PLIMSOLL LINE

OBJECTIVE:

You will understand how a ship's buoyancy varies with differences in water density and will demonstrate how a Plimsoll line (a ship's load line) takes account of these differences.

INTRODUCTION:

The Plimsoll line is a marking on the side of a cargo ship's hull that shows the maximum depth to which a ship may be safely loaded under different conditions.

Before the Plimsoll line was developed and was adopted internationally in 1930, it was difficult to regulate how heavily a cargo ship could be safely loaded. A loaded ship will float at different heights in the water depending on whether it is in warm tropical waters or cold polar waters, or whether it is in fresh or sea water. This is because a ship's ability to float depends on it being less dense than the water it displaces, and the density of water is affected by temperature and salinity (how much salt it contains). Upthrust—the force that makes a boat able to float—is produced by water being displaced when an object is placed in the water (see figure 1). The amount of upthrust is equal to the volume of water displaced. In warm water, which is less dense than colder water, more water is needed to produce the same upthrust, so a ship will float lower in the water.

Until the mid-nineteenth century, there was no way to regulate how much load a ship could safely carry because different loads float at the same level depending on where the ship travels. A ship in the Caribbean, for instance, would float at the same height in water as one carrying a much larger load in the cold waters of the North Atlantic.

British politician Samuel Plimsoll (1824–1898) became concerned at shipowners' tendency to overload cargo ships to dangerous levels. In 1875, he helped put through legislation in Britain requiring the use of a load marker on cargo ships. The Plimsoll line, as it came to be known, takes into account the differences in water density with temperature and salinity variations. It shows the safe level at which a ship can settle when loaded in different types of water (see figure 2).

In this investigation, you are using a drinking straw to represent the hull of a ship, and the markings on the straw represent the Plimsoll line. The straw holds a relatively large volume of air and is sensitive to density changes in the water in which it floats.

Figure 1

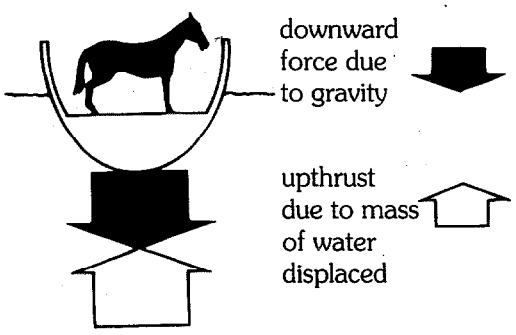
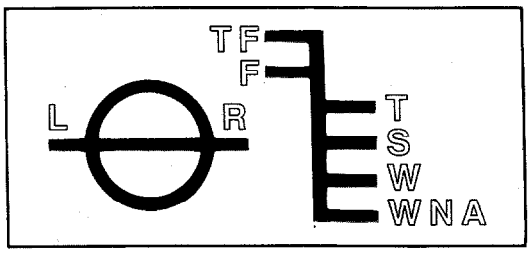
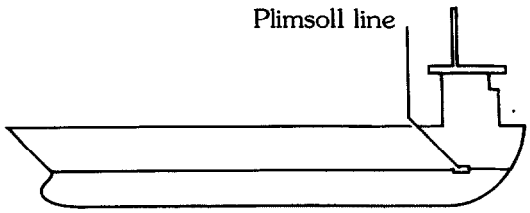


Figure 2



key LR = Lloyds register
TF = Tropical Freshwater
F = Freshwater
T = Tropical
S = Summer
W = Winter
WNA = Winter North Atlantic



TIME NEEDED:

3/4 hour

MATERIALS:

plastic drinking straw about 5 mm in diameter
Funtak®
250ml beaker
ice cubes
0–100°C thermometer
waterproof marker
metric ruler
glass stirring rod
electronic scale measuring to the nearest 0.1 g
40 g salt
scissors

Safety Precautions

Please read and copy the safety precautions at the beginning of this book.

PROCEDURE:

Part 1—Determining Plimsoll marks for fresh and salt water

1. Fill the beaker with 200 ml water at room temperature, direct from the faucet. Check the temperature of the water using a thermometer. It should be about 10–25°C.
2. Use the scissors to cut the drinking straw to 10 cm long. Use a waterproof marker to draw a line marking the midpoint of the straw. Using a ruler, add further marks at 0.5cm intervals to produce a scale (see figure 3).
3. Mold a small lump of Funtak® around one end of the straw, making sure it forms a watertight seal.
4. Carefully place the straw—Funtak® end down—in the beaker of water. When set up properly, the straw will float upright, with half above and half below the water. Adjust the amount of Funtak®, removing some if the straw sinks too deep or adding more if it floats too high, until the straw floats with its midline precisely at the water level (see figure 4).

Figure 3

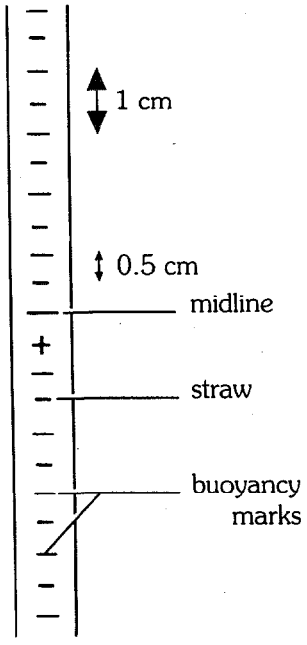
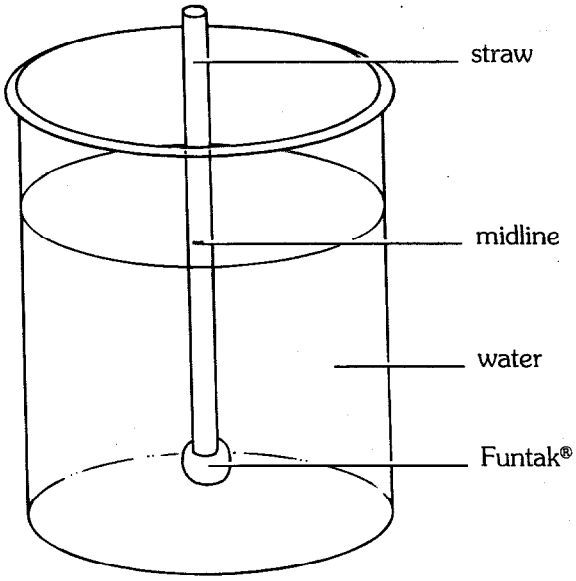


Figure 4



5. Remove the straw. Add 20 g of salt to the water in the beaker and stir continuously until the salt completely dissolves. Place the straw in the salty water and record in the Data Table the height at which it floats (- indicates it is lower in the water, + that it is higher).

6. Remove the straw, dissolve a further 20 g of salt in the beaker of water, and then return the straw to the water, again recording the height at which the straw floats.

Part 2—Determining Plimsoll marks for warm and cold water

7. Remove the straw, discard the water, rinse out the beaker, and then fill it with 200 ml lukewarm water at a temperature of about 40°C. Check the temperature using the thermometer. Place the straw back in the beaker and record in the Data Table the height at which it floats.

8. Repeat step 7 but using water at about 60°C. Again, record the height at which the straw floats.

9. Empty the beaker and rinse it with water from the faucet. Half fill the beaker with ice and then fill it to the 200ml mark with water from the faucet. Check the temperature of the water. Place the straw back in the beaker and record the height at which it floats.

DATA TABLE

	Height at which straw floats (in.)
Part 1 Fresh water	
Salt water (20 g)	
Salt water (40 g)	
Part 2 Lukewarm water	
Warm water	
Ice water	

ANALYSIS:

1. What happened to the straw when it was placed in salty water? Were the changes related to the amount of salt in the water? Explain what happened and why.
2. What happened when the straw was placed in warm water? Why did this happen?
3. Suggest ways you could test whether:
   a) Salt water is more dense than freshwater.
   b) Warm water is less dense than cold water.

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific investigation. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly when you are constructing or demonstrating a model invention. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each project you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while carrying out these projects. Be sure to check the individual projects in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning projects
—Read the instructions before you start
—Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one project at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk or bench
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders
—Never look directly at the sun with your observation devices

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES