

Program Title FORTRESS

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## Program Description, Equations, Variables

YOU HAVE 7 TURNS TO INVADE A TRIANGULAR FORTRESS (SEE TRIANGLE WITH CORNERS 1,2,3, PAGE 2 ) AND CAPTURE ITS DEFENDER WITHOUT BEING CAPTURED THERE YOURSELF. A CAPTURE IS MADE BY MOVING FROM ONE NUMBERED POINT TO AN ADJACENT POINT OCCUPIED BY THE ENEMY. THE DEFENDER (YOUR CALCULATOR) IS CONFINED TO THE FORT AND MOVES FROM ONE CORNER TO ANOTHER ON EACH TURN. HE LEARNS FROM EVERY DEFEAT, YET IT IS ALWAYS POSSIBLE FOR YOU TO WIN. YOU START FROM POINT 6,7,8,9, OR 10, AND THEREAFTER MOVE TO ONE ADJACENT NUMBERED POINT ON EACH TURN. IF YOU CAPTURE THE DEFENDER, YOU WIN; IF NOT, HE WINS. YOU ALSO HAVE OPTIONS TO SPECIFY THE LEARNING RATE, R, OR ANY CONSTANT PROBABILITY OF ACCURATE PLAY FOR THE DEFENDER. R VARIES FROM 1 (SLOW) TO 7 (FAST), BUT IS AUTOMATICALLY 4 (AVERAGE) UNLESS CHANGED. NOTATION:  $P_1$  AND  $P_7$  ARE PROBABILITIES FOR DEFENDER TO MAKE AN ACCURATE MOVE AND TO FORCE A WIN IN 7 MOVES, RESPECTIVELY. EQUATION:  $P_7 = (P_1)^7$ .

## Operating Limits and Warnings

"DEFENDER" DOES NOT CHECK ACCURACY OF INPUTS.

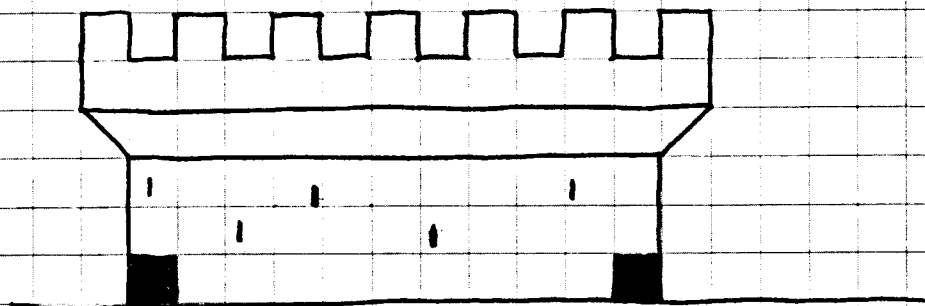
NOTE THAT FLAG 3 AFFECTS OPERATION OF STEPS 2,5, AND 9 TO 13.

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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Sketch(es)



Sample Problem(s)

THESE TWO EXAMPLES, BELOW, SHOW FIRST A WIN THEN A LOSS (NOT FORCED) FOR THE ATTACKER AGAINST AN UNSKILLED DEFENDER.

(PARENTHESES INDICATE PAUSES.)

TWO DIFFERENT COINS MAY BE USED TO REPRESENT THE OPPONENTS ON THE PLAYING BOARD, PAGE 2.

Solution(s)

KEYSTROKES

.987654321 [A] → 0.00

10 [B] → (7.) N  
→ 10.2 L<sub>A</sub>.L<sub>D</sub>

12 [C] → (6.) N  
→ 12.1 L<sub>A</sub>.L<sub>D</sub>

1 [C] → 1.0 L<sub>A</sub>.0

WIN

KEYSTROKES

7 [B] → (7.) N  
→ 7.1 L<sub>A</sub>.L<sub>D</sub>

5 [C] → (6.) N  
→ 5.2 L<sub>A</sub>.L<sub>D</sub>

3 [C] → (5.) N  
→ 0.3 0.L<sub>D</sub>

LOSS

Reference(s)

BASED ON A PROBLEM IN "RECREATION IN MATHEMATICS," BY R. SPRAGUE. LONDON, BLACKIE AND SON, (1963), 61 PP. SEE P. 20.

1

SEED

RATE

START

FORTRESS

MOVE

WINS? P<sub>1</sub>, P<sub>2</sub>?

2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	LOAD SIDES 1 AND 2.		<input type="text"/> <input type="text"/>	
2	INPUT SEED, (ANY DECIMAL NUMBER).	SEED	<input type="text"/> A <input type="text"/>	0
3	OPTIONAL: SPECIFY LEARNING RATE, R, OF DEFENDER, FROM 1 (SLOW) TO 7 (FAST). OTHERWISE, R=4 (AVERAGE).	R	<input type="text"/> f <input type="text"/> B	R
4	PICK INITIAL LOCATION, L <sub>A</sub> =6,7,8,9, or 10, NOTE TOTAL NUMBER OF TURNS, AND DEFENDERS LOCATION, L <sub>D</sub> .	L <sub>A</sub>	<input type="text"/> B <input type="text"/>	7
5	MOVE TO AN ADJACENT POINT, NOTE NUMBER OF MOVES LEFT, AND DEFENDER'S NEW LOCATION.	L <sub>A</sub>	<input type="text"/> C <input type="text"/>	L <sub>A</sub> ·L <sub>D</sub>
6	REPEAT STEP 5 TO CONCLUSION. (L <sub>A</sub> =0 OR L <sub>D</sub> =0 MEANS ATTACKER OR DEFENDER HAS LOST.)		<input type="text"/> <input type="text"/>	N
7	GO TO STEP 4 FOR NEXT GAME.		<input type="text"/> <input type="text"/>	L <sub>A</sub> ·L <sub>D</sub>
	OPTIONAL:		<input type="text"/> <input type="text"/>	
8	NOTE NUMBERS OF GAMES WON BY ATTACKER, G <sub>A</sub> , AND DEFENDER, G <sub>D</sub> .		<input type="text"/> D <input type="text"/>	G <sub>A</sub>
9	NOTE CURRENT PROBABILITIES OF DEFENDER MAKING CORRECT MOVE, P <sub>1</sub> , AND FORCING A WIN, P <sub>2</sub> .		<input type="text"/> E <input type="text"/>	G <sub>D</sub>
10	RECALL CURRENT LOCATIONS.		<input type="text"/> <input type="text"/>	P <sub>1</sub>
11	FIX A CONSTANT PROBABILITY (DECIMAL) OF DEFENDER MAKING CORRECT MOVE.	P <sub>1</sub>	<input type="text"/> C <input type="text"/>	P <sub>2</sub>
12	CANCEL COMMAND IN STEP 11, RETURNING P <sub>1</sub> TO ITS PREVIOUS VALUE.	0	<input type="text"/> E <input type="text"/>	L <sub>A</sub> ·L <sub>D</sub>
13	RESET G <sub>A</sub> , G <sub>D</sub> , P <sub>1</sub> , AND P <sub>2</sub> TO ZERO, AND R TO 4.		<input type="text"/> <input type="text"/>	P <sub>1</sub>
			<input type="text"/> A <input type="text"/>	0
	NOTE: FOR VARIABLE P <sub>1</sub> ,		<input type="text"/> <input type="text"/>	
	$P_1 = \frac{m_1}{m_1 + m_2}, \quad m_1 = G_A, \quad m_2 = e^{4-R},$		<input type="text"/> <input type="text"/>	
	$P_2 = P_1^7.$		<input type="text"/> <input type="text"/>	

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBL B	31 25 12	INITIAL LOCATIONS DECIDED.	057	F? 2	35 71 02	DEFENDER'S CHOICE OF MOVE.
002	GSB 8	31 22 08		058	ST I	35 33	
003	RCL C	34 13		059	GSB (λ)	31 22 24	
004	PAUSE	35 72		060	RCI	35 34	
005	ST 0 6	33 06		061	RCL B	34 12	
006	GSB 9	31 22 09		062	÷	81	
007	GSB 0	31 22 00		063	ST 0 + 0	33 61 00	
008	3	03		064	RCL 0	34 00	
009	X	71		065	DSP 1	23 01	
010	INT	31 83		066	RTN	35 22	
011	1	01	EACH SIDE MOVES.	067	*LBL f 2	32 25 15	FIND "RANDOM" NUMBER.
012	+	61		068	1	01	
013	F? 2	35 71 02		069	ST 0 + 4	33 61 04	
014	RCL 3	34 03		070	ST 0 - 6	33 51 06	
015	ST I	35 33		071	ST 0 + 9	33 61 09	
016	RCL B	34 12		072	DSP 1	23 01	
017	÷	81		073	RCL 0	34 00	
018	ST 0 + 0	33 61 00		074	RTN	35 22	
019	CF 3	35 61 03		075	*LBL f d	32 25 14	
020	GSB (i)	31 22 24		076	1	01	
021	DSP 1	23 01		077	ST 0 + 8	33 61 08	
022	RCL 0	34 00		078	RCL 0	34 00	
023	RTN	35 22		079	F? 0	35 71 00	
024	*LBL C	31 25 13		080	ST I	35 33	
025	F? 3	35 71 03		081	CFO	35 61 00	
026	GT 0 7	22 07		082	RCI	35 34	
027	RCL 0	34 00		083	RCL B	34 12	
028	DSP 1	23 01		084	÷	81	
029	RTN	35 22		085	DSP 1	23 01	
030	*LBL 7	31 25 07		086	RTN	35 22	
031	GSB 8	31 22 08		087	*LBL 9	31 25 09	
032	RCI	35 34		088	GSB 0	31 22 00	
033	RCL 0	34 00		089	RCL 4	34 04	
034	X = y	32 51		090	RCL 5	34 05	
035	GT 0 f 2	22 31 15		091	+	61	
036	4	04		092	RCL 4	34 04	
037	X > y	32 81		093	X ≥ y	35 52	
038	SFO	35 51 00		094	÷	81	
039	1	01		095	F? 1	35 71 01	
040	ST 0 - 6	33 51 06		096	RCL D	34 14	
041	RCL 6	34 06		097	RCL E	34 15	
042	PAUSE	35 72		098	X ≤ y	32 71	
043	X = 0	31 51		099	SF 2	35 51 02	
044	GT 0 f d	22 31 14		100	RTN	35 22	
045	F? 0	35 71 00		101	*LBL 0	31 25 00	
046	GT 0 f d	22 31 14		102	π	35 73	
047	GSB 9	31 22 09		103	RCL E	34 15	
048	RCL 3	34 03		104	+	61	
049	RCL 1	34 01		105	5	05	
050	X = y	32 51		106	y x	35 63	
051	RCL 2	34 02		107	FRAC	32 83	
052	ST I	35 33		108	ST 0 E	33 15	

REGISTERS									
0 $L_A \cdot L_D$	1 1,3,2	2 2,1,3	3 1,2,3	4 $m_1 \geq 0$	5 $m_2 = 1?$	6 $N \leq 7$	7	8 $G_D$	9 $G_A$
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A R	B 10	C 7	D FIXED $P_i$	E "RAND." NO.	F $L_D = 1,2,3$				

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
113	$\frac{1}{2}$	81	DEFENDER STRATEGY.	169	RTN	35 22	FIND AND DISPLAY P <sub>1</sub> AND P <sub>2</sub> .
114	FRAC	32 83		170	*LBL E	31 25 15	
115	3	03		171	F? 3	35 71 03	
116	X	71		172	GT 0 6 a	22 31 11	
117	DSP 0	23 00		173	RCL 4	34 04	
118	RND	31 24	DEFENDER'S MOVE OPTIONS.	174	RCL 5	34 05	ALTER LEARNING RATE.
119	X=0	31 51		175	RCL 4	34 04	
120	3	03		176	+	61	
121	ST 0 3	33 03		177	$\frac{1}{2}$	81	
122	RTN	35 22		178	DSP 2	23 02	
123	*LBL 1	31 25 01		179	F? 1	35 71 01	
124	2	02		180	RCL D	34 14	
125	ST 0 1	33 01		181	PAUSE	35 72	
126	3	03		182	7	07	
127	ST 0 2	33 02		183	4X	35 63	
128	RTN	35 22	DISPLAY SCORES.	184	RTN	35 22	
129	*LBL 2	31 25 02		185	*LBL 6	32 25 12	
130	3	03		186	CF 3	35 61 03	
131	ST 0 1	33 01		187	ST 0 A	33 11	
132	1	01		188	CHS	42	
133	ST 0 2	33 02		189	4	04	
134	RTN	35 22		190	+	61	
135	*LBL 3	31 25 03		191	2X	32 52	
136	1	01		192	ST 0 5	33 05	
137	ST 0 1	33 01	STORE SEED, INITIALIZE.	193	CLX	44	
138	2	02		194	ST 0 4	33 04	
139	ST 0 2	33 02		195	DSP 2	23 02	
140	RTN	35 22		196	RCL A	34 11	
141	*LBL D	31 25 14		197	RTN	35 22	
142	CF 3	35 61 03					
143	RCL 9	34 09					
144	DSP 0	23 00					
145	PAUSE	35 72					
146	RCL 8	34 08					
147	RTN	35 22	INCORPORATE FIXED P <sub>1</sub> .				
148	*LBL A	31 25 11					
149	F? 3	35 71 03					
150	ST 0 E	33 15					
151	EEX	43					
152	1	01					
153	ST 0 B	33 12					
154	7	07					
155	ST 0 C	33 13					
156	1	01					
157	ST 0 5	33 05					
158	CLX	44					
159	ST 0 8	33 08					
160	ST 0 9	33 09					
161	ST 0 4	33 04					
162	RTN	35 22					
163	*LBL 6 a	32 25 11					
164	ST 0 D	33 14					
165	X $\neq$ 0	31 61					
166	SFI	35 51 01					
167	X=0	31 51					
168	CF 1	35 61 01					

LABELS					FLAGS	SET STATUS		
A INITIAL.	B SET UP	C MOVES	D SCORES	E P <sub>1</sub> , P <sub>2</sub>	0 LOSS?	FLAGS	TRIG	DISP
a STORE P <sub>1</sub>	b SET R	c	d LOSS	e WIN	1 P <sub>1</sub> FIXED	ON OFF	DEG <input checked="" type="checkbox"/>	FIX <input checked="" type="checkbox"/>
0 "RAND." #	1 ST 0 2, 3	2 ST 0 3, 1	3 ST 0 1, 2	4	2 # < P <sub>1</sub> ?	0 <input type="checkbox"/> <input checked="" type="checkbox"/>	GRAD <input type="checkbox"/>	SCI <input type="checkbox"/>
5	6	7 USED	8 USED	9 FIND P <sub>1</sub>	3 USED	1 <input type="checkbox"/> <input checked="" type="checkbox"/>	RAD <input type="checkbox"/>	ENG <input type="checkbox"/>
						2 <input type="checkbox"/> <input checked="" type="checkbox"/>		n <u>2</u>
						3 <input type="checkbox"/> <input checked="" type="checkbox"/>		