CLASS 11 PHYSICS — FORMULA SHEET

Chapter 3 : Motion in a Plane (NCERT)

3.1 Scalars and Vectors

Concept	Detail
Scalar	Has magnitude only (mass, speed, distance, time, energy, temperature)
Vector	Has magnitude AND direction (displacement, velocity, force, acceleration)
Unit vector	$\hat{A} = A / \lvert A \rvert$; magnitude 1, gives direction only
Standard unit vectors	$\hat{i}, \hat{j}, \hat{k}$ along x, y, z axes (mutually perpendicular)
Equal vectors	Same magnitude AND direction
Negative vector	Same magnitude, opposite direction (−A)
Null (zero) vector	Zero magnitude, arbitrary direction
Collinear / parallel	Act along the same or parallel lines

3.2 Vector Addition & Resolution

Concept	Formula
Component form	$A = A_x\hat{i} + A_y\hat{j}$; $A_x = A\cos\theta$, $A_y = A\sin\theta$
Magnitude	$\lvert A \rvert = \sqrt{(A_x^2 + A_y^2)}$
Direction	$\tan\theta = A_y \div A_x$
Triangle / parallelogram law	Resultant R = A + B (placed head-to-tail / on adjacent sides)
Resultant magnitude	$R = \sqrt{(A^2 + B^2 + 2AB\cos\theta)}$ (θ = angle between A and B)
Direction of resultant	$\tan\alpha = (B\sin\theta) \div (A + B\cos\theta)$
Max & min resultant	$R_{max} = A + B$ ($\theta = 0°$) ; $R_{min} = \lvert A - B \rvert$ ($\theta = 180°$)
Perpendicular vectors (θ = 90°)	$R = \sqrt{(A^2 + B^2)}$

3.3 Product of Vectors

Product	Formula / Property
Scalar (dot) product	$A \cdot B = AB\cos\theta$ (gives a scalar)
Dot in components	$A \cdot B = A_xB_x + A_yB_y + A_zB_z$
Dot properties	$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1$; $\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\cdot\hat{i} = 0$; commutative
Vector (cross) product	$A \times B = AB\sin\theta\,\hat{n}$ (gives a vector ⊥ to both)
Cross magnitude	$\lvert A \times B \rvert = AB\sin\theta$ = area of parallelogram
Cross properties	$\hat{i}\times\hat{j} = \hat{k}$, $\hat{j}\times\hat{k} = \hat{i}$, $\hat{k}\times\hat{i} = \hat{j}$; $A\times B = -(B\times A)$; $A\times A = 0$
Angle between vectors	$\cos\theta = (A \cdot B) \div (\lvert A \rvert\lvert B \rvert)$

3.4 Motion in a Plane (2-D Kinematics)

Quantity	Formula
Position vector	$r = x\,\hat{i} + y\,\hat{j}$
Velocity	$v = dr/dt = v_x\hat{i} + v_y\hat{j}$
Acceleration	$a = dv/dt = a_x\hat{i} + a_y\hat{j}$
Equations (vector form)	$v = u + a\,t$; $r = u\,t + \frac{1}{2}\,a\,t^2$
Independence of motions	x and y motions are independent (treated separately)

3.5 Projectile Motion

Quantity	Formula (launch speed u, angle θ)
Horizontal velocity	$u_x = u\cos\theta$ (constant throughout)
Vertical velocity	$u_y = u\sin\theta$ (changes due to g)
Equation of path	$y = x\tan\theta - (g\,x^2) \div (2u^2\cos^2\theta)$ → parabola
Time of flight	$T = (2u\sin\theta) \div g$
Maximum height	$H = (u^2\sin^2\theta) \div (2g)$
Horizontal range	$R = (u^2\sin 2\theta) \div g$
Maximum range	$R_{max} = u^2 \div g$ at $\theta = 45°$
Range equal for	θ and (90° − θ) give the same range
Velocity at time t	$v = \sqrt{(u_x^2 + (u_y - gt)^2)}$

3.6 Uniform Circular Motion

Quantity	Formula
Angular displacement	θ (radian) ; $s = r\,\theta$
Angular velocity	$\omega = \theta/t = 2\pi/T = 2\pi f$
Linear–angular relation	$v = r\,\omega$
Time period	$T = 2\pi/\omega = 2\pi r/v$
Frequency	$f = 1/T = \omega/2\pi$
Centripetal acceleration	$a_c = v^2/r = \omega^2\,r = 4\pi^2 f^2\,r$ (directed toward centre)
Centripetal force	$F_c = mv^2/r = m\omega^2\,r$
Angular acceleration (non-uniform)	$\alpha = d\omega/dt$; tangential accel $a_t = r\alpha$

3.7 Relative Velocity in a Plane

Concept	Formula
Relative velocity	$v_{AB} = v_A - v_B$ (vector subtraction)
River–boat (cross straight)	Point boat upstream at angle θ where $\sin\theta = v_{river} \div v_{boat}$
Resultant speed across river	$v = \sqrt{(v_{boat}^2 - v_{river}^2)}$ (for shortest path)
Rain–man problem	$v_{rain,man} = v_{rain} - v_{man}$; tilt umbrella along this resultant

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Resultant formula	R = √(A² + B² + 2AB cosθ). Max at θ=0 (A+B), min at θ=180° (|A−B|).
Dot vs Cross	Dot → scalar (AB cosθ) ; Cross → vector (AB sinθ, perpendicular).
î ĵ k̂ cross cycle	î×ĵ=k̂, ĵ×k̂=î, k̂×î=ĵ (cyclic +) ; reverse order gives minus.
Projectile splits	Horizontal: constant velocity. Vertical: free fall under g. Solve separately.
Range max at 45°	R = u²sin2θ/g ; maximum when 2θ = 90°, i.e. θ = 45°.
Complementary angles	θ and (90°−θ) give the SAME range (e.g. 30° and 60°).
H : R relation	At θ = 45°, R = 4H. Useful quick check.
Centripetal a	$a_c = v^2/r = \omega^2 r$, always pointing toward the centre.