

An Engineer's Perspective: What Caused the Titanic to Sink?

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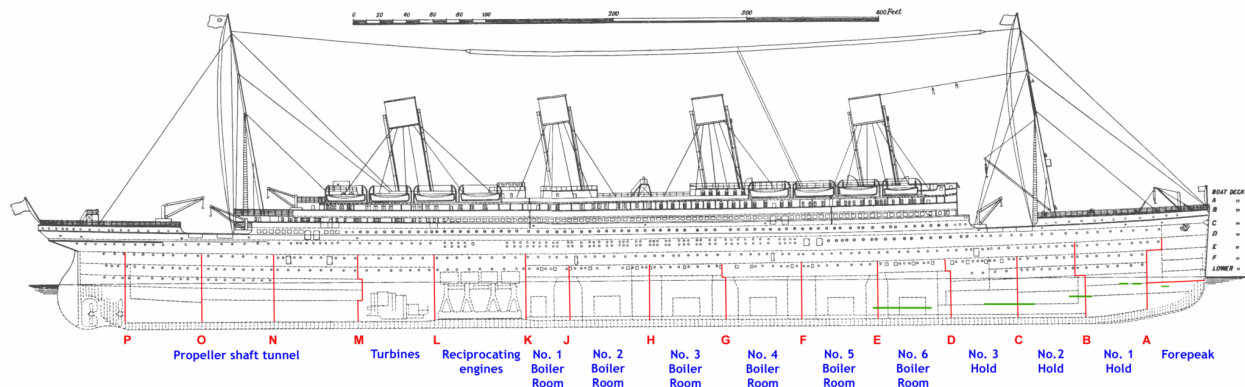
On April 14th, 1912, the Titanic departed from Southampton, England on the way to New York, United States. At the time of its construction, the Titanic was the largest, the most luxurious, and the most technologically advanced ship ever built. It was considered to be unsinkable due to the addition of sixteen major watertight compartments that were to be used to keep the ship afloat should it be damaged. As we now know, the Titanic was definitely not unsinkable. It took less than three hours for the Titanic to sink after colliding with an iceberg leading to the deaths of around 1,500 passengers and crew. So, what made this supposedly unsinkable ship sink? From an engineering and physics perspective, the Titanic sank due to design flaws and poor-quality materials.

The RMS Titanic was designed by Thomas Andrew as a way to compete with White Star Lines' opponents. The design of the Titanic's hull was considered revolutionary. It was divided into sixteen watertight compartments that were built to stay afloat even if some of the components were flooded. This design truly was ingenious and it helped White Star Lines market the Titanic as an "Unsinkable Ship." It must be noted that public opinion at the time was that there was no chance that the Titanic would sink. According to the National Archives and Records Administration, at the time of the launch of the Titanic, an employee of the White Star Line said "Not even God himself could sink this ship" (1998). Confidence was so high that the Titanic was not equipped with sufficient lifeboats as they were deemed unnecessary. When these lifeboats were deployed, they gave priority to first-class passengers. No one was really surprised by this fact but it should be noted that everyone on the ship should've had equal opportunity for a chance at surviving. Figure 1 shows the Titanic's watertight compartments. The problem with these compartments was that they were not fully watertight. There were doors that let passengers

and crew walk past them instead of having to climb up a flight of stairs. Also, these compartments were not enclosed. If water reached the levels above the red lines seen in Figure 1, these watertight compartments became useless.

Figure 1

Titanic's Watertight Compartments

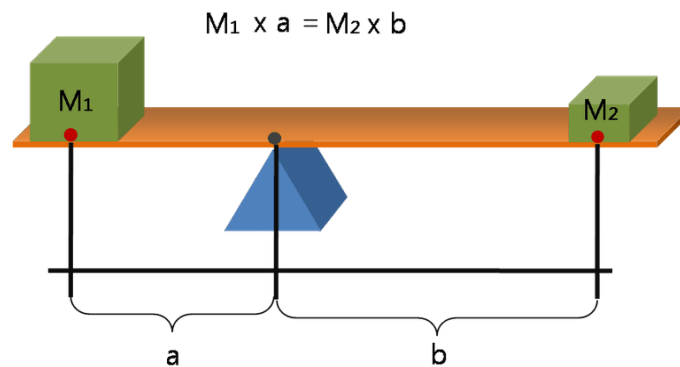


Leading up to the collision with the iceberg, numerous reports came to the Titanic regarding an unusually high concentration of icebergs along its planned route. On April 15, 1912, at 11:35 pm, lookouts spotted a huge iceberg only $\frac{1}{4}$ mile ahead. Frantically, the engines were cut and put in reverse and emergency evasive maneuvers were conducted in an attempt to avoid the iceberg. At 11:40, The Titanic sideswiped the iceberg, damaging nearly 300 feet of the hull (Bassett, 1998). By midnight, the watertight compartments were filling with water. At 2:18 am the bow rips loose and the stern rises to practically vertical. And finally, at 2:20 am, the entire ship slips below the surface.

Physics principles of momentum, density, and lever actions all contributed to the sinking of the Titanic. When Captain Edward Smith tried to avoid the iceberg, momentum shows why this was practically impossible. The Titanic was traveling at 22 knots (about 25 mph) and the iceberg was seen when it was less than a quarter of a mile away. The Titanic had the full momentum of its massive weight (46,000,000 kg) driving it straight toward the iceberg. As a result, turning took a ridiculously long distance and could not be achieved before the collision with the iceberg. Due to the collision with the iceberg, the damage to the hull of the Titanic was significant enough for water to flood six of the sixteen watertight compartments. “The design of these watertight sections allowed for three sections to flood with water and the ship would still remain buoyant. That means that the influx of water to any three compartments would not be enough to throw off the balance of density between the boat and the sea around it” (Neal, 2012). Since more than three (six) compartments were flooded, the balance of density between the heavy boat and the ocean was thrown off. The Titanic’s bow began to tilt down in the front and dip below the surface. The stern of the ship had three heavy propellers and began to lift out of the water. As shown in Figure 2, just like a lever, if the board is not strong enough when there is a force being pushed down on one side and a heavy load on the other side, the board breaks. This is almost identical to what occurred on the Titanic. The front of the ship began to sink, leading to the stern lifting out of the water. Once the ship was at about a 45-degree angle, the stress on the ship exceeded the material limits of steel and the Titanic snapped in half. Once the Titanic was in two pieces, it sank to its final resting place at the bottom of the ocean.

Figure 2

Lever Action with Two Loads on Either End



One of the main reasons why the Titanic sank was the impact on the hull. The high speed of the Titanic during the collision with the iceberg was the beginning. Once the collision occurred, “the hull steel and wrought iron rivets failed, due to ‘brittle fracture’” (Harish, 2022). What is a brittle fracture? “A brittle fracture occurs when an otherwise elastic material fractures without any apparent sign or little evidence of material deformation prior to failure” (Eyres and Bruce, 2012). This is basically a clean break and it is what happened to the hull of the Titanic. Some of the circumstances that increase the chance of a brittle fracture include low temperature, high-impact loading, and high sulfur content. All three were present during the Titanic catastrophe. The freezing Atlantic Ocean meant that the hull was below freezing, there was a high-impact collision with the iceberg, and the hull steel contained high levels of sulfur. Evidence of this was found during dives to the Titanic rest site. Divers retrieved metal pieces from the hull that showed no sign of yielding or deformation. The hull had simply snapped. Before the construction of the ship, Charpy impact test should have been conducted. These tests measure the brittleness of different materials. When steel from the hull of the Titanic was tested, it shattered. The impact on the hull steel was one of the keys to why the Titanic sank.

In terms of engineering, a few things could have been done better. First, the hull steel should have been more ductile. Engineers have learned from this mistake and modern steel can survive a bigger impact as it bends instead of breaking. Next, the design of the watertight compartments was not flawless. The tops of these compartments were open. While this wouldn't have stopped the Titanic from sinking, it would have prolonged the process allowing for other ships to come to rescue the passengers and crew. These watertight compartments actually accelerated the sinking process as they kept the water towards the bow of the ship. While the construction of the biggest ship at the time was an impressive engineering feat, there were still areas that could have been improved.

Although the Titanic was considered an unsinkable ship, this is far from the truth. The Titanic had design flaws and used poor materials. On the night of the Titanic's doom, everything that could go wrong went wrong. The iceberg wasn't noticed until too late. In an attempt to avoid the iceberg, 300 feet of the ship's hull was damaged. The conditions were perfect for a brittle fracture to occur. And human negligence was at an all-time high. The Titanic is an important lesson for engineers as it shows that it is possible for anything to go wrong. Engineers must account for all possible disaster scenarios even if it's they are 100% percent sure that accidents won't occur.

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Whether%20or%20not%20an%20object,the%20ship%20hit%20the%20iceberg.