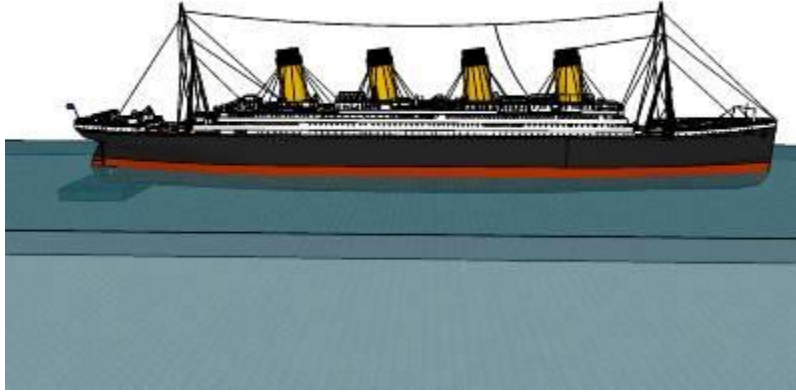


# Curiosity: What Sank the Titanic

(From the “Titanic: 100<sup>th</sup> Anniversary Collection)



In probably the world’s most famous maritime disaster, the luxury ocean liner *Titanic* struck an iceberg in the Atlantic Ocean four days out from Southampton, England, on it’s maiden voyage and sank to the bottom. Out of over 2,200 people on board, only about 700 survived. This film goes to great lengths to reenact accurately the events that led up to, and occurred during, the disaster. Many of the characters, including the ship’s captain, designer, first officer, telegraph operators and so on are depictions of real people.

1. In the seafaring world, the weight of a ship is quoted as the amount (weight) of water displaced by the ship when it is operating as intended. Because the ship is floating, the weight of displaced water must equal the weight of the ship. This is Archimedes Law.
  - a. The maximum displacement of the *Titanic* is quoted as being 52,000 long tons. How much is this in English Pounds (lbs)? (Use 1 long ton = 2,240 lbs)
  - b. However, during the voyage as fuel is consumed the displacement should decrease, and by the time of the accident, the *Titanic*’s displacement was probably around 48,000 long tons. How much is this in lbs?
  - c. If 1 ton = 2000 lbs, then how many regular tons is this?
  - d. How much is this in Newtons (N)? (Use 4.45 N = 1 lbs)
  - e. Use Newton’s law to calculate the mass in Kg:  $W = Mg$  (Use  $g = 9.8 \text{ m/s}^2$ )

- f. The average density of seawater at the surface of the ocean is  $1,027 \text{ kg/m}^3$ . Calculate the volume of displaced water by the *Titanic*: (Use  $D = M/V$ )

[Note: This volume must be equal to the volume of the part of the ship that lies below the waterline.]

- g. When discussing ships, the word “ton” is **also** used to mean something completely volume contained by the ship. A ton in this context is equal to  $2.82 \text{ m}^3$ . So the gross tonnage of the *Titanic* was about 46,000 tons. How much does this equal to in  $\text{m}^3$ ? (We'll call this  $V_x$ )
- h. Because the weight of the ship must equal the weight of displaced water, then what is the density of the *Titanic*?

*Hint:  $M = (D \text{ of ship})(V_x \text{ of ship}) = (D \text{ of water})(V \text{ of water displaced})$*

2. How many men work on the Black Gang?
- According to the movie, how many tons of Coal does the *Titanic* burn each day?
  - According to the movie, how many tons of Coal does the *Titanic* burn each mile?
  - From the calculations, in part (a & b), calculate the average speed of the *Titanic* in miles per hour?
3. According to the movie, how many yards long is the *Titanic*?
4. What was the name of the Captain on the *Titanic*?
5. At 11:40 PM on April 14, 1912, the *Titanic* nearly collides into an iceberg. However it runs over an Ice Run of the iceberg on the *Titanic's* port side in the waters off of Newfoundland. This scrap punctured six compartments near the bow.
- Sketch the incident of the *Titanic* running over the Ice Run of the iceberg.

6. According to the eyewitnesses and an estimation from the video, the iceberg was somewhere between 50-100 feet high and 200-400 feet long. From this information we can estimate the total volume and mass of the iceberg. Let's approximate the shape of the berg to be roughly that of a four-sided pyramid with volume =  $\frac{1}{3} Ah$ .
- We'll take the height to be 75 ft. and the length of the base at the waterline to be 300 ft. Change the ft. to meters: (Use 2.54 cm = 1 inch)
  - Calculate the volume in  $m^3$  of the iceberg using the provided formula: [This is the volume of ice above the waterline]
  - Because the density of ice is 90% that of seawater, what is its density?  
 $D_i = ?$
  - This also means that 90% of the volume of the iceberg is submerged. Therefore, what is the total volume of the iceberg?  
 $V_i = ?$
  - What is the mass of the iceberg? Use:  $M_i = D_i V_i$
  - How does this mass compare with the mass of the *Titanic "M"*?

(Note: the submerged segment, which extends outward from the exposed base, is where a ship is most likely to collide. The *Titanic* was struck approximately 4 m above the keel)

- Why does it take  $\frac{1}{2}$  mile to stop the *Titanic*?
- Since they couldn't stop in time, what did they attempt to do to miss the iceberg?
  - Did they make it?
  - Why did they first turn left and then order a hard to Port (right) into the iceberg?  
Use a sketch:

9. The *Titanic* contained design innovations that theoretically should have made it safer in the event of a collision. In particular, the hull was divided into 16 separate compartments, separated by watertight doors that could be closed in the event of a puncture. Therefore, if one compartment was punctured it could be sealed off, preventing water from entering the rest of the ship and keeping the vessel afloat. However, in the iceberg incident, six separate compartments were punctured with holes that were no more than an inch wide and 144 feet long to Boiler Room #6. Unfortunately, the bulkheads (walls) that separated the compartments only came up 2/3 of the way up the hull and only 10 feet above the water line. If water got above the level of a bulkhead it would start flooding the adjacent compartments even if they were intact. If the compartments had been completely watertight, that is if water could not spill over the top of the bulkheads, then *Titanic* would not have sunk. Let's do some rough calculations to see what happened.
- Let's assume for the sake of simplicity that the ship's compartments have equal volumes, even though some of the forward compartments were actually a little smaller. Therefore, from #1 (f), the *Titanic* floats optimally with  $V$  of its volume submerged. Then dividing this volume among 16 compartments gives a new volume  $V'$  per compartment. What is  $V'$ ?  
[Note: Because the top of the compartments are actually another 10 feet above the waterline this would take away from the compartment volume that can fill with water so we'll stick with the  $V'$  as a reasonable estimate].
  - The ship can drop 3 m (10 ft.) deeper before water can spill over the top of the bulkheads in the other compartments. Additionally, the distance from the waterline to the boat deck was 60 feet under normal conditions. From #1 (g); *Titanic's* total volume is  $V_x$ , then what volume of the ship lies above the waterline?  
Use: Total Volume ( $m^3$ ) – Submerged Volume ( $m^3$ ) =  $V_x - V = V_a$
  - If the ship drops 10 feet, then approximately 1/6 th of that volume will be submerged. What is this volume?
  - Remember, each compartment has a volume  $V'$  from part (a). If you fill four compartments, how many cubic meters can you submerge to? Hint:  $4 \times V'$
  - This means the water level inside the compartments will not rise above 10 feet. What will happen if you fill the 5<sup>th</sup> compartment? [Hint: Compare this with part (c)].

[This is later called the Tipping Point: Boiler Room #6 is the 4<sup>th</sup> compartment and Boiler Room #5 is the 5<sup>th</sup> compartment]

- f. To prevent Boiler Room #6 from filling up with water, they use 2 pumps and 2 drains. According to the movie, how many tons of water do they pump per minute? Does this work at first?
10. What is the Name of the President of the Whitestar Line (The company who owns the *Titanic*)?
11. The punctures on the hull of the *Titanic* were around 4 meters above the keel, or 6 meters below the waterline. We can use Bernoulli's principle to estimate the velocity at which water would be entering the ship through the various punctures. According to Bernoulli's equation:

$$P_1 + \frac{1}{2}Dv_1^2 + D g y_1 = P_2 + \frac{1}{2}Dv_2^2 + D g y_2$$

In this case we are looking at the water at the ocean surface (which is at atmospheric pressure, and essentially has a velocity of zero) versus the water rushing in at the punctures (6 m below the level of the ocean's surface, but also at atmospheric pressure when it enters the ship).

- a. Therefore the equation reduces to:

$D g y_1 = \frac{1}{2} D v_2^2 + D g y_2$ , and setting  $y_2 = 0$ ; and canceling  $D$  on both sides; we get

$g y_1 = \frac{1}{2} v_2^2$ ; Solve for  $v_2$ :

Use  $g = 9.8 \text{ m/s}^2$  and  $y_1 = 6 \text{ m}$ .

- b. Calculate the Area of the puncture if it runs at least 1 inch by 140 feet:  
Give the units as  $\text{in}^2$  and  $\text{m}^2$ .  
Note: 12 inches = 1 foot;  $16.4 \text{ cm}^2 = 1 \text{ in}^2$ ;  $1,000,000 \text{ cm}^2 = 1 \text{ m}^2$   
 $A = ?$
- c. Calculate the flow rate in  $\text{m}^3/\text{sec}$ : Use the formula  $Q_a = A v_2 = \text{Flow rate}$
- d. Change your units from  $\text{m}^3/\text{sec}$  to  $\text{m}^3/\text{min}$ :
- e. Since  $1 \text{ m}^3$  of water is 1000 kg or 2200 lbs, then how many Kg/min, lbs/min and tons/min is that?
- f. How does this compare to #9 (f)? Does this agree with the movie?
- g. However, these calculations assume that the *Titanic* not moving. According to the movie, the President of the Whitestar Line convinces the Chief Engineer to

get the *Titanic* moving. What does this do to your calculations? According to the movie, the added velocity of the *Titanic* pushes the water into Boiler Room #6 Twenty times faster. If this is true, how does this compare with your pump rate in #9 (f)?

- h. As the ship sinks further down, how does this effect your calculations in part (c)?
  - i. Once the Captain realizes the mistake of moving the ship, what does he do?
  - j. Why couldn't the captain reverse the engines to stop the ship more abruptly?
12. Why was it important to release the steam from the Boiler Engines.
13. How many stewards were there compared to passengers? Why did this lead to a communication problem?
14. What was the Radio Called that sent out the distress signals.
- a. Where were the aerials located?
  - b. In the distress signal, were there reported location correct? If not, how far off were they?
  - c. How far away from land were they?
  - d. What was the name of the closest ship? How long would it take to get there?
15. Why did the Chief Engineer open the Watertight doors again.
- a. Why was this a good thing for the Captain?
  - b. Did the Chief Engineers plan work? Explain.
  - c. Did the Captains plan work? Explain.
16. How many lifeboats did the *Titanic* have?
- a. How many lifeboats did the *Titanic* need for all the passengers?
  - b. How many lifeboats did the *Titanic* require by law?

17. In the movie, the men successfully pumped and drained the water from Boiler Room # 5  
However, what type of door failed, allowing the water to crash through into Boiler Room #5?  
Why was this, the final blow, that caused the sinking of the *Titanic*?
18. What did most of the people die of, once the *Titanic* sunk?
19. Why did the Stern come out of the water? What happened after this?
20. How many working funnels did the *Titanic* have?
21. What happened to the Cabins in the bow when they 1<sup>st</sup> sunk?
22. What time did the *Titanic* sink?
23. How many people died that night?
24. How many dead bodies did the rescuers find?
25. How did the disaster affect the survivors?
26. In your opinion, what was the critical mistake, that caused the sinking of the *Titanic*?