterfly option is actually the combination of one bull spread and one bear spread i.e. the purchase of one high, one low and the sale of two middle option on the same underlying stock. If the stock closes between the high and low strike prices (including consideration of commissions and premiums) the investor will generally profit with maximum profit occurring in the middle strike price. Program assumes a standard option commission of \$25 per option per transaction.

Calculation formulas are shown on the program listing using the following variables.

$E_L$  = Lowest Exercise Price

$P_L$  = Price of Low Strike Option

$E_M$  = Middle Exercise Price

$P_M$  = Price of Middle Strike Option

$E_H$  = High Exercise Price

$P_H$  = Price of High Strike Option

$BE_H$  = Upside Breakeven Price

**Operating Limits and Warnings** Always hit E as the first step. Maximum "Profit" may be negative indicating merely the minimum loss. Similarly, if premiums work out right, maximum "Loss" may be positive, equally minimum profit (and meaning no cash is needed as an investment).

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# Program Description II

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Sketch(es)

N O N E

**Sample Problem(s)** Given XYZ stock with the following options available and due simultaneously:

Strike price 40 selling at 13 1/4

Strike price 50 selling at 7

Strike price 60 selling at 1 5/8

Calculate maximum profit, maximum loss (investment), upside break-even price, downside breakeven price if a butterfly is developed and commissions are assumed at \$25 per option per transaction.

**Solution(s)** E; 40A 13.25 R/S 50 R/S 7 R/S 60 R/S 1.625 R/S yields 787.50 = max profit; B yields -262.50 = max loss (equals investment); C yields 57.38 = upside breakeven price; D yields 42.13 = downside breakeven price;

E initializes for new case. All 6 variables must be entered for each case.

**Reference(s)** A one for one translation of the 65 User's Library program 3768 by Morris A. Nunes.



# 97Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA		Enter Low	057	RCL5		
002	ST04		Exercise	058	2		
003	R/S			059	x		
004	ST01		Enter Low Price	060	RCL2		
005	R/S			061	2		
006	ST05		Enter Mid Exercise	062	x		
007	R/S			063	+		
008	ST02		Enter Mid Price	064	RCL4		
009	R/S			065	-		
010	ST06		Enter High Exercise	066	RCL1		
011	R/S			067	-		
012	ST03		Enter High Price	068	RCL3		
013	RCL5			069	-		
014	RCL4			070	1		
015	-			071	.		
016	RCL1			072	7		
017	-			073	5		
018	RCL2			074	-		
019	2			075	RTN		
020	x			076	*LBLD		
021	+			077	RCL5		
022	RCL3			078	2		
023	-			079	x		
024	RCL7			080	XZY		
025	x			081	-		
026	RCL7			082	.		
027	-			083	5		
028	2			084	-		
029	5			085	RTN		
030	-			086	*LBLB		
031	RTN			087	CLRG		
032	*LBLB			088	1		
033	RCL6			089	0		
034	RCL4			090	0		
035	-			091	ST07		
036	RCL1			092	0		
037	-			093	ENT1		
038	RCL6			094	ENT1		
039	RCL5			095	ENT1		
040	-			096	ENT1		
041	RCL2			097	RTN		
042	XZY			098	R/S		
043	-						
044	2						
045	x						
046	+						
047	RCL3						
048	-						
049	RCL7						
050	x						
051	1						
052	7						
053	5						
054	-						
055	RTN						
056	*LBLC						

REGISTERS									
0	1Low Exer	2Low Price	3Mid Exer	4Mid Price	5High Exer	6High Price	7 100	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

# Program Description I

**Program Title** 67 - STOCK PRICE 30-WEEK MOVING AVERAGE WITH DATA STORAGE  
**Contributor's Name** Delmer D. Hinrichs  
**Address** 2116 S. E. 377th Ave.  
**City** Washougal **State** Washington **Zip Code** 98671

**Program Description, Equations, Variables** This program allows both the data and the program for a 30-unit moving average to be stored on one card. This is especially convenient for calculating and periodic updating of 30-week moving averages of stock prices. After loading the data and program from a card, the previous average may be displayed, and only the new data entered. The updated average is displayed after each data entry. When all available data have been entered, the updated data may be recorded on the card.

Data may be entered as 5-digit integers, as 3-digit integers plus quarter points, or as 2-digit integers plus eighth points. For example, using eighth points, for 25  $\frac{1}{8}$  enter 25.1; for 56  $\frac{7}{8}$  enter 56.7; for  $38\frac{1}{2}$  enter 38.4; for 17 enter 17; etc. All data to be averaged together must be entered in the same mode (integer, quarters, eighths).

The 30 data units are stored in 15 registers, two per register, as 5-digit integers. Data for quarter points or eighth points are also stored as 5-digit integers, but with the decimal point shifted. The decimal point is shifted back again before displaying the average. The data are not moved from register to register for each new entry, but only the oldest datum is replaced by the new datum, and the index is incremented. The "I" register contains both the index, and the sum of all the data stored as a decimal fraction.

There is no output of an average until 30 units have been entered.

Entries are checked for format and size errors. Negative Nos. or zero are illegal.

Do not clip side 1 of the card, to allow updating of the stored data.

**Operating Limits and Warnings** Put data on side 1 and program on side 2 of card.

Clear registers and flags before starting a new series of data entries.

Press "Reset" only once after loading data and program.

After an erroneous entry ("Error" display) press "CLx", but do not Reset.

All data entries for a series must be in the same mode.

Be sure to press "f P  $\rightarrow$  S" before loading data onto a card. Ignore "Crđ" after data load.

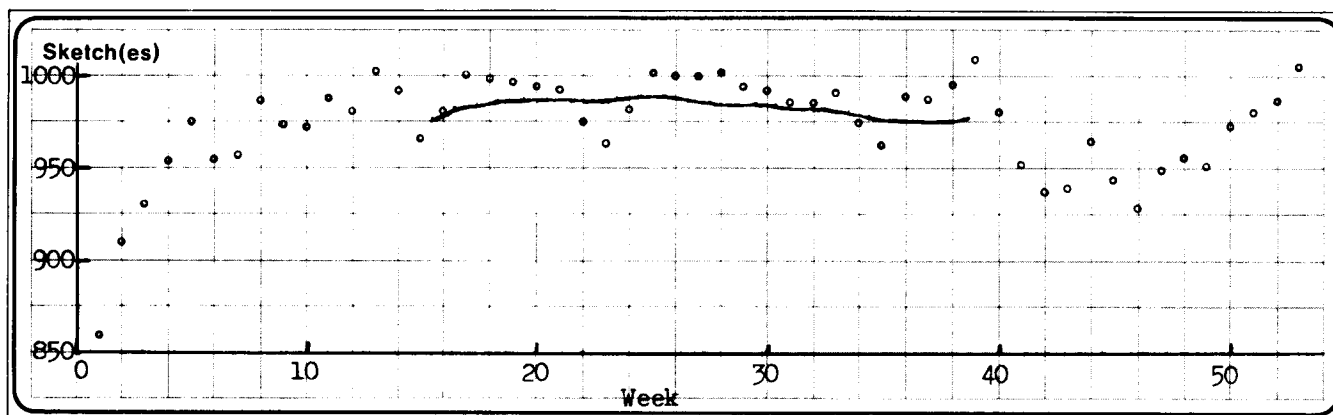
Max. size of whole No. is 5 digits for Integer; 3 digits for Quarter; 2 digits for Eighth.

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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# Program Description II

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## Sample Problem(s)

Calculate a 30-Week Moving Average of 1976 DJIA Data:

Week	DJIA	Week	DJIA	Week	DJIA	Week	DJIA	Week	DJIA	Week	DJIA
1	859	9	973	17	1001	25	1002	33	990	41	952
2	911	10	973	18	997	26	1000	34	974	42	937
3	930	11	988	19	996	27	1000	35	964	43	939
4	954	12	980	20	993	28	1003	36	989	44	965
5	975	13	1003	21	991	29	993	37	988	45	943
6	955	14	992	22	975	30	991	38	995	46	928
7	958	15	968	23	964	31	985	39	1009	47	949
8	988	16	980	24	979	32	986	40	980	48	957

A moving average is correctly plotted in the center of the span of the averaged data. With a 30-unit span, as with this program, the first average must then be plotted between the 15th and the 16th data points, as shown below. Thus the output always lags 15 weeks behind the current data, so the 15 most recent weeks have no average to plot.

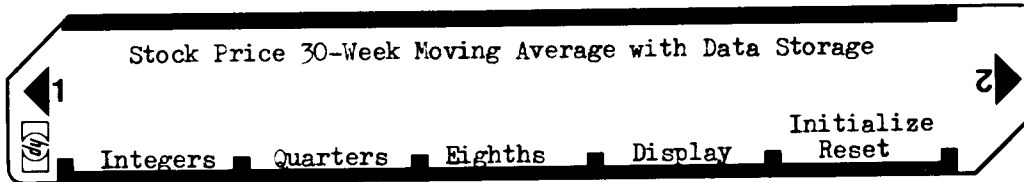
For this example, the HP-67 was set to "DSP 0", so that the output shown below was rounded to the nearest integer.

Week	DJIA	Avg	Week	DJIA	Avg	Week	DJIA	Avg	Week	DJIA	Avg	Week	DJIA	Avg
1	859	---	12	980	---	22	975	987	32	986	979	43	939	---
2	911	---	13	1003	---	23	964	987	33	990	977	44	965	---
3	930	---	14	992	---	24	979	988	34	974	976	45	943	---
4	954	---	15	968	976	25	1002	989	35	964	975	46	928	---
5	975	---	16	980	980	26	1000	987	36	989	975	47	949	---
6	955	---	17	1001	982	27	1000	986	37	988	975	48	957	---
7	958	---	18	997	984	28	1003	984	38	995	976	49	951	---
8	988	---	19	996	985	29	993	983	39	1009	---	50	973	---
9	973	---	20	993	985	30	991	982	40	980	---	51	979	---
10	973	---	21	991	986	31	985	980	41	952	---	52	986	---
11	988	---	22	975	---	32	986	---	42	937	---	53	1005	---

Reference(s) HP-65 Users' Library Program No. 03133



## User Instructions

[illegible]

## 67 Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL B	31 25 12	Enter 1/4 Points		RCL (i)	34 24	
	h SF 0	35 51 00			g FRAC	32 83	
	GTO 0	22 00			f x=0	31 51	30 Entries Yet?
	f LBL C	31 25 13	Enter 1/8 Points	060	h RTN	35 22	No, Display Zero
	h SF 1	35 51 01			1	01	Yes, Continue
	f LBL 0	31 25 00			h RC I	35 34	
	f INT	31 83			g FRAC	32 83	
	h LST x	35 82			RCL 7	34 07	
	g FRAC	32 83			$\frac{\div}{\div}$	81	
010	h F? 0	35 71 00	1/4 Points Entered?		h F? 0	35 71 00	1/4 Points Entered?
	RCL 4	34 04	Yes		RCL 2	34 02	Yes
	h F? 1	35 71 01	1/8 Points Entered?		h F? 1	35 71 01	1/8 Points Entered?
	RCL 8	34 08	Yes		RCL 3	34 03	Yes
	X	71		070	X	71	
	+	61	Convert to Decimal		h RTN	35 22	Display Average
	h F? 0	35 71 00			g LBL f e	32 25 15	Initialize, New Data
	RCL 2	34 02			h SF 2	35 51 02	
	h F? 1	35 71 01			f LBL E	31 25 15	Reset, Save Old Data
	RCL 3	34 03			f P $\leftrightarrow$ S	31 42	
020	$\div$	81	Convert to Integer		EEX	43	
	f LBL A	31 25 11	Enter Integers		1	01	
	f LN	31 52			STO 1	33 01	
	h LST x	35 82			h F? 2	35 71 02	Set for New Data?
	f INT	31 83		080	h ST I	35 33	Yes
	h LST x	35 82	Error Checking:		EEX	43	
	g x $\neq$ y	32 61	Entry $\leq$ Zero?		2	02	
	g SIN <sup>-1</sup>	32 62	Entry Non-Integer?		CHS	42	
	RCL 5	34 05	Entry Oversize?		STO 2	33 02	
	g x $\leq$ y	32 71			EEX	43	
030	g SIN <sup>-1</sup>	32 62			3	03	
	h R $\downarrow$	35 53			CHS	42	
	RCL (i)	34 24			STO 3	33 03	
	g FRAC	32 83			2	02	
	h LST x	35 82		090	.	83	
	f INT	31 83			5	05	
	RCL 5	34 05	Update Data		STO 4	33 04	
	$\div$	81			EEX	43	
	h R $\uparrow$	35 54			5	05	
	+	61			STO 5	33 05	
040	STO (i)	33 24			3	03	
	CLx	44			EEX	43	
	RCL 1	34 01			7	07	
	h R $\uparrow$	35 54			CHS	42	
	RCL 5	34 05		100	STO 7	33 07	
	$\div$	81			1	01	
	h R $\uparrow$	35 54			.	83	
	-	51			2	02	
	f DSZ	31 33	Update Sum and		5	05	
	RCL 3	34 03	Increment Index		STO 8	33 08	
050	X	71			CLx	44	
	h RC I	35 34			h RTN	35 22	Stop & Display Zero
	+	61			f LBL 1	31 25 01	Subroutine to Reset
	g x $\leq$ y	32 71			1	01	Data Index
	f GSB 1	31 22 01		110	5	05	
	h ST I	35 33			+	61	
	f LBL D	31 25 14	Display Average		h RTN	35 22	

## REGISTERS

0	1	2	3	4	5	6	7	8	9
	10	0.01	0.001	2.5	100000		$3 \times 10^{-7}$	1.25	
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
Data	Data	Data	Data	Data	Data	Data	Data	Data	Data
A		B		C		D		E	
Data		Data		Data		Data		Index, Sum	

[illegible]

# Program Description I

Program Title Exponential Smoothing

Contributor's Name Ted Bright

Address 40 Woodland Road

City Fairfax

State California

Zip Code 94930

## Program Description, Equations, Variables

Projections from time-series data are computed using a weighted moving average, eliminating the need to retain past observations.

First, a smoothed moving average,  $S_{t+i}(x)$  is calculated from the current series value,  $X_{t+i}$ , and the prior average,  $S_{t+i-1}(x)$ , according to the formula:

$$S_{t+i}(x) = \alpha X_{t+i} + (1-\alpha) S_{t+i-1}(x), \text{ (recalled by keying c)}$$

where  $\alpha$  is the smoothing constant, determined in the program as a function of the number of observations to be smoothed,  $n$ , by the relationship  $\alpha = \frac{2}{n+1}$

The change in average,  $C_{t+i}$ , is simply:

$$C_{t+i} = S_{t+i}(x) - S_{t+i-1}(x) \text{ (recalled by keying fc)}$$

From this is found a new trend,  $T_{t+i}$ , thru the equation:

$$T_{t+i} = \alpha C_{t+i} + (1-\alpha) T_{t+i-1} \text{ (recalled by keying D)}$$

Finally, expected demand,  $D_{t+i+1}$ , is defined as:

$$D_{t+i+1} = S_{t+i}(x) + \frac{1-\alpha}{\alpha} T_{t+i} \text{ (displayed after each iteration)}$$

With the entry of a new  $x$  value, a prediction error can be expressed as:

$$e_{t+i} = D_{t+i} - X_{t+i} \text{ (recalled by keying E)}$$

The user may wish to increase the sensitivity of the program to anticipated trends with an increase in the value of  $\alpha$  observing that  $0 < \alpha < 1$ .

The initial trend is assumed to be 0 unless a value is entered.

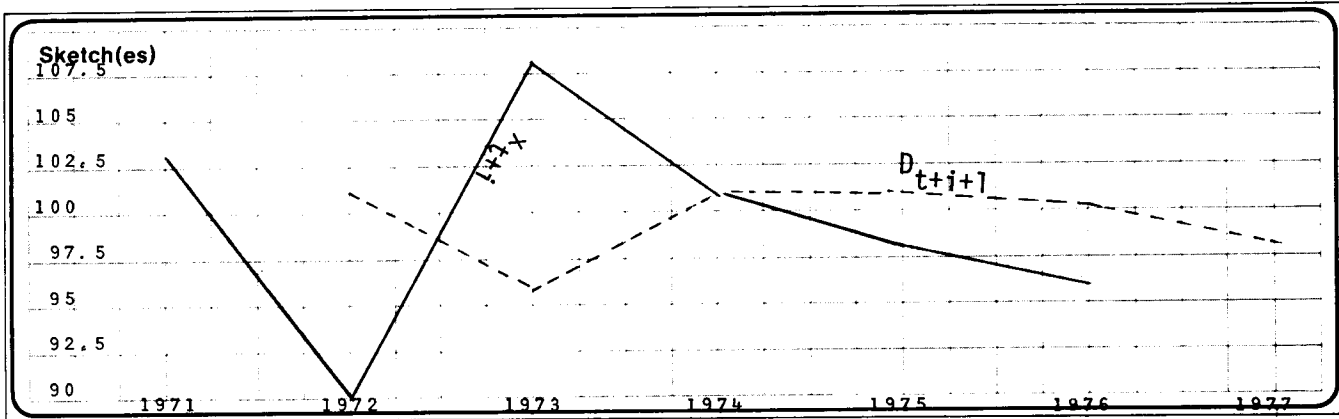
## OPERATING LIMITS AND WARNINGS

There being no prior value of  $D$ ,  $e$  on the first iteration will be meaningless.

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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# Program Description II



## Sample Problem(s)

The chart below shows six ( $n=6$ ) values,  $x_{t+i}$ , for 1971 thru 1976. The program, using an initial estimate for the smoothed average,  $S_{t+i-1}(x)$ , of 100, will produce the remaining data, including a projected quantity,  $D_{t+i+1}$ , for 1977.

Initialize using the keystrokes 6[↑], 100[A].

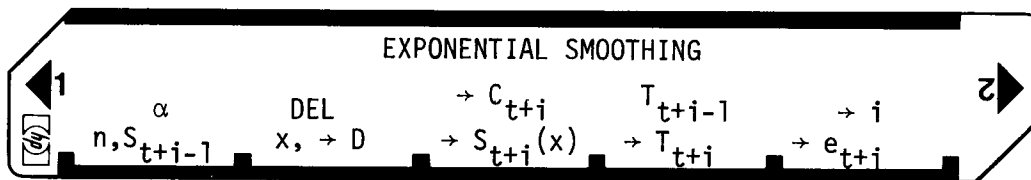
Then enter the value of  $x_{t+i}$  for 1971 (103), press [B], and observe that the output displayed agrees with the first solution under  $D_{t+i+1}$ . Press [C], f[C], [D], and [E], likewise noting the results in their respective columns. Enter the  $x_{t+i}$  values for each succeeding year followed by the keystrokes above each column.

Keystrokes			B	C	fc	D	E
	i	$x_{t+i}$	Expected Demand $D_{t+i+1}$	Smoothed Average $S_{t+i}(x)$	Change in Smoothed Average $C_{t+i}$	Trend $T_{t+i}$	Error $e_{t+i}$
	0			100		0	
1971	1	103	101.47	100.86	.86	.24	-
1972	2	90	95.98	97.76	-3.10	-.71	11.47
1973	3	108	101.50	100.68	2.93	.33	-12.02
1974	4	101	101.42	100.77	.09	.26	.50
1975	5	98	99.88	99.98	-.79	-.04	3.42
1976	6	96	97.96	98.84	-1.14	-.35	3.88

## Reference(s)

Charles T. Clarke and Lawrence L. Schkade, Statistical Methods for Business Decisions (Cincinnati, Ohio: South-Western Publishing Co. 1969), pp 702-711.

## User Instructions

[illegible]

# 97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Initialization routine	057	RTN	24	Dt+ti displayed
002	CLRG	16-53		058	*LBLb	21 16 12	error recovery routine
003	STO3	35 03	St+1-i(X)	059	DSZI	16 25 46	decrement I
004	CLX	-51		060	RCLA	36 11	Tt+1-i
005	1	01		061	STO5	35 05	Tt+1-i
006	+	-55		062	RCL9	36 09	St+1-i(X)
007	2	02	$\alpha$ computed	063	STO3	35 03	St+1-i(X)
008	XZY	-41		064	RCL8	36 08	Dt+1
009	=	-24		065	STO2	35 02	Dt+1
010	*LBL0	21 00		066	RTN	24	Dt+1 displayed
011	STO0	35 00	$\alpha$	067	*LBLC	21 13	St+1(X) display routine
012	1	01		068	RCL3	36 03	St+1(X)
013	STO1	35 01		069	RTN	24	
014	RCL0	36 00	1- $\alpha$ computed	070	*LBLc	21 16 13	Ct+1 display routine
015	ST-1	35-45 01	1- $\alpha$	071	RCL4	36 04	Ct+1
016	RTN	24	$\alpha$ displayed	072	RTN	24	
017	*LBLa	21 16 11	$\alpha$ option routine	073	*LBLD	21 14	Tt+1 display routine
018	STO0	22 00		074	RCL5	36 05	Tt+1
019	*LBLB	21 12	Dt+1+i routine	075	RTN	24	
020	STO7	35 07	Xt+1	076	*LBLd	21 16 14	Tt+1 entry routine
021	RCL2	36 02	Dt+1	077	STO5	35 05	Tt+1
022	STO8	35 08	Dt+1	078	RTN	24	
023	RCL3	36 03	St+1-i(X) copied	079	*LBLE	21 15	Et+1 display routine
024	STO9	35 09	St+1-i(X) for error	080	RCL6	36 06	Et+1
025	RCL5	36 05	Tt+1-i recovery	081	RTN	24	
026	STOa	35 11	Tt+1-i routine	082	*LBL e	21 16 15	i display routine
027	ISZI	16 26 46	i indexed	083	RCL1	36 46	i
028	RCL2	36 02	Dt+1	084	RTN	24	
029	RCL7	36 07	Xt+1	085	R/S	51	
030	-	-45	Et+1 computed				
031	STO6	35 06	Et+1				
032	RCL7	36 07	Xt+1				
033	RCL0	36 00	$\alpha$				
034	x	-35					
035	RCL1	36 01	1- $\alpha$				
036	RCL3	36 03	St+1-i(X) St+1(X) computed				
037	x	-35					
038	+	-55					
039	STO3	35 03	St+1(X)				
040	RCL9	36 09	St+1-i(X)				
041	-	-45	Ct+1 computed				
042	STO4	35 04	Ct+1				
043	RCL0	36 00	$\alpha$				
044	x	-35					
045	RCL1	36 01	1- $\alpha$				
046	RCL5	36 05	Tt+1-i Tt+1 computed				
047	x	-35					
048	+	-55					
049	STO5	35 05	Tt+1				
050	RCL1	36 01	1- $\alpha$				
051	RCL0	36 00	$\alpha$				
052	=	-24					
053	x	-35					
054	RCL3	36 03	St+1(X) Dt+1+i computed				
055	+	-55					
056	STO2	35 02	Dt+1+i				

SET STATUS			
FLAGS		TRIG	DISP
0	<input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
1	<input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF	GRAD <input type="checkbox"/>	SCI <input type="checkbox"/>
2	<input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF	RAD <input type="checkbox"/>	ENG <input type="checkbox"/>
3	<input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF		n.2

REGISTERS									
0 $\alpha$ Smoothing constant	1 1- $\alpha$	2 Dt+1 expected demand	3 St+1(X) smoothed moving avg	4 Ct+1 change in average	5 Tt+1 trend	6 Et+1 error in forecast	7 Xt+1 Value in series at t+1	8 Dt+1 saved for error recovery	9 St+1-i(X) saved for error recovery
S0 Tt+1-i saved for error recovery	S1	S2	S3	S4	S5	S6	S7	S8	S9
A		B		C		D		E	
									I time period

# Program Description I

Program Title **MULTIPLE LINEAR REGRESSION**

Contributor's Name **HEWLETT-PACKARD COMPANY**

Address **Corvallis Division**  
**1000 N.E. Circle Boulevard**

City **Corvallis, OR 97330**

State

Zip Code

## Program Description, Equations, Variables

This program performs a least squares multiple linear regression for a series of data points  $x, y, z$ . Linear regression is a statistical method for finding a straight line that best fits a set of data points. The equation of this straight line expresses the linear relationship between independent ( $x$  and  $y$ ) and dependent ( $z$ ) variables and is of the form:

$$z = a + bx + cy$$

Independent variables are input by pressing **B**. If one or more of the data points was entered incorrectly, simply re-enter the incorrect value(s) and press **f A**. Then continue as before. The three coefficients ( $a, b, c$ ) are calculated by pressing **C**.

In addition, the program also calculates the coefficient of determination  $r^2$  (**D**). This is an indication of the "goodness of fit" for the calculated straight line, and is a number between 0 and 1. Values closer to 1 indicate "better" fits than values closer to 0.

Having determined the equation (the **C** key), the user can then project estimates of  $z$  for given  $x, y$  values (**E**). The sums ( $\sum x_i, \sum y_i, \sum z_i$ ), the sums of squares ( $\sum x_i^2, \sum y_i^2, \sum z_i^2$ ), and the sums of cross products ( $\sum x_i y_i, \sum x_i z_i, \sum y_i z_i$ ) are stored in registers 7-9, 4-6, and 1-3 respectively.

An option is available (**f E**) to automatically print/pause the calculated values. Pressing **f E** sets and clears the print option. Successive use of **f E** will alternately display 1.00 and 0.00, indicating that the print/pause mode is on or off respectively.

## Operating Limits and Warnings

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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# Program Description II

## Sketch(es)

## Sample Problem(s)

### 18. Multiple Linear Regression

$$z = a + bx + cy$$

$$\Sigma z_i = an + b \Sigma x_i + c \Sigma y_i \quad i = 1, 2, \dots, n$$

$$\Sigma x_i z_i = a \Sigma x_i + b \Sigma x_i^2 + c \Sigma x_i y_i$$

$$\Sigma y_i z_i = a \Sigma y_i + b \Sigma x_i y_i + c \Sigma y_i^2$$

$$c = \frac{A - B}{[n \Sigma x_i^2 - (\Sigma x_i)^2] [n \Sigma y_i^2 - (\Sigma y_i)^2] - [n \Sigma x_i y_i - (\Sigma x_i) (\Sigma y_i)]^2}$$

where:

$$A = [n \Sigma x_i^2 - (\Sigma x_i)^2] [n \Sigma y_i z_i - (\Sigma y_i) (\Sigma z_i)]$$

$$B = [n \Sigma x_i y_i - (\Sigma x_i) (\Sigma y_i)] [n \Sigma x_i z_i - (\Sigma x_i) (\Sigma z_i)]$$

$$b = \frac{[n \Sigma x_i z_i - (\Sigma x_i) (\Sigma z_i)] - c [n \Sigma x_i y_i - (\Sigma x_i) (\Sigma y_i)]}{n \Sigma x_i^2 - (\Sigma x_i)^2}$$

## Solution(s)

$$a = \frac{1}{n} (\Sigma z_i - c \Sigma y_i - b \Sigma x_i)$$

$$R^2 = \frac{a \Sigma z_i + b \Sigma x_i z_i + c \Sigma y_i z_i - \frac{1}{n} (\Sigma z_i)^2}{(\Sigma z_i^2) - \frac{(\Sigma z_i)^2}{n}}$$

## Reference(s)

# Program Description II

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## Sketch(es)

## Sample Problem(s)

### Example 1:

A commercial land appraiser has examined 5 vacant lots in the downtown section of a local community, all of which have different depths, frontages, and values as shown below. Based on this data, what is the relationship between depth, frontage, and lot value? What is the coefficient of determination? What predicted value would a lot have with a 50 foot depth and 70 foot frontage? With a 75 foot depth and 80 foot frontage?

Lot Depth (feet)	Lot Frontage (feet)	Lot Value
70	70.8	\$101,000
90	60.0	82,190
85	90.0	170,000
40	70.0	100,000
100	60.0	90,000

### Keystrokes:

### Outputs:

**A** 70 **ENTER** 70.8 **ENTER** 101000 **B**  
 90 **ENTER** 60 **ENTER** 82190 **B**  
 85 **ENTER** 90 **ENTER** 170000 **B**  
 40 **ENTER** 70 **ENTER** 100000 **B**  
 100 **ENTER** 60 **ENTER** 90000 **B** → 5.00 (number of entries)  
**C** → -118499.03 (a)  
**R/S** → 314.71 (b)  
**R/S** → 2892.02 (c)  
 Hence,  $z = -118499.03 + 314.71x + 2892.02y$   
**D** → 0.98 ( $r^2$ )  
 50 **ENTER** 70 **E** → 99678.08 (value of 50 × 70 foot lot)  
 75 **ENTER** 80 **E** → 136466.08 (value of 75 × 80 foot lot)

Notice that if your lot has a depth of 50 feet and a frontage of 10 feet a negative \$ value results (-73843.26). You may have difficulty selling this property!

## Solution(s)

## Reference(s)

## User Instructions

Diagram illustrating a Turing Machine tape configuration for Multiple Linear Regression. The tape contains the text "Multiple Linear Regression" and symbols for start, sum, addition, multiplication, and division. Arrows indicate the head's position at the start and end of the tape.

STEP	INSTRUCTIONS				INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2						
2	Optional: Select print/pause mode				<b>F E</b>	1.00 or 0.00	
3	Initialize (START)				<b>A</b>	0.00	
4	Key in x and y, and corresponding z value	x			<b>ENTER</b>		
		y			<b>ENTER</b>		
		z			<b>B</b>	# entries	
5	Repeat step 4 for all x, y, z data pairs.						
6	If a data pair was input incorrectly, re-enter incorrect x, y, z values	x			<b>ENTER</b>		
		y			<b>ENTER</b>		
		z			<b>F A</b>	# entries - 1	
7	Calculate coefficients:				<b>C</b>	a	
					<b>R/S</b>	b	
					<b>R/S</b>	c	
	If the print/pause mode is on (1.00), b and c are automatically calculated.						
8	Optional: Calculate the coefficient of determination: $r^2$				<b>D</b>	$r^2$	
9	Optional: Key in x and y values and calculate the estimated z value. (This may be repeated as often as desired.)	x			<b>ENTER</b>		
		y			<b>E</b>	$\hat{z}$	
10	For a new case, go to step 2.						

# 97 Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Initialize	057	-	-45	
002	CLRG	16-53		058	STOI	35 46	
003	CF1	16 22 01		059	R4	-31	
004	0	00		060	X <sup>2</sup>	53	
005	RTN	24		061	GSB2	23 02	
006	*LBLB	21 12	Input $x_i, y_i, z_i$	062	ST+i	35-55 45	Calculate a,b,c
007	STOC	35 13		063	RTN	24	
008	R4	-31		064	*LBLC	21 13	
009	STOB	35 12		065	RCL0	36 00	
010	R4	-31		066	RCL4	36 04	
011	STOA	35 11	Compute $\Sigma x_i, \Sigma y_i, \Sigma z_i$ $\Sigma x_i^2, \Sigma y_i^2, \Sigma z_i^2$ $\Sigma x_i y_i, \Sigma y_i z_i, \Sigma z_i x_i$	067	x	-35	
012	F0?	16 23 00		068	RCL7	36 07	
013	GSB8	23 06		069	X <sup>2</sup>	53	
014	7	07		070	-	-45	
015	STOI	35 46		071	STOD	35 14	
016	R4	-31		072	RCL0	36 00	
017	GSB1	23 01		073	RCL3	36 03	
018	8	08		074	x	-35	
019	STOI	35 46		075	RCL8	36 08	
020	RCLB	36 12		076	RCL9	36 09	
021	F0?	16 23 00		077	x	-35	
022	GSB6	23 06		078	-	-45	
023	GSB1	23 01		079	x	-35	
024	9	09		080	STOC	35 13	
025	STOI	35 46		081	RCL0	36 00	
026	RCLC	36 13		082	RCL1	36 01	
027	F0?	16 23 00		083	x	-35	
028	GSB6	23 06		084	RCL7	36 07	
029	GSB1	23 01		085	RCL8	36 08	
030	RCLA	36 11		086	x	-35	
031	RCLB	36 12		087	-	-45	
032	x	-35		088	STOA	35 11	
033	GSB2	23 02		089	RCL0	36 00	
034	ST+1	35-55 01		090	RCL2	36 02	
035	RCLA	36 11		091	x	-35	
036	RCLC	36 13		092	RCL7	36 07	
037	x	-35		093	RCL9	36 09	
038	GSB2	23 02		094	x	-35	
039	ST+2	35-55 02		095	-	-45	
040	RCLB	36 12		096	STOB	35 12	
041	RCLC	36 13		097	x	-35	
042	x	-35		098	RCLC	36 13	
043	GSB2	23 02		099	X <sup>2</sup> Y	-41	
044	ST+3	35-55 03		100	-	-45	
045	1	01		101	RCLD	36 14	
046	GSB2	23 02		102	RCL0	36 00	
047	ST+0	35-55 00		103	RCL5	36 05	
048	RCL0	36 00		104	x	-35	
049	F0?	16 23 00		105	RCL8	36 08	
050	GSB6	23 06		106	X <sup>2</sup>	53	
051	RTN	24	Subroutine for $\Sigma x_i, \dots$ $\Sigma x_i^2, \dots$	107	-	-45	
052	*LBL1	21 01		108	x	-35	
053	GSB2	23 02		109	RCLA	36 11	
054	ST+i	35-55 45		110	X <sup>2</sup>	53	
055	RCLI	36 46		111	-	-45	
056	3	03		112	÷	-24	

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REGISTERS										
0	$n$	1 $\Sigma x_i y_i$	2 $\Sigma x_i z_i$	3 $\Sigma y_i z_i$	4 $\Sigma x_i^2$	5 $\Sigma y_i^2$	6 $\Sigma z_i^2$	7 $\Sigma x_i$	8 $\Sigma y_i$	9 $\Sigma z_i$
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9	
A Used		B Used		C Used		D Used		E Used		I Used

# 97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
113	STOC	35 13		169	F0?	16 23 00	
114	RCLB	36 12		170	GSB6	23 06	
115	RCLA	36 11		171	RCLC	36 13	
116	RCLC	36 13		172	X	-35	
117	X	-35		173	X*Y	-41	
118	-	-45		174	RCLB	36 12	
119	RCLD	36 14		175	X	-35	
120	÷	-24		176	+	-55	
121	STOB	35 12		177	RCLA	36 11	
122	RCL9	36 09		178	+	-55	
123	RCLC	36 13		179	GT09	22 09	Correction of input values.
124	RCL8	36 08		180	*LBLa	21 16 11	
125	X	-35		181	SF1	16 21 01	
126	-	-45		182	GSBB	23 12	
127	RCLB	36 12		183	CF1	16 22 01	
128	RCL7	36 07		184	RTN	24	Print instructions
129	X	-35		185	*LBLc	21 16 15	
130	-	-45		186	F0?	16 23 00	
131	RCL0	36 00		187	GT05	22 05	
132	÷	-24		188	SF0	16 21 00	
133	STOA	35 11	a	189	1	01	
134	GSB7	23 07		190	RTN	24	
135	RCLB	36 12	b	191	*LBL5	21 05	
136	GSB9	23 09		192	0	00	
137	RCLC	36 13	c	193	CF0	16 22 00	
138	GT09	22 09		194	RTN	24	
139	*LBLD	21 14		195	*LBL7	21 07	
140	RCLA	36 11		196	F0?	16 23 00	
141	RCL9	36 09		197	SPC	16-11	
142	X	-35	Calculate r <sup>2</sup>	198	*LBL9	21 09	
143	RCLB	36 12		199	F0?	16 23 00	
144	RCL2	36 02		200	GT06	22 06	
145	X	-35		201	R/S	51	
146	+	-55		202	RTN	24	
147	RCLC	36 13		203	*LBL6	21 06	
148	RCL3	36 03		204	PRTX	-14	
149	X	-35		205	RTN	24	
150	+	-55		206	*LBL2	21 02	Change sign for correction.
151	RCL9	36 09		207	F1?	16 23 01	
152	X <sup>2</sup>	53		208	CHS	-22	
153	RCL0	36 00		209	RTN	24	
154	÷	-24		210	*LBL8	21 08	
155	-	-45		211	SPC	16-11	
156	RCL6	36 06		212	GT09	22 09	
157	RCL9	36 09		213	R/S	51	
158	X <sup>2</sup>	53					
159	RCL0	36 00					
160	÷	-24					
161	-	-45					
162	÷	-24					
163	GT07	22 07					
164	*LBLc	21 15	Calculate 2 for given x,y.	220			
165	X*Y	-41					
166	F0?	16 23 00					
167	GSBB	23 08					
168	X*Y	-41					

LABELS					FLAGS	SET STATUS		
A Start	B Σ+	C a;b;c	D r <sup>2</sup>	E ^ Z	0 Print	FLAGS	TRIG	DISP
a Σ-	b	c	d	e Print?	1 Correction	ON OFF 0 <input type="checkbox"/> <input checked="" type="checkbox"/>	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
0	1 Used	2 Used	3	4	2	1 <input type="checkbox"/> <input checked="" type="checkbox"/>	GRAD <input type="checkbox"/>	SCI <input type="checkbox"/>
5 Used	6 Used	7 Used	8 Used	9 Used	3	2 <input type="checkbox"/> <input checked="" type="checkbox"/>	RAD <input type="checkbox"/>	ENG <input type="checkbox"/>
						3 <input type="checkbox"/> <input checked="" type="checkbox"/>		n <u>2</u>

# Program Description I

**Program Title** Curve Fitting, Selecting Best Function

**Contributor's Name** C.D. Bopp

**Address** 306 Virginia Road

**City** Oak Ridge

**State** Tenn.

**Zip Code** 37830

**Program Description, Equations, Variables** This program compares the coefficients of determination for the four functions described in the HP67/97 Standard Pac Program 03. The function having the largest coefficient of determination is indicated by displaying a code number, as explained in the User Instructions.

**Operating Limits and Warnings** The calculating time is roughly about one minute. Negative coordinates are not admissable. To enter another set of points, turn calculator off and on.

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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# Program Description II

Sketch(es)

**Sample Problem(s)** Given the points (x,y) 1,2; 2,3; 3,4; find (a) which of above-mentioned four correlations gives the highest coefficient of determination (COD), (b) compute the value of the COD, (c) with x equal to 4 project the value for y, and (d) compute the COD and project y for two of the other three correlations.

**Solution(s)** Part (a): 2 (↑) 1 (A) 3 (↑) 2 (A) 4 (↑) 3 (A) (B) → 1, indicating that the linear fit is best (using the coding numbers as described in the User Instructions).

Part (b): (RCL) (C) → 1.000, the COD.

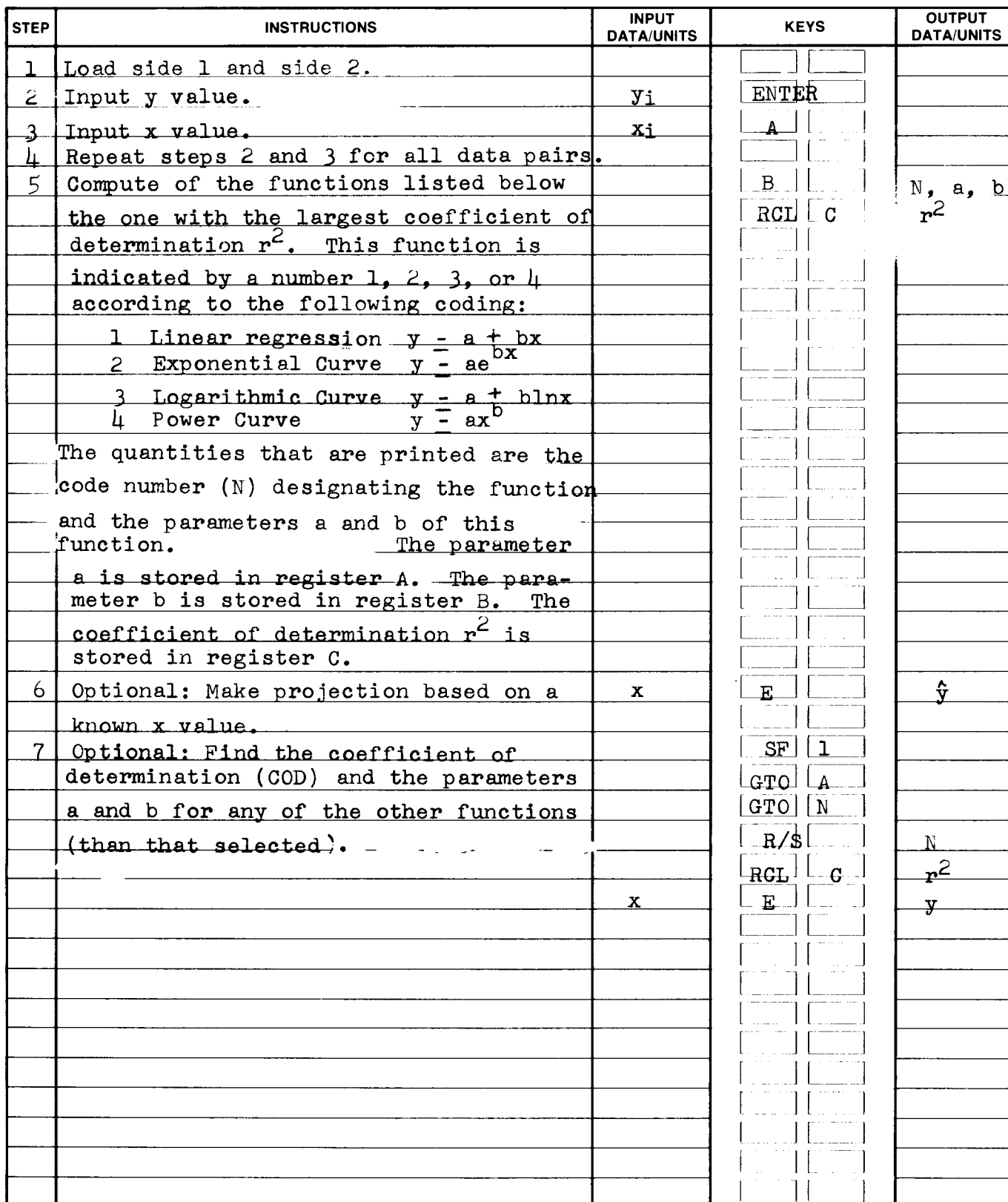
Part (c): 4 (E) → 5.000, the projected y.

Part (d): (SF)(1) (GTO) (A) (GTO) (2) (R/S) (RCL) (C) → 0.990, the COD for the exponential fit. 4 (E) → 5.77, the projected y.

(GTO) (A) (GTO) (3) (R/S) (RCL) (C) → 0.978, the COD for the logarithmic fit. 4 (E) → 4.40, the projected y.

Reference(s)

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# 97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11			ST00	35 00	
	$\Sigma$	56			1	01	
	LSTX	16 63			7	07	
	STOA	35 11		060	GSOB	23 00	
	LN	32			STOE	35 15	
	STOB	35 12			GSBC	23 13	
	$X \neq Y$	-41			1	01	
	STOC	35 13			F2?	16 23 02	
	LN	32			STOD	35 14	
010	STOD	35 14			RTN	24	
	RCLB	36 12			*LBL2	21 02	
	$P \neq S$	16-51			SF0	16 21 00	
	$\Sigma$	56			RCL6	36 06	
	RCLD	36 14		070	ST01	35 01	
	RCLA	36 11			RCL7	36 07	
	X	-35			STOE	35 15	
	ST+3	35-55 03			1	01	
	RCLB	36 12			3	03	
	RCLC	36 13			GSOB	23 00	
020	X	-35			ST03	35 03	
	ST+2	35-55 02			1	01	
	$P \neq S$	16-51			4	04	
	RTN	24			GSOB	23 00	
	*LBLB	21 12		080	ST02	35 02	
	0	00			1	01	
	STOC	35 13			5	05	
	GSOB	23 01			GSOB	23 00	
	GSOB	23 02			ST00	35 00	
	GSOB	23 03			GSBC	23 13	
030	GSOB	23 04			CF0	16 22 00	
	RCLD	36 14			2	02	
	ST01	35 46			F2?	16 23 02	
	GSOB	23 45			STOD	35 14	
	RCLD	36 14		090	RTN	24	
	PRTX	-14			*LBL3	21 03	
	RCLA	36 11			RCL4	36 04	
	PRTX	-14			ST02	35 02	
	RCLB	36 12			RCL5	36 05	
	PRTX	-14			ST00	35 00	
040	R/S	51			1	01	
	*LBL1	21 01			2	02	
	1	01			GSOB	23 00	
	8	08			ST03	35 03	
	GSOB	23 00		100	1	01	
	ST03	35 03			6	06	
	1	01			GSOB	23 00	
	4	04			ST01	35 01	
	GSOB	23 00			1	01	
	ST02	35 02			7	07	
050	1	01			GSOB	23 00	
	6	06			STOE	35 15	
	GSOB	23 00			GSBC	23 13	
	ST01	35 01			3	03	
	1	01		110	F2?	16 23 02	
	5	05			STOD	35 14	
	GSOB	23 00			RTN	24	

## REGISTERS

0 used	1 used	2 used	3 used	4 $\Sigma \ln x$	5 $\Sigma (\ln x)^2$	6 $\Sigma \ln y$	7 $\Sigma (\ln y)^2$	8 $\Sigma \ln x \ln y$	9 n
S0	S1	S2 $\Sigma y \ln x$	S3 $\Sigma x \ln y$	S4 $\Sigma x$	S5 $\Sigma x^2$	S6 $\Sigma y$	S7 $\Sigma y^2$	S8 $\Sigma xy$	S9 n
A a	B b	C r <sup>2</sup>	D used	E used	I used				

# 97 Program Listing II

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	*LBL4	21 04			RCLC	36 13	
	SFO	16 21 00		170	$x > y?$	16-34	
	RCL8	36 08			GT06	22 06	
	ST03	35 03			$x \neq y$	-41	
	RCL4	36 04			ST0C	35 13	
	ST02	35 02			SF2	16 21 02	
	RCL6	36 06			LBL6	21 06	
120	ST01	35 01			1	01	
	RCL5	36 05			GSB0	23 00	
	ST00	35 00			2	02	
	RCL7	36 07			GSB0	23 00	
	ST0E	35 15		180	RCLB	36 12	
	GSBC	23 13			x	-35	
	CFO	16 22 00			-	-45	
	4	04			RCL9	36 09	
	F2?	16 23 02			$\div$	-24	
	STOD	35 14			F0?	16 23 00	
130	RTN	24			e <sup>x</sup>	33	
	*LBLG	21 13			STOA	35 11	
	3	03			RTN	24	
	GSB0	23 00			*LBLO	21 00	
	2	02		190	STOI	35 46	
	GSB0	23 00			R↓	-31	
	1	01			RCLi	36 45	
	GSB0	23 00			RTN	24	
	x	-35			*LBLE	21 15	
	RCL9	36 09			RCLD	36 14	
140	$\div$	-24			STOI	35 46	
	-	-45			R↓	-31	
	STOB	35 12			GT0i	22 45	
	0	00			*LBL1	21 01	
	GSB0	23 00		200	RCLB	36 12	
	2	02			x	-35	
	GSB0	23 00			RCLA	36 11	
	x <sup>2</sup>	53			$\pm$	-55	
	RCL9	36 09			RTN	24	
	$\div$	-24			*LBL2	21 02	
150	-	-45			RCLB	36 12	
	$\div$	-24			x	-35	
	RCLB	36 12			e <sup>x</sup>	33	
	$x \neq y$	-41			RCLA	36 11	
	STOB	35 12		210	x	-35	
	$x \neq y$	-41			RTN	24	
	x	-35			*LBL3	21 03	
	2	02			LN	32	
	4	04			RCLB	36 12	
	GSB0	23 00			x	-35	
160	1	01			RCLA	36 11	
	GSB0	23 00			$\pm$	-55	
	x <sup>2</sup>	53			RTN	24	
	RCL9	36 09			*LBL4	21 04	
	$\pm$	-24		220	RCLB	36 12	
	-	-45			y <sup>x</sup>	31	
	$\div$	-24			RCLA	36 11	
	F1?	16 23 01			x	-35	
	STOC	35 13			RTN	24	

LABELS					FLAGS	SET STATUS		
A	B	C	D	E	0	FLAGS	TRIG	DISP
$y_1 \uparrow x_1$	$\rightarrow D, A, B$	used		$x \rightarrow \hat{y}$	used	ON OFF		
a	b	c	d	e	1 used	0 <input type="checkbox"/> <input checked="" type="checkbox"/>	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
0 used	1 used	2 used	3 used	4 used	2 used	1 <input type="checkbox"/> <input checked="" type="checkbox"/>	GRAD <input type="checkbox"/>	SCI <input type="checkbox"/>
5	6 used	7	8	9	3	2 <input type="checkbox"/> <input checked="" type="checkbox"/>	RAD <input type="checkbox"/>	ENG <input type="checkbox"/>
						3 <input type="checkbox"/> <input checked="" type="checkbox"/>		n <u>2</u>

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