Dynamics and Statics

Titanic Model

(Ireland)

Background

The R.M.S. Titanic sank as water from one compartment over spilled into another as the compartment walls were not high enough, and the iceberg it had struck cut through several compartments laterally.

In this model coloured water can be added to the “compartments” to show that for a ship to sink a large number of compartments (pill bottles) need to be filled with water. A ship can list or be down at the bow/stern but still float quite well.

The overall density of the entire ship must change enough before sinking can happen i.e. the number of particles in a fixed space (volume) increases.

This answers student questions about why metal ships float but a density cube of steel will sink, using a particle theory approach. This reinforces the classical particle theory concepts and approaches density in a non-mathematical manner.

You will need….

- ✓ Felt-tip marker
- ✓ Scissors/cutting pliers
- ✓ Sheet of acrylic plastic cut into the outline of a ship
- ✓ Plastic pill bottles
- ✓ Glue
- ✓ Transparent plastic box
- ✓ Water
- ✓ Food colouring (cake colouring paste)
- ✓ Plastic jug (2 L)

Follow these steps:

1. Draw the outline of a ship’s keel onto the plastic sheet
2. Place the pill bottles so that they fill the shape completely with as few gaps as possible between each bottle. Readjust the keel shape as needed.
3. Glue the pill bottles in position and allow to set. It may be useful to place a flat, heavy object (a thick books) on top of the bottles to prevent sliding while the glue sets.
4. After setting is may be necessary to add some additional glue to ensure that pill bottles at the edges are secure.
5. Three-quarters fill a transparent plastic box with tap water (ocean).
6. To a 2 L jug of water add some food die. Cake fondant colouring pastes are best, as the colours are vibrant and can be clearly seen at a distance.
7. Before placing the Titanic Model into the “ocean”, ask your students if the pill bottle “compartments” air empty.
8. Place the model into the ocean and ask students to predict what will happen as you add the coloured water to the compartments.
9. You will be able to demonstrate that the model tilts at various angles, and can sit quite low in the ocean, before sinking.
10. In this modelling it is possible to get the Titanic to “turn turtle”, rotate and invert along its long axis, which then dumps coloured water into the ocean.

11. While filling the compartments it is useful to give a commentary on how the R.M.S. Titanic actually sank:

The iceberg cut through several compartments at once (front to back)

The compartment walls were not high enough, so as each compartment filled, water over-topped into the next compartment

In this way the compartments filled more quickly than they should have, and the weight of so much water caused the ship to break into two halves

The sister ship of Titanic, Olympic was retrofitted to correct this, and since then compartmentalisation has been an important ship design factor.

Compartments with water-tight doors allowed many battle-damaged ships in WW1 and WW2 to make if to harbour without sinking.

12. It is useful to repeat the "sinking" several times in each demonstration to ensure all students get the chance to see what happens.
13. Prompt questions about how the air particles in the compartments were displaced by water particles, and how the number of particles in the fixed space has increased are important at this point.

So what happened?

Adding water to the compartments increases density because the number of particles within each compartment, and the overall "ship" increased. Combined with the mass of the plastic the overall density of the ship was more that the water in which it sat, so it then sank.

Relating this back to real life, steel-hulled ships are not solid blocks of metal: they have large air pockets, so their overall density is lower than the density of water.

What next?

- This can be linked to the operation of submarines which take in ballast (water) to increase density and dive, or expel the water (using compressed air)
- Ships which have adjustable ballast tanks of water, to increase stability when sailing, especially if cargo holds are empty.
- It is possible to link this model with iceberg density, at the point were the model has largely sunk – its density is close to that of water, so is mostly sunk but has a small amount above the water line (as with icebergs)
- A live demonstration, with teacher commentary, helps students understand density through particle theory without becoming confused by also trying to apply the density formula, but a video clip linked to a student worksheet, can be useful as a consolidation or extension exercise for homework

This demonstration is the first of three consecutive demonstrations; see Relative Floatation 1 and Relative Floatation 2.