- A wooden block of specific gravity 0.7 and having a size of 2 m × 0.5m × 0.25 m is floating in water. Determine the volume of concrete of specific weight 25 kN/m3, that may be placed which will immerse (i) the block completely in water, and (ii) the block and concrete completely in water. 0.0294 m4 (Ans.), 0.0483 m3 (Ans.)
- Find the density of a metallic body which floats at the interface of mercury of specific gravity 13.6 and water such that 35 percent of its volume is submerged in mercury and 65 percent in water.

Solution. Let, V = Volume of the body, m^3.

Then, volume of body submerged in mercury

$$= \frac{35}{100} \times V = 0.35\, V\, m^3$$

Volume of body submerged in water

$$= \frac{65}{100} \times V = 0.65\, V\, m^3$$

The body will be in equilibrium when,

Total buoyant (upward) force = weight of the body

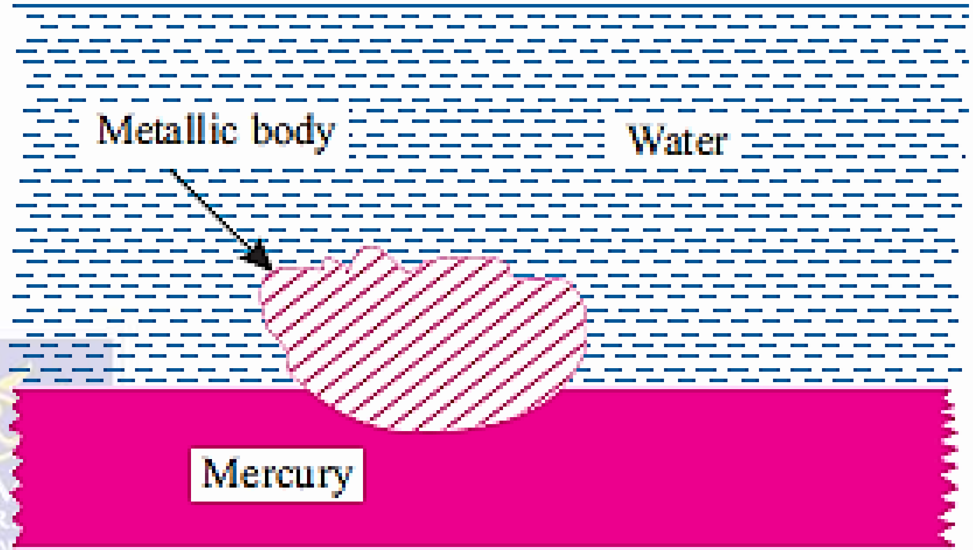


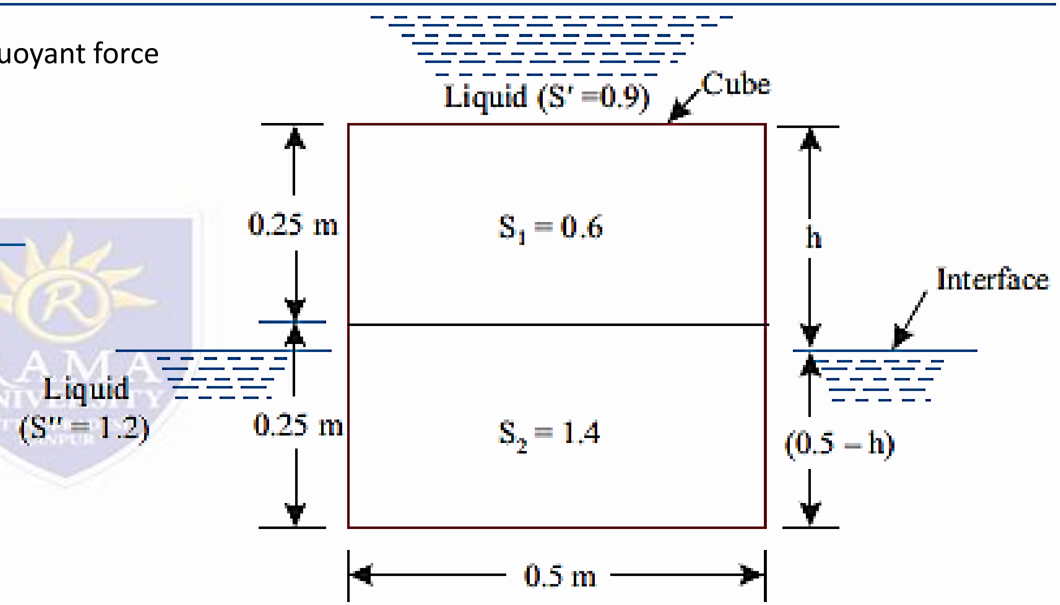
Fig. 4.2

- body
- But, Total buoyant force = Force of buoyancy due to water + force of buoyancy due to mercury
- = weight of water displaced by the body + weight of mercury displaced by the body
- = (weight density of water × volume of water displaced) + (weight density of mercury × volume of mercury displaced)
- = 9.81 × 0.65 V (kN) + 13.6 × 9.81 × 0.35 V (kN)
- and, Weight of the body = weight density × volume of the body = wbody × V
- (where, wbody = weight density of the metallic body), For equilibrium, we have:
- 9.81 × 0.65 V + 13.6 × 9.81× 0.35 V = wbody × V
- ∴ wbody = 53.07 kN/m3 (Ans.)

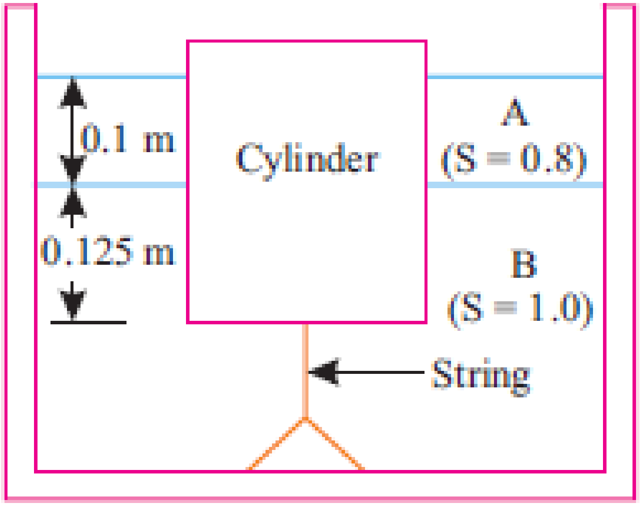
Fluid Properties

- cube 50 cm side is inserted in a two-layer fluid with specific gravity 1.2 and 0.9 respectively. The upper and lower halves of the cube are composed of materials with specific gravity 0.6 and 1.4 respectively. What is the distance of the top of cube above interface?
- Solution. Refer to Fig.
- Weight of cube = [S1 (= 0.6) × 9.81× 0.5 × 0.5 × 0.25)] + [S2 (= 1.4) × 9.81× 0.5 × 0.5 × 0.25] = 1.226 kN
- Let, h = Height of top of the cube above the interface. Then, Buoyant force = Weight of lighter and heavier liquids displaced by the block
- = [S′ (= 0.91) × 9.81× 0.5 × 0.5 × h] + [S′′ (= 1.2) × 9.81 × 0.5 × 0.5 (0.5 – h)]
- = 2.207 h + 1.471 – 2.943 h = – 0.736 h = 1.471
- As per principle of floatation, we have: Weight of block = Buoyant force
- i.e. 1.226 = – 0.736 h + 1.471

$$h = \frac{(1.471 - 1.226)}{0.736} = 0.333 \text{ m or } 33.3 \text{ cm (Ans.)}$$

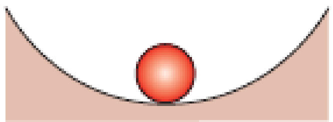


- A cylinder of mass 10 kg and area of cross-section 0.1 m2 is tied down with string in a vessel containing two liquids as shown in figure 4.7. Calculate gauge pressure on the the cylinder bottom and the tension in the string. Density of water = 1000 kg/m3. Specific gravity of A = 0.8. Specific gravity of B (water) = 1.0

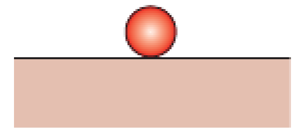


- Solution. Given: Mass of cylinder, m = 10 kg
- Area of cross-section = 0.1m2
- Density of water (liquid B) = 1000 kg/m3
- Density of liquid A = 0.8 × 1000 = 800 kg/m3
- Tension in string, T:
- Volume of liquid A displaced = 0.1 × 0.1
- = 0.01 m3
- ∴ Mass of liquid A displaced, mA = 0.01 × 800 = 8 kg
- ∴ Volume of liquid B displaced = 0.1 × 0.125 = 0.0125 m3
- ∴ Mass of liquid B displaced, mB = 0.0125 × 1000 = 12.5 kg
- Total mass of liquid displaced = mA + mB = 8 + 12.5 = 20.5 kg
- Upward thrust = 20.5 × 9.81 = 201.1 N
- Weight of cylinder = mg = 10 × 9.81 = 98.1 N
- Net upward thrust = 201.1 – 98.1 = 103 N
- ∴ Tension in the string, T = 103 N (Ans.)
- Pressure (gauge) on the cylinder bottom, p:

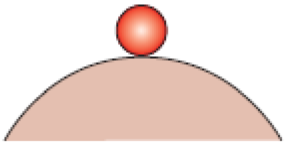
$$p = \frac{\text{Net upward thrust}}{\text{Area of cross-section}} = \frac{103}{0.1} = 1030 \text{ N/m}^2 \text{ (Ans.)}$$



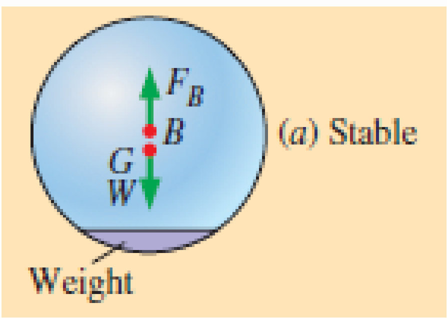
(a) Stable

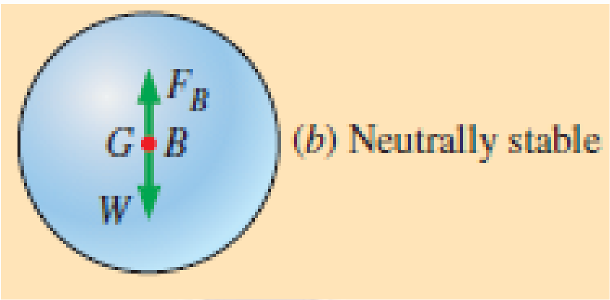


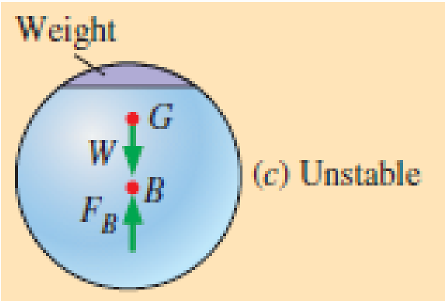
(b) Neutrally stable



(c) Unstable



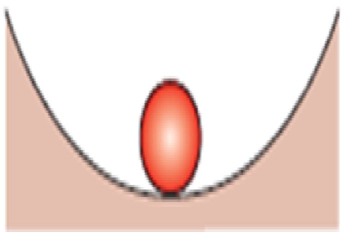




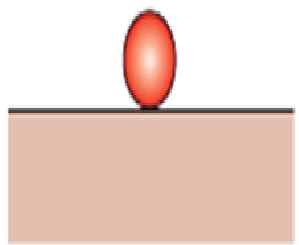
An immersed neutrally buoyant body is (a) stable if the center of gravity G is directly below the center of buoyancy B of the body, (b) neutrally stable if G and B are coincident, and (c) unstable if G is directly above B.

Fluid Properties

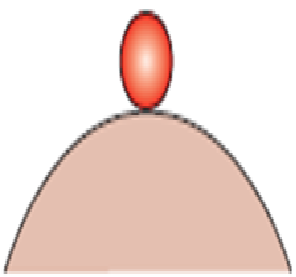
- Stable Equilibrium
- When a body is given a small angular displacement (i.e. tilted slightly), by some external force, and then it returns back to its original position due to the internal forces (the weight and the upthrust), such an equilibrium is called stable equilibrium.
- Unstable Equilibrium
- If the body does not return to its original position from the slightly displaced angular position and heels farther away, when given a small angular displacement, such an equilibrium is called an unstable equilibrium.
- Neutral Equilibrium
- If a body, when given a small angular displacement, occupies a new position and remains at rest in this new position, it is said to possess a neutral equilibrium.



(a) Stable



(b) Neutrally stable



(c) Unstable

Fluid Properties

- three balls at rest on the floor.
- Case (a) is stable since any small disturbance (someone moves the ball to the right or left) generates a restoring force (due to gravity) that returns it to its initial position.
- Case (b) is neutrally stable because if someone moves the ball to the right or left, it would stay put at its new location. It has no tendency to move back to its original location, nor does it continue to move away.
- Case (c) is a situation in which the ball may be at rest at the moment, but any disturbance, even an infinitesimal one, causes the ball to roll off the hill—it does not return to its original position; rather it diverges from it. This situation is unstable.

When the center of gravity *G* of an immersed neutrally buoyant body is not vertically aligned with the center of buoyancy *B* of the body, it is not in an equilibrium state and would rotate to its stable state, even without any disturbance.