

The Amazing Dr.Nim



Invented by John Thomas Godfrey, copyright E.S.R. Inc., 1966.

(12" x 14.5" x 1.75" cardboard box, 11.5" high x 12.5" wide plastic board, 15 5/8" marbles)

The first page of the booklet describes how to play the basic game (as well as information about the game and variations such as starting with a different numbers of marbles):

Position the top three flippers right, right, left, and position the middle flipper (the "equalizer") to the right.

If you want to go first, position the lowest flipper to the right, and push the trigger in the lower right corner 1, 2, or 3 times to play 1, 2, or 3 marbles.

Then perform these steps for each round of play:

1. Position the lowest flipper to the left.
2. Push the trigger on the lower right once to make Dr. Play, who will then drop 1, 2, or 3 marbles (after done he will leave the lower flipper positioned right.)
3. Push the trigger on the lower right 1, 2, or 3 times to play 1, 2, or 3 marbles.

The loser is the one who drops the last marble.

Winning Strategy:

Let n denote the current number of marbles waiting to be played, and define:

$state = (n \text{ MOD } 4) =$ the remainder when n is divided by 4

If Dr. Nim plays when the $state = 1$, you respond by playing the number of marbles to return the state to 1, and in the final round when only 1 marble is left, he loses.

The initial state of 15 marbles is $15 \text{ MOD } 4 = 3$.

If Dr. Nim goes first, the position of the center flipper to the right forces him to drop only one marble on the first turn, giving you a chance to play only one marble. Or if you go first, you can play 2 marbles. Either way, from 13 marbles, continue with a winning strategy that leaves him 9 marbles, then 5, and finally just 1.

Dr. Nim Directions (first page from the booklet)

HOW TO SET UP DR. NIM FOR EACH NEW GAME

1. PUT THE 15 MARBLES IN THE TOP ROW OF THE MACHINE.
2. SET THE FLIP-FLOPS SO THEY LOOK LIKE THIS.
3. FLIP THE EQUALIZER TO THE START POSITION, LIKE THIS.



HOW TO PLAY AGAINST DR. NIM

1. If you want to go first, flip the *TURN SWITCH* to player.
2. You may take 1 or 2 or 3 marbles on each turn.
3. The one who takes the *LAST* marble *LOSES*.
4. Next, *PUSH* the *TRIGGER* once for each of the 1 or 2 or 3 marbles you may want to take.
5. After your turn, flip the *TURN SWITCH* to *DR. NIM* . . . Then push the *TRIGGER* only *ONCE* and Dr. Nim will take his turn.
6. When he is finished, Dr. Nim will flip the *TURN SWITCH* back to *PLAYER* for your turn.
7. Repeat steps 4 and 5 until only *ONE MARBLE IS LEFT*.

WHOEVER HAS TO TAKE THAT LAST MARBLE LOSES!

IF YOU SHOULD WANT TO LET DR. NIM GO FIRST, FLIP THE *TURN SWITCH* TO *DR. NIM* AND PLAY AS ABOVE.

If you play correctly, you can beat THE AMAZING DR. NIM, but remember, DR. NIM hates to lose . . . so don't make any mistakes.

Example Game Where Dr. Nim Wins

0. Starting position with 15 marbles ($state = 3$).



1. Drop 1 marble, leaving 14 ($state = 2$).



2. Dr. Nim drops 1 marble, leaving 13 ($state = 1$).



3. Drop 1 marble, leaving 12 ($state = 0$).



4. Dr. Nim drops 3 marbles, leaving 9 ($state = 1$).



(Example Game Where Dr. Nim Wins, continued)

5. Drop 3 marbles, leaving 6 (*state = 2*).



6. Dr. Nim drops 1 marble, leaving 5 (*state = 1*).



7. Drop 2 marbles, leaving 3 (*state = 3*).



8. Dr. Nim drops 2 marbles, leaving 1 (*state = 1*).



9. Drop 1 marble (and lose).



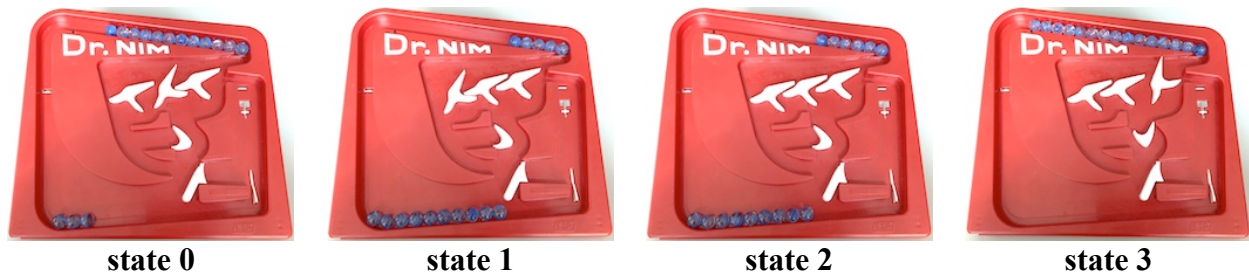
How Dr. Nim Works

The lowest flipper when positioned to the right routes the marble directly to the bottom, but when positioned to the left, routes the marble to the bottom by first rolling over the release lever, which causes another marble to drop.

The booklet call the center flipper the "equalizer"; once flipped left it stays left. It prevents Dr. Nim from making the correct move of 2 marbles when he goes first. The booklet says that this is just Dr. Nim being a "true gentleman":

DR. NIM, being a true gentleman, purposely makes a mistake on his first move to give the player a chance. That is what the "Equalizer" is for. If you forget to set it to "Start" and "DR. NIM" goes first, you can't win, except in the * case. In the * case if DR. NIM goes second and you forget to set it to "START", DR. NIM will always win.

The row of three flippers on the top records the current *state* of the machine; that is, the current number of marbles MOD 4, which is one of 0, 1, 2, or 3 (the position of the equalizer does not affect state). In the example on the preceding two pages, each step notes the state that remains after that step has completed. For example:



When the bottom flipper is to the left, and with n marbles waiting to drop, when a marble drops, the state changes from $n \text{ MOD } 4$ to $(n - 1) \text{ MOD } 4$, and if the resulting state is not 1, the marble is shunted to the right center channel to cause another marble to drop (except when Dr. Nim moves first and the equalizer flipper prevents the marble from making a second marble drop).

Dr. Nim's state transition rule is simple: Each time a marble drops, state 3 goes to state 2, state 2 goes to state 1, state 1 goes to state 0, and state 0 goes to state 3 because:

$$(-1) \text{ MOD } 4 = (-1 + 0) \text{ MOD } 4 = (-1 + 4) \text{ MOD } 4 = (3) \text{ MOD } 4 = 3$$

When it is his turn, Dr. Nim does not know the current number of marbles. But assuming that the flippers were set correctly at the start (and there have been no mechanical problems like a flipper sticking or two balls dropping at the same time), he always knows the number MOD 4.

If it is his turn and state is not 1, he drops the number of marbles to leave a state of 1 (and continue with a winning strategy to win the game).

If it is his turn and state is 1, he drops just one marble, in the hope that you don't know the strategy and make an incorrect decision next round.

Dr. Nim Box Top and Bottom



Dr. Nim Board Front and Back

Here is the starting position when Dr. Nim goes first:



Here is the back of the board. A metal piece folds out so the board will be positioned on a slant, and a long plastic piece along the edge connects the push lever to the ball release:



Dr. Nim Booklet Pages



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HOW TO PLAY

Dr. NIM™



HOW TO SET UP DR. NIM FOR EACH NEW GAME

1. PUT THE 15 MARBLES IN THE TOP ROW OF THE BACKING.
2. SET THE FLIP-FLIPS AS THEY LOOK LIKE THIS.
3. FLIP THE EQUALIZER TO THE "LAST MOVE" POSITION. USE THIS.



HOW TO PLAY AGAINST DR. NIM

1. If you want to go first, flip the TIGER SWITCH to "FIRST".
2. You may take 1 or 2 or 3 marbles on each turn.
3. The one who takes the LAST MARBLE LOSES!
4. Next, FLIP the TRIGGER FOR each of the 1 or 2 or 3 marbles you may take.
5. After you take, flip the TIGER SWITCH to DR. NIM . . . Then, just the EQUALIZER ONLY (not Dr. Nim) will take his turn.
6. When he is finished, Dr. Nim will flip the TIGER SWITCH back to FLIP-FLOP for you to take.
7. Repeat steps 1-4 and 5 until only ONE MARBLE IS LEFT.

WHOEVER HAS TO TAKE THAT LAST MARBLE LOSES!

IF YOU WOULD RATHER TO LET DR. NIM GO FIRST, FLIP THE TIGER SWITCH TO DR. NIM AND PLAY AS ABOVE.

If you play correctly, you can beat THE AMAZING DR. NIM. But remember, DR. NIM never loses . . . so don't make any mistakes.

VARIATIONS ON THE GAME

You may use DR. NIM with any number of marbles. You may use any different settings for the Flip-Flips. Here are the Starting Positions for some of the different numbers of marbles you may play with.

Number of Starting Marbles for "Last Marble Loser" Games	Starting FLIP-FLIP Positions	Starting EQUALIZER Position
15 (3 x 5)		LAST
12 (3 x 4)		LAST
9 (3 x 3)		LAST
6 (2 x 3)		LAST
3 (1 x 3)		LAST

You should be able to beat DR. NIM for all these games, whether you take the first turn or have DR. NIM take the first turn. From this table you can figure out the starting settings for more than 20 marbles. If you don't put the marbles in the correct starting position, and let DR. NIM go FIRST, so marked how you play DR. NIM will always win, except in the cases marked with an "X". For that reason, if you don't put the marbles in the correct starting position, and let DR. NIM go FIRST, he can never lose when you play DR. NIM with always the equalizer in the correct starting position and with you taking the first turn.

NOTE: To play with more than 15 marbles, simply set the minimum number of marbles back as in the top row (see above) and let DR. NIM go first. For example, to play with 20 marbles, set the EQUALIZER to "LAST MARBLE LOSER" and let DR. NIM go first. Then after 15 marbles have been taken, let DR. NIM go for a 5 or 6.

HOW FOR A WHOLE NEW SET OF GAMES

We will now change the rules so that the one who TAKES THE LAST MARBLE WINS!

To do this a different starting arrangement for the Flip-Flips is used. Everything else is the same as for the above games. Here are the starting conditions.

Number of Starting Marbles for "Last Marble Wins" Games	Starting FLIP-FLIP Positions	Starting EQUALIZER Position
15 (3 x 5)		FIRST
12 (3 x 4)		FIRST
9 (3 x 3)		FIRST
6 (2 x 3)		FIRST
3 (1 x 3)		FIRST

You should be able to beat DR. NIM for all of these games. In addition, if you happen to get the EQUALIZER to the correct starting position and DR. NIM goes first, then DR. NIM will always win!

From the above table you can figure out starting settings for more than 20 marbles.

STILL MORE GAMES TO PLAY WITH YOUR DR. NIM

1. You may use DR. NIM to play against another person. To do this, simply follow all the above rules, but leave the TIGER SWITCH as PLAYER 1 all times.
2. Another game is to watch DR. NIM play against himself. To do this, flip the TIGER SWITCH back to DR. NIM after each play. Call the first turn yours (DR. NIM Number 1) and the second turn yours (DR. NIM Number 2). Try this with the EQUALIZER in the FIRST position. Then for the same game with the EQUALIZER in the LAST position. In each case, DR. NIM Number 1, or DR. NIM Number 2, is each of these cases. Can you guess who this happens?

ABOUT THE GAME OF NIM

The basic game of NIM, of which DR. NIM is a variation, is thought to have been played in the Far East, perhaps China, thousands of years ago. It is interesting to realize that this simple, but intriguing game has withstood the tests of time and has undoubtedly been played by millions of people over the centuries. It is, therefore, that you find it so interesting and delightful to play DR. NIM and that you will have at least as much fun with the workings of computers.

DR. NIM AND COMPUTERS


By now you have played against DR. NIM enough to respect and appreciate his ability. One who really "wins" from computers has to do a lot of thinking to beat him. But he has no "brain". You will probably see that DR. NIM does not "think" despite the fact that he plays a "logic" game of NIM. If this is your reason, you should also be convinced by these facts that a logic electronic computer does not "think" either. The logic computer is made to solve DR. NIM in the simplest manner like a human. By the way, you "THINK" AGAIN! DR. NIM can solve that you positioned to set his elements at the beginning of each game.

So, let us have this solution of "Can Machines Think?" for the moment, and consider DR. NIM first from the computer solution point of view and then the computer programming point of view. Then we will come back to the question of thinking machines.


engineers to the implies that are created through an electronic computer. The electronic can solve the problem of the computer. They are added operations by the computer and they are changed, depending upon the results.

Consider how three elements should be connected. Each Flip-Flop is a mechanical device. It is either open to permit a marble to go through or it is closed and does not permit a marble to pass through, but marbles do go in the next Flip-Flop. As we need above, DR. NIM is a binary digital computer, his logic elements having only two states.

Suppose we use the three Flip-Flops A, B, and C, with the left one A, the center one B and the right one C. Then, when we could call the "last" switch D and the "equalizer" E.



If one of the Flip-Flops is open like this,



for instance, the A Flip-Flop, then we will get a bar over the A, writing it A-bar. Also, suppose we put a bar over the D when the "last" switch is set to "LAST MARBLE LOSER", and over the E when the "equalizer" is set to "FIRST".

Now we can rewrite the starting position table on Page 4 using these symbols instead of the positions.

Number of Starting Marbles for "Last Marble Loser" Games	Starting FLIP-FLIP Positions	Starting EQUALIZER Position
15 (3 x 5)	A B C E	L
12 (3 x 4)	A B C E	L
9 (3 x 3)	A B C E	L
6 (2 x 3)	A B C E	L
3 (1 x 3)	A B C E	L

Now that we have this shorthand at our disposal, let us play a Game of NIM on paper. Suppose we play the game of "Last Marble Loser", with 15 marbles and DR. NIM goes first.

No. of Marbles Left	Flip-Flop Setting	Turn Switch Setting	Equalizer Setting
15	A B C E	L	L
14	A B C D E	L	L

DR. NIM will take one and write (Write that D and E change status.) Then it's the player's turn and the settings are:

14	A B C D E	L	L
13	A B C D E	D	L
12	A B C D E	D	L

Now it's DR. NIM's turn again and he will take 3.

12	A B C D E	D	L
10	A B C D E	D	L
9	A B C D E	D	L

The player takes 3.

7	A B C D E	D	L
7	A B C D E	D	L

This time DR. NIM will take 2.

5	A B C D E	D	L
4	A B C D E	D	L
4	A B C D E	D	L

The Flip-Flop takes 1.

4	A B C D E	D	L
3	A B C D E	D	L
2	A B C D E	D	L

And DR. NIM will take 1.

1	A B C D E	D	L
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The Player takes 1 and loses.

1	A B C D E	D	L
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DR. NIM stopped when there were 1, or 5, or 9 or 14. That is, when the Flip-Flops were in the states described by the following equation:

$$11010 + 10100 + 10010 + 10000 = 10000$$

LET'S WRITE THIS GAME IN THE FORM OF EQUATIONS.

$$15 = A + B + C + D + E$$

$$14 = A + B + C + D + E$$

$$12 = A + B + C + D + E$$

$$10 = A + B + C + D + E$$

$$9 = A + B + C + D + E$$

$$8 = A + B + C + D + E$$

$$7 = A + B + C + D + E$$

$$6 = A + B + C + D + E$$

$$5 = A + B + C + D + E$$

$$4 = A + B + C + D + E$$

$$3 = A + B + C + D + E$$

$$2 = A + B + C + D + E$$

$$1 = A + B + C + D + E$$

The first thing we should notice is that the A, B & C Flip-Flops have a common. Every fourth equation has the same setting for A, B & C. (For instance, whether there are 1, 5, 9, or 13 marbles left, the terms are A, B, C.)

The next thing we should notice is when DR. NIM decides to lose but enough, that is when he changes the "last" switch from "LAST MARBLE LOSER" to "FIRST". In our equations it would be when D is changed to D-bar. When there are 11, 10, or 9 marbles left, he will take one more and stop. Except for the first turn, when there were 15 marbles, DR. NIM stopped when there was one more than a multiple of 4 marbles taken (there were 1, 5 or 9).

This could all be expressed in a language called Boolean Algebra. It is the basis for all digital computer operations, whether it be an ordinary one like DR. NIM or a game electronic form.

To illustrate the basic ideas involved in using Boolean Algebra, let us now look back at the equations on Page 5. DR. NIM should not lose when there is one marble left.

DR. NIM stopped when there were 1, or 5, or 9 or 14. That is, when the Flip-Flops were in the states described by the following equation:

$$11010 + 10100 + 10010 + 10000 = 10000$$

Further Reading



Wikipedia Page, from: https://en.wikipedia.org/wiki/Dr._Nim

Mad Scientist Page, from: <https://www.evilmadscientist.com/2013/dr-nim>

Rougetet Article, from: <https://hal.archives-ouvertes.fr/hal-01349260/document>

Playback Article, from: <https://pbgames.wordpress.com/2012/07/08/1940-nimatron>

History Computers Article, from: <https://history-computer.com/ModernComputer/Relays/Condon.html>

Condon Patent, from: www.uspto.gov - patent no. 2,215,54