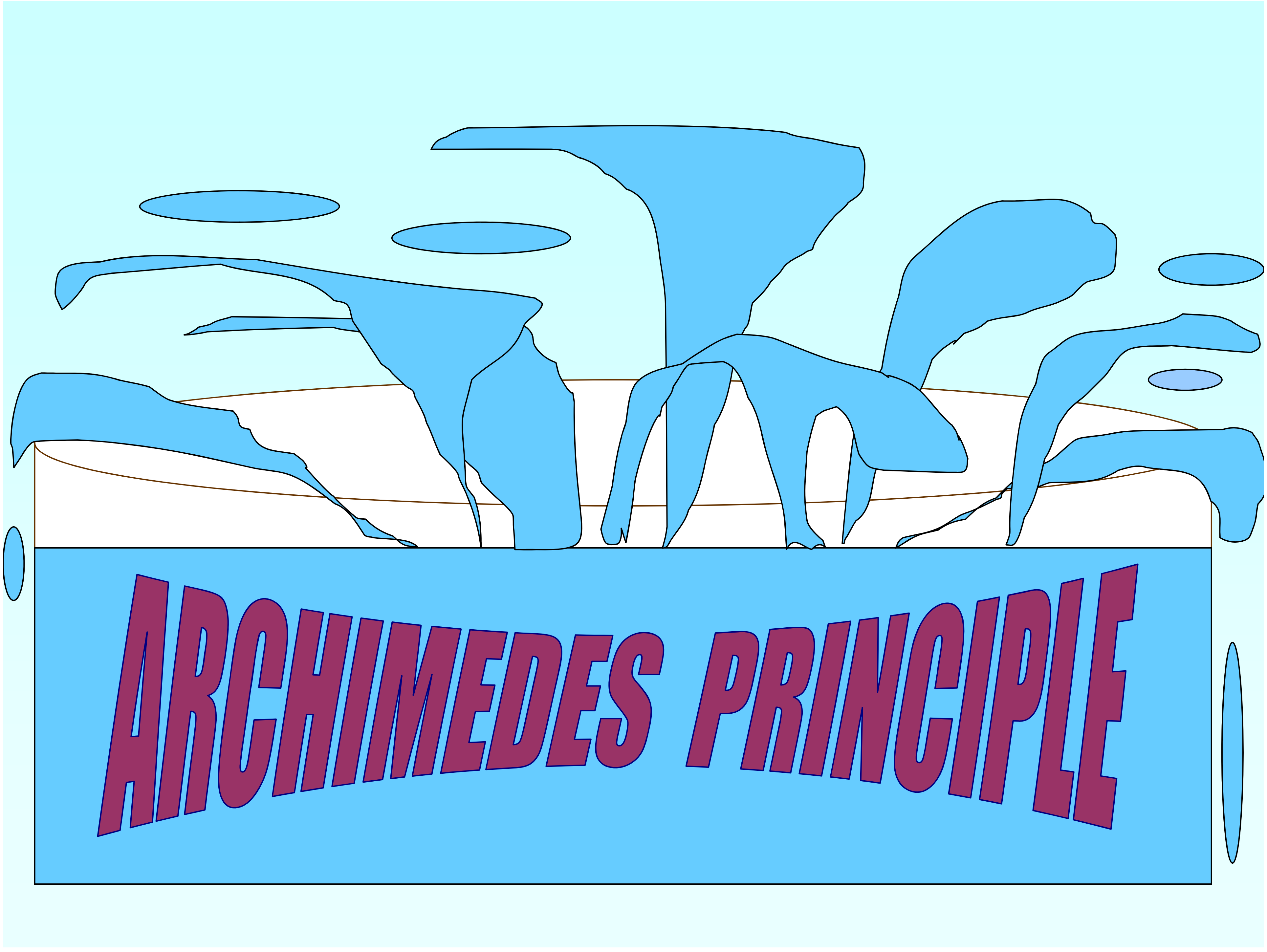

ARCHIMEDES PRINCIPLE

Age : 15 years

Subject : Physics

Topic : Archimedes' Principle

Sub Topic - Theory and applications of the Archimedes' Principle

Syllabus : X th ICSE

Author : Dr. Madhuri Sawant

Special features : A practical approach to the study of Archimedes' Principle with an emphasis on explanation through the simple experiments based on this principle . A digitized movie and animated experiments will make the concept of this principle clear to the users.

Objectives : To show the importance of this principle in our daily life.

To develop clear understanding about the loss in weight and

displaced liquid by the object when immersed in water and how it is related to density of the liquid..

To build confidence in students to perform experiments independently with proper understanding of the procedure.

Teaching Aids: Computer, projection equipment with sound, blackboard

Methodology : Teachers must refer to the speaker notes before explaining this lesson.

The movie and explanation can create interest among the students to know more about this topic.

The work sheet challenges the students to apply learning from this lesson in various fields.

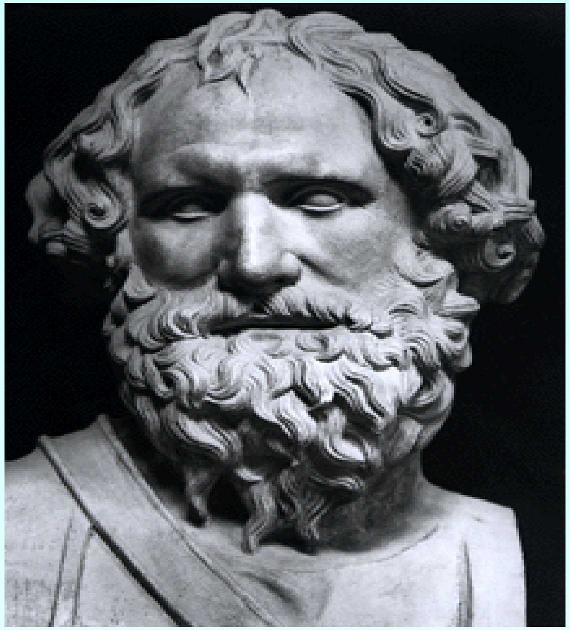
Learning outcome : Students will able to understand the two basic concepts on which the Archimedes' Principle is based

They will able to solve examples based on this principle.

Duration ; 60 min *Running time* : 15 min

ARCHIMEDES

(287 BC--212 BC)



A Great Greek scientist, *Archimedes,* made a thorough study of liquids and their nature and formulated the laws of floatation of bodies immersed in liquids.He was a Great mathematician too.He wrote books such as 'On Floating Bodies', 'Measurement of the Circle' and 'On Balances and Levers'.

Rationale of the experiment

To perform this experiment we need to know the density of the solid.

By knowing the weight of that object, we can find out the volume of the object by using the formula D = Mass(weight) / volume

In case of gold as the density is the highest among the metals that are usually mixed with it, the volume of the impure gold is always more than the volume of the pure gold of the same weight. This can also be shown by calculations

When a solid object is fully immersed in water then the amount of water displaced by the object is equal to the volume of that object.

When the object is fully immersed in water, the loss in weight of the object is equal to the weight of the weight of the displaced water.

In the experiment that follows, the impure crown displaces more water than a pure crown would have

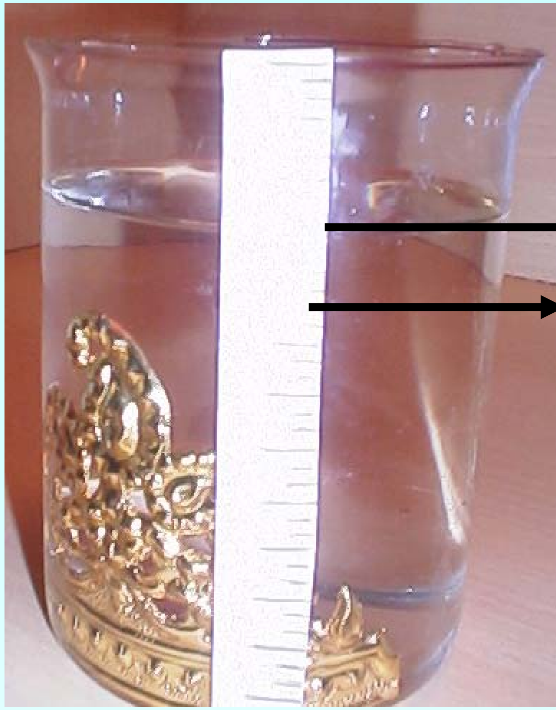
Archimedes' experiment

Aim :- To test the purity of a gold crown.

Weight of the gold crown = 100 gms

<u>*Displacement of water*</u>

85.0 ml



90.5 ml

5.5 ml

Beaker with water

Rise in the water level in a beaker after putting the crown in water

Observation :- water displaced by a crown = 5.5 ml

Displacement of water

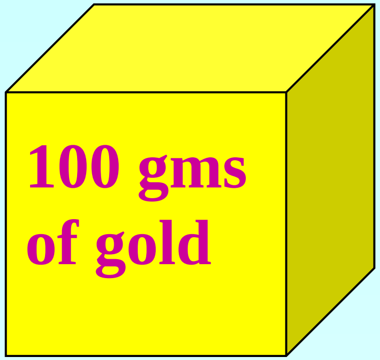
5.5 ml

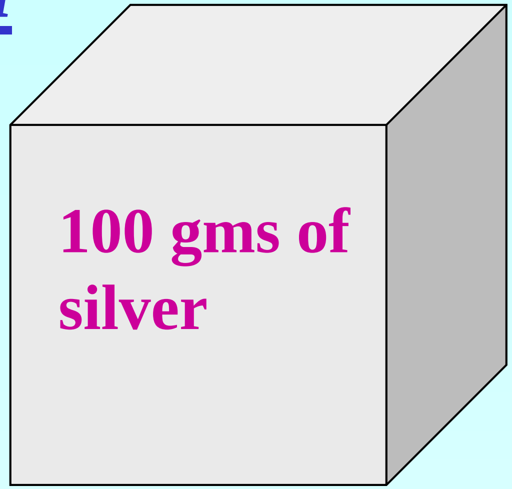
Beaker with water **Water displaced by a crown**

Observation :- water displaced by a crown = 5.5 ml

Water displaced by 100 gms of pure gold = 5.2 ml

Volume by calculation





Density = mass / volume

Density of gold = 19.3 gms /cm^3
Weight of gold = 100 gms
Volume of gold = 100 / 19.3

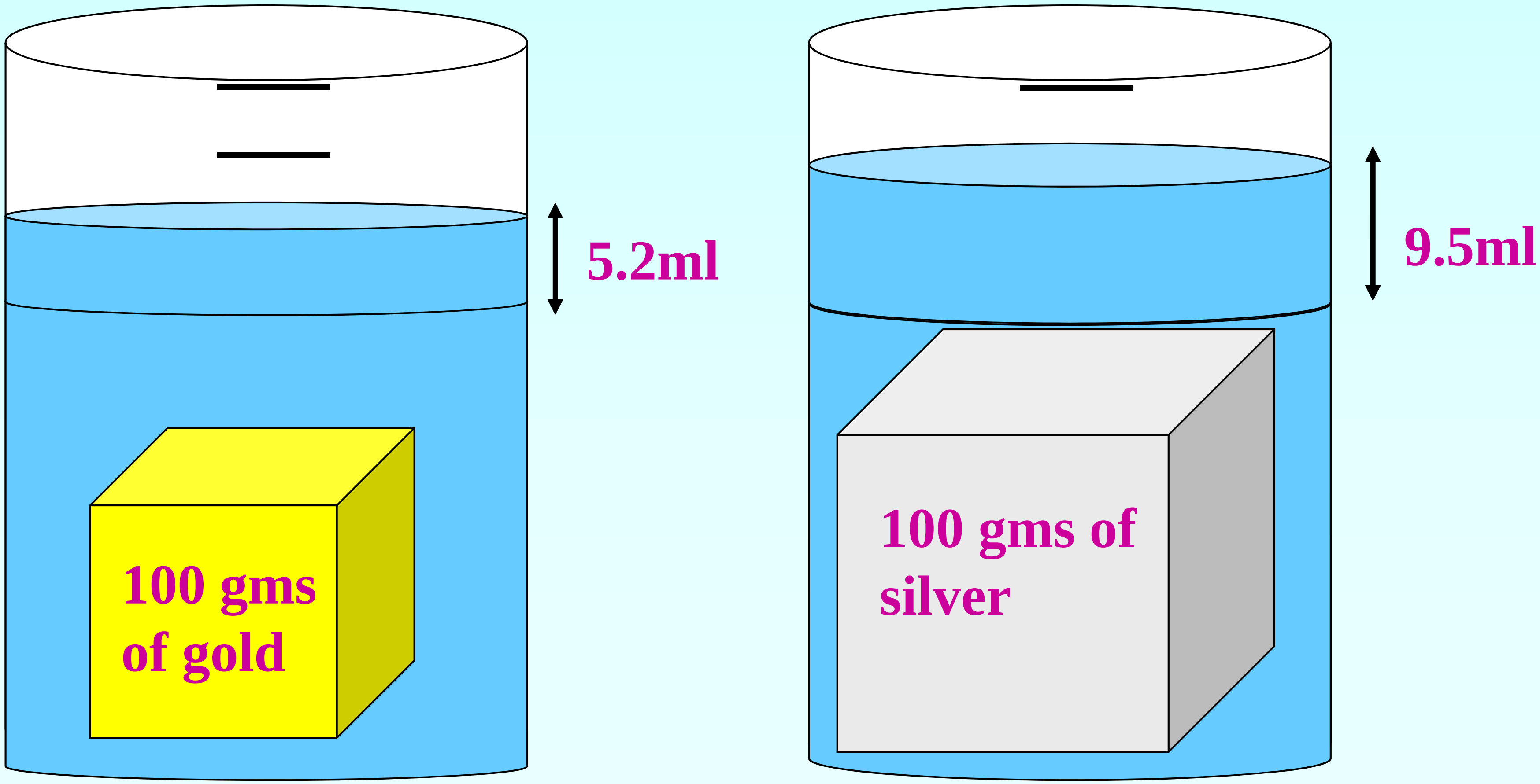
Density of silver = 10.5 gms /cm^3
Weight of silver = 100 gms
Volume of silver = 100 /10.5

Volume of 100 gms of gold = 5.2 cm^3

Volume of 100 gms of silver = 9. 5 cm^3

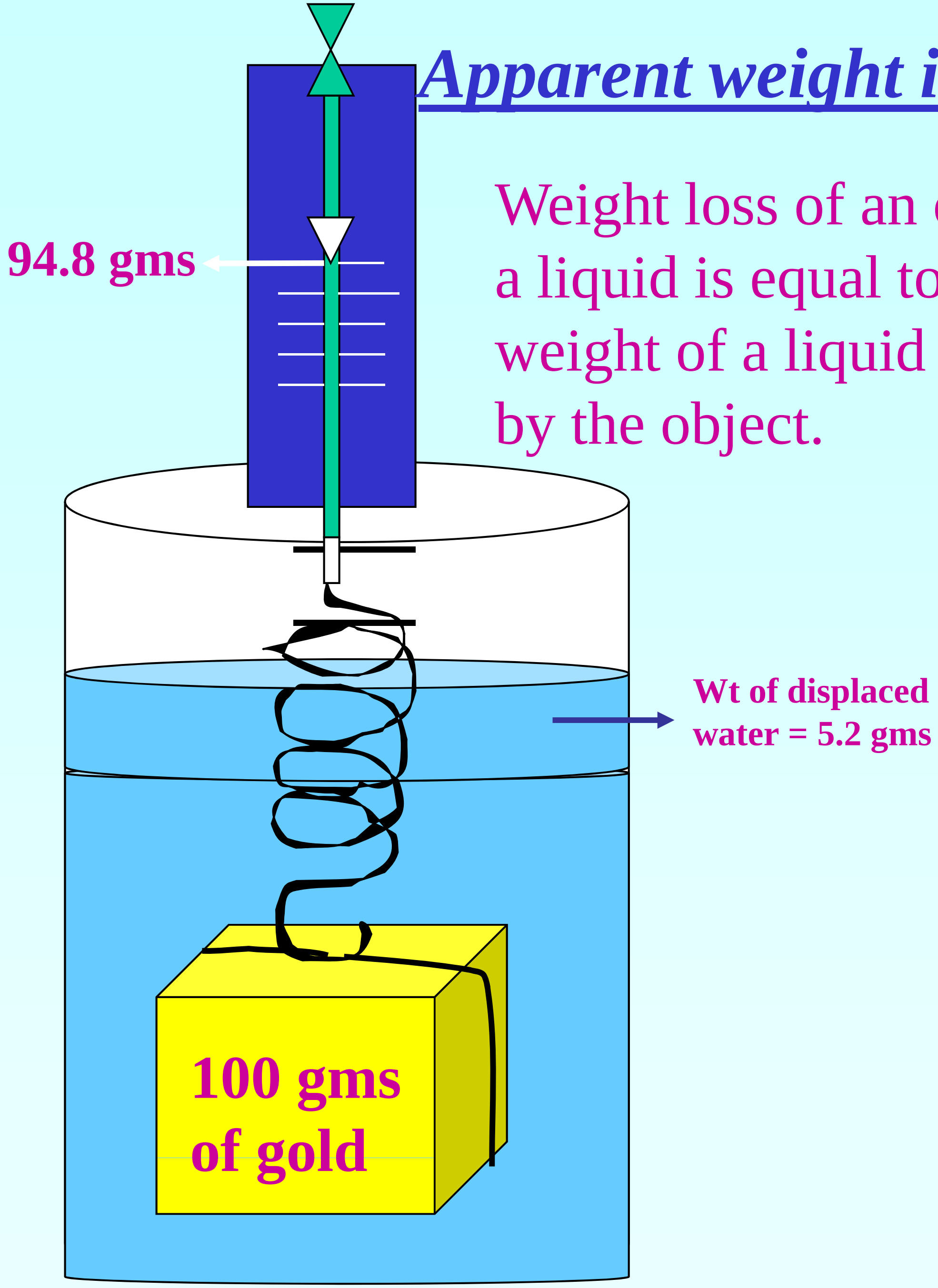
Volume by measuring the displaced water

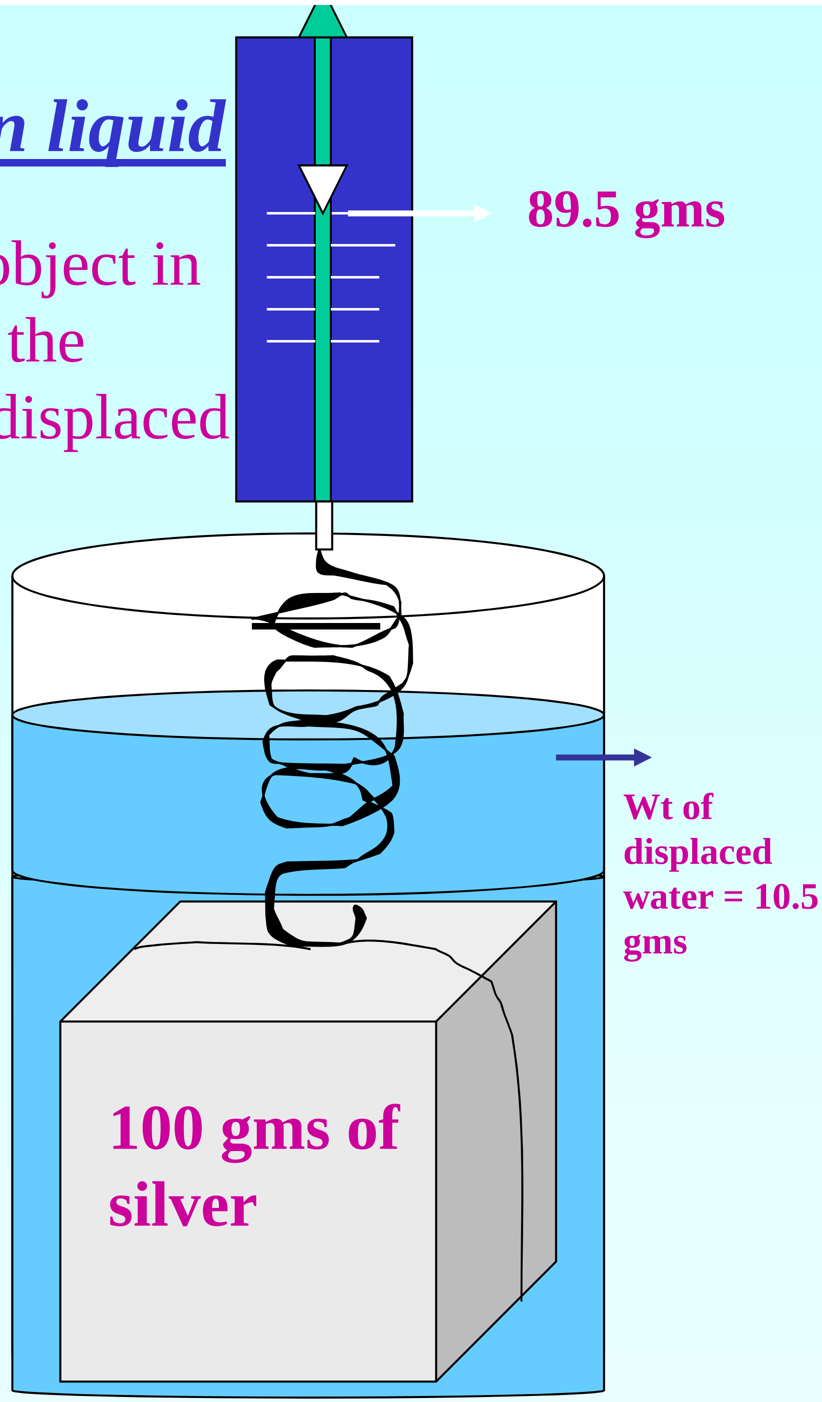
When a *solid object* is immersed in a liquid, the *volume* of displaced liquid is equal to the *volume of that object.*



Apparent weight in liquid

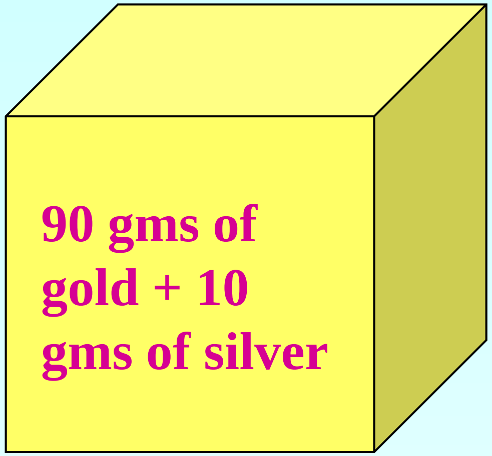
Weight loss of an object in a liquid is equal to the weight of a liquid displaced by the object.





Volume of impure gold

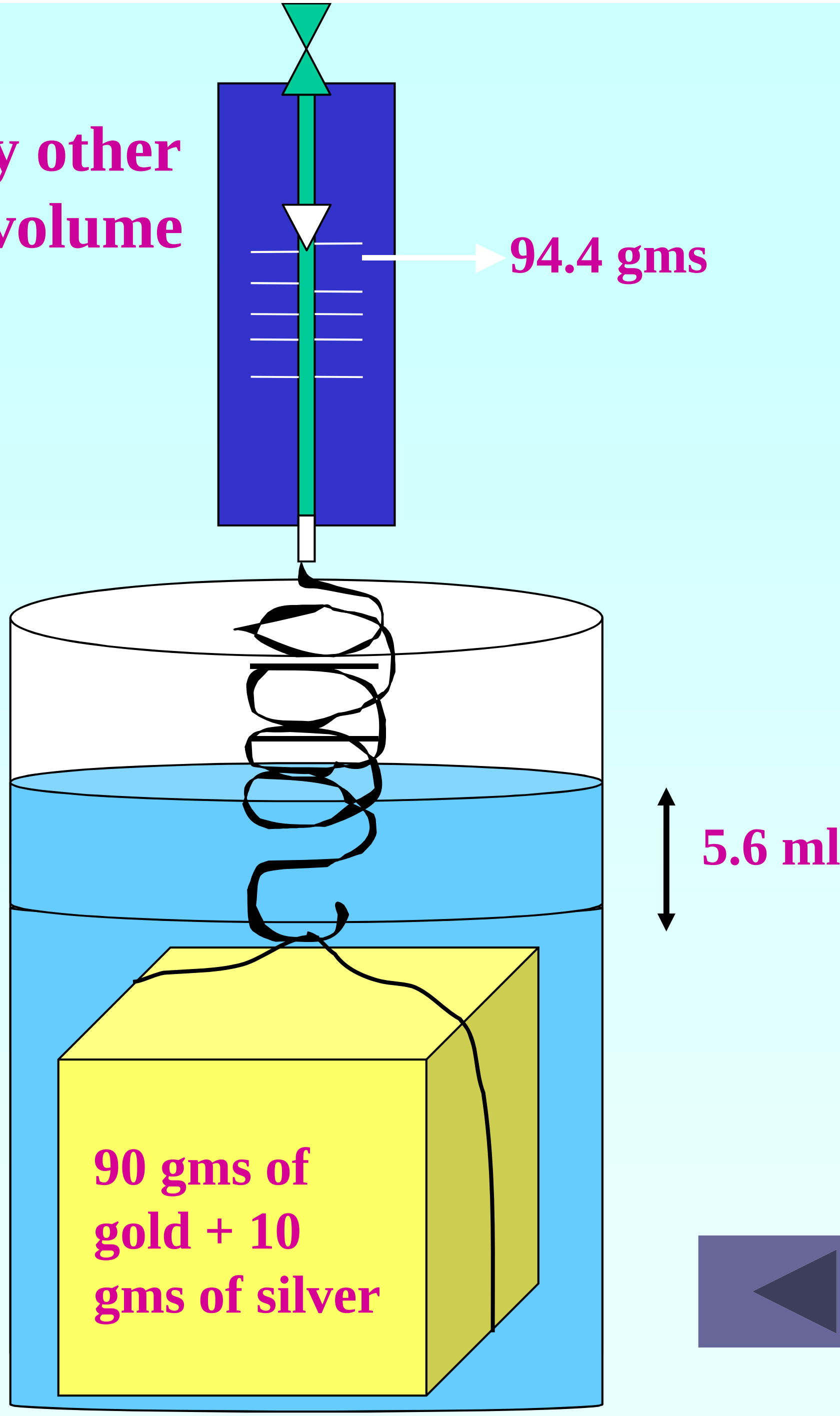
When gold is mixed with silver or any other metal there is always increase in the volume of same weight of a mixture.



Total wt = 100gms

Volume of displaced water by 100 gms of pure gold = 5.2 ml

Volume of displaced water by a mixture of gold and silver = 5.6 ml



Displacement of water

5.5 ml

Beaker with water

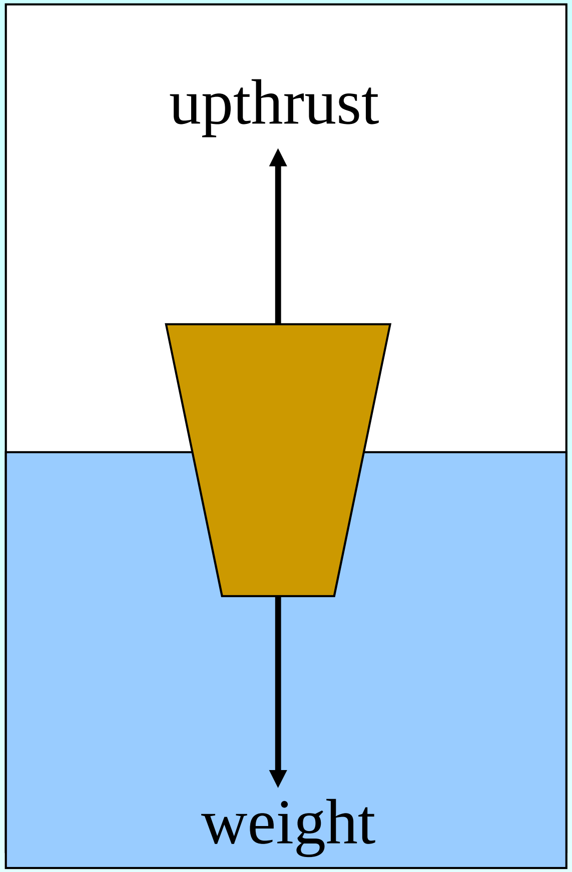
Water displaced by a crown

Observation :- water displaced by a crown = 5.5 ml

Water displaced by 100 gms of pure gold = 5.2 ml

Conclusion :- The crown was made up of impure gold.

FORCES ACTING ON AN IMMERSED BODY



A body partially or completely immersed in a liquid experiences two forces

--downward pull due to earth's gravity (i.e. weight of the body)

--upward force exerted by a liquid (i.e. upthrust or a buoyant force)

UPTHRUST OR BUOYANCY

The upward force exerted by a liquid tending to lift up a body immersed in it is called *UPTHRUST* or *BUOYANT FORCE*

This phenomenon is called ***Buoyancy***

The magnitude of *upthrust* or *buoyant force* depends upon

1) **the volume of a liquid displaced by a body immersed in it and**

2) **the density of a liquid in which it is immersed.**

Why does the weight of the object differ in different liquids?

The buoyant force depends on the density of a liquid.

More the density of a liquid, more is the buoyant force exerting on the object and less will be the weight in that liquid

Weight of the object in air = 20 gms, Volume of the object = 5 cm^3

Weight in grams of the same object shown in different liquids

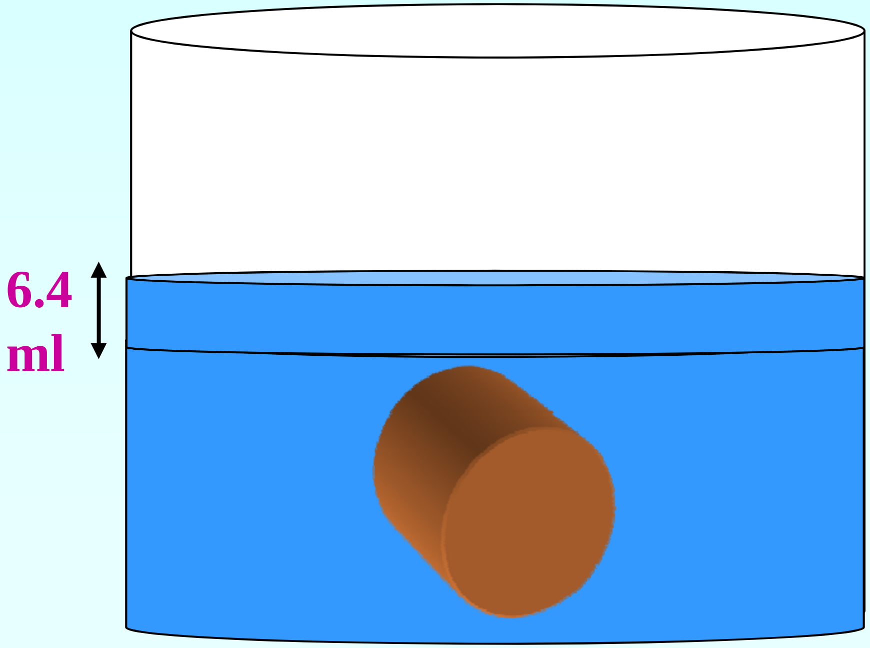
Liquid	Density	Weight
Alcohol	0.8	16.0
Kerosene	0.88	15.6
Water	1 . 0	15.0
Salt water	1.1	14.5

FLOATING BODIES

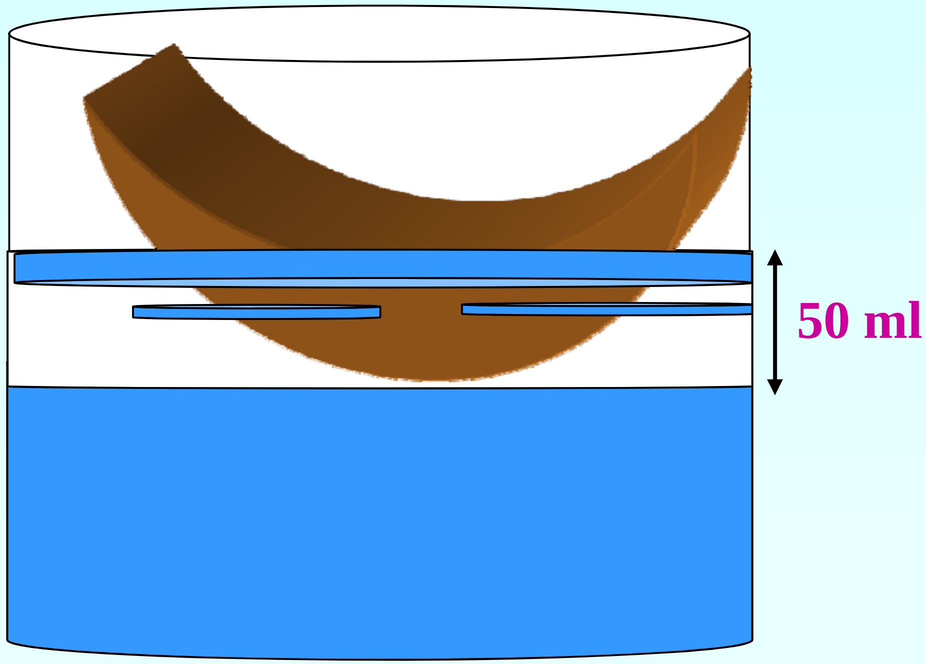
If the weight of a liquid displaced by an immersed part of an object is

a. less than the weight of an object, the object sinks.

b. equal to the weight of an object, the object floats.



50 gms of iron piece



50 gms of iron in the form of a boat

ARCHIMEDES PRINCIPLE

When a body is immersed, partially or fully in a liquid, it experiences an upthrust (i.e. loss in weight of the body) or a buoyant force which is equal to the weight of the liquid displaced by it.

This is also known as ***Laws of floatation.***

When the weight of a body is,

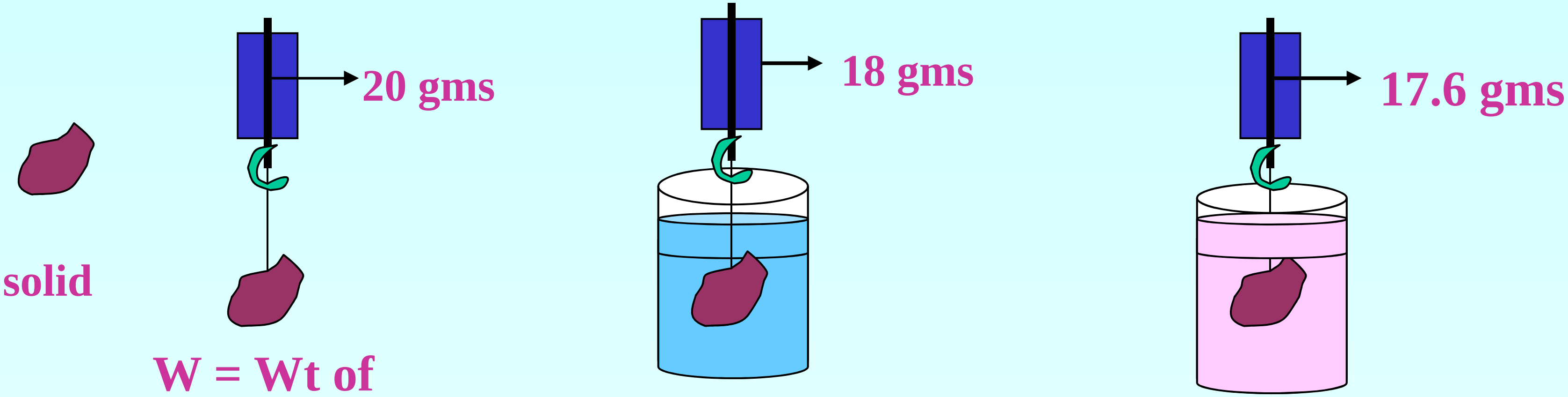
- more than weight of the liquid displaced, the body sinks.
- equal to the weight of the liquid displaced, body just floats.
- less than weight of the liquid displaced, the body floats.
- ***In the floating position, the body is weightless and its apparent weight is zero.***

EXPERIMENT- 1

To determine the relative density of unknown liquid using Archimedes principle.

Requirements :- solid object, spring balance, beaker, water, liquid

Procedure :-



W = Wt of object in air **W_1 =Wt of object in water** **W2 =Wt of object in liquid**

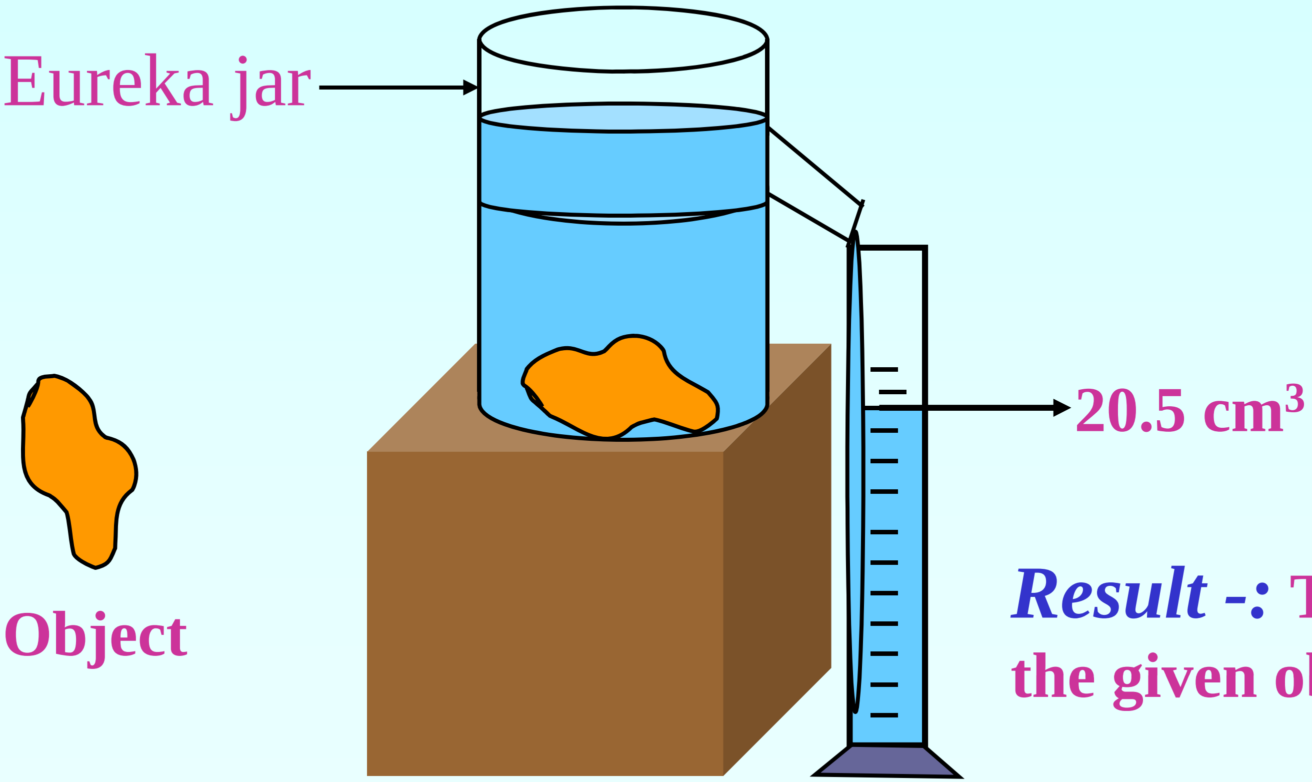
Procedure :-Using a spring balance, weigh the object. Let this be 'W' gms. Immerse this object in water. Weigh again. Let the weight be W_1 gms. Remove this object from water. Dry it, immerse it in a liquid. Weigh again.Let this be W_2 gms. From the formula

$$\text{R.Density of liquid} = \frac{\text{Loss in weight of solid in liquid}}{\text{Loss in weight of solid in water}} = \frac{W - W2}{W - W1}$$

Experiment - 2

Aim - To determine the volume of an uneven object using Eureka jar

Requirements - Eureka jar, water, measuring cylinder



Result -: **The volume of the given object is 20.5 cm^3**

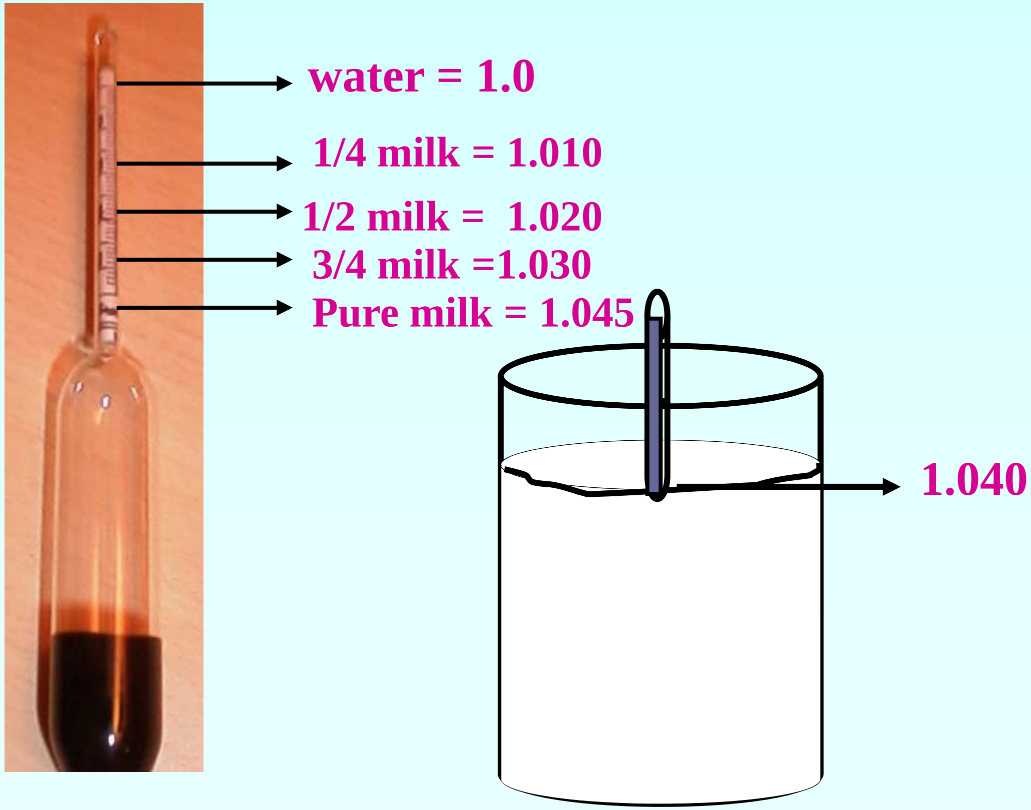
Applications

Lactometer:-measures relative density of milk.

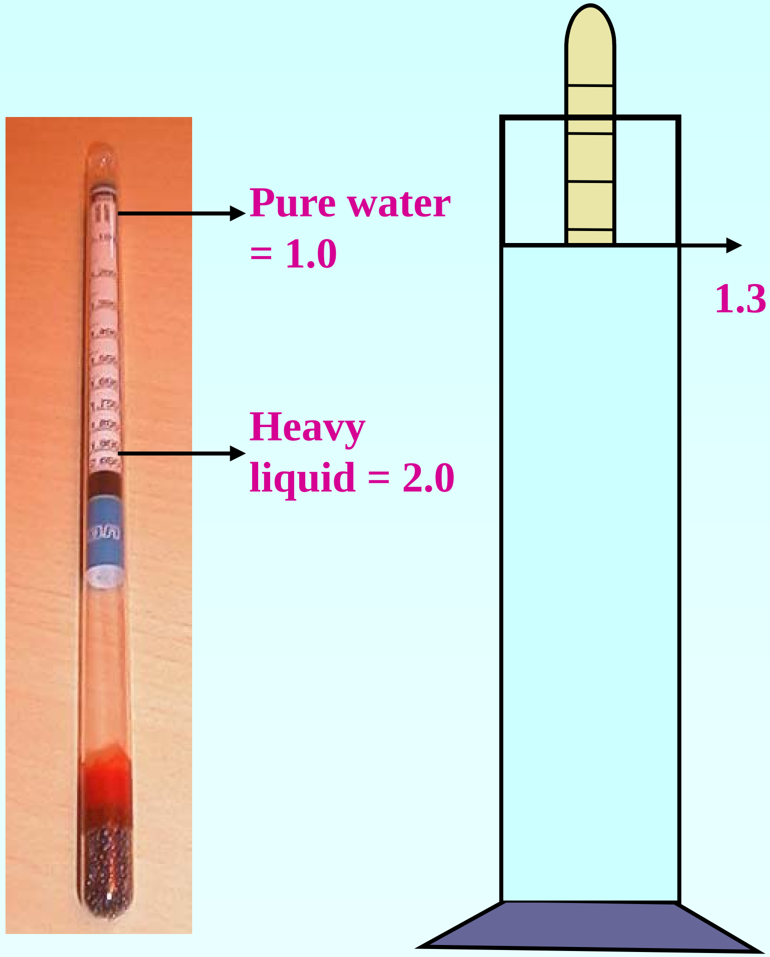
Aim :-To test the purity of milk

Hydrometer :- measures relative density of a liquid

Aim :- To measure the salinity of water.



Dip lactometer in the milk sample



ICEBERG…….

Why does ice float on water ?

When water freezes at 0^0C, the volume increases . Density of water is 1.0 g/cm^3 and density of an ice is 0.9 g/cm^3. Hence ice floats on water.

What fraction of an iceberg is exposed?

1/10 of an iceberg floats on water and 9/10 th of an iceberg remains underwater because of small difference in the densities of water and ice.

What fraction of an iceberg is exposed? Prove with the help of equation.

Let the weight of the iceberg =$W_i = \rho_i V_i\, g$

where V_i is volume of iceberg, ρ_i is the density of ice

volume of a water displaced by an iceberg = V_w

buoyant force $F_b = \rho_w\, V_w g$

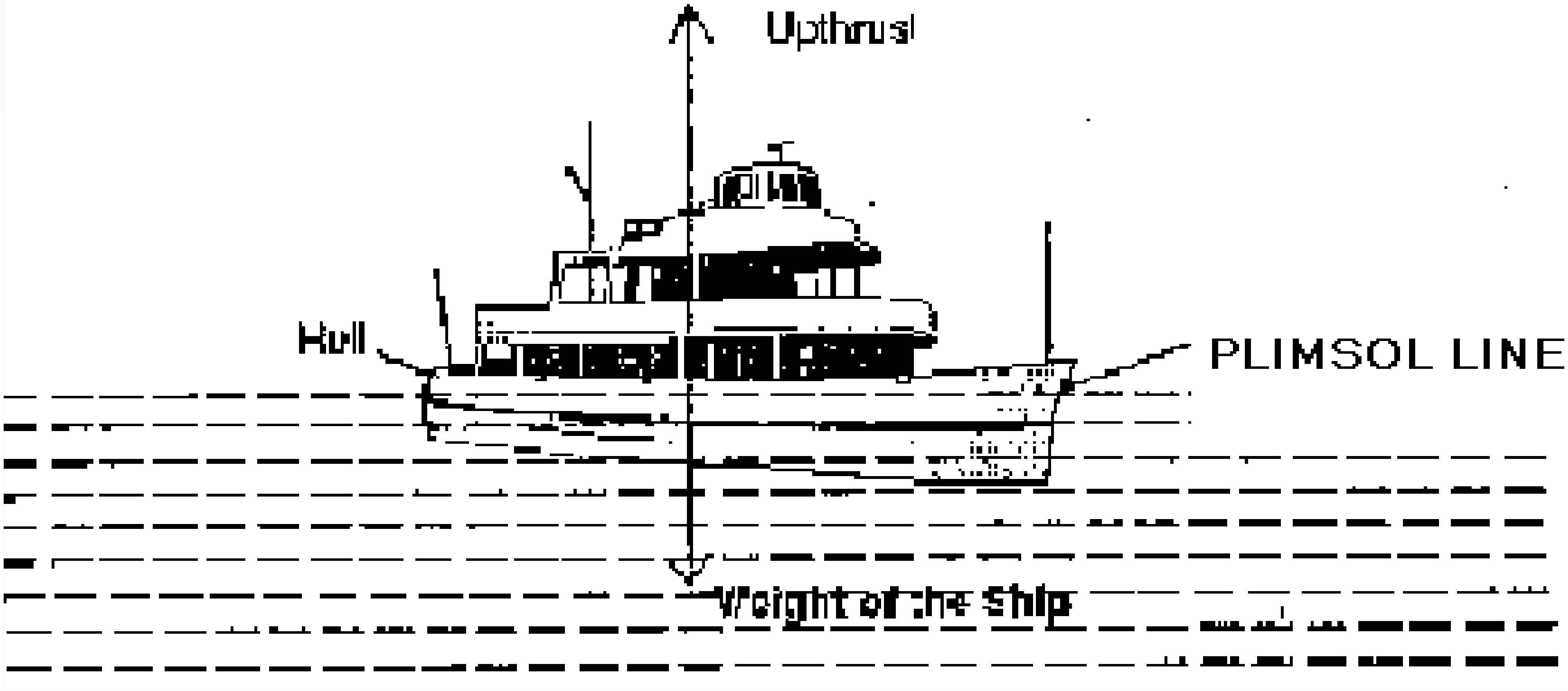
but $F_b = W_i$ therefore $\rho_i V_i\, g = \rho_w V_w g$

Using densities,

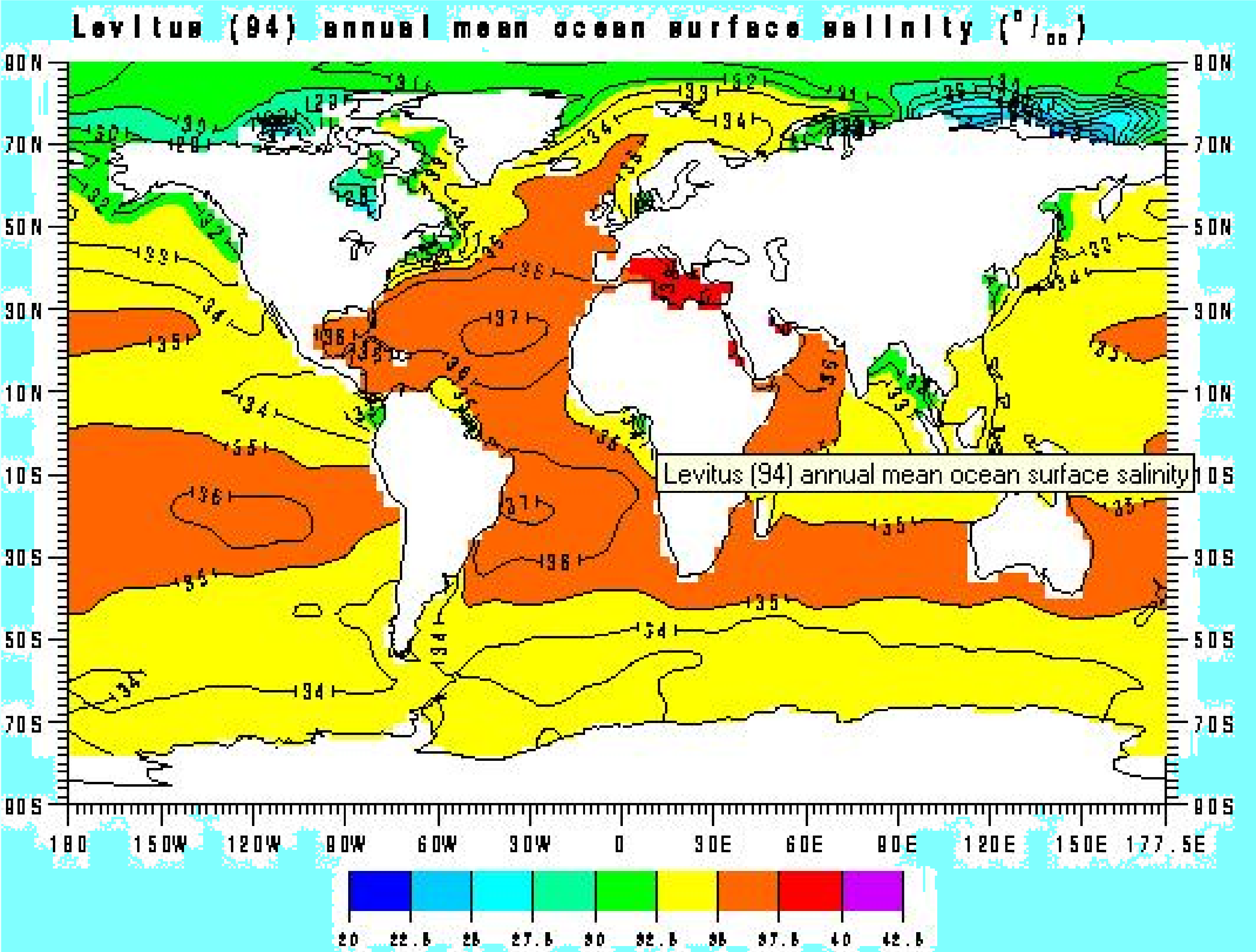
$$\frac{V_w}{V_i} = \frac{\rho_i}{\rho_w} = \frac{917\ \mathrm{kg/m^3}}{1000\ \mathrm{kg/m^3}} = 0.9$$

Conclusion :- 9/10 fraction of an iceberg is submerged and 1/10 is exposed.

Plimsoll line on a ship -The ship is loaded upto this line



Mean Ocean surface salinity



Salinity levels in the decreasing order

Highest

Dead Sea (Seven times as high as that of any other sea)

Mediterranean sea, black sea

Atlantic, Pacific and Indian ocean

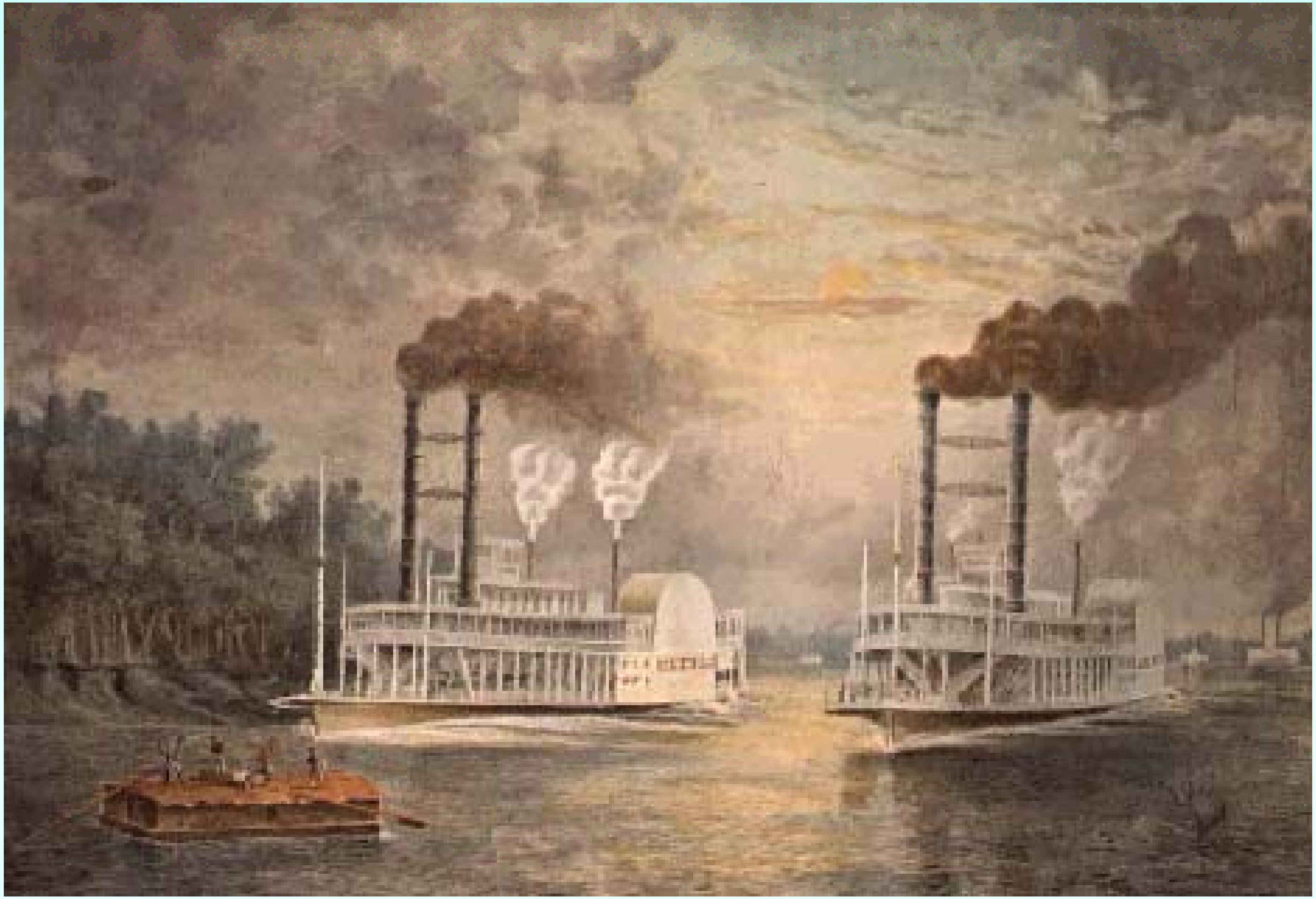
Atlantic, Pacific and Indian ocean near equator

Fresh water e.g . Water from river and lakes

Panama canal (due to continuous rainfall, salinity is even less than that of fresh water)

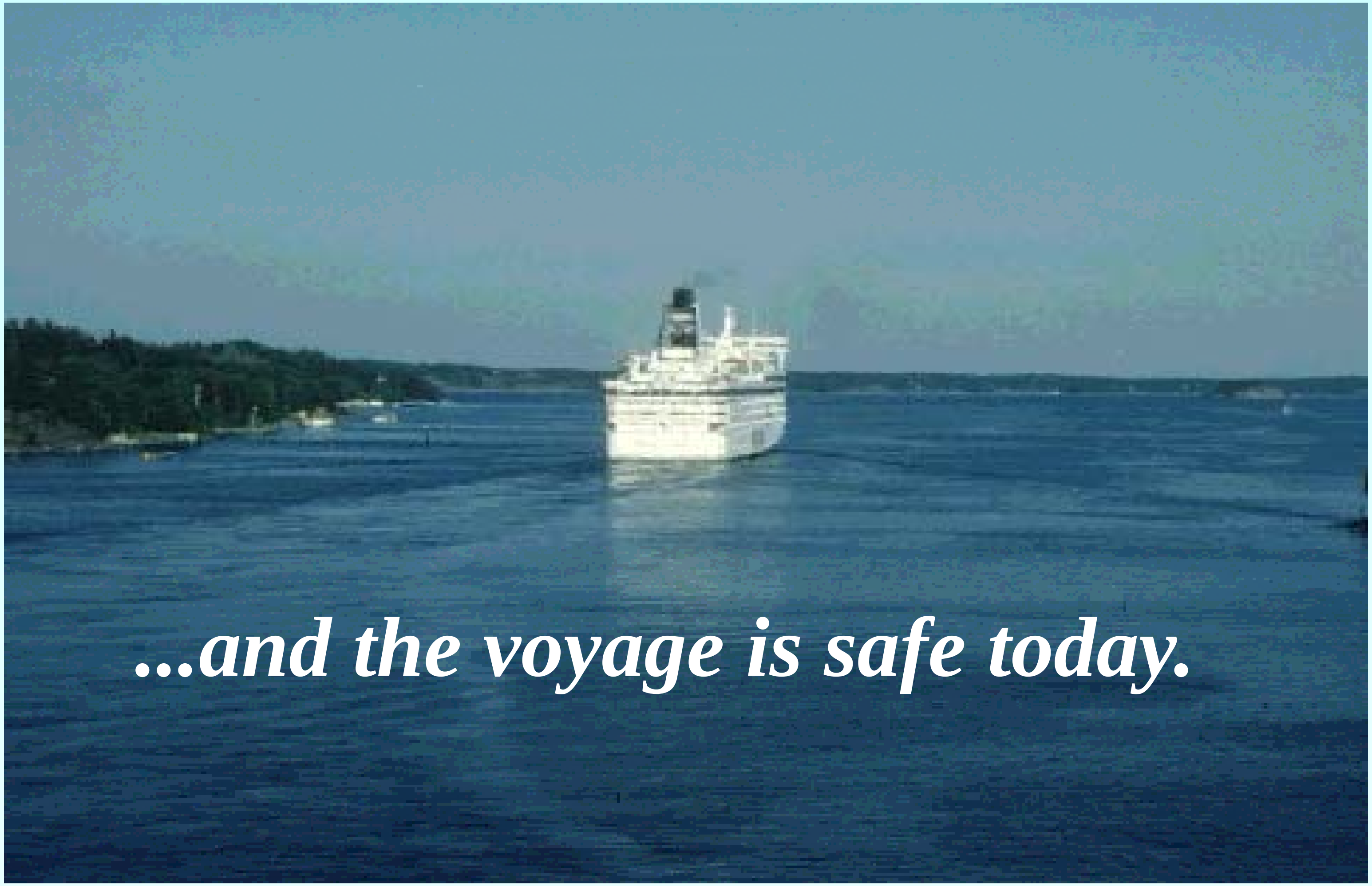
Lowest

The voyage begins………….



THE CARGO……..

The cruise liner…….


...and the voyage is safe today.

WORK - SHEET - 1

Find the location of Dead sea, Mediterranean sea, Suez canal and Panama canal.

Arrange the salinity of Panama canal, Dead sea, Mediterranean sea and Atlantic ocean in the increasing order.

WORKSHEET- 2

- What is Archimedes principle?
- Find out the volume of the given uneven object.
- The weight of an object is 60 gms and its volume is 15 cm^3.What will be its weight in a liquid of density 0.94 g/cm^3?
- Can you find the weight of a floating cork with the help of a spring balance? Explain.
- What are the properties of floating objects?
- Can you find out the amount of salt dissolved in the solution using hydrometer?

TECHNOLOGY USED

- Digitized video movie - The TV Ontario - The science Alliance (Matter)
- digital camera pictures
- recorded voice
- internet sites
- PowerPoint animation
- sound from CD ROM music album
- Internet sites http://icp.giss.nasa.gov/research/oceans/oceanchars/salinity.html