Aim

To determine the density of a solid (denser than water) by using a spring balance and a measuring cylinder.

APPARATUS REQUIRED

A metallic object (any shape), an iron stand, a spring balance, a measuring cylinder (preferably 0-250ml)

THEORY

1. The mass per unit volume of a substance is called the density of a given substance.
2. Let Me be the mass of a given substance/object and V be its volume. Its density ρ is given by
   $\rho = MV$ = Mass of Object Volume of Object. Its S.I. unit is kg m^{-3}.
3. Let the weight of the object being measured by the spring balance in air = W g-wt.
4. The initial volume of water in the measuring cylinder = V_1 ml.
5. The final volume of water in the measuring cylinder when an object is fully immersed in water = V_2 ml.
6. Volume of object = Volume of displaced water = $(V_2 - V_1)$ ml
7. Therefore, the density of the object $(\rho) = WV_2{-}V_1$ g cm^{-3}.
8. The force with which a body is attracted towards the centre of the earth is called weight. Mathematically, it is the product of mass M and acceleration due to gravity g.
   $W = Mg$
9. The density of a given substance is the mass per unit volume. Let M be the mass of the given solid body and V be its volume, then its density ρ is given by the relation:
   $\rho = \frac{M}{V}$

PROCEDURE

1. Hang the spring balance vertically with the help of an iron stand as shown in Fig.(i).
2. Find its least count by using the given formula:
3. Least Count = Range of given spring balance × total number of divisions
4. Check the zero error (if any) and record it with the proper sign.

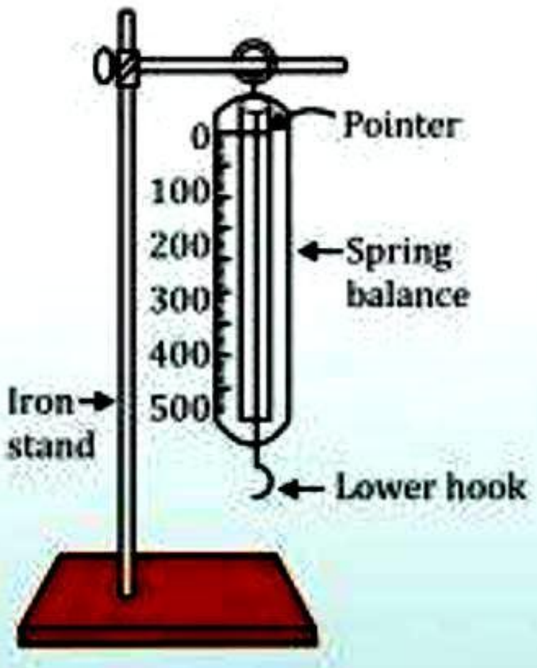

Fig (i) Vertical position of spring balance

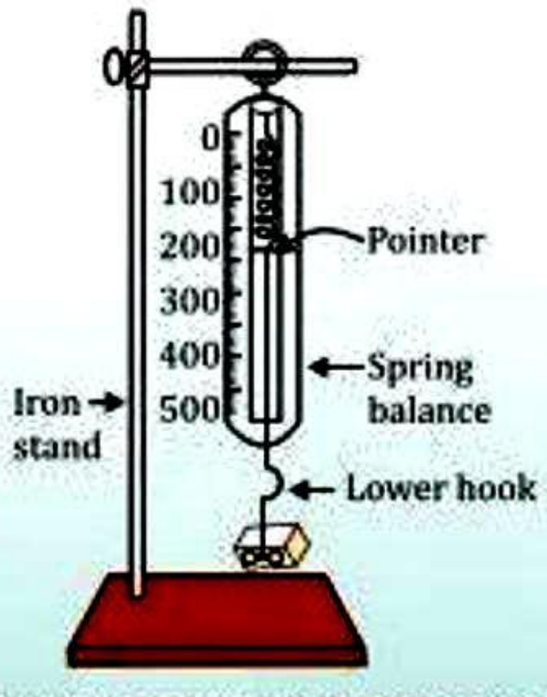

Fig (ii) Measurement of weight of a solid object in air

5. This is the reading of spring balance when no weight is suspended from its lower hook.
6. Hang the metallic object with the lower hook of the spring balance as shown in Fig. (ii).
7. Take the reading of spring balance when the metallic object becomes static.
8. Obtain the true weight of the given metallic object by subtracting the zero error (if any) from the observed weight.
9. Repeat the experiment thrice and find its mean weight.

Measurement of the volume of a given metallic object:

- Pour some water into the measuring cylinder and record the initial level of water (lower position of meniscus) as shown in Fig.(iii). Let the initial volume be V_1 (mL).
- Remove the metallic object from the spring balance and tie it with a thin strong thread and immerse it fully in the water in the measuring cylinder.
- Note down the new position of meniscus V_2 (mL) in the measuring cylinder as shown in Fig.(iv). The level of water rises because the immersed object displaces water from its initial level.
- Obtain the volume of the immersed metallic object by subtracting the two positions of the meniscus (water level) i.e., $V_2 - V_1$
- Repeat the experiment thrice and find its mean volume

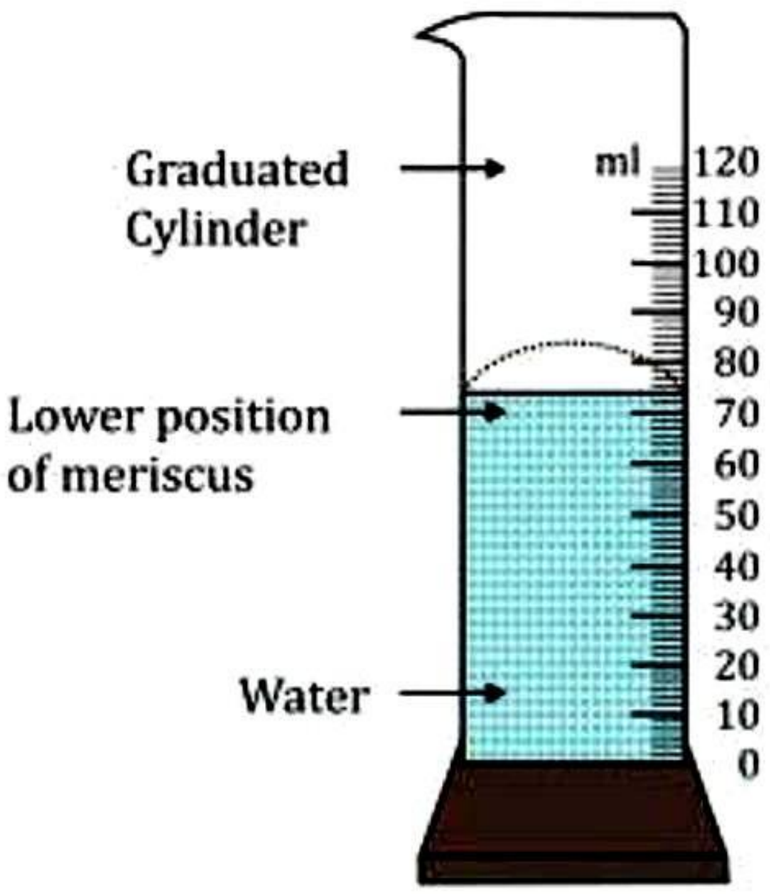

Fig (iii) Measuring cylinder

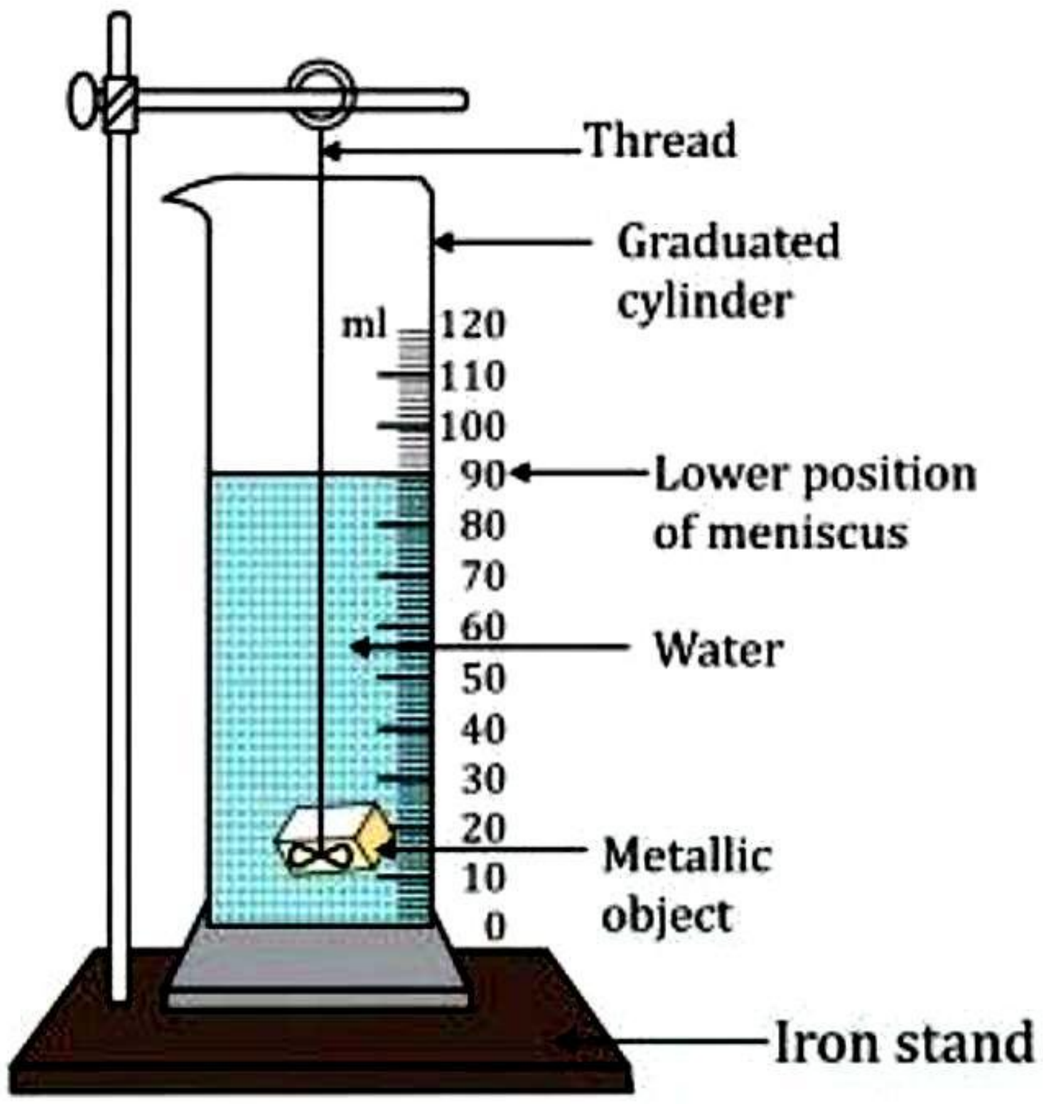

Fig (iv) Measurement of a volume of given solid

OBSERVATIONS

Least count of spring balance: ..... g wt.

Zero error of the spring balance: ..... g wt.

Least count of measuring cylinder:..... mL

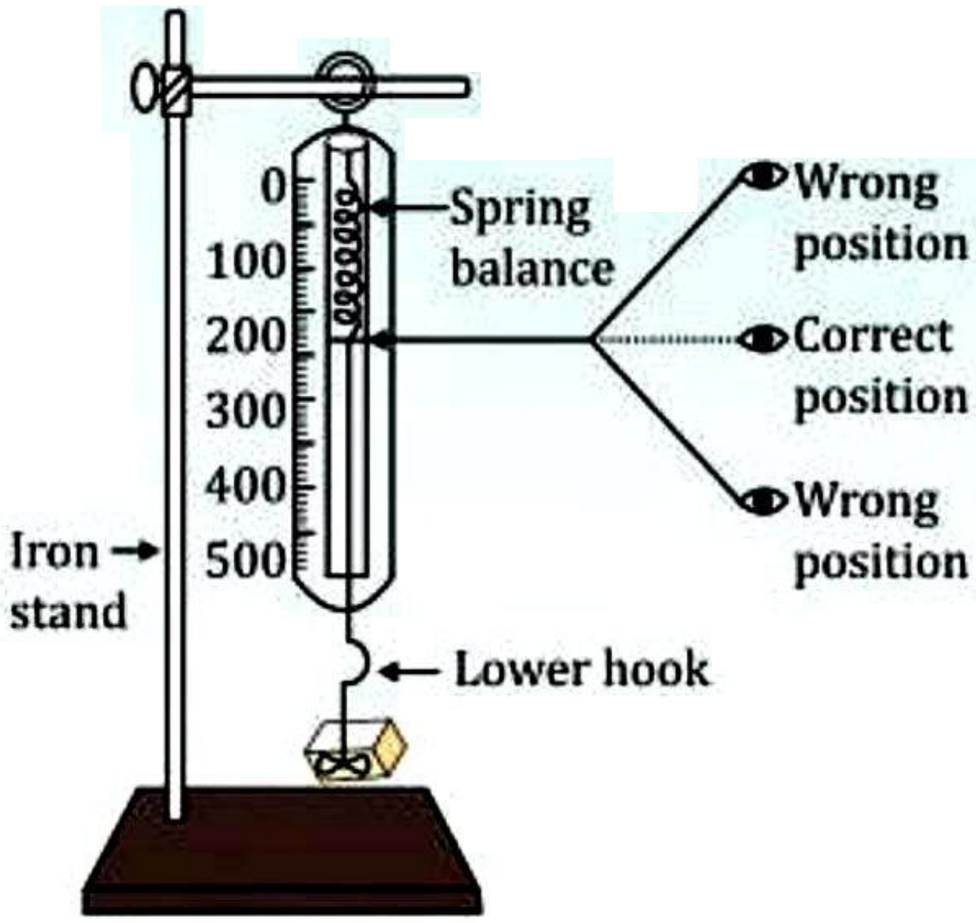

Fig (v) Reading of spring balance

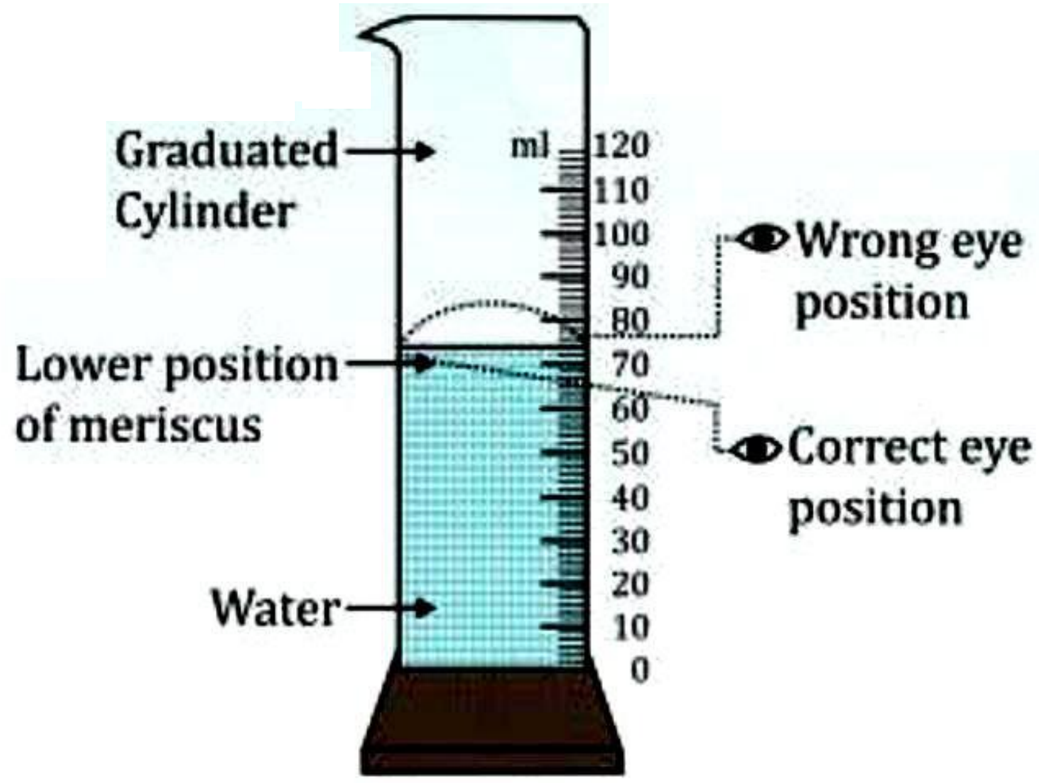

Fig (vi) Reading of lower meniscus of water level

Table: Measurement of the weight of a given metallic object.

S. No.	Reading of spring balance		Weight of the metallic object	
	(Without object) W_1 (g wt.)	(With object) W_2 (g wt.)	The weight of the object observed $W_2 - W_1$ (g wt.)	The true weight of object $W = (W_2 - W_1) -$ (Zero error) (g wt.)
1.				W'_1 =
2.				W'_2 =
3.				W'_3 =

S. No.	The initial position of the meniscus (Without metallic object) V_1 (mL)	The final position of the meniscus (Metallic object immersed) V_2 (mL)	Volume of object $V = V_2 - V_1$ (mL)
1.			V'_1 =
2.			V'_2 =
3.			V'_3 =

Mean weight of given metallic object = $W'_1+W'_2+W'_3$ ..... g wt.

Mass of the given metallic object by a spring balance, (M) = ... g.

Table: Measurement of volume of a given metallic object

Mean volume $V = V'_1+V'_2+V'_3$ = ...

Calculations

The true mass of a given object = ... g

The volume of the given object = ... ml.

Density of a given metallic object = Mass of Object = Volume of Object = MV g/mL = ... g/mL = ... kg m^{-3} (1000 kg m^{-3} = 1 gmL^{-1})

RESULT

The density of the given solid (heavier than water) = ... kg m^{-3}.

PRECAUTIONS

1. Spring balance should be sensitive, stable and error-free.
2. The horizontal pointer should move freely along the scale of the spring balance.
3. Spring balance must be suspended vertically from the fixed support of the iron stand.
4. Reading should be taken only when the oscillation of the hanging object dies completely.
5. An eye should be kept in line (exactly horizontal) while taking the reading of spring balance as well as measuring the cylinder as shown in Fig.(v)and (vi).
6. The solid object should be dried completely before measuring mass in air and when allowed to immerse in water.
7. While measuring the volume of an object, the object should not touch the sides and bottom of a measuring cylinder.
8. The water of the measuring cylinder should not fall out during the immersion of a solid object.

VIVA VOCE

Q1. What is the aim of your object?

Ans. To determine the density of a given solid (denser than water) by using a spring balance and measuring cylinder.

Q2. Is there any effect of temperature on the density?

Ans. Yes, the density of a substance decreases with the temperature rise.

Q3. What is the density of water at 4°C?

Ans. It is 10^3 kg/m^3 or 1 gm/cm^3.

Q4. What is the difference between mass and weight?

Ans. Mass is a measure of the quantity of matter which is constant all over the universe. Weight is proportional to the mass but depends on the gravity of the planet.

Q5. What is weight?

Ans. Weight is the force exerted on a body by the gravitational attraction of the planet (earth).

Q6. Convert 500 g mass into a unit of force.

Ans. Unit of force is newton (N)F = mg = 500 × 0.00980 = 4.9 N

Q7. Name the device which measures the mass and weight.

Ans. Mass is measured by physical balance. Weight is measured by spring balance.

Q8. What is the working principle of spring balance?

Ans. The extension in the length of the spring when the body is suspended from its free end is directly proportional to the weight of the body.

Q9. You stated that weight was measured by a spring balance, then how can you deduce mass from weight?

Ans. The weight of the body in gram-weight is numerically equal to the mass of a solid, i. e., 100 g wt. = 100 gf = 100 g. or 100 kg wt. = 100 kg f = 100 kg.

Q10. How can we minimize the error in the measurement of the volume of water in the measuring cylinder?

Ans. We can use the measuring cylinder having a scale of less least count.

Q11. What change in volume of water observe water is heated uniformly from 0°C to 100°C?

Ans. The volume of water decreases up to 4°C and then further increases.

Q12. Which water has the lesser density River water or Sea water?

Ans. River water.

Q13. Can you determine the density of a porous solid by using a spring balance and a measuring cylinder? Give reasons in support of your answer.

Ans. The density of the porous solid cannot be found by using a measuring cylinder and spring balance. This is because the mass of the solid when immersed in water will increase instead of decreasing as it will absorb water and the amount of water displaced by the porous solid will be affected.

Q14. How the presence of an air bubble in the liquid taken in the measuring cylinder can affect the volume of the solid?

Ans. The air bubble in the liquid taken in the measuring cylinder for an experiment will affect the volume of the solid because the air bubble occupies some space in the liquid, and this increases the volume of the liquid.

Q15. The density of sealing was is 1.8 g/cm^3 Express it in kg/m^3.

Ans. Density = mass/ volume

Density of sealing wax =1.8 g/cm

1 g/cm^3= 1000 kg/m^3

In kg/m^3 the above density will be = 1.8 × 1000 kg/m^3 = 1800 kg/m^3

Q16. A metal cylinder is melted and the whole mass is cast in the shape of a cube. What happens to its density? Give reasons.

Ans. The density in both cases will be the same because the mass remains the same and the volume of the water displaced by the metal cylinder and the cube remains the same.

Q17. At which temperature is the density of water maximum?

Ans. The density of water is maximum 4°C.