

PICK PREP

LEARN • THINK • GROW

**NEET
PHYSICS
ESSENTIALS**

MECHANICAL PROPERTIES OF FLUIDS

NEET PHYSICS ESSENTIALS

CONCEPT SUMMARY

KEY CONCEPTS | FORMULAS | RECOGNITION CUES
MISCONCEPTIONS | EXAM TRAPS | QUICK CHECKS



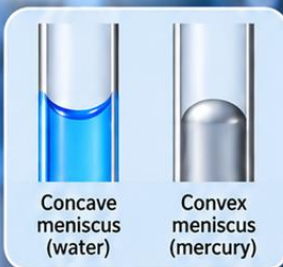
UNDERSTAND
THE PHYSICS



RECOGNIZE
THE PATTERN



SOLVE WITH
CONFIDENCE



Concave
meniscus
(water)

Convex
meniscus
(mercury)

**SAME PHYSICS.
A HIGHER SCORE.**

1. Chapter Introduction

Fluids can flow. This chapter studies how fluids exert pressure, support immersed bodies, move through pipes, resist motion and form liquid surfaces.

Revision rule: identify the physical situation first, choose the model, check its assumptions, then use the relation.

2. Chapter in One View

Central idea: Fluid statics is organized by pressure and buoyancy; ideal fluid flow by conservation of mass and energy; real-fluid flow by viscosity; liquid surfaces by surface tension.

Mental Map: identify whether the fluid is at rest or moving; choose pressure/buoyancy for statics, continuity/Bernoulli for ideal flow, viscosity models for real-fluid motion, and surface-tension relations for liquid surfaces.

- Fluid at rest → density, pressure, depth, manometers, Pascal's law.
- Body in a fluid → buoyancy, apparent weight and floating.
- Fluid in motion → steady flow, continuity, Bernoulli and efflux.
- Real-fluid effects → viscosity, Stokes drag, terminal speed, Reynolds number and Poiseuille flow.
- Liquid surface → surface tension, excess pressure and capillary action.

3. Must-Know Concepts

- Density ρ = mass/volume; SI unit kg/m^3 . Relative density is dimensionless.
- Pressure is normal force per area; SI unit Pa. In a static fluid, pressure at a point acts equally in all directions.
- Hydrostatic pressure depends on vertical depth and fluid density, not container shape. For a liquid open to air, $P_{\text{absolute}} = P_{\text{atm}} + \rho gh$.
- Pascal's law: a pressure change applied to an enclosed fluid is transmitted throughout the fluid.
- Archimedes' principle: buoyant force equals the weight of displaced fluid.
- Floating equilibrium: buoyancy equals weight; for a uniform floating body, submerged fraction = $\rho_{\text{body}}/\rho_{\text{fluid}}$.
- Steady flow: velocity at each fixed point is constant with time. Streamlines show the local flow direction and do not cross.
- Continuity is conservation of mass. For steady incompressible flow, Av is constant.
- Bernoulli relates pressure, kinetic and gravitational energy per unit volume for ideal steady flow along a streamline.
- Viscosity describes resistance to relative motion between fluid layers. Stokes' law applies only in its low-Reynolds-number regime.
- Terminal speed occurs when the net force becomes zero.

- Surface tension acts along a liquid surface per unit length. A soap film has two surfaces.
- Capillary rise/depression depends on T , contact angle θ , tube radius, fluid density and g .

4. Formula + Meaning

$$\rho = m/V$$

Meaning: Mass per unit volume.

Use when: Mass and volume are given.

Condition: Use consistent SI units.

Exam trap: Relative density is a ratio; it has no unit.

$$P = F_{\perp}/A$$

Meaning: Normal force per unit area.

Use when: A force acts perpendicular to a surface.

Condition: Use the normal component of force.

Exam trap: Pressure unit is Pa, not N.

$$P_{gauge} = \rho gh ; P_{absolute} = P_{atm} + \rho gh$$

Meaning: Pressure above atmosphere and total pressure at depth in a static liquid open to air.

Use when: A point is at vertical depth h below the free surface.

Condition: Liquid density is uniform and the liquid is at rest.

Exam trap: Use vertical depth, not container-wall length; add atmospheric pressure only for absolute pressure.

$$\Delta P = \rho_m g \Delta h$$

Meaning: Pressure difference balanced by a single manometer-liquid column.

Use when: A manometer has a known vertical level difference and the relevant column density is identified.

Condition: For multiple fluids, balance pressure step-by-step using each fluid's density and vertical height change.

Exam trap: The simple form is not a universal formula for every multi-fluid manometer.

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Meaning: Equal transmitted pressure in an ideal hydraulic system.

Use when: Hydraulic lift or brake relates piston forces and areas.

Condition: Compare pistons at the same level or include hydrostatic head if levels differ.

Exam trap: Force multiplication is accompanied by a smaller displacement; energy is not created.

$$F_B = \rho_f V_{displaced} g$$

Meaning: Buoyant force equals displaced-fluid weight.

Use when: An immersed or floating body displaces fluid.

Condition: ρ_f is fluid density; $V_{displaced}$ is volume of fluid displaced.

Exam trap: Do not automatically use the entire body volume if only partly immersed.

$$W_{\text{apparent}} = mg - F_B$$

Meaning: Apparent weight for a body supported vertically while immersed, with no other vertical forces.

Use when: A spring balance reading in a fluid is asked for.

Condition: The body is in static equilibrium or the stated force balance applies.

Exam trap: If other vertical forces act, write the full force equation.

$$\frac{V_{\text{submerged}}}{V_{\text{body}}} = \frac{\rho_{\text{body}}}{\rho_{\text{fluid}}}$$

Meaning: Fraction of a uniform body's volume submerged while floating.

Use when: A body floats at rest in a fluid.

Condition: Weight equals buoyant force; body is uniformly dense.

Exam trap: This relation is for floating equilibrium, not for a sinking or accelerating body.

$$Q = Av; \dot{m} = \rho Av$$

Meaning: Volume flow rate and mass flow rate.

Use when: Fluid volume or mass passing a section per unit time is required.

Condition: A is cross-sectional area normal to flow; v is average speed over that area.

Exam trap: Q has units m^3/s ; mass flow rate has units kg/s .

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$; for constant ρ : $A_1 v_1 = A_2 v_2$

Meaning: Conservation of mass between pipe sections.

Use when: Steady flow through a pipe of changing area.

Condition: Use the density form for compressible flow; use Av constant for incompressible flow.

Exam trap: Area and speed vary inversely only when density is constant.

$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$

Meaning: Pressure, kinetic and gravitational energy per unit volume.

Use when: Compare two points along the same streamline in ideal flow.

Condition: Steady, incompressible, non-viscous model; no unaccounted pump/turbine work or losses.

Do not use blindly when: Do not apply blindly to strongly viscous/turbulent flow or across unmodelled devices.

Exam trap: At equal height, higher speed corresponds to lower static pressure under the model.

$v = \sqrt{2gh}$

Meaning: Ideal efflux speed from a small hole.

Use when: A small opening is h below the free surface of a large tank.

Condition: Both points are at atmospheric pressure; tank surface speed is negligible; ideal-flow assumptions hold.

Exam trap: h is the vertical depth below the free surface.

$$F = \eta A \left(\frac{dv}{dy} \right)$$

Meaning: Magnitude of viscous shear force in a Newtonian fluid-layer model.

Use when: Viscosity, area and velocity gradient are known.

Condition: Use the appropriate layer model and velocity gradient perpendicular to the layers.

Exam trap: Dynamic viscosity η has unit $\text{Pa}\cdot\text{s}$; do not confuse it with surface tension.

$$F_{\text{drag}} = 6\pi\eta r v$$

Meaning: Stokes drag on a small sphere.

Use when: A small sphere moves slowly through a viscous fluid.

Condition: Low Reynolds number / creeping-flow regime.

Do not use blindly when: Do not use for high-speed or turbulent motion.

Exam trap: Drag opposes relative motion between sphere and fluid.

$$v_t = \frac{2r^2(\rho_s - \rho_f)g}{9\eta}$$

Meaning: Terminal speed of a small sphere falling in a viscous fluid.

Use when: A sphere has reached terminal speed and Stokes drag is valid.

Condition: Spherical body; low-Reynolds-number regime; sinking body has $\rho_s > \rho_f$.

Do not use blindly when: Do not use if Stokes' law is invalid or before terminal speed is reached.

Exam trap: Doubling r makes v_t four times as large under the same assumptions.

$$Re = \frac{\rho v L}{\eta}$$

Meaning: Ratio of inertial to viscous effects.

Use when: A question asks about likely flow regime or applicability of a model.

Condition: Use the characteristic length and speed appropriate to the geometry.

Exam trap: Critical values depend on geometry and flow conditions; do not treat one threshold as universal.

$$Q = \frac{\pi r^4 \Delta P}{8\eta L}$$

Meaning: Poiseuille volume flow rate through a cylindrical tube.

Use when: Flow rate through a long circular tube is required.

Condition: Steady laminar flow of a Newtonian fluid; tube is straight and radius is uniform.

Do not use blindly when: Do not use for turbulent flow or where the tube assumptions fail.

Exam trap: Radius appears to the fourth power: doubling r gives 16 times Q if other variables stay fixed.

$$T = \frac{F}{L}; F = TL$$

Meaning: Surface tension as force per unit length for one surface/contact line.

Use when: Force along a liquid surface is asked for.

Condition: Use the relevant contact-line length and stated surface count.

Exam trap: A soap film has two surfaces, so its force/work expressions may include a factor of 2.

$$W = T\Delta A(\text{one surface}); W = 2T\Delta A(\text{soap})$$

Meaning: Work needed to increase surface area.

Use when: Surface-area change and surface tension are given.

Condition: For a soap film, ΔA is the increase in area of one face; both faces contribute.

Exam trap: Check whether ΔA refers to one face or total area of both faces.

$$\Delta P_{drop} = \frac{2T}{r}; \quad \Delta P_{soap\ bubble} = \frac{4T}{r}$$

Meaning: Excess pressure caused by surface curvature.

Use when: Pressure inside a spherical drop or soap bubble is required.

Condition: Spherical shape; uniform surface tension; r is radius.

Exam trap: A soap bubble has two liquid surfaces; a liquid drop has one.

$$h = \frac{2T \cos \theta}{\rho g r}$$

Meaning: Capillary rise or depression relative to the reservoir surface.

Use when: Liquid level changes in a narrow circular tube.

Condition: θ is measured through the liquid; r is tube radius. Sign of $\cos \theta$ gives rise or depression.

Exam trap: Use radius, not diameter; a wetting liquid usually rises and a non-wetting liquid may be depressed.

5. Formula Selection Guide

Situation	Think This Model	Use This Relation
Point below a still liquid surface	Hydrostatic pressure	$P_{\text{gauge}} = \rho g h$
U-tube / manometer levels	Pressure balance	Step through levels using $\rho g \Delta h$ for each fluid

Situation	Think This Model	Use This Relation
Connected pistons	Pascal's law	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$
Immersed body / displaced volume	Archimedes' principle	$F_B = \rho_f V_{\text{displaced}} g$
Floating body and density ratio	Floating equilibrium	Submerged fraction = $\rho_{\text{body}} / \rho_{\text{fluid}}$
Pipe area changes	Conservation of mass	$\rho A v = \text{constant}; \text{for constant } \rho, A v = \text{constant}$
Pressure, speed, and height at 2 points	Bernoulli model	$P + \frac{1}{2} \rho v^2 + \rho g h = \text{constant}$
Small hole below tank surface	Torricelli theorem	$v = \sqrt{2gh}$
Small sphere moving slowly in fluid	Stokes drag	$F_{\text{drag}} = 6\pi\eta r v$
Sphere at constant terminal speed	Force balance	Weight = Buoyancy + Drag (for downward motion)
Long circular tube, laminar flow	Poiseuille flow	$Q = \frac{\pi r^4 \Delta P}{8\eta L}$

Situation	Think This Model	Use This Relation
Drop vs soap bubble	Surface curvature / surface count	$2T/r$ for drop; $4T/r$ for soap bubble
Liquid rises or falls in narrow tube	Capillary action	$h = \frac{2T \cos \theta}{\rho g r}$

6. When to Use / When Not to Use

Bernoulli's equation

- Use when comparing pressure, speed and height for ideal steady flow along a streamline.
- Do not use blindly if viscosity, turbulence, pumps, turbines, compressibility or energy losses are important and not included.

Continuity

- Use $A_1 v_1 = A_2 v_2$ for steady incompressible flow.
- For compressible flow, keep density: $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$.

Stokes' law and terminal speed

- Use for a small sphere in slow, low-Reynolds-number motion.
- At terminal speed, net force is zero. For a sphere falling downward: weight = buoyancy + viscous drag.
- Do not use the terminal-speed formula during the initial acceleration phase or outside the Stokes regime.

Poiseuille's law

- Use for steady laminar flow through a long, straight, circular tube for a Newtonian fluid.
- Do not use for turbulent flow, irregular short passages or when the model assumptions fail.

Surface-tension relations

- Identify whether the problem asks for force, work, excess pressure or capillary height; these are different models.
- Count surfaces carefully: liquid drop has one surface; soap bubble/film has two.

7. Common Misconceptions

- Wrong: Pressure at the same depth depends on container shape. → Correct: In a static uniform liquid, it depends on depth and density. → Why: Container shape is not a term in hydrostatic pressure.
- Wrong: Buoyant force always equals body weight. → Correct: It equals displaced-fluid weight; it equals body weight for a floating body in equilibrium. → Why: Immersed and floating are not identical conditions.
- Wrong: Narrower pipe means lower flow rate. → Correct: For steady incompressible flow, Q is constant and speed increases in the narrower section. → Why: Area and speed adjust together.

- Wrong: Bernoulli applies to every fluid in motion. → Correct: It is an ideal-flow relation with specific assumptions. → Why: Viscous losses can change the energy balance.
- Wrong: Viscosity is surface tension. → Correct: Viscosity resists layer motion; surface tension acts along a liquid surface. → Why: Their physical meanings and units differ.

Wrong: A concave or convex meniscus alone is the formula. → Correct: Use $h = \frac{2T \cos\theta}{\rho g r}$, with θ measured through the liquid. → Why: The contact angle determines the sign; the meniscus is a visual clue.

8. Exam Traps

- Adding atmospheric pressure when the question asks only for gauge pressure.
- Using the length along a manometer tube instead of vertical height difference.
- Using full body volume instead of displaced volume for a partly immersed body.
- Applying $A_1 v_1 = A_2 v_2$ without checking steady incompressible flow.
- Using Bernoulli without checking assumptions and whether points lie on the same streamline.
- Substituting diameter where radius is required, especially in r^2 and r^4 relations.
- Forgetting the two surfaces of a soap film/bubble.

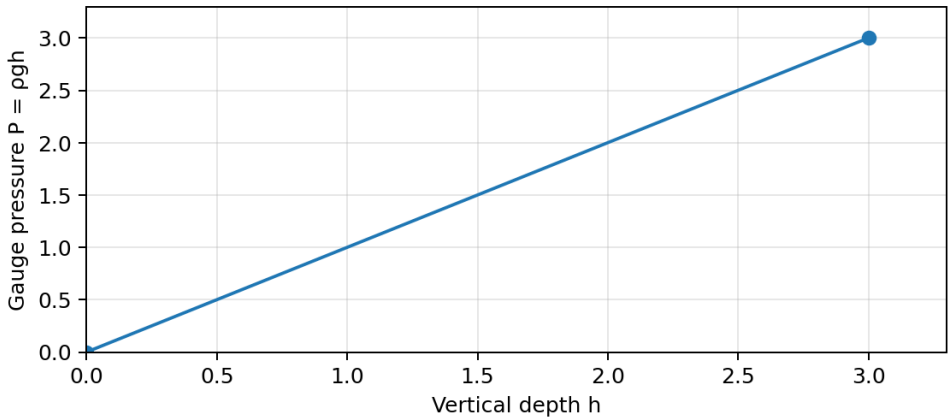
- Using Stokes' law before checking whether low-Reynolds-number conditions apply.

9. See This → Think This

- Same liquid, greater depth → greater gauge pressure.
- Gauge pressure → pressure above atmosphere; absolute pressure → include atmospheric pressure.
- Body floating at rest → buoyancy balances weight.
- Steady incompressible pipe narrows → speed rises; volume flow rate stays constant.
- Horizontal ideal flow speeds up → static pressure falls along the streamline.
- Small hole in a large tank → efflux speed depends on depth below the surface.
- Falling sphere moves at constant speed → use terminal force balance.
- Tube radius doubles in Poiseuille flow → ideal flow rate becomes 16 times larger.
- Soap bubble → check for two surfaces.
- Thin capillary → magnitude of capillary height increases as radius decreases.

10. Key Diagrams / Graphs

Gauge pressure increases linearly with depth

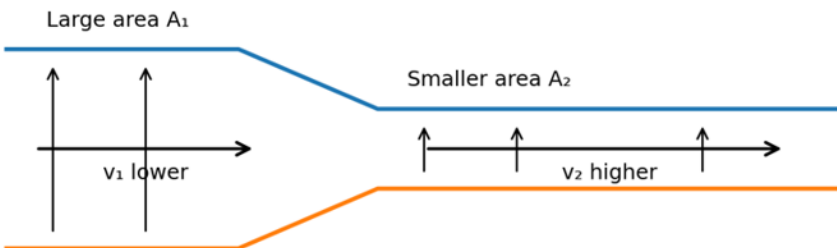


Pressure–depth graph

Notice: Gauge pressure starts at zero at the free surface and increases linearly with vertical depth for a liquid of constant density.

Exam Use: The slope is ρg . If absolute pressure is plotted, the intercept is P_{atm} for a free surface open to air.

Steady incompressible flow: $A_1 v_1 = A_2 v_2$

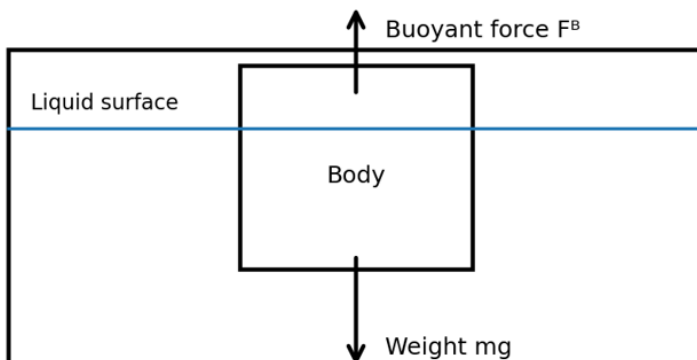


Flow through a narrowing pipe

Notice: The same volume per second passes both sections in steady incompressible flow; the narrow section has higher speed.

Exam Use: Apply continuity first. If pressure is asked, apply Bernoulli only after checking ideal-flow conditions.

Buoyancy: upward force equals displaced-fluid weight

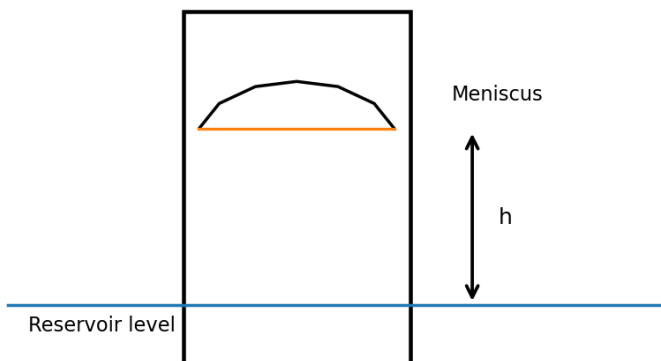


Buoyant force on an immersed body

Notice: Buoyancy acts upward; weight acts downward. The buoyant force equals the weight of displaced fluid.

Exam Use: For floating equilibrium, the two forces balance. For a fully immersed accelerating body, do not assume they are equal.

Capillary rise (wetting liquid shown schematically)

**Capillary rise**

Notice: For a wetting liquid, the meniscus and surface forces can lift liquid above the reservoir level.

Exam Use: Use $h = \frac{2T\cos\theta}{\rho gr}$ identify θ through the liquid, and use tube radius.

Meniscus cue: concave water in clean glass usually means $\theta < 90^\circ$ and rise; convex mercury in glass usually means $\theta > 90^\circ$ and depression. Confirm with $\cos\theta$, because θ sets the sign.

10A. Concave and Convex Menisci – Why They Form

A meniscus is the curved surface of a liquid near the wall of its container. Its shape depends mainly on the balance between adhesion (attraction between the liquid and the solid) and cohesion (attraction between molecules of the liquid).

Concave meniscus — water in clean glass

Water usually wets clean glass because the attraction between water and glass is stronger than the attraction that would keep the water surface pulled away from the wall. Water climbs slightly along the walls, leaving the middle lower; the surface is concave. The contact angle measured through the water is usually less than 90° .

Convex meniscus — mercury in glass

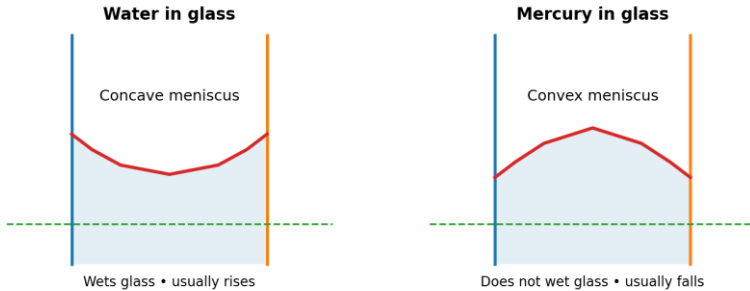
Mercury does not wet clean glass because cohesion within mercury is stronger than adhesion between mercury and glass. Mercury pulls away from the walls and the middle of the surface sits higher; the surface is convex. The contact angle measured through mercury is usually greater than 90° .

How the meniscus controls capillary rise or depression

Surface tension acts tangentially to the liquid surface. Its vertical component along the tube wall is upward when $\cos\theta$ is positive ($\theta < 90^\circ$), so the liquid rises; it is downward when $\cos\theta$ is negative ($\theta > 90^\circ$), so the liquid is depressed. At $\theta = 90^\circ$, $\cos\theta = 0$ and the ideal capillary height is zero.

$h = \frac{2T\cos\theta}{\rho g r}$, θ is measured through the liquid. Concave/convex shape is a useful clue, but the contact angle—not the label alone—sets the sign of h .

Meniscus shape depends on liquid-solid wetting



Schematic comparison: concave water meniscus and convex mercury meniscus in glass.

11. Quick Checks

- Q: SI unit of pressure? → Pa (N/m^2).
- Q: Does static pressure at the same depth depend on container shape? → No, for the same uniform liquid and pressure reference.
- Q: What volume determines buoyant force? → Displaced-fluid volume.
- Q: A floating body has density 600 kg/m^3 in water of density 1000 kg/m^3 . Fraction submerged? → 0.60 (60%).
- Q: If pipe area halves in steady incompressible flow, what happens to speed? → It doubles.
- Q: SI unit of volume flow rate? → m^3/s .
- Q: What conditions are needed for standard Bernoulli? → Steady, incompressible, non-viscous ideal flow along a streamline, without unaccounted energy input/loss.

- Q: If sphere radius doubles, what happens to Stokes terminal speed? → It becomes four times as large, if the same assumptions remain valid.
- Q: If capillary radius halves, what happens to the magnitude of capillary height? → It doubles, with the same liquid and contact angle.
- Q: Excess pressure in a spherical soap bubble? → $4T/r$.

Meniscus quick check: Water in glass → concave, $\theta < 90^\circ$, $\cos\theta > 0$, capillary rise. Mercury in glass → convex, $\theta > 90^\circ$, $\cos\theta < 0$, capillary depression.

Q: What is the ideal capillary height when $\theta = 90^\circ$? → Zero, because $\cos 90^\circ = 0$.

12. Mini Exam Reasoning

Clue: A point is h below the free surface of a liquid at rest. →

Situation: Hydrostatic pressure. → Model: Liquid column. →

Relation: $P_{\text{gauge}} = \rho gh$. → Check: Is absolute pressure requested?

Clue: A body floats in water and its density is given. → Situation:

Vertical equilibrium. → Model: Weight balances buoyancy. →

Relation: Submerged fraction = $\rho_{\text{body}}/\rho_{\text{water}}$. → Check: The body is floating at rest.

Clue: A horizontal pipe becomes narrower. → Situation: Steady

incompressible flow. → Model: Continuity, then Bernoulli if

pressure is needed. → Relations: $A_1 v_1 = A_2 v_2$; $P + \frac{1}{2}\rho v^2 =$

constant. → Check: Ideal-flow assumptions.

Clue: A sphere reaches constant downward speed in a viscous liquid. → Situation: Terminal motion. → Model: Net force is zero. → Relation: Weight = buoyancy + drag. → Check: Stokes' law must be valid.

Clue: Mercury forms a convex meniscus in glass. → Situation: Capillary depression. → Model: Contact angle and surface tension. → Relation: $h = \frac{2T \cos \theta}{\rho g r}$. → Check: $\theta > 90^\circ$, so $\cos \theta < 0$ and h is negative relative to the reservoir level.

13. One-Minute Recall

- $\rho = m/V$; $P = F_{\perp}/A$.
- Static liquid: $P_{\text{gauge}} = \rho g h$; absolute pressure adds P_{atm} .
- Manometer: use vertical level changes and balance pressure through each fluid.
- Pascal: transmitted pressure; hydraulic force gain does not create energy.
- Buoyancy = weight of displaced fluid.
- Floating fraction = $\rho_{\text{body}}/\rho_{\text{fluid}}$.
- Continuity: $\rho A v$ is constant; $A v$ is constant for incompressible flow.
- Bernoulli: $P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$ under ideal conditions.
- Efflux: $\sqrt{2gh}$
- Stokes drag: $6\pi\eta r v$; terminal speed scales as r^2 under Stokes conditions.

- Poiseuille: $Q \propto r^4$.
- Surface tension: count one or two surfaces.
- Drop excess pressure = $2T/r$; soap bubble = $4T/r$.
- Capillary height = $2T \cos\theta/(\rho g r)$.

Want to Go Deeper?

The complete NEET Physics Essentials Concept Book develops concepts step by step with detailed diagrams, microquestions after concepts, solved numericals, integrated problem-solving and a complete exam playbook.

Understand the Physics → Recognize the Pattern → Solve with Confidence

Website: www.pickprep.com

WhatsApp: +919737240300

Email: pickprep03@gmail.com

