BY AP Sir, Sakaar Classes

Topic: Vectors (Physics)

Formula Name / Topic	Formula(e)	Conditions / Usage
1. Magnitude of a Vector	If $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$: $\|\vec{A}\| = \sqrt{A_x^2 + A_y^2 + A_z^2}$	Used to find the size/length of a vector from its Cartesian components.
2. Unit Vector	$\hat{n} = \frac{\vec{A}}{\|\vec{A}\|}$	Represents direction only. Magnitude is always 1.
3. Vector Addition (Parallelogram Law)	**Resultant (R):** $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$ **Direction (α with $\vec{A}$):** $\tan\alpha = \frac{B\sin\theta}{A + B\cos\theta}$	θ is the angle between $\vec{A}$ and $\vec{B}$ (tail-to-tail). $R_{max} = A + B$ (at 0°), $R_{min} = \|A - B\|$ (at 180°).
4. Vector Subtraction	**Magnitude:** $\|\vec{A} - \vec{B}\| = \sqrt{A^2 + B^2 - 2AB\cos\theta}$ **Direction:** $\tan\alpha = \frac{B\sin\theta}{A - B\cos\theta}$	Used for relative velocity ($\Delta\vec{v}$). θ is the angle between original vectors.
5. Resolution of Components	$A_x = A\cos\theta$	θ is the angle made with the X-axis.

	$A_y = A \sin\theta$	
6. Direction Cosines	$l = \frac{A_x}{A}, \quad m = \frac{A_y}{A}, \quad n = \frac{A_z}{A}$	l, m, n are cosines of angles with X, Y, Z axes.
	$l^2 + m^2 + n^2 = 1$	
7. Dot Product (Scalar)	$\vec{A} \cdot \vec{B} = AB\cos\theta$	Result is Scalar.
	$\vec{A} \cdot \vec{B} = A_xB_x + A_yB_y + A_zB_z$	**Perpendicular if:** $\vec{A} \cdot \vec{B} = 0$.
8. Angle Between Vectors	$\cos\theta = \frac{\vec{A}\cdot\vec{B}}{\lvert\vec{A}\rvert\lvert\vec{B}\rvert}$	Vectors must be tail-to-tail.
9. Cross Product (Vector)	**Magnitude:** $\lvert\vec{A} \times \vec{B}\rvert = AB\sin\theta$	Result is Vector $\perp$ to $\vec{A}$ and $\vec{B}$.
		Parallel if: $\vec{A} \times \vec{B} = 0$.
	Determinant Form:	
	$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$	
10. Lami's Theorem	$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$	Only for 3 concurrent forces in equilibrium.
11. Relative Velocity	$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$	Velocity of A w.r.t B.
12. Rain-Man Concept	$\vec{v}_{rm} = \vec{v}_r - \vec{v}_m$	θ with vertical.
	$\tan\theta = \frac{v_m}{v_r}$	
13. River Boat: Min Time	$t_{min} = \frac{d}{v_b}$	Head perpendicular to flow.
	Drift $x = v_r \times t_{min}$	
14. River Boat: Shortest Path	$\sin\theta = \frac{v_r}{v_b}$	Head upstream at angle θ.

	$t = \frac{a}{\sqrt{v_b^2 - v_r^2}}$	Cond: $v_b > v_r$.
15. Area of Triangle	Area $= \frac{1}{2}\lvert\vec{A} \times \vec{B}\rvert$	$\vec{A}, \vec{B}$ are adjacent sides.
16. Area of Parallelogram	Sides: $\lvert\vec{A} \times \vec{B}\rvert$	
	Diagonals: $\frac{1}{2}\lvert\vec{d_1} \times \vec{d_2}\rvert$	
17. Vol. of Parallelepiped	$V = \lvert\vec{A} \cdot (\vec{B} \times \vec{C})\rvert$	Coplanar if Volume = 0.
	$V = \begin{vmatrix} A_x & A_y & A_z \\ B_x & B_y & B_z \\ C_x & C_y & C_z \end{vmatrix}$	