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DECUS NO.	FOCAL8-107
TITLE	NIM
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SOURCE LANGUAGE	FOCAL

DECUS Program Library Write-up DECUS No. FOCAL8-107

REQUIREMENTS

PDP-8/S, 8/I, 8/L 4K Memory

Load FOCAL tape using the binary loader. Follow the FOCAL operating instructions to remove extended functions. Place NIM GAME tape in the reader. Read in program according to FOCAL operating instructions. Remove = sign from the output.

RULES OF THE GAME OF NIM

The game of NIM consists of three columns of coins where the number of coins in each column is different. For this version there are 5, 6, 7 coins in columns I, II III.

1) You first decide whether you or the computer shall make the first move.

2) You then choose the number of the column and the number of coins you wish to remove. (You may remove any number of coins, but only from one column during your turn.)

3) Moves alternate between you and the computer.

4) The object of the game is to remove the last coin or coins from the playing board. The one doing this is declared the winner.

COMMENTS AND ANALYSIS ABOUT THE GAME OF NIM

It is possible for the human to beat the computer, but only if he moves first. If the computer starts first, it will always win. If the number of coins in each row is represented as its equivalent in the binary number system and these numbers arranged in a column, it will be possible for the human to decide the correct winning move. When there are an add number of ones in either the ones', twos', or fours' position, this is a favorable condition. If there is an even number of ones in each of the ones', twos', or fours' position then this is an unfavorable condition.

EXAMPLE:

	I	II	III
	5 coins	6 coins	7 coins
	4's	2's	1's
I	1	0	1
II	1	1	0
III	1	1	1

Here we see an odd number of ones in the fours' position; hence, a winning move would be to take four coins from any column. If we did this in the third column then:

	I	II	III
	5 coins	6 coins	3 coins
	4's	2's	1's
I	1	0	1
II	1	1	0
III	0	1	1

Now we see that there is an even number of ones in each of the ones', twos', or fours' position. Therefore regardless of the opponent's move, there will be an odd number of ones left in at least one of the ones', twos', or fours' positions.

Using this theory, if the human chooses to go first he can always win. However, one wrong move can be fatal since the computer also knows these rules!

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Ø1.7Ø  S   A(1)=5;S A(2)=6;S A(3)=7;T %5
Ø1.8Ø  A   !,"TO GO FIRST TYPE 1, OTHERWISE TYPE Ø ",AA
Ø1.84  I   (AA-1)1.86,12.1,1.88
Ø1.86  I   (AA)1.88,1.9,2Ø.1
Ø1.88  T   !,"FOLLOW DIRECTIONS  ";G 1.8
Ø1.9Ø  S   A(3)=3;G 12.1

Ø3.1Ø  A   !,"TYPE 1,2,OR 3 FOR THE COLUMN",C
Ø3.15  A   ! "TYPE THE NUMBER OF COINS YOU WISH TO REMOVE",N
Ø3.16  I   (N)3.18,3.18,3.17
Ø3.17  I   (N-FITR(N) )3.2,3.2
Ø3.18  T   !,"ILLEGAL MOVE   ";G 3.1
Ø3.2Ø  I   (C-3)3.3,3.6,3.5
Ø3.3Ø  I   (C-2)3.4,3.6
Ø3.4Ø  I   (C-1)3.5,3.6
Ø3.5Ø  T   !,"FOLLOW DIRECTIONS  ";G 3.1
Ø3.6Ø  I   (A(C)-N)3.7,3.8,3.8
Ø3.7Ø  T   !,"ONLY",A(C),"    COIN(S) IN COLUMN",C;G 3/1
Ø3.8Ø  S   A(C)=A(C)-N

Ø5.1Ø  F   B=1,1,3; DO 6.Ø
Ø5.2Ø  G   7.1

Ø6.1Ø  S   R(B) =FITR(A(B)/4)
Ø6.2Ø  S   RE = A(B)-(R(B)*4)
Ø6.3Ø  S   T(B) = FITR(RE/2)
Ø6.4Ø  S   O(B) = RE - (T(B)*2)

Ø7.1Ø  S   S(1) = R(1) + R(2) + R(3)
Ø7.2Ø  S   S(2) = T(1) + T(2) + T(3)
Ø7.3Ø  S   S(3) = O(1) + O(2) + O(3)
Ø7.4Ø  F   B = 1,1,3; D 8.Ø
Ø7.5Ø  G   9.1

Ø8.1Ø  I   (S(B)-3)8.2,8.3
Ø8.2Ø  I   (S(B)-1)8.4,8.3,8.4
Ø8.3Ø  S   S(B) = 5
Ø8.4Ø  R

Ø9.1Ø  I   (S(1)-5)9.2,9.4
Ø9.2Ø  I   (S(2)-5)9.3,9.6
Ø9.3Ø  I   (S(3)-5)11.6,9.8,11.6
Ø9.4Ø  F   B=1,1,3;D 16.Ø
Ø9.41  G   1Ø.1
Ø9.6Ø  F   B = 1,1,3; D 17.Ø
Ø9.61  G   1Ø.2
Ø9.8Ø  F   B =1,1,3;D 18.Ø
Ø9.81  G   11.1
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10.10  I   (S(2)-5)10.2,10.3
10.20  I   (S(3)-5)11.1,10.4
10.30  I   (T(G) )20.1,10.32,10.34
10.32  S   T(G)=1;G 10.2
10.34  S   T(G)=0;G 10.2
10.40  I   (O(G) )20.1,10.42,10.44
10.42  S   O(G)=1;G 11.1
10.44  S   O(G)=0

11.10  F   B=1,1,3;S A(B)=4*R(B)+2*T(B)+O(B)
11.20  G   11.8
11.60  F   B =1,1,3;D 19.0
11.80  I   (A(1)+A(2)+A(3) )20.1,15.1,11.9
11.90  I   (A(1)+A(2)+A(3)-1)20.1,14.1,12.1

12.10  T   !,"   COL 1     COL 2     COL 3
12.20  T   !,   A(1),"     ",A(2),"     ",A(3);G 3.1

14.10  T   !!,"YOU WIN,   LUCKY",!!;G 15.2

15.10  T   !!," I WIN    ",!!
15.20  A   !!,"   PLAY AGAIN?   ",W
15.40  I   (W-0YES)15.6,1.7
15.60  Q

16.10  I   (R(B) )8.4,8.4,16.2
16.20  S   R(B) = 0;S G = B;S B = 4;R

17.10  I   (T(B) )8.4,8.4,17.2
17.20  S   T(B)=0;S G=B;S B=4;R

18.10  I   (O(B) )8.4,8.4,18.2
18.20  S   O(B)=0;S B=4;R

19.10  I   (A(B) )8.4,8.4,19.2
19.20  S   A(B)=A(B)-1;S B=5;R

20.10  T   !,"HELP    HELP   "
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SAMPLE GAMES PLAYED

```
GO

TO GO FIRST TYPE 1,  OTHERWISE TYPE Ø :1
     COL 1        COL 2        COL 3
       5            6            7
TYPE 1,2,OR 3 FOR THE COLUMN:1
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:4
     COL 1        COL 2        COL 3
       Ø            6            7
TYPE 1,2,OR 3 FOR THE COLUMN:3.4
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:3
FOLLOW DIRECTIONS
TYPE 1,2,OR 3 FOR THE COLUMN:3
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:4
     COL 1        COL 2        COL 3
       Ø            3            3
TYPE 1,2,OR3 FOR THE COLUMN:2
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:4
ONLY     3        COIN(S) IN COLUMN      2
TYPE 1,2,OR3 FOR THE COLUMN:2
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:Ø
ILLEGAL MOVE
TYPE 1,2,OR 3 FOR THE COLUMN:2
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:2.3
ILLEGAL MOVE
TYPE 1, 2,OR 3 FOR THE COLUMN:3
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:3

I  WIN

PLAY AGAIN?     :NO  *
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SAMPLE GAMES PLAYED

```
*GO

TO GO FIRST TYPE 1, OTHERWISE TYPE Ø   :1
    COL 1       COL 2       COL 3
      5           6           7
TYPE 1,2,OR 3 FOR THE COLUMN:3
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:4
    COL 1       COL 2       COL 3
      4           6           3
TYPE 1,2,OR 3 FOR THE COLUMN:3
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:1
    COL 1       COL 2       COL 3
      3           6           2
TYPE 1,2,OR 3 FOR THE COLUMN:2
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:5
    COL 1       COL 2       COL 3
      2           1           2
TYPE 1,2,OR 3 FOR THE COLUMN:2
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:1
    COL 1       COL 2       COL 3
      1           Ø           2
TYPE 1,2,OR 3 FOR THE COLUMN:3
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:1

YOU WIN   LUCKY

PLAY AGAIN?  :YES

TO GO FIRST TYPE 1, OTHERWISE TYPE Ø   :Ø
    COL 1       COL 2       COL 3
      5           6           3
TYPE 1,2,OR 3 FOR THE COLUMN:1
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:4
    COL 1       COL 2       COL 3
      1           2           3
TYPE 1,2,OR 3 FOR THE COLUMN:3
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:2
    COL 1       COL 2       COL 3
      1           Ø           1
TYPE 1,2,OR 3 FOR THE COLUMN:1
TYPE THE NUMBER OF COINS YOU WISH TO REMOVE:1

I WIN
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