Trimaran Canoe

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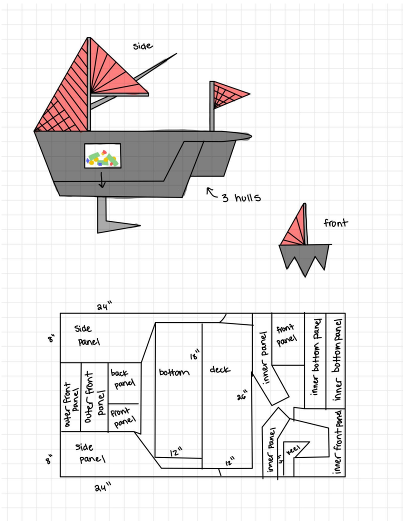

Figure 1. Iteration 1

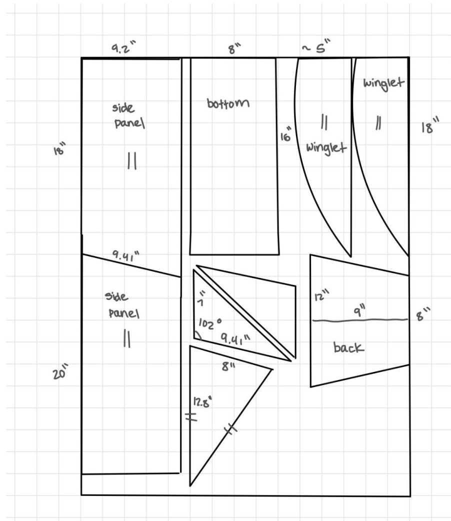

Figure 2. Iteration 2

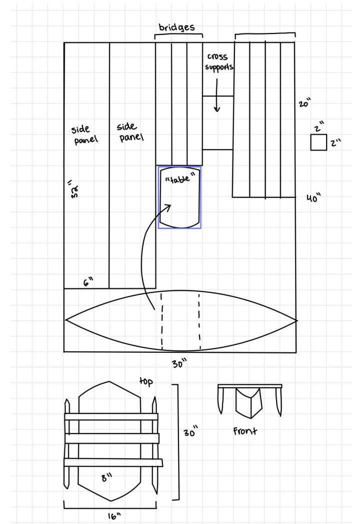

Figure 3. Iteration 3

Preliminary Designs

Iteration 1: Our first iteration was a very rough sketch of a trimaran boat that featured three different hulls. The design made use of elements such as extra sails and a keel which aided in navigability. The dimensions shown in Figure 1 were preliminary and were primarily used to begin thinking about how our pieces would fit on our board.

Iteration 2: After modeling our design in SolidWorks, we discovered that our original design would have been extremely difficult to perform calculations on and construct. This realization led us to our second iteration, depicted in Figure 2, which featured side winglets to provide stability and featured only a singular hull to improve hydrodynamics. The issue we ran into with this design, is that in order to hit a target located 12" above the water level, our payload would need to be located much higher up from the bottom of the boat, than what was feasible with the amount of excess foam board.

Iteration 3: For the trimaran element of the canoe, the design features two outriggers connected to the main canoe through three bridges. The reason we decided to simplify our design again was to make optimization easier. We needed the boat to be stable, but require less surface area. With these changes, we were able to heighten the payload and make efficient use of materials.

Table 1. Calculations

Measurement	Iteration 1	Iteration 3
surface area (ft^2) = length*width	7.5428	6.1953
boat volume (ft^3) = length*width*height	0.6250	0.5305
mass with payload (slugs) = (surface area)*thickness*ρ_f + payload	0.2388	0.3068
weight without payload (lb) = mass*g	1.0702	3.2501
buoyancy (lb) = volume*g*ρ_w	39.0425	33.1403
ΣFy (lb) = buoyancy - weight	31.3521	26.1279
specific gravity = mass/(volume*ρ_w)	0.1970	0.2116
waterline (ft) = specific gravity*height	0.3132	0.1058
height of target on mast (ft) = waterline + 1ft	1.3132	1.1058
distance between center of mass and center of buoyancy (measure of stability)	0.6148	0.4344

Justifications:

One of the tradeoffs that we made for our third design is reducing the surface area and volume to improve speed. This reduced the buoyant force, but it is still large enough to compensate for the payload weight.

Hull: Our hull design is vaguely based off of a Polynesian outrigger canoe: we highly increased speed and hydrodynamics while still maintaining our trimaran boat style that would successfully carry a payload and joust. In an attempt to optimize lowering the center of mass and lengthening the joust, we adjusted the height of the payload table to 4 inches.

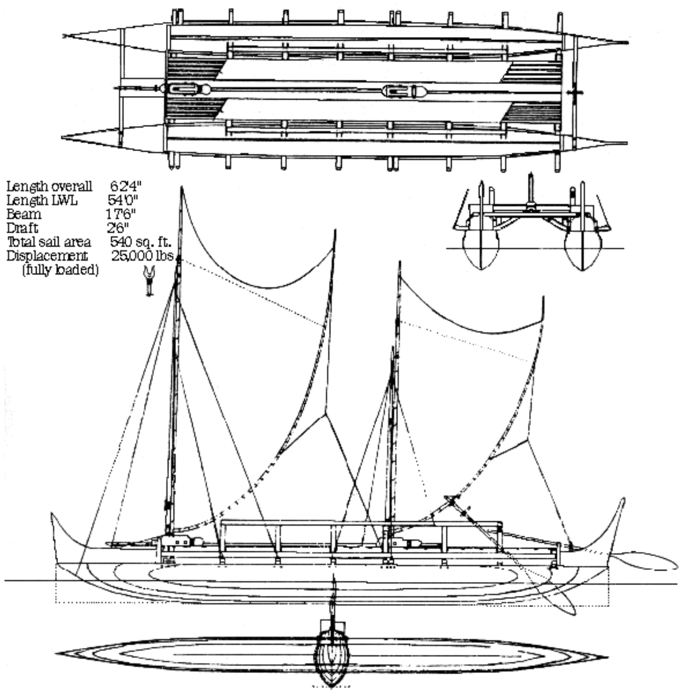

Figure 4. Polynesian outrigger canoe

Sail/mast:
We chose to include a trapezoidal sail on our boat. Since we designed our sails after crafting the boat's hull, one ratio we looked at was sail area to water displacement (Rustler Yachts).

$$\frac{\text{Sail area in ft}^2}{(\text{Displacement in ft}^3)^{2/3}}$$

Figure 5. Sail Area Ratio

Apparently, this ratio can be between 10 and 20 for a successful boat, but we chose 20 because this corresponds to a faster design.

sail area = 20*(water displacement) = 20*(area of base)*(waterline height) = 4.7 ft^2
area of trapezoid = $0.5*(b_1+b_2)*h$

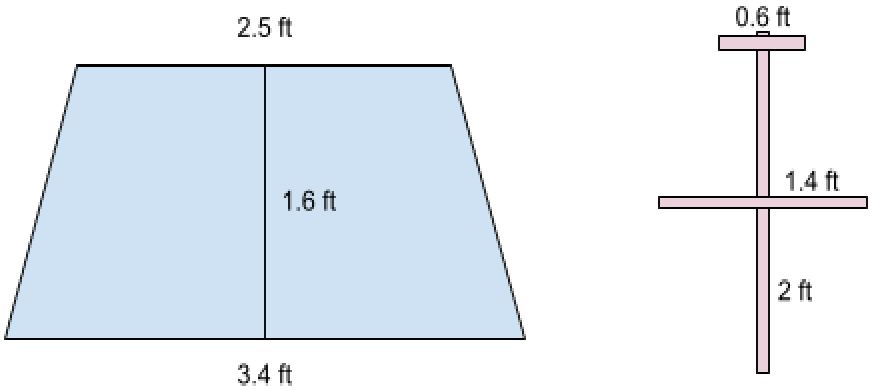

Figure 6. Sail and Mast Design

We chose the orientation of our point of sail based on this image:

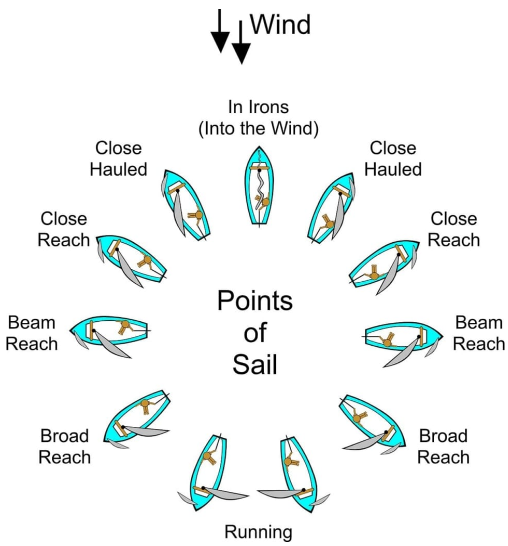

Figure 7. Point of Sail

Our project has an advantage because we can change the direction of our wind with a fan. Consequently, we decided to aim for a running point of sail since our goal is to steer mostly forward.

Progress: We have completed assembly of the hull, payload housing, and outriggers. These three sections have been flexsealed and our next step will be to assemble them together with the mast, sail, and joust. We also have not finalized our joust design, but we have ideas that we will decide on today.

Sources:

https://archive.hokulea.com/ike/kalai_waa/kane_search_voyaging_canoe.html
https://www.rustleryachts.com/useful-formulas-to-help-you-choose-a-boat/