Designing a Model Ship

NORMANDY 2

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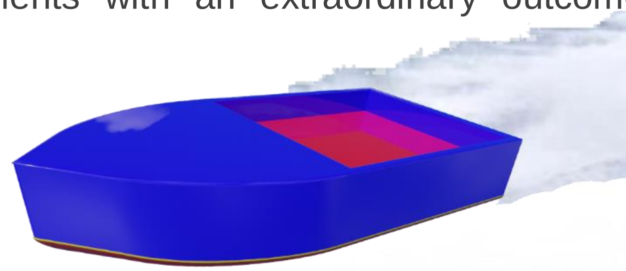
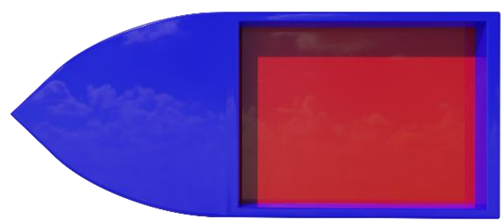
Abstract

As it is required to build a ship with the ability to carry a standard cargo load of 1 can of soft drink (330ml) and must be stable in both cases loaded or unloaded. As a cooperative team, we fulfilled the requirements with an extraordinary outcome "*Normandy 2*".



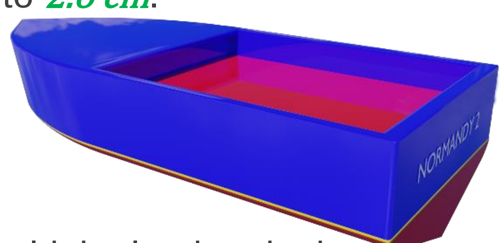
Design Evolution

Phases were tackled by the team members to develop a fruitful result beginning with brainstorming and collaboration where we shared our ideas and developed them together followed by the illumination phase where we put the strategy, the costs, material selection, and the timeline to get the work done due to the set deadline. As everything comes to an end, implementation was our last to make ideas real and test the creation.



Frame Design

The boat's frame was carefully designed to be stable loaded and unloaded. For fixations, a squared groove was made to maintain the components. The unloaded boat's dimensions are *36 cm* in length and *20 cm* in width, *1598.16883* cm^3 in volume, and *3689.3515* cm^2 in area, where its height from the hull to the waterline is *1.4 cm*. These dimensions include the likes of the motor, the propeller, and the battery. When the can is included the height of the water line increases to *2.6 cm*.



Material Selection

Foam has proved its ability in compromising strength to hold the load and other components and being stable while loaded and unloaded. Foam appeared to be the most cost-effective compared to other materials such as wood or plastic polymers.

Calculations

Immersed Volume :

Unloaded :

Boat Mass = 470 grams, Seawater Density = 1030 kg/m^3, Immersed Height = 1.4 cm

$$Volume_{immersed} \times \rho_{fluid} = Volume_{body} \times \rho_{solid}$$
$$V_{imm} = \frac{m_{body}}{\rho_{fluid}} = \frac{0.47}{1030}$$
$$V_{imm} = 4.56 \times 10^{-4}\ m^3$$

Loaded :

Boat Mass = 840 grams, Seawater Density = 1030 kg/m^3, Immersed Height = 2.6 cm

$$Volume_{immersed} \times \rho_{fluid} = Volume_{body} \times \rho_{solid}$$
$$V_{imm} = \frac{m_{body}}{\rho_{fluid}} = \frac{0.84}{1030}$$
$$V_{imm} = 8.155 \times 10^{-4}\ m^3$$

Stability Check :

Unloaded :

Boat Mass = 470 grams, Center of Gravity (From Solidworks) = 50 mm
Center of Buoyancy (From Solidworks) = 12.48 mm, Volume $_{immersed}$ = 4.56 x 10^{-4} m^3
Second moment of area (From Solidworks) = 197200620.36 mm^4

$$BG = KG - KB = 50 - 12.48$$
$$BG = 37.52\ mm$$

$$BM = \frac{I}{V_{imm}} = \frac{197200620.36 \times (10^{-3})^4}{4.56 \times 10^{-4}}$$
$$BM = 0.432\ m = 432.46\ mm$$

$$BM > BG \rightarrow \therefore Boat\ is\ stable$$

Loaded :

Boat Mass = 840 grams, Center of Gravity (From Solidworks) = 50 mm
Center of Buoyancy (From Solidworks) = 22 mm, Volume $_{immersed}$ = 8.16 x 10^{-4} m^3
Second moment of area (From Solidworks) = 143052480.16 mm^4

$$BG = KG - KB = 50 - 22$$
$$BG = 28\ mm$$

$$BM = \frac{I}{V_{imm}} = \frac{143052480.16 \times (10^{-3})^4}{8.16 \times 10^{-4}}$$
$$BM = 0.175\ m = 175.42\ mm$$

$$BM > BG \rightarrow \therefore Boat\ is\ stable$$

Ship Resistance (Drag Force) :

Unloaded :

Seawater Density = $1030\ \mathrm{kg/m^3}$, Velocity (Calculated after trials) = $0.4667609\ \mathrm{m/s}$,
Wetted Area = $0.11401175\ \mathrm{m^2}$, Water's Kinematic Viscosity = $1\ \mathrm{mm^2/s}$

$$Re = \frac{Velocity \times Length}{Kinematic\ viscosity} = \frac{0.4667609 \times 0.36}{1 \times 10^{-6}} = 168033.924$$

$$Resistance\ coefficient = \frac{0.075}{(\log_{10} Re - 2)^2} = 7.2 \times 10^{-3}$$

$$Resistance = Cf \times \frac{1}{2} \times \rho \times v^2 \times A_{imm}$$
$$Res = 7.2 \times 10^{-3} \times \frac{1}{2} \times 1030 \times 0.4667609^2 \times 0.11401175$$
$$Resistance = 0.0921\ N$$

Loaded :

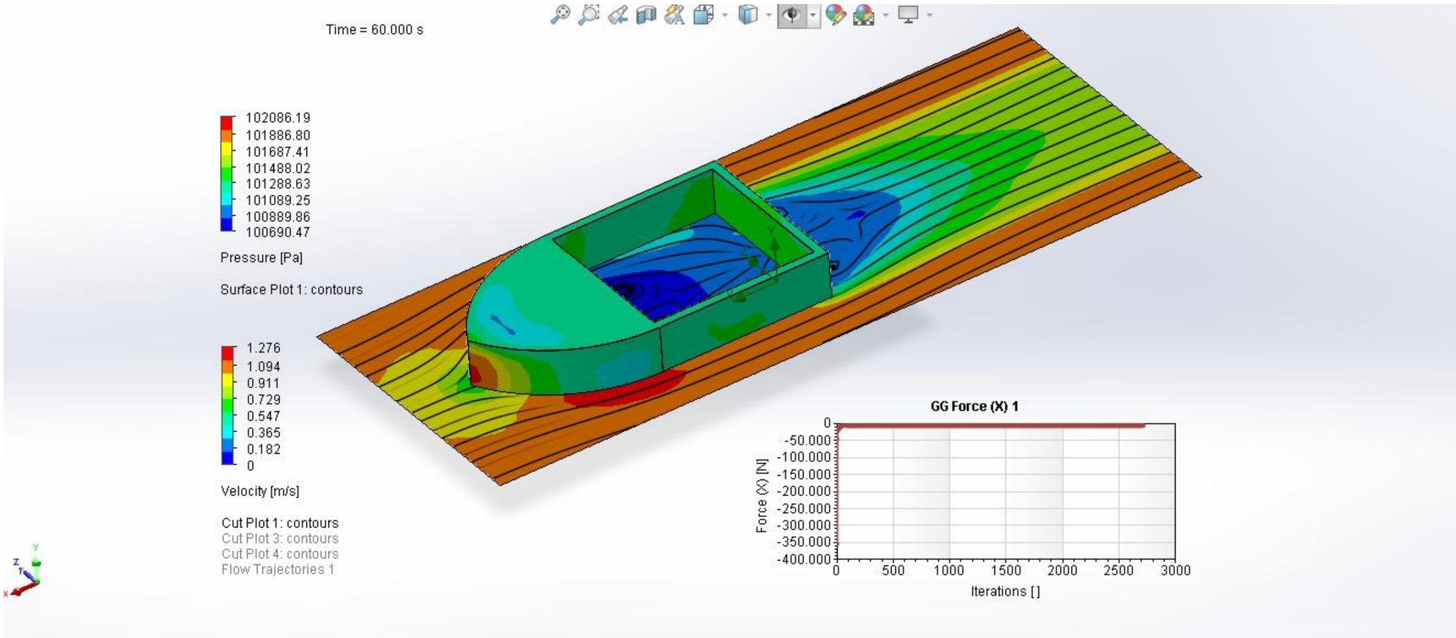
Seawater Density = $1030\ \mathrm{kg/m^3}$, Velocity (Calculated after trials) = $0.37362729\ \mathrm{m/s}$,
Wetted Area = $0.18644327\ \mathrm{m^2}$, Water's Kinematic Viscosity = $1\ \mathrm{mm^2/s}$

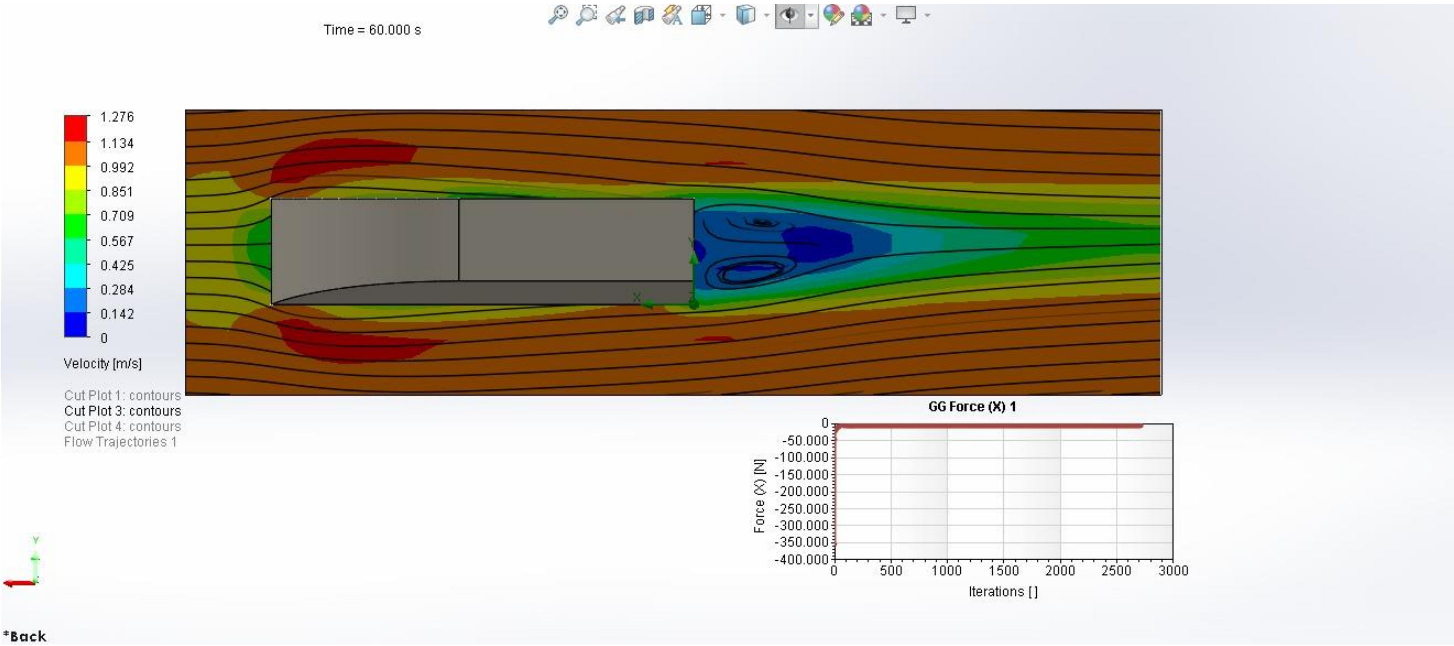
$$Re = \frac{Velocity \times Length}{Kinematic\ viscosity} = \frac{0.37362729 \times 0.36}{1 \times 10^{-6}} = 134505.82$$

$$Resistance\ coefficient = \frac{0.075}{(log_{10} Re - 2)^2} = 7.66 \times 10^{-3}$$

$$Resistance = Cf \times \frac{1}{2} \times \rho \times v^2 \times A_{imm}$$
$$Res = 7.66\ x\ 10^{-3} \times \frac{1}{2} \times 1030 \times 0.37362729^2 \times 0.18644327$$
$$Resistance = 0.1027\ N$$

Flow Simulation :





Drag Force = 0.09 Newtons

Cost Analysis

Component	Description	Status	Cost
Foam sheet	142 gm	New	**300.0**
Dc motor	Dc motor with gearbox 9V	New	**140.0**
Battery	Camelion battery 9V 6F22	New	**20.0**
Battery cap	Battery cap 9V	New	**2.0**
Propeller	Red plastic 4 blades propeller	New	**15.0**
Switch	On/off red switch 3 pins 6A 250VAC 15x21mm	New	**2.0**
			479.0