Title: Thinking about Sinking

*(@ Tow Tank/Vorticity Tank*)Paul: Let us imagine that these two boxes here, ORCA I and ORCA II, are ships. They kind of look like barges.

Since foam is less dense than water, we know that they’ll both float (*place 2 boxes on top of the water*).

Now, lets take ORCA I out of the water and damage it below the waterline (*Take ORCA I out of water and cut hole into box*).

What do you think will happen when I put ORCA I in the water? (*motion of putting box in water*)(*Go to GoPro footage* *while box is sinking*)

If you guessed that the weight of the added water would be enough to sink her (while sinking, still GoPro)… (*cut to CU of box at bottom of tank with Paul*) you’d be right (*box sinks*)

Now let’s take ORCA II and damage it in the same spot and see what happens (*Grab vessel, walk over to table, create same damage, place in water, doesn’t sink).*

You can see that ORCA II did not sink, although it is trimmed, that means angled, to the bow. So, why did ORCA II, a seemingly identical ship, not sink? How do we prevent ships from sinking? (*pause*)

The answer lies in subdivision.

(*B-Roll of sound and showing fast forward vessel traffic at a container terminal/cruise ships, harbor traffic, etc?)*

(*At Hart Nautical Collection @ MIT Museum with Hereshoff half hulls as a backdrop*) If we remove the tops of both ships, called the weather deck, and take a look inside (*Video a close up of removing the decks, just audio voice*), (*back to presenting*) we can see that ORCA II is divided into compartments by these walls called transverse bulkheads, while ORCA I is not.

These compartments are watertight which means that they can be filled with water, without leaking into other compartments (look at camera). This subdivision reduces the amount of water that can enter the vessel if damaged. So a ship can be damaged and still not sink!

(*Top down angle, showing the ships*) So why don’t we just add hundreds of watertight bulkheads, then the ship would never sink? Now remember, most ships are made with materials that sink, like steel, so lets have Archimedes help answer this!

(*Back at Tow Tank*) Archimedes was a Greek mathematician long ago. The story goes that he was in the bathtub when he discovered that the weight of an object is equal to the weight of water it displaces.

(*Different camera angle*) In other words, if we take the underwater volume of the ship and fill it with water, we get the weight of the ship. (*Animation, highlight the underwater volume of ship*) This is best described by Archimedes Principle which states that the Force of Buoyancy = the weight of a unit volume of water times the underwater volume of the ship.

(*@ Tow Tank, CU, boxes out of focus in backdrop*) So what does this have to do with subdivision? Well, if we pretend the box is steel, and we kept adding more watertight bulkheads, which I have indicated by these weights, then the ship would get heavier, causing a larger underwater volume.

You may be asking, “So what! As we have learned, the force of buoyancy equals the weight of the water displaced, so with more underwater volume, there is more upward buoyant force.”

You would be correct. But it gets to a point where if we add too much weight, the ship cannot produce any more upward buoyant force.

(*Animation*) A basic way to describe it is like this. If we take a steel vessel and fill it with more and more steel bulkheads, so much so, that it resembles a solid piece of steel, than it will sink as we already know. In effect, we have taken out all of the air in the vessel, and replaced it with a dense metal. So the density turns out to be greater than 1 and the ship sinks!

(*Pratt School Museum, in uniform*) As a Coast Guard Marine Inspector and naval architect, I have lost sleep over the thought of ships sinking and people being injured. We have to ensure that people on ships are safe by knowing how to divide the compartments. The job carries a lot of responsibility, as does any engineering discipline, but by using science and math we can make sure that our loved ones return safely from the sea!

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