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FORMULA POSTER

CBSE Class 12 Mathematics

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formula-sheet-cbse12
Interactive version

CBSE gives no formula booklet: learn every result on this sheet. Organised by NCERT chapter.

1 Relations & Functions

Reflexive $(a,a) \in R\ \forall a$; symmetric $(a,b) \in R \Rightarrow (b,a) \in R$; transitive $(a,b),(b,c) \in R \Rightarrow (a,c) \in R$; equivalence = all three → Reflexive, symmetric or transitive: a counter-example when one fails

One-one: $f(x_1) = f(x_2) \Rightarrow x_1 = x_2$. Onto: range = codomain. Bijective: both → Decide whether functions are one-one, onto, both or neither

Watch for: Prove one-one and onto algebraically, not by examples

Counting, $|A| = m$, $|B| = n$: relations on A: 2^{m^2}; functions $A \to B$: n^m → Count relations and functions between finite sets

One-one $A \to B$ $(m \le n)$; bijections $(m = n)$: $\frac{n!}{(n-m)!}$; $n!$ → Count one-one functions and bijections

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Watch for One-one: $f(a) = f(b) \Rightarrow a = b$

2 Inverse Trigonometric Functions

Principal ranges: $\sin^{-1} : [-1,1] \to \left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$, $\cos^{-1} : [-1,1] \to [0,\pi]$, $\tan^{-1} : \mathbb{R} \to \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$ → Principal values such as $\sin^{-1}\left(-\frac{1}{2}\right)$ and $\cos^{-1}\left(-\frac{\sqrt{3}}{2}\right)$

Watch for: Know the ranges: $\sin^{-1}$ in $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$, $\cos^{-1}$ in $[0,\pi]$

More ranges: $\cot^{-1} : \mathbb{R} \to (0,\pi)$, $\sec^{-1} : [0,\pi] - \{\frac{\pi}{2}\}$, $\operatorname{cosec}^{-1} : \left[-\frac{\pi}{2}, \frac{\pi}{2}\right] - \{0\}$ → Domain and range of each inverse trig function

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$\sec^{-1}$, $\operatorname{cosec}^{-1}$ domain: $\mathbb{R} - (-1,1)$ → Domain and range of each inverse trig function

$\sin(\sin^{-1} x) = x$ for $x \in [-1,1]$; $\sin^{-1}(\sin x) = x$ only for $x \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$ (similarly for the others) → Compositions such as $\sin^{-1}(\sin x)$ outside the principal branch

Watch for Know the principal value ranges

3 Matrices

Product $A_{m\times n}B_{n\times p}$ is $m \times p$; in general $AB \neq BA$; $AB = O$ is possible with $A, B \neq O$ → Multiply matrices when the product is defined

Transpose: $(A^T)^T = A$, $(A+B)^T = A^T + B^T$, $(kA)^T = kA^T$, $(AB)^T = B^T A^T$ → Verify results such as $(AB)' = B'A'$

Symmetric $A^T = A$; skew-symmetric $A^T = -A$ (diagonal entries 0) → Identify symmetric and skew-symmetric matrices

Any square A: $A = \frac{1}{2}(A + A^T) + \frac{1}{2}(A - A^T)$ → Write a square matrix as symmetric plus skew-symmetric

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Inverse: $AB = BA = I \Rightarrow B = A^{-1}$; $(AB)^{-1} = B^{-1}A^{-1}$ → Check whether two matrices are inverses of each other

4 Determinants

2×2: $\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$ → Evaluate determinants of 2×2 and 3×3 matrices

Minor; cofactor: M_{ij}; $A_{ij} = (-1)^{i+j} M_{ij}$ → Minors and cofactors to expand a determinant

Watch for: Cofactor signs follow the $+ - +$ pattern

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$|A| = \sum_j a_{ij} A_{ij}$ along any row (or column); elements × cofactors of a different row sum to 0 → Expand along the row or column with most zeroes

Area of triangle: $\frac{1}{2}\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}$; collinear $\iff$ det $= 0$ → Area of a triangle from its vertices; zero area means collinear

Adjoint = transpose of the cofactor matrix: $A(\operatorname{adj} A) = (\operatorname{adj} A)A = |A|I$ → Find the adjoint of a square matrix

Inverse: $A^{-1} = \frac{1}{|A|}\operatorname{adj} A$ $(|A| \neq 0)$ → Inverse when the determinant is non-zero

Watch for: Check $|A| \neq 0$, then divide adj A by $|A|$

Order n: $|AB| = |A||B|$, $|A^T| = |A|$, $|kA| = k^n|A|$, $|\operatorname{adj} A| = |A|^{n-1}$, $|A^{-1}| = \frac{1}{|A|}$ → Simplify expressions and find unknown determinants

$AX = B$: $|A| \neq 0$: $X = A^{-1}B$ (unique) → Solve three equations by the matrix method

$X = A^{-1}B$

$|A| = 0$: $(\operatorname{adj} A)B \neq O \Rightarrow$ inconsistent; $(\operatorname{adj} A)B = O \Rightarrow$ infinitely many or none → Decide whether a system is consistent or inconsistent

Watch for Check $|A| \neq 0$ and the cofactor signs

5 Continuity & Differentiability

Continuous at c: $\lim_{x\to c^-} f(x) = \lim_{x\to c^+} f(x) = f(c)$ → Test continuity by comparing left-hand and right-hand limits

Differentiable at c: LHD = RHD; differentiable ⇒ continuous (not conversely, e.g. $|x|$ at 0) → Test differentiability with left-hand and right-hand derivatives

Standard: $(x^n)' = nx^{n-1}$, $(\sin x)' = \cos x$, $(\cos x)' = -\sin x$, $(\tan x)' = \sec^2 x$ → Differentiate composite functions with the chain rule

More trig: $(\cot x)' = -\operatorname{cosec}^2 x$, $(\sec x)' = \sec x \tan x$,

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$(\operatorname{cosec} x)' = -\operatorname{cosec} x \cot x$ → Differentiate composite trigonometric functions

Exp, log: $(e^x)' = e^x$, $(a^x)' = a^x \log a$, $(\log x)' = \frac{1}{x}$, $(\log_a x)' = \frac{1}{x \log a}$ → Differentiate e^{3x} and $\log(\sin x)$

Inverse trig: $(\sin^{-1} x)' = \frac{1}{\sqrt{1-x^2}}$, $(\cos^{-1} x)' = -\frac{1}{\sqrt{1-x^2}}$, $(\tan^{-1} x)' = \frac{1}{1+x^2}$ → Differentiate $\sin^{-1}(2x)$ and $\tan^{-1}(\sqrt{x})$

Rules: $(uv)' = u'v + uv'$, $\left(\frac{u}{v}\right)' = \frac{u'v - uv'}{v^2}$, $\frac{dy}{dx} = \frac{dy}{dt} \cdot \frac{dt}{dx}$ → Write each step of the chain rule clearly

Logarithmic, $y = u^v$: $\log y = v \log u \Rightarrow \frac{1}{y}\frac{dy}{dx} = v' \log u + \frac{vu'}{u}$ → Differentiate x^x and products of several factors

Parametric: $\frac{dy}{dx} = \frac{dy/dt}{dx/dt}$, $\frac{d^2y}{dx^2} = \frac{\frac{d}{dt}\left(\frac{dy}{dx}\right)}{dx/dt}$ → $\frac{dy}{dx}$ for curves in parametric form

Implicit: differentiate term by term, $\frac{d}{dx}(y^2) = 2y\frac{dy}{dx}$ → $\frac{dy}{dx}$ in terms of x and y for implicit functions

Log means natural log (base e) in NCERT.

6 Application of Derivatives

Rate of change: $\frac{dA}{dt} = \frac{dA}{dr} \cdot \frac{dr}{dt}$ → Rate of change, such as how fast a circle's area grows

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$f'(x) > 0$ on (a,b): strictly increasing; $f'(x) < 0$: strictly decreasing → Intervals where a function is strictly increasing or decreasing

Critical point: $f'(c) = 0$ or $f'(c)$ undefined → Local maxima and minima

Watch for: Solve $f'(x) = 0$ fully before testing

First derivative test: f' changes + → − (max), − → + (min), no change (neither) → Local maxima and minima by the first derivative test

Second derivative test: $f'(c) = 0$: $f''(c) < 0$ max, $f''(c) > 0$ min, $f''(c) = 0$ test fails → Optimisation: maximise a box's volume or minimise a cost

Watch for: Apply the test to each point; answer in context

Absolute max/min on $[a,b]$: compare f at critical points and at a, b → Absolute maximum and minimum on a closed interval

Watch for Solve $f'(x) = 0$ fully, then test each point

7 Integrals

Basic: $\int x^n\,dx = \frac{x^{n+1}}{n+1} + C$ $(n \neq -1)$, $\int \frac{1}{x}\,dx = \log|x| + C$ → Indefinite integrals from the standard formulae

Watch for: Write $+C$ on every indefinite integral

Exp: $\int e^x\,dx = e^x + C$, $\int a^x\,dx = \frac{a^x}{\log a} + C$ → Indefinite integrals from the standard formulae

Trig: $\int \sin x\,dx = -\cos x + C$, $\int \cos x\,dx = \sin x + C$, $\int \sec^2 x\,dx = \tan x + C$ → Integrate $\sin^2 x$ and $\cos^3 x$ with trigonometric identities

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Trig: $\int \operatorname{cosec}^2 x\,dx = -\cot x + C$, $\int \sec x \tan x\,dx = \sec x + C$, $\int \operatorname{cosec} x \cot x\,dx = -\operatorname{cosec} x + C$ → Indefinite integrals from the standard formulae

Trig: $\int \tan x\,dx = \log|\sec x| + C$, $\int \cot x\,dx = \log|\sin x| + C$ → Indefinite integrals from the standard formulae

sec, cosec: $\int \sec x\,dx = \log|\sec x + \tan x| + C$, $\int \operatorname{cosec} x\,dx = \log|\operatorname{cosec} x - \cot x| + C$ → Indefinite integrals from the standard formulae

Inverse trig: $\int \frac{dx}{\sqrt{1-x^2}} = \sin^{-1} x + C$, $\int \frac{dx}{1+x^2} = \tan^{-1} x + C$ → Special forms such as $\frac{1}{x^2+a^2}$ and $\frac{1}{\sqrt{a^2-x^2}}$

Special: $\int \frac{dx}{x^2-a^2} = \frac{1}{2a}\log\left|\frac{x-a}{x+a}\right| + C$, $\int \frac{dx}{a^2-x^2} = \frac{1}{2a}\log\left|\frac{a+x}{a-x}\right| + C$ → Integrals that match the special standard forms

Special: $\int \frac{dx}{x^2+a^2} = \frac{1}{a}\tan^{-1}\frac{x}{a} + C$, $\int \frac{dx}{\sqrt{a^2-x^2}} = \sin^{-1}\frac{x}{a} + C$ → Integrals that match the special standard forms

Special: $\int \frac{dx}{\sqrt{x^2 \pm a^2}} = \log\left|x + \sqrt{x^2 \pm a^2}\right| + C$ → Complete the square to reach a special standard form

Root: $\int \sqrt{a^2 - x^2}\,dx = \frac{x}{2}\sqrt{a^2 - x^2} + \frac{a^2}{2}\sin^{-1}\frac{x}{a} + C$ → Complete the square under a root, then integrate

Root: $\int \sqrt{x^2 \pm a^2}\,dx = \frac{x}{2}\sqrt{x^2 \pm a^2} \pm \frac{a^2}{2}\log\left|x + \sqrt{x^2 \pm a^2}\right| + C$ → Complete the square under a root, then integrate

By parts (ILATE for the first function u): $\int uv\,dx = u\int v\,dx - \int\left(u' \int v\,dx\right)dx$ → Integrate xe^x and $x\sin x$ by parts

Special form: $\int e^x\left[f(x) + f'(x)\right]dx = e^x f(x) + C$ → Integrals of $e^x[f(x) + f'(x)]$

$ax^2 + bx + c$: complete the square; for $\frac{px+q}{ax^2+bx+c}$ write $px + q = A\frac{d}{dx}(ax^2 + bx + c) + B$ → Complete the square in a quadratic denominator

Partial fractions: $\frac{px+q}{(x-a)(x-b)} = \frac{A}{x-a} + \frac{B}{x-b}$, $\frac{\cdots}{(x-a)^2(x-b)} = \frac{A}{x-a} + \frac{B}{(x-a)^2} + \frac{C}{x-b}$ → Rational functions with linear and repeated linear factors

Watch for: Repeated $(x-a)^2$ needs $\frac{A}{x-a} + \frac{B}{(x-a)^2}$

Quadratic factor: $\frac{\cdots}{(x-a)(x^2+bx+c)} = \frac{A}{x-a} + \frac{Bx+C}{x^2+bx+c}$ → Partial fractions with a quadratic factor

Watch for: An irreducible quadratic needs $(Bx + C)$ on top

Fundamental theorem: $\int_a^b f(x)\,dx = F(b) - F(a)$ → Evaluate definite integrals by substituting the limits

Properties: $\int_a^b f = -\int_b^a f$, $\int_a^b f = \int_a^c f + \int_c^b f$, $\int_a^b f(x)\,dx = \int_a^b f(a+b-x)\,dx$ → Split the interval and reverse the limits

Properties: $\int_0^a f(x)\,dx = \int_0^a f(a-x)\,dx$ → Replace x by $a + b - x$ to evaluate integrals

Properties: $\int_0^{2a} f\,dx = 2\int_0^a f\,dx$ if $f(2a-x) = f(x)$, 0 if $f(2a-x) = -f(x)$ → Simplify definite integrals with their properties

Even / odd: $\int_{-a}^a f\,dx = 2\int_0^a f\,dx$ (even), 0 (odd) → Definite integrals of odd and even functions

Watch for Write $+C$ and show the substitution line

8 Application of Integrals

Area: $\int_a^b |y|\,dx$, $\int_c^d |x|\,dy$ → Area bounded by a curve and the x-axis or y-axis

Watch for: Sketch the region and find intersection points first

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Circle $x^2 + y^2 = a^2$: area πa^2; ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$: area πab → Areas enclosed by circles and ellipses using symmetry

Region between a curve and a line: integrate (upper − lower) between the intersection points → Area between a curve and a line

Watch for: Integrate (top − bottom) between the intersections

Watch for Sketch the region and find the intersection points

9 Differential Equations

Order = highest derivative; degree = power of it (when polynomial in derivatives). General solution has as many constants as the order → Order and degree of a differential equation

Variables separable: $\int \frac{dy}{g(y)} = \int f(x)\,dx + C$ → Separate the variables; use a given condition

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Homogeneous $\frac{dy}{dx} = F\left(\frac{y}{x}\right)$: $y = vx$, $\frac{dy}{dx} = v + x\frac{dv}{dx}$ → Homogeneous equations with $y = vx$

Linear $\frac{dy}{dx} + Py = Q$: I.F. $= e^{\int P\,dx}$, $y \cdot$ I.F. $= \int Q \cdot$ I.F. $dx + C$ → Linear equations $\frac{dy}{dx} + Py = Q$ with an integrating factor

Watch for: $y\times$ IF $= \int Q\times$ IF $\mathrm{d}x + C$, then divide by IF

Linear $\frac{dx}{dy} + P_1 x = Q_1$: I.F. $= e^{\int P_1\,dy}$, $x \cdot$ I.F. $= \int Q_1 \cdot$ I.F. $dy + C$ → Treat x as the dependent variable

Watch for IF $= e^{\int P}\mathrm{d}x$; then divide everything by IF

10 Vector Algebra

Magnitude; unit vector: $|\vec{a}| = \sqrt{x^2 + y^2 + z^2}$, $\hat{a} = \frac{\vec{a}}{|\vec{a}|}$ → Magnitude and direction of vectors

Direction cosines: $l = \frac{x}{|\vec{r}|}$, $m = \frac{y}{|\vec{r}|}$, $n = \frac{z}{|\vec{r}|}$, $l^2 + m^2 + n^2 = 1$ → Direction cosines and direction ratios of a vector

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$\overrightarrow{PQ}$: $(x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$ → Write vectors in component form

Section, $m : n$ internal; external: $\frac{m\vec{b} + n\vec{a}}{m+n}$, $\frac{m\vec{b} - n\vec{a}}{m-n}$ → Position vectors of dividing points

Dot product: $\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}|\cos\theta = a_1b_1 + a_2b_2 + a_3b_3$ → Angle between vectors; projection of one on another

Perpendicular; projection of $\vec{a}$ on $\vec{b}$: $\vec{a} \cdot \vec{b} = 0$; $\frac{\vec{a}\cdot\vec{b}}{|\vec{b}|}$ → Projection of one vector on another

Cross product: $\vec{a} \times \vec{b} = |\vec{a}||\vec{b}|\sin\theta\,\hat{n} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$ → A vector perpendicular to both

Area: parallelogram; triangle: $|\vec{a} \times \vec{b}|$; $\frac{1}{2}|\vec{a} \times \vec{b}|$ → Areas of triangles and parallelograms

Parallelogram from its diagonals: $\frac{1}{2}|\vec{d}_1 \times \vec{d}_2|$ → Areas of parallelograms with the vector product

Parallel $\vec{a} \times \vec{b} = \vec{0}$; $\vec{a} \times \vec{b} = -\vec{b} \times \vec{a}$; $\hat{i} \times \hat{j} = \hat{k}$, $\hat{j} \times \hat{k} = \hat{i}$, $\hat{k} \times \hat{i} = \hat{j}$ → Choose the right product for each part

11 Three Dimensional Geometry

DCs from direction ratios a, b, c: $l = \frac{a}{\sqrt{a^2+b^2+c^2}}, \ldots$ → Convert between direction cosines and direction ratios

Line through $\vec{a}$ parallel to $\vec{b}$: $\vec{r} = \vec{a} + \lambda\vec{b}$; $\frac{x-x_1}{a} = \frac{y-y_1}{b} = \frac{z-z_1}{c}$ → Line in space through a point parallel to a vector

Through two points: $\vec{r} = \vec{a} + \lambda(\vec{b} - \vec{a})$; $\frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_2-y_1} = \frac{z-z_1}{z_2-z_1}$ → Line in space through two points

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Angle between lines: $\cos\theta = \frac{|a_1a_2 + b_1b_2 + c_1c_2|}{\sqrt{a_1^2+b_1^2+c_1^2}\sqrt{a_2^2+b_2^2+c_2^2}}$ → Angle between two lines from direction ratios

Perpendicular; parallel: $a_1a_2 + b_1b_2 + c_1c_2 = 0$; $\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$ → Decide whether lines are parallel or perpendicular

Shortest distance, skew lines: $d = \frac{|(\vec{b}_1 \times \vec{b}_2) \cdot (\vec{a}_2 - \vec{a}_1)|}{|\vec{b}_1 \times \vec{b}_2|}$ → Shortest distance between skew lines

Parallel lines: $d = \frac{|\vec{b} \times (\vec{a}_2 - \vec{a}_1)|}{|\vec{b}|}$ → Distance between two parallel lines in space

Lines intersect ⇔ shortest distance = 0. Foot of perpendicular from P: general point Q on the line with $\overrightarrow{PQ} \cdot \vec{b} = 0$ → Foot of the perpendicular; image of a point

12 Linear Programming

Maximise/minimise $Z = ax + by$ subject to linear constraints, $x, y \geq 0$ → Formulate problems: objective function and constraints

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Corner point method: the optimum occurs at a corner of the feasible region. Bounded region: both max and min exist → Evaluate the objective function at each corner point

Unbounded: M is the max only if $ax + by > M$ has no point in the feasible region (use $< m$ for the min) → Unbounded feasible regions and multiple optimal solutions

13 Probability

Conditional: $P(E \mid F) = \frac{P(E \cap F)}{P(F)}$, $P(F) \neq 0$ → Conditional probabilities and their properties

Watch for: The given event goes after the bar

Properties: $P(S \mid F) = 1$, $P(E' \mid F) = 1 - P(E \mid F)$ → Use the properties of conditional probability

Multiplication rule: $P(E \cap F) = P(E)P(F \mid E) = P(F)P(E \mid F)$ → Successive draws without replacement

Independent: $P(E \cap F) = P(E)P(F)$ → Decide whether events are independent

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Union: $P(E \cup F) = P(E) + P(F) - P(E \cap F)$ → Probabilities of combinations of events

Total probability (partition $E_1, \ldots, E_n$): $P(A) = \sum_{j=1}^n P(E_j)P(A \mid E_j)$ → An event that can happen in several ways

Bayes' theorem: $P(E_i \mid A) = \frac{P(E_i)P(A|E_i)}{\sum_{j=1}^n P(E_j)P(A|E_j)}$ → Which machine produced a faulty item

Watch for: Define events in words; show the total-probability line

Random variable: $p_i \geq 0$, $\sum p_i = 1$, $E(X) = \mu = \sum x_i p_i$ → Mean of a random variable from its distribution

Watch for Write $P(A \mid B)$ with the given event after the bar

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