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SOFTWARE DEVELOPMENT FOUNDATIONS

APRIL 20, 2020

ConnectX Project Requirements Report

CONTENTS

Project Overview 3

Functional Requirements 3

Non-Functional Requirements 4

ConnectXController Class 5

UML Class Diagram 5

UML Activity DIAGRAM: processButtonClick 6

AbsGameBoard Class 7

UML Class Diagram 7

UML Activity Diagram 7

GameBoard Class 8

UML Class Diagram 8

UML Activity Diagrams 8

GameBoardMem Class 10

UML Class Diagram 10

UML Activity Diagrams 11

UML Class-Relationships Diagram 15

Testing 16

PROJECT OVERVIEW

FUNCTIONAL REQUIREMENTS

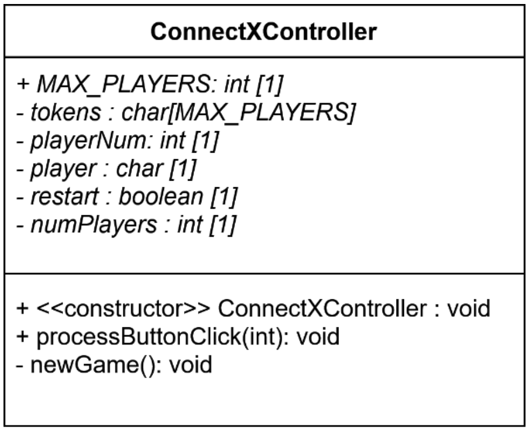
I. As a user, I can place my token in any available column, so that I can play the game
II. As a user, I can set the number of rows on the board, so that I have the ability to customize my game
III. As a user, I can set the number of columns on the board, so that I have the ability to customize my game
IV. As a user, I can set the (number to win) tokens, so that I have the ability to customize my game
V. As a user, I can set the number of players, so that I have the ability to customize my game
VI. As a user, I can set the token for each player, so that I know who is who
VII. As a user, I can place (number to win) tokens in vertical order
VIII. As a user, I can place (number to win) tokens in horizontal order
IX. As a user, I can place (number to win) tokens in diagonal order
X. As a user, I can see whose turn it is before each play, so that I know when it is and isn't my turn to play.
XI. As a user, I can see the current state of the board after each play, so that I can plan my next move.
XII. As a user, I can start a new game after the current one ends, so that I can have another chance to play from the beginning.
XIII. As a user, I can try to place four of my tokens in the same row, column, or diagonal order consecutively, so that I can win the game.
XIV. As a user, I can quit the game at any time.
XV. As a user, I can see if the game ended in a win
XVI. As a user, I can see if the game ended in a tie
XVII. As a user, I can only enter my tokens in columns with space available, so that I can follow the rules of the game.
XVIII. As a user, I can only enter tokens in the first available row in a column, so that I do not overwrite existing tokens.
XIX. As a user, if I am the first one to specify a player token, then I will go first.
XX. As a user, if someone wins the game, I can see the winning board.
XXI. As a user, I can choose to not play a new game
XXII. As a user, I can choose to play a new game
XXIII. As a user, I can choose the fast implementation / mode
XXIV. As a user, I can choose the memory-efficient implementation / mode
XXV. As a user, I can be prompted to enter a new column if my first choice is invalid
XXVI. As a user, I can be prompted to enter a new player token if my first choice was already taken
XXVII. As a user, I can be prompted to enter a new number of rows if my first input was out of range
XXVIII. As a user, I can be prompted to enter a new number of columns if my first input was out of range

NON-FUNCTIONAL REQUIREMENTS

1. Must be implemented with the Java coding language
2. Must be able to run after unzipping with the IntelliJ IDE
3. Any code should utilize encapsulation, separation of concerns, information hiding, and programming to the interface
4. The program should follow the idea and rules of design by contract
5. Must be completely reliable; no crashes mid-game, when starting a new game, etc.
6. There should be a minimal, unnoticeable processing time between each turn
7. The GameBoard and BoardPosition classes must follow the exact method signatures specified in the project guidelines document.
8. The project should have a high degree of adaptability and modularity, so that future additions are less complicated and easier.
9. The project should keep the contents of the board private, as to avoid tampering.
10. The game should be extremely easy to play, and straightforward – in other words, someone with no prior experience with Connect4 (X) should be able to play the game.
11. Any prompts for user input should be clear and easy to understand
12. The game board must be an upright grid
13. All code must follow all best practices discussed in class
14. All function signatures specified in the requirements document should be followed exactly
15. The number of rows on the board is greater than 3
16. The number of rows on the board is less than 20
17. The number of columns on the board is greater than 3
18. The number of columns on the board is less than 20
19. The number of tokens needed to win is greater than or equal to 3
20. The number of tokens needed to win is less than or equal to 20
21. The number of players is greater than or equal to 2
22. The number of players is less than or equal to 10
23. ConnectX should have a fast implementation
24. ConnectX should have a memory-efficient implementation
25. The game should work with 2 to 10 players
26. The program should not have any magic numbers
27. The memory-efficient (Map) implementation should not create keys for the blank space [‘ ‘]
28. The game should not allow for a number of tokens needed to win greater than the number of rows
29. The game should not allow for a number of tokens needed to win greater than the number of columns
30. The program should have descriptive comments
31. The program should follow the principles of design by contract, utilizing Javadoc comments
32. The program should utilize event-driven programming / logic
33. The program should follow the Model View Controller (MVC) architectural pattern
34. The provided class ConnectXApp should not be modified
35. The provided class SetupView should not be modified
36. The provided class SetupController should not be modified
37. The provided class ConnectXView should not be modified

CONNECTXCONTROLLER CLASS

UML CLASS DIAGRAM

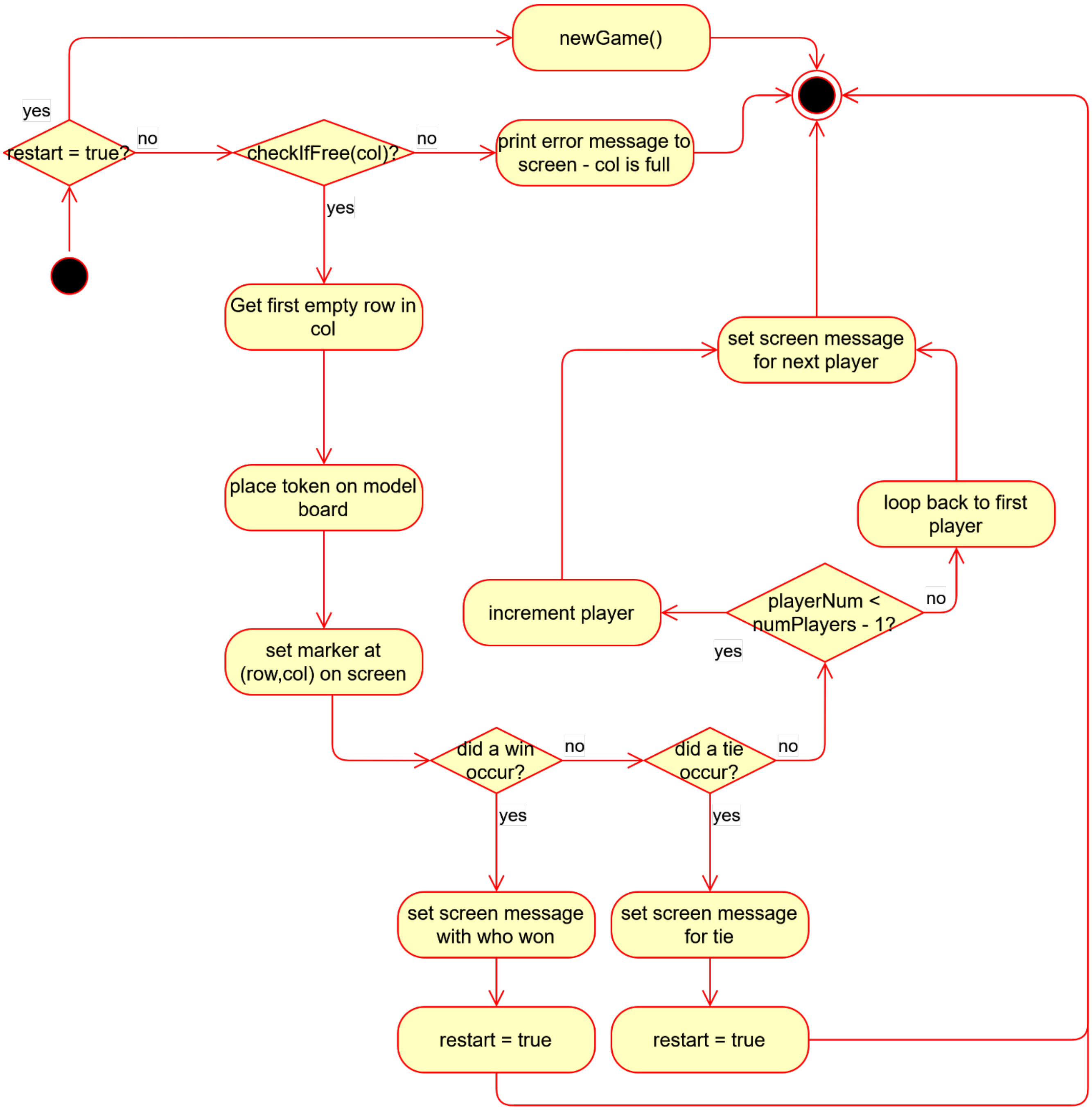


ConnectXController

+ MAX_PLAYERS: int [1]
- tokens : char[MAX_PLAYERS]
- playerNum: int [1]
- player : char [1]
- restart : boolean [1]
- numPlayers : int [1]

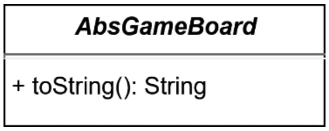
+ <<constructor>> ConnectXController : void
+ processButtonClick(int): void
- newGame(): void

UML ACTIVITY DIAGRAM: PROCESSBUTTONCLICK


newGame()
yes
restart = true?
no
checkIfFree(col)?
no
print error message to screen - col is full
yes
Get first empty row in col
set screen message for next player
place token on model board
loop back to first player
increment player
playerNum < numPlayers - 1?
no
yes
set marker at (row,col) on screen
did a win occur?
no
did a tie occur?
no
yes
yes
set screen message with who won
set screen message for tie
restart = true
restart = true

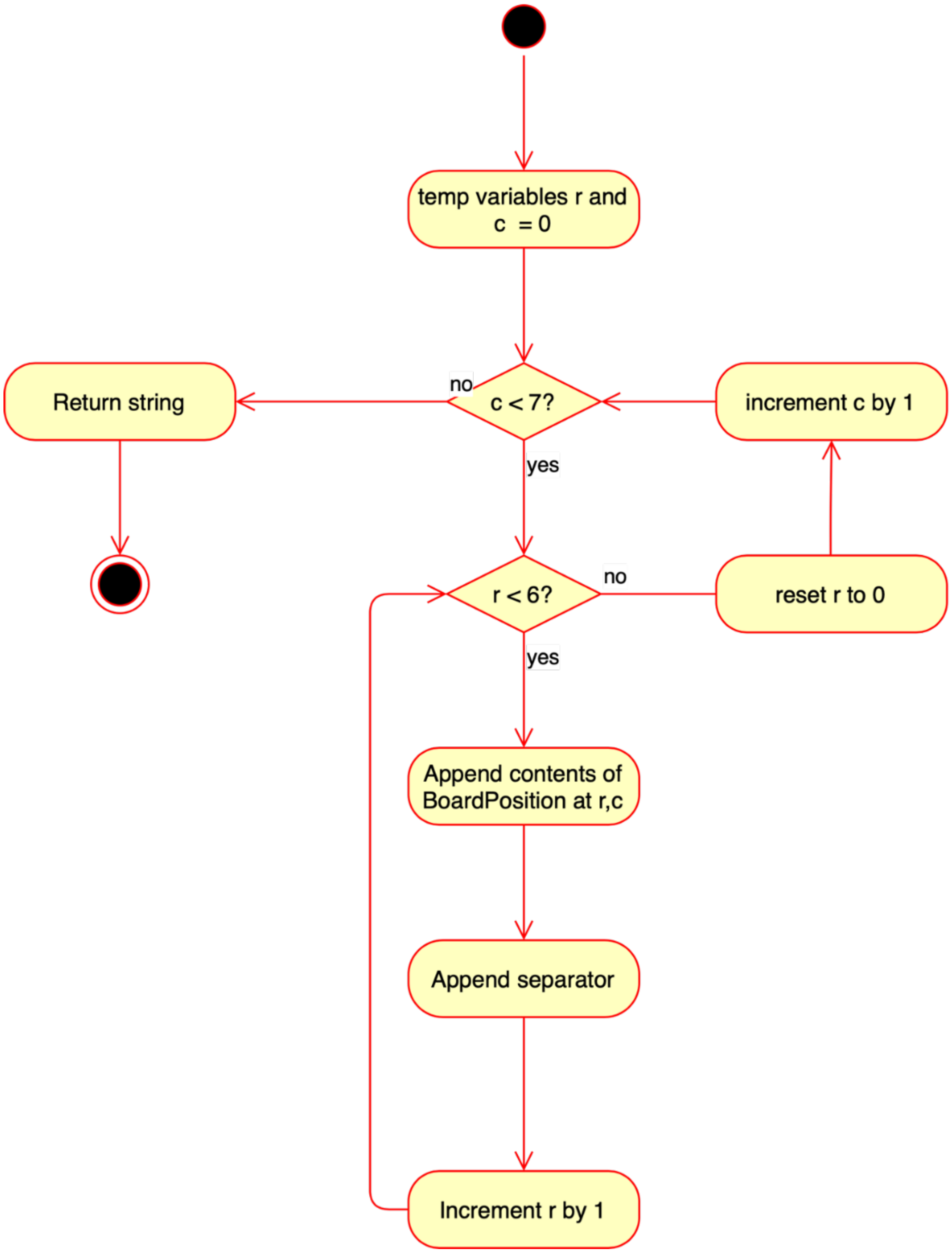
ABSGAMEBOARD CLASS

UML CLASS DIAGRAM



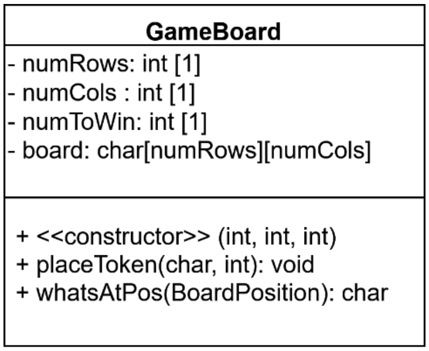
UML ACTIVITY DIAGRAM

TOSTRING



GAMEBOARD CLASS

UML CLASS DIAGRAM



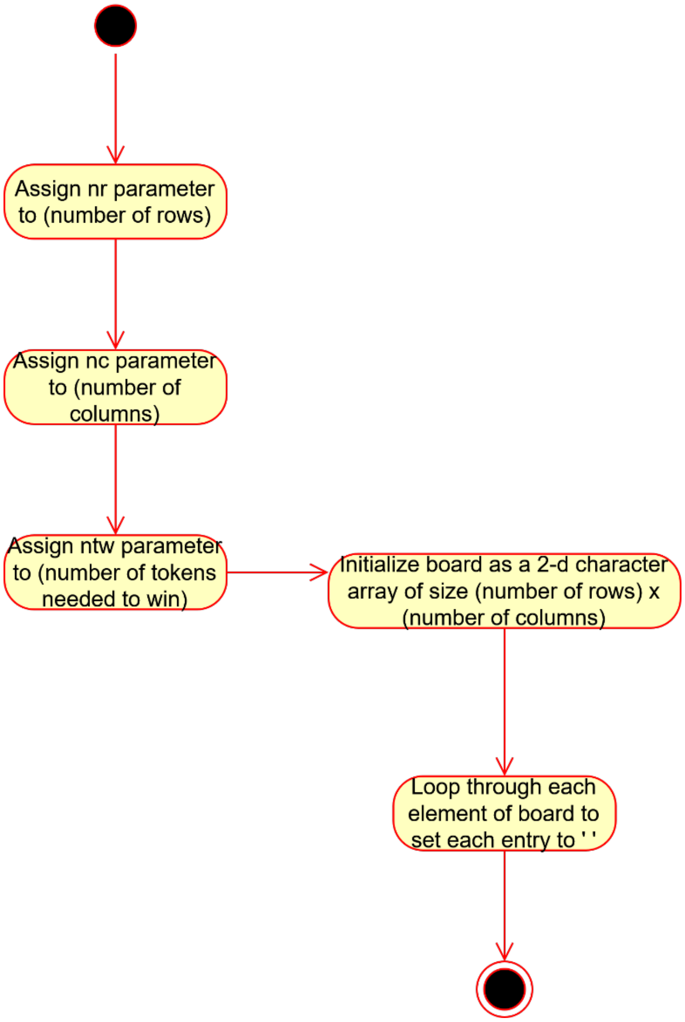
GameBoard

- numRows: int [1]
- numCols : int [1]
- numToWin: int [1]
- board: char[numRows][numCols]

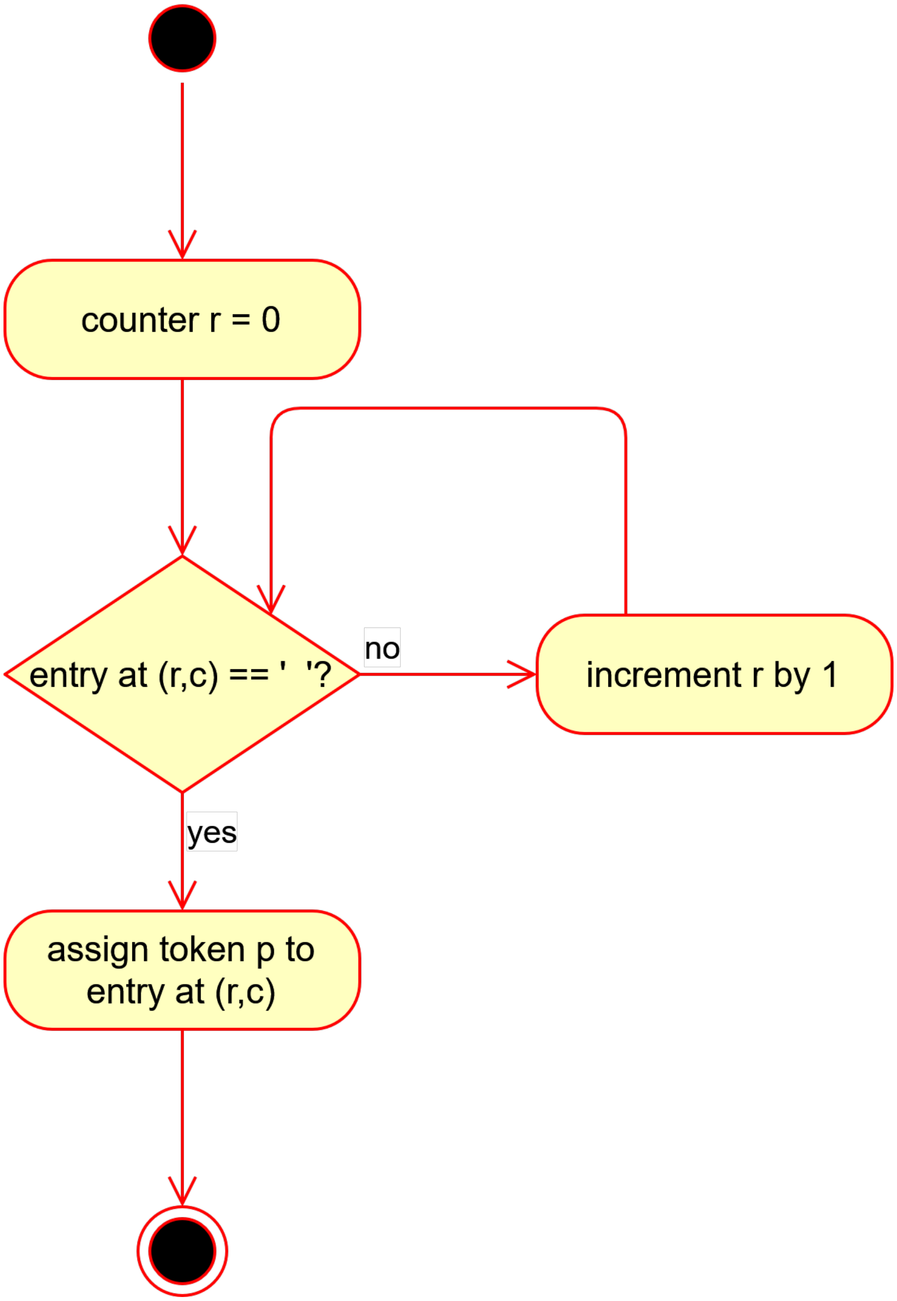
+ <<constructor>> (int, int, int)
+ placeToken(char, int): void
+ whatsAtPos(BoardPosition): char

UML ACTIVITY DIAGRAMS

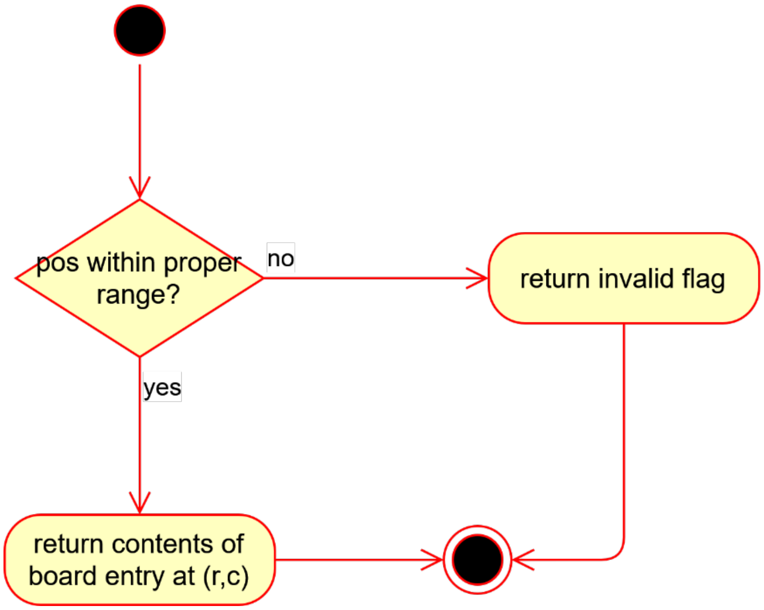
CONSTRUCTOR


Assign nr parameter to (number of rows)
Assign nc parameter to (number of columns)
Assign ntw parameter to (number of tokens needed to win)
Initialize board as a 2-d character array of size (number of rows) x (number of columns)
Loop through each element of board to set each entry to ' '

PLACETOKEN

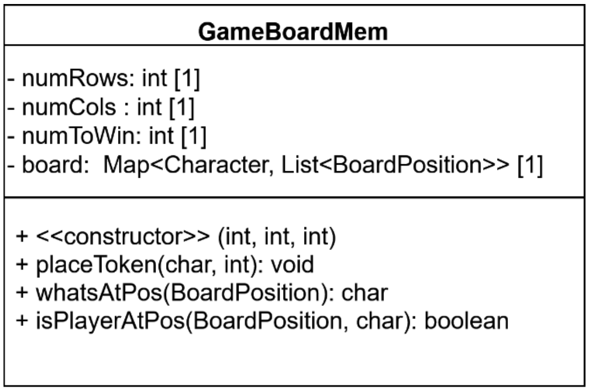

counter r = 0
entry at (r,c) == ' '?
no
increment r by 1
yes
assign token p to entry at (r,c)

WHATSATPOS



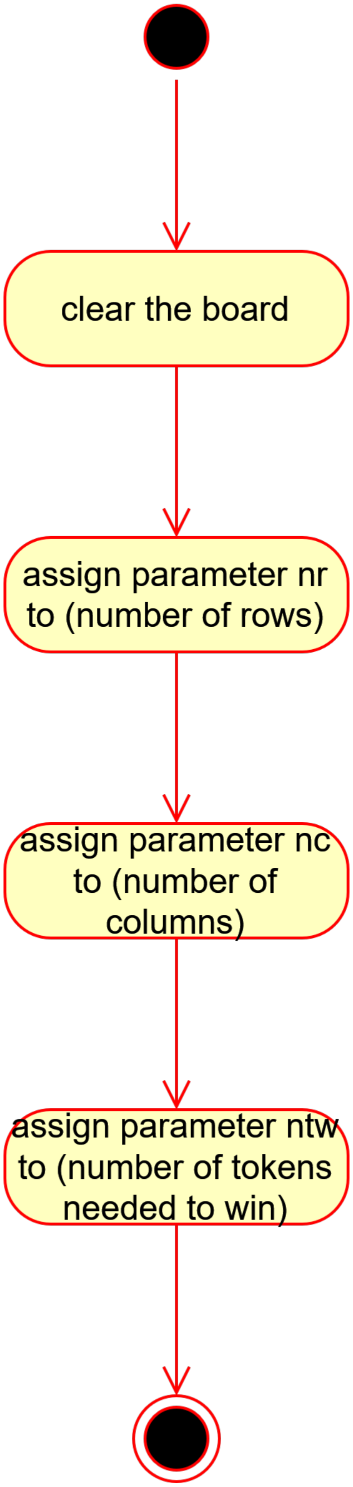
GAMEBOARDMEM CLASS

UML CLASS DIAGRAM

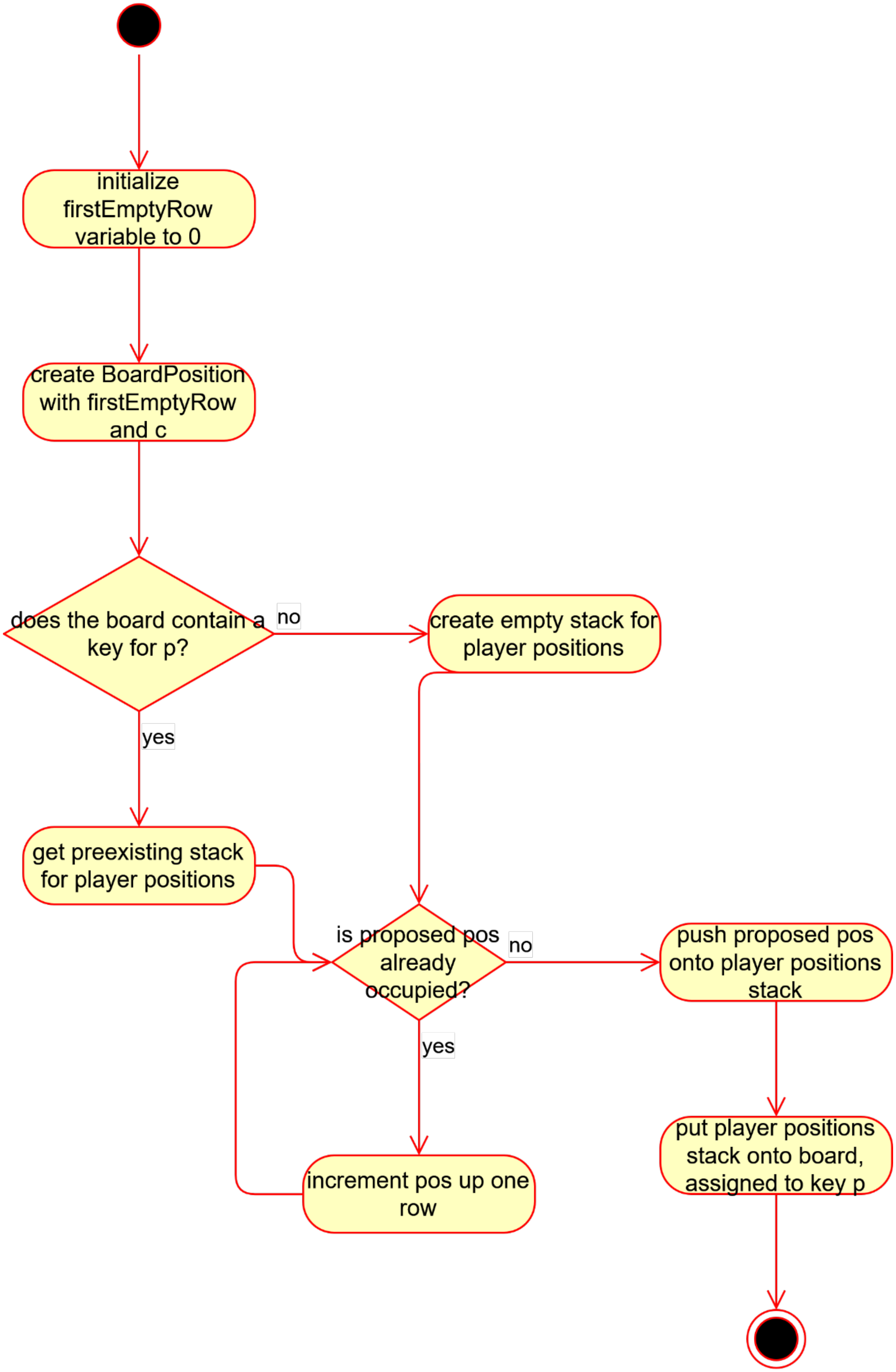

GameBoardMem
- numRows: int [1]
- numCols : int [1]
- numToWin: int [1]
- board: Map<Character, List<BoardPosition>> [1]
+ <<constructor>> (int, int, int)
+ placeToken(char, int): void
+ whatsAtPos(BoardPosition): char
+ isPlayerAtPos(BoardPosition, char): boolean

UML ACTIVITY DIAGRAMS

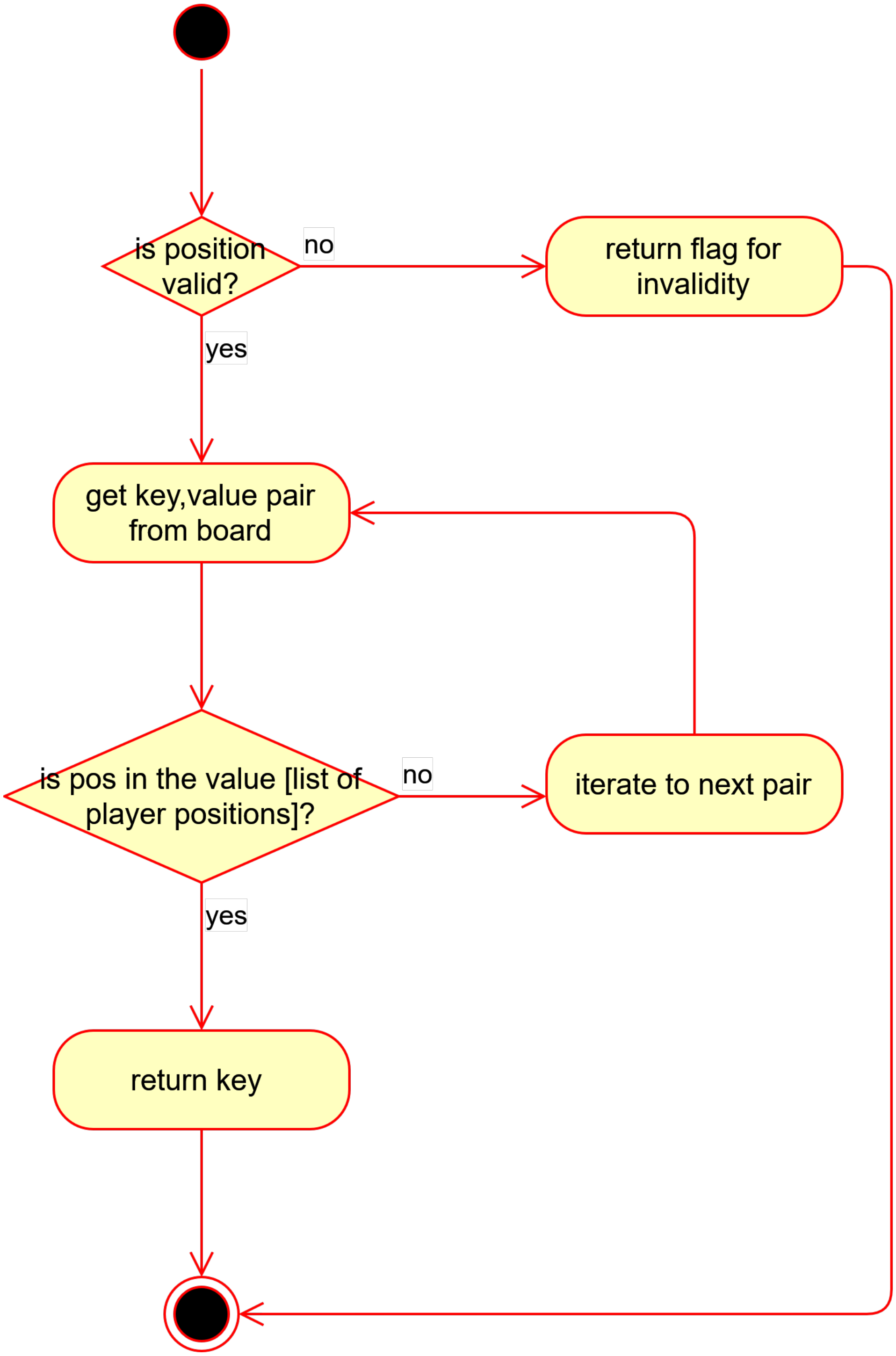
CONSTRUCTOR


clear the board
assign parameter nr to (number of rows)
assign parameter nc to (number of columns)
assign parameter ntw to (number of tokens needed to win)

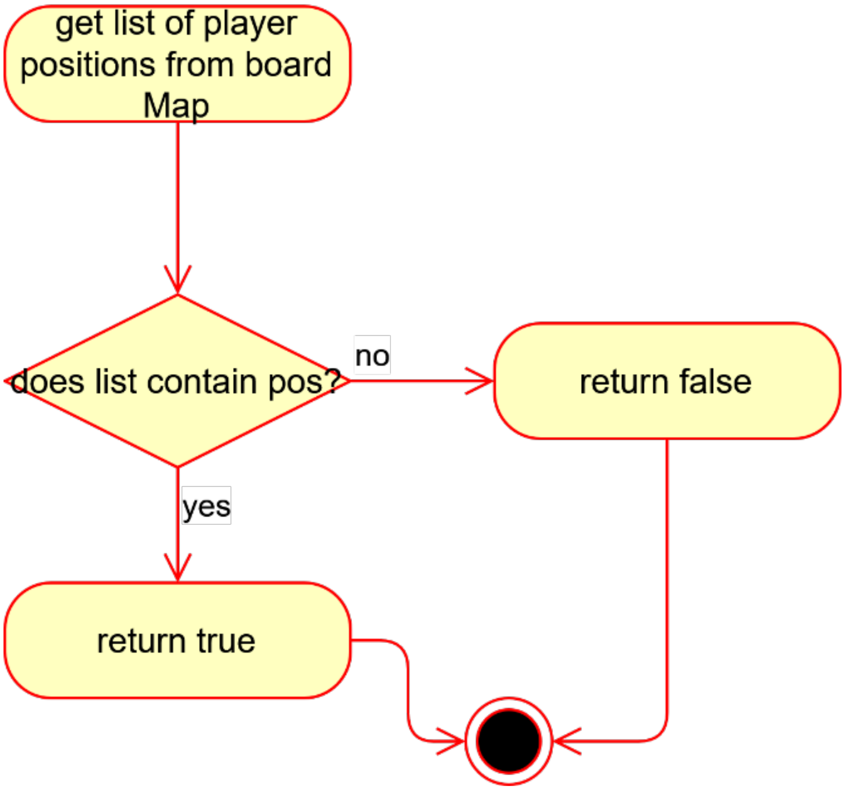
PLACETOKEN


initialize firstEmptyRow variable to 0
create BoardPosition with firstEmptyRow and c
does the board contain a key for p?
no
create empty stack for player positions
yes
get preexisting stack for player positions
is proposed pos already occupied?
no
push proposed pos onto player positions stack
yes
increment pos up one row
put player positions stack onto board, assigned to key p

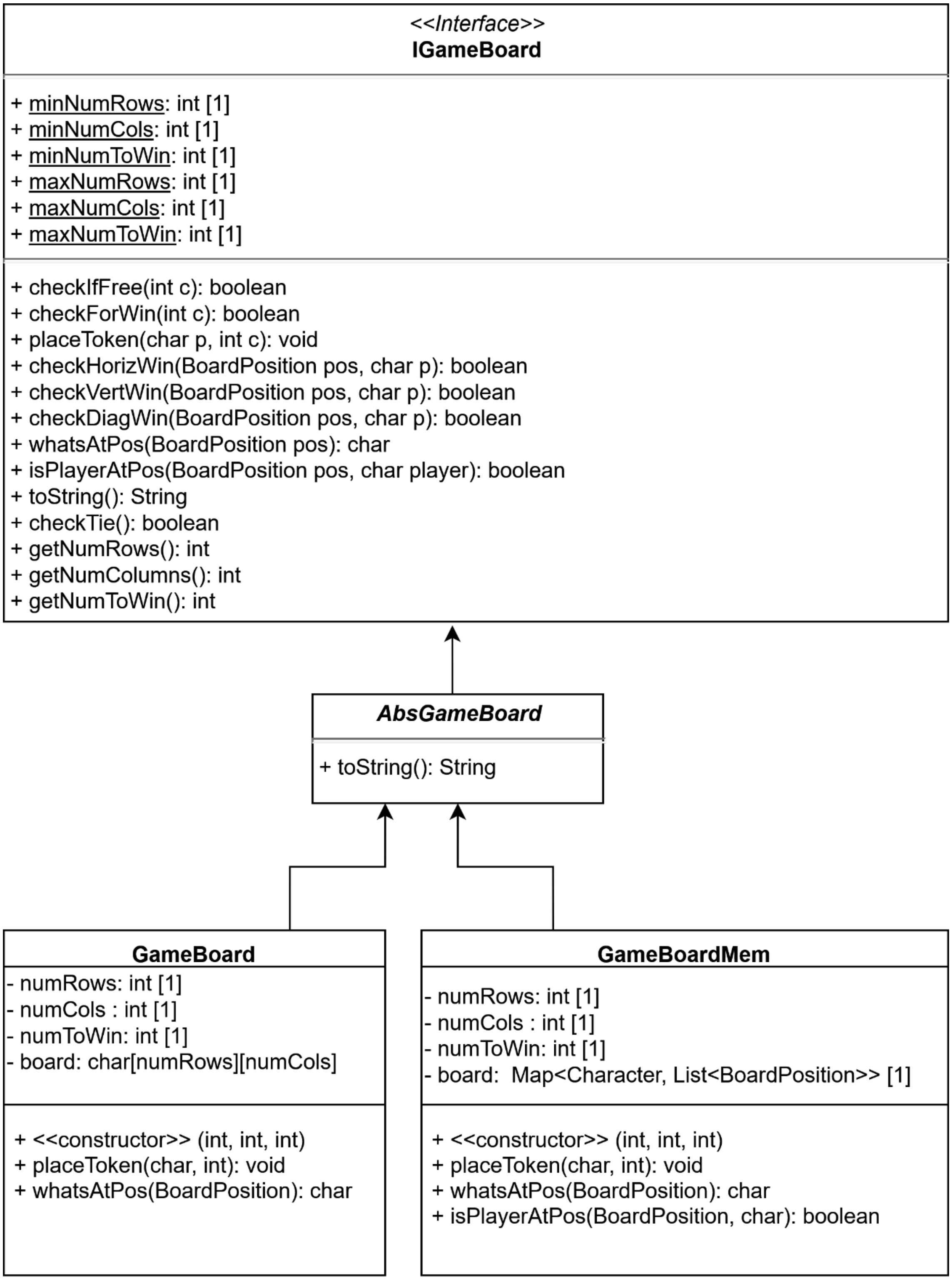
WHATSATPOS


is position valid?
no
return flag for invalidity
yes
get key,value pair from board
is pos in the value [list of player positions]?
no
iterate to next pair
yes
return key

ISPLAYERATPOS

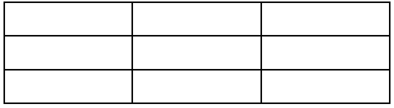


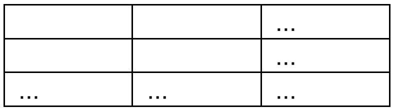
UML CLASS-RELATIONSHIPS DIAGRAM

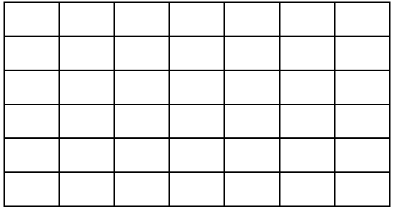

<<Interface>>
IGameBoard
+ minNumRows: int [1]
+ minNumCols: int [1]
+ minNumToWin: int [1]
+ maxNumRows: int [1]
+ maxNumCols: int [1]
+ maxNumToWin: int [1]
+ checkIfFree(int c): boolean
+ checkForWin(int c): boolean
+ placeToken(char p, int c): void
+ checkHorizWin(BoardPosition pos, char p): boolean
+ checkVertWin(BoardPosition pos, char p): boolean
+ checkDiagWin(BoardPosition pos, char p): boolean
+ whatsAtPos(BoardPosition pos): char
+ isPlayerAtPos(BoardPosition pos, char player): boolean
+ toString(): String
+ checkTie(): boolean
+ getNumRows(): int
+ getNumColumns(): int
+ getNumToWin(): int
AbsGameBoard
+ toString(): String
GameBoard
- numRows: int [1]
- numCols : int [1]
- numToWin: int [1]
- board: char[numRows][numCols]
+ <<constructor>> (int, int, int)
+ placeToken(char, int): void
+ whatsAtPos(BoardPosition): char
GameBoardMem
- numRows: int [1]
- numCols : int [1]
- numToWin: int [1]
- board: Map<Character, List<BoardPosition>> [1]
+ <<constructor>> (int, int, int)
+ placeToken(char, int): void
+ whatsAtPos(BoardPosition): char
+ isPlayerAtPos(BoardPosition, char): boolean

TESTING

public GameBoard(int nr, int nc, int ntw)

Input
nr = minNumRows [3]
nc = minNumCols [3]
ntw = minNumToWin [3]
	Output
	3x3 GameBoard
	
		Reason:
		This test case is unique and distinct because it is a boundary case; it evaluates whether or not the constructor can produce the smallest allowed game board.

Input
nr = maxNumRows [100]
nc = maxNumCols [100]
ntw = maxNumToWin [25]
	Output
	100x100 GameBoard
	
		Reason:
		This test case is unique and distinct because it is a boundary case; it evaluates whether or not the constructor can produce the largest allowed game board.

Input
nr = 6
nc = 7
ntw = 4
	Output
	6x7 GameBoard
	
		Reason:
		This test case is unique and distinct because it is a routine case; it tests whether or not the constructor can produce a common-sized game board

public boolean checkIfFree(int c)

Input

State: (number to win = 4)

X						
X						
X						
O						
X						
X						

R = 5	C = 0	P = X

Output

6x7 GameBoard

X						
X						
X						
O						
X						
X						

checkIfFree(C) returns ***false***

Reason:

This test case is a unique and distinct boundary case, because it tests whether or not checkIfFree() can correctly process a full column.

Input

State: (number to win = 4)

R = N/A	C = N/A	P = N/A

Output

6x7 GameBoard

checkIfFree(C) returns ***true***

Reason:

This test cause is a unique and distinct boundary case, because it tests whether or not checkIfFree() can correctly process an empty column.

Input

State: (number to win = 4)

		X				
		X				
		X				

R = 2	C = 2	P = X

Output

6x7 GameBoard

		X				
		X				
		X				

checkIfFree(C) returns ***true***

Reason:

This test case is a unique and distinct routine case, as it tests whether or not checkIfFree() can handle typical usage; the majority of the time, checkIfFree() will be given a column that is partially full.

public boolean checkHorizWin(int c)

<table>
<tr>
<td><b><i>Input</i></b>
State: (number to win = 4)
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>X</td><td>X</td><td>X</td><td></td><td></td><td></td><td></td></tr>
</table>
<table><tr><td>R = 0</td><td>C = 3</td><td>P = X</td></tr></table>
</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>X</td><td>X</td><td>X</td><td><b>X</b></td><td></td><td></td><td></td></tr>
</table>
checkHorizWin(C,P) = <b><i>true</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, because it tests whether or not checkHorizWin() can correctly identify a typical horizontal win scenario.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win = 4)
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>X</td><td>X</td><td>X</td><td></td><td></td><td></td><td></td></tr>
</table>
<table><tr><td>R = 0</td><td>C = 3</td><td>P = O</td></tr></table>
</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td>X</td><td><b>O</b></td><td></td><td></td><td></td></tr>
</table>
checkHorizWin(C,P) = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>
This test cause is a unique and distinct routine case, because it tests whether or not checkHorizWin() can correctly identify a typical scenario where no horizontal win will occur.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td>X</td><td>X</td><td></td><td>X</td><td></td><td></td></tr>
</table>
<table><tr><td>R = 0</td><td>C = 3</td><td>P = X</td></tr></table>
</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td>X</td><td>X</td><td><b>X</b></td><td>X</td><td></td><td></td></tr>
</table>
checkHorizWin(C,P) = <b><i>true</i></b>
</td>
<td><b><i>Reason:</i></b>
This test is a unique and distinct challenging case, because it tests whether or not checkHorizWin() can correctly identify successive tokens in both the left and right directions.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
<table>
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<tr><td></td><td></td><td></td><td>X</td><td>X</td><td>X</td><td></td></tr>
</table>
<table><tr><td>R = 0</td><td>C = 6</td><td>P = X</td></tr></table>
</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td>X</td><td>X</td><td>X</td><td><b>X</b></td></tr>
</table>
checkHorizWin(C,P) = <b><i>true</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, because it tests whether or not checkHorizWin() can correctly identify a win when the winning token is placed in the rightmost possible row.</td>
</tr>
</table>

public boolean checkVertWin(int c)

<table>
<tr>
<td><b><i>Input</i></b>
State: (number to win = 4)
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
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6x7 GameBoard
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
checkVertWin(C,P) = <b><i>true</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, as it tests whether or not checkVertWin() can correctly identify a typical vertical win scenario.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win = 4)
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<tr><td></td><td></td><td></td><td><b>O</b></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td>X</td><td></td><td></td><td></td></tr>
</table>
checkVertWin(C,P) = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, as it tests whether or not checkVertWin() can correctly identify a scenario where a vertical win will not occur.</td>
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</td>
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6x7 GameBoard
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
checkVertWin (C,P) = <b><i>true</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not checkVertWin() can correctly identify a win when the winning token is placed in the uppermost possible row.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
<table><tr><td>R = 0</td><td>C = 1</td><td>P = X</td></tr></table>
</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
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<tr><td></td><td><b>X</b></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
checkVertWin (C,P) = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct challenging case, as it tests whether or not checkVertWin() functions correctly when the board only has one token, in the column that checkVertWin() is called on.</td>
</tr>
</table>

public boolean checkDiagWin(int c)

Input

State: (number to win = 4)

		X	O			
	X	O	O			
X	O	O	O			

R = 3	C = 3	P = X

Output

6x7 GameBoard

			X			
		X	O			
	X	O	O			
X	O	O	O			

checkDiagWin(C,P) = ***true***

Reason:

This test case is a unique and distinct routine case, as it tests whether or not checkDiagWin() can correctly identify a typical win with the successive tokens in the upwards diagonal direction.

Input

State: (number to win = 4)

X						
O	X					
O	O	X				
O	O	O				

R = 0	C = 3	P = O

Output

6x7 GameBoard

X						
O	X					
O	O	X				
O	O	O	**X**			

checkDiagWin(C,P) = ***true***

Reason:

This test case is a unique and distinct routine case, as it tests whether or not checkDiagWin() can correctly identify a typical win with the successive tokens in the downwards diagonal direction.

Input

State: (number to win =4)

X						
O						
O	O	X				
O	O	O	X			

R = 2	C = 1	P = X

Output

6x7 GameBoard

X						
O	**X**					
O	O	X				
O	O	O	X			

checkDiagWin(C,P) = ***true***

Reason:

This test case is a unique and distinct challenging case, as it tests whether or not checkDiagWin() can correctly identify a win when the winning token is placed in the middle of a upwards-diagonal succession.

Input

State: (number to win =4)

			X			
		X	O			
		O	O			
X	O	O	O			

R = 1	C = 1	P = X

Output

6x7 GameBoard

			X			
		X	O			
	X	O	O			
X	O	O	O			

checkDiagWin(C,P) = ***true***

Reason:

This test case is a unique and distinct challenging case, as it tests whether or not checkDiagWin() can correctly identify a win when the winning token is placed in the middle of a downwards-diagonal succession.

<table>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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</table>
<table><tr><td>R = 0</td><td>C = 1</td><td>P = X</td></tr></table>
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<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td></td><td><b>X</b></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
checkDiagWin(C,P) = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not checkDiagWin() can correctly process a column with only one token in it.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td><td></td></tr>
</table>
checkDiagWin(C,P) = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>

This test case is a unique and distinct challenging case, as it tests whether or not the algorithm to detect successive diagonal tokens works correctly.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td>X</td><td>O</td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
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<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td></td><td></td><td>X</td><td>O</td><td></td><td></td><td></td></tr>
<tr><td></td><td>X</td><td>O</td><td>O</td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>O</td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
</table>
checkDiagWin(C,P) = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>

This test case is a unique and distinct routine case, as it tests whether or not checkDiagWin() can correctly identify a typical no-win scenario.</td>
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</table>

public boolean checkTie()

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<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
</table>
checkTie() = <b><i>true</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not checkTie() can correctly identify a tie, i.e. when the board is completely full.</td>
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<td><b><i>Input</i></b>
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</table>
checkTie() = <b><i>false</i></b>
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<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not checkTie() can correctly process an empty board.</td>
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State: (number to win =4)
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
checkTie() = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not checkTie() can correctly process a board with only one token on it.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
</table>
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<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
</table>
checkTie() = <b><i>false</i></b>
</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, as it tests whether or not checkTie() can correctly identify a typical no-tie situation.</td>
</tr>
</table>

public char whatsAtPos(BoardPosition pos)

<table>
<tr>
<td><b><i>Input</i></b>
State: (number to win = 4)
<table>
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</table>
Pos = (3,5)</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
whatsAtPos(pos) = ‘ ‘</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not whatsAtPos() can correctly process a blank space on the board.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win = 4)
<table>
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Pos = (0,0)</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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</table>
whatsAtPos(pos) = ‘X’</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not whatsAtPos() works on the leftmost and lowest board position.</td>
</tr>
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State: (number to win =4)
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>O</td></tr>
</table>
Pos = (5, 6)</td>
<td><b><i>Output</i></b>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>O</td></tr>
</table>
whatsAtPos(pos) = ‘X’</td>
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This test case is a unique and distinct boundary case, as it tests whether or not whatsAtPos() works on the rightmost and highest board position.</td>
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<tr>
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Pos = (5,0)</td>
<td><b><i>Output</i></b>
6x7 GameBoard
<table>
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<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
whatsAtPos(pos) = ‘X’</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not whatsAtPos() works on the leftmost and highest board position.</td>
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State: (number to win =4)
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<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
</table>
Pos = (2,1)</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>X</td><td>X</td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
</table>
whatsAtPos(pos) = ‘X’</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, as it tests whether or not whatsAtPos() correctly extracts the contents of a position in the middle of the board.</td>
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</table>

public boolean isPlayerAtPos(BoardPosition pos, char p)

<table>
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State: (number to win = 4)
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</table>
Pos = (3,5)</td>
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</table>
whatsAtPos(pos, X) = <b><i>false</i></b></td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not isPlayerAtPos() can correctly process an empty board position.</td>
</tr>
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<td><b><i>Input</i></b>
State: (number to win = 4)
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Pos = (0,0)</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
isPlayerAtPos(posdo,O) = <b><i>false</i></b></td>
<td><b><i>Reason:</i></b>
This test cause is a unique and distinct challenging case, as it tests whether or not isPlayerAtPos() can discern that a board position is (1) occupied and (2) occupied by the specific player token O.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Pos = (1, 2)</td>
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6x7 GameBoard
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>O</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
isPlayerAtPos(pos, X) = <b><i>true</i></b></td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, as it tests whether or not isPlayerAtPos() can correctly identify whether a specific token p is at a specific position pos; position p is in the middle of the board.</td>
</tr>
<tr>
<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Pos = (0,0)</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
isPlayerAtPos(pos) = ‘X’</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not isPlayerAtPos() will work for the leftmost and lowest possible board position.</td>
</tr>
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<td><b><i>Input</i></b>
State: (number to win =4)
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>X</td></tr>
</table>
Pos = (5,6)</td>
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6x7 GameBoard
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isPlayerAtPos(pos) = ‘X’</td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not isPlayerAtPos() will work for the rightmost and highest possible board position.</td>
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public void placeToken(char p, int c)

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State: (number to win = 4)
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</table>
Pos = (0,5) ; p = ‘X’</td>
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6x7 GameBoard
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<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not placeToken() will correctly place a token in an empty column.</td>
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State: (number to win = 4)
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<tr><td></td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Pos = (5,1); p = ‘X’</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not placeToken() will correctly place a token in a nearly-full column.</td>
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State: (number to win =4)
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</table>
Pos = (0, 0); P = ‘X’</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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<tr><td><b>X</b></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct boundary case, as it tests whether or not placeToken() will correctly place a token in the leftmost column.</td>
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<td><b><i>Input</i></b>
State: (number to win =4)
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</table>
Pos = (0,6); P = ‘X’</td>
<td><b><i>Output</i></b>
6x7 GameBoard
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This test case is a unique and distinct boundary case, as it tests whether or not placeToken() will correctly place a token in the rightmost column.</td>
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</table>
Pos = (2,2); p = ‘X’</td>
<td><b><i>Output</i></b>
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<tr><td></td><td></td><td><b>X</b></td><td>O</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>O</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>X</td><td>O</td><td></td><td></td><td></td></tr>
</table></td>
<td><b><i>Reason:</i></b>
This test case is a unique and distinct routine case, as it tests whether or not placeToken() will correctly place a token in one of the middle columns.</td>
</tr>
</table>