

# CPSC 2150 Project Report

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## Requirements Analysis

### Functional Requirements:

1. As a player, I need to be able to start a new game so that I can play.
2. As a player, I need to be able to choose how many players should be able to play the game so that I can play with more than one other person if I wish.
3. As a player, I need to be able to choose how many rows the game board should have so that I can play whatever size board I wish.
4. As a player, I need to be able to be alerted if the number of rows I have entered is invalid so that I can enter a valid input instead.
5. As a player, I need to be able to choose how many columns the game board should have so that I can play whatever size board I wish.
6. As a player, I need to be able to be alerted if the number of columns I have entered is invalid so that I can enter a valid input instead.
7. As a player, I need to be able to choose how many tokens should be required in a row to win the game so that I can make the game more challenging.
8. As a player, I need to be able to be alerted if the number of tokens in a row I have entered is invalid so that I can enter a valid input instead.
9. As a player, I need to be able to see which player's turn it is so that I can either take my turn or give control of the computer to my opponent.
10. As a player, I need to be able to see the game board so that I can tell what spaces have already been filled so that I can decide where to drop a token.
11. As a player, I need to be able to visually determine what column on the game board corresponds to what number column so that I can drop a token in the correct column.
12. As a player, I need to be able to enter the column number that I wish to drop a token in so that I can drop a token in the correct column.
13. As a player, I need to be able to tell if the result of a turn is the conclusion of the game or not so that I can determine whether to continue playing.
14. As a player, I need to be able to tell if a game has concluded due to a tie or due to either myself or my opponent winning so that I can determine if there is a winner.
15. As a player, I need to be able to opt to play the game again so that I can participate in a re-match.
16. As a player, I need to be able to be alerted if I have tried to drop a token in a column that is already full so that I can instead drop a token in a column that is not already full.
17. As a player, I need to be able to drop tokens in such a way that they are arranged in a sequence of five horizontally so that I can win the game.
18. As a player, I need to be able to drop tokens in such a way that they are arranged in a sequence of five vertically so that I can win the game.

19. As a player, I need to be able to drop tokens in such a way that they are arranged in a sequence of five diagonally so that I can win the game.
20. As a player, I need to be able to tie the game by dropping a token in such a way that all the spaces on the game board are filled without either myself or my opponent winning so that I can prevent my opponent from winning.

### **Non-Functional Requirements**

1. The game must be able to run on Unix and it must run as a graphical user interface application.
2. The game must be written in Java.
3. The game must be programmed using the Model-View-Controller architectural pattern.
4. The game must include three sub-packages: models, views, and controllers.
5. The game's GUI must be implemented using Java Swing in the "views" sub-package.
6. The game must include a ConnectXApp class which will contain the program's main() method and initialize the graphical user interface.
7. The game must include classes within the "views" sub-package, namely SetupView and ConnectXView, that include methods that are responsible for getting user inputs for the number of rows on a game board, the number of columns on a game board, the number of consecutive tokens required to win a game, and the number of players in a game, as well as methods and functionalities that are responsible for displaying information to the user graphically.
8. The game must include classes within the "controllers" sub-package, namely SetupController and ConnectXController, that include methods and functionalities that are responsible for alternating turns between players, outputting whose turn is currently being played, handing the process of playing a token in a user-specified column (including ensuring that the column is available), advancing to the next turn, and checking for wins and tie games.
9. The ConnectXController class must alert the user if they are trying to place a token in a column which cannot accept any more tokens.
10. The ConnectXController class must alert the user if the result of a play is a win or a tie.
11. The ConnectXController class must allow the user to begin a new game after a win or tie by simply pressing any visible button on the screen.
12. All program input and output must happen within classes within the "views" sub-package, namely ConnectXView.
13. The BoardPosition class must keep track of a single space on the game board as accessed by the row number and column number. There must be variables for both row and column numbers.
14. The BoardPosition class must have only one constructor that takes two ints (row and column), and the constructor must be the only way to set the data in the class.
15. The BoardPosition class must have methods that return the row number and the column number.
16. The BoardPosition class must have an overridden equals() method that determines whether or not two BoardPosition objects are equal by checking if both their row and column values are equal.
17. The BoardPosition class must have an overridden toString() method that creates a string in the format "<row>,<column>".

18. There must be an IGameBoard interface that abstractly represents the actual game board. All of the attributes must be public static final, public methods implemented by a class which implements IGameBoard, or default methods.
19. The IGameBoard interface must contain constant variables to represent the minimum and maximum values for the number of rows, number of columns, and number of consecutive tokens required to win.
20. The IGameBoard interface must contain a default method called checkIfFree that determines if a specified column can accept another token.
21. The IGameBoard interface must contain a method called placeToken, which updates the game board with the specified player's token in the specified column, that will be implemented by a class that implements IGameBoard.
22. The IGameBoard interface must contain a default method called checkForWin that determines whether the last token placed in the specified column resulted in the game concluding with a win.
23. The IGameBoard interface must contain a default method called checkTie that determines whether all of the spaces on the game board have been filled.
24. The IGameBoard interface must contain a default method called checkHorizWin that determines whether the last token placed in the specified BoardPosition resulted in the winning number of tokens in a horizontal row for the specified player.
25. The IGameBoard interface must contain a default method called checkVertWin that determines whether the last token placed in the specified BoardPosition resulted in the winning number of tokens in a vertical column for the specified player.
26. The IGameBoard interface must contain a default method called checkDiagWin that determines whether the last token placed in the specified BoardPosition resulted in the winning number of tokens diagonally for the specified player.
27. The IGameBoard interface must contain a method called whatsAtPos, which determines what player's token (if any) is found at the specified position, that will be implemented by a class that implements IGameBoard.
28. The IGameBoard interface must contain a default method called isPlayerAtPos that determines whether the specified player's token is at the specified position.
29. The IGameBoard interface must contain a method called getNumRows, which returns the number of rows on the game board, that will be implemented by a class that implements IGameBoard.
30. The IGameBoard interface must contain a method called getNumColumns, which returns the number of columns on the game board, that will be implemented by a class that implements IGameBoard.
31. The IGameBoard interface must contain a method called getNumToWin, which returns the number of consecutive tokens required to win, that will be implemented by a class that implements IGameBoard.
32. There must be an abstract AbsGameBoard class that implements the IGameBoard interface and provides an overridden toString method which returns a string representing the current state of the game board.
33. There must be a GameBoard class that implements the IGameBoard interface and extends the AbsGameBoard class. All of the attributes in the class must be private or static and final.

34. The game board within the GameBoard class must be represented by a 2D array where [0][0] is the bottom left corner of the board and [8][6] is the top right.
35. The values of the 2D array within the GameBoard class must contain a ' ' (space) by default, until a player drops a token in that position.
36. When a player drops a token in a given space, that space within the 2D array within the GameBoard class should change to either an 'X' or an 'O' depending on which player drops the token.
37. A constructor for the GameBoard class should be provided with parameters for the number of rows, number of columns, and number of consecutive tokens required to win.
38. There must be a GameBoardMem class that implements the IGameBoard interface and extends the AbsGameBoard class. All of the attributes in the class must be private or static and final.
39. The game board within the GameBoardMem class must be represented by a map where the keys are type Character and the values are type List<BoardPosition>.
40. The key/value pairs of the map within the GameBoardMem class must only exist if a player has dropped a token at a position.
41. When a player drops a token in a given space, the map within the GameBoardMem class must be updated with the new key (if the key does not already exist within the map) and the new BoardPosition value corresponding to the player's token and the space that has been filled.
42. A constructor for the GameBoardMem class should be provided with parameters for the number of rows, number of columns, and number of consecutive tokens required to win.
43. The GameBoardMem class must override the default IGameBoard implementation of the isPlayerAtPos method in such a way that works for the game board represented as a map and does not rely on whatsAtPos.

## Deployment Instructions

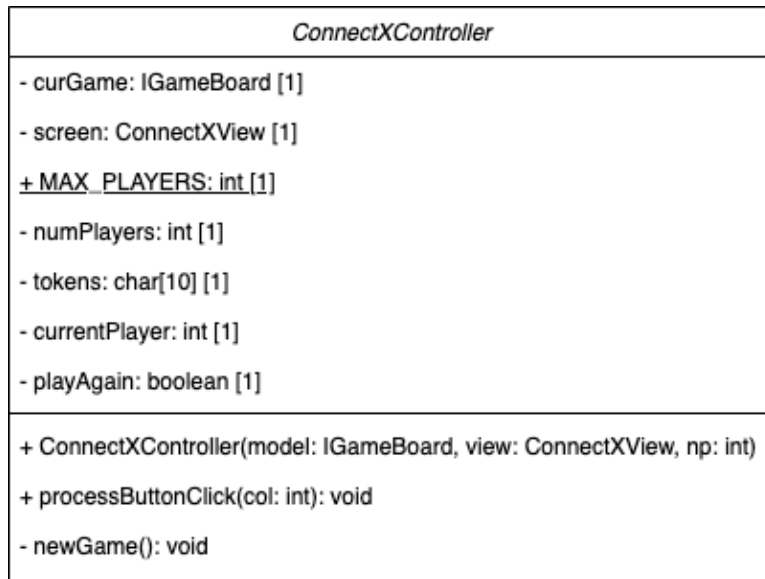
Details in Projects 2-5.

- To compile and run ConnectXGui, open the ConnectXGui IntelliJ IDEA project in IntelliJ IDEA 2020 or later, then run the “ConnectXApp” build configuration.
  - If the “ConnectXApp” build configuration does not exist, create a new build configuration targeting the ConnectXApp class’s main() method.

# System Design

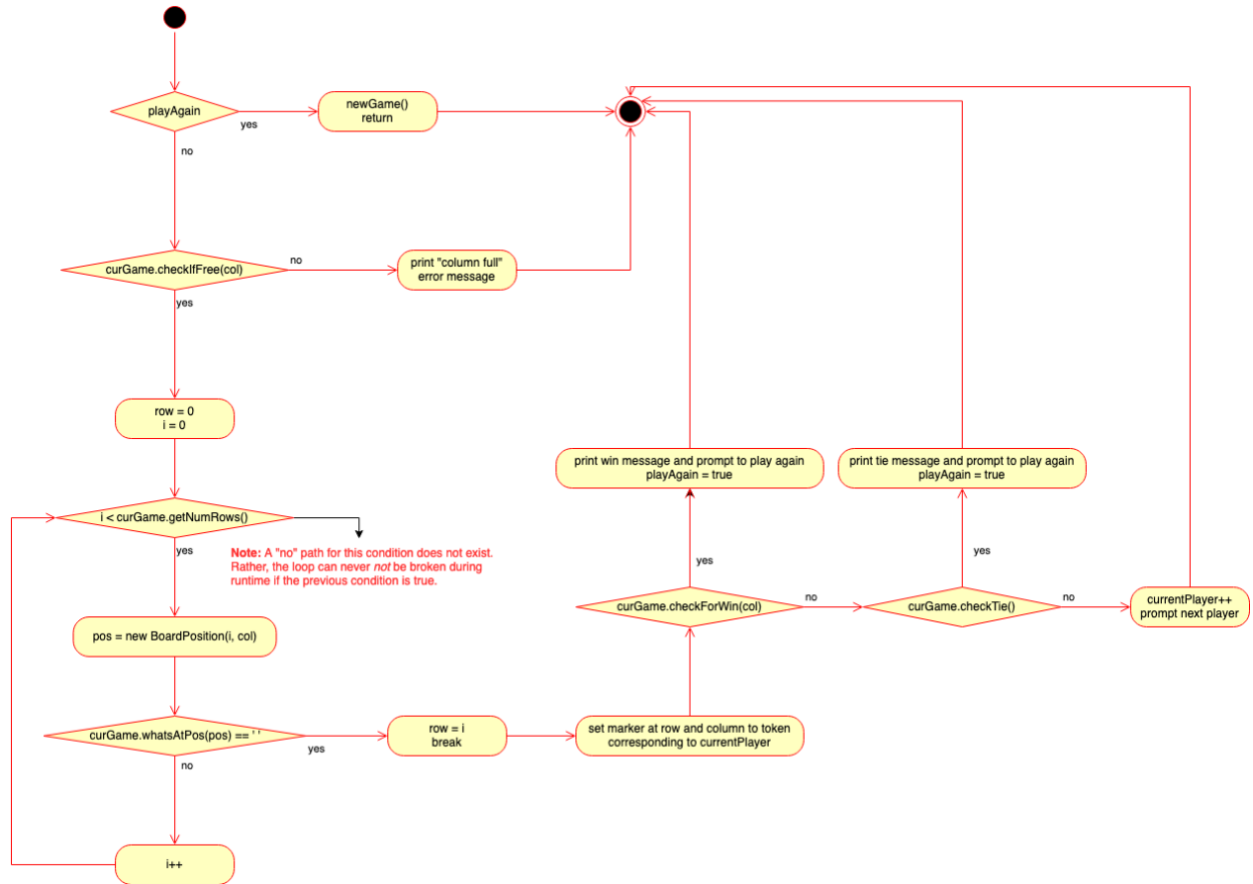
## Class 1: ConnectXController

### Class diagram



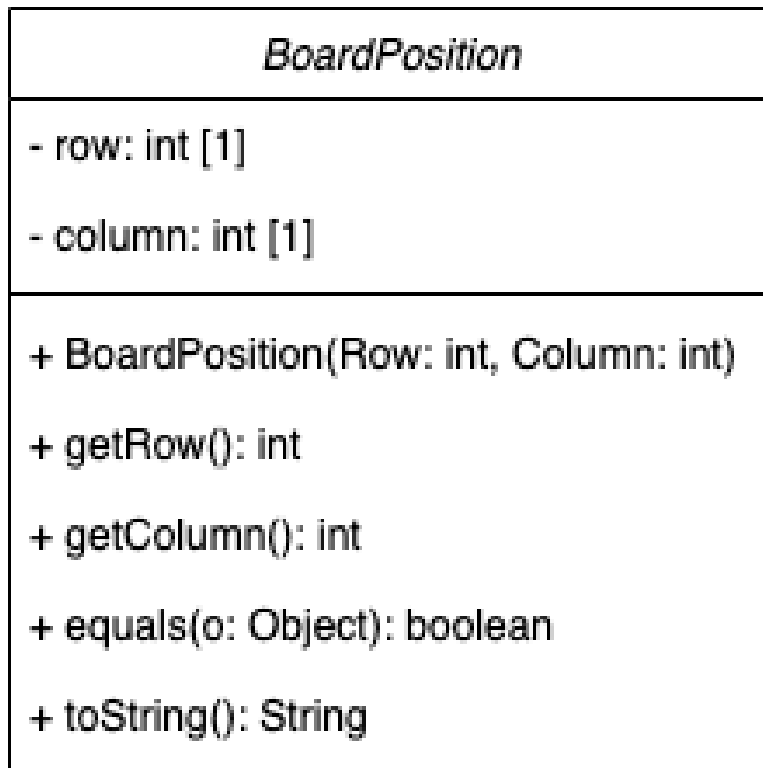
## Activity diagrams

### processButtonClick:



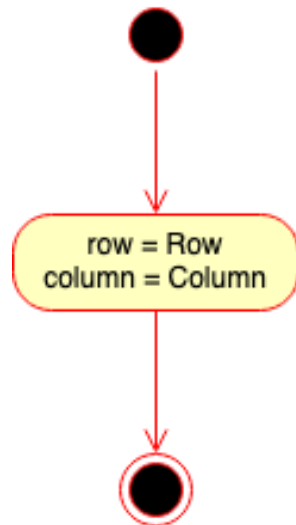
**Class 2:** BoardPosition

**Class diagram**

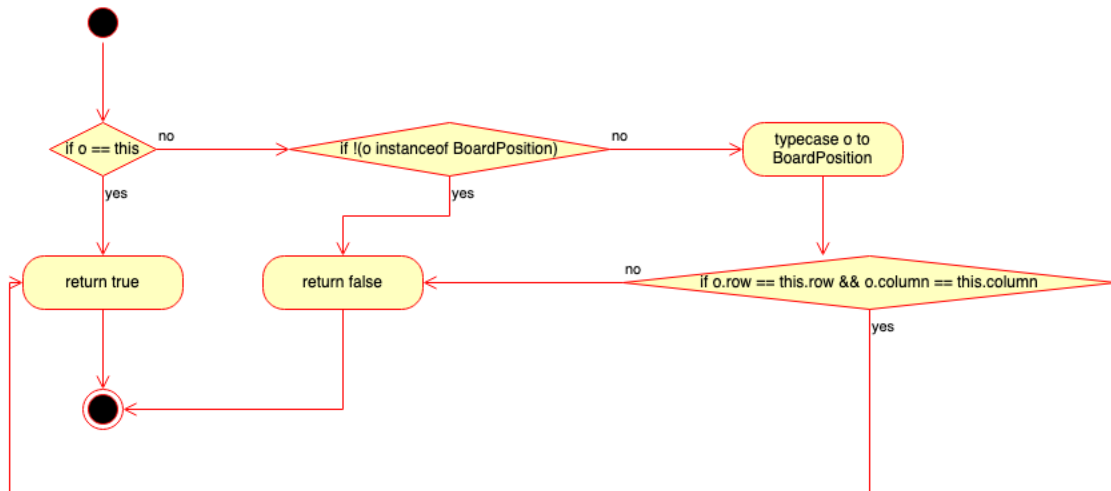


## Activity diagrams

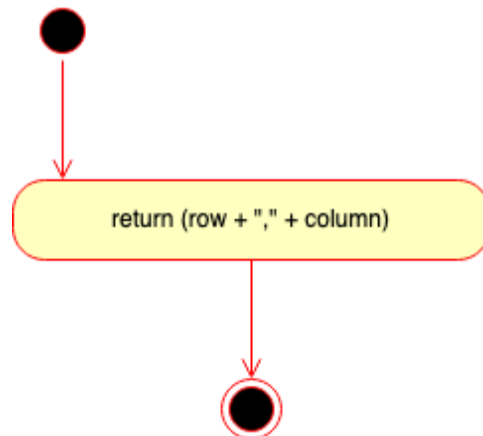
### Constructor (BoardPosition):



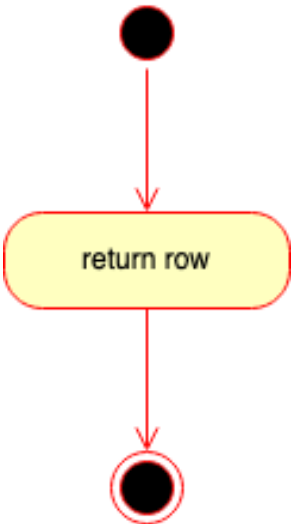
### equals:



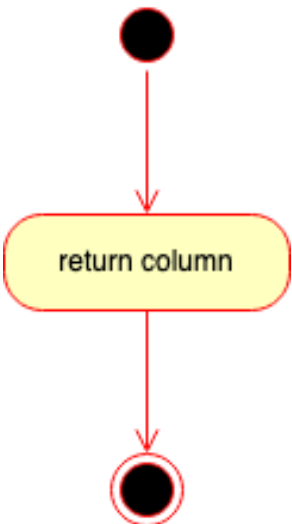
### toString:



getRow:

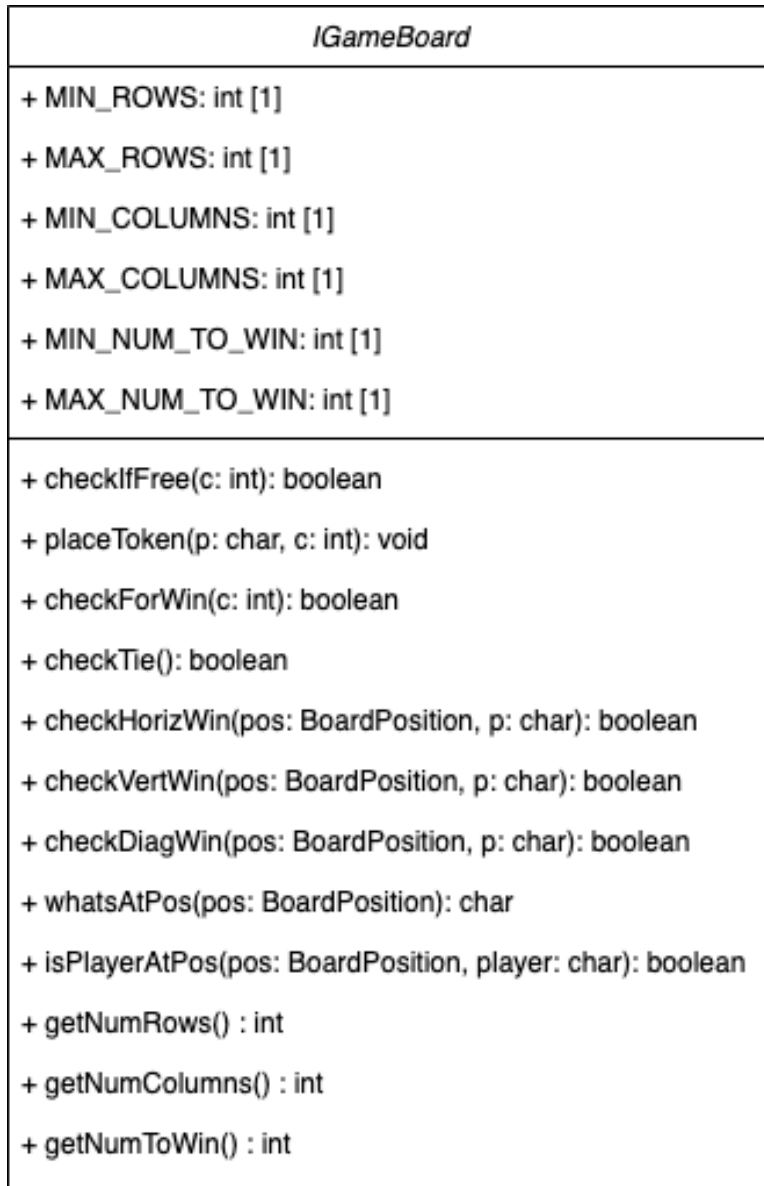


getColumn:



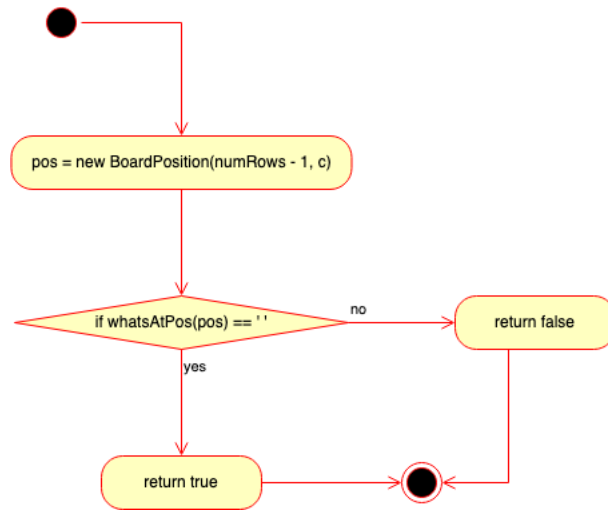
## Interface 1: IGameBoard

### Interface diagram

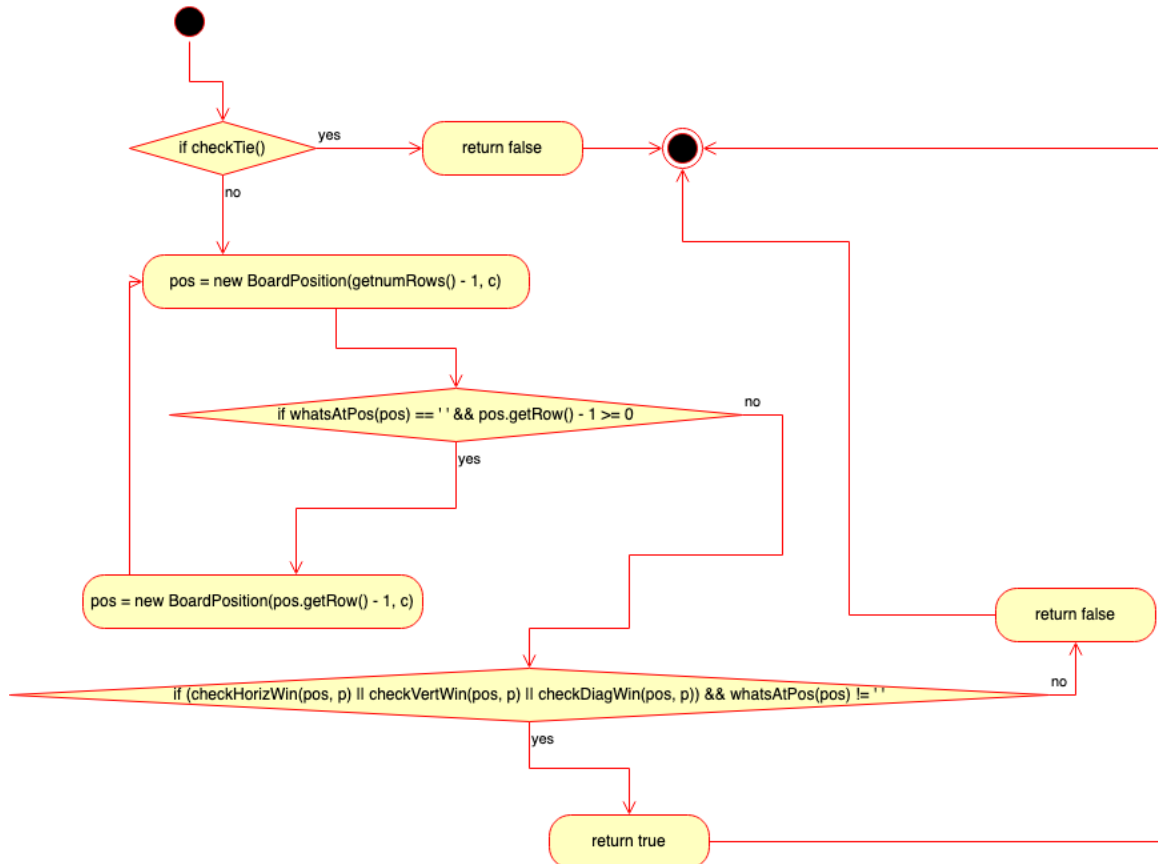


## Activity diagrams

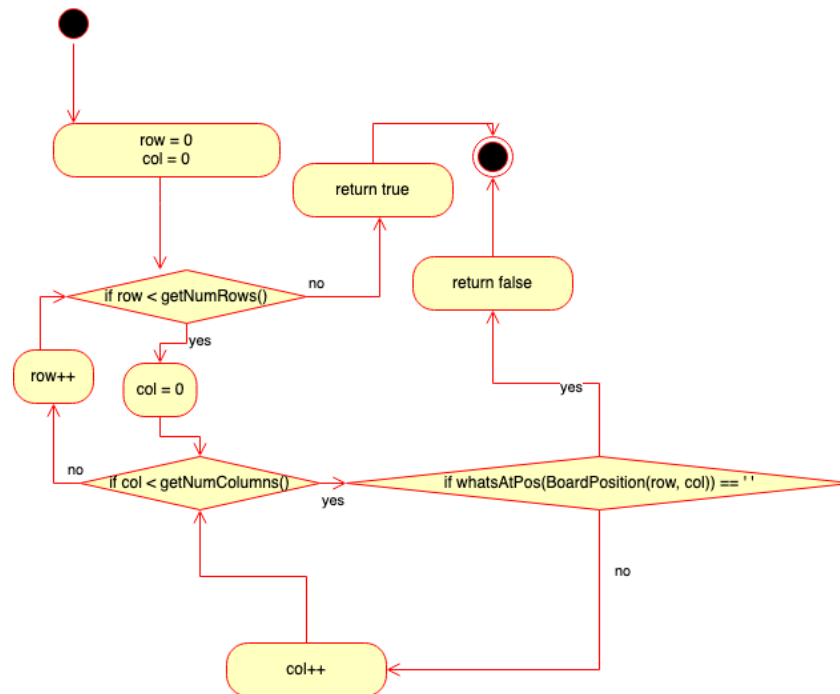
### checkIfFree:



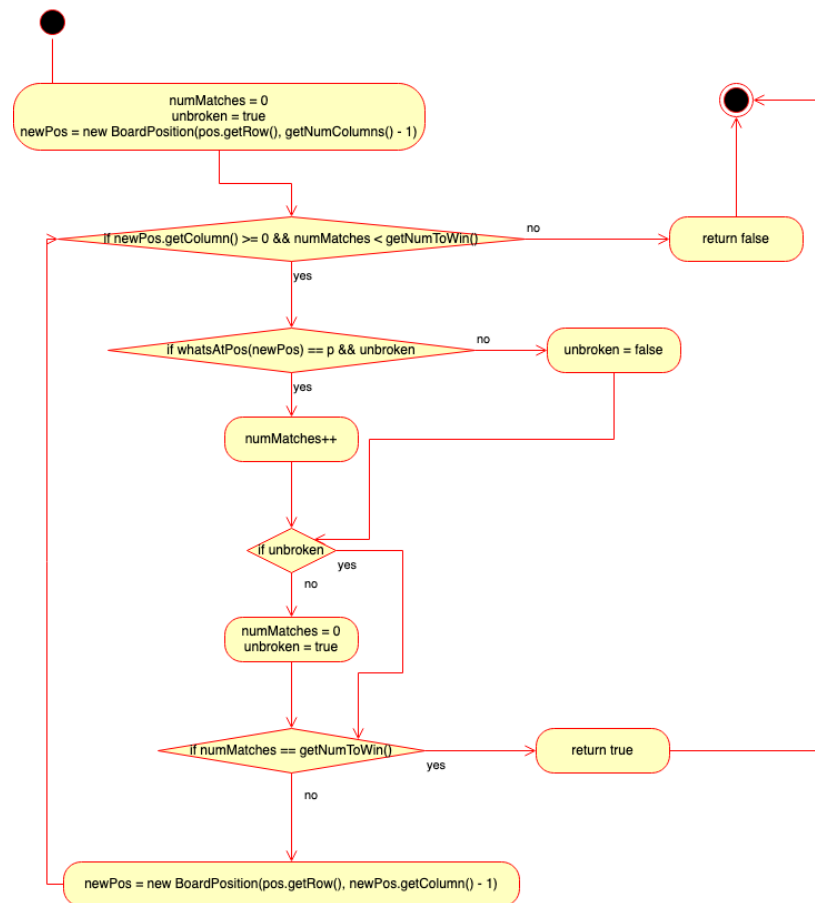
### checkForWin:



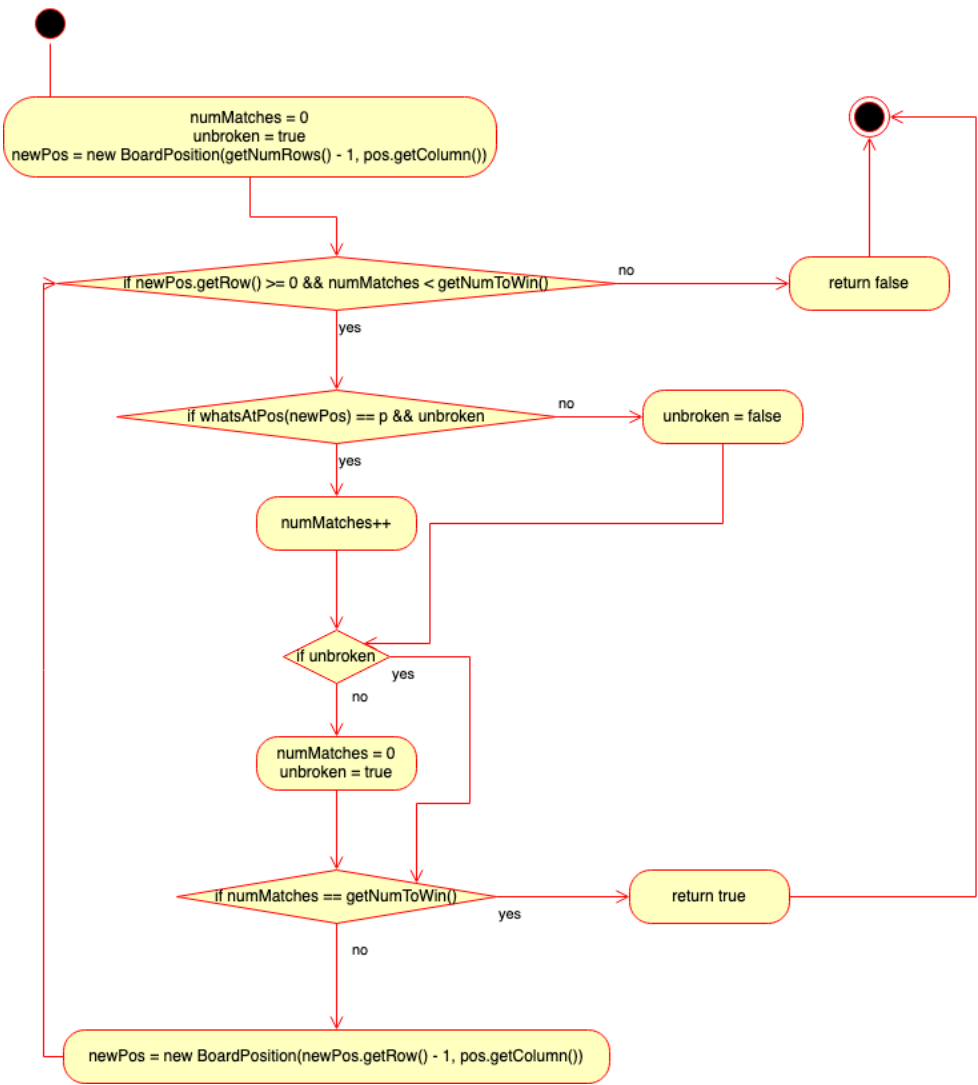
### checkTie:



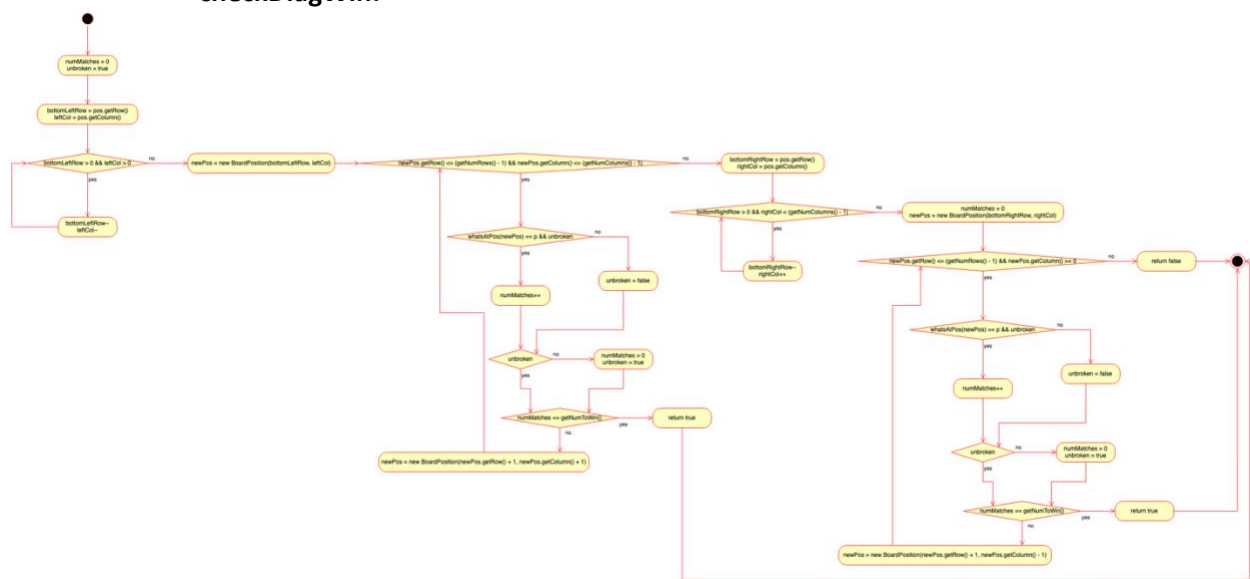
### checkHorizWin:



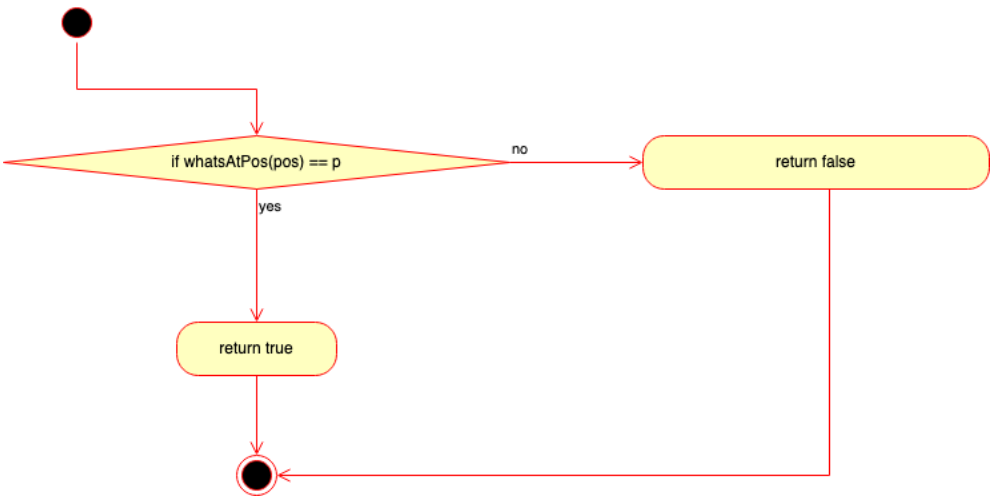
checkVertWin:



checkDiagWin:

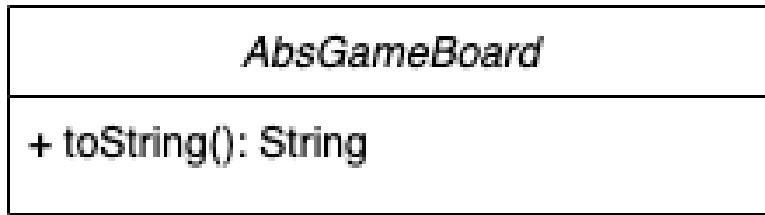


isPlayerAtPos:



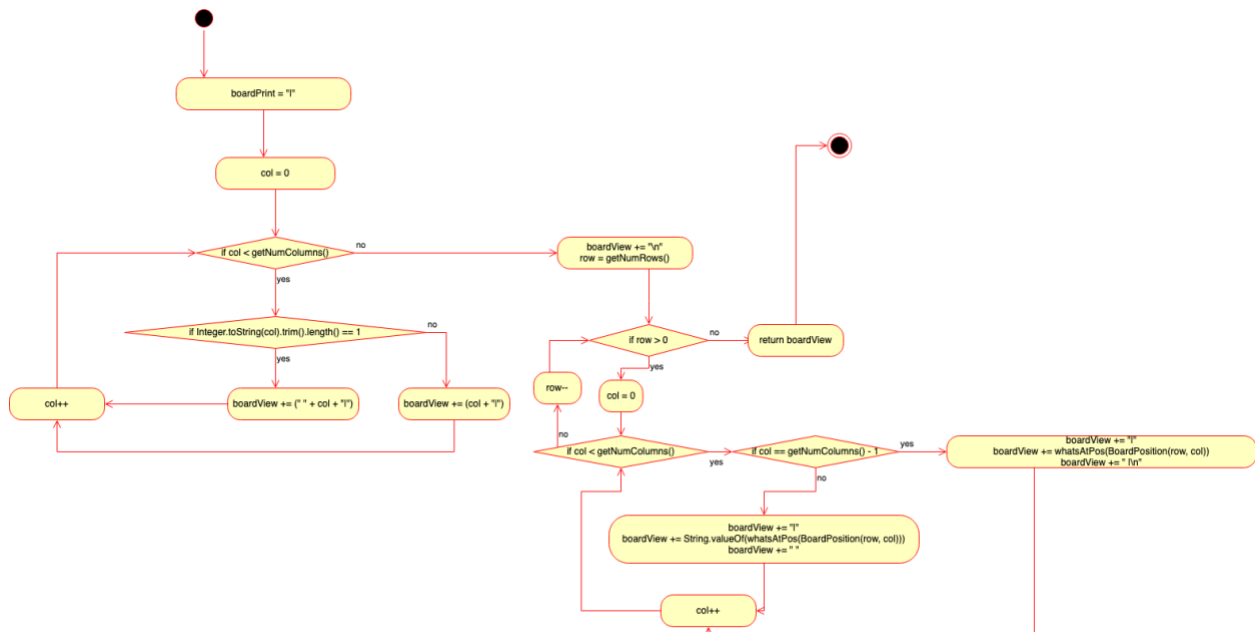
### Class 3: AbsGameBoard

## Class diagram



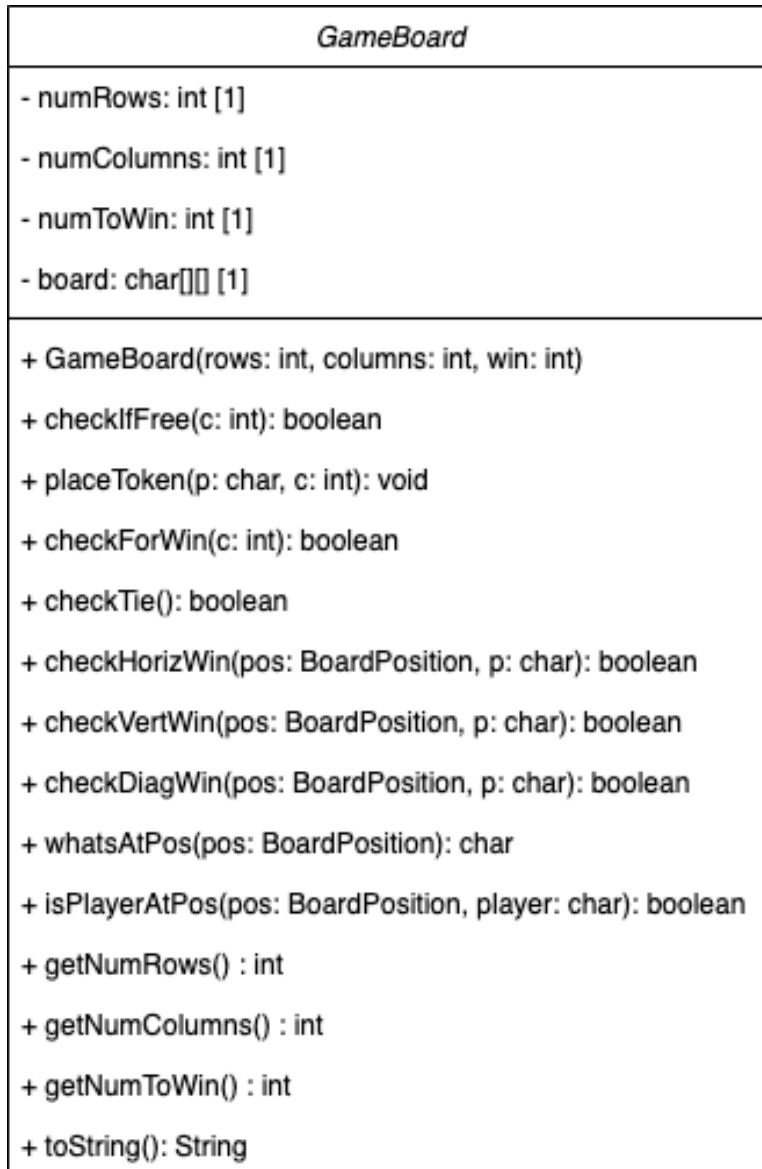
## Activity diagrams

**toString:**



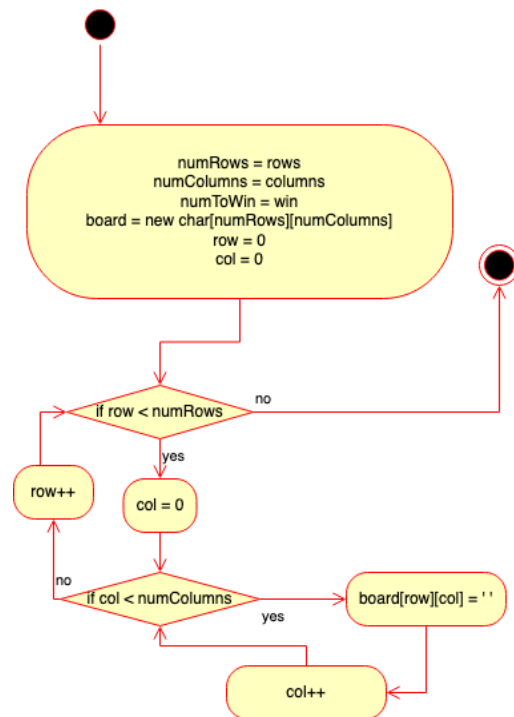
#### Class 4: GameBoard

##### Class diagram

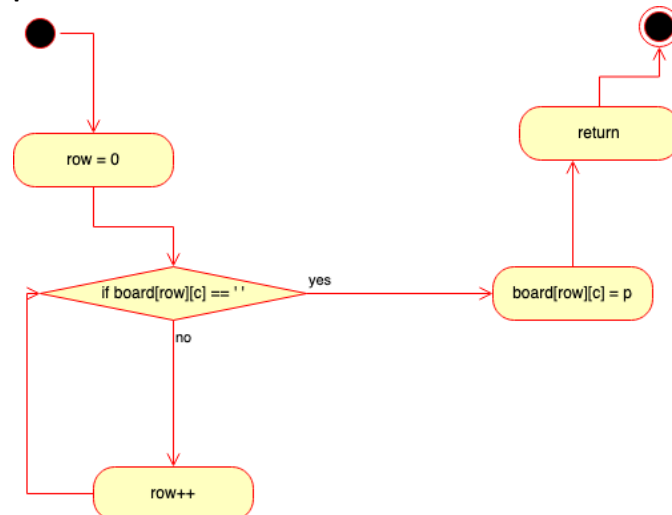


## Activity diagrams

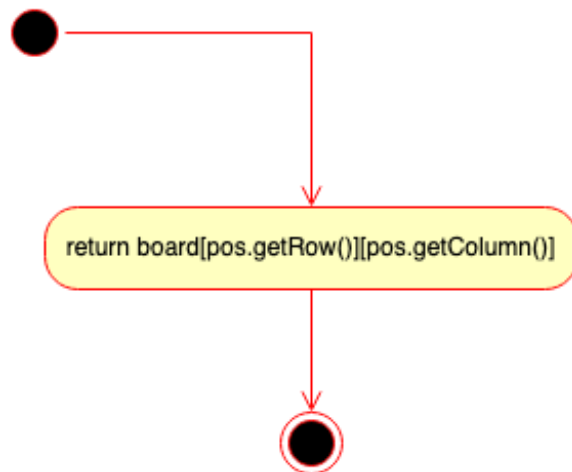
### Constructor (GameBoard):



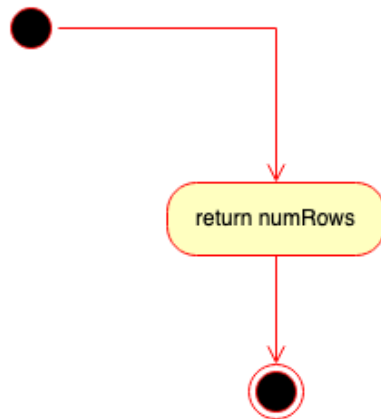
### placeToken:



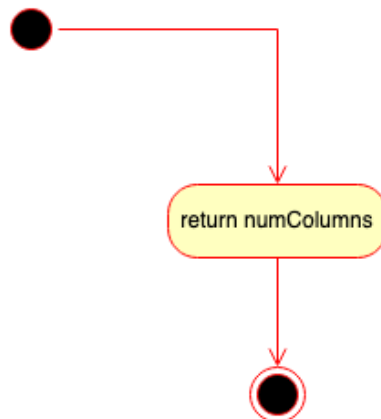
**whatsAtPos:**



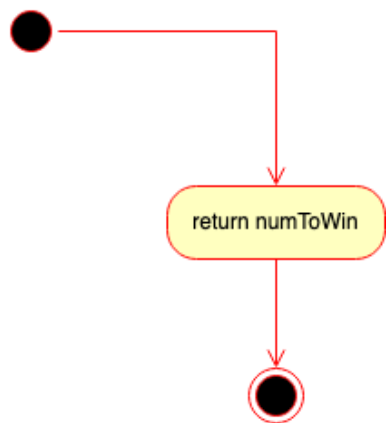
**getNumRows:**



**getNumColumns:**

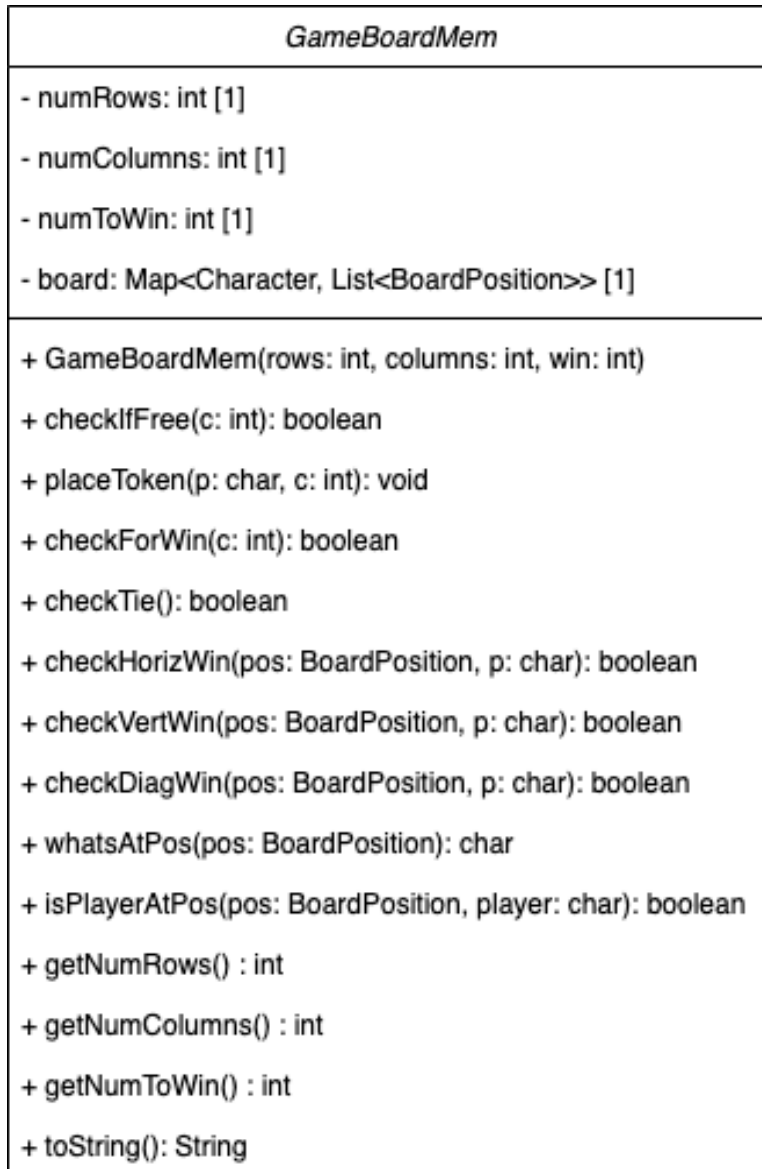


**getNumToWin:**



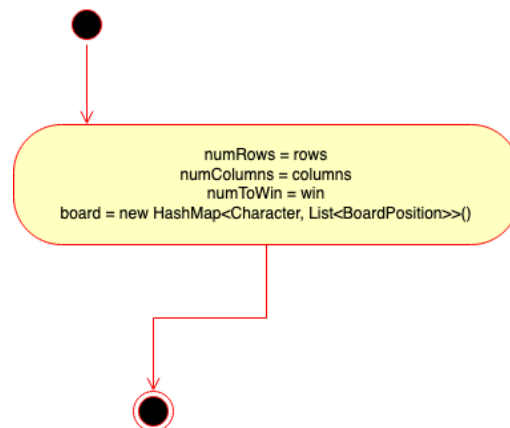
#### Class 4: GameBoardMem

##### Class diagram

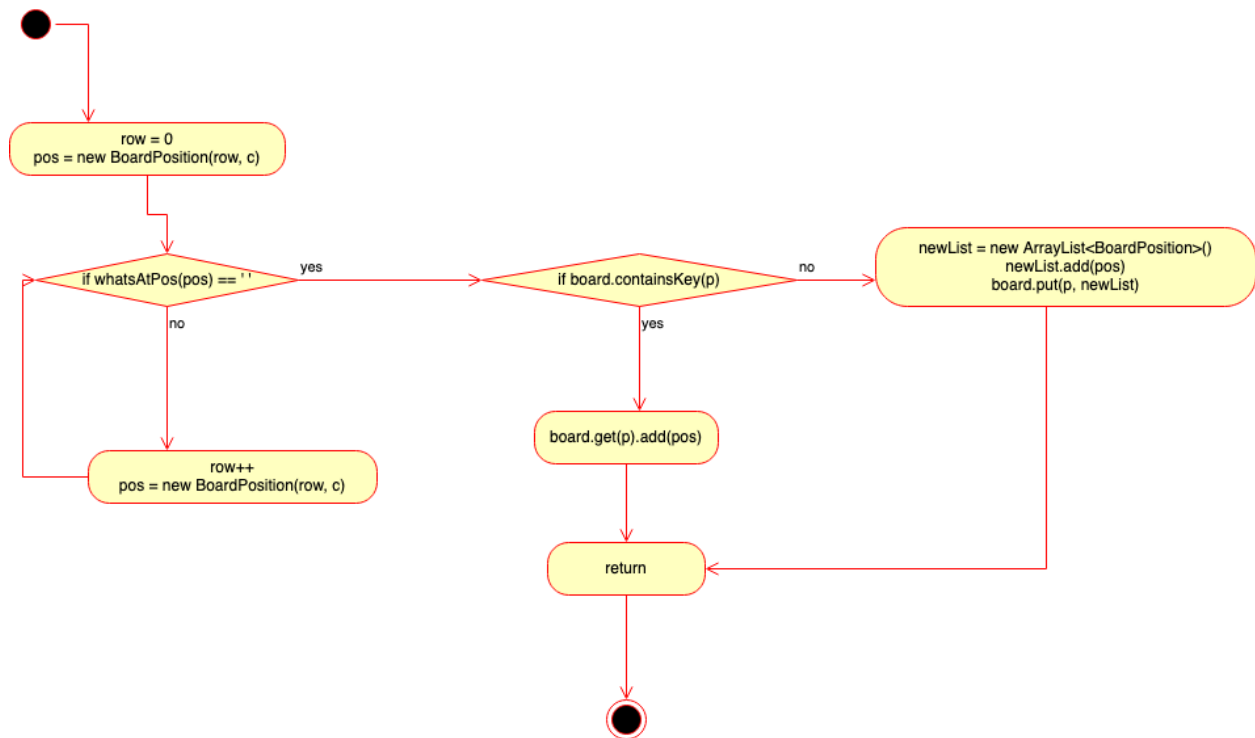


## Activity diagrams

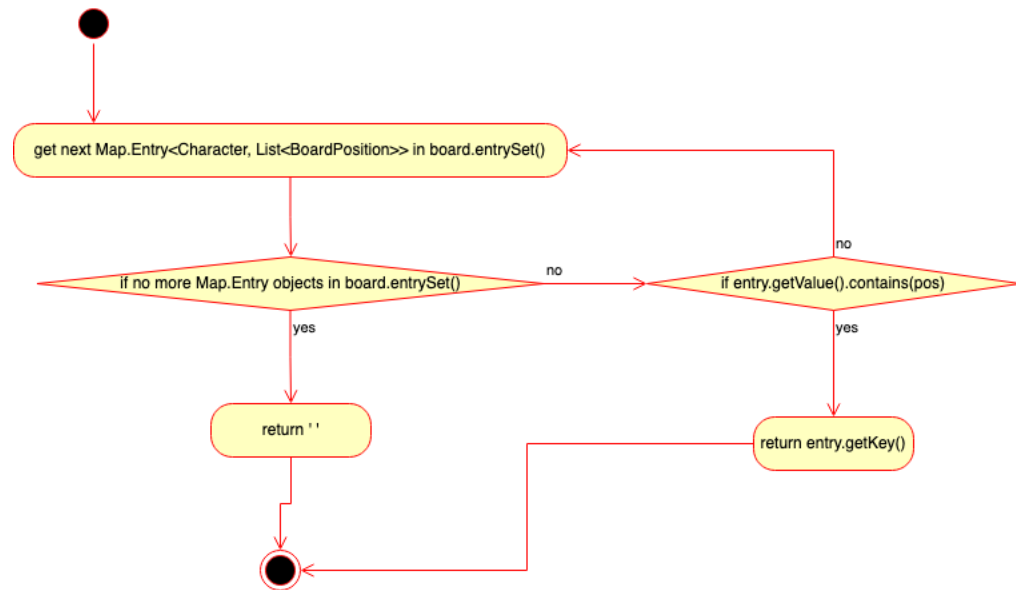
### Constructor (GameBoardMem):



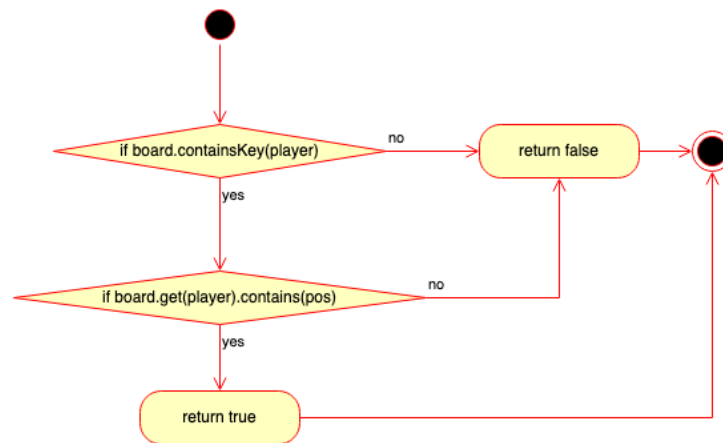
### placeToken:



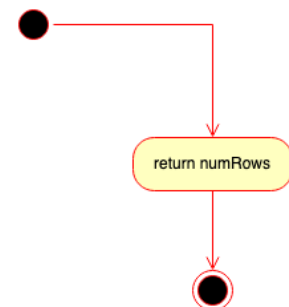
### whatsAtPos:



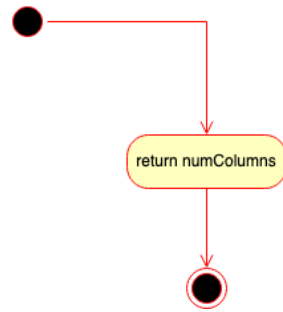
### isPlayerAtPos:



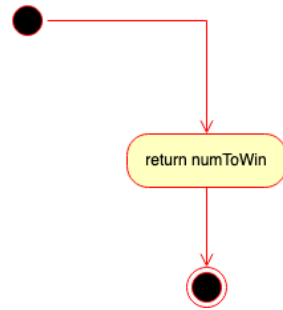
### getNumRows:



**getNumColumns:**



**getNumToWin:**



## Test Cases

GameBoard(int rows, int columns, int win)

GameBoardMem(int rows, int columns, int win)

|                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Input:</b></p> <p>State:</p> <table border="1" data-bbox="204 478 570 590"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> </table> <p>rows =<br/>IGameBoard.MIN_ROWS<br/>columns =<br/>IGameBoard.MIN_COLUMNS<br/>win =<br/>IGameBoard.MIN_NUM_TO_WIN</p> |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  | <p><b>Output:</b></p> <p>Board is initialized with IGameBoard.MIN_ROWS rows, IGameBoard.MIN_COLUMNS columns, and IGameBoard.MIN_NUM_TO_WIN number to win</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test case is unique and distinct because the GameBoard is being initialized to the minimum values specified in IGameBoard, which could be changed by the interface implementer.</p> <p><b>Function name:</b><br/>testConstructor_minimum_values</p> |
|                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
| <p><b>Input:</b></p> <p>State:</p> <p>100x100 grid with uninitialized tokens (not shown due to table limits)</p> <p>rows =<br/>IGameBoard.MAX_ROWS<br/>columns =<br/>IGameBoard.MAX_COLUMNS<br/>win =<br/>IGameBoard.MAX_NUM_TO_WIN</p>                                                                                          | <p><b>Output:</b></p> <p>Board is initialized with IGameBoard.MAX_ROWS rows, IGameBoard.MAX_COLUMNS columns, and IGameBoard.MAX_NUM_TO_WIN number to win</p> <p>State of the board is unchanged</p>                                                                                   | <p><b>Reason:</b></p> <p>This test case is unique and distinct because the GameBoard is being initialized to the maximum values specified in IGameBoard, which could be changed by the interface implementer.</p> <p><b>Function name:</b><br/>testConstructor_maximum_values</p>                                                                                               |  |  |  |  |  |  |  |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
| <p><b>Input:</b></p> <p>State:</p> <p>[random]x[random] grid with uninitialized tokens (not shown due to inability to predict random number generation)</p> <p>rows = [random number between</p>                                                                                                                                 | <p><b>Output:</b></p> <p>Board is initialized with a random number between IGameBoard.MIN_ROWS and IGameBoard.MAX_ROWS, columns is initialized with a random number between IGameBoard.MIN_COLUMNS and IGameBoard.MAX_COLUMNS, and the number to win is initialized with a random</p> | <p><b>Reason:</b></p> <p>This test case is unique and distinct because the GameBoard is being initialized to random values between the bounds specified in IGameBoard, which could be changed by the interface implementer, and it could theoretically test the constructor with any possible set of values.</p> <p><b>Function name:</b><br/>testConstructor_random_values</p> |  |  |  |  |  |  |  |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |

|                                                                                                                                                                                                                                                              |                                                                                                                                  |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--|
| IGameBoard.MIN_ROWS and<br>IGameBoard.MAX_ROWS]<br>columns = [random number<br>between<br>IGameBoard.MIN_COLUMNS<br>and<br>IGameBoard.MAX_COLUMNS]<br>win = [random number<br>between<br>IGameBoard.MIN_NUM_TO_<br>WIN and<br>IGameBoard.MAX_NUM_TO_<br>WIN] | number between<br>IGameBoard.MIN_NUM_TO_<br>WIN and<br>IGameBoard.MAX_NUM_TO_<br>_WIN.<br><br>State of the board is<br>unchanged |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--|

```
boolean checkIfFree(int c)
```

|                                                                                                                                                                                                                    |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--|--|---|--|--|---|--|--|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="204 338 474 451"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> </table><br>c = 0     |   |  |  |   |  |  |   |  |  | <b>Output:</b><br>checkIfFree = true<br><br>State of the board is unchanged  | <b>Reason:</b><br>This test case is unique and distinct because checkIfFree is being tested when the column passed as a parameter is completely empty, which could highlight issues with checkIfFree if it is counting spaces as tokens for some reason.<br><br><b>Function name:</b><br>testCheckIfFree_column_empty                                         |
|                                                                                                                                                                                                                    |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
|                                                                                                                                                                                                                    |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
|                                                                                                                                                                                                                    |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="204 693 474 806"> <tr><td>X</td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> </table><br>c = 0  | X |  |  | X |  |  | X |  |  | <b>Output:</b><br>checkIfFree = false<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because checkIfFree is being tested when the column number passed as a parameter is completely full, which could highlight issues with checkIfFree if it is under-counting the number of tokens in a column for some reason.<br><br><b>Function name:</b><br>testCheckIfFree_column_full              |
| X                                                                                                                                                                                                                  |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
| X                                                                                                                                                                                                                  |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
| X                                                                                                                                                                                                                  |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="204 1047 474 1161"> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> </table><br>c = 0 |   |  |  | X |  |  | X |  |  | <b>Output:</b><br>checkIfFree = true<br><br>State of the board is unchanged  | <b>Reason:</b><br>This test case is unique and distinct because checkIfFree is being tested when the column number passed as a parameter is only partially full, which could highlight issues with checkIfFree if it is over-counting the number of tokens in a column for some reason.<br><br><b>Function name:</b><br>testCheckIfFree_column_partially_full |
|                                                                                                                                                                                                                    |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
| X                                                                                                                                                                                                                  |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |
| X                                                                                                                                                                                                                  |   |  |  |   |  |  |   |  |  |                                                                              |                                                                                                                                                                                                                                                                                                                                                               |

boolean checkHorizWin(BoardPosition pos, char p)

|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--|--|--|--|--|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|---|---|---|---|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|---|---|---|---|--|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input:</b><br><br>State: (number to win = 3)<br><table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>X</td><td>X</td><td>X</td><td></td></tr></table><br><br>pos.getRow = 0<br>pos.getCol = 2<br>p = 'X'                                                                                            |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  | X | X | X |   | <b>Output:</b><br>checkHorizWin = true<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because checkHorizWin is being tested when there is an unbroken chain of the same token placed from the left-most column, with no other tokens placed before or after the chain, which could highlight problems with checkHorizWin if it is under-counting the number of unbroken tokens for some reason.<br><br><b>Function name:</b><br>testCheckHorizWin_unbroken_chain_left   |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
| X                                                                                                                                                                                                                                                                                                                                                                                                       | X | X |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State: (number to win = 3)<br><table><tr><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr><tr><td>O</td><td>X</td><td>X</td><td>X</td><td></td></tr></table><br><br>pos.getRow = 0<br>pos.getCol = 3<br>p = 'X' |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  | O | X | X | X |  | <b>Output:</b><br>checkHorizWin = true<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because checkHorizWin is being tested when there is an unbroken chain of the same token placed after at least one token representing a different player, which could highlight problems with checkHorizWin if it is counting the other player's token for some reason.<br><br><b>Function name:</b><br>testCheckHorizWin_unbroken_chain_middle |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
| O                                                                                                                                                                                                                                                                                                                                                                                                       | X | X | X |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State: (number to win = 3)<br><table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td>X</td><td>X</td><td>X</td></tr></table><br><br>pos.getRow = 0<br>pos.getCol = 1<br>p = 'X'                                                                                            |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   | X | X | X | <b>Output:</b><br>checkHorizWin = true<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because checkHorizWin is being tested when there is an unbroken chain of the same token placed from the right-most column, with no other tokens placed before or after the chain, which could highlight problems with checkHorizWin if it is under-counting the number of unbroken tokens for some reason.<br><br><b>Function name:</b><br>testCheckHorizWin_unbroken_chain_right |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         | X | X | X |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State: (number to win = 3)<br><table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr></table>                                                                                                                                                                                                                                            |   |   |   |  |  |  |  |  | <b>Output:</b><br>checkHorizWin = false<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because checkHorizWin is being tested when a token other than the first is placed before the last token in a chain, simulating what happens when another player intentionally cuts off a player's horizontal win ability, |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |  |  |  |  |  |                                                                                |                                                                                                                                                                                                                                                                                   |  |  |   |   |   |   |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |  |   |   |   |   |  |                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                        |

|                                                                                                                                                                   |   |   |  |  |   |   |   |  |  |                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|--|--|---|---|---|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <table><tr><td></td><td></td><td></td><td></td></tr><tr><td>X</td><td>O</td><td>X</td><td></td></tr></table> <p>pos.getRow = 0<br/>pos.getCol = 2<br/>p = 'X'</p> |   |   |  |  | X | O | X |  |  | <p>which could highlight problems with checkHorizWin if it is counting the other player's token for some reason.</p> <p><b>Function name:</b><br/>testCheckHorizWin_broken_chain</p> |
|                                                                                                                                                                   |   |   |  |  |   |   |   |  |  |                                                                                                                                                                                      |
| X                                                                                                                                                                 | O | X |  |  |   |   |   |  |  |                                                                                                                                                                                      |

boolean checkVertWin(BoardPosition pos, char p)

|                                                                                                                                                                                                                                                                                                                                                                      |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--|--|--|---|--|--|--|---|--|--|--|---|--|--|--|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td></td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr></table> <p>pos.getRow = 2<br/>pos.getColumn = 0<br/>p = 'X'</p>                                                |   |  |  |  | X |  |  |  | X |  |  |  | X |  |  |  | <p><b>Output:</b></p> <p>checkVertWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test case is unique and distinct because checkVertWin is being tested when there is an unbroken chain of the same token terminated at the bottom-most row, with no other tokens placed before or after the chain, which could highlight problems with checkVertWin if it is under-counting the number of unbroken tokens for some reason.</p> <p><b>Function name:</b><br/>testCheckVertWin_unbroken_chain_bottom</p> |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                      |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td>O</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>O</td><td></td><td></td><td></td></tr></table> <p>pos.getRow = 3<br/>pos.getColumn = 0<br/>p = 'X'</p> | O |  |  |  | X |  |  |  | X |  |  |  | X |  |  |  | O                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  | <p><b>Output:</b></p> <p>checkVertWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test case is unique and distinct because checkVertWin is being tested when there is an unbroken chain of the same token placed after at least one token representing a different player and before another token representing a different player, which is different than placing the winning token at the very top of the column, which could highlight problems with checkHorizWin if it is counting the other player's token for some reason.</p> <p>This unit test is valid for checkVertWin because it functions separately from GameScreen's normal checks after each token placement, and instead works even with other tokens placed out of order.</p> <p><b>Function name:</b><br/>testCheckVertWin_unbroken_chain_middle</p> |
| O                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| O                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>O</td><td></td><td></td><td></td></tr></table> <p>pos.getRow = 3<br/>pos.getColumn = 0<br/>p = 'X'</p>                                               | X |  |  |  | X |  |  |  | X |  |  |  | O |  |  |  | <p><b>Output:</b></p> <p>checkVertWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test case is unique and distinct because checkVertWin is being tested when there is an unbroken chain of the same token terminated at the top-most row, with no other tokens placed before or after the chain, which could highlight problems with checkVertWin if it is under-counting the number of unbroken tokens for some reason.</p> <p><b>Function name:</b><br/>testCheckVertWin_unbroken_chain_top</p>       |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| X                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| O                                                                                                                                                                                                                                                                                                                                                                    |   |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table border="1"><tr><td></td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>O</td><td></td><td></td><td></td></tr><tr><td>X</td><td></td><td></td><td></td></tr></table> <p>pos.getRow = 2<br/>pos.getColumn = 0<br/>p = 'X'</p> |  |  |  |  | X |  |  |  | O |  |  |  | X |  |  |  | <p><b>Output:</b></p> <p>checkVertWin = false</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test case is unique and distinct because checkVertWin is being tested when a token other than the first is placed before the last token in a chain, simulating what happens when another player intentionally cuts off a player’s vertical win ability, which could highlight problems with checkVertWin if it is counting the other player’s token for some reason.</p> <p><b>Function name:</b><br/>testCheckVertWin_broken_chain</p> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|---|--|--|--|---|--|--|--|---|--|--|--|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                  |  |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| X                                                                                                                                                                                                                                                                                                                                |  |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| O                                                                                                                                                                                                                                                                                                                                |  |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| X                                                                                                                                                                                                                                                                                                                                |  |  |  |  |   |  |  |  |   |  |  |  |   |  |  |  |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

boolean checkDiagWin(BoardPosition pos, char p)

|                                                                                                                                                                                                                                                                                                                          |   |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|-----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table> <p>pos.getRow = 1<br/>pos.getCol = 1<br/>p = 'X'</p>                                                                                  |   |   |   |   |   |   |   |   |   | <p><b>Output:</b></p> <p>checkDiagWin = false</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when the GameBoard is completely empty, which could highlight issues with checkDiagWin if it is having trouble working without any tokens available for some reason.</p> <p><b>Function name:</b><br/>testCheckDiagWin_empty_board</p> |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          |   |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          |   |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          |   |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>X</td><td></td></tr><tr><td></td><td>X</td><td>O</td><td></td></tr><tr><td>X</td><td>O</td><td>O</td><td></td></tr></table> <p>pos.getRow = 2<br/>pos.getCol = 2<br/>p = 'X'</p>    |   |   |   |   |   |   | X |   |   | X                                                                                        | O                                                                                                                                                                                                                                                                                                                              |   | X | O | O |   | <p><b>Output:</b></p> <p>checkDiagWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when an unbroken sequence of a player's token is found diagonally from left to right moving upwards, which could highlight issues with checkDiagWin if it is not properly counting tokens for some reason.</p> <p><b>Function name:</b><br/>testCheckDiagWin_unbroken_left_right_up</p>     |
|                                                                                                                                                                                                                                                                                                                          |   |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          |   | X |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          | X | O |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| X                                                                                                                                                                                                                                                                                                                        | O | O |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td>X</td><td></td><td></td><td></td></tr><tr><td>O</td><td>X</td><td></td><td></td></tr><tr><td>X</td><td>O</td><td>X</td><td></td></tr><tr><td>O</td><td>X</td><td>O</td><td></td></tr></table> <p>pos.getRow = 1<br/>pos.getCol = 2<br/>p = 'X'</p> | X |   |   |   | O | X |   |   | X | O                                                                                        | X                                                                                                                                                                                                                                                                                                                              |   | O | X | O |   | <p><b>Output:</b></p> <p>checkDiagWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when an unbroken sequence of a player's token is found diagonally from left to right moving downwards, which could highlight issues with checkDiagWin if it is not properly counting tokens for some reason.</p> <p><b>Function name:</b><br/>testCheckDiagWin_unbroken_left_right_down</p> |
| X                                                                                                                                                                                                                                                                                                                        |   |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| O                                                                                                                                                                                                                                                                                                                        | X |   |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| X                                                                                                                                                                                                                                                                                                                        | O | X |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| O                                                                                                                                                                                                                                                                                                                        | X | O |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td></td><td></td><td></td><td>X</td></tr><tr><td></td><td></td><td>X</td><td>O</td></tr><tr><td></td><td>X</td><td>O</td><td>X</td></tr><tr><td></td><td>O</td><td>X</td><td>O</td></tr></table>                                                      |   |   |   | X |   |   | X | O |   | X                                                                                        | O                                                                                                                                                                                                                                                                                                                              | X |   | O | X | O | <p><b>Output:</b></p> <p>checkDiagWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when an unbroken sequence of a player's token is found diagonally from right to left moving downwards, which could highlight issues with checkDiagWin if it is not properly counting tokens for some reason.</p> <p><b>Function name:</b></p>                                               |
|                                                                                                                                                                                                                                                                                                                          |   |   | X |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          |   | X | O |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          | X | O | X |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                          | O | X | O |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                     |

|                                                                                                                                                                                                                                                                                                                       |   |                                                  |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------------------------------------------------|---|---|---|---|---|---|---|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|---|---|---|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>pos.getRow = 1<br/>pos.getCol = 1<br/>p = 'X'</p>                                                                                                                                                                                                                                                                  |   | <p>testCheckDiagWin_unbroken_right_left_down</p> |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td>X</td><td></td><td></td></tr><tr><td></td><td>O</td><td>X</td><td></td></tr><tr><td></td><td>X</td><td>O</td><td>X</td></tr></table> <p>pos.getRow = 0<br/>pos.getCol = 3<br/>p = 'X'</p> |   |                                                  |   |   |   | X |   |   |   | O                                                                                        | X                                                                                                                                                                                                                                                                                                                                                                                                                              |  |  | X | O | X | <p><b>Output:</b></p> <p>checkDiagWin = true</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when an unbroken sequence of a player's token is found diagonally from right to left moving upwards, which could highlight issues with checkDiagWin if it is not properly counting tokens for some reason.</p> <p><b>Function name:</b></p> <p>testCheckDiagWin_unbroken_right_left_up</p> |
|                                                                                                                                                                                                                                                                                                                       |   |                                                  |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                       | X |                                                  |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                       | O | X                                                |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
|                                                                                                                                                                                                                                                                                                                       | X | O                                                | X |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td>X</td><td>O</td><td>X</td></tr><tr><td>O</td><td>X</td><td>O</td></tr><tr><td>X</td><td>O</td><td>X</td></tr></table> <p>pos.getRow = 2<br/>pos.getCol = 2<br/>p = 'X'</p>                                                                      | X | O                                                | X | O | X | O | X | O | X | <p><b>Output:</b></p> <p>checkDiagWin = true</p> <p>State of the board is unchanged</p>  | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when a player's token is the last token placed in the GameBoard, which could highlight issues with checkDiagWin if it is mistakenly failing to bother checking for a win if the board is full.</p> <p><b>Function name:</b></p> <p>testCheckDiagWin_unbroken_placed_last</p>                                                           |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| X                                                                                                                                                                                                                                                                                                                     | O | X                                                |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| O                                                                                                                                                                                                                                                                                                                     | X | O                                                |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| X                                                                                                                                                                                                                                                                                                                     | O | X                                                |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| <p><b>Input:</b></p> <p>State: (number to win = 3)</p> <table><tr><td>X</td><td></td><td></td></tr><tr><td>O</td><td>O</td><td></td></tr><tr><td>X</td><td>O</td><td>X</td></tr></table> <p>pos.getRow = 0<br/>pos.getCol = 2<br/>p = 'X'</p>                                                                         | X |                                                  |   | O | O |   | X | O | X | <p><b>Output:</b></p> <p>checkDiagWin = false</p> <p>State of the board is unchanged</p> | <p><b>Reason:</b></p> <p>This test is unique and distinct because it tests checkDiagWin when a player's token is placed in a broken sequence (where another player's token exists), which could highlight issues with checkDiagWin if it is incorrectly counting another player's token as part of the current player's win sequence for some reason.</p> <p><b>Function name:</b></p> <p>testCheckDiagWin_broken_sequence</p> |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| X                                                                                                                                                                                                                                                                                                                     |   |                                                  |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| O                                                                                                                                                                                                                                                                                                                     | O |                                                  |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |
| X                                                                                                                                                                                                                                                                                                                     | O | X                                                |   |   |   |   |   |   |   |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |   |   |   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                    |

boolean checkTie()

|                                                                                                                                                                  |   |   |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input:</b><br><br>State: <table><tr><td>X</td><td>X</td><td>X</td></tr><tr><td>X</td><td>X</td><td>X</td></tr><tr><td>X</td><td>X</td><td>X</td></tr></table> | X | X | X | X | X | X | X | X | X | <b>Output:</b><br>checkTie = true<br><br>State of the board is unchanged  | <b>Reason:</b><br>This test case is unique and distinct because it tests checkTie when all of the tokens on the board are the same, which could highlight issues with checkTie if it is looking for differences in tokens for some reason.<br><br><b>Function name:</b><br>testCheckTie_full_all_same_tokens                 |
| X                                                                                                                                                                | X | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| X                                                                                                                                                                | X | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| X                                                                                                                                                                | X | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| <b>Input:</b><br><br>State: <table><tr><td>X</td><td>O</td><td>X</td></tr><tr><td>O</td><td>X</td><td>O</td></tr><tr><td>X</td><td>O</td><td>X</td></tr></table> | X | O | X | O | X | O | X | O | X | <b>Output:</b><br>checkTie = true<br><br>State of the board is unchanged  | <b>Reason:</b><br>This test case is unique and distinct because it tests checkTie when all of the tokens on the board are not the same, which could highlight issues with checkTie if it is looking for all of the tokens to be the same for some reason.<br><br><b>Function name:</b><br>testCheckTie_full_different_tokens |
| X                                                                                                                                                                | O | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| O                                                                                                                                                                | X | O |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| X                                                                                                                                                                | O | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| <b>Input:</b><br><br>State: <table><tr><td>X</td><td></td><td>X</td></tr><tr><td>X</td><td>X</td><td>X</td></tr><tr><td>X</td><td>X</td><td>X</td></tr></table>  | X |   | X | X | X | X | X | X | X | <b>Output:</b><br>checkTie = false<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests checkTie when all but one of the tokens on the board are filled, which could highlight issues with checkTie if it is mis-counting the number of full spaces for some reason.<br><br><b>Function name:</b><br>testCheckTie_one_empty                 |
| X                                                                                                                                                                |   | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| X                                                                                                                                                                | X | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| X                                                                                                                                                                | X | X |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
| <b>Input:</b><br><br>State: <table><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table>          |   |   |   |   |   |   |   |   |   | <b>Output:</b><br>checkTie = false<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests checkTie when all of the tokens on the board are empty, which could highlight issues with checkTie if it is counting spaces as a valid token for some reason.<br><br><b>Function name:</b><br>testCheckTie_all_empty                                |
|                                                                                                                                                                  |   |   |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
|                                                                                                                                                                  |   |   |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |
|                                                                                                                                                                  |   |   |   |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                                                                                                                                              |

```
char whatsAtPos(BoardPosition pos)
```

|                                                                                                                                                                                                                                                      |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="207 342 443 453"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> </table><br>pos.getRow = 1<br>pos.getCol = 1            |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   | <b>Output:</b><br>whatsAtPos = ' '<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests whatsAtPos when the space at pos is empty, which could highlight issues with whatsAtPos if it is not properly returning space characters for empty positions for some reason.<br><br><b>Function name:</b><br>testWhatsAtPos_empty_space                      |
|                                                                                                                                                                                                                                                      |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                      |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
|                                                                                                                                                                                                                                                      |   |   |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="207 701 443 812"> <tr><td>X</td><td>O</td><td>X</td></tr> <tr><td>O</td><td>X</td><td>O</td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>pos.getRow = 2<br>pos.getCol = 0   | X | O | X | O | X | O | X                                                                         | O                                                                                                                                                                                                           | X | <b>Output:</b><br>whatsAtPos = 'X'<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests whatsAtPos with a position at the very top-left corner of the GameBoard, which could highlight issues with whatsAtPos if it is incorrectly offsetting the row number for some reason.<br><br><b>Function name:</b><br>testWhatsAtPos_top_left_corner          |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| O                                                                                                                                                                                                                                                    | X | O |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="207 1068 443 1180"> <tr><td>X</td><td>O</td><td>X</td></tr> <tr><td>O</td><td>X</td><td>O</td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>pos.getRow = 0<br>pos.getCol = 0 | X | O | X | O | X | O | X                                                                         | O                                                                                                                                                                                                           | X | <b>Output:</b><br>whatsAtPos = 'X'<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests whatsAtPos with a position at the very bottom-left corner of the GameBoard, which could highlight issues with whatsAtPos if it is incorrectly offsetting the column number for some reason.<br><br><b>Function name:</b><br>testWhatsAtPos_bottom_left_corner |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| O                                                                                                                                                                                                                                                    | X | O |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="207 1457 443 1568"> <tr><td>X</td><td>O</td><td>X</td></tr> <tr><td>O</td><td>X</td><td>O</td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>pos.getRow = 2<br>pos.getCol = 2 | X | O | X | O | X | O | X                                                                         | O                                                                                                                                                                                                           | X | <b>Output:</b><br>whatsAtPos = 'X'<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests whatsAtPos with a position at the very top-right corner of the GameBoard, which could highlight issues with whatsAtPos if it is incorrectly offsetting the row number for some reason.<br><br><b>Function name:</b><br>testWhatsAtPos_top_right_corner        |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| O                                                                                                                                                                                                                                                    | X | O |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| <b>Input:</b><br><br>State:<br><table border="1" data-bbox="207 1824 443 1898"> <tr><td>X</td><td>O</td><td>X</td></tr> <tr><td>O</td><td>X</td><td>O</td></tr> </table>                                                                             | X | O | X | O | X | O | <b>Output:</b><br>whatsAtPos = 'X'<br><br>State of the board is unchanged | <b>Reason:</b><br>This test case is unique and distinct because it tests whatsAtPos with a position at the very bottom-right corner of the GameBoard, which could highlight issues with whatsAtPos if it is |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| X                                                                                                                                                                                                                                                    | O | X |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |
| O                                                                                                                                                                                                                                                    | X | O |   |   |   |   |                                                                           |                                                                                                                                                                                                             |   |                                                                           |                                                                                                                                                                                                                                                                                                                                        |

|                                                                                            |   |   |   |  |                                                                                                                                      |
|--------------------------------------------------------------------------------------------|---|---|---|--|--------------------------------------------------------------------------------------------------------------------------------------|
| <table><tr><td>X</td><td>O</td><td>X</td></tr></table><br>pos.getRow = 0<br>pos.getCol = 2 | X | O | X |  | <p>incorrectly offsetting the column number for some reason.</p> <p><b>Function name:</b><br/>testWhatsAtPos_bottom_right_corner</p> |
| X                                                                                          | O | X |   |  |                                                                                                                                      |

```
boolean isPlayerAtPos(BoardPosition pos, char player)
```

|                                                                                                                                                                                                                                        |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|---|---|---|---|---|---|---|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> </table><br>pos.getRow = 0<br>pos.getCol = 0<br>player = 'X'          |                |                |   |   |   |   |   |   |   | <b>Output:</b><br>isPlayerAtPos = false<br><br>State of the board is unchanged | <b>Reason:</b><br>This test is unique and distinct because it tests isPlayerAtPos when the GameBoard is completely empty, which could highlight issues with isPlayerAtPos if it is incorrectly trying to account for an empty board by making up a token for some reason.<br><br><b>Function name:</b><br>testIsPlayerAtPos_empty_board                                                                 |
|                                                                                                                                                                                                                                        |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                                                                                                                                                                                                        |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                                                                                                                                                                                                        |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td>X</td><td>O</td><td>X</td></tr> <tr><td>O</td><td>X</td><td>O</td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>pos.getRow = 0<br>pos.getCol = 0<br>player = 'X' | X              | O              | X | O | X | O | X | O | X | <b>Output:</b><br>isPlayerAtPos = true<br><br>State of the board is unchanged  | <b>Reason:</b><br>This test is unique and distinct because it tests isPlayerAtPos when the GameBoard is completely full, which could highlight issues with isPlayerAtPos if it is incorrectly trying to account for a full board by clearing the board for some reason.<br><br><b>Function name:</b><br>testIsPlayerAtPos_full_board                                                                    |
| X                                                                                                                                                                                                                                      | O              | X              |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| O                                                                                                                                                                                                                                      | X              | O              |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| X                                                                                                                                                                                                                                      | O              | X              |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td>X</td><td></td><td>X</td></tr> <tr><td>O</td><td>X</td><td>O</td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>pos.getRow = 2<br>pos.getCol = 1<br>player = 'X'  | X              |                | X | O | X | O | X | O | X | <b>Output:</b><br>isPlayerAtPos = false<br><br>State of the board is unchanged | <b>Reason:</b><br>This test is unique and distinct because it tests isPlayerAtPos when the token immediately below the specified position is the same as the token being checked for, which could highlight issues with isPlayerAtPos if it is defaulting to the next-lowest instance of the player's token for some reason.<br><br><b>Function name:</b><br>testIsPlayerAtPos_player_immediately_below |
| X                                                                                                                                                                                                                                      |                | X              |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| O                                                                                                                                                                                                                                      | X              | O              |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| X                                                                                                                                                                                                                                      | O              | X              |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> </table><br>pos.getRow = 0<br>pos.getCol = 0<br>player = 'X'         |                |                |   |   |   |   | X |   |   | <b>Output:</b><br>isPlayerAtPos = true<br><br>State of the board is unchanged  | <b>Reason:</b><br>This test is unique and distinct because it tests isPlayerAtPos when the token at pos is the player's token and is the only token on the GameBoard, which could highlight issues with isPlayerAtPos if it is failing to find the correct token for some reason.<br><br><b>Function name:</b><br>testIsPlayerAtPos_player_is_only_token                                                |
|                                                                                                                                                                                                                                        |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                                                                                                                                                                                                        |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| X                                                                                                                                                                                                                                      |                |                |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Input:</b>                                                                                                                                                                                                                          | <b>Output:</b> | <b>Reason:</b> |   |   |   |   |   |   |   |                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                         |

|                                                                                                                                                                                                                     |  |  |  |  |  |  |   |  |  |                                                                     |                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|---|--|--|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>State:</p> <table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> </table> <p>pos.getRow = 0<br/>pos.getCol = 0<br/>player = 'O'</p> |  |  |  |  |  |  | X |  |  | <p>isPlayerAtPos = false</p> <p>State of the board is unchanged</p> | <p>This test is unique and distinct because it tests isPlayerAtPos when the token at pos is not the player's token, which could highlight issues with isPlayerAtPos if it is incorrectly returning true when the wrong token is found for some reason.</p> <p><b>Function name:</b><br/>testIsPlayerAtPos_not_correct_token</p> |
|                                                                                                                                                                                                                     |  |  |  |  |  |  |   |  |  |                                                                     |                                                                                                                                                                                                                                                                                                                                 |
|                                                                                                                                                                                                                     |  |  |  |  |  |  |   |  |  |                                                                     |                                                                                                                                                                                                                                                                                                                                 |
| X                                                                                                                                                                                                                   |  |  |  |  |  |  |   |  |  |                                                                     |                                                                                                                                                                                                                                                                                                                                 |

```
void placeToken(char p, int c)
```

|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------|--|---|--|--|---|---|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--|--|---|--|--|---|---|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td>O</td><td></td></tr> </table><br>p = 'X'<br>c = 2   |                              |                                                                                                              |  |   |  |  | X | O |   | <b>Output:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table>   |   |  |  |   |  |  | X | O | X | <b>Reason:</b><br>This test case is unique and distinct because it tests placeToken with a column that is empty, which could highlight issues with placeToken if it is not correctly finding the bottom space in an empty column for some reason.<br><br><b>Function name:</b><br>testPlaceToken_bottom_row                                 |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 | O                            |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 | O                            | X                                                                                                            |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>p = 'X'<br>c = 0  |                              |                                                                                                              |  |   |  |  | X | O | X | <b>Output:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table>  |   |  |  | X |  |  | X | O | X | <b>Reason:</b><br>This test case is unique and distinct because it tests placeToken with a column that has only one token in it already, which could highlight issues with placeToken if it is not correctly finding the next available space in the column for some reason.<br><br><b>Function name:</b><br>testPlaceToken_only_one_in_row |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 | O                            | X                                                                                                            |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 | O                            | X                                                                                                            |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table><br>p = 'O'<br>c = 0 |                              |                                                                                                              |  | X |  |  | X | O | X | <b>Output:</b><br><br>State:<br><table border="1"> <tr><td>O</td><td></td><td></td></tr> <tr><td>X</td><td></td><td></td></tr> <tr><td>X</td><td>O</td><td>X</td></tr> </table> | O |  |  | X |  |  | X | O | X | <b>Reason:</b><br>This test case is unique and distinct because it tests placeToken with a column that only has one free token space left, which could highlight issues with placeToken if it is incorrectly treating a column as full for some reason.<br><br><b>Function name:</b><br>testPlaceToken_row_almost_full                      |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 | O                            | X                                                                                                            |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| O                                                                                                                                                                                                 |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| X                                                                                                                                                                                                 | O                            | X                                                                                                            |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| <b>Input:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> </table><br>p = 'X'<br>c = 1     |                              |                                                                                                              |  |   |  |  |   |   |   | <b>Output:</b><br><br>State:<br><table border="1"> <tr><td></td><td></td><td></td></tr> <tr><td></td><td></td><td></td></tr> <tr><td></td><td>X</td><td></td></tr> </table>     |   |  |  |   |  |  |   | X |   | <b>Reason:</b><br>This test case is unique and distinct because it tests placeToken with a GameBoard that is completely empty, which could highlight issues with placeToken if it is incorrectly checking to make sure the board is not empty for some reason.<br><br><b>Function name:</b><br>testPlaceToken_empty_board                   |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   |                              |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                                                   | X                            |                                                                                                              |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |
| <b>Input:</b><br><br>State:                                                                                                                                                                       | <b>Output:</b><br><br>State: | <b>Reason:</b><br>This test case is unique and distinct because it tests placeToken with a GameBoard that is |  |   |  |  |   |   |   |                                                                                                                                                                                 |   |  |  |   |  |  |   |   |   |                                                                                                                                                                                                                                                                                                                                             |

|                  |   |   |   |   |   |                                                                                                                                                                                                                                                   |
|------------------|---|---|---|---|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X                |   | X | X | O | X | almost completely full, which could highlight issues with placeToken if it is incorrectly checking to make sure placing a token does not result in a full board for some reason.<br><br><b>Function name:</b><br>testPlaceToken_board_almost_full |
| O                | X | O | O | X | O |                                                                                                                                                                                                                                                   |
| X                | O | X | X | O | X |                                                                                                                                                                                                                                                   |
| p = 'O'<br>c = 1 |   |   |   |   |   |                                                                                                                                                                                                                                                   |