User Story 420 – Analysis / Implementation

Introduction:

In this document we'll be describing how we derived all the formulas needed to calculate the various parameters for acceptance criteria. Also we'll be talking about how we implemented said formulas in java and into our application.

Analysis:

In this user story, we are requested to calculate the height above water of a loaded container ship, the total mass of the containers and the pressure that said containers exerted on the water. In order to achieve the required calculations, we resorted to Arquimedes' principle which states that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially, is equal to the weight of the fluid that the body displaces. We also know that, in order for a solid to remain afloat, this buoyant force must be equal to its weight.

The buoyant force is calculated from the following formula:

$$\mathcal{F}i = d * g * \mathcal{V}$$

Where:

- d represents the fluid's density;
- g represents the gravitational acceleration;
- and $\mathcal{V}$ represents the volume of water displaced.

The weight of the body is calculated from the following formula:

$$\mathcal{P} = m * g$$

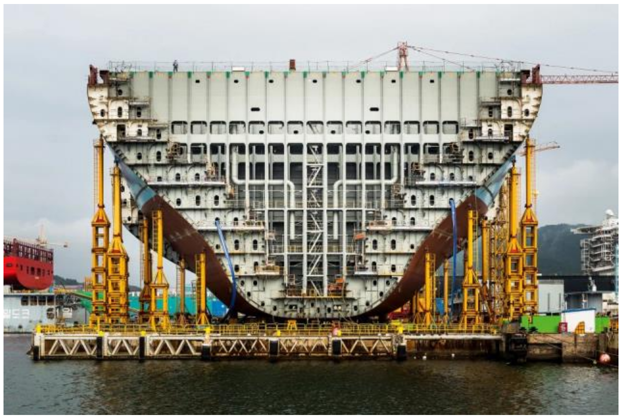
Where:

- m represents the mass of the body.

Therefore, we can derive the following formula:

$$\mathcal{F}i = \mathcal{P} \Leftrightarrow m = d * \mathcal{V}$$

For the resolution of the problem, we also simplified the ship's shape into 2 prisms. A rectangular prism represents the top half of the ship, above the water line, and a trapezoidal prism represents the under half.



Seeing as, for this exercise, only the effects of the container ships' weight on the ship are relevant to us, we can ignore the ship's weight and apply the container ship's weight to the top half prism. Imagine we have a weightless prism floating above water, and we start applying the container's weight to that prism.

To calculate the prisms volume underwater we simply multiply height by area. Which leads us to this formula for underwater volume:

$$V = h * w * l$$

Applying it to our last equation:

$$m = d * w * l * h \Leftrightarrow h = m / (d * w * l)$$

Now we have a formula to calculate the ship's height difference depending on cargo weight. From here it is as simple as subtracting this value to the ship's draft to obtain the ship's current height above water:

$$\text{height above water} = \text{draft} - \text{height difference}$$

Implementation:

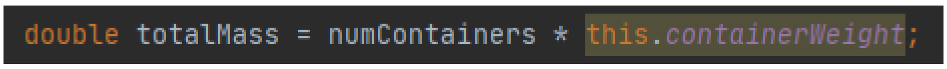
Now, we'll talk about how we implemented this function in java. As in most other US, we split the main operation in 2 classes. One class that serves as a user interface (*ShipWaterPhysicsUI*) the other serves as a controller and contact with the other classes of the application (*ShipWaterPhysicsController*). In the controller class there are also 3 variables with constant values; those are:

- "*waterDensity*", this stores the average density of salt water (1.030 kg/m^3);
- "*containerWeight*", this stores the weight of every container (500 kg);
- "*gravityAccelaration*", this one stores the acceleration of gravity (9.81 m/s^2).

The UI promptly displays a list of ships stored in the data base, through the method "*getShipCaptainShips*" store in the "*DataBaseUtils*" class. After picking the desired ship, the user is then presented again with a choice of which cargo manifest to pick from a list. This list is, again, gotten from the "*DataBaseUtils*" with the "*getShipCargoManifest*" method.

After picking the desired cargo manifest, the user may then be presented with the total mass and pressure exerted of the container ships, as well as the height above the water of the ship, the original draft height and the height difference. To achieve this, the user interface class simply calls upon the "*calculateData*" method from the controller which then proceeds to make call 3 other methods to calculate needed.

The first calculation done is the total mass of the containers. The controller calls the "*countContainerByCargoManifest*" method from the "*DataBaseUtils*" class again, with the previously selected *"cargoManifest String"* as a parameter. This method is used to get the number of containers present in the cargo manifest. It then call its own "*calculateTotalMass*" method with the number of containers as the parameter. The total mass should be calculated by simply multiplying the container count by the weight of every unit:



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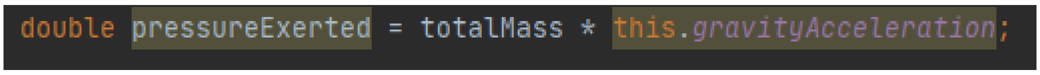
double totalMass = numContainers * this.containerWeight;
```

The next calculation to be needed is the pressure exerted on the water surface by the total mass of the containers. The controller calls the "*calculatePressureExerted*" method, using the *"totalMass"* variable as the parameter. It then calculates the pressure by simply applying the before mentioned formula and multiplying total mass by the gravitational acceleration:



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double pressureExerted = totalMass * this.gravityAcceleration;
```
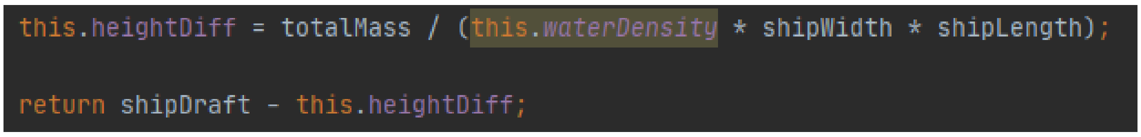

Finally the last calculation needed is the calculation of the height above water. To reach this, the controller, again, calls upon the "*calculateHeightAboveWater*" method using the total mass of the containers, the ship's width, the ship's length and the ship's draft as the parameters. It then simply applies the before mentioned formula to get the height difference and then subtracts that from the ship's draft height:



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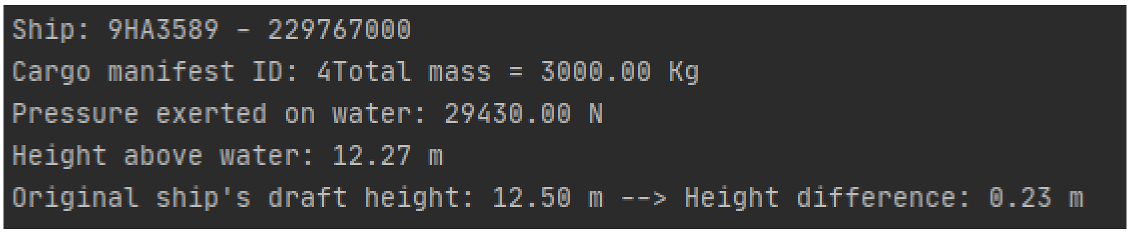
this.heightDiff = totalMass / (this.waterDensity * shipWidth * shipLength);

return shipDraft - this.heightDiff;
```

All of this information is stored in the controller as the variables:

- "*totalMass*", total mass of the containers;
- "*pressureExerted*", pressure exerted on the water by the mass of the containers;
- "*heightDiff*", height submerged under water, caused by the additional weight of the containers;
- "*heightAboveWater*", height of the ship above water.

The UI then promptly calls the "*SummaryString*" method from the controller class, which organizes all the previously gathered information and presents it to the user.



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Ship: 9HA3589 - 229767000
Cargo manifest ID: 4Total mass = 3000.00 Kg
Pressure exerted on water: 29430.00 N
Height above water: 12.27 m
Original ship's draft height: 12.50 m --> Height difference: 0.23 m
```