

# APT Lab 2 Exercises

## APT Lab 2 Exercises

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### Hints

For some reason that I cannot understand, students are tempted to spoil their code with output statements that haven't been specified. Imagine that the `sin` function was implemented in such a way that it printed intermediate values on the console while calculating the result: it would be totally unusable.

Make sure that your code does not produce any output (not even error messages) unless this kind of output is required (i.e. specified to be produced in the description of the methods). If you want to add debug output during development, make sure that the statements are **deleted** (not only commented out) before submitting the code. Personally, I recommend to use the debugger instead of debug statements.

Use self-documenting names for variables! E.g. when iterating over the rows and columns, don't use "i" and "j" as loop variables, rather use `row` and `column` (or `col`).

Note that you may not have heard in the lecture yet about all techniques required to solve this exercise efficiently when you get access to it. Keep in mind that you are supposed to work on this exercise for several weeks. So think about the modeling and the required algorithms first, i.e. before you start to program. And once you have an idea what you want to do, consider the information from the lecture as hints how you can do it.

### Introduction

This assignment is about creating an OO model of the game Battleship (see [https://en.wikipedia.org/wiki/Battleship\\_\(game\)](https://en.wikipedia.org/wiki/Battleship_(game))). The goal for the initial version of the program is to replace the sheet of paper, i.e. a player can use the program to arrange his ships, keep track of the opponent's shots, and keep track of the results of his own shots. You won't implement a multi-player game. The user of your program will still have to talk to his opponent, who can continue to use a sheet of paper.

Contrary to games such as Reversi, the state of a game such as Battleship cannot be represented by the state of the fields on the board only, because we have to find out about such things as the distance of ships and the number of ships (when arranging the own ships on the board) or whether a hit is a final hit, i.e. sinks the ship.

The assignment has three major parts that successively enrich the model from basic elements to the complete game representation. You don't have to take "snapshots" at the end of each part. Any

"intermediate" simplification can simply be substituted by the real solution as you proceed.

When working on the different aspects, remember that "Google is your friend".<sup>[1]</sup> Simply querying for things like "C++ integer to string" will usually provide you with sufficient hints to easily solve the problem at hand.

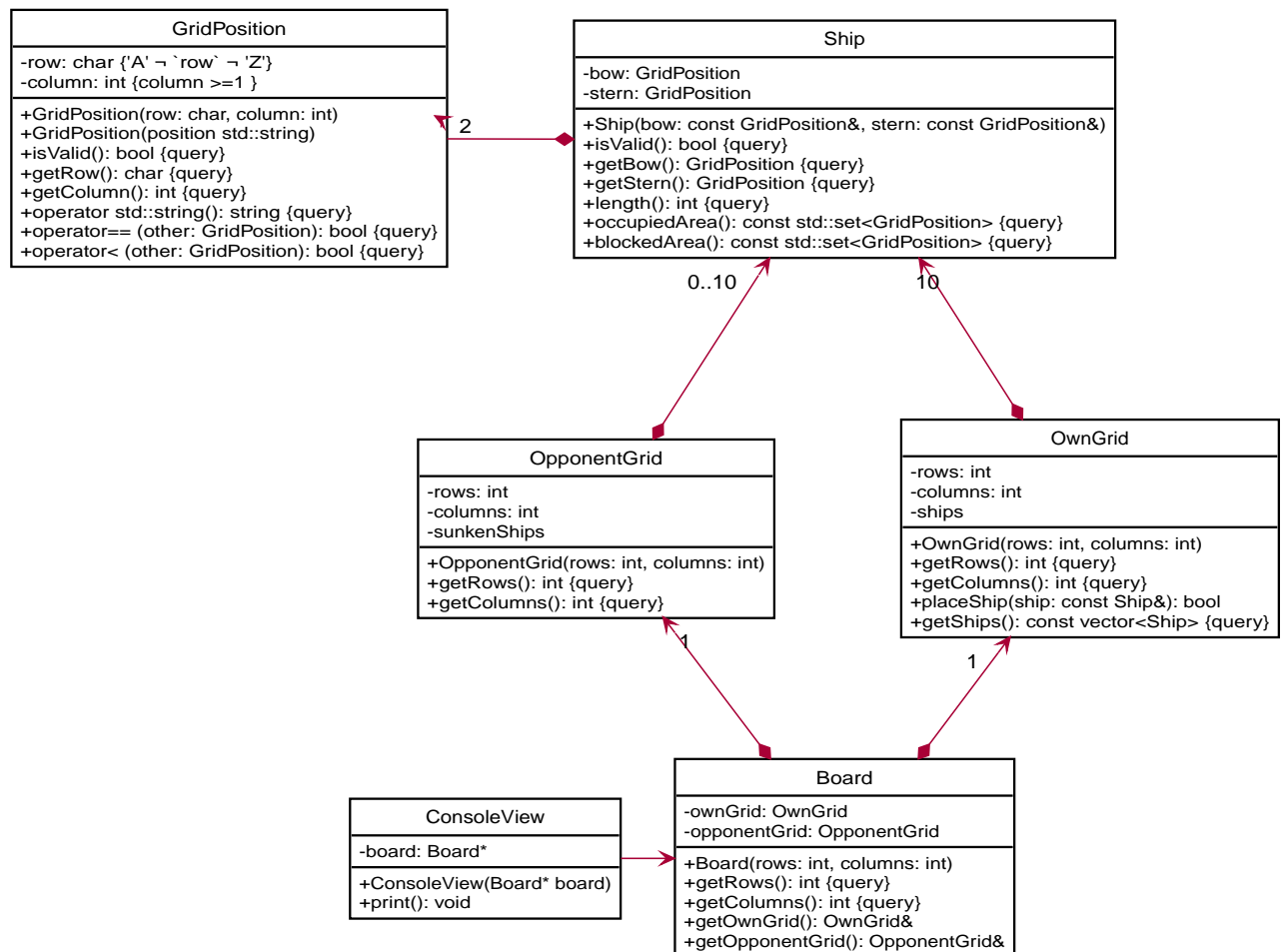
Make sure to use the smart pointers and container classes from the C++ standard library when implementing the classes and methods for this assignment. They will make your life a lot easier!

## Exercise 2.1: Basic classes

The most basic class represents a grid position, i.e. a row and a column on the board. The class is immutable. Once an object is created, its state cannot be modified. A `GridPosition` can be created from individually specified row and column arguments or from a string such as "B10".

Because we have to create an object no matter what arguments are passed to the constructor (e.g. '@' and -15) the created object may have invalid values in its data members. The validity can be checked by calling `isValid`. The method checks that `'A' ≤ row ≤ 'Z'` and `column > 0`. (You'll learn about a better way to handle such a situation later during this course.)

The overloaded cast to `string` returns the concatenation of the row and the column (e.g. "B10"). The behavior of the equals operator should be obvious. The less than operator assumes the fields to be ordered from top left to bottom right (e.g. A1 ... J10). We need the less than operator for a very specific reason. Once you have found out why, add the reason to the documentation of the method.



A ship has as data members two grid fields, named bow and stern. Of course, the two are indistinguishable when looking at the ships' representation on the paper. But these names are better than "end1" and "end2" or something alike.

Just like **GridPosition**, class **Ship** is immutable. The values for bow and stern are passed to the constructor as arguments. Again, it is possible to invoke the constructor with illegal values. Method **isValid** checks if the grid positions for bow and stern are valid, whether the ship is positioned horizontally or vertically and whether the length is between 2 and 5. Member function **length** returns the length of the ship, calculated from the distance between bow and stern.

The method **occupiedArea** returns all grid positions that are occupied by the ship. If e.g. the ship's bow is at B2 and its stern at E2, then the function return B2, C2, D2, E2. The method **blockedArea** will be explained later, it doesn't have to be implemented to get full marks for this first exercise.

Note that the classes **GridPosition** and **Ship** are described completely in the class diagram above. You may not add any members. The other classes are incomplete. You have to find out about e.g. the types of some data members and maybe add member functions due to the requirements following. Always try to achieve your goal with the member functions already defined before adding new ones.

In the initial phase of the game, a player arranges the ships on his own grid by calling **placeShip** (ignore the return value for now). The opponent grid is used to track the player's interaction with the opponent. It holds e.g. the information about the ships that have been sunken. Of course, initially, when the game starts, there are no sunken ships.

Both grids are part of the `Board` which models the game from one player's perspective (it would be silly to call this class "Sheet" although it effectively models the sheet of paper that you use when playing the game in the "analog" world). In order to be able to adapt to the different board sizes mentioned in Wikipedia, the number of rows and columns can be specified when creating the board. Apart from returning the specified dimensions, `Board`'s only capabilities are to provide access to the grids using the getter-functions.

Systematic testing is an import (sub-)task of software development. You can download a file with some test cases for the basic classes from Moodle. Make sure that your class implementations pass all tests.

## Exercise 2.2: Display and Arrangement rules

### 2.2.1 Display

The class `ConsoleView` shows the current state of the board on the Console. It obtains the information about the state of the game from `Board` and writes it to the console. Initially, it is sufficient to properly display the arranged own ships and prepare the display of the opponent grid. The recommended approach for implementing the `print` method is to allocate a char array for each grid, use the information from each grid to fill the char arrays and output the char arrays. Defining private helper methods may simplify this task significantly. Of course, you are free to choose a different approach.

To check you implementation, create an instance of `Board` (10 by 10), arrange three ships on the board (B2/B4, D4/G4, F6/F9), create a console view and invoke `print`.<sup>[2]</sup>

Here is the sample output for this board:

```

          1                               1
    1 2 3 4 5 6 7 8 9 0    1 2 3 4 5 6 7 8 9 0
A ~ ~ ~ ~ ~ ~ ~ ~ ~ A ~ ~ ~ ~ ~ ~ ~ ~ ~
B ~ # # # ~ ~ ~ ~ ~ B ~ ~ ~ ~ ~ ~ ~ ~ ~
C ~ ~ ~ ~ ~ ~ ~ ~ ~ C ~ ~ ~ ~ ~ ~ ~ ~ ~
D ~ ~ ~ # ~ ~ ~ ~ ~ D ~ ~ ~ ~ ~ ~ ~ ~ ~
E ~ ~ ~ # ~ ~ ~ ~ ~ E ~ ~ ~ ~ ~ ~ ~ ~ ~
F ~ ~ ~ # ~ # # # ~ F ~ ~ ~ ~ ~ ~ ~ ~ ~
G ~ ~ ~ # ~ ~ ~ ~ ~ G ~ ~ ~ ~ ~ ~ ~ ~ ~
H ~ ~ ~ ~ ~ ~ ~ ~ ~ H ~ ~ ~ ~ ~ ~ ~ ~ ~
I ~ ~ ~ ~ ~ ~ ~ ~ ~ I ~ ~ ~ ~ ~ ~ ~ ~ ~
J ~ ~ ~ ~ ~ ~ ~ ~ ~ J ~ ~ ~ ~ ~ ~ ~ ~ ~
```

### 2.2.2 Arrangement rules

Up to now, we haven't checked whether the arrangement of the player's own ships is legal. We apply the rules from the German battleship version ([https://de.wikipedia.org/wiki/Schiffe\\_versenken](https://de.wikipedia.org/wiki/Schiffe_versenken)).

1. Ships may not touch each other
2. The grid fields occupied by a ship form a straight line
3. Ships may be positioned at the edges of the grid
4. Ships must be positioned horizontally or vertically
5. Each player has 10 ships as follows:

Ship class	Length	Number of ships
Carrier	5	1
Battleship	4	2
Destroyer	3	3
Submarine	2	4

Check all conditions in `OwnGrid::placeShip`. Return false if a condition is violated.

The most difficult to check condition seems to be the first. Actually, it is quite simple if you use set theory. Implement the method `Ship::blockedArea`. It returns the set of grid positions occupied by the ship and all surrounding grid positions. This set can be calculated easily from the occupied area:

1. Start with an empty result set
2. For each grid position from occupied area
  - a. add the position and all eight surrounding positions to the result

Having `occupiedArea` and `blockedArea` available, the "ships mustn't touch" rules comes down to

1. For a ship to be placed on the grid check
  - a. for each ship already on the grid that
    - i. the intersection of the already placed ship's blocked area and the new ship's occupied area is the empty set.

To check the number of ships of a given length use the following approach:

1. Create a `map<int,int>` that you initialize with the pairs "length"/"number of ships" from the table above.
2. Each time to want to add a new ship with a given length
  - a. check if the value associated with the length is greater zero and
  - b. decrement the value associated with the given length

Add a file "`part2tests.cpp`" to your project and provide tests for the alignment rules following the pattern outlined by the tests provided for exercise 1.

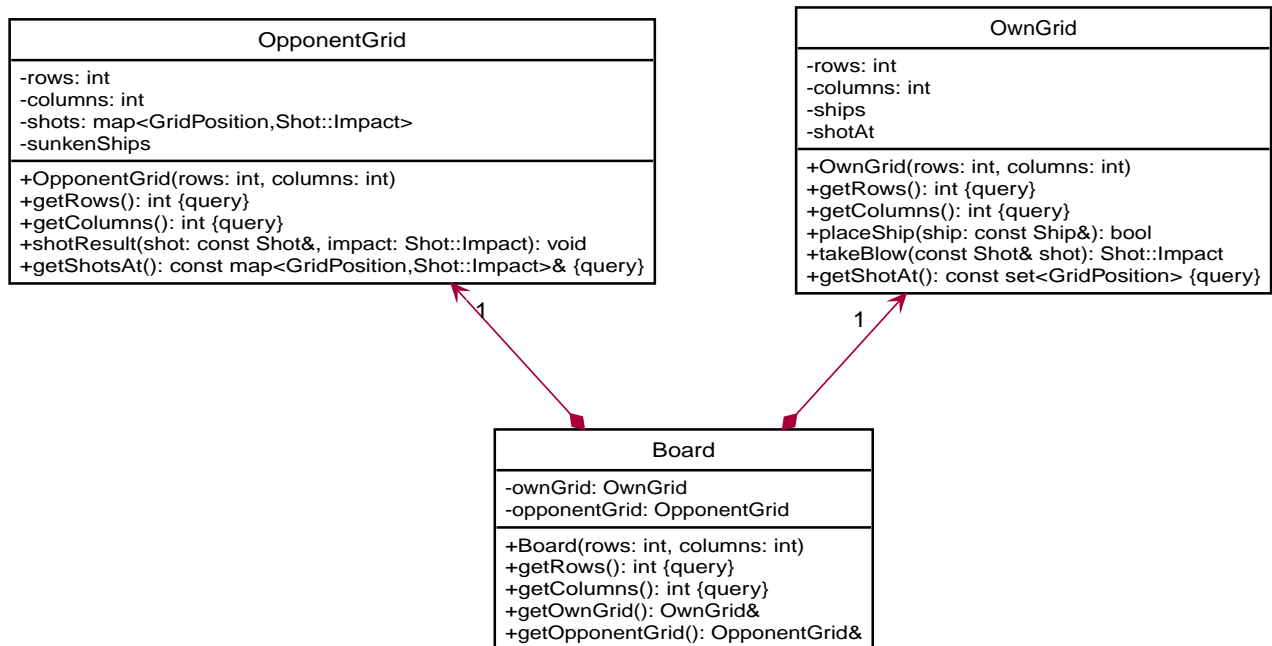
## Exercise 2.3: Shots

Now we add the class `Shot` to the model.

Shot
-targetPosition: GridPosition
+Shot(targetPosition: GridPosition) +getTargetPosition(): GridPosition {query}

«Enum» Shot::Impact
NONE HIT SUNKEN

Add the method `Shot::Impact takeBlow(const Shot& shot)` to `OwnGrid`.



If the shot doesn't hit a ship, the value `Shot::Impact::NONE` is returned. If a ship is hit, `Shot::Impact::HIT` is returned. If the hit is the final hit, i.e. the ship is sunk by the hit, `Shot::Impact::SUNKEN` is returned. To detect a hit, iterate over all ships and check if the target position is a member of the occupied positions. To detect the final hit, check the intersection of the ship's occupied fields and all taken blows before the current one. If the size of the intersection is one less than the length of the ship, the current hit is the final one.

Add a file `"part3tests.cpp"` to your project and provide tests for shots (misses, hits, final shots) following the pattern outlined by the tests provided for exercise 1. You may give it a try to write the tests first, thus documenting your developing comprehension of the problem, and provide the implementation later. In a way, tests can also serve as a documentation of a software's behavior. In a real project, the implementation and the tests are usually written by two teams in parallel. This can help to make sure that people from two groups with different perspectives have the same understanding of a specification (this is one of the topics of software engineering).

Update the class `ConsoleView` to also show the misses (use a circumflex instead of the dot) and the hits (use an 'O' instead of the sharp).

Here is the sample output for the board after shooting at B3, B4 and B5:

[illegible]

Finally, we have to include the information about the opponent's ships into our model. Add the method `shotResult` (as specified by the UML class diagram) to the class `OpponentGrid`. The method adds the shot and its result to the data member `shots` and updates the list of sunken ships. Find out yourself how to derive the information about whether a ship has been sunken by a shot and about its bow and stern yourself. Be prepared to explain your approach during the review. Add tests to `"part3tests.cpp"` that confirm the working detection of sunken ships.

Again, update the implementation of `ConsoleView::print` to also display the information obtained about the opponent's ships.

Here is the sample output for the board after having hit one of opponent's ships twice and sunk another one (and there were some misses, of course).

[illegible]

For the presentation of your work, it is sufficient to simulate the game by invoking the appropriate member functions one after the other and display the updated state after each change. You don't have to implement a "command line interpreter" that reads from `cin` and updates the model interactively. Although, of course, this would be a nice voluntary addition that allowed you to really play the game with a fellow student.

[1] Or some other search engine.

[2] Don't be tempted to produce fixed output. Arbitrary modifications of the ships' positions will be part of the review.