

Program Description I

Program Title 67 - RATIONAL TIC-TAC-TOE

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 randomly chooses a center, side, or corner opening move (the only possible opening moves in tic-tac-toe). It then plays a very aggressive game, allowing no user wins, and taking every possible opportunity to force an HP-67 win. Any user mistakes are taken advantage of by completing a row-of-three, or by setting a trap (a "fork") to force a win. This differs from a merely "unbeatable" game.

The keyboard of the HP-67 is used as the playing board, with each digit representing one of the nine cells. The HP-67 moves first, and the user may move into any one of the eight remaining cells. As play continues, the user may move into any unoccupied cell.

The program operates on a game tree look-up basis; for 22 of the 24 possible combinations of opening move and initial user move, a sequence of "forcing moves" is selected from the response library in one of the registers. Actually, for 13 of these 22 conditions, the program has two alternate winning strategies, which are selected by chance. Thus the HP-67 may respond differently to the same user move. For the last two possible combinations, rational play precludes the use of "forcing moves", so the second user move is checked, and an appropriate response made. If the non-forced user move is not correct, the program sets a trap.

The flow diagram will help in following the program logic. Small squares represent direct program entry of the enclosed digit. "Moves" refer to user moves. Divided hexagons are subroutine (a). Flags 0, 1, and 2 have multiple uses, as does register I.

Operating Limits and Warnings

The response library must be loaded into the data registers before starting play.

The program does not check for illegal user moves (move less than 1, greater than 9, or to an occupied cell). If an illegal move is accidentally made, start a new game.

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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Revised

Sketch(es)	Sample Game (Random seed is zero; HP-67 plays "X", User plays "O")					
Turn: 1	2	3	4	5	6	7

Block & HP-67
2-in-row Wins

~~Sample Problem(s)~~Response Library

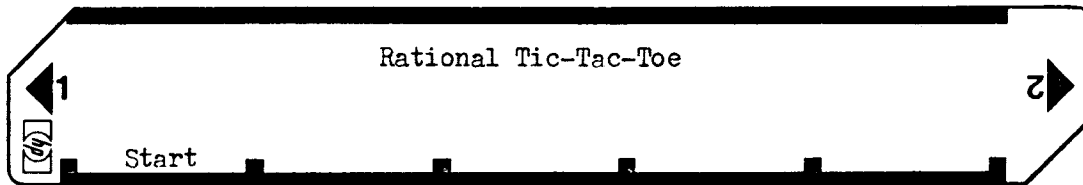
Register No.	Register Contents	Register No.	Register Contents
0	0	13 (S3)	.1374609081
1	.46823791	14 (S4)	.3157758317
2	.7314937694	15 (S5)	.13589
3	.28641971	16 (S6)	.1574636574
4	.1937173892	17 (S7)	.31587
5	0	18 (S8)	.4756859743
6	.9182737129	19 (S9)	.9578374958
7	.82196431	20 (A)	.5928332956
8	.9163419743	21 (B)	.5932732579
9	.64287319	22 (C)	.2358895326
10 (S0)	.58736491	23 (D)	.3259674539
11 (S1)	.58641971	24 (E)	.7435232745
12 (S2)	.1359758317	25 (I)	0

These register contents are intended to be stored on a data card, for ease of loading.

Solution(s)		Display			
Turn	Operation	Keys	Pause (User Move)	Stable	Flashing (HP-67 Wins)
--	Load Library, Program	--	--	0.000000000	--
1	Start Game	A	--	2.010000000	--
2, 3	Enter Move "8"	8, R/S	8.010000020	9.010000021	--
4, 5	" " "5"	5, R/S	5.010020021	3.011020021	--
6, 7	" " "6"	6, R/S	6.011022021	--	1.111022021
-1	Start a New Game	R/S, A	--	5.000010000	--
2, 3	Enter Move "1"	1, R/S	1.200010000	4.200110000	--
4, 5	" " "6"	6, R/S	6.200112000	8.200112010	--
6, 7	" " "3"	3, R/S	3.202112010	--	2.212112010
Etc.					

Reference(s) Gardner, Martin Mathematical Puzzles & Diversions
Simon and Schuster, New York 1959 pages 37 - 46

HP-65 Users' Library, programs No. 03363A and No. 03641A

[illegible]

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Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	Start: (Initialize for new game)		EEX	43	
	h CF 0	35 61 00			1	01	
	h CF 1	35 61 01			X	71	
	h CF 3	35 61 03		060	h ST I	35 33	
	0	00			f INT	31 83	
	STO 0	33 00	Random No. Generator (0, 1, or 2)		f x=0	31 51	Spacer in responses? Yes, try again Response, move match? Yes, try again HP-67 3-in-row win? Yes,
	2	02			GTO 3	22 03	
	h RC I	35 34			g x=y	32 51	
	h π	35 73			GTO 3	22 03	
010	+	61			h F? 2	35 71 02	
	g x^2	32 54	Center game? -- --		GTO 6	22 06	HP-67 fork win? Yes
	g FRAC	32 83			h RC I	35 24	
	h ST I	35 33			g FRAC	32 83	
	3	03		070	f x=0	31 51	
	X	71			GTO 7	22 07	
	f INT	31 83	Side game? Yes Side game? Yes If center game, replace 0 with 5 Display, user move		h R \downarrow	35 53	Display, user move Find next response Corner game, move 5
	f x=0	31 51			g GSB f a	32 22 11	
	h SF 0	35 51 00			GTO 3	22 03	
	g x=y	32 51			f LBL 1	31 25 01	
020	h SF 1	35 51 01			9	09	
	f x=0	31 51	Center game? Yes Side game? Yes Corner game. Move 5? Yes No, Add 5 or 6 to move		g GSB f a	32 22 11	Display, user move 2nd user move is 3? Yes
	5	05			3	03	
	g GSB f a	32 22 11			g x=y	32 51	
	5	05		080	GTO 2	22 02	
	h x \rightarrow y	35 52			4	04	
	h F? 0	35 71 00	Center game? Yes Side game? Yes		+	61	2nd user move is 7? Yes
	GTO 5	22 05			g x=y	32 51	
	h F? 1	35 71 01			GTO 2	22 02	
	GTO 4	22 04			h R \downarrow	35 53	
030	g x=y	32 51			h LST x	35 82	
	GTO 1	22 01	Then add 10 Center, Side reentry Store register index		\div	81	2nd user move 4 or 8? No
	g x \leq y	32 71			g FRAC	32 83	
	6	06			f x \neq 0	31 61	
	+	61		090	h SF 1	35 51 01	
	EEX	43			RCL 5	34 05	
	1	01	Response register		g GSB f b	32 22 12	Calculate response Previous move 4 or 8? No, 7 replaces 3
	+	61			3	03	
	f LBL E	31 25 15			h F? 1	35 71 01	
	h ST I	35 33			7	07	
040	EEX	43			RCL 5	34 05	
	5	05	Times 10^5 or 1		h x \rightarrow y	35 52	HP-67 wins w/3 or 7? Yes No, calc. responses for draw game
	RCL (i)	34 24			g x \neq y	32 61	
	h F? 2	35 71 02			GTO 6	22 06	
	1	01		100	g GSB f b	32 22 12	
	X	71			GTO f b	22 31 12	
	DSP 5	23 05	Round to 5 digits		f LBL 2	31 25 02	2nd user move is 3,7
	f RND	31 24			5	05	
	DSP 9	23 09			-	51	
	f LBL D	31 25 14			f x < 0	31 71	
050	h SF 2	35 51 02			g x^2	32 54	
	h ST I	35 33	Store responses Loop, find response		h x \rightarrow y	35 52	2nd user move is 3? Yes, replace with 4 No, replace with 2 Calculate response
	f LBL 3	31 25 03			g GSB f b	32 22 12	
	RCL 5	34 05			h R \uparrow	35 54	
	g GSB f d	32 22 14		110	g x \neq y	32 61	
	h RC I	35 34			GTO 6	22 06	
	g FRAC	32 83	Flag 2 flip-flop		4	04	No,

REGISTERS

0 Board	1 Library	2 Library	3 Library	4 Library	5 User Move	6 Library	7 Library	8 Library	9 Library
S0 Library	S1 Library	S2 Library	S3 Library	S4 Library	S5 Library	S6 Library	S7 Library	S8 Library	S9 Library
A Library	B Library	C Library	D Library	E Library	I Seed, Index, Responses				

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
	+	61			4	04	
	GTO 6	22 06	HP-67 wins w/6 or 8	170	g x>y	32 81	2nd user move 1, 3?
	g LBL f b	32 25 12	Calculate responses for user move 5		GTO C	22 13	Yes
	EEX	43			CLx	44	
	1	01			6	06	
	h x≠y	35 52			g x≤y	32 71	2nd user move 6, 7?
	-	51			GTO B	22 12	Yes
120	g GSB f a	32 22 11	Display, user move		3	03	
	h RTN	35 22			g GSB f a	32 22 11	Display, user move
	g LBL f a	32 25 11	Display response and accept new user move		1	01	
	f GSB 0	31 22 00			g x=y	32 51	3rd user move is 1?
	R/S	84		180	6	06	Yes, replace 1 w/6
	STO 5	33 05			GTO 6	22 06	HP-67 wins w/1 or 6
	f GSB 0	31 22 00			f LBL B	31 25 12	2nd user move 6, 7
	h LST x	35 82			1	01	
	h RTN	35 22			g GSB f a	32 22 11	Display, user move
	f LBL 0	31 25 00	Update board, display current move + board		3	03	
130	CHS	42			g x=y	32 51	3rd user move is 3?
	g 10 ^x	32 53			5	05	Yes, replace 3 w/5
	STO + 0	33 61 00			GTO 6	22 06	HP-67 wins w/3 or 5
	h F? 3	35 71 03	User move?		f LBL C	31 25 13	2nd user move 1, 3
	STO + 0	33 61 00	Yes	190	h SF 2	35 51 02	
	CLx	44			CLx	44	
	RCL 0	34 00			1	01	
	h LST x	35 82			g x=y	32 51	2nd user move is 1?
	CHS	42			h CF 2	35 61 02	Yes, use 2nd 1/2 reg.
	+	61			h R↑	35 54	No, use 1st 1/2 reg.
140	h PAUSE	35 72	Display		GTO E	22 15	
	h RTN	35 22			f LBL 5	31 25 05	Center game
	f LBL 4	31 25 04	Side game		2	02	
	2	02			÷	81	
	÷	81		200	g FRAC	32 83	
	g FRAC	32 83			f x≠0	31 61	User move odd?
	f x=0	31 51	User move even?		GTO f c	22 31 13	Yes
	h SF 0	35 51 00	Yes, set for 4 or 6		RCL 5	34 05	
	RCL 5	34 05			GTO E	22 15	
	8	08			g LBL f c	32 25 13	Center game, odd
150	g x=y	32 51	1st user move is 8?		RCL 5	34 05	
	GTO 8	22 08	Yes		h ST I	35 33	
	+	61			RCL (i)	34 24	Response register
	EEX	43			GTO D	22 14	
	1	01		210	f LBL 7	31 25 07	HP-67 has fork win
	g x≤y	32 71	1st user move is 1?		h R↓	35 53	
	h R↓	35 53	Yes I=10; No I=move+8		h F? 1	35 71 01	Disable win signal?
	h CF 1	35 61 01	Enable fork win		GTO f a	22 31 11	Yes
	h F? 0	35 71 00	1st user move 4 or 6?		f LBL 6	31 25 06	HP-67 wins game
	GTO E	22 15	Yes		f GSB 0	31 22 00	Prepare display
160	h ST I	35 33	No, user move odd		f LBL 9	31 25 09	HP-67's win loop
	RCL (i)	34 24			g GSB f d	32 22 14	
	GTO D	22 14			h PAUSE	35 72	Winning move & board
	f LBL 8	31 25 08	Side game, 1st move 8		GTO 9	22 09	Loop again
	+	61		220	g LBL f d	32 25 14	Flag 2 flip-flop
	9	09			h F? 2	35 71 02	
	g GSB f a	32 22 11	Display, user move		h RTN	35 22	
	h x≠y	35 52			h SF 2	35 51 02	
	CLx	44			h RTN	35 22	

LABELS					FLAGS		SET STATUS		
A Start	B Skip	C Skip	D Reentry	E Reentry	0 Used	1 Used	FLAGS	TRIG	DISP
^a User Move	^b Calc.Resp.	^c Center,Odd	^d Flip-Flop	^e			ON OFF		
⁰ Update	¹ Corner, 5	² Move 3, 7	³ Resp.Looping	⁴ Side Game	² Used		0 <input type="checkbox"/> <input checked="" type="checkbox"/>	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
⁵ Center G.	⁶ HP-67 Wins	⁷ Fork Win	⁸ Side, 8	⁹ Win Loop	³ Used		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__9__

