Class 11 Physics Chapter 9: Mechanical Properties of Fluid

Very Short Answers

11. Is viscosity a vector?

Answer: No, viscosity is not a vector quantity. It is a scalar quantity and it is a property of liquid with no direction.

---

12. Is surface tension a vector?

Answer: Surface tension is a scalar quantity as it has a specific direction.

---

13. Iceberg floats in water with part of it submerged. What is the fraction of the volume of iceberg submerged if the density of ice is $\rho_i = 0.917\ g/cm^3$?

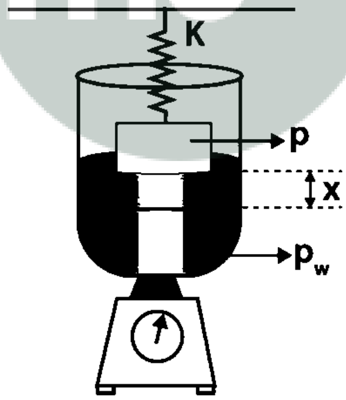
Solution:

- Density of ice: $\rho_i = 0.917\ g/cm^3$
- Density of water: $\rho w = 1\ g/cm^3$
- For floating equilibrium: Weight of iceberg = Buoyant force
- $\rho_i V_i g = \rho w V w g$
- Fraction submerged = $Vw/V_i = \rho_i/\rho w = 0.917$

---

14. A vessel filled with water is kept on a weighing pan and the scale adjusted to zero. A block of mass M and density ρ is suspended by a massless spring of spring constant k. This block is submerged inside into the water in the vessel. What is the reading of the scale?

Solution:

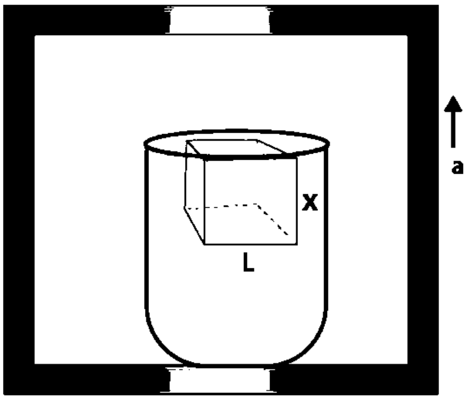


- When block is submerged, it displaces water volume $V = M/\rho$
- Buoyant force on block = $V\rho w g = (M/\rho)\rho w g = Mg\rho w/\rho$
- By Newton's third law, water exerts equal and opposite force on the vessel
- Scale reading = $V\rho w g = Mg\rho w/\rho$

---

15. A cubical block of density ρ is floating on the surface of water. Out of its height L, fraction x is submerged in water. The vessel is in an elevator accelerating upwards with acceleration a. What is the fraction immersed?

Solution: For equilibrium in normal conditions:



- Weight of block = Weight of displaced water
- $\rho L^3 g = \rho w x_1 L^2 g$
- $x_1 = \rho/\rho w$

In accelerating elevator with acceleration a:

- Effective acceleration = g + a
- $\rho L^3(g + a) = \rho w x_1 L^2(g + a)$
- $x_1 = \rho/\rho w = x$ (same as before)

The fraction immersed remains the same because both weight and buoyant force are multiplied by the same factor (g + a)/(g).

Short Answer

16. The sap in trees, which consists mainly of water in summer, rises in a system of capillaries of radius $r = 2.5 \times 10^{-5}$ m. The surface tension of sap is $T = 7.28 \times 10^{-2}$ N/m and the angle of contact is 0°. Does surface tension alone account for the supply of water to the top of all trees?

Solution: Maximum height of capillary rise: $h = (2T \cos \theta)/(r\rho g)$

Given:

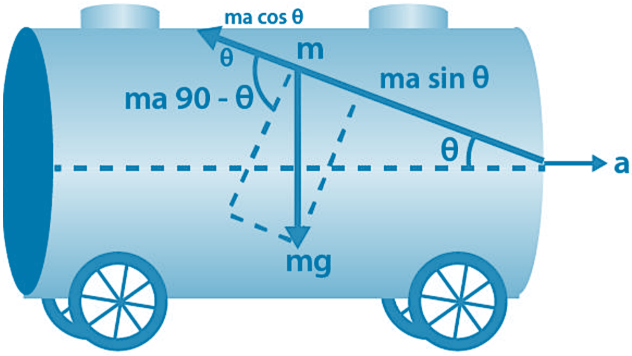
- $r = 2.5 \times 10^{-5}$ m
- $T = 7.28 \times 10^{-2}$ N/m
- $\theta = 0°$, so $\cos \theta = 1$
- $\rho = 10^3$ kg/m³
- $g = 9.8$ m/s²

$h = (2 \times 7.28 \times 10^{-2} \times 1)/(2.5 \times 10^{-5} \times 10^3 \times 9.8) = 0.6$ m

Since h = 0.6 m, surface tension alone cannot account for water supply to tall trees, which can be tens of meters high.

---

17. The free surface of oil in a tanker, at rest, is horizontal. If the tanker starts accelerating the free surface will be tilted by an angle θ. If the acceleration is a m/s², what will be the slope of the free surface?



Solution: Consider an element of oil at the surface:

- Pseudo force = ma (horizontal, backward)
- Weight = mg (vertical, downward)

For equilibrium along the inclined surface:

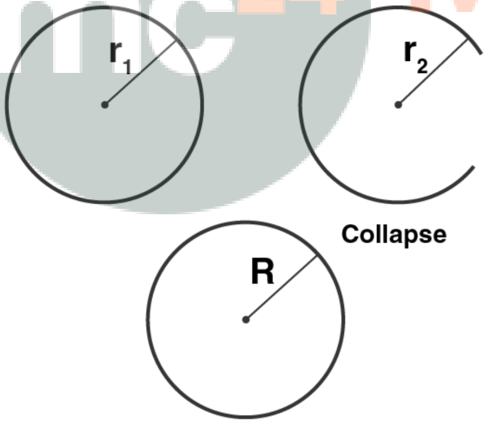
- $ma \cos\theta = mg \sin\theta$
- $\tan\theta = a/g$
- $\theta = \tan^{-1}(a/g)$

The slope of the free surface is $\tan\theta = a/g$.

---

18. Two mercury droplets of radii 0.1 cm and 0.2 cm collapse into one single drop. What amount of energy is released? The surface tension of mercury T = 435.5×10^{-3} N/m.

Solution: Given:



- $r_1 = 0.1$ cm $= 10^{-3}$ m
- $r_2 = 0.2$ cm $= 2 \times 10^{-3}$ m
- $T = 435.5 \times 10^{-3}$ N/m

Volume conservation: $(4/3)\pi R^3 = (4/3)\pi(r_1^3 + r_2^3)$ $R^3 = (10^{-3})^3 + (2 \times 10^{-3})^3 = 10^{-9} + 8 \times 10^{-9} = 9 \times 10^{-9}$ $R = 2.1 \times 10^{-3}$ m

Change in surface area: $\Delta A = 4\pi R^2 - (4\pi r_1^2 + 4\pi r_2^2)$ $\Delta A = 4\pi[R^2 - (r_1^2 + r_2^2)]$ $\Delta A = 4\pi[(2.1 \times 10^{-3})^2 - ((10^{-3})^2 + (2 \times 10^{-3})^2)]$ $\Delta A = 4\pi[4.41 \times 10^{-6} - 5 \times 10^{-6}] = -4\pi \times 0.59 \times 10^{-6}$ m²

Energy released: $E = |T \times \Delta A| = 435.5 \times 10^{-3} \times 4\pi \times 0.59 \times 10^{-6} = 3.23 \times 10^{-6}$ J