Tic-tac-toe

Tic-tac-toe, also spelled tick tack toe, or noughts and crosses/Xs and Os as it is known in the UK, Australia and New Zealand, is a pencil-and-paper game for two players, X and O, who take turns marking the spaces in a 3×3 grid. The X player usually goes first. The player who succeeds in placing three respective marks in a horizontal, vertical, or diagonal row wins the game.

The following example game is won by the first player, X:

```
+---+---+---+
|   |   | X   |
+---+---+---+
|   | O |   |
+---+---+---+
| O |   |   |
+---+---+---+
```

Players soon discover that best play from both parties leads to a draw. Hence, tic-tac-toe is most often played by young children. This reputation for ease has led to casinos offering gamblers the chance to play tic-tac-toe against trained chickens called chick tac toe.[1]

The simplicity of tic-tac-toe makes it ideal as a pedagogical tool for teaching the concepts of combinatorial game theory and the branch of artificial intelligence that deals with the searching of game trees. It is straightforward to write a computer program to play tic-tac-toe perfectly, to enumerate the 765 essentially different positions (the state space complexity), or the 26,830 possible games up to rotations and reflections (the game tree complexity) on this space.

The first known video game, OXO (or Noughts and Crosses, 1952) for the EDSAC computer played perfect games of tic-tac-toe against a human opponent.

The earliest known variant of tic-tac-toe originated in the Roman Empire around the first century BC. It was called Terni Lapilli and instead of having any number of pieces, each player only had three, thus they had to move them around to empty spaces to keep playing. The game's grid markings have been found chalked all over Rome.

One example of a Tic-Tac-Toe playing computer is the Tinkertoy computer, developed by MIT students, and made out of Tinker Toys.[2] It only plays Tic-Tac-Toe and has never lost a game. It is currently on display at the Museum of Science, Boston.
Number of possible games

Despite its apparent simplicity, it requires some complex mathematics to determine the number of possible games. This is further complicated by the definitions used when setting the conditions.

In theory, there are 19,683 possible board layouts ($3^9$ since each of the nine spaces can be X, O or blank), and 362,880 (i.e. $9!$) different sequences for placing the Xs and Os on the board; that is, without taking into consideration winning combinations which would make many of them unreachable in an actual game.

When winning combinations are considered, there are 255,168 possible games. Assuming that X makes the first move every time:

- 131,184 finished games are won by (X)
  - 1,440 are won by (X) after 5 moves
  - 47,952 are won by (X) after 7 moves
  - 81,792 are won by (X) after 9 moves
- 77,904 finished games are won by (O)
  - 5,328 are won by (O) after 6 moves
  - 72,576 are won by (O) after 8 moves
- 46,080 finished games are drawn

Ignoring the sequence of Xs and Os, and after eliminating symmetrical outcomes (i.e. rotations and/or reflections of other outcomes), there are only 138 unique outcomes. Assuming once again that X makes the first move every time:

- 91 unique outcomes are won by (X)
  - 21 won by (X) after 5 moves
  - 58 won by (X) after 7 moves
  - 12 won by (X) after 9 moves
- 44 unique outcomes are won by (O)
  - 21 won by (O) after 6 moves
  - 23 won by (O) after 8 moves
- 3 unique outcomes are drawn
Strategy

A player can play perfect tic-tac-toe (win or draw) given they move according to the highest possible move from the following table.\[4\]

1. **Win**: If the player has two in a row, play the third to get three in a row.
2. **Block**: If the opponent has two in a row, play the third to block them.
3. **Fork**: Create an opportunity where you can win in two ways.
4. **Block opponent's fork**:
   - Option 1: Create two in a row to force the opponent into defending, as long as it doesn't result in them creating a fork or winning. For example, if "X" has a corner, "O" has the center, and "X" has the opposite corner as well, "O" must not play a corner in order to win. (Playing a corner in this scenario creates a fork for "X" to win.)
   - Option 2: If there is a configuration where the opponent can fork, block that fork.
5. **Center**: Play the center.
6. **Opposite corner**: If the opponent is in the corner, play the opposite corner.
7. **Empty corner**: Play in a corner square.
8. **Empty side**: Play in a middle square on any of the 4 sides.

The first player, whom we shall designate "X", has 3 possible positions to mark during the first turn. Superficially, it might seem that there are 9 possible positions, corresponding to the 9 squares in the grid. However, by rotating the board, we will find that in the first turn, every corner mark is strategically equivalent to every other corner mark. The same is true of every edge mark. For strategy purposes, there are therefore only three possible first marks: corner, edge, or center. Player X can win or force a draw from any of these starting marks; however, playing the corner gives the opponent the smallest choice of squares which must be played to avoid losing.\[5\]

The second player, whom we shall designate "O", must respond to X's opening mark in such a way as to avoid the forced win. Player O must always respond to a corner opening with a center mark, and to a center opening with a corner mark. An edge opening must be answered either with a center mark, a corner mark next to the X, or an edge mark opposite the X. Any other responses will allow X to force the win. Once the opening is completed, O's task is to follow the above list of priorities in order to force the draw, or else to gain a win if X makes a weak play.

Variations

Many board games share the element of trying to be the first to get \(n\)-in-a-row: three men's morris, nine men's morris, pente, gomoku, Qubic, Connect Four, Quarto, Gobblet. Generalizing the original Tic-tac-toe game, we get the so-called \(n^d\)-game, played on the \(d\)-dimensional cube with edge \(n\). Then, the ordinary Tic-tac-toe is the \(3^2\)-game. The \(m,n,k\)-games are a family of generalized games based on tic-tac-toe.

- 3-dimensional tic-tac-toe on a 3×3×3 board, though the first player has an easy win by playing in the centre if 2 people are playing. Another variant is played on a 4×4×4 board, though it was solved by Oren Patashnik in 1980 (the first player can force a win).\[7\] A more complex variant can be played on boards utilising higher dimensional space, most commonly 4 dimensions in a 3×3×3×3 board. In such games the aim is to fill up the board and get more rows of three in total than the other player or to play with 4 people and get 1 row of 3.
- In *misère tic-tac-toe* the player wins if the opponent gets \(n\) in a row. A 3×3 game is a draw.


- **Tic Tac Tactic**: A new game played on a three-dimensional board. Each player takes it in turns to send their ball at least half way round the curved board until it drops down into one of the 9 indents of the 3 x 3 grid. The player wins balls by forming a row of 3, and they can, using a rubber device, change the outcome of their ball's path and bounce their ball to where they want. Each 3-in-a-row wins a ball of the player. The winner is skilful enough to have won five balls off his opponent.

- **In nine board tic-tac-toe** nine tic-tac-toe boards are themselves arranged in a 3x3 grid. The first player's move may go on any board; all moves afterwards are placed in the empty spaces on the board corresponding to the square of the previous move (that is, if a move were in the upper-left square of a board, the next move would take place on the upper-left board). If a player cannot move because the indicated board is full, the next move may go on any board. Victory is attained by getting 3 in a row on any board. This makes the game considerably longer and more involved than tic-tac-toe, with a definite opening, middle game and endgame.

- **super tic-tac-toe** is played like nine board tic-tac-toe except that the game does not end when a player wins a game on one of the small boards. Instead, the position of the small board where that player won is marked on a 3x3 grid, and a player wins when they form 3-in-a-row on that grid.

- **In Tic-Tac-Chess**, players play a game of chess and tic-tac-toe simultaneously. When a player captures an opponent's piece, the player can make a play on the tic-tac-toe board regardless if the other player has not yet made a play. The first person to get 3 X's or O's in a row wins the game. This makes for a much more defensive game of chess.

- There is a game that is isomorphic to tic-tac-toe, but on the surface appears completely different. Two players in turn say a number between one and nine. A particular number may not be repeated. The game is won by the player who has said three numbers whose sum is 15. Plotting these numbers on a 3x3 magic square shows that the game exactly corresponds with tic-tac-toe, since three numbers will be arranged in a straight line if and only if they total 15. This can be helpful in programming computer adaptations of the game, by assigning the squares of the grid to their corresponding number on the magic square.

- Two players fill out a 3x3 grid with numbers one through nine in order of priority. They then compare their grids and play tic-tac-toe by filling in the squares by the priority they listed before.

- In the 1970s, there was a two player game made by Tri-ang Toys & Games called Check Lines, in which the board consisted of eleven holes arranged in a geometrical pattern of twelve straight lines each containing three of the holes. Each player had exactly five tokens and played in turn placing one token in any of the holes. The winner was the first player whose tokens were arranged in two lines of three (which by definition were intersecting lines). If neither player had won by the tenth turn, subsequent turns consisted of moving one of one's own tokens to the remaining empty hole, with the constraint that this move could only be from an adjacent hole.

- **Toss Across** is a tic-tac-toe game where players throw bean bags at a large board to mark squares.

- **Star Tic Tac Toe** is tic-tac-toe game where it is played with checkers like movable pieces on 3x3 board. Each player gets 3 pieces. The players move the pieces into empty cells until someone wins. This adds dynamism. In addition each player gets a special piece marked with a star. The stars can be swapped. This adds surprise.

- **Mojo, Mojo Too and Mojo 2** is a tic-tac-toe game played on a 3x3 board with original and unique movable pieces and pawns - the latter is played for points. The players move the pieces and pawn(s) onto empty positions until someone wins.

- Various game shows have been based on the game:
  - On **Hollywood Squares** nine celebrities filled the cells of the tic-tac-toe grid.
  - In **Tic-Tac-Dough** players put symbols up on the board by answering questions in various categories.
  - In **Beat the Teacher** contestants answer questions to win a turn to influence a tic-tac-toe grid.
  - On **The Price Is Right**, several national variants feature a pricing game called "Secret X," in which players must guess prices to win Xes to place on a blank board. They must place the Xes in position to guess the location of the titular "secret X" hidden in the center column of the board and form a tic-tac-toe line across. There are no O's in this variant of the game.
The object of the fictional D'ni game of **Gemedet** is to get six balls in-a-row in a 9×9×9 cube grid.

The object of the fictional game Squid-Tac-Toad is to get four (or five) pieces in-a-row on a 4×4 or 5×5 checkerboard grid.

Some children play where getting a Y formation also counts as a win. This effectively guarantees a win, since all of the cat's game scenarios feature some form of Y formation.

Quantum tic tac toe allows players to place a quantum superposition of numbers on the board.

Another variation on tic-tac-toe is played on a larger grid (say 10×10) where the object is to get 5 in a row. The increased amount of space creates a greater complexity.

There is a variation on tic-tac-toe that is popular in Vietnam, in which the player has to get 5 in a row to win the game. Each player takes turns to mark "x" or "o" on the board. The strategy is to not only block the opponent, but create chances for yourself to form 5 in a row in any direction. The board is unlimited and has no boundary until one wins. See Go-moku

The game can also be varied by limiting the number of pieces and then allowing movement. The three-a-side then becomes Three Men's Morris (see Nine Men's Morris).

### Alternative English names

The game has a number of alternative English names.

- Tick-tack-toe, tic-tac-toe, tick-tat-toe, or tit-tat-toe (USA, Canada)
- Noughts and crosses or Naughts and crosses (Great Britain, Republic of Ireland, Australia, New Zealand, South Africa, Russian Federation)
- Exy-Ozys, Xsie-Osies (verbal name only) (Northern Ireland)
- X's and O's (Egypt, Republic of Ireland, Canada, Scotland, Zimbabwe)
- Zero/Katta(Cross) (India)

In the United States, the name "noughts and crosses" is not well understood, as the word "nought" is archaic in usage, and where X-shaped objects are not generally called crosses except in the case of specific named crosses like St. Patrick’s Cross.

Sometimes, the games Tic-tac-toe (where players keep adding "pieces") and Three Men's Morris (where pieces start to move after a certain number have been placed) are easily confused with each other.

### History

According to Claudia Zaslavsky's book *Tic Tac Toe: And Other Three-In-A Row Games from Ancient Egypt to the Modern Computer*, the game Tic Tac Toe is originally from ancient Egypt.\[8\]

### Etymology

The name "tic-tac-toe" may ultimately derive from "tick-tack", the name of an old version of backgammon first described in 1558. The first print reference to "noughts and crosses", the British name appeared in 1864. The first print reference to a game called "tick-tack-toe" occurred in 1884, but referred to "a children's game played on a slate, consisting in trying with the eyes shut to bring the pencil down on one of the numbers of a set, the number hit being scored". The U.S. renaming of noughts and crosses as tic-tac-toe occurred in the 20th century.\[9\]
In popular culture

In the 1983 film WarGames, tic-tac-toe is used as an allegory for nuclear war. In the climax of the film, the protagonist prevents an out of control military defense computer from launching nuclear missiles by making it repeatedly play tic-tac-toe against itself. After quickly learning that good strategy by both players produces no winner, the computer then plays through all known nuclear strike scenarios, again finding no winner. The computer concludes, "The only winning move is not to play."

References

[3] Based on an image published by (http://xkcd.com/832/) Randall Munroe on xkcd

External links

- How many Tic-Tac-Toe games are possible? (http://www.btinternet.com/~se16/hgb/tictactoe.htm)
- Demonstration of isomorphism between Tic-Tac-Toe and 'Game of 15' (http://www numbertwopencil.net/further/one/intro.html)
Tic-tac-toe

Image Sources, Licenses and Contributors


License

Creative Commons Attribution-Share Alike 3.0 Unported
http://creativecommons.org/licenses/by-sa/3.0/