CLASS 11 PHYSICS — FORMULA SHEET

Chapter 9 : Mechanical Properties of Fluids (NCERT)

9.1 Pressure in Fluids

Concept	Formula / Detail
Pressure	$P = F \div A$ (force per unit area; scalar) ; SI unit Pa (N/m^2)
Density	ρ = mass ÷ volume (kg/m^3)
Relative density	= density of substance ÷ density of water (no unit)
Pressure due to liquid column	$P = \rho g h$ (gauge pressure at depth h)
Absolute pressure	$P = P_0 + \rho gh$ (P_0 = atmospheric pressure)
Gauge pressure	$P_{gauge} = P - P_0 = \rho gh$
Atmospheric pressure	1 atm = 1.013×10^5 Pa = 76 cm of Hg
Pascal's law	Pressure applied to an enclosed fluid is transmitted equally in all directions

9.2 Applications of Pascal's Law & Buoyancy

Concept	Formula
Hydraulic lift / press	$F_2 = F_1 \times (A_2 \div A_1)$ (force multiplied by area ratio)
Hydraulic principle	$P_1 = P_2 \rightarrow F_1/A_1 = F_2/A_2$
Archimedes' principle	Buoyant force = weight of fluid displaced = $\rho_{fluid} V_{submerged}\, g$
Apparent weight (submerged)	$W_{app} = W - F_{buoyant} = V g (\rho_{body} - \rho_{fluid})$
Law of floatation	Floats if $\rho_{body} \leq \rho_{fluid}$; weight = buoyant force
Fraction submerged (floating)	$V_{submerged} \div V_{total} = \rho_{body} \div \rho_{fluid}$

9.3 Fluid Flow & Bernoulli's Principle

Concept	Formula
Equation of continuity	$A_1v_1 = A_2v_2$ = constant (Av = volume flow rate)
Consequence	Narrow pipe → higher velocity (smaller area, faster flow)
Bernoulli's equation	$P + ½\rho v^2 + \rho gh$ = constant (along a streamline)
Bernoulli (per unit volume)	Pressure energy + KE + PE per unit volume = constant
Speed of efflux (Torricelli)	$v = \sqrt{(2gh)}$ (liquid out of a hole at depth h)
Venturimeter	$v = \sqrt{[2(P_1 - P_2) \div \rho]}$; measures flow speed
Dynamic lift / aerofoil	Faster air on top → lower pressure → upward lift

9.4 Viscosity

Concept	Formula
Viscous force (Newton)	$F = -\eta A (dv/dx)$; η = coefficient of viscosity

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Concept	Formula
SI unit of η	Pa·s (or poiseuille) ; CGS: poise (1 Pa·s = 10 poise)
Stokes' law (sphere in fluid)	$F = 6\pi\eta rv$ (drag on a small sphere of radius r)
Terminal velocity	$v_t = [2r^2(\rho - \sigma)g] \div (9\eta)$ (ρ = sphere, σ = fluid density)
Reynolds number	$Re = (\rho\ v\ D) \div \eta$ (dimensionless)
Flow type by Re	Re < 1000 laminar ; 1000-2000 unstable ; > 2000 turbulent
Poiseuille's equation	$Q = (\pi\ P\ r^4) \div (8\ \eta\ L)$ (volume flow rate through a pipe)

9.5 Surface Tension

Concept	Formula
Surface tension (T)	T = Force ÷ length = F/L ; SI unit N/m
Surface energy	= T × increase in surface area
Excess pressure (liquid drop)	$P = 2T \div R$
Excess pressure (soap bubble)	$P = 4T \div R$ (two surfaces)
Excess pressure (air bubble in liquid)	$P = 2T \div R$
Capillary rise (Jurin's law)	$h = (2T \cos\theta) \div (\rho\ g\ r)$ (θ = angle of contact)
Angle of contact	θ < 90° wetting (water-glass) ; θ > 90° non-wetting (mercury-glass)

9.6 Effect of Temperature & Key Facts

Concept	Detail
Viscosity vs temperature	Liquids: viscosity DECREASES with temperature ; Gases: INCREASES
Surface tension vs temperature	Decreases with rise in temperature; zero at critical temperature
Effect of impurities on T	Soluble impurities (salt) increase T ; soap/detergent decreases T
Why drops are spherical	Surface tension minimises surface area → sphere (least area per volume)
Streamline vs turbulent	Streamline: orderly layers ; Turbulent: irregular, eddies

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Pressure with depth	$P = P_0 + \rho gh$. Depends on depth, NOT on shape or area of container.
Pascal → hydraulic lift	$F_2 = F_1(A_2/A_1)$. Small force on small piston lifts big load.
Continuity	Av = constant → pinch a hose, water shoots faster.
Bernoulli	$P + \frac{1}{2}\rho v^2 + \rho gh$ = constant. High speed → low pressure.
Torricelli	Efflux speed $v = \sqrt{(2gh)}$ — same as a freely falling body.
Terminal velocity	$v_t \propto r^2$. Bigger sphere falls faster in a viscous fluid.
Drop vs bubble	Drop/air-bubble: 2T/R ; Soap bubble: 4T/R (two surfaces).
Capillary rise	$h = 2T\cos\theta/\rho gr$. Narrower tube → higher rise.

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