## High-Quality Code Exam – Boat Racing Simulator

It’s the summer, blue skies, crazy heat, perfect time for the beach and you’re at home writing a boat racing simulator, aren’t you lucky. Well as luck would have it, last week you were commissioned by **Motorboat McGee**, an owner of a gaming website, to fix their new game. Their last developer suddenly had a life realization, that he should become a life guard, so he abandoned the project and ran away. With no one left to turn to **Motorboat McGee** found you – a freelancer and offered to hire you permanently as their new main developer if you can refactor the game to a good state.

Your task is to **refactor the code**, using all best practices in **object-oriented design** and **object-oriented programming**, **SOLID** principles, and **design patterns**. You have to **improve the code quality**. You also have to **fix any bugs** that maybe left, and **improve the general performance** (execution speed) of the code. Since the last person on the job didn’t understand unit testing he didn’t **write** any **unit tests**, so you have to write them as well.

You are given the original code and the design document, specifying the task at hand. Motorboat McGee also gave you two sample test cases to help you check how the application works, he also told you that the project passed code review at some earlier stage in development, so **parts of the code are already well written and following the specification** and don’t need to be refactored, but feel free to refactor them if you think you can improve them.

**Ensure the application follows the design document strictly.**

## Overview

The Boat Racing Simulator holds information about **Boats, Boat engines** and a **Race**.

The system contains methods for **creating boat engines, creating boats, opening a race, signing up boats** (for the race)and **starting the race.**

There are four types of boats:

* **Row Boat** which hasa **model, weight** and **oars.**
* **Sail Boat** which has a **model, weight** and **sail efficiency.**
* **Power Boat** which has a **model, weight** and **two** **boat** **engines.**
* **Yacht** which has a **model**, **weight, boat engine** and **cargo weight.**

A boat’s **model** is **unique** – there cannot be two boats with the same model.

A **Boat Engine** has **model** and **output,** there are two types of engines **Jet Engines** and **Sterndrive Engines**. An engine receives **horsepower** and **displacement** and calculates its own **output**. The formulas are as follows:

|  |  |
| --- | --- |
| Engine Type | Output |
| Jet Engines | (Horsepower \* 5) + Displacement |
| Sterndrive Engines | (Horsepower \* 7) + Displacement |

A boat engine’s **model** is **unique** – there cannot be two boat engines with the same model.

A **Race** contains **distance, wind speed, ocean current speed**, a collection of participants (boats that have signed up for the race) and an **AllowMotorboats** propertythat signifies if motor boats (boats which have an engine) are allowed. A **Race** also contains methods for adding to and returning the collection of participants, adding participants should check if a participant with the same **Model** has already been registered for the race and throw a **DuplicateModelException** in such a case.

**CreateBoatEngine** triesto make a new boat engine of the specified type and if the parameters passed are valid saves the resulting engine in the system.   
**Note:** The only valid engine types at the current time are “Jet” and “Sterndrive”.

There are four methods for creating boats - **CreateRowBoat, CreateSailBoat, CreatePowerBoat and CreateYacht,** each tries to create anew boat of its type and if the parameters passed are valid saves the resulting boat in the system.

**OpenRace** creates a race with the specified parameters and tries to set the current race to the created one. There can only be one race at a time, if there is an already set up race the command fails.

**SignUpBoat** attempts to sign the boat with the specified **model** into the current race, if the type of the boat does not meet the requirements of the race (i.e. the boat is a Yacht and the race does not allow Motorboats) the command fails and throws an exception.

**StartRace** starts the current race, all boats that signed up for the current race compete and the 3 with the fastest time for the race are printed as winners, after this command the current race is cleared. The way to calculate the speed (m/s) for the current race for each boat type is as follows:

|  |  |
| --- | --- |
| Boat Type | Speed |
| Row Boat | (Oars \* 100) - Boat Weight + Race Ocean Current Speed |
| Sail Boat | (Race Wind Speed \* (Boat Sail Efficiency / 100)) – Boat’s Weight + (Race Ocean Current Speed / 2) |
| Power Boat | (Engine 1 Output + Engine 2 Output) - Boat’s Weight + (Race Ocean Current Speed / 5); |
| Yacht | Boat Engine Output - (Boat Weight + Cargo Weight) + (Race Ocean Current Speed / 2); |

**It is important to note** that the resulting speed for boats **CAN be negative or 0,** in that situation the boat will **NEVER finish** and in place of its Time it should print **“Did not finish!”. If two or more boats have the same time/did not finish, their placements are determined by the order of signing up to the race.** (check the sample output to gain a better idea of how it works).

## System design

The core of the system is the **engine**, it reads lines from the standart input (console) splits each into command name and parameters and passes them to a **Command Handler,** the engine also **catches any exceptions** and prints their message on the standart output(console).

A sample input line is shown below:

CommandName\value1\value2\..

**Values** will consist only of **Latin letters** and **numbers**. The **command name** and **values** will be seperated by a single **“\”. All commands given will be correct** (will contain only correct command names, number of parameters and parameter types), **you don’t have to check them specifically**.

The **Command Handler** delegates all actions to a **controller.** Using the parsed input from the engine, it calls actions from the **controller** and optionally **parses the passed parameters** if needed.

In order to work with model collections, the project has a **data layer**. The data layer consists of **repositories**. A repository contains objects of the same type and provides methods for the following:

* **Getting an item** by its unique Model (should throw **NonExistantModelException** if an item with the given model does not exist in the database).
* **Adding** a new item (should throw **DuplicateModelException** if an item with the same model already exists in the database).

A **database** class combines all repositories defined for the application.

The **controller** contains the main business logic of the application. It contains a **database** and all the **actions**. An **action** is a public method which either returns a **string result** or throws an **exception** and can optionally accept parameters.

The **controller** checks the validity of the current action. For example, if a command for starting a race is received while there is no currently set race the system will reject the request and throw a **NoSetRaceException** with the message **"There is currently no race set."**.

**Models** are classes containing information about the real-world objects the system works with. The system should supportall the above mentioned types of **Boats, Boat Engines** and **Race**:

Not all models are valid. The validation rules for the models are given below:

* A Boat’s model must be at least 5 symbols long.
* A Boat Engine’s model must be at least 3 symbols long.

In case the validation fails the system throws an **ArgumentException** with the message:

**Model's name must be at least [min model's length] symbols long.**

* A Boat’s Weight must be a positive (non-zero) integer.
* A Row Boat’s Oars must be a positive (non-zero) integer.
* A Yacht’s Cargo Weight must be a positive (non-zero) integer.
* A Boat Engine’s Horsepower must be a positive (non-zero) integer.
* A Boat Engine’s Displacement must be a positive (non-zero) integer.
* A Race’s Distance must be a positive (non-zero) integer.

In case the validation fails the system throws an **ArgumentException** with the message:

**[Parameter's name] must be a positive integer.**

Where Parameter’s name can only be one of the following **“Weight”, ”Oars”, “Cargo Weight”, ”Horsepower”, “Displacement”, “Distance”.**

* A Sail Boat’s Sail Effectiveness must be between [1…100].

In case the validation fails, the system throws an **ArgumentException** with the message:

**Sail Effectiveness must be between [1...100].**

## System functionality

The air conditioner tester system contains the following commands:

* **CreateBoatEngine\<model>\<horsePower>\<displacement>\<type>**Creates a new boat engine of the specified type model, horsepower and displacement.

|  |  |  |
| --- | --- | --- |
| **Case** | **Message** | **Exception** |
| Success | Engine model [model] with [horsepower] HP and displacement [displacement] cm3 created successfully. | None |

* **CreateRowBoat\<model>\<weight>\<oars>**
* **CreateSailBoat\<model>\<weight>\<sailEfficiency>**
* **CreatePowerBoat\<model>\<weight>\<boatEngine>\<secondEngine>**
* **CreateYacht\<model>\<weight>\<boatEngine>\<cargoWeight>**Depending on the method creates a new Row Boat,Sail Boat, Power Boat or Yacht with the given parameters.

|  |  |  |
| --- | --- | --- |
| **Case** | **Message** | **Exception** |
| Success | [Boat type] with model [model] registered successfully. | None |

* **OpenRace\<distance>\<windSpeed>\<oceanCurrentSpeed>\<allowsMotorboats>**Creates a new Race with the specified parameters and tries to set it as the current Race, if the currentRace is already set, the command fails and throws and exception.

|  |  |  |
| --- | --- | --- |
| **Case** | **Message** | **Exception** |
| Success | A new race with distance [distance] meters, wind speed [windSpeed] and ocean current speed [oceanCurrentSpeed] has been set. | None |
| The current race has already been set. | The current race has already been set. | RaceAlreadyExistsException |

* **SignUpBoat\<model>**Signs up the boat with the specified model in the current Race. If there is no currently set up Race or the type of boat is not allowed by the race, the command fails and throws an exception.

|  |  |  |
| --- | --- | --- |
| **Case** | **Message** | **Exception** |
| Success | Boat with model [model] has signed up for the current Race. | None |
| The current Race has not been set. | There is currently no race set. | NoSetRaceException |
| The specified boat does not meet the race constraints. | The specified boat does not meet the race constraints. | ArgumentException |

* **StartRace**Start the current Race, each participant’s time for completing the race is calculated and the 3 with the best times (smallest times) are printed in ascending order. The current Race should be cleared(removed) after this command.  
  **Note:**Time should be **rounded to exactly two decimal places**.

|  |  |  |
| --- | --- | --- |
| **Case** | **Message** | **Exception** |
| Success | First place: [typeOfBoat] Model: [model] Time: [boatsRaceTime]  Second place: [typeOfBoat] Model: [model] Time: [boatsRaceTime]  Third place: [typeOfBoat] Model: [model] Time: [boatsRaceTime] | None |
| The current Race has not been set. | There is currently no race set. | NoSetRaceException |
| There are less than 3 boats registered for the race. | Not enough contestants for the race. | InsufficientContestantsException |

Model the system and all entities using the best established practices in object-oriented design and object-oriented programming.

The input should be read from the console. The output is written to the console. The input and output formats have been specified above.

## Sample Input 1

|  |
| --- |
| CreateBoatEngine\GPH01\250\100\Jet  CreateBoatEngine\GPH02\150\150\Sterndrive  CreateRowBoat\Rower15\450\6  CreatePowerBoat\PB150\2200\GPH01\GPH02  CreateSailBoat\SailBoatPro\200\98  OpenRace\1000\10\5\true  SignUpBoat\SailBoatPro  SignUpBoat\Rower15  SignUpBoat\PB150  StartRace |

## Sample Output 1

|  |
| --- |
| Engine model GPH01 with 250 HP and displacement 100 cm3 created successfully.  Engine model GPH02 with 150 HP and displacement 150 cm3 created successfully.  Row boat with model Rower15 registered successfully.  Power boat with model PB150 registered successfully.  Sail boat with model SailBoatPro registered successfully.  A new race with distance 1000 meters, wind speed 10 m/s and ocean current speed 5 m/s has been set.  Boat with model SailBoatPro has signed up for the current Race.  Boat with model Rower15 has signed up for the current Race.  Boat with model PB150 has signed up for the current Race.  First place: PowerBoat Model: PB150 Time: 2.85 sec  Second place: RowBoat Model: Rower15 Time: 6.45 sec  Third place: SailBoat Model: SailBoatPro Time: Did not finish! |

## Sample Input 2

|  |
| --- |
| CreateBoatEngine\SI20\200\100\Sterndrive  CreateBoatEngine\SI10\300\200\Jet  CreateRowBoat\MasterRower10\200\4  CreateRowBoat\MasterRower12\100\0  StartRace  CreateRowBoat\MasterRower11\200\4  CreatePowerBoat\Turbo220\1550\SI20\SI10  CreateYacht\Luxury101\1000\SI20\150  SignUpBoat\MasterRower11  CreateSailBoat\SailBoatPro\80\98  OpenRace\1500\150\10\false  SignUpBoat\SailBoatPro  SignUpBoat\Turbo220  OpenRace\2000\80\80\false  StartRace  SignUpBoat\MasterRower11  SignUpBoat\MasterRower10  SignUpBoat\Luxury101  StartRace |

## Sample Output 2

|  |
| --- |
| Engine model SI20 with 200 HP and displacement 100 cm3 created successfully.  Engine model SI10 with 300 HP and displacement 200 cm3 created successfully.  Row boat with model MasterRower10 registered successfully.  Oars must be a positive integer.  There is currently no race set.  Row boat with model MasterRower11 registered successfully.  Power boat with model Turbo220 registered successfully.  Yacht with model Luxury101 registered successfully.  There is currently no race set.  Sail boat with model SailBoatPro registered successfully.  A new race with distance 1500 meters, wind speed 150 m/s and ocean current speed 10 m/s has been set.  Boat with model SailBoatPro has signed up for the current Race.  The specified boat does not meet the race constraints.  The current race has already been set.  Not enough contestants for the race.  Boat with model MasterRower11 has signed up for the current Race.  Boat with model MasterRower10 has signed up for the current Race.  The specified boat does not meet the race constraints.  First place: RowBoat Model: MasterRower10 Time: 7.14 sec  Second place: RowBoat Model: MasterRower11 Time: 7.14 sec  Third place: SailBoat Model: SailBoatPro Time: 20.83 sec |

## Problem 1. Code Refactoring

**Refactor the source code** to improve its quality following the best practices introduced in the course  
“[High-Quality Code](https://softuni.bg/courses/high-quality-code/)”. You may refactor anything, as long as it improves the code quality. You may create as many classes, interfaces, enumerations, structures, etc. as you wish.

**30 score**

## Problem 2. StyleCop

Make StyleCop run without any errors on your code (ignore all documentation-related errors). Use the following StyleCop settings:



**4 score**

## Problem 3. Bug Fixing

**Debug the code** and fix any bugs you find.

**4 score**

## Problem 4. Code Documentation

**Document the following interfaces and methods** using C# XML documentation:

* The interface for the **Race** model (declaration + members)
* The controller method implementing the **CreateBoatEngine** action in the Controller Interface.
* The controller method implementing the **SignUpBoat** action in the Controller Interface.

Any other documentation is **not** required. Each documentation gives 0.75 score.

**6 score**

## Problem 5. Unit Testing

Design and implement **unit tests for** **the following methods:**

* The method implementing the **OpenRace** action.
* The method implementing the **StartRace** action.

Any other code is not required to be tested. The **code coverage** should be **at** **least 80% for the specified methods** (you do not need to cover the class that parses the input commands and prints the output). Be sure to test **all major execution scenarios** + all interesting **border cases** and **special cases**. Use Visual Studio Team Test (VSTT) and VS code coverage.

**30 score**

## Problem 6. Performance Bottlenecks

Find any **performance bottlenecks** and briefly describe them with the following **comment in the code**:

**// PERFORMANCE: <your description of why you think this is a performance bottleneck>**

**Fix the problems** if possible (and leave the bottleneck descriptions in addition to the fixes).

**4 score**

## Problem 7. Correct Results in the Judge System

You are given an automated judge system to submit your solution. If your code is correct (all bugs are fixed) and runs fast enough (the performance bottlenecks are fixed), your solution will pass all the tests. The last 2 tests measure performance. The others measure correctness.

**12 score**

## Problem 8. Mocking

Test the controller action **SignUpBoat** using mocking. You are free to do it manually or use a framework (like Moq for example).

Note that you may need to make your code testable first.

**10 score**

## Problem 9\*. Implement a GetStatistic Command

Implement a **GetStatistic** command which prints the percentage of participants for each boat type in the current race **sorted in alphabetical order** and **rounded to two decimal places**. A third zero test is provided speciffically for this command. Check the example bellow to get a better understanding of the task.

**10 score (bonus)**

## Example input

|  |
| --- |
| CreateBoatEngine\Engine1\100\100\Sterndrive  CreateBoatEngine\Engine2\150\100\Jet  CreateSailBoat\ExampleSailBoat\50\90  CreateRowBoat\ExampleRowBoat\100\4  CreateRowBoat\ExampleRowBoat2\120\6  CreatePowerBoat\ExamplePowerBoat\800\Engine1\Engine2  CreateYacht\ExampleYacht\700\Engine2\150  OpenRace\100\10\5\true  SignUpBoat\ExampleSailBoat  SignUpBoat\ExampleRowBoat  SignUpBoat\ExampleRowBoat2  SignUpBoat\ExamplePowerBoat  SignUpBoat\ExampleYacht  **GetStatistic**  StartRace |

## Example output

|  |
| --- |
| Engine model Engine1 with 100 HP and displacement 100 cm3 created successfully.  Engine model Engine2 with 150 HP and displacement 100 cm3 created successfully.  Sail boat with model ExampleSailBoat registered successfully.  Row boat with model ExampleRowBoat registered successfully.  Row boat with model ExampleRowBoat2 registered successfully.  Power boat with model ExamplePowerBoat registered successfully.  Yacht with model ExampleYacht registered successfully.  A new race with distance 100 meters, wind speed 10 m/s and ocean current speed 5 m/s has been set.  Boat with model ExampleSailBoat has signed up for the current Race.  Boat with model ExampleRowBoat has signed up for the current Race.  Boat with model ExampleRowBoat2 has signed up for the current Race.  Boat with model ExamplePowerBoat has signed up for the current Race.  Boat with model ExampleYacht has signed up for the current Race.  **PowerBoat -> 20.00%**  **RowBoat -> 40.00%**  **SailBoat -> 20.00%**  **Yacht -> 20.00%**  First place: PowerBoat Model: ExamplePowerBoat Time: 0.12 sec  Second place: RowBoat Model: ExampleRowBoat2 Time: 0.21 sec  Third place: RowBoat Model: ExampleRowBoat Time: 0.33 sec |