

Mechanical Properties of Fluids — CBSE Pattern Test 2

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 2 — CBSE Pattern (90 minutes, 40 marks)

Class 11 Physics · Mechanical Properties of Fluids · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.
(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
(3) For MCQ questions choose the single correct option; for VSA answers write a single line.
(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- For an incompressible fluid in steady flow, $A_1v_1 = A_2v_2$ is the
 - equation of continuity
 - Bernoulli's equation
 - equation of state
 - Pascal's law
- Where the cross-section of a pipe narrows, the speed of an incompressible fluid
 - increases
 - decreases
 - stays the same
 - becomes zero
- Bernoulli's principle states that where fluid speed is higher, the pressure is
 - lower
 - higher
 - equal
 - undetermined
- The lift on an aeroplane wing is explained by
 - Bernoulli's principle
 - Archimedes' principle
 - Pascal's law
 - Stokes' law
- The property of a fluid that resists relative motion between its layers is called
 - viscosity
 - surface tension
 - density
 - pressure
- The SI unit of coefficient of viscosity is
 - poiseuille (Pa s)
 - N m^{-1}
 - kg m^{-3}
 - $\text{W m}^{-1} \text{K}^{-1}$
- Stokes' law for a falling sphere gives the viscous force as
 - $6\pi\eta rv$

(B) $6\pi r^2 v$

(C) $4\pi r^3/3$

(D) $2T/r$

8. Terminal velocity is the constant speed at which

(A) the viscous force balances the weight of the falling body

(B) the body starts accelerating

(C) the buoyancy vanishes

(D) the density equals the fluid's

9. Define surface tension. Write its SI unit.

10. What is the condition for a body to float in a liquid?

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. A sphere of radius 1 mm falls through water of viscosity 0.001 Pa s at a terminal velocity of 2 cm/s. Find the viscous force on it.

12. A body floats with one quarter of its volume above water. Find the ratio of its density to that of water.

13. Water flows through a horizontal pipe of cross-section 30 cm^2 where its speed is 2 m/s and pressure $2 \times 10^5 \text{ Pa}$. In a narrower section of area 10 cm^2 the speed rises; find the pressure there. ($\rho = 1000 \text{ kg m}^{-3}$)

14. A rain drop of radius 0.1 mm falls through air with viscosity $1.8 \times 10^{-5} \text{ Pa s}$. Estimate its terminal velocity. ($\rho_{\text{water}} = 1000 \text{ kg m}^{-3}$, $\rho_{\text{air}} \approx 0$, $g = 10 \text{ m/s}^2$)

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. A hydraulic lift has pistons of areas 10 cm^2 and 200 cm^2 . What force is needed on the small piston to lift a car of weight 2000 N?

16. Derive the expression for the excess pressure inside a liquid drop and inside a soap bubble.

17. A liquid of surface tension 0.072 N m^{-1} rises to 2 cm in a capillary tube of radius 0.36 mm. Find the density of the liquid. ($\cos\theta = 1$, $g = 10 \text{ m/s}^2$)

18. Explain Stokes' law and derive the expression for the terminal velocity of a sphere falling in a viscous fluid.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Derive the equation of continuity and Bernoulli's equation. Water flows through a horizontal pipe of cross-section 30 cm^2 where its speed is 2 m/s and pressure $2 \times 10^5 \text{ Pa}$; in a narrower section of area 10 cm^2 find the speed and the pressure. ($\rho = 1000 \text{ kg m}^{-3}$)

20. State Archimedes' principle and use it to show the condition for floatation. A cube of side 5 cm floats in water with 60% of its volume submerged — find the density of the cube.

Answer Key (Marking Scheme)

Q1 — (A) equation of continuity. Q2 — (A) increases. Q3 — (A) lower. Q4 — (A) Bernoulli's principle.

Q5 — (A) viscosity. Q6 — (A) poiseuille (Pa s). Q7 — (A) $6\pi\eta rv$. Q8 — (A) viscous force balances the weight.

Q9 — Force per unit length along the free surface of a liquid; SI unit N m^{-1} .

Q10 — The body's average density must be less than the fluid's density; it floats with the fraction $\rho_{\text{body}}/\rho_{\text{fluid}}$ submerged.

Q11 — $F = 6\pi\eta rv = 6\pi \times 0.001 \times 10^{-3} \times 0.02 \approx 3.8 \times 10^{-7} \text{ N}$.

Q12 — Fraction submerged = $3/4$, so $\rho_{\text{body}}/\rho_{\text{water}} = 0.75$.

Q13 — $v_2 = (30/10) \times 2 = 6 \text{ m/s}$; $P_2 = 2 \times 10^5 - \frac{1}{2} \times 1000 \times (36 - 4) = 1.84 \times 10^5 \text{ Pa}$.

Q14 — $v_t = 2r^2\rho g/(9\eta) = 2 \times (10^{-4})^2 \times 1000 \times 10/(9 \times 1.8 \times 10^{-5}) \approx 1.2 \text{ m/s}$.

Q15 — $F = 2000 \times 10/200 = 100 \text{ N}$.

Q16 — Liquid drop: excess $2T/r$ (one surface); soap bubble: excess $4T/R$ (two free surfaces).

Q17 — $\rho = 2T/(h r g) = 0.144/(0.02 \times 3.6 \times 10^{-4} \times 10) = 2000 \text{ kg m}^{-3}$.

Q18 — $F = 6\pi\eta r v$; at terminal velocity $F = mg - \text{buoyancy}$ $\dot{Q}_t = 2r^2(\rho - \sigma)g/(9\eta)$.

Q19 — $v_2 = 6 \text{ m/s}$; $P_2 = 2 \times 10^5 - 1.6 \times 10^4 = 1.84 \times 10^5 \text{ Pa}$.

Q20 — $\rho_{\text{cube}} = 0.6 \times 1000 = 600 \text{ kg m}^{-3}$.