

# Tic Tac Toe Project, Fall 2025

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## 1 CopyRight Warning

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## 2 File Structures

1. Provide the following files
  - (a) Header file of TicTacToeBoard: **TicTacToeBoard.hpp**
  - (b) Header file of TicTacToeGame: **TicTacToeGame.hpp**
  - (c) Automate the process of building executable programs and other files from source code: **makefile**
  - (d) Source code to test TicTacToeGame class: **TestTicTacToeGame.cpp**
  - (e) Source code to test important methods of TicTacToeBoard class: **TestTicTacToeBoard.cpp**

2. You implement TicTacToeBoard and TicTacToeGame classes, that is,

- (a) Define TicTacToeBoard.cpp.
- (b) Define TicTacToeGame.cpp.

## 2.1 TicTacToeBoard.hpp

The contents of header file TicTacToeBoard is as follows.

```
1 #ifndef TicTacToeBoard_H
2 #define TicTacToeBoard_H
3 #include <iostream> //std
4 #include <vector>
5
6 class TicTacToeBoard {
7 public:
8     //a default 3x3 TicTacToe board
9     TicTacToeBoard();
10
11    //If the provided size is less than 3, default to creating a 3x3 board.
12    //Otherwise, initialize the board with the given size for both rows and
13    //columns.
14    TicTacToeBoard(int givenSize);
15
16    //Set each element of the board to be a space (' ').
17    void clear();
18
19    //Return the value at cell (row, col)
20    char getValue(int row, int col) const;
21
22    //Checks if the cell at (row, col) is available.
23    //A cell is available if its value is a space character (' ').
24    bool isAvailable(int row, int col) const;
25
26    //Check whether the given parameter row is valid row index or not.
27    //that is, whether row is in [0, board.size()-1]
28    bool isValidRow(int row) const;
29
30    //Check whether the given parameter col is a valid column index or not
31    //that is, whether col is in [0, board.size()-1]
32    bool isValidCol(int col) const;
33
34    //Return the size of tic tac toe board
35    int size() const;
36
37    //Place playerId at board[row][col].
38    void mark(int row, int col, char playerId);
```

```

38 //Returns a string that visually represents the current layout of the
39 //board's elements.
40 std::string to_string() const;
41
42 //If every single row, column, main diagonal, AND anti-diagonal
43 //each contain both 'X' and 'O' symbols,
44 //then the board is in a tie state (return true).
45 //Otherwise, if any of those lines (row/col/diagonals) is missing
46 //an 'X' or an 'O', it means a win is still possible (return false).
47 bool tie() const;
48
49 //Check whether the player at row and col wins.
50 //If there is any win in horizontal, vertical,
51 //diagonal, or anti-diagonal direction, return true,
52 //otherwise, return false.
53 bool win(int row, int col) const;
54
55 //Check Horizontal Win:
56 //Evaluate the row containing the cell (row, col).
57 //If the current player's symbol forms a continuous,
58 //unbroken sequence of the required length within this row,
59 //the function returns true (win found); otherwise, it returns false.
60 //Check whether the player at (row, col) can win that row or not.
61 bool winByRow(int row, int col) const;
62 //Check Vertical Win:
63 //Evaluate the column containing the cell (row, col).
64 //If the current player's symbol forms a continuous,
65 //unbroken sequence of the required length within this column,
66 //the function returns true (win found); otherwise, it returns false.
67 bool winByCol(int row, int col) const;
68 //Check Digonal (including both diagonal and anti-diagonal) Win:
69 //If the cell (row, col) is not in diagonal or anti-diagonal, return
70 //false.
71 //If the cell (row, col) is in the diagonal,
72 //evaluate the diagonal containing the cell (row, col).
73 //If the current player's symbol forms a continuous,
74 //unbroken sequence of the required length within this diagonal,
75 //the function returns true (win found);
76 //otherwise, evaluate the anti-diagonal containing the cell (row, col).
77 //If the current player's symbol forms a continuous,
78 //unbroken sequence of the required length within this anti-diagonal,
79 //the function returns true (win found); otherwise, return false.
80 bool winByDiagonal(int row, int col) const;
81
private:

```

```

82     std::vector<std::vector<char>> board; //board is a 2d array of chars
83 }
84 #endif

```

## 2.2 Header File of TicTacToeGame Class: TicTacToeGame.hpp

```

1 #ifndef TicTacToeGame_H
2 #define TicTacToeGame_H
3 #include "TicTacToeBoard.hpp"
4 class TicTacToeGame {
5 public:
6     TicTacToeGame();
7     TicTacToeGame(int size);
8     void runRepeat();
9     //start to play the game
10    void start();
11    bool isGameOver() const;
12
13    //This is how the user plays:
14    //Enter row and col such that
15    //1. row is in [0, size-1]
16    //2. col is in [0, size-1]
17    //3. the corresponding cell in the board is available
18    // (hint: call board.getValue(row, col) to check the return is 0 or
19    // not).
20    //As long as the input row or col is not valid
21    //begin
22    //    prompt what error(s) are, for example,
23    //    * row is not in [0, size-1]
24    //    * col is not in [0, size-1]
25    //    * the corresponding cell in board is not available
26    //    prompt user to re-enter.
27    //end
28    //
29    //Once we exit the above repetition loop,
30    //row and col are valid,
31    //mark the corresponding cell in the board by HUMAN_ID.
32    void humanPlay();
33
34    //computer play
35    //Computer checks the board from the first row to the last row.
36    //In each row, the computer checks from the first column to the last
37    //column.
38    //A more sophisticated approach is to use "mark first; if unfit, then
39    //remove mark"

```

```

37 //1. Try to win first.
38 //  Mark an available cell by computerId,
39 //  if this leads to win by computer,
40 //  take this cell and return,
41 //  otherwise, do not take this cell (that is, set this cell to be
42 //  available).
43 //2. Try to block the opponent from winning.
44 //  This approach is adopted after the try-to-win approach fails.
45 //  Mark an available cell by userId (that is, suppose this cell is
46 //  taken by userId),
47 //  if this leads to win by user,
48 //  mark this cell by computerId, and return.
49 //  otherwise, do not take this cell (that is, set this cell to be
50 //  available).
51 //3. If neither one of the above two approaches works
52 //  (that is, the computer does not take a cell yet),
53 //  then mark the first available cell.
54 void computerPlay();
55
56 private:
57     TicTacToeBoard tttBoard;
58     int currRow;
59     int currCol; //the row and col the current player chooses.
60     static const char HUMAN_ID = 'X';
61     static const char COMPUTER_ID = 'O';
62 };
63 #endif

```

## 2.3 Source Code to Test Tic Tac Toe Game: TestTicTacToeGame.cpp

```

1 #include "TicTacToeGame.hpp"
2
3 int main() {
4     TicTacToeGame game; //3 x 3 tic tac toe board
5     //TicTacToeGame game(4); //4 x 4 tic tac toe board
6     game.runRepeat();
7 }

```

## 2.4 makefile

When working with several source files for this project, it is highly recommended to use a **makefile** and the **make** utility. This automates the build process, eliminating the need to manually remember and type complex compilation commands for every file. A key advantage of using a Makefile is its efficient dependency tracking: if a change is made to a single source file, the **make** utility intelligently recompiles

only that specific file and then re-links the final executable, significantly reducing build times by avoiding unnecessary recompilation of unmodified files.

```
1 # This is an example Makefile for tic tac toe project. This
2 # program uses TicTacToeBoard, TicTacToeGame, and TestTicTacToeGame modules
3 .
4 # Typing 'make' or 'make run' will create the executable file.
5 #
6 # define some Makefile variables for the compiler and compiler flags
7 # to use Makefile variables later in the Makefile: $()
8 #
9 # -g      adds debugging information to the executable file
10 # -Wall   turns on most, but not all, compiler warnings
11 #
12 # for C++ define CC = g++
13 CC = g++ -std=c++11
14 #CFLAGS = -g -Wall
15
16 # typing 'make' will invoke the first target entry in the file
17 # (in this case the default target entry)
18 # you can name this target entry anything, but "default" or "all"
19 # are the most commonly used names by convention
20 #
21 all: run
22
23 # To create the executable file run we need the object files
24 # TestTicTacToeGame.o, TicTacToeBoard.o
25 run: TicTacToeBoard.o TestTicTacToeGame.o TicTacToeGame.o
26     $(CC) -o run TestTicTacToeGame.o TicTacToeGame.o TicTacToeBoard.o
27
28 # To create the object file TestTicTacToeGame.o, we need the source
29 # files TestTicTacToeGame.cpp and TicTacToeBoard.hpp
30 #
31 TestTicTacToeGame.o: TestTicTacToeGame.cpp
32     $(CC) -c TestTicTacToeGame.cpp
33
34 TicTacGame.o: TicTacGame.cpp
35     $(CC) -c TicTacGame.cpp
36
37 # To create the object file TicTacToeBoard.o, we need the source
38 # files TicTacToeBoard.cpp, TicTacToeBoard.hpp
39 TicTacToeBoard.o: TicTacToeBoard.cpp
40     $(CC) -c TicTacToeBoard.cpp
41
42 # To start over from scratch, type 'make clean'. This
43 # removes the executable file, as well as old .o object
```

```

44 # files and *~ backup files:
45 #
46 clean:
47     $(RM) run *.o *~

```

To use makefile, just type

```
1 make
```

From `-o run` of Line 26 of the above make file, we notice that the runnable file is called `run`. Then run the project using

```
1 ./run
```

When you want to delete all the temporary files generated during the build process (such as object files .o, intermediate data files, and the final executable itself). Run the following command.

```
1 make clean
```

## 2.5 Sample Run

```

1      0   1   2
2      +---+---+---+
3 0 |   |   |   |
4      +---+---+---+
5 1 |   |   |   |
6      +---+---+---+
7 2 |   |   |   |
8      +---+---+---+
9
10 Round 1: User, enter row and col to place X: 0 0
11      0   1   2
12      +---+---+---+
13 0 | X |   |   |
14      +---+---+---+
15 1 |   |   |   |
16      +---+---+---+
17 2 |   |   |   |
18      +---+---+---+
19 Round 2: Computer places 0 at row 0 and col 1.
20      0   1   2
21      +---+---+---+
22 0 | X | 0 |   |
23      +---+---+---+
24 1 |   |   |   |
25      +---+---+---+
26 2 |   |   |   |
27      +---+---+---+

```

```

28 Round 3: User, enter row and col to place X: 1 1
29     0   1   2
30     +---+---+---+
31 0 | X | 0 |   |
32     +---+---+---+
33 1 |   | X |   |
34     +---+---+---+
35 2 |   |   |   |
36     +---+---+---+
37 Round 4: Computer places 0 at row 2 and col 2.
38     0   1   2
39     +---+---+---+
40 0 | X | 0 |   |
41     +---+---+---+
42 1 |   | X |   |
43     +---+---+---+
44 2 |   |   | 0 |
45     +---+---+---+
46 Round 5: User, enter row and col to place X: 2 0
47     0   1   2
48     +---+---+---+
49 0 | X | 0 |   |
50     +---+---+---+
51 1 |   | X |   |
52     +---+---+---+
53 2 | X |   | 0 |
54     +---+---+---+
55 Round 6: Computer places 0 at row 0 and col 2.
56     0   1   2
57     +---+---+---+
58 0 | X | 0 | 0 |
59     +---+---+---+
60 1 |   | X |   |
61     +---+---+---+
62 2 | X |   | 0 |
63     +---+---+---+
64 Round 7: User, enter row and col to place X: 1 0
65     0   1   2
66     +---+---+---+
67 0 | X | 0 | 0 |
68     +---+---+---+
69 1 | X | X |   |
70     +---+---+---+
71 2 | X |   | 0 |
72     +---+---+---+
73 Human wins. Yay!!!

```

```

74 Do you want to continue (yes/no): y
75     0   1   2
76     +---+---+---+
77 0 |   |   |   |
78     +---+---+---+
79 1 |   |   |   |
80     +---+---+---+
81 2 |   |   |   |
82     +---+---+---+
83
84 Round 1: User, enter row and col to place X: 0 0
85     0   1   2
86     +---+---+---+
87 0 | X |   |   |
88     +---+---+---+
89 1 |   |   |   |
90     +---+---+---+
91 2 |   |   |   |
92     +---+---+---+
93 Round 2: Computer places 0 at row 0 and col 1.
94     0   1   2
95     +---+---+---+
96 0 | X | 0 |   |
97     +---+---+---+
98 1 |   |   |   |
99     +---+---+---+
100 2 |   |   |   |
101    +---+---+---+
102 Round 3: User, enter row and col to place X: 1 0
103     0   1   2
104     +---+---+---+
105 0 | X | 0 |   |
106     +---+---+---+
107 1 | X |   |   |
108     +---+---+---+
109 2 |   |   |   |
110    +---+---+---+
111 Round 4: Computer places 0 at row 2 and col 0.
112     0   1   2
113     +---+---+---+
114 0 | X | 0 |   |
115     +---+---+---+
116 1 | X |   |   |
117     +---+---+---+
118 2 | 0 |   |   |
119    +---+---+---+

```

```
120 Round 5: User, enter row and col to place X: 0 2
121     0   1   2
122     +---+---+---+
123 0 | X | 0 | X |
124     +---+---+---+
125 1 | X |   |   |
126     +---+---+---+
127 2 | 0 |   |   |
128     +---+---+---+
129 Round 6: Computer places 0 at row 1 and col 1.
130     0   1   2
131     +---+---+---+
132 0 | X | 0 | X |
133     +---+---+---+
134 1 | X | 0 |   |
135     +---+---+---+
136 2 | 0 |   |   |
137     +---+---+---+
138 Round 7: User, enter row and col to place X: 1 2
139     0   1   2
140     +---+---+---+
141 0 | X | 0 | X |
142     +---+---+---+
143 1 | X | 0 | X |
144     +---+---+---+
145 2 | 0 |   |   |
146     +---+---+---+
147 Round 8: Computer places 0 at row 2 and col 1.
148     0   1   2
149     +---+---+---+
150 0 | X | 0 | X |
151     +---+---+---+
152 1 | X | 0 | X |
153     +---+---+---+
154 2 | 0 | 0 |   |
155     +---+---+---+
156 Computer wins. Yuck.
157 Do you want to continue (yes/no): y
158     0   1   2
159     +---+---+---+
160 0 |   |   |   |
161     +---+---+---+
162 1 |   |   |   |
163     +---+---+---+
164 2 |   |   |   |
165     +---+---+---+
```

```
166
167 Round 1: User, enter row and col to place X: 1 1
168     0   1   2
169     +---+---+---+
170 0 |   |   |
171 +---+---+---+
172 1 |   | X |   |
173 +---+---+---+
174 2 |   |   |
175 +---+---+---+
176 Round 2: Computer places 0 at row 0 and col 0.
177     0   1   2
178     +---+---+---+
179 0 | 0 |   |
180 +---+---+---+
181 1 |   | X |   |
182 +---+---+---+
183 2 |   |   |
184 +---+---+---+
185 Round 3: User, enter row and col to place X: 0 2
186     0   1   2
187     +---+---+---+
188 0 | 0 |   | X |
189 +---+---+---+
190 1 |   | X |   |
191 +---+---+---+
192 2 |   |   |
193 +---+---+---+
194 Round 4: Computer places 0 at row 2 and col 0.
195     0   1   2
196     +---+---+---+
197 0 | 0 |   | X |
198 +---+---+---+
199 1 |   | X |   |
200 +---+---+---+
201 2 | 0 |   |
202 +---+---+---+
203 Round 5: User, enter row and col to place X: 1 0
204     0   1   2
205     +---+---+---+
206 0 | 0 |   | X |
207 +---+---+---+
208 1 | X | X |   |
209 +---+---+---+
210 2 | 0 |   |
211 +---+---+---+
```

```

212 Round 6: Computer places 0 at row 1 and col 2.
213     0   1   2
214     +---+---+---+
215 0 | 0 |   | X |
216     +---+---+---+
217 1 | X | X | 0 |
218     +---+---+---+
219 2 | 0 |   |   |
220     +---+---+---+
221 Round 7: User, enter row and col to place X: 0 1
222     0   1   2
223     +---+---+---+
224 0 | 0 | X | X |
225     +---+---+---+
226 1 | X | X | 0 |
227     +---+---+---+
228 2 | 0 |   |   |
229     +---+---+---+
230 Round 8: Computer places 0 at row 2 and col 1.
231     0   1   2
232     +---+---+---+
233 0 | 0 | X | X |
234     +---+---+---+
235 1 | X | X | 0 |
236     +---+---+---+
237 2 | 0 | 0 |   |
238     +---+---+---+
239 Round 9: User, enter row and col to place X: 0 1
240 The square you pick up is not available.User, re-enter row and col to place
X: 1 0
241 The square you pick up is not available.User, re-enter row and col to place
X: 2 1
242 The square you pick up is not available.User, re-enter row and col to place
X: 2 2
243     0   1   2
244     +---+---+---+
245 0 | 0 | X | X |
246     +---+---+---+
247 1 | X | X | 0 |
248     +---+---+---+
249 2 | 0 | 0 | X |
250     +---+---+---+
251 It is a tie.
252 Do you want to continue (yes/no): no
253 Bye

```

### 3 Task A: Define Constructors, clear, and to\_string methods of TicTacToeBoard.cpp

1. Create a file named TicTacToeBoard.cpp.
2. Implement methods defined in TicTacToeBoard.hpp.
3. Test TicTacToeBoard.cpp locally using provided TestTicTacToeBoard.cpp.
4. Submit TicTacToeBoard.cpp to gradescope for grading.

#### 3.1 Implement TicTacToeBoard.cpp

Put TicTacToeBoard.hpp, TicTacToeBoard.cpp, and TestTicTacToeBoard.cpp in the same directory.  
You need to implement the corresponding source code, that is, define TicTacToeBoard.cpp.

#### 3.2 Hint: help function to Draw Separate Line in to\_string method

```
1 //separate lines of data in board
2 //This function is NOT a member function,
3 //since clients of TicTacToeBoard class do not need to use it.
4 //Only method to_string needs to use it.
5 //Since this is not a method of TicTacToeBoard class,
6 //we need to pass parameter size.
7 std::string separateLine(int size) {
8     std::string str = "    +";
9     for (int i = 0; i < size; i++) {
10         str += "----+";
11     }
12     str += "\n";
13     return str;
14 }
```

#### 3.3 Test TicTacToeBoard.cpp Locally

Use the following TestTicTacToeBoard.cpp to test your TicTacToeBoard.cpp.

```
1 #include <iostream>
2 #include <vector>
3 #include "TicTacToeBoard.hpp"
4 //g++ -o tBoard TicTacToeBoard.cpp TestTicTacToeBoard.cpp
5
6 //test default constructor using
7 //./tBoard A
8
9 //test non-default constructor using
10 //./tBoard B
```

```

11
12 //test clear method using
13 //./tBoard C
14 //and so on.
15
16 const int NUM_COLUMNS = 4;
17 TicTacToeBoard* assignData(char data[][][NUM_COLUMNS]);
18
19 int main(int argc, const char *argv[]) {
20     if (argc != 2) {
21         std::cout << "Need 'A'-'J' in command line parameter" << std::endl;
22         return -1;
23     }
24
25     //unit-testing for constructors and the destructor
26     char type = *argv[1];
27     std::string prompt;
28     TicTacToeBoard *tttBoard;
29
30     if (type == 'A') {
31         prompt = "default constructor TicTacToeBoard board;";
32         tttBoard = new TicTacToeBoard;
33
34     //expected output:
35     //Call default constructor TicTacToeBoard board;
36     //contents of board is
37     // , , ,
38     // , , ,
39     // , , ,
40     //
41     }
42     else if (type == 'B') {
43         std::cout << "Enter size of the board: ";
44         int size;
45         std::cin >> size;
46         prompt = "non-default constructor TicTacToeBoard board(" + std::
47             to_string(size) + ")";
48         tttBoard = new TicTacToeBoard(size);
49
50     //sample input/output:
51     //Enter size of the board: 5
52     //Call non-default constructor TicTacToeBoard board(5);
53     //contents of board is
54     // , , , , ,
55     // , , , , ,

```

```

56 // , , , , ,
57 // , , , , ,
58 //
59
60 //do not take the parameter as it is,
61 //need to make sure that parameter size is >= 3
62 //another sample input/output:
63 //Enter size of the board: 2
64 //Call non-default constructor TicTacToeBoard board(2);
65 //contents of board is
66 // , ,
67 // , ,
68 // , ,
69 //
70 }
71 else if (type == 'C' || type == 'D') {
72     //test clear method,
73     char data[] [NUM_COLUMNS] = {
74         {'X', 'O', 'X', ' '},
75         {'O', 'X', ' ', ' '},
76         {' ', 'O', 'O', ' '},
77         {'X', ' ', ' ', 'X'},
78     };
79
80     tttBoard = assignData(data);
81
82 if (type == 'C') {
83     //test clear method
84     tttBoard->clear();
85
86     //after calling clearing method, each element of board should be
87     ' '
88     bool isWrong = false;
89     for (int row = 0; row < tttBoard->size() && !isWrong; row++) {
90         for (int col = 0; col < tttBoard->size() && !isWrong; col++) {
91             if (tttBoard->getValue(row, col) != ' ') {
92                 std::cout << "clear method is not correct. Each
93                 element should be a space character\n";
94                 isWrong = true; //set a tag
95                 //break; //break only can break the inner loop, the
96                 //outer loop still runs
97             }
98         }
99     }
100 }
```

```

98     if (!isWrong) {
99         std::cout << "clear method is correct\n";
100    }
101    //expected output:
102    //clear method is correct
103 }
104 else if (type == 'D') {
105     //test to_string method
106     std::cout << tttBoard->to_string();
107     //expected output:
108     //      0   1   2   3
109     //      +---+---+---+---+
110     // 0 | X | 0 | X |   /
111     //      +---+---+---+---+
112     // 1 | 0 | X |   /   /
113     //      +---+---+---+---+
114     // 2 |   / 0 | 0 |   /
115     //      +---+---+---+---+
116     // 3 | X |   /   / | X |
117     //      +---+---+---+---+
118 }
119 }
120 else if (type == 'E') {
121     //test winByRow(int row, int col)
122     char data[] [NUM_COLUMNS] = {
123         {'X', '0', 'X', ' '},
124         {'X', '0', '0', ' '},
125         {'0', '0', '0', '0'},
126         {'X', 'X', 'X', ' '},
127     };
128
129     tttBoard = assignData(data);
130
131     bool result;
132     for (int row = 0; row < tttBoard->size(); row++) {
133         for (int col = 0; col < tttBoard->size(); col++) {
134             result = tttBoard->winByRow(row, col);
135             if (result) { //result == true
136                 std::cout << std::boolalpha << result;
137             }
138             std::cout << ',';
139             //std::cout << std::boolalpha << tttBoard->winByRow(row,
140             //col) << ',';
141         }
142         std::cout << std::endl;
143     }

```

```

143 //expected output:
144 //,,
145 //,,
146 //true,true,true,true,
147 //,,
148 }
149 else if (type == 'F') {
150     //test winByCol(int row, int col)
151     char data[] [NUM_COLUMNS] = {
152         {'O', 'X', 'O', ' '},
153         {'O', 'X', 'X', 'O'},
154         {'O', 'X', 'O', ' '},
155         {'X', 'X', ' ', 'X'},
156     };
157
158     tttBoard = assignData(data);
159
160     bool result;
161     for (int row = 0; row < tttBoard->size(); row++) {
162         for (int col = 0; col < tttBoard->size(); col++) {
163             result = tttBoard->winByCol(row, col);
164             if (result) { //result == true
165                 std::cout << std::boolalpha << result;
166             }
167             std::cout << ',';
168
169             //std::cout << std::boolalpha << tttBoard->winByCol(row,
170             //col) << ',';
171         }
172         std::cout << std::endl;
173     }
174 //expected output:
175 //,true,,
176 //,true,,
177 //,true,,
178 }
179 else if (type == 'G') {
180     //test winByDiagonal(int row, int col)
181     char data[] [NUM_COLUMNS] = {
182         {'X', 'X', 'O', ' '},
183         {'O', 'X', 'O', 'O'},
184         {'X', 'O', 'X', ' '},
185         {'O', 'X', ' ', 'X'},
186     };
187

```

```

188     tttBoard = assignData(data);
189
190     bool result;
191     for (int row = 0; row < tttBoard->size(); row++) {
192         for (int col = 0; col < tttBoard->size(); col++) {
193             result = tttBoard->winByDiagonal(row, col);
194             if (result) { //result == true
195                 std::cout << std::boolalpha << result;
196             }
197             std::cout << ',';
198
199             //std::cout << std::boolalpha << tttBoard->winByDiagonal(
200             //row, col) << ',';
201         }
202         std::cout << std::endl;
203     }
204 //expected output:
205 //true,,
206 //,true,,
207 //,,true,
208 //,
209     else if (type == 'H') {
210         //test winByDiagonal(int row, int col)
211         char data[] [NUM_COLUMNS] = {
212             {'X', 'X', 'O', 'O'},
213             {'O', 'X', 'O', 'O'},
214             {'X', 'O', ' ', 'X'},
215             {'O', 'X', ' ', 'X'},
216         };
217
218         tttBoard = assignData(data);
219
220         bool result;
221         for (int row = 0; row < tttBoard->size(); row++) {
222             for (int col = 0; col < tttBoard->size(); col++) {
223                 result = tttBoard->winByDiagonal(row, col);
224                 if (result) { //result == true
225                     std::cout << std::boolalpha << result;
226                 }
227                 std::cout << ',';
228             }
229             std::cout << std::endl;
230         }
231 //expected output:
232 //,,,true,

```

```

233 //,,true,,  

234 //,true,,,  

235 //true,,,  

236 }  

237 else if (type == 'I') {  

238     //test tie()  

239     char data[] [NUM_COLUMNS] = {  

240         {'X', 'X', 'O', ' '},  

241         {'O', 'X', 'O', 'O'},  

242         {'X', 'O', 'X', ' '},  

243         {'O', 'X', ' ', 'X'},  

244     };  

245  

246     tttBoard = assignData(data);  

247  

248     std::cout << std::boolalpha << tttBoard->tie() << '\n';  

249  

250 //expected output:  

251 //false  

252 }  

253 else if (type == 'J') {  

254     //test tie()  

255     char data[] [NUM_COLUMNS] = {  

256         {'X', 'X', 'O', ' '},  

257         {'O', 'X', 'X', 'O'},  

258         {'X', 'O', 'O', ' '},  

259         {'O', 'X', ' ', 'X'},  

260     };  

261  

262     tttBoard = assignData(data);  

263  

264     std::cout << std::boolalpha << tttBoard->tie() << '\n';  

265  

266 //expected output:  

267 //true  

268 }  

269  

270 // 'A' for default constructor and  

271 // 'B' for non-default constructor  

272 if (type == 'A' || type == 'B') {  

273     std::cout << "Call " << prompt << '\n';  

274     std::cout << "contents of board is\n";  

275     for (int row = 0; row < tttBoard->size(); row++) {  

276         for (int col = 0; col < tttBoard->size(); col++) {  

277             std::cout << tttBoard->getValue(row, col) << ',';
278         }

```

```

279         std::cout << '\n';
280     }
281 }
282
283 delete tttBoard; //release dynamic allocated memory
284 tttBoard = nullptr; //handle dangling pointer problem
285
286 return 0;
287 }
288
289 //TODO: need to define mark method of TicTacToeBoard.cpp before using
290 //       assignData function
291 TicTacToeBoard* assignData(char data[][][NUM_COLUMNS]) {
292     TicTacToeBoard *tttBoard = new TicTacToeBoard(NUM_COLUMNS);
293
294     for (int row = 0; row < tttBoard->size(); row++) {
295         for (int col = 0; col < tttBoard->size(); col++) {
296             tttBoard->mark(row, col, data[row][col]); //set board[row][col]
297             //of *tttBoard -- a TicTacToeBoard object -- to be data[row][
298             //col]
299         }
300     }
301
302     return tttBoard;
303 }
```