of trigonometry no more complicated than finding unknown sides or angles in a right triangle using sin, cos and tan functions.

The actual detailed mathematics used are given in the appendix along with a program flow chart and other supplemental data. For purposes of explanation, I will give a somewhat stripped-down version of the program's operation, but first a bit of background to the problem.

I started my research on a particular boat type by making a detailed set of measurements of cross-sections of the boat every 50 cm along with the profile and plan views. These measurements were then translated into a set of two-dimensional lines drawings as shown in figure 1 which is a kayak in the collections of the National Museum of Man. Many of the interesting calculations that are useful for comparative purposes depend on knowing the length of the waterline and its exact location. This will vary depending on where people and cargo are placed in the boat. If I had a usable kayak I could obviously put it in a tank of water and see where the waterline fell under different loading conditions such as when I was in it or when I added a seal inside or one on the after deck, etc. With museum specimens this is not a desirable thing to do. It is simpler and more practical to do a computer simulation of the tank of water and kayak.

Imagine, if you will, an empty boat in a barn suspended over a large horse trough full of water as in figure 2. The boat is held by vertical ropes attached to the bow and stern. The ropes, run through pulleys, can be slacked off to lower the boat. Equate this to figure 1 where the baseline or datum line is equivalent to the water surface in the horse trough. We slowly lower the boat to the surface of the water measuring its vertical travel from the starting position. After is is lowered a little into the water we stop and collect any water that spilled over the side of the tank. We weigh the water and compare it to the weight of the boat which we found previously by putting it on a scale. We find that the boat weighs more than the water so we lower the boat just a little more and add the new water spilled to the amount we had before. Again we compare it to the boat's weight and again find that the water weighs less than the boat. We lower the boat a little more and go throught the whole procedure as many times as necessary until the weight of the water spilled over the top equals the weight of the boat. It would seem, from Archimedes, principle, that we are now in equilibrium and the boat will stay where it is without the ropes attached to the bow and stern. As you suspected, however, there is more to it than that, but let's first see what we have found out.

In the simulation program we mathematically collected and weighed the spilled water by looking at given waterlines on the boat as we lowered it. In other words, we assumed or assigned a waterline and then checked to see if it was correct by computing the volume of that part of the hull that was below the water. Calculating this volume in liters and knowing that one liter equals one kilogram made it simple to compute the weight of water that would fill this volume.

But back to our boat which is part in and part out of the tank. If we let loose the bow and stern ropes we would be in trouble. The boat's bow would rise and the stern fall because the boat was originally suspended from the ceiling with the bow too low. Perfect trim of the boat is achieved when